Model 655 Single Chamber Reactor Facilities Requirements

2.1 General

The end user/customer is responsible for supplying the site specific facilities and interconnections to provide power, process gases and cooling water to the reactor. The following sections provide complete details to facilitize the SP3 reactor.

> **Note: The user must adhere to the requirements contained herein in order to maintain compliance with applicable requirements for CE conformance.**

The vacuum pump is available as an option from SP3 or can be provided by the customer as long as it meets the appropriate specifications. SP3 supplies a vacuum Accessories Kit which includes components to assist with connection of the vacuum lines and either an N2 pump dilution kit or an air pump dilution kit for safety purposes. (See SP3 report on pump exhaust dilution)

Refer to drawing 70114 at the end of this section for all specific facilities connections.

Facilities Panel located in the rear of the Reactor

2.1.1 Environment

The CVD diamond reactor should be operated in a clean environmentally controlled area suitable for comparable equipment. Refer to the recommended Operating Environment specifications in Section 2.3 for temperature and humidity specifications. The Model 655 Series reactors should also be operated in a dust free environment with regular preventive maintenance performed as specified in section 5.1. (See Procedures 95033 and 95034)

2.1.2 Power

The user facility should be prepared to supply the reactor with primary power. A NEMA enclosure, located at the rear of the reactor, houses all of the main power input and distribution components. Large terminal blocks are provided inside this enclosure to attach flexible wiring in rigid or semi-rigid conduit provided by the user facility. The primary power sources are 480 volt 50/60 Hz three phase at 60 amps or optional 380 volt 50/60 Hz three phase at 80 amps. The 480 volt (or optional 380 volt) source should be in a four wire (delta) configuration. If these operating voltages are not available in the User facilities, a transformer with a minimum rating of 30 KVA (at full operating power and temperature) should be supplied for the 380/480VAC source. The vacuum pump may require the user facility to supply 208/220 volt three phase power for a 3 horsepower load as well. User facilities should provide wiring to the system in accordance with the table below. Circuit breakers and/or disconnects for safety and maintenance purposes should be sized according to the following current specifications.

Ratings for the two power sources are as follows.

	Std	**Optional**
	480 VAC	**380 VAC**
Circuit Breaker	60 A	80A
Breaker AIC	10 KA	10 KA
Largest Load Current	60 A	80 A
Wire Gauge	6 AWG	6 AWG

Ref. Schematic No.: 97136 or 97135 Wiring Diagrams, AC Distribution

Note: Any work done on the facility's power should be done in accordance with local governing regulations. Lock-out tag-out (LOTO) procedures should be used.

The following is recommended for all installations: however, the EMC Directive (204/108/EC) mandates the following for Europeans use:

The AC mains and fire suppression control cable shall be enclosed within metal conduit or raceway as specified by local, national or other applicable governmental codes and regulations. The metal conduit is to be grounded to the equipment on both ends to the facilities earth grounding reference.

This system is very complex and requires AC mains voltage with minimum fluctuation . The facilities voltage supplied by the end-user must maintain a voltage fluctuation of not more than +/-5% (+/- 10% in US). Failure to maintain this voltage tolerance may result in system shutdown.

The end-user facilities must provide suitable surge protection.

2.1.3 Cooling Water

The reactor requires cooling water to control the temperature of the chamber walls. A maximum of 20Kwatts power (per reactor) may be transferred to the cooling water during normal operation. The water must be supplied to the rear panel of the reactor, at a temperature of less than 25° C and at a pressure of 60 to 100 psi (4 to 7 kg/cm$^{2)}$. The required volume is 10 gpm (40 lpm) with a pressure drop of approximately 42 psi (3 kg/cm^2). The user facility must also provide a drain or chiller/recirculating pump. The reactor can provide a pneumatic control signal to allow programmatic control of the water flow. If the cooling water is to be circulated through a chiller for reuse then adequate precautions should be taken to prevent the growth of algae in and corrosion of the aluminum chamber. All cooling water used in the system should be of sufficiently low mineral content to prevent precipitation in the water passages.

In order to control contaminants and maintain optimum heat transfer efficiency a water treatment program is recommended. It is important that the program include provisions for control of corrosion, copper transport and scale build-up within the chamber cooling paths. Since the chamber components and the cooling channels are Aluminum, it is equally important that the cooling water not be corrosive to aluminum components or damage may result. Biological contamination must be controlled with biocides if the system is not a totally closed loop. All such treatments should be initiated at system start up and continued regularly.

The pH of the circulating water must be maintained at between 7.5 and 8.3. The cooling system should not employ any components made from Brass or Copper (tubing, valves, pumps, fittings, etc.) due to potential Galvanic reaction which can lead to clogging cooling channels. Heat exchangers can be either galvanized steel or stainless steel as long as appropriate water treatment chemicals for these materials are present in the cooling water. PVC plumbing is recommended where possible.

