THERMAL BOX

User Manual

HYPER CRAFT®

Table of Contents

1 System Overview

Hypercraft's Thermal Box™ is a ready-to-use, integrated system designed to manage the temperature of an electric vehicle's critical components. It combines heating and cooling systems in a compact, durable, and efficient package. The Thermal Box consists of two independent thermal loops providing heating and cooling for the cabin and ESS systems.

Offered in two operating voltage ranges (240-450V) and **(475-805V)**

Plug-and-Play: Thermal Box is designed for easy installation. Built with Amphenol and TE electrical connectors, pre-configured wiring, and o-ring refrigerant fittings in industry standard sizes, for ease of integration into your EV build.

Robustly built with solid mounting points, Thermal Box™ is designed to mount in multiple orientations, in order to fit many different applications.

Constructed of aluminum for lightweight packaging and efficient heat dissipation.

Featuring Positive Temperature Coefficient (PTC) self-regulating, High Voltage electric heaters for safe and efficient ESS heating and provides instant / on demand cabin heating.

Built-in safety features including:

- Automatic system shutdown in the event of overheating.
- Leak Detection: System can self detect coolant leaks and alert the user.
- Failsafe Modes: Predefined modes to ensure the EV remains operational in the event of a non critical component fault or failure.

Thermal Box includes temperature and pressure sensors for the real-time monitoring of both the ESS thermal system and cabin heating loop.

Electronic Control Unit (ECU): Centralized control automatically switches between heating and cooling modes based on real-time data inputs, including cell temperature, ambient temperature and WEG loop temperatures ensuring optimal performance without user intervention.

Thermal Box™ ensures that the EV operates within the system's optimal temperature ranges, enhancing performance, safety, and battery life while providing a user-friendly and efficient solution for temperature management.

All these capabilities have been brought together in one small device, Hypercraft's Thermal Box, the perfect solution to simplify and tidy-up much of the plumbing in your EV build into one compact, elegant and stylish package.

1.1 What's in the Box?

The Thermal Box includes:

- 1x PTC ESS (Battery) Heater
- 1x ESS heating and coolant WEG pump.
- 1x PTC Cabin Heater
- 1x Cabin heater WEG loop pump.
- 1x Chiller Unit (Heat Exchanger, Refrigerant to Coolant)
- 2x Fluid Temperature Sensors
- 1x TXV Expansion Valve
- 1x Refrigerant Drier (serviceable)
- 1x Cabin Loop Refrigerant Solenoid Valve
- 1x Battery Loop Refrigerant Solenoid Valve
- 2x Refrigerant Pressure Sensors
- 1x Auxiliary 12VDC Power Connector for up to Two Additional Coolant Pumps
- Low Voltage Internal sub harness
- HV voltage sub harnesses

1.2 Functionality

Gen 1 - Thermal Box is not stand alone.

This system has been designed to interface with the Hypercraft Powertrain PDM unit. The Thermal Box relies on battery BMS data inputs from the VCU, to automatically activate the ESS heating and cooling systems.

- **If the Thermal Box is intended for bespoke systems, consult sales & confirm the application and controls required prior to ordering.**

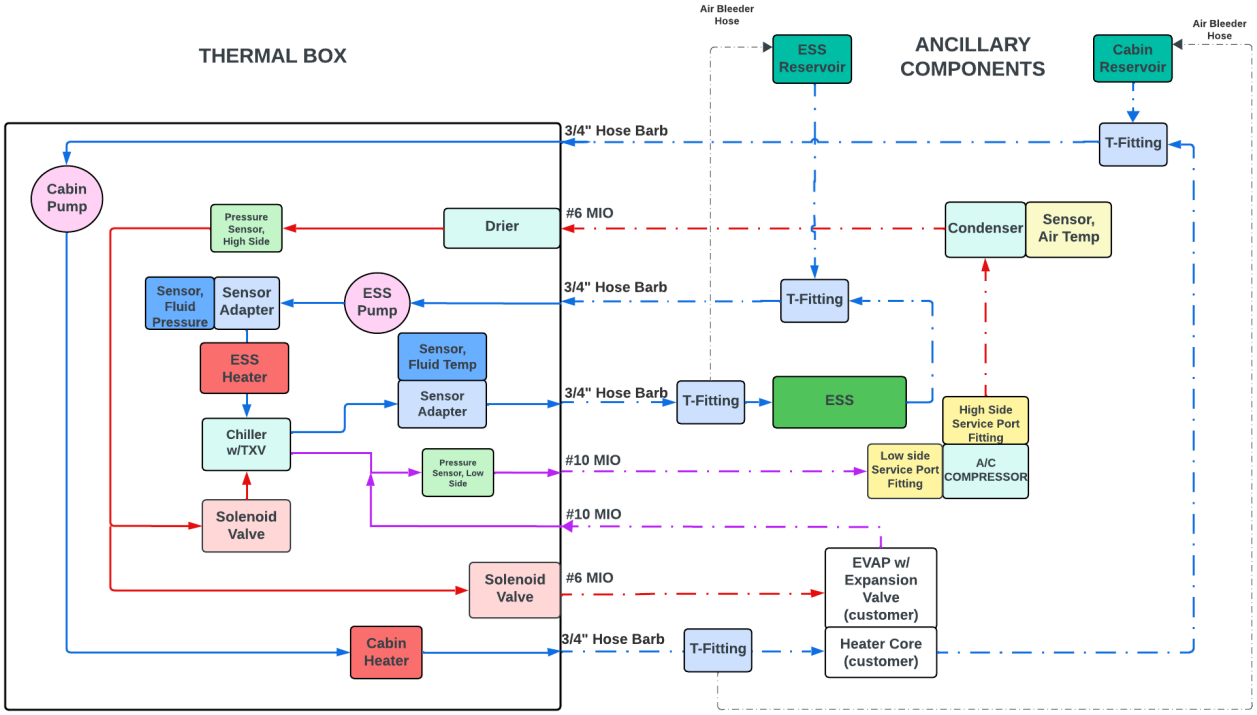
Battery Heating and Cooling: Inside the Thermal Box, WEG is pumped through the Chiller and ESS Heater, to chill or heat the WEG (never at the same time), as required. WEG is then pumped out of the Thermal Box and through the battery system, delivering cooling or heating to the chiller plates inside the ESS before returning to the Thermal Box to repeat this cycle.

Cabin Heating Mode: Inside the Thermal Box, WEG is pumped through the Cabin Heater, heating the fluid to the set temperature. The heated WEG is then plumbed out of the Thermal Box and through the heater core, warming the passenger cabin, before returning to the Thermal Box to repeat this cycle. Cabin heating is activated on/off by providing a low voltage signal to the powertrain PDM.

Cabin Cooling Mode: Inside the Thermal Box, the normally closed cabin A/C solenoid is energized, holding it open to allow pressurized refrigerant to be pumped from the Thermal Box to the cabin's evaporator core (with expansion valve). The blower fan forces air across the evaporator, cooling the passenger cabin, and the refrigerant is then returned to the Thermal Box where its

routed with the ESS return refrigerant to the air conditioning pump, then condenser and back into the thermal box to repeat this cycle.

System Basic Schematic & Plumbing Diagram



2 Definitions

Term	Definition
Amp (A)	The Ampere, or Amp for short, is the unit of measure for electrical current. Current is the quantity of electrons flowing through a conductor.
Ampacity	Ampacity refers to the maximum amount of electric current a conductor or device can carry before sustaining immediate or progressive deterioration.
Volt (V)	A Volt is defined as the potential difference between two points in a conductor when a current of one Ampere (A) dissipates one Watt (W) of power between those points.
Watt (W)	Unit of power, calculated by multiplying Voltage by the Amps being delivered or consumed. One Kilowatt (kW) = 1000 Watts.
Finger Safe	When access to live, high voltage is restricted, so as to, not allow a finger to come in contact, then a terminal is considered finger safe. See standards IEC 60529, NFPA 70E, and IP20.
Fireman's Loop	Wire to cut/pull which quickly shuts down operations of the vehicle's high voltage systems.
WEG	50/50 mixture of distilled Water/Ethylene-Glycol a.k.a (Coolant, or, Anti-freeze).
ESS	Energy Storage Systems (a.k.a. batteries).
IMD	The Insulation Monitoring Device is a device connected to the high- and low-voltage side of the battery, and has monitoring lines connected to the chassis which senses for HV leakage.
VCU	The Vehicle Control Unit is the main controller for all EV system functions, coordinating with subsystem controllers to manage the entire EV system.

