Appendix B - Equipment

- Equipment Schedule
- Cut sheets, Shop Drawings, and Product Data

MOCVD Laboratory Study

Engineering Centers Building

UW-Madison

DFD Proj. No. 14J3G.03

Equipment				
ID	**Description**	**Qty**	**Size**	**Description**
Q1	Aixtron 3x2 CCS MOCVD Reactor	1	167.5" L x 47" W x 79" H	Aixtron - Gas Circuit Diagram - Sheet 1/2
				Aixtron - Gas Circuit Diagram - Sheet 2/2
				Aixtron - Installation Diagram - Sheet 1/2
				Aixtron - Installation Diagram - Sheet 2/2
				Aixtron - External Water Circuit 3x2"
				Aixtron - Design Review Certificate
				Aixtron - General Installation Guidance and Planning
Q2	Gas Cabinets	3	18" W x 19" D x 79" H	Gas Cylinder Cabinets
Q3	Auto-regenerable NH_3 Purifier	1	32" W x 15" D x 54" H	Ammonia Gas Purifier Specification
Q4	In-line H_2 Purifier	1		Micro Torr MC1500 Specification
Q5	In-line N_2 Purifier	1		Micro Torr MC4500 Specification
Q6	Fumehood	1		
Q7	Hydrogen Generator	1	71" W x 32" D x 75" H	Hogen H Series Technical Specifications
Q8	Scrubber	1		Edwards - M150 S Leak - Quotation
Q9	Monitoring Equipment	1		

Ver.	Change No.	Description	Approved Date	Changed/Approved
1	–	ISSUED FOR QUOTATION REVIEW	XX–XX–XX	C – A –

N2 ISO2 · H2 ISO1 · PV H66 · HYD1 NH3 ISO3 · HYD5 SiH4 100ppm ISO7 · HYD6 SiH4 100ppm ISO8

PI · PIS · 30–0–100 pressure switch in gauge set to 20psi falling pressure · 40psi · 35psi · LTV 1 · LTV 2 · CV1 1/3psi (23.3mbar) · CV2 1/3psi (23.3mbar) · PV G25 · PV G24 · 0.25mm · LTV 3 · HYDRIDE SOURCE SUPPLY

CV3 1psi 70mbar · CV4 1psi 70mbar · PV H1 · PV H2 · 10000sccm NH3 M3 · 500sccm NH3 M4

CV11 1psi 70mbar · CV12 1psi 70mbar · PV H9 · PV H10 · 100sccm H2 M15 · 1000sccm H2 M16 · 100sccm H2 M18 · 1000sccm H2 M19 · CV16 700mbar · CV17 700mbar · 100sccm H2 M17 · 100sccm H2 M20

PV G1 · PV H50 · 10000sccm H2 M23 · 5000sccm H2/N2 M24 VENT · RUN/VENT STACK 3 · PV H202 · PV H203 · HYD1–1 · HYD1–2 · LTV 8 · RUN HYD 1 TO LOWER PLENUM

PV G5 · RUN SUPPLY · PV H41 · LTV 9 · RUN MO 1 TO UPPER PLENUM

N2 TO REACTOR PURGE

H2 TO REACTOR PURGE

PV G6 · BLEND SUPPLY · PV H42 · 10000sccm H2 M30 H2/N2 BLEND · 10000sccm H2 M31 · RUN/VENT STACK 1 · 5000sccm H2 M32 VENT · DIFF 1 · ISO10 · 2000sccm H2 M33 · DUMMY 3

PV H211 · PV H214 · PV H216 · PV H219 · PV H221 · PV H223 · PV H224 · PV H226 · PV H227 · MO2 · MO4 · MO6 · MO8 · MO10 · MO11 · HYD5 · HYD6 · NV1 · VENT MANIFOLD · VENT

PV G4 · MO 1 SOURCE H2 SUPPLY · PV H53 · MO 2 SOURCE N2 SUPPLY · PV G3 · PV H52

200sccm H2 M38 · 200sccm H2 M39 · P2 · PV H17 · ISO18 · ISO19 · MO2 RM6 BATH TMGa

200sccm H2 M43 · 200sccm H2 M44 · P4 · PV H19 · ISO22 · ISO23 · MO4 RM6 BATH TMAl

200sccm N2 M49 · 200sccm N2 M50 · P6 · PV H21 · ISO26 · ISO27 · MO6 RM6 BATH TEGa

500sccm N2 M54 · 500sccm N2 M55 · P8 · PV H23 · ISO30 · ISO31 · MO8 RM6 BATH TMIn

200sccm H2 M58 · 200sccm H2 M59 · P10 · PV H25 · ISO34 · ISO35 · MO10 RM6 BATH Cp2Fe

100sccm H2 M60 · 1000sccm H2 M61 · M62 · 100sccm H2 P11 · PV H26 · ISO36 · ISO37 · MO11 RM6 BATH Cp2Mg

IPG 30–0–100 PI · LTV 5 · RM6 BATH · TO LEAK DETECTOR (NOT SUPPLIED) · MO/LT/VAC

CS*****

2/2 WAY VALVE NORMALLY OPEN
2/2 WAY VALVE NORMALLY CLOSED
4/2 WAY VALVE
3/2 WAY VALVE
5/2 WAY VALVE

MANUAL PRESSURE CONTROLLER
PARTICLE FILTER
CHECK VALVE
ELECTRONIC PRESSURE CONTROLLER

LINE HEATING WILL BE UP TO 50° C AND BE FROM OUTLET OF BUBBLER TO INCLUDE RUN/VENT STACK AND FROM THE OUTPUT OF STACK TO REACTOR
DIFFERENTIAL PRESSURE TRANSDUCER
MASS FLOW CONTROLLER
ELECTRONIC PRESSURE CONTROLLER

PT PRESSURE TRANSDUCER
PI PRESSURE INDICATOR
PIS PRESSURE INDICATOR WITH SWITCH

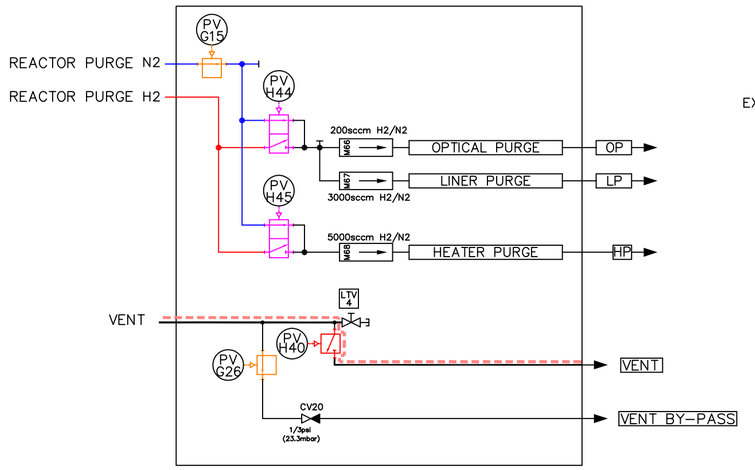
MANUAL NEEDLE VALVE
MANUAL VALVE
LTV LEAKTEST VALVE

H HYGROMETER
EPISON IV
DRY PUMP

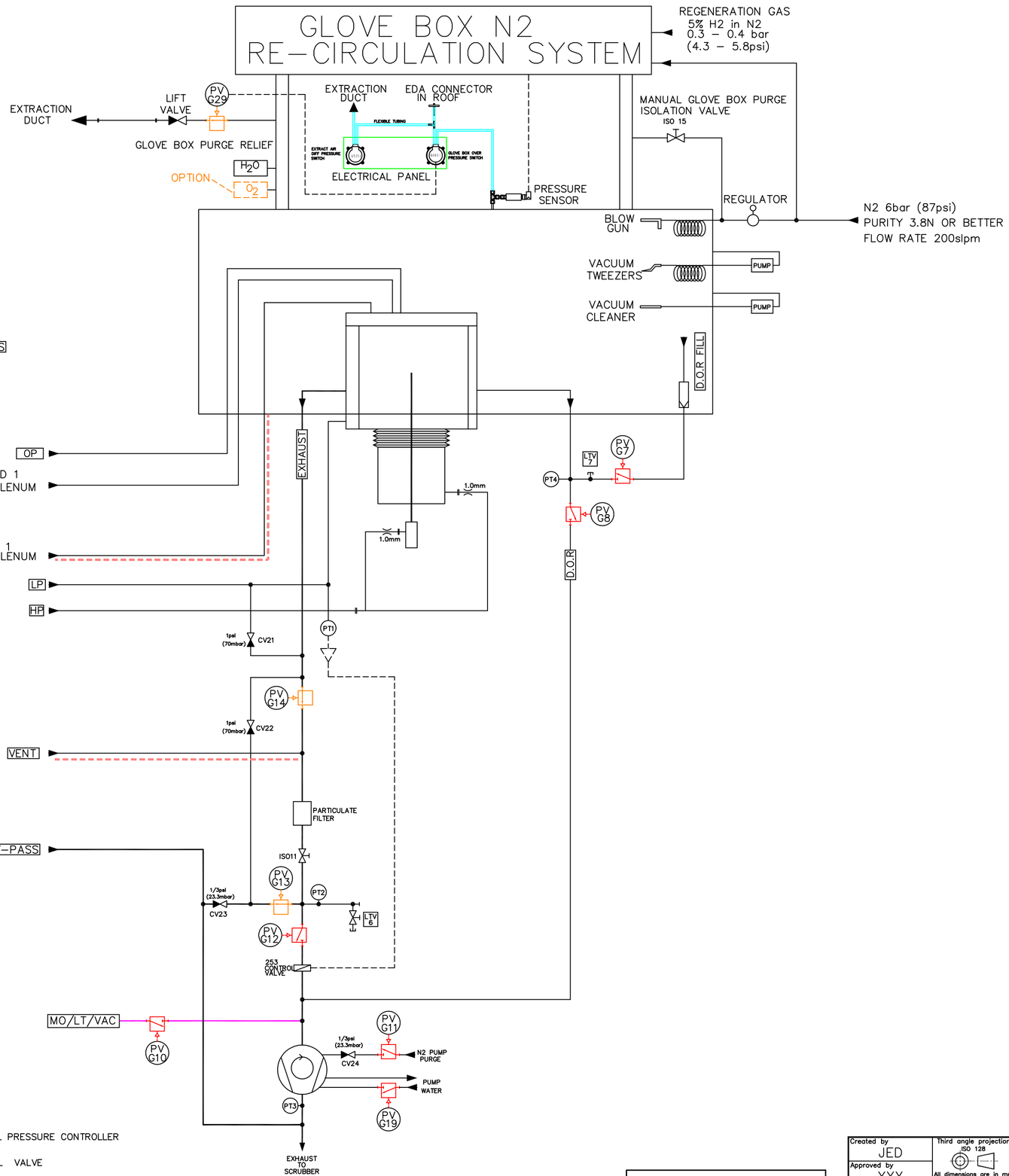
Created by JED	Third angle projection ISO 128	Material —	General tolerances according to ISO 2768 – f H (unless otherwise stated)
Approved by XXX	All dimensions are in mm (unless otherwise stated)	Finish —	General surface texture: ISO 1302 Ra 3.2 (unless otherwise stated)
Date 26–10–15	Scale 1:1	Size A1	Material No. XXXXXXXXX
AIXTRON	Title GAS CIRCUIT DIAGRAM		Document Status WIP · Sheet 1/2
			Document No. Q210815LC · Ver. 1

Ver.	Change No.	Description	Approved Date	Changed/Approved
1	–	ISSUED FOR QUOTATION REVIEW	XX–XX–XX	C – A –

PURGE PANEL



GLOVE BOX N2 RE–CIRCULATION SYSTEM



- 2/2 WAY VALVE NORMALLY OPEN
- 2/2 WAY VALVE NORMALLY CLOSED
- 4/2 WAY VALVE
- 3/2 WAY VALVE
- 5/2 WAY VALVE
- PARTICLE FILTER
- CHECK VALVE
- ELECTRONIC PRESSURE CONTROLLER
- H HYGROMETER
- IE EPISON IV
- LTV LEAKTEST VALVE
- DRY PUMP
- DIFFERENTIAL PRESSURE TRANSDUCER
- MANUAL NEEDLE VALVE
- MFC MASS FLOW CONTROLLER
- EP ELECTRONIC PRESSURE CONTROLLER
- MANUAL PRESSURE CONTROLLER
- MANUAL VALVE
- PT PRESSURE TRANSDUCER
- PI PRESSURE INDICATOR
- PIS PRESSURE INDICATOR WITH SWITCH