Chemicals used to control metal migration and corrosion may include various nitrites and sodium silicate. Biocides should be selected to prevent bacterial growth, which can also lead to reduction of cooling efficiency. Oxidizing biocides should **not** be used as they can potentially erode the Aluminum cooling channels.
For specific recommendations on water treatment contact a compe

tent water treatment supplier in your local area. Deionized water (including distilled water) is **not** recommended for cooling as it is corrosive with respect to Aluminum.

NOTE: Use of distilled or deionized water will automatically void the system warranty.

2.1.4 Process Gases and Pneumatic Controls

The user must provide process and support gases to the rear panel of the reactor. N_2, CH_4 and H_2 (plus 1% Trimethylboron (TMB) in H_2 for Boron doped applications) are the required process gases. In addition, dry Nitrogen at 70 to 100 psi (5 to 7 kg/cm^2) must be provided to the rear of the reactor for the pneumatic control system and for the dilution of the vacuum pump exhaust gases if the N2 dilution method is used. If the air dilution method is used to dilute the exhaust gases the N2 line is simply capped off. The required flow rate for exhaust dilution is approximately 25 scfh (12 lpm). Dry Nitrogen for the process system will be used at a rate of 5 liters per minute for system purge (~10 minutes at completion of each process run). 99.99 % pure Hydrogen is used at a rate of approximately 3 liters per minute and 99.99 % pure Methane at a rate of approximately 0.1 liters per minute during the deposition cycle. N2 should be 99.99% pure as well.

Note: Facilities should be equipped with facility flammable gas sensors (H_2 & CH_4) and alarms to shut off gas flow and alert occupants as to the presence of hazardous gases. For hydrogen and methane gases one alternative may be a Sensidyne 'gas alert' system.

2.1.5 Gas Cabinet Exhaust

When required by local regulations, provide an exhaust blower and outside vent line to remove any hazardous gases from the gas cabinet should there be a leak. A flow rate of approximately 100 to 150 ft./min (150 to 240 NM/hr.) is required for the 4" (10 cm) duct.

2.1.6 System Exhaust

A rectangular (8.3 x 11.75 in.) exhaust duct at the rear of the reactor removes hot air from the filament power supply. This is an internally powered exhaust and can be simply vented outside the room in which the reactor is located.

2.1.7 Mechanical

The Model 655 Series Reactor is supplied with casters to make it easy to position in the desired location. Once in the desired location, retractable feet in each corner adjacent to the casters should be unscrewed to provide a secure footing. The reactor has a very low center of gravity and consequently does not pose any danger of tipping over in the event of an earthquake. However, the reactor feet should be clamped to the floor with ½" diameter (or larger) bolts to assure there is no movement once installation is complete.

2.1.8 Floor Space and Access

The reactor system is approximately 4.5 ft. (1.33 m) by 3.8 ft. (1.17 m) and should be located in a protected area that allows access on all four sides. The vacuum pump is approximately 1 ft. (0.3 m) by 2.3 ft. (0.7 m) and should be located at least 24 inches from the rear of the reactor. The vacuum pump should be mounted on isolators to prevent vibration. It is recommended that the vacuum pump be located in a separate non-inhabited room behind the reactor to maintain acceptable sound levels in the reactor operating environment. The vacuum pump must be provided with an exhaust oil separator and an outside stack/vent, preferably 4 meters above the ground, by the user facility. The reactor exhaust will consist of Hydrogen and Methane diluted with Nitrogen or air to a safe level.

2.2 Safety

SP3 Diamond Technologies products are safe and dependable when used properly. Numerous safety features have been incorporated in the Model 655 Series Reactor to protect personnel, equipment and material being processed. Follow all safety precautions during installation, normal operation and when servicing SP3 equipment.
Contact SP3 for further information and assistance.

2.2.1 Hardware safety interlocks

Equipment and personnel are protected from hazardous situations related to flammable gas, high voltages and high temperatures. The various hardware safety interlocks along with their nominal settings are shown in the table below.

The vacuum high interlock in conjunction with the main vacuum valve closed interlock prevents the flow of flammable gases while the chamber pressure is above 50 Torr (66.6 mBar). Nor will the filament power supply turn on under these conditions. This assures that flammable gases and filament power will always be contained in the process chamber in a vacuum.

The low vacuum interlock prohibits filament voltage when the pressure in the chamber is less than 5 Torr (6.6 mBar). This prevents a plasma condition from occurring in the chamber.