HVIL	A high voltage safety feature. The high voltage connectors are equipped with an integrated High Voltage Interlock Loop (HVIL), a low voltage circuit that indicates an open (unsafe) or closed (safe) state for HV components.
PPE	Personal Protective Equipment is the safety gear required to safely perform work; e.g.: Insulated Tools, HV Gloves, Face Shield, Electrician's Hook, Arc Flash Rated Clothing, Safety Glasses, etc.
Thermal Management System	A system for managing the temperature of the passenger cabin and power electronics (ESS, inverters, motors, chargers, converters).

3 Technician Training Requirements

Hypercraft recommends that technicians are trained per NFPA 70E.
https://www.nfpa.org/product/nfpa-70e-standard/p0070ecode
https://en.wikipedia.org/wiki/NFPA_70E

Additional EV training may be obtained here:
https://continue.weber.edu/professional/programs/evtraining/

4 Uncrating and Inspection

Inspect all products for any signs of damage. If any damage is detected, reject the shipment from the carrier, and immediately contact Hypercraft Technical Service for assistance.

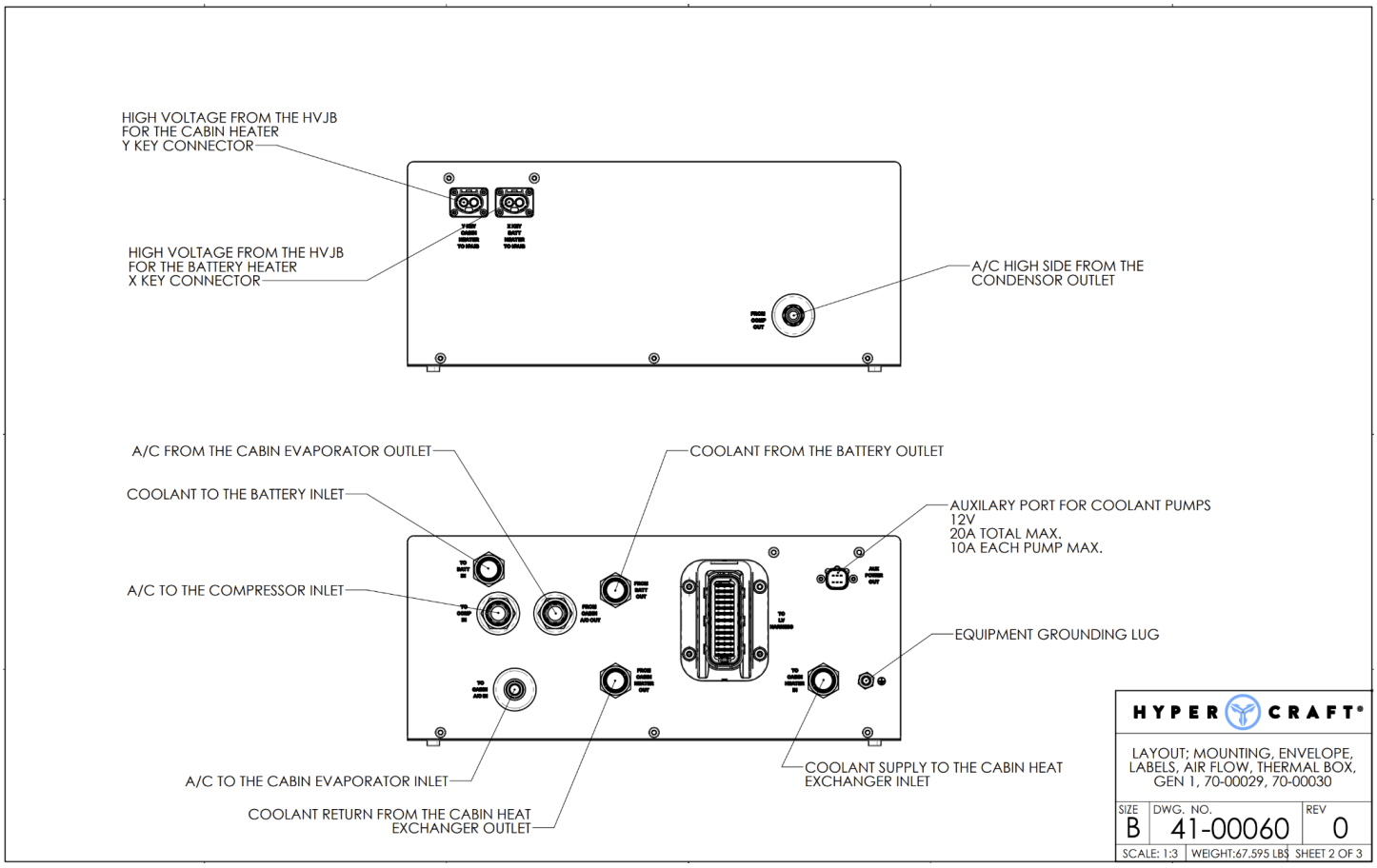
Customer Service (801)317-8475 or email support@hypercraftusa.com

5 Product Specifications

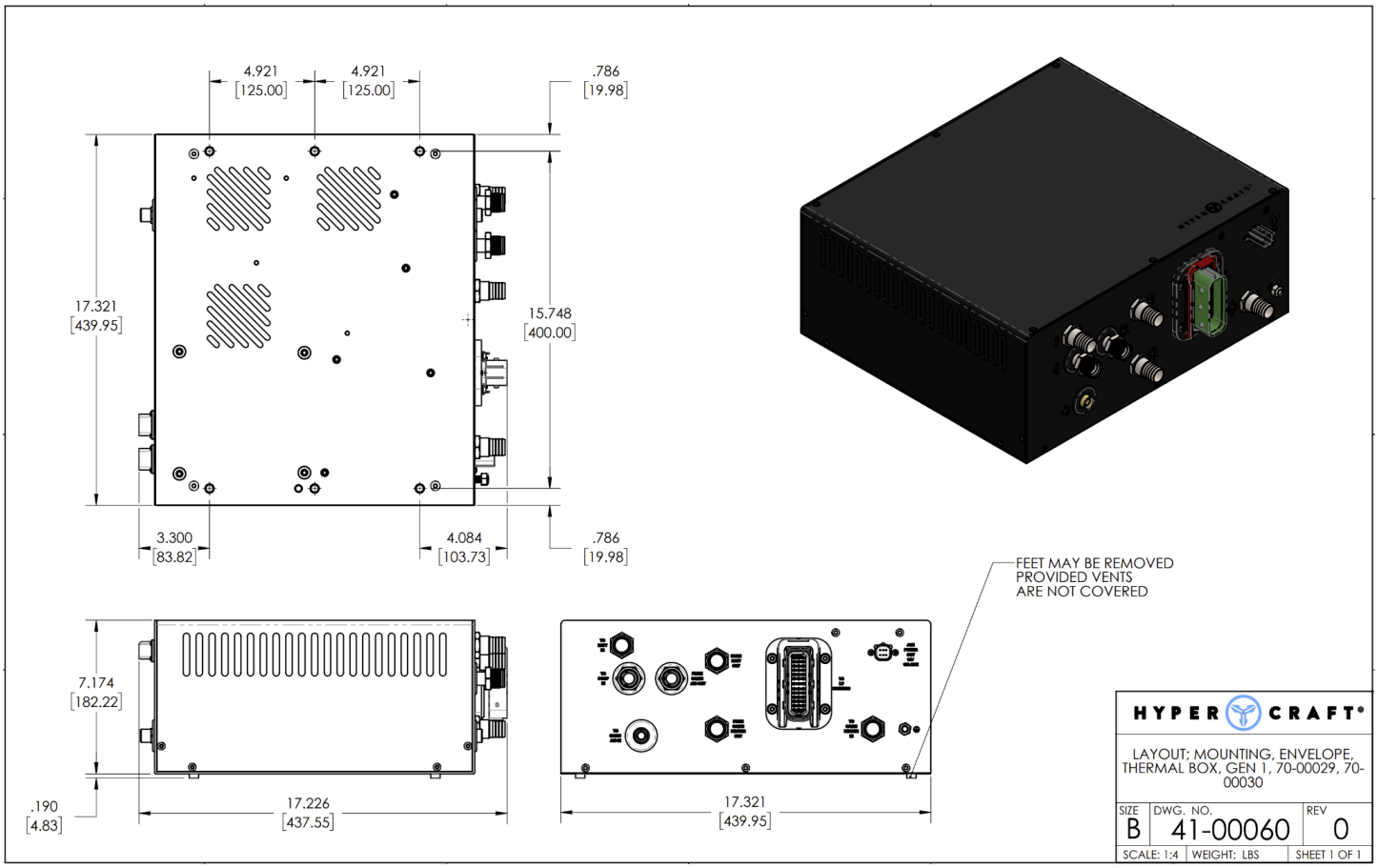
Dimensions without Mating Connections:
439.95 mm L x 437.55 mm W x 182.22 mm H (17.321“ L x 17.226“ W x 7.174“ H)
Dimensions with Allowances for Mating Connections (Hoses, A/C fittings, Electrical Connectors & Harnesses):
439.95 mm L x 659.79 mm W x 182.22 mm H (17.321“ L x 25.976“ W x 7.174“ H)
Mass: (Refer to Technical Drawing)
Material: Aluminum
Finish: Black Anodized
Refrigerant Required: r134a or r1234yf
Fluid Required: 50/50 Water-Ethylene Glycol
Refrigerant Quantity: Minimum of 24oz (680 g), Refer to Fill instructions below for capacity.
Chiller Cooling Capacity: up to 12kW
Battery Heater Output: up to 3kW
Cabin Heater Output: up to 7kW
Oil Type: RL68H (POE)
Oil Quantity: ~30 ml
Recommended Storage Temperature: 25 C (77 F)
Recommended Storage Humidity: 0-15%
Ambient Operating Temperature: -10 C to 50 C