HEATER TEMPERATURE
1300°C

IN–SITU TOOLS
ARGUS
INTERFEROMETER

CS*****

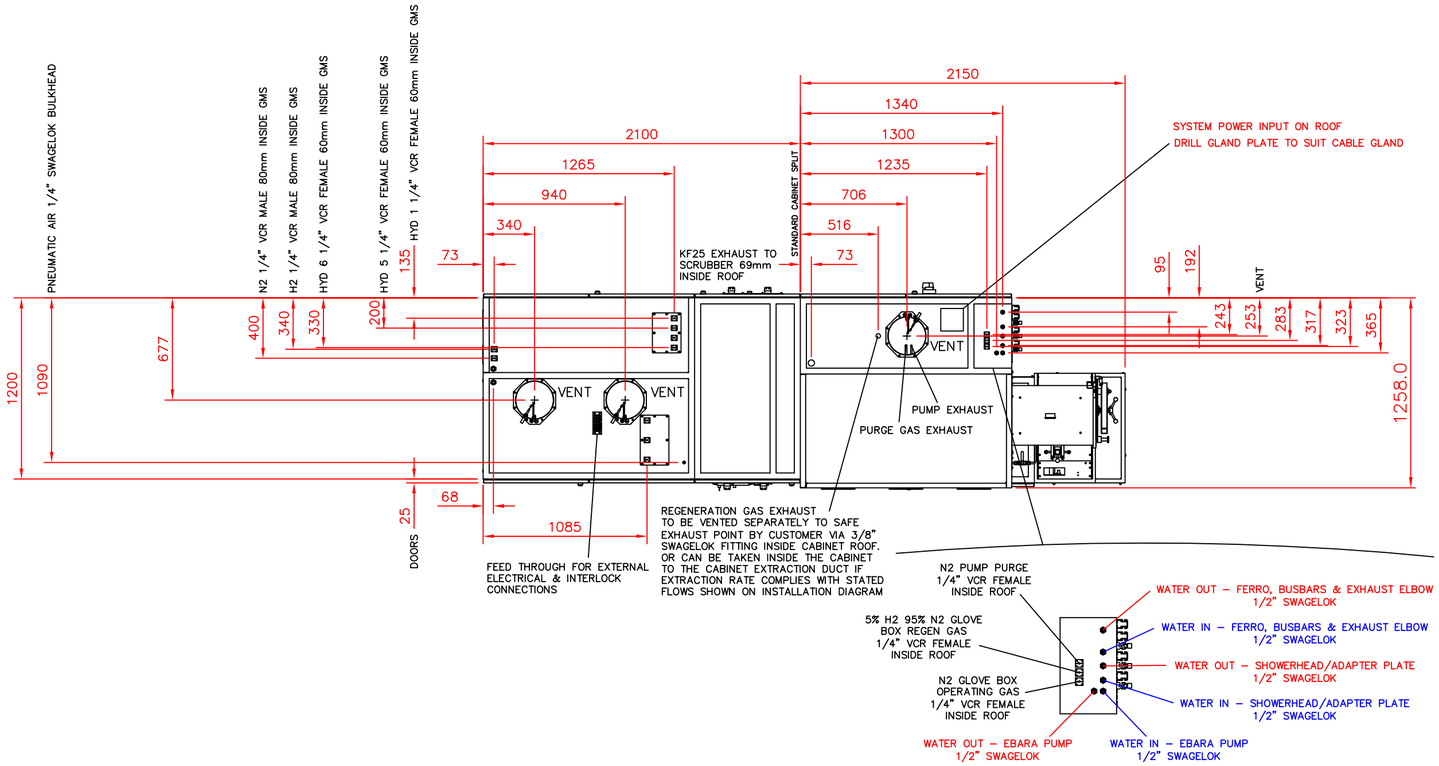
Created by: JED	Third angle projection ISO 128	Material: —	General tolerances according to ISO 2768 – f H (unless otherwise stated)
Approved by: XXX	All dimensions are in mm (unless otherwise stated)	Finish: —	General surface texture: ISO 1302 Ra 3.2 (unless otherwise stated)
Date: 26–10–15	Scale: 1:1	Size: A1	Material No.: XXXXXXXXX
AIXTRON	Title: GAS CIRCUIT DIAGRAM		Document Status: WIP; Sheet: 2/2
			Document No.: Q210815LC; Ver.: 1

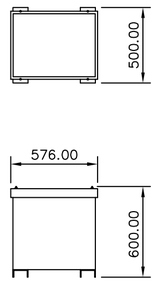
Ver.	Change No.	Description	Approved Date	Changed/Approved
1	–	ISSUED FOR QUOTATION REVIEW	XX–XX–XX	C – A –

MACHINE SERVICE REQUIREMENTS (3 X 2)		
ELECTRICAL SUPPLY TO TRANSFORMER	480V +/–10% 60Hz, 3PNE	
ELECTRICAL SUPPLY FROM TRANSFORMER	FIVE WIRE 3 PHASE WITH NEUTRAL AND EARTH 400V +/– 10% AMPS PER PHASE 100 Hz 60	
PNEUMATIC N2	90 P.S.I. THROUGH 1/4" SWAGELOK BULKHEAD FITTING	
GAS SUPPLY	Psi	MAX FLOW
SYSTEM HYDROGEN	90	* 40 Slm
SYSTEM NITROGEN	90	* 50 Slm
GLOVE BOX NITROGEN SEPARATE SUPPLY PURITY >3.8N OR BETTER	87	200 Slm
NITROGEN SUPPLY EBARA PUMP >3.8N	30	8 – 10 Slm
WATER SUPPLY BUSBARS FEEDTHROUGH	SEE DRAWING A1–53585C	
WATER SUPPLY SHOWERHEAD CHAMBER		
WATER SUPPLY EBARA PUMP		
GLOVE BOX FORMING GAS 5%H2 95%N2	4.3 – 5.8psi	3500L each regen
HYD 1–1 NH3–1	30	* 10000sccm
HYD 1–2 NH3–2	30	* 500sccm
HYD 5 SiH4	30	* 100sccm (100ppm)
HYD 6 SiH4	30	* 100sccm (100ppm)
MO2 TMGa		* 200sccm
MO4 TMAl		* 200sccm
MO6 TEGa		* 200sccm
MO8 TMIn		* 500sccm
MO10 Cp2Fe		* 200sccm
MO11 Cp2Mg		* 100sccm

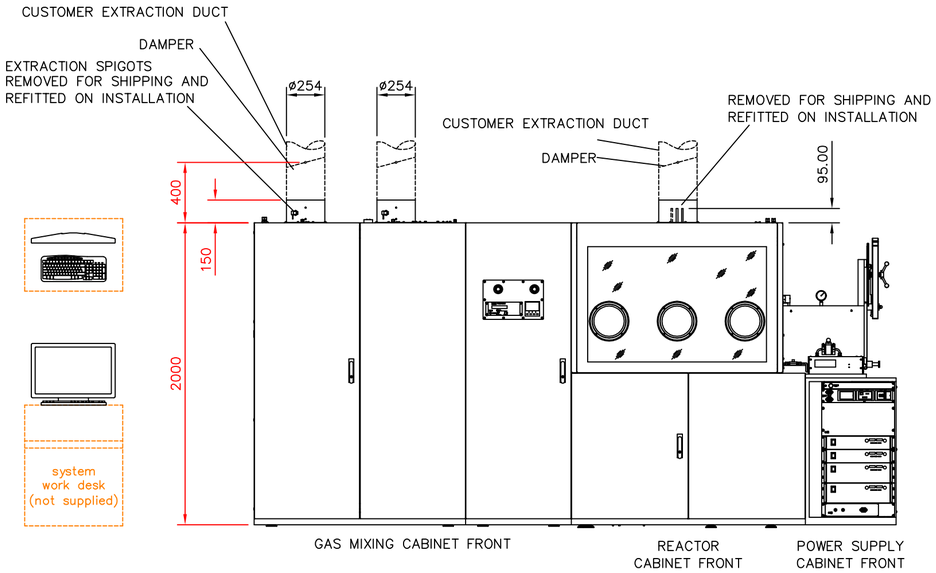
* PLEASE NOTE ALL FLOWS SHOWN ARE MAX CAPACITY
ACTUAL FLOWS AND CONSUMPTION WILL BE PROCESS DEPENDENT

EXTRACT AIR	CONTROL CABINET INLET – 800 CFM FROM ROOM EXTRACT – 2 X 400 CFM DUCTS (SEE NOTE 1)
	REACTOR CABINET INLET – 750 CFM FROM ROOM EXTRACT – 1 X 750 CFM DUCT (SEE NOTE 1)
NOTE 1	EXTRACT SYSTEM MUST HAVE A MINIMUM OF 1" WATER GAUGE EXTRACT PRESSURE. AN ADJUSTABLE DAMPER MUST BE PROVIDED FOR EACH EXTRACT DUCT.

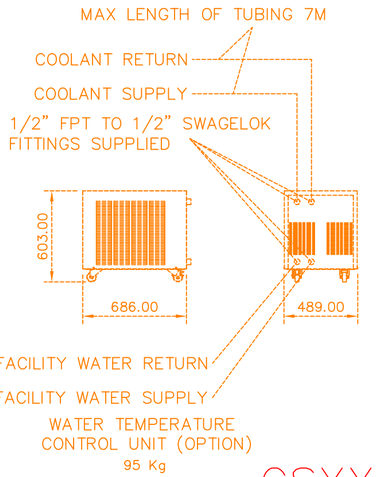




STEP DOWN TRANSFORMER
350 Kg



1550 Kg gas control cabinet
24 Kg RM6 bath without liquid (each)
1225 Kg reactor cabinet
240 Kg pump

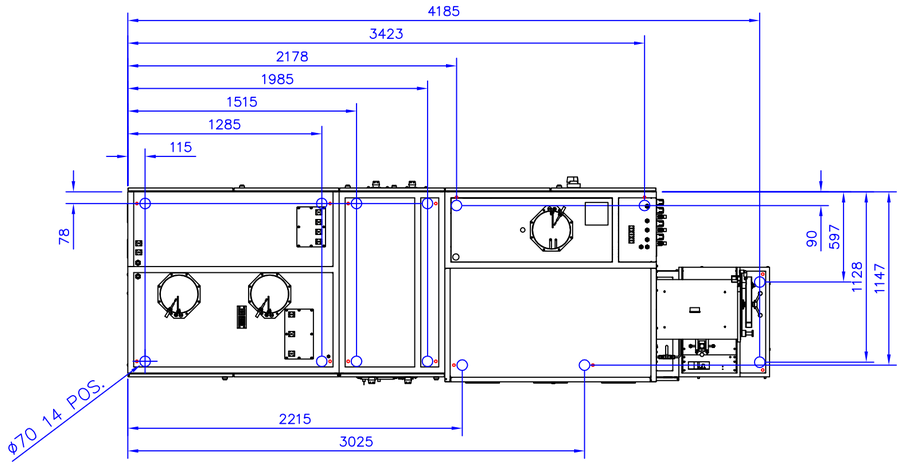


WATER TEMPERATURE CONTROL UNIT (OPTION)
95 Kg

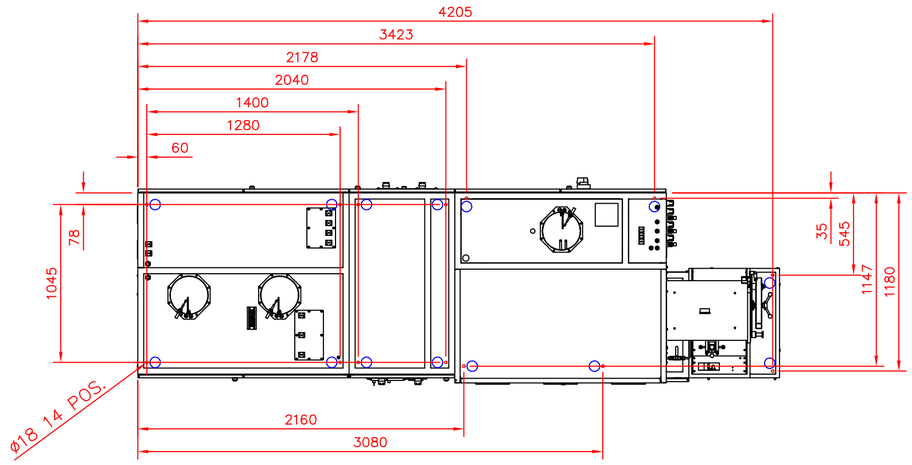
CSXXXXX

Created by JED	Third angle projection ISO 128	Material —	General tolerances according to ISO 2768 – f H (unless otherwise stated)
Approved by XXX	All dimensions are in mm (unless otherwise stated)	Finish —	General surface texture: ISO 1302 Ra 3.2 (unless otherwise stated)
Date 26–10–15	Scale 1:20	Size A1	Material No. XXXXXXXXX
AIXTRON	Manufacture in accordance with Work Instruction 340 unless otherwise stated	Title INSTALLATION DIAGRAM	Document Status WIP; Sheet 1/2; Document No. Q210815Li; Ver. 1

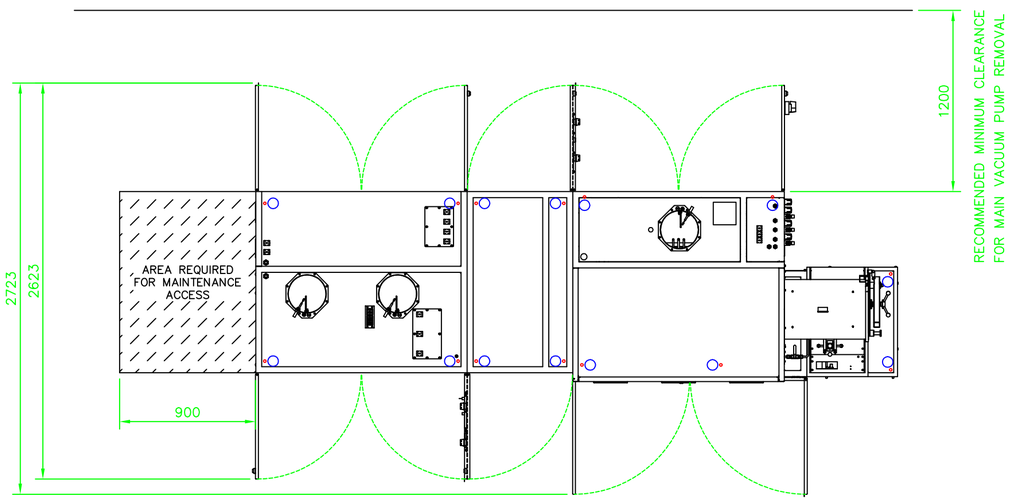
Ver.	Change No.	Description	Approved Date	Changed/Approved
1	–	ISSUED FOR QUOTATION REVIEW	XX–XX–XX	C – A –