Interlock Name	Interlock or Function	Device or Limits
Vacuum High	Main Vacuum Valve Closed	>50 Torr (66.6 mBar) Nominal
Main Vacuum Valve Closed	No H2, No CH4 flows, No Fil. Voltage	Switch on Vacuum Valve
Pump Dilution	No H2, No CH4 flows	Flow sensor, <25cfh (12 L/min)
Vacuum Low	No Filament Voltage	<5 Torr (6.6 mBar) Nominal
H2 Leak Detector	No H2, No CH4 flows	External Input
N2 Supply/Gas Cabinet Scavenge Air Low	No H2, No CH4 flows, No Fil. Voltage	N2 In <60 psi (4.14 Bar) N2 Dilution < 10 psi (0.7 Bar) Air dilution < 30-50 cfm (see Air Flow Rates table below) Scav. Air < 150 ft/min (45.8 m/min)
Low water Flow	No Filament Voltage	Flow Sensor, <0.7 gal/min (2.6 L/min)

If Nitrogen dilution method is used to dilute the vacuum pump exhaust, Nitrogen from the facilities connection at the rear of the reactor is fed into the vacuum pump exhaust to dilute the Hydrogen/Methane gas mixture that exits the vacuum chamber. If the flow of Nitrogen drops below 7.0 Liters per minute the safety interlocks will prevent the flow of flammable gases.
If air dilution method is used, a separate blower must be installed on the pump exhaust line that supplies the minimum air flow to a trimmable vane switch based on the exhaust line diameter. (See table below) If the flow of air drops below the minimum specified, the safety interlocks will prevent the flow of flammable gases. (See schematics 97126 and 97137)
The low water flow safety interlock will inhibit filament voltage whenever the cooling water flow is less than 2.6 Liters per minute.

Air Flow Rates
Approximate actuation/deactuation
SCFM upper, **LPM** lower

Pipe	Trim	N.O.	N.C.
1-1/2”	C	33.4/31.2 946.7/883	33/30.6 935/867
2”	Full	50.2/48.4 1422/1370	50.2/47.7 1422/1352

2.2.2 Software safety interlocks

Various software interlocks are recommended in the creation of process recipes to assure that safeguards will protect the equipment and the material that is being diamond coated. User controlled Alarm/Abort Levels can be set as a percent of the programmed setpoint for all analog values and on the status of certain digital alarm inputs.

Examples of the analog process parameters for which alarm/abort levels are typically set include:

- Filament voltage
- Filament current
- Process gas flows
- Pressure (vacuum)
- Chamber (lid) temperature

Alarm and/or abort commands are preset at the factory for the following Digital inputs.

- N2 Low (pressure switch preset at 60 psi (4.1 Bar) for incoming supply)
- Cooling water flow (flow meter preset at 0.7 gal/min – (2.6 L/min.))
- Atmospheric chamber pressure (atmospheric pressure sensor preset at >700 Torr (933.2 Mbar))
- Vacuum pump N2 exhaust dilution (Nitrogen flow switch is preset at approximately 7 lpm)
- Vacuum pump Air exhaust dilution (Air flow switch preset based on exhaust pipe dia.)
- External hydrogen sensor/controller input (sensor and controller supplied by customer/end user)

It is recommended that customers install a Hydrogen sensor(s) and controller in all locations where the flammable gas supply lines have connections that can leak. This would usually include the room in which the reactor is located and the gas supply cabinet as a minimum. The output of the Hydrogen controller can be connected to the reactor at the rear facilities panel and activation of the Hydrogen alarm will automatically cause the flow of flammable gases to cease or alternatively prevent them from turning on.

2.2.3 EMO operation

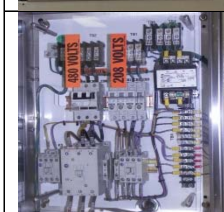
An emergency off (EMO) push-button switch is provided on the Main Control Panel in the event that the reactor must be powered down quickly. This switch will disconnect all primary power to the reactor in the system AC distribution cabinet. It will interrupt any process that is in operation at the time it is pushed. To reactivate the system the EMO switch must be pulled forward before restoring system power.

Note: The EMO switch should be used <u>only</u> in emergencies.

In non-emergency situations the preferred method of shutting down is to first close the SP3 Host software by selecting the desktop button on the left, and selecting file from the menu bar, then selecting exit. Continue to shut down Windows by selecting the start menu in the lower left corner of the desktop, and selecting shutdown. After Windows has been shut down the red EMO button may be pressed to shut off main power to the system.

2.2.4 Safety Warnings

Warning labels are affixed at various locations on and in the reactor. These labels consist of two primary personnel hazards, High Voltage and Hot Surface. Examples of these labels are shown below.

	High Voltage Warning Labels on door of Power Distribution Cabinet
	High Voltage Warning Labels in safety shield and back-plane of Power Distribution Cabinet
	High Voltage Warning Labels on Filament Power Supply cable enclosure
	High Temperature Caution Label on Reactor Lid
	Pinch Point caution on Reactor Hinge