6 Integration - Mechanical

6.1 External Interfaces



6.2 Mechanical Drawing



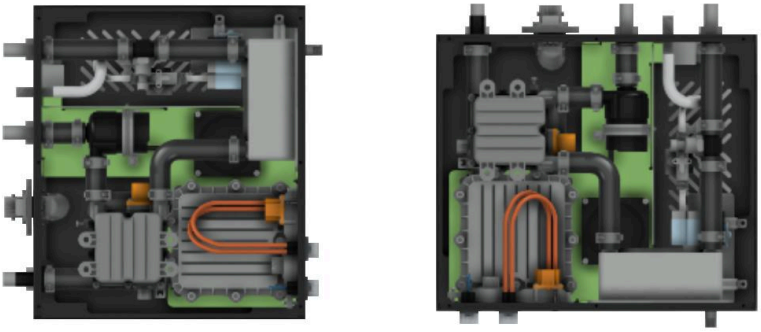
6.3 Mounting

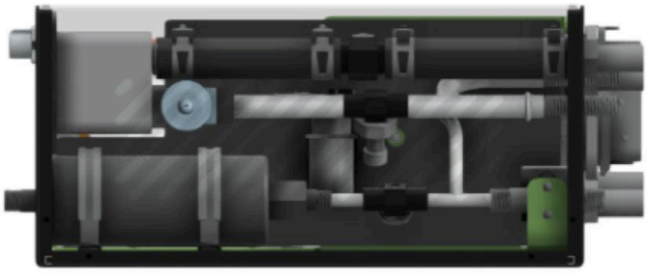
Mounting Points: (Six) M10x1.25 through holes

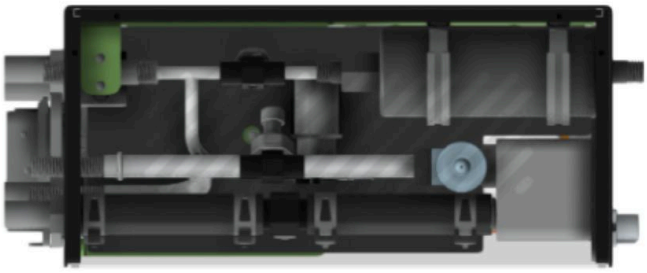
Mounting Fasteners Required: Grade 8.8 Bolts torqued to 30 Nm (22 ft-lbs) with Red Thread Locker, Washer + Lock Washer

Mounting Orientation:
Always mount the Thermal Box below the coolant reservoirs feeding the coolant inlet fittings.
Never mount the Thermal Box with the coolant and refrigerant fittings facing down.
Mount the Thermal Box only in the approved orientations, as shown below.

Note; If the low voltage connector is facing upwards, then a water tight connector boot must be installed to prevent water intrusion via the connector.





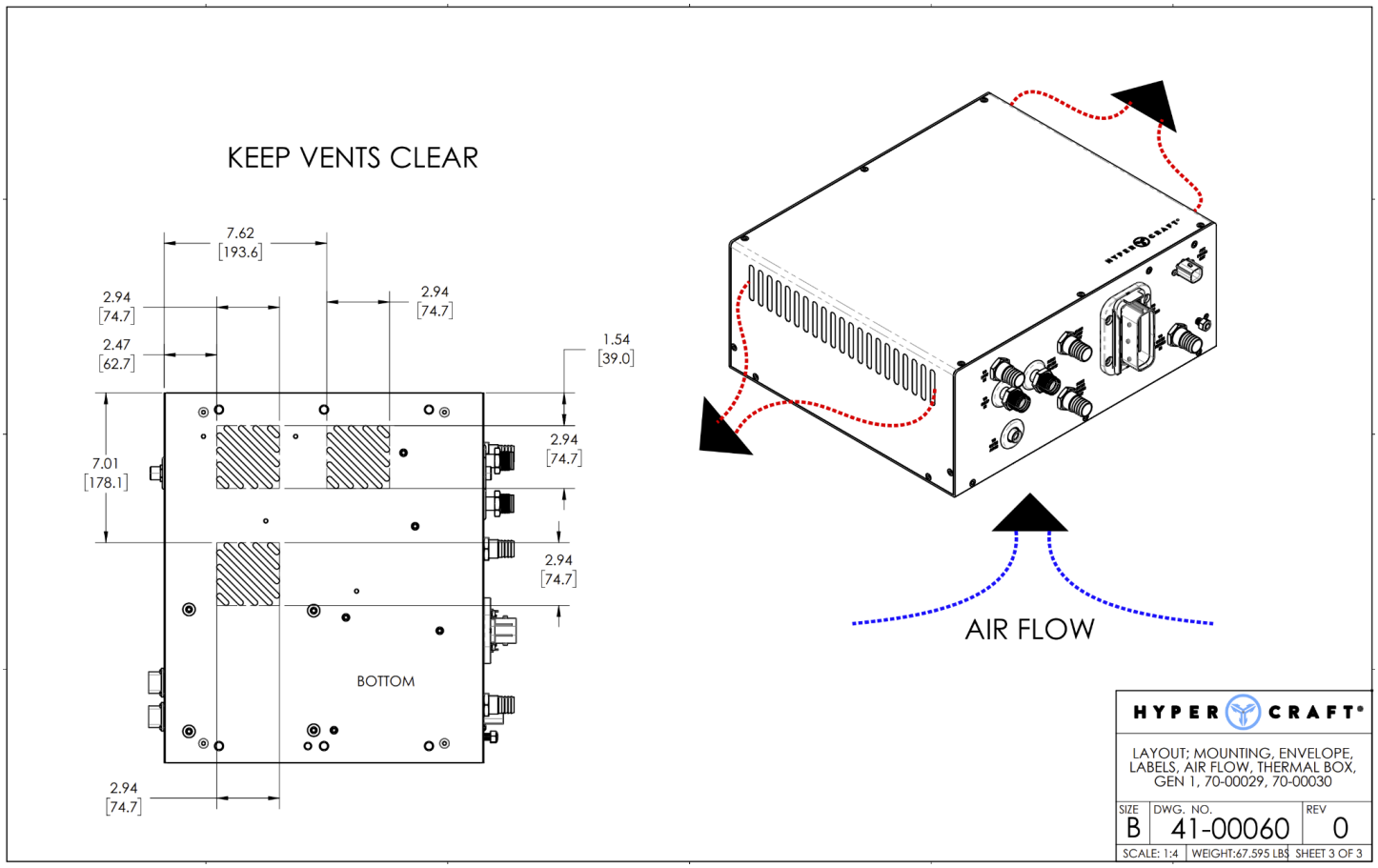


6.4 Dynamic Loads and Forces

Protect the Thermal Box from excessive mechanical shock loads and vibration. Dampen as required to maintain natural vibration to above 18hz.