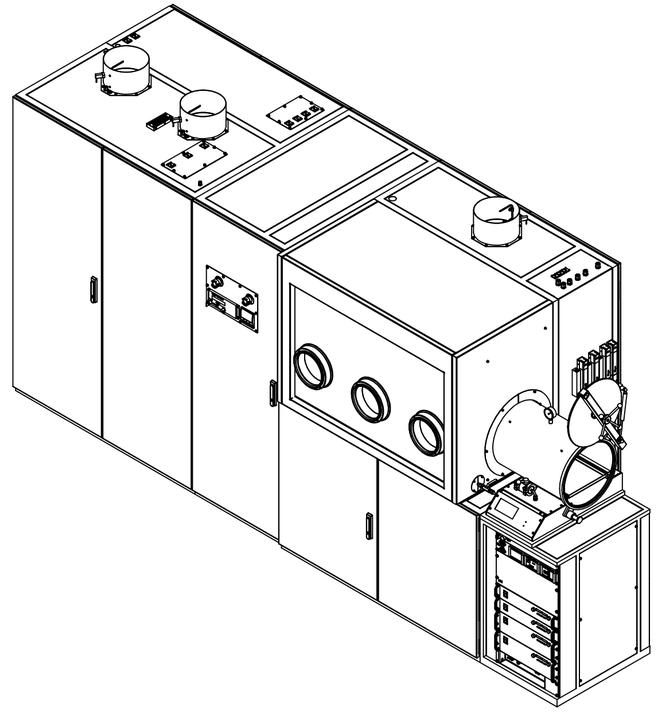
ADJUSTMENT FEET LOCATIONS



BOLT DOWN LOCATIONS



SERVICE DOORS OPEN



CSXXXXX

Created by: JED	Third angle projection ISO 128	Material: —	General tolerances according to ISO 2768 – f H (unless otherwise stated)
Approved by: XXX	All dimensions are in mm (unless otherwise stated)	Finish: —	General surface texture: ISO 1302 Ra 3.2 (unless otherwise stated)
Date: 26–10–15	Scale: 1:20	Size: A1	Material No.: XXXXXXXXX
		Manufacture in accordance with Work Instruction 340 unless otherwise stated	

AIXTRON

Title: INSTALLATION DIAGRAM

Document Status: WIP | Sheet: 2/2

Document No.: Q210815LC | Ver.: 1

Ver.	Change No.	Description	Approved Date	Changed/Approved
1	–	ISSUED FOR PRODUCTION	03-07-14	C JED A TW

FACILITY CHILLED WATER
<25°C NON-CONDENSING
QUALITY SUPPLY.
2 bar DIFF. PRESSURE

REACTOR
CABINET ROOF
1/2" SWAGELOK

RETURN

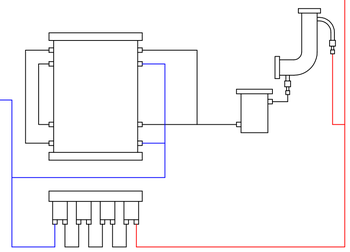
SUPPLY 6L/min
3.5 bar
0.35MPa

MAX HEATLOAD
SEE TABLE

FM2

6L/min
Min. Flow

1.3L/min
Alarm Level



1

RETURN

SEE TABLE
3.5 bar
0.35MPa

COOLANT
RETURN

MAX HEATLOAD
SEE TABLE

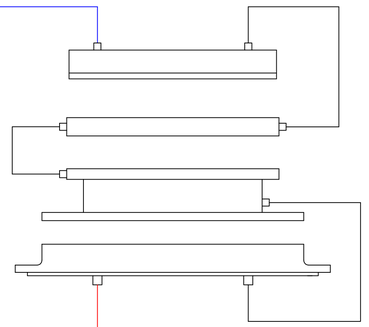
PUMP

COOLANT
SUPPLY
2.5 bar

FM1

INTERLOCKS TO MOCVD
FLOW, TEMP, LEVEL

SHOWERHEAD
HEAT EXCHANGER



2

8L/min
Min. Flow

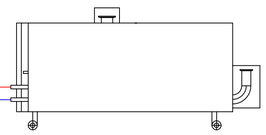
4L/min
Alarm Level

RETURN

MAX HEATLOAD

3.7kW

SUPPLY 8L/min
3.5 bar
0.35MPa



3

3/8" SWAGELOK

8L/min
Min. Flow

3.5L/min
Alarm Level

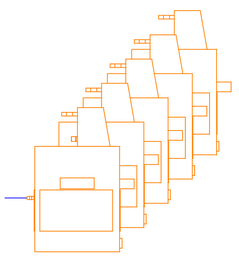
GAS CONTROL
CABINET ROOF
3/4" SWAGELOK

RETURN

MAX HEATLOAD

1.5kW per bath

SUPPLY 24L/min
3.5 bar
0.35MPa



4

OPTION

24L/min
Min. Flow

12L/min
Alarm Level

CIRCUITS:

1:– BUSBARS, ROTARY FEEDTHROUGH,
FILTER & EXHAUST ELBOW

2:– SHOWERHEAD & CHAMBER

3:– EBARA DRY PUMP

4:– WATER COOLED BATHS (OPTION)

HEATLOAD PER CIRCUIT (kW)		
PROCESS TEMP	BUSBARS, FILTER & EXHAUST ELBOW	SHOWERHEAD & CHAMBER
950°C	1	6
1200°C	1	10
1300°C	3	14

HEAT EXCHANGER SUPPLY	
PROCESS TEMP	WATER FLOW (L/min)
950°C	3
1200°C	4
1300°C	5

Created by: JED	Third angle projection ISO 128		Material: —	General tolerances according to ISO 2768 – f H (unless otherwise stated)
Approved by: TW	All dimensions are in mm (unless otherwise stated)		Finish: —	General surface texture: ISO 1302 (unless otherwise stated) Ra 3.2
Date: 03-07-14	Scale: 1:1	Size: A1	Manufacture in accordance with Work Instruction 340 unless otherwise stated	Material No.: 100187032
AIXTRON	Title: EXTERNAL WATER CIRCUIT 3x2"			Document Status: RELEASED; Sheet: 1/1; Document No.: A1-53585C; Ver.: 1

Design Review Certificate

for

AIXTRON MOCVD-SYSTEM

Due date to be returned to AIXTRON:	**with date of meeting**

System Type: 3x2” FT GaN

Customer: University of Wisconsin
Madison, Wisconsin 53715-1218
USA

Quotation No.: 210815L dated: September 15, 2015

Contents:

Design Review Package, including:

A. GENERAL INFORMATION
B. CUSTOMER OBLIGATIONS
C. CUSTOMER COMMENTS
D. APPENDICES

1.1 List of Material Requirements for Start-up
1.2 Requirements for Characterization Tools and Procedures
1.3 Acceptable Materials for Process Demonstration
2. Specification of Water Quality

The customer hereby confirms that he has read the information contained in this Design Review Package, and he has understood the obligations described.

The customer certifies that the MOVPE system configuration, as described herein, is true and accurate, and he acknowledges that AIXTRON shall manufacture and install the system as specified herein.

Any changes to the agreements contained in the Design Review Package may result in an increase of cost and/or lead time and shall be the sole responsibility of the customer. This shall include, but not be limited to the customer’s preparation of the facility and safety requirements, the submission of the floor plan and the system configuration.

This Design Review Certificate has been signed by both parties and is duly binding.

Date: _____

University of Wisconsin
Madison, Wisconsin 53715-1218
USA

_____
(_____)

AIXTRON Inc.
1139 Karlstad Drive
Sunnyvale, CA 94089
USA

_____
(_____)

Please sign this document and return it before the due date together with your floor plan and comments (if applicable)

Please do not hesitate to contact your Project Manager at AIXTRON if you have any questions regarding this Design Review Package.

Design Review Package

A GENERAL INFORMATION

Main Customer contact:
Project Manager: _____
Phone: _____

Main AIXTRON Inc. contact:
Project Manager: Brian Dlugosch
Phone: +1 (612) 242-1273
mailto: b.dlugosch@aixtron.com

Main AIXTRON SEcontact:
Project Manager: Dr. Stefan Droege
Phone: +49-2407-9030-589
mailto: s.droege@aixtron.com

Delivery address:

tbd

System configuration (Please refer to the attached drawings):

Installation Plan: Q210815Li-01 sheet 1-2
Gas Mixing System: Q210815LC sheet 1+2

B CUSTOMER OBLIGATIONS

Facility Requirements:

The Customer shall be responsible for the connection of the system. This shall include, but not be limited to:
- electrical connections
- all process gases: i.e. H_2, N_2, Forming Gas, AsH_3, PH_3, NH_3, HCl, Hydride-dopant …
- process gas exhaust from system to scrubber
- cabinet ventilation
- cooling water

Vibration specification (for systems with transfer module):

Emission and immission	each < 1e-2 m/s^2 at 50-60Hz each < 1e-4 m/s^2 other

ATTENTION! The Equipment is not intended to restrict the flow of the carrier gases (e. g. H_2 and N_2) connected to the inlet. Process gas flowing under normal operating conditions is limited by the sum of all MFC max values in the respective line. The safety interlock of the equipment prevents the uncontrolled release of hazardous gases under the required safety regulations. The system will switch to N_2 purge if emergency conditions occur.

This does not apply to intentional deactivation of safety functions.

If any gas treatment unit connected to the equipment requires a limitation of the maximum flow allowed, the customer is responsible for taking the necessary precautionary measures. Furthermore it is required to inform AIXTRON about such requirements.

Detailed feeding specifications are defined in the attached Installation Plan.

Please note that it is the customer's responsibility to provide the specified voltages.

The environment (laboratory) temperature shall be below 25°C at all times. The humidity shall be low enough to prevent condensing at cooling water temperature at all times. Please refer to the attached Dew Point Diagram for further information.

The customer shall provide cable trays for all cables, e. g.
- System / E-rack
- System / RF-generator (if applicable)
- Transformer / System (if applicable)
- Transformer / RF-generator (if applicable)

In order to ensure a smooth delivery of the system, the following points must be clarified prior to shipment

- Access route for a 20 ton truck
- It is the customer's responsibility to provide appropriate means to transport the system into the customer's facilities. Should a loading platform not be available, or if steps are at the on-site transport route, a fork lift truck with an appropriate load capacity is required.
- Clearances (e. g. door frames, hall ways, elevators, etc.) and weight limits for the transport route. Please, refer to the "Installation Plan" for verification of the dimensions and weight of the system components. It is the customer's responsibility to ensure that the system can be moved into the facility without tilting.

Customer's obligations:

It is the customer's obligation to submit a floor plan of the customer's facilities to AIXTRON Group together with the signed Design Review Certificate. The floor plan shall indicate the ceiling height and the routing of all system cables. Upon receipt of such floor plan, AIXTRON Group shall define all system cable lengths according to the information contained in the floor plan.

The project will proceed upon receipt of the correct floor plan. Please note that any delay in regard to the floor plan may affect the project schedule, and may therefore cause a delay to delivery.

Safety Requirements:

The customer's facility must comply with all local, state, provincial, federal or national safety regulations.

The customer warrants the following:

- All necessary reviews and permits for the use of hydrogen, metal organic compounds and hydride gases in the facilities have been obtained.
- Facility safety systems are installed and are operational. Appropriate alarms are activated and explained to the AIXTRON Group staff before they commence working on the premises. Emergency safety systems mandatory for operation include:
  - Hydrogen detection (at least for room air control, within the MOCVD system exhaust and spaces through which gas supply and exhaust lines are routed if separated from the room by walls, ceilings etc.)
  - Toxic gas detection (at least for room air control, within the MOCVD system exhaust, within the scrubber exhaust and spaces through which gas supply and exhaust lines are routed if separated from the room by walls, ceilings etc.)
  - Fire detection
  - Smoke detection
  - For all the above indicated safety system alarms, potential free contacts are available to be connected to the AIXTRON system
- Hazardous and toxic gas handling system must comply with general safety requirements as stated below:
  - Interlocked with facility safety system
  - Fail safe shut off valves
  - He-leak tightness < 10^{-9} mbar l/sec
  - Plumbing quality complies with specified gases
- The customer is responsible for the connection of an appropriate and functional detoxification (scrubbing) system.
  - Exhaust line shall be in stainless steel
- Each connection in the exhaust shall be leak tested by the overpressure method:

  Pressurize the exhaust line by using an appropriate searching gas or gas mixture and scan all connections by a suitable gas sniffer. The pressure ratio between inside and outside shall be larger than 1.

  Separable (non-welded) connections in the exhaust line shall be monitored continuously by appropriate gas detection system.