1. Dampen excessive shock loads that could compromise safety or performance.
2. Damping isolators are recommended for installation with a hardness (commonly) Shore 80-90A hardness to achieve a natural vibration frequency above 18Hz.
3. The Thermal box must be mounted with isolation from all stresses from all connected A/C lines, WEG hoses, electrical harness & cable connections. Ensure each mating interface is secured independently, and within 6 inches from the thermal box connection to maintain electrical and mechanical integrity during the life of the vehicle.

6.5 Air Flow Requirements



Grilles in the Thermal Box's outer casing are designed to provide cooling to the A/C drier and lines via convection cooling. Heat from the refrigerant lines rises through the upper grille while the lower grille draws in cooler air, dissipating heat without the use of a fan.

- Do not block air flow through the grilles.
- Do not install your Thermal Box in a sealed compartment.

7 Integration - Electrical

7.1 Connector Interfaces

Purpose	Qty	Positions	Connector
High Voltage Heater (3kW)	**1**	**2**	**Amphenol PL082X-61-10 (Receptacle)**
High Voltage Heater (7kW)	**1**	**2**	**Amphenol PL082Y-61-10 (Receptacle)**
Main Low Voltage Connector (Controls and Sensors)	**1**	**39**	**TE 5-2387150-1 (Male)**
Auxiliary Coolant Pumps (12VDC)	**1**	**6**	**Molex 148028-6001 (Male)**
Grounding Point	**1**	**1**	**M8-1.25 x 16mm (Male Stud)**

Thermal Box is equipped with one M8-1.25 x 16mm grounding stud, which must be grounded to the chassis prior to energizing.

Recommended grounding method: Braided, tin-plated, 4 gauge, copper grounding strap with M8 (~5/16") terminal lugs, bolted to the vehicle chassis.

CAUTION:

Failure to ground the Thermal Box can result in faulty operation, damage to the internal components, and renders the vehicles IMD inoperable to detect high voltage leakage or faults, which can result in serious injury and/or death.

7.1 Main LV Connector, Pinout Diagram

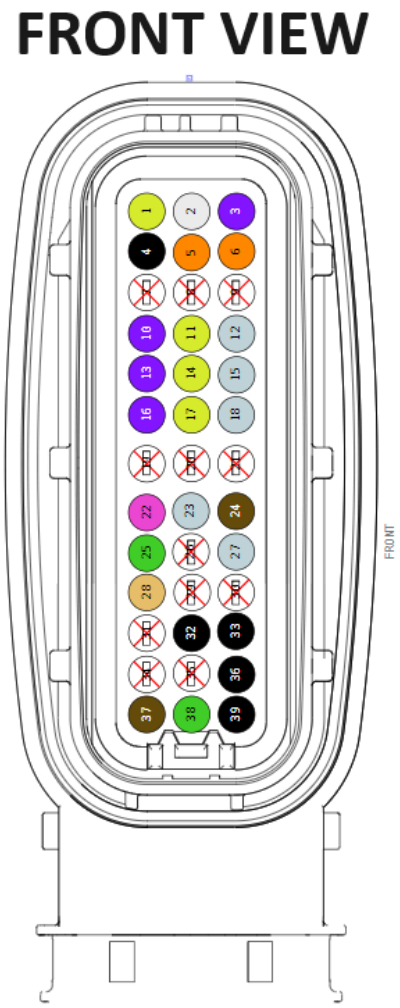


Image is for Reference only:
Refer to the Thermal Box Schematic / Controlled Drawing for the most up to date information. Located in the resources tab on www.hypercrafusa.com

CAVITY	COLOR	AWG	SIGNAL
1	Yellow	20	IGNITION POWER
2	White	20	CAN3 H
3	Violet	20	CAN3 L
4	Black	20	CHASSIS GROUND
5	Orange	20	HVIL, HEATERS, COMBINED
6	Orange	20	HVIL, HEATERS, COMBINED
7			
8			
9			
10	Violet	20	5V POWER, A/C PRESSURE SENSOR, HIGH SIDE
11	Yellow	20	A/C PRESSURE SENSOR, HIGH SIDE SIGNAL
12	Gray	20	A/C PRESSURE SENSOR, HIGH SIDE SIGNAL RETURN
13	Violet	20	5V POWER, A/C PRESSURE SENSOR, LOW SIDE
14	Yellow	20	A/C PRESSURE SENSOR, LOW SIDE SIGNAL
15	Gray	20	A/C PRESSURE SENSOR, LOW SIDE SIGNAL RETURN
16	Violet	20	5V POWER, COOLANT PRESSURE SENSOR (BATT)
17	Yellow	20	COOLANT PRESSURE SENSOR SIGNAL
18	Gray	20	COOLANT PRESSURE SENSOR SIGNAL RETURN
19			
20			
21	Blue	20	PWM, INTERNAL PUMPS, COMBINED
22	Pink	20	COOLANT TEMPERATURE SENSOR
23	Gray	20	COOLANT TEMPERATURE RETURN
24	Brown	16	BATTERY PUMP 12V POWER
25	Green	16	CABIN PUMP 12V POWER
26			
27	Gray	18	CABIN A/C SOLENOID POWER
28	Tan	18	BATT A/C SOLENOID POWER
29			
30			
31			
32	Black	14	INTERNAL PUMPS GROUND, COMBINED
33	Black	16	A/C SOLENOIDS GROUND, COMBINED
34			
35	Blue	20	PWM, AUXILIARY PUMPS, COMBINED
36	Black	14	GROUND, AUXILIARY PUMP 1
37	Brown	14	POWER, AUXILIARY PUMP 1
38	Green	14	POWER, AUXILIARY PUMP 2
39	Black	14	GROUND, AUXILIARY PUMP 2

Table is for Reference only:
Refer to the Thermal Box Schematic / Controlled Drawing for the most up to date information. Located in the resources tab on www.hypercrafusa.com

When building the mating connector harness, please carefully follow the manufacturer's assembly instructions.

TE Internal #: 5-2385846-1

TE Internal Description: AMP MCP2.8 RECEPTACLE HSG.,39 POS.,ASSY

All unused cavities must be plugged and all wires must be sealed.

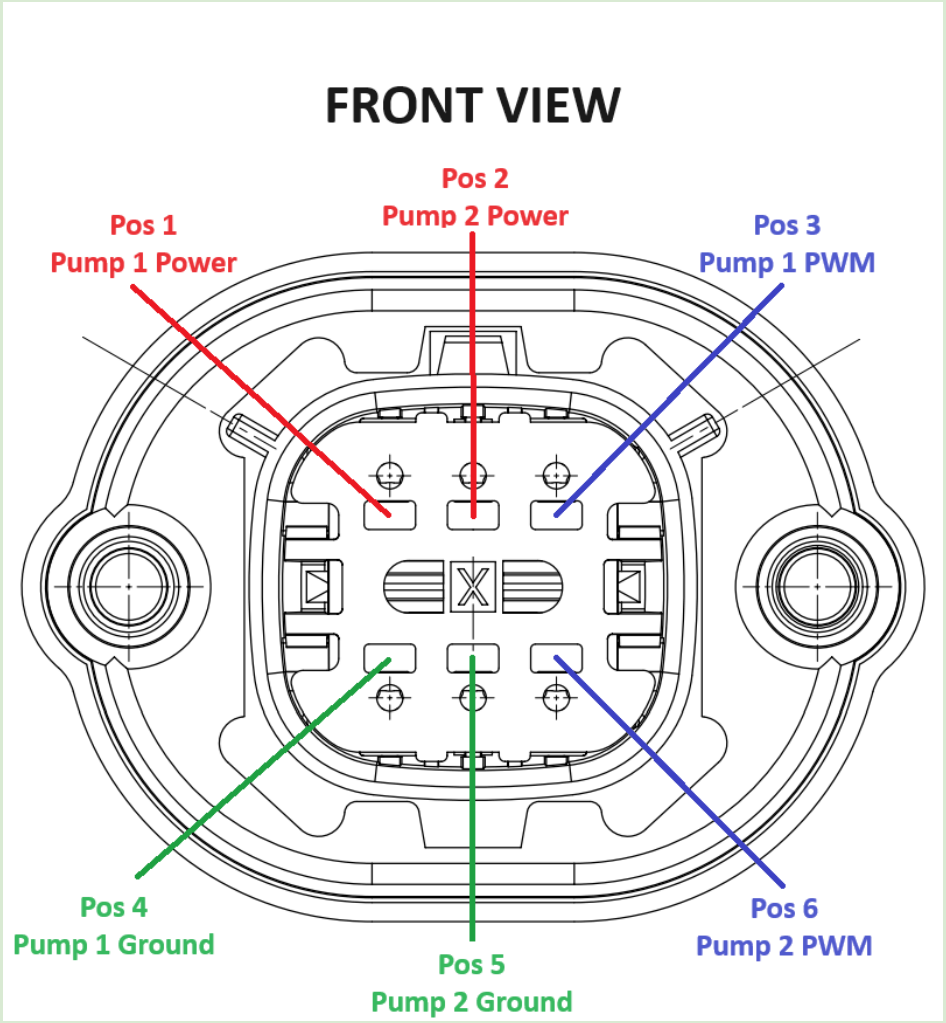
7.3 Auxiliary Pump 12VDC Connector, Pinout Diagram

Thermal Box is fitted with a six position auxiliary 12VDC power connector (**Molex 148028-6001)** to energize up to two additional coolant pumps, when needed, capable of delivering 9A max continuous per pump, as well as PWM signal.

When routing wire to your auxiliary coolant pumps, use **14 AWG (2.1 mm²)** conductor or larger, and do not exceed **3 meters (9.8 ft)**. This will compensate for any voltage drop in the harness, ensuring the pumps will receive at least 12VDC. Use an inline 10A automotive fuse for each pump, for overcurrent protection.

When building the mating connector harness, ensure the wires are terminated and seated correctly, per the manufacturer's assembly instructions.

- MX150 Mat-Sealed Female Connector Assembly, Dual Row, 6 Circuits, Keying Option A, with Connector Position Assurance, Black MPN: 334720606

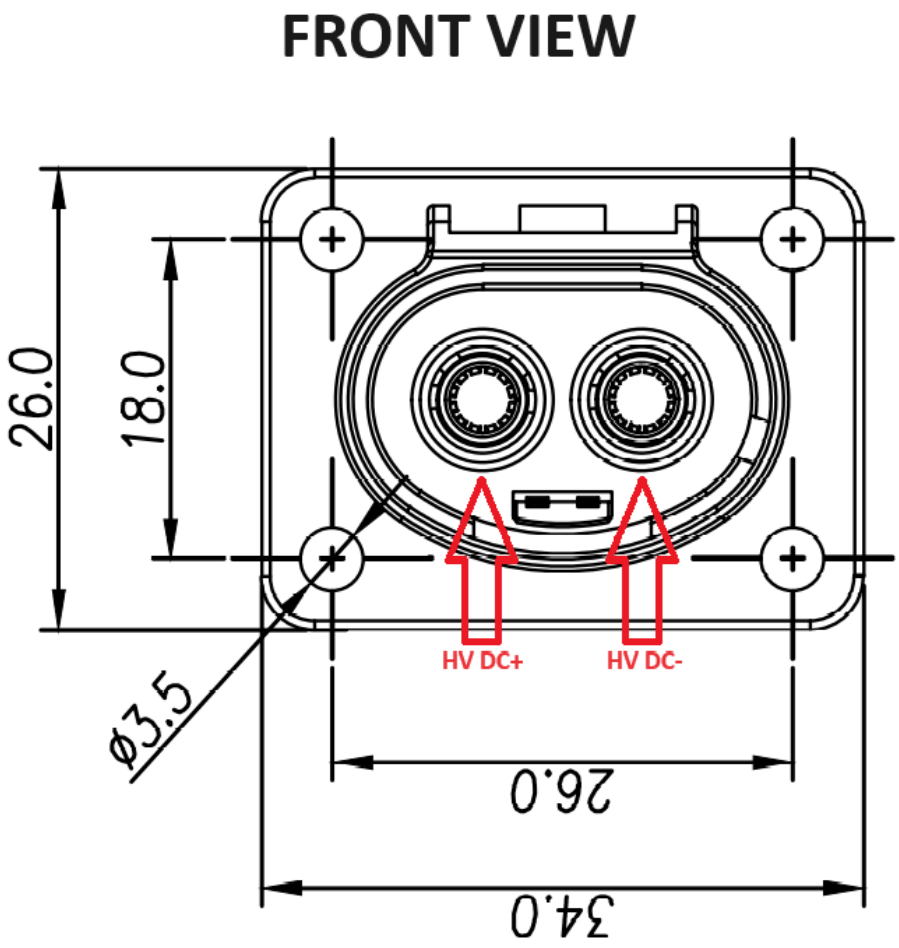


7.4 High Voltage Connectors, Pinout Diagram

Thermal Box is fitted with two HV connectors, supplying power for the HV Heaters - Amphenol PL082X-61-10 and PL082Y-61-10.

It is critical the mating HV harness are assembled correctly, per manufacturer specifications, with shielded, 10 mm², stranded, single conductor HV cable rated for the system voltage.

Ensure polarity is correctly pinned out (see diagram below); Incorrect polarity can result in damage to the HV heaters and is not covered under warranty.



7.5 Wire Management

Planning a Route:

Plan a route for the harnesses before connecting to the high voltage batteries or HVJB. Avoid manipulating any cables while connected.

Proper routing is crucial to safeguard against damage from vibration, moisture, and harsh conditions.

General Rules and Guidelines:

Connectors facing upwards must have a sealed backshell to prevent water pooling on the seals. If water is left on connector seals, then the connector will not hold its given IP rating.

All connector cables and looms require a drip loop close to the connectors, this is a slight depression in the cable route to make water drip off the cable prior to reaching the connectors when possible. The same result can be achieved by routing upwards and then turning into the connectors.

1. Avoid routing near sharp edges, moving or rotating objects, and potential pinch points.
2. Avoid routing in areas that may encounter excess moisture and road debris.
3. Ensure High Voltage and Low Voltage harnesses intersect at a 90-degree angle rather than running parallel to minimize electromagnetic interference. If forced to route HV and LV cables parallel to each other, then maximize distance between the routes, and never bundle together.
4. Bends
    a. Maintain a bend radius equal to 5 times the cable diameter to prevent damage to the cable's insulation.
    b. Allow cables to exit the rear of the connector without bending for approximately 3 inches to prevent stress on the cable and ensure proper sealing.
    c. Handle cables with care, avoiding twisting, kinking, or excessive tension during installation.

Securing the Harness:
Secure the harness firmly to a static object every 12 inches, ensuring fasteners are tight enough to prevent slipping without over-tightening, which could damage the cable jacketing/insulation. Use cushioned clamps or grommets to prevent abrasion and damage to the cables.

Managing Conflicts:
If conflicts arise between these guidelines and your vehicle's constraints, consult ISO standards for guidance. Additionally, consider consulting with qualified professionals or engineers experienced in high voltage cable and harness management for tailored solutions.

8 Integration - Coolant & Refrigerant Systems

8.1 Plumbing Interfaces

Thermal Box is equipped with the following plumbing connections:

Coolant Inlet/Outlets: 19mm (¾") Hose Barbs
High Pressure A/C Inlet (from Condenser): #6 Male Insert O-RIng (MIO)
High Pressure A/C Branch Away (to Evaporator): #6 Male Insert O-RIng (MIO)
Low Pressure A/C Branch Return (from Evaporator): #10 Male Insert O-Ring (MIO)
Low Pressure A/C Outlet (to Compressor): #10 Male Insert O-Ring (MIO)

Thermal Box is designed with industry standard plumbing connections, for ease of integration with most vehicles' thermal management systems. However, there are outliers, and depending on the end user's heater core and evaporator setup, adapting up or down in size may be required.

8.2 Plumbing Guide

If installing **multiple batteries** or power electronics in the same coolant circuit, the plumbing **should always be routed in parallel**, never in series. Manifolds are required to route coolant to and from multiple branches.