- If the scrubber outlet is connected to the same extraction channel as the cabinet ventilation, the distance of the point of connection shall be not less than 2m from the cabinet.
- Failure of air extraction from the scrubber shall cause a safety alarm similar to scrubber failure.
- **Scrubber equipment shall be individual for each reactor in operation. In case the customer intends to connect more than one piece of equipment to a scrubber inlet port together with AIXTRON equipment, he is required to inform AIXTRON Group and agree on necessary measures together with AIXTRON Group.**
- The facility is equipped with emergency exits. Exits and emergency escape routes must be explained to AIXTRON Group staff members prior to commencement of work. The emergency escape route must not be obstructed by any construction or installation work.
- The customer nominates at least one qualified person who is familiar with work safety issues, proceedings to recover alarm situations trained in first aid and who will be available, while the AIXTRON Group personnel are on-site.
- Any installation, construction or building work in the immediate vicinity that may create dust or interfere with the operation of the system directly or indirectly, or obstruct an escape path or emergency exits, is to be completed prior to the commencement of work by AIXTRON Group personnel.
- Access to self-contained breathing apparatus such as Draeger or comparable is ensured. (Special training required to use SCBAs by our engineers will be specified in advance).
- Any safety equipment or safety gear required by facility or local regulations is available. Any special training required will be specified in advance.
- All safety systems are checked in order to obtain official permission to flow the process gases as well as being connected to the reactor's safety interlocks according to the cause/effect matrix.
- All gas line connections outside of the exhausted cabinet are welded. Any non-welded connection (Swagelok, KF, DN etc.) outside of the cabinets is enclosed by a ventilated housing with appropriate safety monitoring.
- The exhaust/outlet of the scrubbing unit is monitored for hydrides. The detection of hydrides passing through the scrubbing unit due to insufficient or inappropriate behavior, failing or any other malfunction of the scrubbing unit activates a scrubber failure alarm and generates a shutdown of the AIXTRON system. The functionality of the monitoring device must be demonstrated to the AIXTRON Group engineer.
- The customer is responsible for the completion and leak check of the gas lines feeding into the system and the exhaust lines. This includes the connections between the customer's installations (gas feeding lines, exhaust lines) and the AIXTRON system. The customer's installations require an appropriate leak test possibility (leak test port). Leak test certificates must be presented to the AIXTRON Group engineers in English.

The Safety Requirements have been acknowledged and accepted:

Date: _____ Signature: _____

( )

General Support Requirements

- During the commissioning and start-up, the customer shall not interfere with the AIXTRON hardware unless in direct cooperation with the AIXTRON Group engineer (for training purposes or direct support).
- For service and / or start-up, special tools and a functioning direct data transfer connection between an external PC (here: a notebook brought by AIXTRON service / start up engineer) and the MOCVD tool is required. Specific software which is not available in the public domain must be applied. The availability of and the right to store data being generated during service / start-up on dedicated media to the AIXTRON staff is mandatory.
- The customer shall provide access to the following items to the AIXTRON Group engineer:
  - Desk and telephone with long distance capability in the working area
  - Leak detector incl. valid calibration certificate and bottled Helium with pressure reducer and spraying gun (background leak rate $\leq$ 1x10-9 mbar l/sec in bar l/sec reachable without problems)
  - Portable H_2 / toxic gas monitor
  - Tool and utility set
    - Standard metric tools (set of open end wrenches, set of Allen wrenches, set of screwdrivers, pliers)
    - Multipurpose meter for electrical measurements
    - Clean room clothes, clean room gloves, wipes and dust masks.
    - Aluminum foil
    - Working area and appropriate agents for etching and rinsing the quartz parts. Cleaning of these parts is to be done by the customer under the supervision of an AIXTRON engineer if required
    - Tool tweezers
    - VCR gaskets
- The customer shall be responsible for the availability of all necessary materials and characterization equipment according to the Installation Milestone Plan (Attachment 1), the List of Material Requirements for Start-up (Attachment 2.1), the Requirements for Characterization Tools and Procedures (Attachment 2.2), and the List of Acceptable Materials for Process Demonstration (Attachment 2.3)
- The customer is to provide access for the AIXTRON Group's engineer to inspect the gas supply and all other equipment connected to the AIXTRON system.
- At least one week of purging with N_2 or H_2 (purity $\geq$ 6.0) of the machine including hydride gas lines shall be assured by Customer after 2nd Acceptance before process start.

C CUSTOMER COMMENTS:

It is the customer's responsibility to indicate any deviation from the documents contained in this Design Review Package.

Any deviation from the information contained in the Design Review Package will have an impact on cost and lead time (to be advised by AIXTRON).

An increase in cost and/or lead time shall be the sole responsibility of the customer. This shall include, but not be limited to, the customer's submission of the floor plan and comments as part of the Design Review Package.

The customer acknowledges his responsibility to comply with the information contained herein and for any consequences on delivery and installation of the system. AIXTRON shall inform the customer of these consequences as soon as possible.

The customer acknowledges that he has understood and agreed that any modification requested after completion of the Design Review requires a change to the order and will impact on cost and lead time.

D ATTACHMENTS:

1.1. List of Material Requirements for Start up

- Hydrides:
  - AsH_3 and PH_3 shall prove to have a dew point below -70°C (@ 1 bar).
  - NH_3 - an appropriate purifier must be used.
  - N_2 and H_2 shall prove to have a dew point below -100°C (@ 1 bar).
  - HCl purity shall be 4.8 or better.
- MO Chemicals
  - TMGa, TMIn, TEGa and TMAl purity must be at least special grade and sourced from a high quality supplier from AIXTRON's recommended materials list.

1.2. Requirements for Characterization Tools and Procedures

- Characterization results shall be available within 2 hours.
  - Characterization tools shall be accessible for AIXTRON engineer.
  - The customer shall make all test wafers, results, mappings, files etc. obtained during the start-up available to AIXTRON upon request in printed and/or computer media stored form. These data shall be filed by AIXTRON SE.
- Characterization tools according to the list of start up specifications must be available.
  - Additional tools suggested for process development.
    - Microscope with phase contrast capability
    - Equipment for thickness measurement with mapping capability (e.g. white light interference measurement)
    - X-ray diffraction system with mapping capability (omega and theta-2theta scan)
    - Van der Pauw/Hall measurement equipment including contact evaporation etc.
    - PL mapper for emission wavelength determination in appropriate wavelength regime. **Laser power measurement capability is mandatory!**
    - ECV equipment
    - Access to low temperature PL (<10K) if not specified may be off site
    - Access to SEM
- Chemicals and chemical equipment required
  - Clean work bench for substrate preparation including clean beakers (inner diameter of beakers must be larger than maximum wafer size)
  - Tweezers for wafer handling
  - Hot plate ($T_{max} \geq 300°C$)
  - Spinner or N_2 - blow dryer for substrate drying
  - Glass or plastic vessels of suitable dimensions for reactor quartz ware cleaning
  - Steel beakers and buckets for steel part cleaning
  - Oven with suitable dimensions for drying the quartz reactor parts ($T_{max} \geq 150°C$)
  - Chemicals for general cleaning needs:
    - HCl (e.g. Merck No. 100317) and HNO_3 (e.g. Merck No. 100455) in sufficient quantities
    - DI water (>18MΩcm) for rinsing

- For GaAs based materials
  - DI water (18MΩcm) for rinsing
  - Cleaning chemicals (followed by an accepted Merck Number or comparable purity from another supplier)
    - HCl (>32%) (Merck No. 100322)
    - H_2SO_4 (Merck No. 100728 or 100709)
    - H_2O_2 (Merck No. 107298)
    - Propanol (Merck No. 100992 or 107038)

- For InP based Materials
  - DI water (18MΩcm) for rinsing
  - Cleaning chemicals (followed by an accepted Merck Number or comparable purity from other supplier)
    - H_2SO_4 (Merck No. 100728 or 100709)
    - H_2O_2 (Merck No. 107298)
    - Propanol (Merck No. 100992 or 107038)

1.3. Acceptable Materials for Process Demonstration

For the start-up the customer must provide precursor materials that comply with this information sheet. For further information please contact Mr. D. Schmitz or Dr. B. Schineller at AIXTRON SE, Aachen, Germany, Phone: +49 (241) 89090 (switchboard) Fax: +49 (241) 89098034.

Organic Sources

TMGa	•	Dow Chemical Opto Grade
	•	AKZO Nobel (Epiproof)
	•	Sigma Aldrich SAFC-Hitech
TMIn	•	Dow Chemical Opto Grade
	•	AKZO Nobel (Epiproof)
	•	Sigma Aldrich SAFC-Hitech
TMAl	•	Dow Chemical Opto Grade
	•	AKZO Nobel (Epiproof)
	•	Sigma Aldrich SAFC-Hitech
TBAs	•	*Dockweiler Chemicals*
TBP	•	*Dockweiler Chemicals*
UDMH	•	*Dockweiler Chemicals*

Hydride Gases

AsH_3	**(100 %)**	•	Air Products and Chemicals, Phoenix (5.5) quality or
		•	Solkatronic, best grade
		•	Linde
PH_3	**(100 %)**	•	Linde
HCl	**(100 %)**	•	Linde
NH_3	**(100%)**	•	**NH_3 qualification is not applicable anymore**
			Condition is the use of a released NH_3 purifier

Substrates

GaAs

Freiberger	epi ready finish, one side polished, doping and orientation according to specifications
Mitsubishi cable	epi ready finish, one side polished, doping and orientation according to specifications
Wafer Technology	epi ready finish, one side polished, doping and orientation according to specifications
Sumitomo	epi ready finish, one side polished, doping and orientation according to specifications

InP

Sumitomo	epi ready finish, one side polished, doping and orientation according to specifications 2”, 3” wafers qualified
Showa Denko	epi ready finish, one side polished, doping and orientation according to specifications 2”, 3”, 4” wafers qualified
Wafer Technology	epi ready finish, one side polished, doping and orientation according to specifications
InPact	epi ready finish, one side polished, doping and orientation according to specifications. 2”, 4” wafers qualified

Al_2O_3 (Sapphire)

Silian

2” Type 81015
C-Axis
0.3 +/- 0.1° towards M plane
0.0 +/- 0.1° towards A plane
50.8 mm +/- 0.05 mm x 430 µm +/- 20 µm thickness
major flat
Surface
front finish epi polish Ra < 0.3 nm
back finish fine ground Ra < 1 µm
TTV < 10 µm, Bow/Warp < 10 µm

100 mm Type 81016
C-Axis
0.3 +/- 0.1° towards M plane
0.0 +/- 0.1° towards A plane
100 mm +/- 0.05 mm x 650 µm +/- 20 µm thickness
major flat
Surface
front finish epi polish Ra < 0.3 nm
back finish fine ground Ra < 1 µm
TTV < 20 µm, Bow/Warp < 20 µm
Laser Mark backside

150 mm Type 94518
C-Axis
0.35 +/- 0.15° towards M plane
0.0 +/- 0.1° towards A plane
150 mm +/- 0.2 mm x 1300 µm +/- 25 µm thickness
notch
Surface
front finish EPI ready
back finish fine ground Ra < 1 µm
TTV < 20 µm, Bow/Warp < 20 µm
Laser Mark backside

Kyocera

2” Type TS-9072
C-Axis
0.3 +/- 0.1° towards M plane
0.0 +/- 0.1° towards A plane
50.8 mm +/- 0.05 mm x 430 µm +/- 20 µm thickness
major flat
Surface
front finish epi polish Ra < 0.3 nm
back finish fine ground Ra < 1 µm
TTV < 10 µm, Bow/Warp < 10 µm
Laser Mark backside

100 mm TS-9073
C-Axis
0.3 +/- 0.1° towards M plane
0.0 +/- 0.1° towards A plane
100 mm +/- 0.05 mm x 650 µm +/- 20 µm thickness
major flat
Surface
front finish epi polish Ra < 0.3 nm
back finish fine ground Ra < 1 µm
TTV < 20 µm, Bow/Warp < 20 µm
Laser Mark backside

100 mm TS-9078
C-Axis
0.3 +/- 0.1° towards M plane
0.0 +/- 0.1° towards A plane
100 mm +/- 0.05 mm x 850 µm +/- 20 µm thickness
major flat
Surface
front finish epi polish Ra < 0.3 nm
back finish fine ground Ra < 1 µm
TTV < 20 µm, Bow/Warp < 20 µm
Laser Mark backside

150 mm TS-9887
C-Axis
0.35 +/- 0.15° towards M plane
0.0 +/- 0.1° towards A plane
150 mm +/- 0.2 mm x 1340 µm +/- 25 µm thickness
notch
Surface
front finish EPI ready
back finish fine ground Ra < 1 µm
TTV < 20 µm, Bow/Warp < 20 µm
Laser Mark backside

Rubicon

150 mm F554A
C-Axis
0.3° +/- 0.1°
0.0° +/- 0.1°
150 mm + 0.1 mm / - 0.2 mm
1340 µm +/- 25 µm
Notch
Surface
Front finish epi polish Ra < 0.2 nm
Back finish fine ground Ra < 1 µm
TTV < 25 µm, bow < 30 µm, warp < 40 µm
Laser Mark backside

200 mm F445
[0001]
0.3° +/- 0.15°
0.0° +/- 0.15°
200 mm +/- 0.3 mm
1340 µm +/- 25 µm
notch
front finish epi polish Ra < 0.2 nm
back finish fine ground Ra < 1 µm
TTV < 25 µm, bow < 30 µm, warp < 40 µm
Laser Mark backside

Silicon

150 mm

Siltronic / Okmetic

article no.	150mm Si-PRIME T675	150mm Si-PRIME T1000
orientation	<111> Cz	<111> Cz
coductivity	P (Boron)	P (Boron)
Resistivity	<10Ohmcm	<10Ohmcm
diameter	150mm+-0,1	150mm+-0,1
thickness	675µm+-25	1000µm+-25
edge	rounded edge	rounded edge
front finish	epi ready	epi ready
back finish	etched	etched
bow	+-30µm	+-30µm
warp	30µm	30µm

200 mm

Siltronic

article no.	200mm Si-PRIME T725	200mm Si-Prime T1000-12000
orientation	<111> Cz	<111> Cz
coductivity	P (Boron)	P (Boron)
Resistivity	<10Ohmcm	<10Ohmcm
diameter	200mm+-0,1	200mm+-0,2
thickness	725µm+-25	1000-12000µm+-25
edge	rounded edge	rounded edge
front finish	epi ready	epi ready
back finish	Etched	etched
bow	+-30µm	+-30µm
warp	30µm	30µm

3. Specification of Water Quality

General

Production runs on AIXTRON MOCVD systems can cause temperatures up to 1200 °C at the substrate's support devices. To avoid overheating of system components, a reliable cooling of single reactor components is necessary. In case of a break-down of the system's cooling water supply - with no or an insufficient water flow – the thermal energy of the hot components cannot be dissipated. Damage to the system can occur.

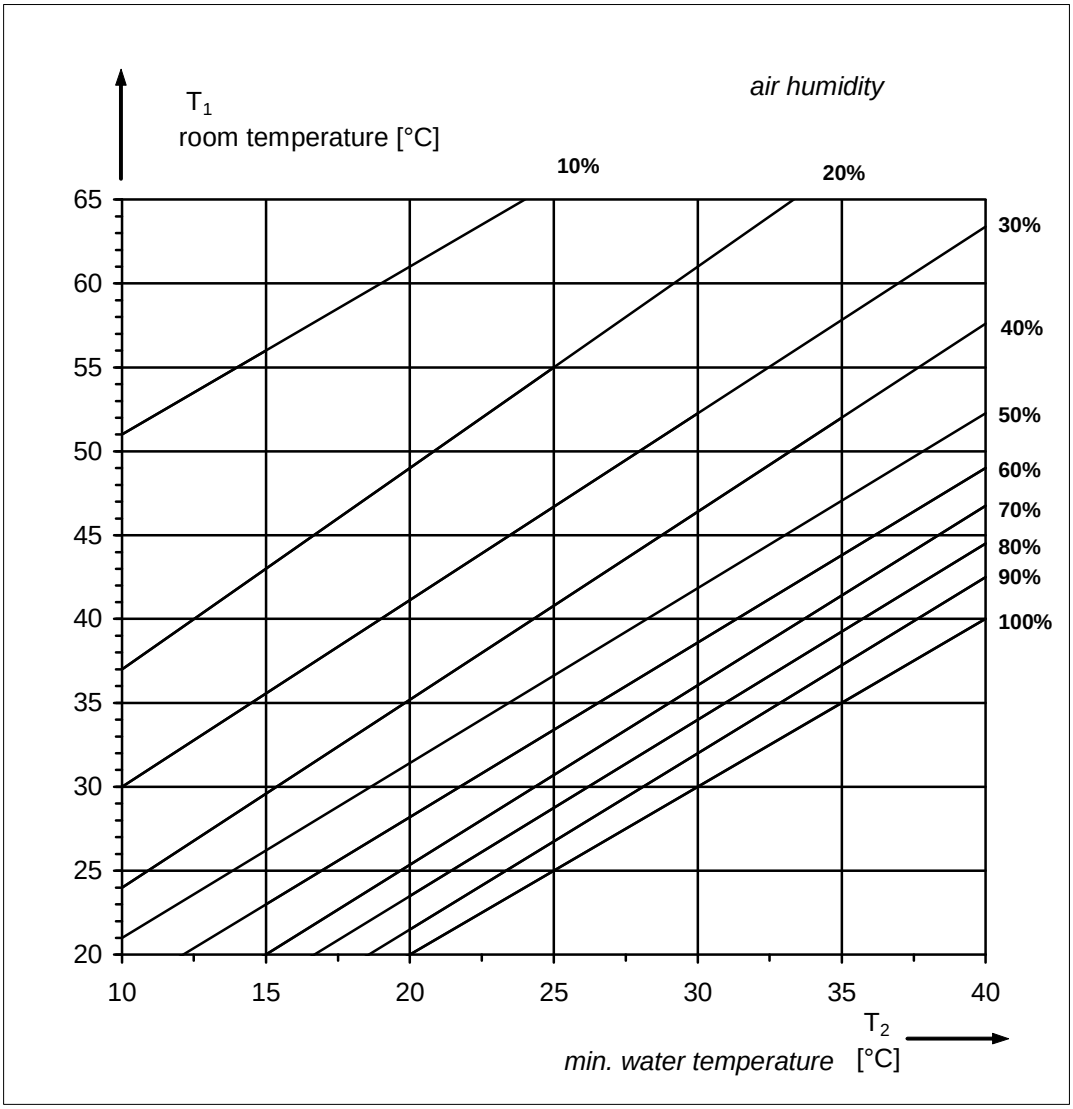
A continuous water supply has to be provided by the customer.

Never use inflammable or corrosive fluids in your cooling system.

Never use distilled or deionized water since there is a high risk of corrosion of the cooling system.

Dew Point Diagram

The dew point diagram shows the minimum required water temperature for the cooling circulation in relation to the room temperature and the relative air humidity.



Attention

In order to avoid water condensation the temperature of the cooling water must exceed the dew point temperature of room air.

Water condensation on electronic components can cause component and/ or system malfunction. Water condensation on water leak detectors can cause the process to stop.

Requirements on Water Quality for Aluminum Containing Loops (for AIXTRON Planetary Reactor systems)

Recommended values for water without intentional additives.
A minimum quota of dissolved ions is required (conductivity > 2 µS/CM)

Item	value	dimension
pH	7.5-8.0	
Inorganic anions and cations		
Chloride concentration	< 0.5	ppm
Sulfate concentration	< 20	ppm
Nitrate concentration	< 0.1	ppm
Cyanide concentration	6-12	ppm
Sodium	< 0.5	ppm
Calcium	0.6	ppm
Magnesium	0.1	ppm
Potassium	0.3	ppm
Silicates	< 0.1	ppm
Copper	< 30	ppb
Aluminum	< 1	ppm
Ammonia concentration	< $1.7x10^{-3}$	ppm
Oxygen concentration	< 20	ppm
Ozone concentration	< 0.1	ppm
Other parameters		
German water hardness	< 7,5	°dH
Total dissolved solids	1-2	ppm
Oil concentration	< 1	ppm
Bacteria	< 10^2	cfu (colony forming units)
Conductivity (compens. at 25 °C)	2 - 25	µS/cm
Resistivity (compens. at 25 °C)	40000 -500000	Ω cm
max. water inlet temperature	40	°C
max. water inlet temperature HT systems	20	°C

Due to absence of copper it is necessary to treat the cooling water with a biocide. The biocide should level the quota of bacteria at a continuous low level as indicated above.

Cooling water specifications for Ebara Vacuum Pump

The maximum cooling water temperature at the water inlet of the Ebara pump should not exceed 25 °C.

Cooling water specifications for Lydall Affinity Chiller

Cooling water for showerhead cooling should not contain particles of with a diameter of more than 50μm.

Requirements on Water Quality for Aluminum Free Loops

Recommended values for water without intentional additives.

Item	value	dimension
pH	7.0-8.0	
Inorganic anions and cations		
Chloride concentration	< 10	ppm
Sulfate concentration	< 25	ppm
Sodium	< 0.3	ppm
Calcium	0.6	ppm
Magnesium	0.1	ppm
Potassium	0.3	ppm
Silicates	< 1.0	ppm
Other parameters		
German water hardness	< 7,5	°dH
US water hardness	< 0.05	ppm
Total dissolved solids	10	ppm
Oil concentration	< 1	ppm
Bacteria	< 10^2	cfu (colony forming units)
Conductivity (compens. at 25 °C)	< 110	µS/cm
max. water inlet temperature	25	°C

Unfavorably high total ionized solids (TIS) can accelerate the rate of corrosion. These contaminants can function as electrolytes, which increase the potential for corrosion and lead to local corrosion (pitting).

To reduce the risk of corrosion, a closed-loop water cooling system fulfilling the above specifications is recommended. The cooling water should not be exposed to the atmosphere in order to minimize oxygen absorption.

Confirmation of Requirements before start of 2nd ATP

Please confirm the fulfillment of below-mentioned Design Review Certificate Requirements and return the document to the regional manager, no later than 1 week before the start of the 2nd ATP. Add a comment in case of deviations between below-mentioned requirements and the on-site situation.

- **Facility Requirements**
- **Safety Requirements**
- **General Support Requirements**
- **List of Material Requirements for Start up**
- **Requirements for Characterization Tools and Procedures**
- **Materials for Process Demonstration**
- **Specifications of Water Quality**

Comments

(In case of any deviation to requirements)

Date: _____ Signature: _____

( )

AIXTRON LTD.

GENERAL INSTALLATION GUIDANCE & PLANNING - CCS 3X2FT & 6X2FT REACTOR

TABLE OF CONTENTS

1 INTRODUCTION

This document is intended to assist with any questions that may arise with the installation of a CCS 3x2FT or 6x2FT system from AIXTRON Ltd.

	*If there is any conflict between values in the installation diagram and those stated in this generic manual, then the installation diagram should be used as the authoritative document.*

Part of the applicable data will be supplied at the Design Review Meeting (DRM), and at this point you will:

1. Confirm and sign off the Gas Circuit Diagram, and
2. Confirm and sign off the Installation Drawing.

At a later point, nearer the 1st ATP customer sign off at the AIXTRON Ltd. factory it will be necessary to

3. Complete and return the Services Check List at the end of this document.

Should you require any guidance please contact either the Sales Project Management department at AIXTRON, or your local AIXTRON regional office. If required, further more detailed information is found in the System manual, which can be supplied on request.

2 INSTALLATION - GENERAL PROCEDURE & INFORMATION

2.1 DELIVERY

It is the customer's responsibility to:

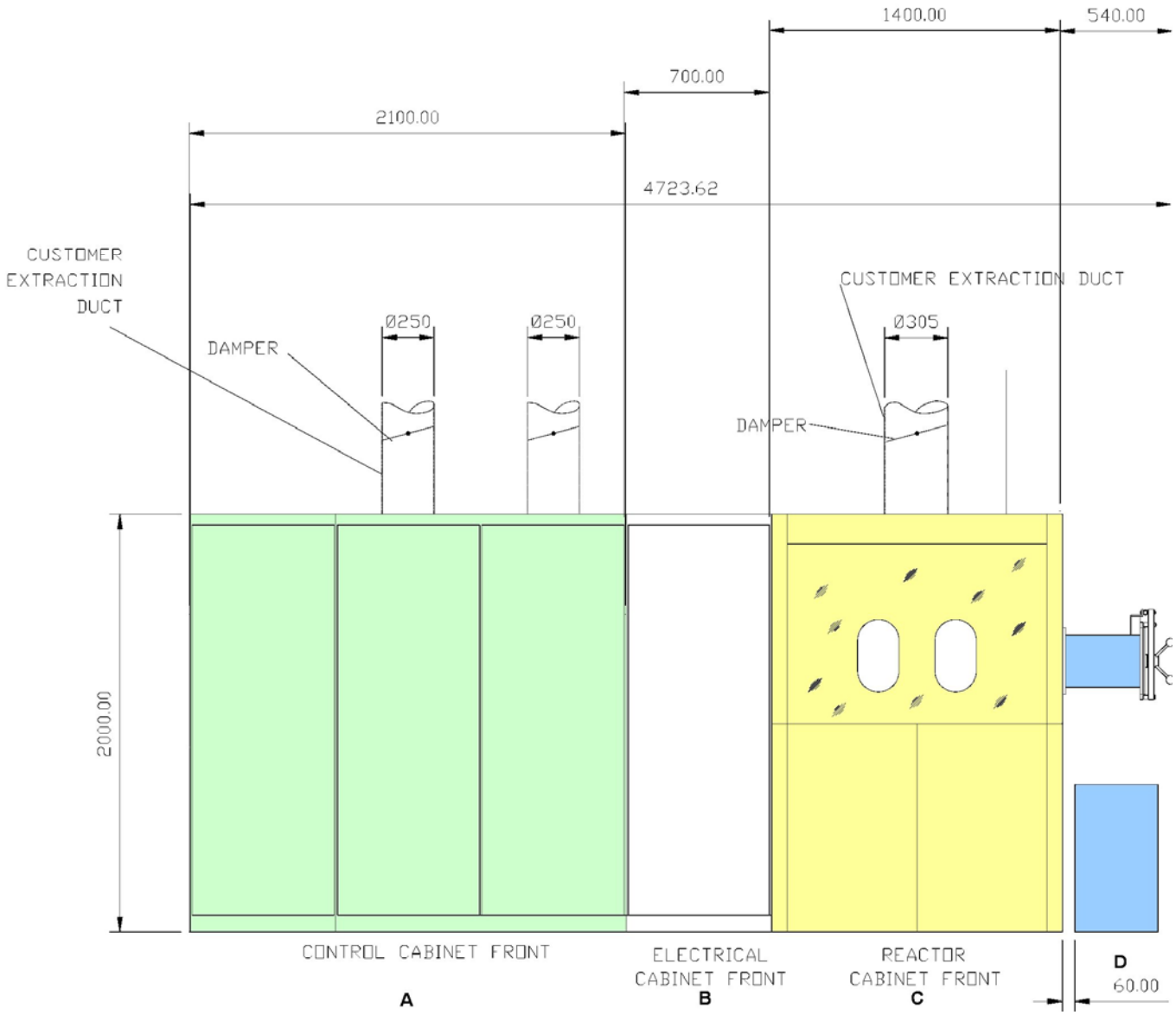
- Unload the system from the truck,
- Remove the system from its packing cases,
- Provide a suitable form of lifting equipment, and
- Move the system into its final position before the arrival of Installation personnel.

Note that AIXTRON group GSO engineers are not trained or insured to carry out this work.

2.1.1 Dimensions and weight

Precise equipment dimensions can be found on the installation plan for the system.

There are two variants of Gas cabinet – either 2 panels at 1400mm width, or 3 panels at 2100mm width. The drawings below show a 3-panel cabinet, which is a 2100mm width. This may be different on your system.