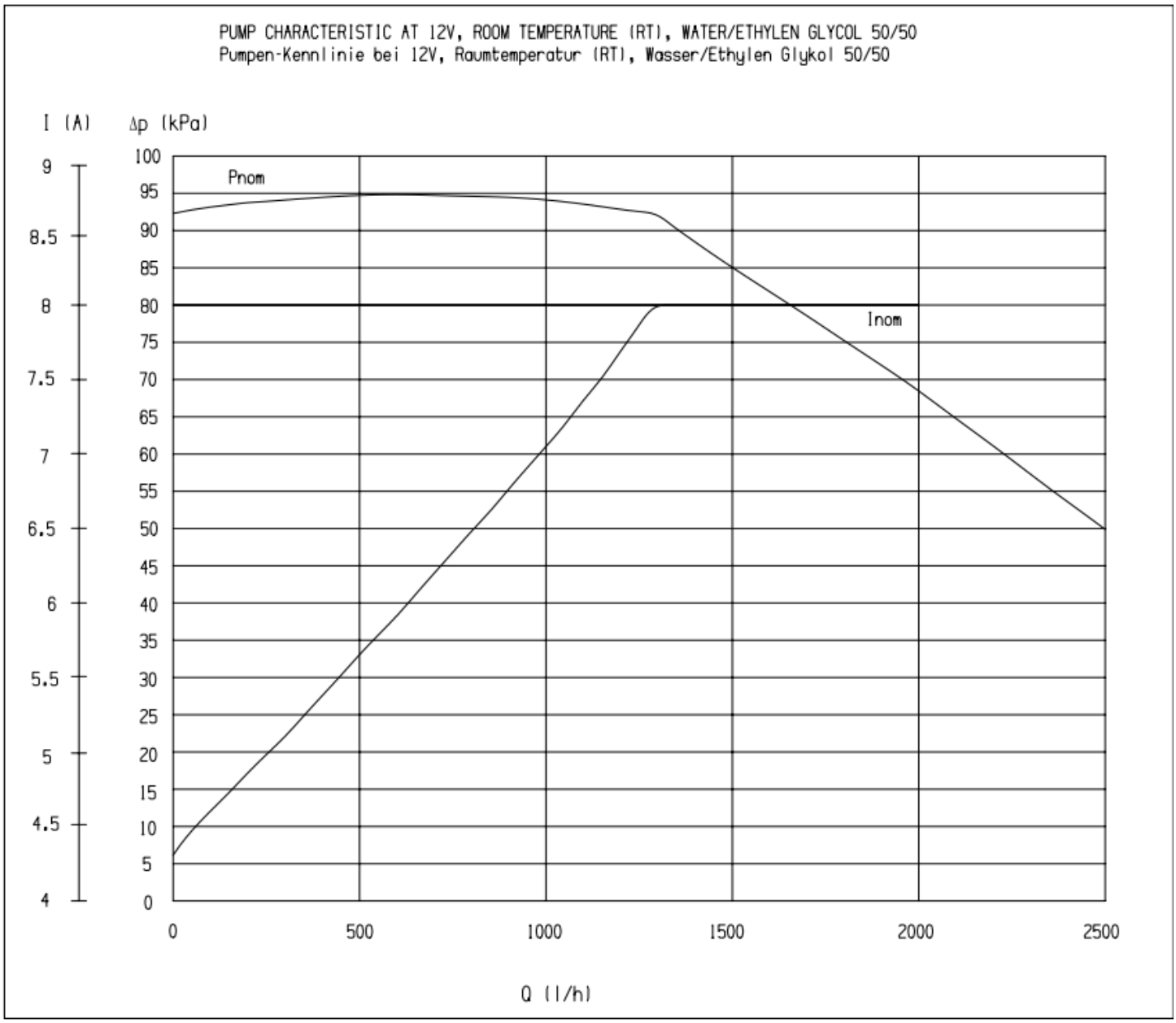
It is the responsibility of the installer to ensure minimum flow requirements are met for each device. Pressure drops in each branch must be determined, in order to calculate the number of pumps required to achieve flow requirements.

Coolant will flow with a bias through branches with less resistance. Therefore, if one pump is providing flow for parallel branches with the same flow requirement, this requires equalizing the pressure drop in each of the branches.

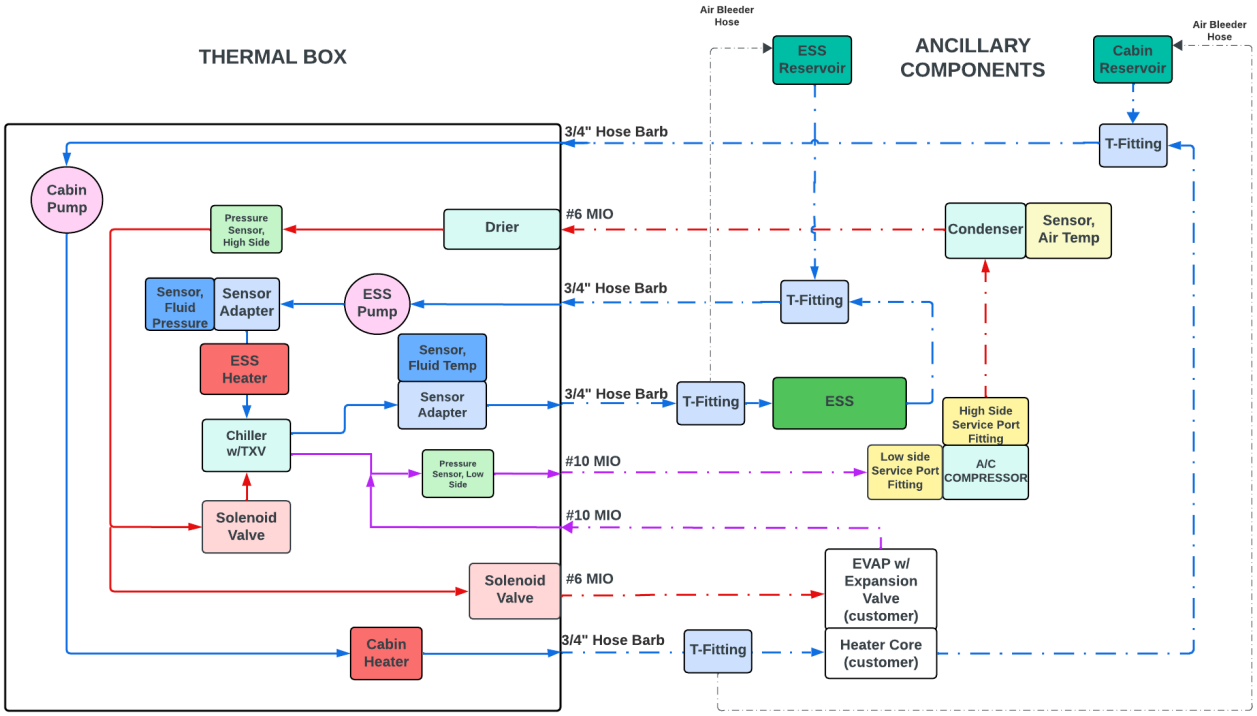
Hose lengths, fittings, flow restrictions/bottlenecks, devices' internal flow resistance, and mounting locations all affect pressure drop in a branch. Devices mounted higher or further away from the pump relative to other devices will have greater pressure drops. Hoses with smaller ID have more pressure drop than larger ID hose for a given length.

Please refer to the HyperPack user manual for more information on battery plumbing guidelines.

Coolant Pump Performance Chart
Thermal Box is equipped with two coolant pumps - one on the battery branch, one on the cabin branch. Please reference the chart below to determine flow rate at a given pressure.
If your battery system pressure drop data is known, you can calculate how many auxiliary coolant pumps are needed on your battery branch, if any. Auxiliary coolant pumps can be powered via the 12VDC auxiliary pump connector on the front of the Thermal Box.



Coolant Pump Performance Chart



Plumbing Diagram

8.3 Coolant Filling Procedure

Before filling:

- Ensure the reservoirs are highest points in their respective plumbing loops.
- Ensure all coolant fittings have hoses attached and routed in accordance with the plumbing diagram above.
- Ensure all hose connections are securely clamped.
- Add an air bleeder return line to actively bleed air from the system. Refer to your systems manual for more information, or, the powertrain thermal diagram.

Step 1: Remove the reservoir fill cap and pour coolant into the system until it's nearly full.

Step 2: Turn on the pumps and fully open any valves (if applicable). The coolant level will drop as it circulates, deaerating the system.

Step 3: Top off the coolant.

Step 4: Continue running the pumps and topping off the coolant until the fluid level is no longer dropping.

Step 5: Reinstall the fill cap.

Step 6: With the pumps running and valves fully open (if applicable), inspect all hose connections, ensuring there are no coolant leaks.

Note: The time required to fully deaerate your system is dependent upon the complexity of your plumbing setup. Failure to fully deaerate your system can result in poor performance or damage to components.

8.4 A/C Integration & Maintenance

When installing or servicing any A/C system, special care must be taken to keep fittings free of debris, and their o-rings lubricated and undamaged. When connecting A/C lines to the Thermal Box, hold the device-side bulkhead fittings firmly in place with a spanner wrench as you tighten the external fittings.

CAUTION:

Do not apply force to the external mating fittings without supporting the device-side bulkhead fittings.

A/C O-Ring Fitting Torque Specification

Fitting End	Thread Size	Torque Spec
#6	⅝”-18	11-13 FT/LB (15-17 Nm)
#8	¾”-16	15-20 FT/LB (21-27 Nm)
#10	⅞”-14	21-27 FT/LB (29-36 Nm)

8.5 Moisture Integrity

Caution:

The compressor is shipped without oil, and must be oiled prior to operation.

Add oil to the compressor via the high side port (the smaller opening). Attach and tighten fittings as soon as oiling is completed, resealing the system from outside air. Please reference section 5 Product Specifications for type and quantity of oil required.

It is extremely important that A/C systems are kept sealed air-tight. Thermal Box ships with caps on all the external fittings the end user must interface with.

Do not remove these caps until ready to install external fittings.

Thermal Box contains a drier whose purpose is to absorb moisture from the A/C system. Refrigerant oil is also very hygroscopic and will absorb moisture from the air, if exposed. Excessive moisture in a refrigerant system can reduce performance, shorten component life, and cause system failure.

For these reasons, it is critical the A/C system is kept sealed to prevent exposure to air for more than five minutes. A/C ports must be kept sealed until the lines are to be attached. Any lines

not sealed on both ends must be plugged until the moment they are installed, to prevent moisture contamination.

Failure to do this will require replacing the drier, and evacuating and replacing the oil and refrigerant in the system. Such damage will not be covered under warranty.

8.6 Vacuum Test and Line Evacuation

Attach a vacuum pump to the high and low side service port fittings on your A/C lines, via a refrigerant gauge tool. Pull a vacuum of at least -20 psi (-1.38 bar) for *at least* 45 minutes. Water has a lower boiling point in a vacuum, so this process will boil any moisture in your A/C system and pull the vapor out.

After pulling the vacuum, close the valves and detach the gauge tool. Let the system sit undisturbed for 15 minutes, then reattach the gauges and open the valves. If the vacuum has been lost or reduced, that means there may be a leak in the system and further investigation is required.

Investigate, repair, and repeat the vacuum test.

Potential Leak Causes: Damaged O-Rings, Loose Fittings, Improperly Crimped A/C Hoses, Cross Threaded Fittings

Leak Finding Aids: UV Dye Kit, Halogen Detector, Smoke Kit

If your A/C system holds a vacuum, proceed to fill the refrigerant.

8.7 Refrigerant Fill Procedure

Preface: The Thermal Box's chiller and your vehicle's cabin evaporator are expansion valve controlled devices. To determine the correct amount of refrigerant to add, you must calculate the subcool during the filling operation.

The amount will vary based on the length and size of lines used, and the volume of your evaporator.

Plan for at least 24oz (680 g) to get it close in most cases, and then measure the subcool as it nears that fill level. Subcool is the difference between the refrigerant saturation temperature at the high side compressor outlet, and the measured temperature of the refrigerant at the condenser outlet. **The target is 10˚F (5.5˚C) subcool.** Meaning the liquid exiting the condenser is 10˚F (5.5˚C) less than the saturation point at the high side compressor outlet and therefore must be fully in the liquid phase. Many gauge sets have markings to simply read the saturation temperature directly on the gauge.

Caution:

Refrigerant systems operate at high pressures, and with known carcinogenic substances. Improper understanding while filling any a/c system can result in serious injuries.

The person carrying out this fill procedure should have a sound understanding of A/C systems. If you are inexperienced with A/C systems, we strongly recommend seeking professional assistance, or, at the very least, familiarizing yourself with the explanation above through video demonstrations.

Step 1: Attach gauge set to the low side service port fitting with the hose valve closed.

Caution: Never charge refrigerant into the high pressure side of the a/c system. This can result in serious injury.

Step 2: Ensure the valve is closed at the end of the middle hose (usually yellow) on the gauge set, then screw on the R134A refrigerant canister.

Step 3: Push in the schrader valve at the opposite end of the middle hose, near the gauges, while opening the valve at the refrigerant canister. The pressurized refrigerant will purge the hose of air. Let off the schrader valve as soon as refrigerant begins to escape; this should only take a moment or two.

Step 4: Energize both A/C solenoids (see section 7.1 for low voltage jumper information required) Open the hose valve on the low side service port fitting. Refrigerant will begin to rush into your A/C system. Fill the system with as much refrigerant as it will take without running the compressor. On the gauge set, there should be a sight glass to view the refrigerant flow into the system. Once you are certain the refrigerant is no longer flowing into the system from the canister, proceed to Step 5.

Step 5: Turn on the compressor. Depending on your A/C compressor control setup, this will vary. If you purchased the HV A/C Compressor and control device from Hypercraft, you will need to send an A/C 'activate' signal to the compressor via the user interface knobs/switches on your vehicle's dash.

Step 6: With your control device software, gradually increase the speed and power output of the compressor until it is running at max speed and full power. Do not exceed a change of 1000 RPM/min and 1kW/min during this ramp-up process. This will pull in the refrigerant needed for operating at peak performance. When the gauge reads 10˚F (5.5˚C) subcool, disconnect the refrigerant canister, close the hose valves, and remove the filling equipment.

Caution: Do not operate the Thermal Box above 300 psi (~20.7 bar). Do not overfill or underfill the A/C system. This will cause reduced performance and potential damage to components. If you are unable to achieve 10˚F (5.5˚C) subcool, seek professional assistance.

9 Troubleshooting

Fault	Solution
System is Leaking / Won't Hold Vacuum	Visually inspect o-rings for chips, cracks, cuts or other damage. Replace as necessary and lubricate. Verify fittings are not cross threaded or over/under tightened. Ensure hoses are fully seated in their fittings and crimped properly (if applicable). If the system is not charged, using a smoke detector kit or UV dye kit can help locate the leak. If the system is already charged with refrigerant and slowly leaking, use a halogen detector to find the leak.
Can't Achieve 10°F (5.5°C) Subcool	Ensure both A/C solenoids are open while filling the system. Ensure the compressor is running at max speed and full power output while filling the refrigerant. Ensure the condenser fan is running while filling the refrigerant. Ensure the system is not over/under-filled. Ensure you're using the correct refrigerant type. Ensure the drier has not been saturated with moisture. After checking the above and 10°F (5.5°C) subcool is still not achieved, please seek assistance from a licensed A/C technician.
No Cold Coolant or Cold Air	Ensure subcool is 10°F (5.5°C). Verify your blower motor is operational. Verify the condenser fan is operational. Verify the A/C solenoids are operational. Verify coolant pumps are operational.
No Hot Coolant or Hot Air	Verify communication with heaters. Verify coolant pumps are working. Verify that the LV battery is connected and adequately charged, while also assessing for any damage to the LV harness. If no damage is visible, ensure LV harnesses are plugged in and fully seated.
No Communication with Heaters	Ensure CAN bus wires are routed as twisted pairs and properly terminated. Ensure your CAN bus wires are routed separately from HV cables, in order to minimize EMI. Verify LV wires are correctly pinned out per section 7.1, sealed and fully seated in the main LV connector. With a multimeter, check if the corresponding main LV connector pins are receiving power.