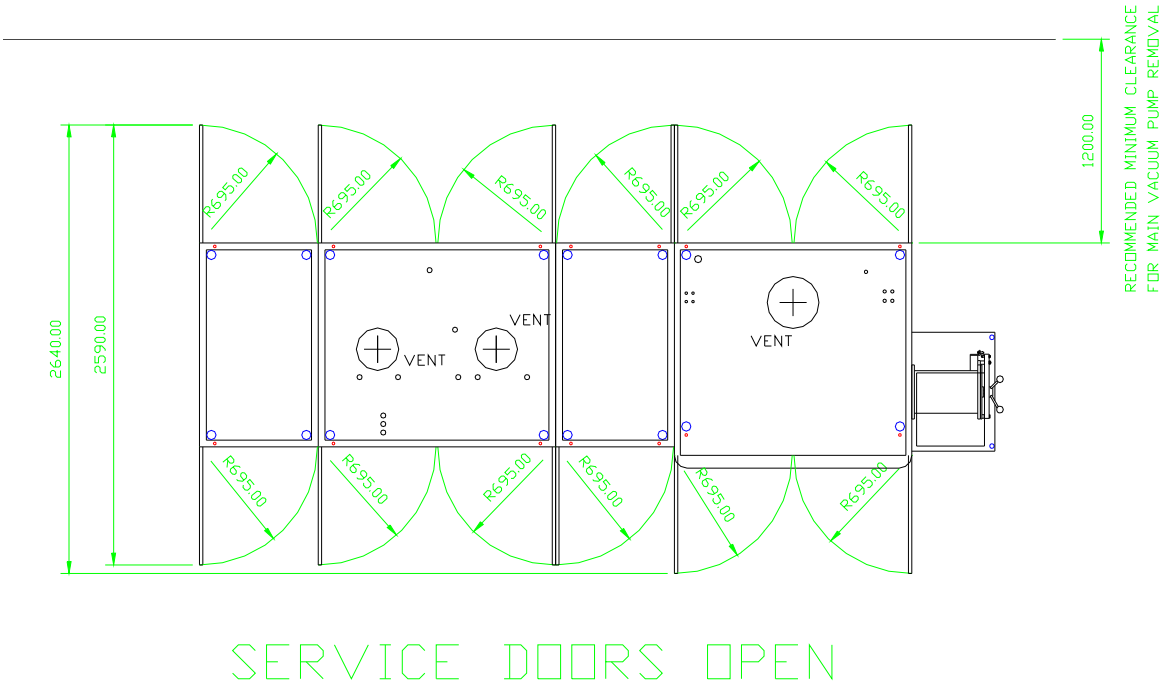
If size limitations exist for the move in for the system (e.g. lift or door / corridor limitations), then these must be discussed at the DRM, and the split points for the systems can be agreed at the 1st ATP customer sign off at the AIXTRON Ltd. factory.

Shipping weights can be provided on request to the Sales Department at AIXTRON Ltd., and system weights will be approximately as below:

Component		Approximate Weight [kg]
Gas mixing cabinet **A**	*(1400mm)*	1050
	(2100mm)	1550
Lauda RM6 Bath without fluid (each)		24
Electrical Cabinet **B**		150
Reactor cabinet **C**		1225
Ebara ESA25D Vacuum Pump		240
Step Up Transformer (if applicable)		155
Affinity Heat Exchanger		95

Location

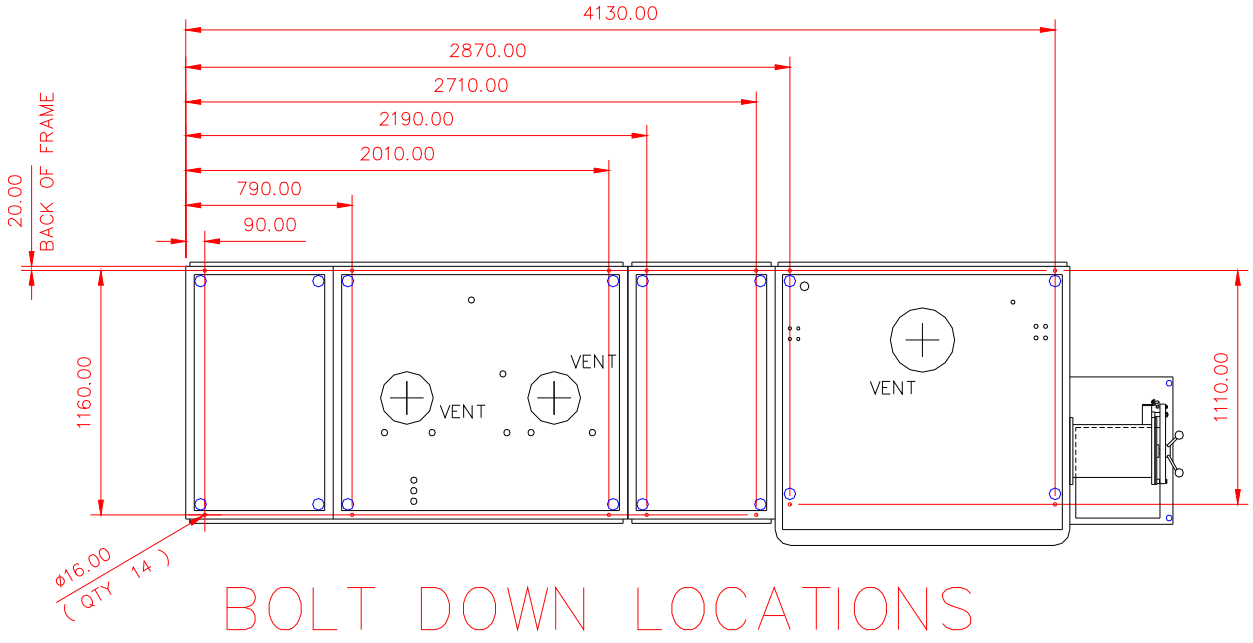
The system should be at least 1200mm from any rear wall, in order to allow clearance for the Ebara Vacuum pump to be removed e.g.



Anywhere else, sufficient clearance (min. 1000mm) must be allowed for maintenance purposes around any opening doors - please refer to your installation diagram for exact details.

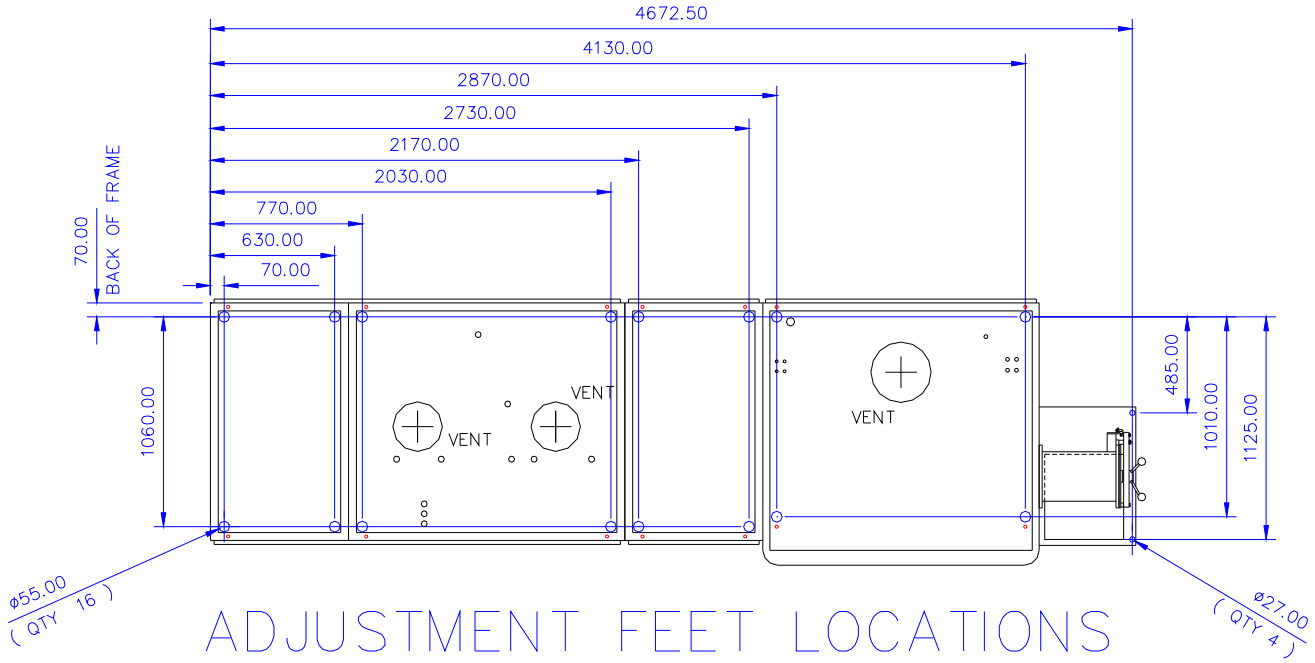
Bolt down

Bolt down points on the system, for example for earthquake restraints purposes will be broadly as follows below. Note that this may be different on your system - please refer to your installation diagram for exact details.



Adjustment Feet

If it is desired to place any supports or bracing under the adjustment feet on the system, or correlate support plate location against suspended floor tiles, then refer to the Installation Diagram. The will be equal weight distribution for each cabinet. This will broadly be as follows - - please refer to your installation diagram for exact details:



2.1.2 During Transit

Temporary storage must be avoided. The system will be shipped in a vacuum foil wrapping, and is sealed and pressurised with nitrogen to 15psi (1 bar) in the gas cabinet.

- The system components may only be transported standing vertically
- The packed items labelled "Fragile" must be handled with appropriate care
- The system is to be protected from moisture.
- When transporting the MOCVD system, proceed with care to avoid damage caused by the effects of careless loading and unloading.
- Avoid large temperature changes during transportation to prevent the formation of condensed water
- The transport is preferably to be undertaken in a truck with air suspension. Ensure that during transport the components are strapped down to prevent the crates sliding or falling.

2.1.3 Transport route

To ensure a problem free delivery, the following points must be clarified prior to shipping:

- Access route for a 20-ton truck, allow for:
  - Height > 4.00 m
  - Width > 3.00 m
- Should a loading platform not be available, or if steps are to be negotiated, a fork lift truck with a load capacity of at least 2000 kg or higher is essential
- Doors or lifts:
  - Height > 2.20 m
  - Width > 1.50 or 2.20m (dependant on where system is split)
  - Depth > 1.40 m
  - Designed for loads up to 2000 kg or higher.
- The reactor is **not** provided with castors/ transit wheels, and therefore the Customer is responsible for providing a suitable form of lifting equipment, and then moving the system into position before the arrival of Installation personnel.

2.1.4 Documentation and reporting of transport damage

In the event of any external damage, report this immediately to the transport company and also to AIXTRON Ltd.
A detailed written damage report should be made, together with photos if possible.

2.1.5 General Procedure and requirements

Note:
ALL SERVICES SHOULD BE AVAILABLE FOR CONNECTION AS DETAILED ON THE AIXTRON LTD. INSTALLATION DRAWING.

Please do not commit to installation before services are in place.

Prior to commissioning by an AIXTRON group GSO engineer, the customer is required to complete the following:

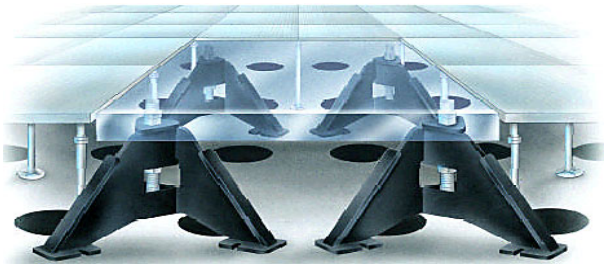
1. Unpack the Reactor Cabinet, Gas Cabinet and Electrical cabinet, from the main wooden crates

2. The Reactor, Electrical and Gas Cabinets are shipped in Vacuum Foil packing - do not remove this until the unit is in the clean room

3. Move all cabinets into their final position within the clean room

4. Wipe down in position. Dust should be cleared from the surfaces of the equipment using standard clean-room tacky rags. Stains on working surfaces should be removed with wipes soaked in Iso-Propyl alcohol; all wipes should be disposed in accordance to local environmental policy or law

5. Locate Reactor, Electrical and Gas Cabinet in required position, mounted on firm flat floor. It is the customer's responsibility to ensure that the strength of the clean room floor is adequate for the purpose – if the clean room floor is a suspended floor, either a concrete frame may be required under the mounting feet, or additional support feet under the floor



Pictures ©Technical Manufacturing Corporation
Tel: +1 (978) 532-6330, Fax: +1 (978) 531-8682, e-mail: sales@techmfg.com

6. All other boxes should be left sealed – these will be unpacked and checked against the packing documents by the Installation Engineer. If there are any boxes missing or damaged please notify AIXTRON Ltd. immediately at the following address:

AIXTRON LTD.,
ANDERSON ROAD, BUCKINGWAY BUSINESS PARK,
SWAVESEY, CAMBRIDGE.
CB24 4FQ, U.K.
Tel: +44 1223 519444
Fax: +44 1223 519888
E-Mail: sales@aixtron.com

7. Contact your local AIXTRON Global Service office to schedule a GSO engineer for installation.

8. On completion of Installation the local GSO office will schedule a Process Specialist to conduct process optimisation and growth trials if specified in the contract.

2.1.5.1 Responsibilities

The customer is responsible for:

1. Unpacking and siting of the equipment purchased, in accordance with the AIXTRON Ltd. Installation diagram. This includes the provision of:
    - Any support structures, underfloor bracing and support plates for floor tiles,
    - Lifting and moving equipment such as forklifts, and lift trucks.

2. Provision and facilitisation of all services, (right up to the outside limits of the system), is the sole responsibility of the customer. This includes verifying the leak tightness of the exhaust line, and of all the gas lines connected to the MOCVD system, to a leak rate of better than $1x10^{-9}$mbar l s^{-1}.