	Check if other devices are receiving power. If they are not, the problem is likely not a communication issue.
Communication with Heaters but No HV	Remove the fireman loop. (The fireman loop ensures HV is disconnected and allows for safe connection/disconnection of cables.) Inspect HV cables for any signs of damage across the vehicle. Ensure there is no ground isolation fault in the vehicle's HV system; check the IMD. Ensure all switches/knobs are in the "on" position. Verify HV connectors are fully seated with locking tabs engaged and HVIL circuit properly wired. Verify HV cables' polarity is not backwards (see section 7.4).
Auxiliary Coolant Pumps Not Working	Ensure auxiliary pumps are wired per section 7.3 of this user manual. Please reference your pumps' datasheet for pinout, PWM signal frequency, voltage and duty cycle. Verify wires are of appropriate gauge for required ampacity for your length, current draw and ambient temperatures. Ensure wires are terminated, sealed and seated correctly in the connector.
Compressor Not Operating	Verify electrical control systems are sending and receiving power and command signals. Verify operational status of relay, contactors and fuse. Verify correct sizing of precharger resistor circuit, if applicable. Please reference your manufacturer's user manual for these specifications.
Blower Motor Not Operating	Check the variable resistor, fuse and relay. If there's no continuity through one or more of these components, they've likely burned out and will need to be replaced. Please reference your manufacturer's user manual for blower motor current draw.

10 Storage & Care

Cleaning

Wipe down with a dry or damp towel.

Warning: Never pressure wash any electrical components. High pressure water can damage electrical components and may result in serious injury or death. Such damage will not be covered under warranty.

Storage

Store in a cool, dry place, away from direct sunlight and humidity. Moisture can also lead to corrosion, and sunlight can degrade materials over time.

Do not drop, compress, deform or otherwise inflict excessive force to your Thermal Box.

11 Safety

1.1 Overcurrent Protection

Thermal Box is not internally fused. All DC power sources entering the Thermal Box must be fused to prevent overcurrent. If you've purchased harnesses and junction boxes from Hypercraft with your Thermal Box, these circuits will be fused and ready for safe use. If you are installing your own overcurrent protection devices, please reference the following conductor and fuse sizing requirements below:

Device	Conductor Size	Fuse Rating
Cabin Heater HV circuit	8 awg / 10 mm^2	30A
Battery Heater HV circuit	8 awg / 10 mm^2	30A
Cabin Heater LV circuit	20 awg / 0.75 mm^2	1A
Cabin Heater LV circuit	20 awg / 0.75 mm^2	1A
Compressor HV circuits	Reference your compressor's user manual.	Reference your compressor's user manual.
Compressor LV circuits	Reference your compressor's user manual.	Reference your compressor's user manual.
Cabin Refrigerant Solenoid	14 awg / 2.1 mm^2	2A
Battery Refrigerant Solenoid	14 awg / 2.1 mm^2	2A
Internal Coolant Pumps	14 awg / 2.1 mm^2	10A
External Auxiliary Coolant Pumps	Reference your pumps' user manual.	Reference your pumps' user manual.

1.2 General Safety Guidelines

Caution: The HV Heaters require polarity specific power delivery. If your HV cables are terminated backwards, the HV Heaters will go into uncontrolled heating when powered. **It is critical the HV cables are terminated correctly, per section 7.3.**

Caution: Do not touch hot refrigerant lines.

Caution: Refrigerant system is pressurized, do not release pressure without proper refrigerant recovery equipment.

Caution: Coolant may be hot.

11.3 HVIL

Thermal Box is equipped with heavy-duty Amphenol PowerLok 60 Series connectors. These connectors are engineered to handle 1kV and 60A. They are IP67 rated, finger safe, EMI shielded and offer the HVIL safety feature.

Both HV connectors must be plugged in to create a closed HVIL circuit in your HV system. The heaters will not operate without a closed HVIL circuit, adding another level of safety to your Thermal Box.

11.4 Electrical Safety Rules

Never	Always
Never disconnect an energized connector.	Always keep connectors dry and free of debris when disconnected.
Connectors are physically keyed to their mates and should fit together without resistance; never force two connectors together.	When mating two connectors together, always ensure they are fully seated with the cam or latching tab mechanism fully engaged.
Never pressure wash high voltage equipment.	Always ensure fluid can run off of electrical connectors. Do not allow fluid to collect inside the connectors.
Never mount the Thermal Box where fluid can pool in or on electrical connectors.	Always handle electrical circuitry with caution and appropriate PPE.

Never energize a circuit without forewarning while someone is working on it.	Always practice lock-out/tag-out. Always check the energized status of circuitry before working on it.

11.5 High Voltage PPE

Recommended High Voltage PPE:

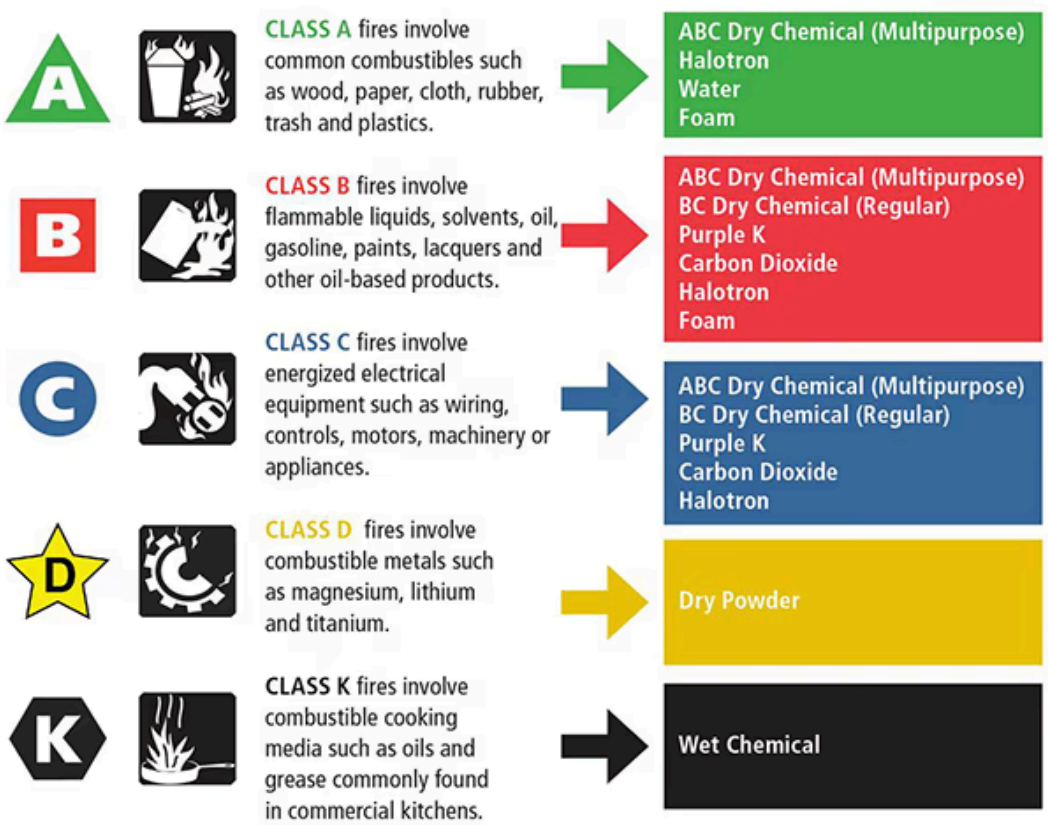
- Class 0 (1000V AC / 1500V DC) Electrical-Insulating Glove Kit (Rubber Inner Glove with Leather Outer Glove)
- Arc Flash Rated Clothing, 12 cal/sq cm (Smock or Jumper, Leggings and Balaclava)
- Arc Flash Rated Helmet with Face Shield, 20 cal/sq cm

11.6 Fire Safety

Like all electrical devices, practice fire safety when energizing the Thermal Box. The Thermal Box contains High Voltage and Low Voltage electrical systems, both of which pose the risk of electrical fire, if handled incorrectly.
Ensure the correct wire gauges are used in the external harnesses for the Amperage, ambient temperature and conductor length.
Ensure conductor insulation is rated for the appropriate Voltage and environment.
Ensure terminals are crimped, seated and sealed to manufacturer specifications.

Should an electrical fire ignite, use the appropriate extinguishing method:

Fire Extinguishing Symbols, Classifications & Agents



Always refer to specific safety guidelines and protocols provided by your employer or regulatory agencies when working with electricity. Additionally, ensure that proper ventilation is available in the workspace, especially in enclosed areas, to minimize potential exposure to fumes or gasses.

12 Support

If you have any questions or concerns related to Thermal Box™, please feel free to contact Hypercraft:

Email: support@hypercraftusa.com

Customer Service: (801)317-8475

13 Document Revision

Version	Change Description	Approved By	Release Date
1	Initial Release	EF	9.5.24

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