3. Availability of all materials and equipment, i.e.

- Process Gases,
- Metal Organic Bubbler Sources,
- Chemicals,
- Substrates,
- Measurement Tools,
- Clean Room Equipment, and
- Wet Bench

4. The customer has to provide a toxic gas and a hydrogen monitoring system in the working area and accessible emergency exits. Evacuation procedures and safety protocol for the laboratory will be explained to AIXTRON group GSO engineers personnel upon arrival.

5. AIXTRON group GSO engineers have the right to inspect the gas supply, and safety equipment, and to withdraw from an installation or process demo after consultation in the event of an unsafe situation.

6. The Installation schedule will be agreed with the customer prior to despatch. If for any reason the customer is unable to adhere to the agreed schedule a lengthy delay may result. If the installation is delayed whilst the installation engineer is on-site for reasons attributable to the customer, AIXTRON Ltd. reserve the right to recall the engineer and request additional payment to cover the costs incurred. Confirmation of service details will be provided on receipt of contract.

7. **Definitions:**
   - **Installation** includes the re-assembly of the system, calibration, functional testing, and leak testing. Access to a helium leak system is required. The System Price includes costs for AIXTRON Ltd. engineer for installation of the system, including all costs of transportation, and subsistence

   - **System purge** - A minimum period of one week will be required for purging the MOCVD system and all the process gas lines connected to the MOCVD system with high purity nitrogen or hydrogen (≥6-9's i.e. ≥6N).

   - **Commissioning** includes a demonstration of the agreed material specification between the customer and AIXTRON Ltd. The System Price includes costs for an AIXTRON group process engineer for commissioning of the system, including all costs of transportation, and subsistence. The quoted cost is exclusive of materials. It is the practice for the customer to supply all the materials necessary for the completion of system commissioning. AIXTRON group GSO personnel will inform the customer of acceptable source materials for commissioning. Prior to commencing the commissioning AIXTRON group GSO personnel will require an audit of the available characterisation equipment.
     It is expected that the process demonstration will normally take between two and three weeks after completion of the installation of the MOCVD system, and signature of the second ATP (signifying customer acceptance of the installation). The customer has responsibility for ensuring that all the necessary characterisation equipment is available to demonstrate the specification.

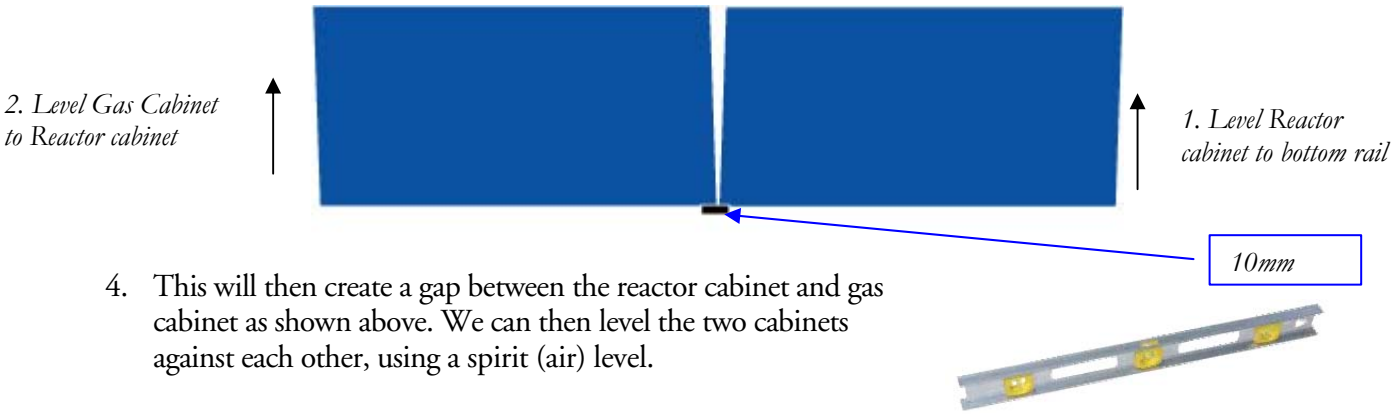
2.1.6 Levelling

In general AIXTRON Ltd. or your local AIXTRON service network will deal with levelling the system, and system interconnections. If for any reason this is not the case, the following procedure should be followed.

1. Remove transit wheels when in position, and lower levelling feet.

2. The levelling feet will have been retracted for shipping and can be adjusted using a wrench.

3. AIXTRON Ltd. recommends a spacing of around 10mm (3/8-inch) between the floor and the bottom rail of the system. This is required to allow extraction air flow to enter the system. One method of levelling is to set a fixed distance e.g. 10mm by use of a shim at the joint between the reactor cabinet and gas cabinet e.g.



4. This will then create a gap between the reactor cabinet and gas cabinet as shown above. We can then level the two cabinets against each other, using a spirit (air) level.

5. Care must be taken that no pipes are damaged during the levelling operation.

6. First, take **the horizontal base framework of the Reactor Cabinet as the reference, and** make level by using the adjustable feet inside the cabinet. In general this will give a separation of 2 – 10mm. If the floor is sufficiently uneven that level cannot be achieved, then a larger shim than 6mm may be required

7. Then, level the gas cabinet against the reactor cabinet. The gap between the system Gas Cabinet and Reactor Cabinet should disappear.

8. In areas susceptible to earthquakes, it may be more appropriate to use shims instead of the levelling feet and then bolt the system to the floor using the anchor points provided.

9. **All** doors need to be checked for correct operation before any services are connected

10. If it is desired to site multiple machines, then a laser pointer or laser level may be used to give a visual indication of correct positioning to datum points.

11. Bolt together the Reactor Cabinet and Gas Control Cabinet using the M6 bolts provided which will be found attached to the work surface in the Reactor cabinet.

12. The Gas Bottle Cabinet (if supplied) should be positioned with respect to the system Gas Cabinet according to installation drawing.

13. The Scrubber (if supplied) should be positioned with respect to system Gas Cabinet according to the Installation Drawing, and interconnecting tubing fitted.

14. Interconnections may then be made between the Control Cabinet and the Gas Bottle Cabinet (if supplied).

2.1.7 Site Requirements

Vibrations

During the deposition process, the system must not be exposed to notable vibrations. For this reason, make sure that no equipment creating heavy vibrations is installed in the vicinity of the system. Also make sure that the ground on which the system is installed is capable of absorbing vibrations.

Operating media

The system must be supplied with the required operating media. The supply lines must be laid in keeping with the local safety regulations and with the information in the facility (media) diagrams.

Space requirements

The clearance distance for escape routes must be in keeping with the local safety regulations. Safety doors, covers, etc. must be installed in such a way that the system remains accessible from all sides for maintenance and service work. The system should be at least 1200mm from any rear wall, in order to allow
clearance for the Ebara Vacuum pump to be removed. Anywhere else, sufficient clearance (min. 1000mm) must be allowed for maintenance purposes around any opening doors

Media connection

The end user has to install lockable interfaces for the media supplies. When users provide isolation devices for the electricity or hazardous fluid pressure sources they must be located where there is no risk of personnel being exposed to serious risks of tripping, or falling, or of coming in contact with energized electrical parts, moving machinery, surfaces or objects operating at high temperatures, or other hazardous equipment

The end user is also responsible to control and interlock the gas supply in his facility (facility-safety concept), controlled by his own facility-safety control system.
If a toxic gas or hydrogen detection alarm occur, the customer must shut off (close) all toxic and flammable gas feed lines to the system.

Annulus pump for Arsine line (Option)

On a GaAs/InP system, the Arsine line may be fitted with an optional Annulus pump. If so, configuration will be as follows:-
The arsine line runs through a coaxial pipe, where Arsine is carried in the inner pipe, while the outer pipe is sealed at the end nearest the reactor, and open to an Annulus pump at the other end.
When the system is first set up, the annulus pump will pump the outer pipe to near vacuum, i.e. 0 mbar. The pump will then be turned off, but the pipe should hold a vacuum indefinitely.
If the value of the pressure in the annulus rises above 0 mbar, there is a leak.

2.2 Installation - Air, Water And Electrical

2.2.1 Pneumatic Supply

The Pneumatic supply is brought into the equipment via 6mm/ ¼ inch tubing where it is internally regulated to 90 p.s.i. (6.0 bar). The Pneumatic supply to the system must be pre-regulated to 120psi.
The Pneumatic supply is recommended to be a low purity N_2 supply, to prevent any oxygen entering the Hydrogen lines in the unlikely event of a valve leaking its pneumatic feed over the valve stem.
The connection is brought into the top of the Gas control cabinet to a ¼ inch Swagelok bulkhead connection. (See section 6.1.4)

2.2.2 Cooling Water

The reactor has a requirement for two Water supplies. There will be a 'hot' circuit feeding the reactor chamber and showerhead via the Affinity chiller, and a 'cold' circuit, fed from the city water supply that is used to take the heat out the bottom end of the reactor (Busbars, Filter and Exhaust Elbow, Ebara Dry Pump).

Additionally a further supply may be required for an EpiCat dry NH_3 scrubber (if supplied).
Total heat load and cooling water flow requirements for each cooling circuit is detailed below:

Cooling Circuit	System	Total Max. Heat load (Kw)	Temp range (deg C)	Min. Flow Trip Level (slm)	Min. Recommended Water Flow (slm)
Showerhead and Chamber	3x2 InP	6	20 – 60 (typ. 50°C)	4	8
	3x2 GaN	10	20 – 40 (typ. 35°C)	4	8
	6x2 InP	10	20 – 60 (typ. 50°C)	4	8
	6x2 GaN	18	20 – 40 (typ. 35°C)	4	8
Filter, Busbars, & Exhaust Elbow	3x2 InP	1	Ambient + 5 deg	1.3	6
	3x2 GaN	1	Ambient + 5 deg	1.3	6
	6x2 InP	2	Ambient + 5 deg	1.2	6
	6x2 GaN	2	Ambient + 5 deg	1.2	6
Ebara Pump	ESA25D	3.7	Ambient + 5 deg	3.5	8
EpiCat Scrubber *(if applicable)*		2.5	Ambient + 5 deg	8	10

If specified at the time of order, the showerhead and chamber may be cooled by a thermostatically controlled water supplied by AIXTRON Ltd. This is a water heat exchanger (barrier cooler) connected between the customer's facility cooling water (primary circuit) and the reactor (secondary circuit). This offers the benefits of a constant, known, chamber and showerhead temperature and, in the case of phosphide growth, allows the reactor temperature to be maintained at a temperature well above that of the facility cooling water (typically ~50 °C), effectively preventing condensation of phosphorous.
The chiller will require a water supply below 25 deg C at the stated rating in the table above. However the cold circuit for Filter, Busbars, Exhaust elbow and Feedthrough, and for the Ebara Pump can share the same cold circuit feeding the Heat Exchanger Water Chiller, assuming that this has sufficient flow.

In order to ensure adequate cooling, the customer's facility cooling water supply should be rated to provide the recommended total water flow for all cooling circuits, (including the heat exchanger), assuming a pressure drop of 2.5 bar across the MOCVD system and be capable of removing the maximum heat load while maintaining a supply temperature of no more than 25 °C (non-condensing). Filtration should be provided to 10 µm or better.

In order to ensure adequate heat removal, the customer's facility cooling water should be capable of supplying the heat exchanger with the sum of the recommended showerhead and chamber flows, assuming a pressure drop across the heat exchanger of 2.5 bar at a supply temperature of no more than 25 °C (non-condensing)..

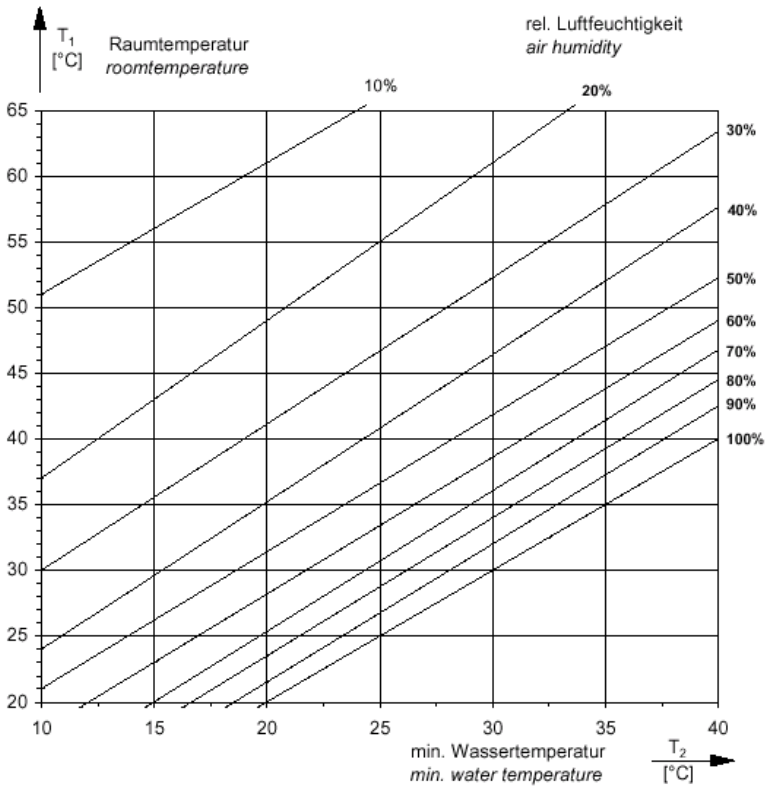
Water is normally introduced at the rear of the reactor cabinet via ½ inch Swagelok fittings (as applicable and shown on the installation diagram) for the showerhead and reactor circuits, or 3/8 Swagelok fittings for the Ebara Dry Vacuum pump.

Note:

In order to prevent galvanic corrosion occurring within the system components, (such as within the showerhead and chamber), it is recommended that the supply pipes and fittings use only stainless steel and / or rubber, and do not use copper.

Specific facility details and flow requirements are shown on the installation drawing. Water temperature rise will depend upon the instantaneous heat load, and input temperature. It is recommended to use a water supply feed of potable quality.

Note : *In order to avoid water condensation, the temperature of the cooling water must exceed the dewpoint temperature of room air, as shown in the graph below.*
***E.g.** At a room temperature of 25°C and a relative air humidity of 60%, the temperature of the cooling water must be>17°C, otherwise there is risk of condensation.*



	Distilled and deionized water may be aggressive and cause material corrosion, especially when used at elevated temperatures. *Please contact AIXTRON Ltd. before subjecting the system or parts of the system to prolonged exposure to distilled or deionized water.*

High levels of total ionized solids (TIS) can accelerate the rate of galvanic corrosion within the system. These contaminants can function as electrolytes, which increase the potential for galvanic cell corrosion and lead to localized corrosion such as pitting.

It is recommended to maintain the water quality at a measured resistivity of between 1 and 10 megohm-cm (compensated to 25°C), by using a purification system. Although the initial fill may be as high as 10 megohm-cm, the desired level for long time usage is 0.1 to 3 megohm-cm. In order to remove any microbiological contamination, UV sterilisation should be present at either the fill point of the system, or within the Recirculation path.

Cooling water specification for system		
	Desirable (ppm)	**Permissible (ppm)**
Microbiologicals	0	0
Calcium	0.6	<40
Chloride	<25	<80
Magnesium	0.1	<12
Potassium	0.1	<20
Sodium	0.3	<20
Sulphate	<50	<80
Total dissolved solids	10	50
pH	7-8	6.5-8.5
Cooling water should be filtered to better than 10µm		

In order to eliminate air locks from the showerhead cooling gallery on flip-top reactors, the following procedure is suggested when first filling the system with cooling water:

1. With the showerhead supply and return pipes disconnected, fill the showerhead with water using a jug, blank the connections then open and close the reactor several times. Repeat the filling and tilting procedure several times until no more water can be poured into the water passages. A SMALL amount of surfactant may be used to assist wetting the stainless steel surfaces, but foaming should not be allowed.
2. Prime the supply pipework by briefly allowing water to flow round the cooling circuit, using a suitable receptacle to collect the excess water.
3. Reconnect the supply / return pipework

2.2.3 Electrical Supply

The CCS 3x2FT and 6x2FT systems are designed to function with a three phase mains voltage input of 400V, and to withstand mains borne transient voltages.

Voltage	400 V ± 5% (3 / N / PE)
Frequency	50/60 Hz ± 1%
Current	100A for all systems; (*3x2InP, 3x2GaN, 6x2InP, 6x2GaN*)
Fuse protection in building on-site	Local regulations and routing factors dictate this, dependant on the system configuration, and if a transformer is used.
Mains power supply line **(conductor cross-section)**	

For all other voltage inputs at the customer's facility a step-up or step-down transformer of suitable rating (as advised) will be necessary.
The supply is 3 Phase 5 wire.
The power cable for the three-phase supply enters the equipment through a hole in the top of the Reactor cabinet. No gland is fitted as the entry position is dependent on the cable size - therefore a suitable hole should be cut in the roof panel, using the 10mm pilot hole provided. The cable must however be protected from chafing at its entry point. The cable is connected to the incoming mains isolator as indicated on the electrical Mains Distribution Circuit Diagram

All electrical connections should be made in accordance with local electrical and wiring regulations, and should be carried out by qualified electrical personnel or contractors.

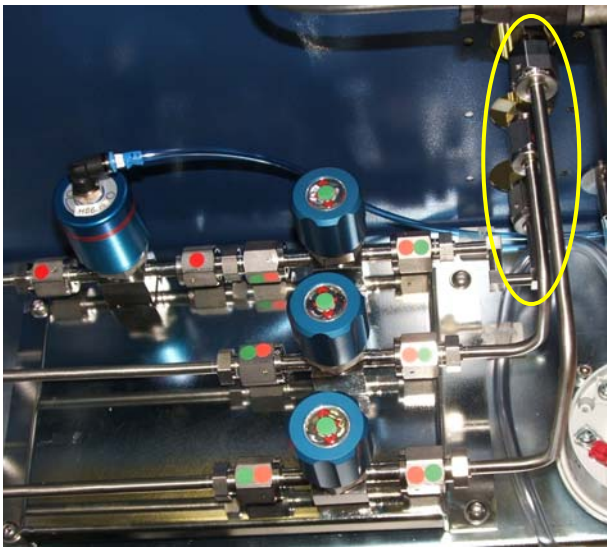
Electrical connections to the main isolator on the system should be regularly checked, to fix any loosening of connections due to relaxation of the cable strands. This must be done with the incoming supply to the machine ***isolated*** *at its feed point.*

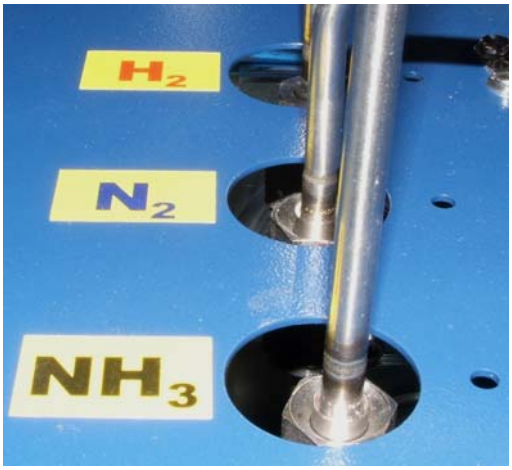
Care should be taken with moveable system components not to damage connection cables.


Phase 1-3 Connection Points (Main Breaker input)
Neutral Connection Point (Blue Terminal Block)
Earth Connection Point (Green Terminal Block)

2.3 INSTALLATION – HIGH PRESSURE HYDROGEN SUPPLY

A regulated supply of Hydrogen is required, at an input pressure of 90 p.s.i.g., (or 200 p.s.i.g. if a palladium diffuser is fitted). The Hydrogen is fed into the top of the Gas cabinet, passing through the clamp plates and connected to the VCR, internally. The incoming line should be manufactured in 1/4" stainless tubing, which should be clean to avoid contamination. A blow-off device for this line set at ~150 p.s.i.g. is recommended , as no input pressure protection is included in the system, (or 250 p.s.i.g. if a palladium diffuser is fitted).





If Hydrogen is obtained from compressed storage cylinders, the cylinder bank should include a manifold designed to minimise the ingress of air, when cylinders or banks of cylinders are being changed.

It is recommended that the Hydrogen supply be filtered to 0.003µm or better with a Hydrogen filter sized to give an appropriate flow at the supply pressure.
Flow rates are as follows:

System	H_2 Carrier (slm)	H_2 Total (slm)	H_2 Max. Capacity (slm)
3x2FT InP	14	19	30
3x2FT GaN	10	30	36
6x2FT InP	22	27	35
6x2FT GaN	20	40	50

Local safety requirements must be observed in the installation of this line.
In order to get adequate growth results it is recommended that the Hydrogen gas supply must be *at least* n7.0 (99.99999%) – although if a palladium diffuser is used then at least an n5.0 (99.999%) purity cylinder feed can be used.

If you are in doubt about the purity of the gas, then the feed gas should be analysed and if necessary pre-treatment equipment, such as a catalytic converter, installed.

Common contaminants of bottled H_2 gas are:

1. Chlorine and its compounds - found in electrolytically produced Hydrogen. Tolerance less than 1 PPM causes intermolecular corrosion of the membrane.

2. CO - found in Hydrogen produced from hydrocarbons. Tolerances of 1 - 2% cause blockage of the membrane.

3. Metallic elements - Arsenic especially is found in Hydrogen streams from organic processes and tungsten from furnace beds. These impurities cause fatigue failure of the membrane.

4. Sulphur and its compounds - found in Hydrogen streams from some petroleum processes. Causes blockage of the membrane.

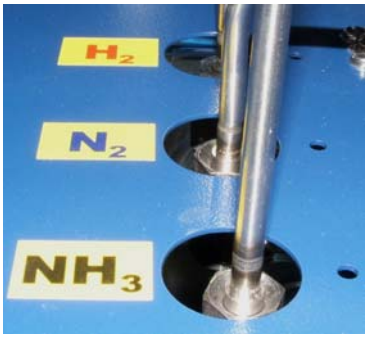
5. Significant quantities of free Oxygen - caused by air leaks in the system. The water formed may cause hot spots on the membrane creating fractures, or in extreme cases, an explosive mixture.

2.4 INSTALLATION – NITROGEN SUPPLY

(See Installation Drawing.)

The system has a requirement for three Nitrogen supplies, at two different gas qualities. These are:

Supply	Quality
Process N2 Supply	Process (>n6.0)
Glovebox supply	Purge (>n3.8)
Ebara dry pump shaft seal purge	
(where Ebara pump fitted)	Purge (>n3.8)



There are different purity requirement for the process supply and the glovebox feed and pump purge. It is appropriate to use a high quality cylinder feed (e.g. at least n6.0 (99.9999%) purity) for the process supply and a lower quality (e.g. n3.8 (99.98%) purity) for the purges. It is recommended that the Nitrogen supply be filtered to 0.003µm or better with a Nitrogen filter sized to give an appropriate flow at the supply pressure. Where purifiers are used, the lifetime of the purifier is dependant upon the input gas purity, and when used with an n6.0 purity feed or better, should have a lifetime based in years.
Supplies should be regulated as follows:

Supply	Pressure (psig)	Maximum Flow rate (slm)
Process N2 (without purification)	90	*See diagram*
Process N2 (with purification)	90*	*See diagram*
Glovebox	Internally set to 20	200 (intermittent)
Ebara Pump	30	8-10

* *Dependant upon purifier model selected to achieve required flow, may be higher.*

Process N_2 Flow rates are as follows:

System	N_2 Total (slm)	N_2 Max. Capacity (slm)
3x2FT InP	4-30	40
3x2FT GaN		
6x2FT InP	4-40	50
6x2FT GaN		

The purge gas is fed into the top of the Gas Control Cabinet, passing through clamp plates and connected to the designated ¼ inch VCR fitting under the clamp plate.

Note:

The system will consume purge gas (N_2 and H_2:N_2 mixture) ALL THE TIME, i.e. between growth runs, overnight and at weekends. With flows optimised for minimum use a typical system will have a usage between 1.5 and 2.5 l/min.

The system does not incorporate over-pressure protection for any gas input line - this should be addressed externally according to local safety standards.

Connections should be in clean 316 Stainless Steel tubing. Welds must be free from internal oxidation. The line should be leak tested.
If the gases are obtained from compressed storage cylinders, the cylinder bank must include a manifold designed to minimise the ingress of air, when cylinders or banks of cylinders are being changed.
The nitrogen must be maintained as pure as possible, to avoid contamination of the equipment, or to prolong the life of the purifier, if fitted.

2.5 INSTALLATION – OTHER GAS SUPPLIES

(See Installation Drawing.)

Additional gas supplies on the system will include the following:

1. Forming gas (5% H_2 in N_2 mixture), used purely to reform the Glovebox De-Oxy Drier column
2. Any Hydride gases as specified on Gas Circuit and Installation diagrams

In general other supplies will be as follows:

Gas	Pressure (psi)	Total Gas (slm)	Max. Capacity (slm)	Fitting
Glovebox Forming Gas 5%H_2 in 95%N_2	4.3 - 5.8	3500L each regen		¼ VCR
NH_3	30		20	¼ VCR
Other Hydrides	20		*See Installation Drawing*	¼ VCR

All process gases are fed into the top of the Gas Control Cabinet, passing through clamp plates and connected to the designated ¼ inch VCR fitting under the clamp plate. The process gases should be regulated to the stated pressure in psig and be capable of supplying the appropriate maximum flow rate as specified on the Installation diagram.

The Reactor system does not incorporate over-pressure protection for any gas input line - this should be addressed externally according to local safety standards.
Connections should be in clean 1/4" 316 Stainless Steel tubing. Welds must be free from internal oxidation. The lines must be leak tested.

If the gases are obtained from compressed storage cylinders, the cylinder bank must include a manifold designed to minimise the ingress of air, when cylinders or banks of cylinders are being changed.

If pyrophoric or highly toxic gases are to be run in uncontrolled or unventilated areas, then secondary containment should be considered in accordance with SEMI F6-92 or similar, and may be mandatory according to local regulations or law.

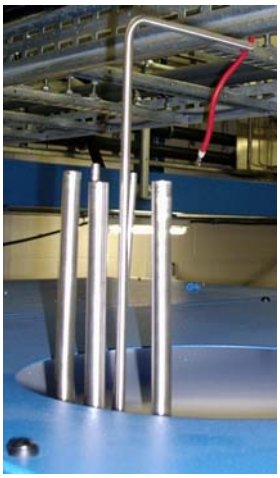
2.6 INSTALLATION – AIR EXTRACTION

(See Installation Drawing.)

The ducting flanges shown must be connected to a suitable leak-tight ducting and fan, typically mounted at roof level. A toxic monitor should be included within the extract system. Each branch **must** include a damper.

The basis of the recommended extraction rate is the maintenance of a linear velocity into the equipment on opening any operationally accessible panel. This is ½ m/sec and is sufficient to reduce out-diffusion to a generally acceptable level. Clearly when a panel is removed the impedance to extract airflow is reduced and consequently the defined flows represent conditions of flow when the input ducting is not impeded. When all panels are closed, the flow can reduce to approximately $^{2}/_{3}$ of the stated value. The reduction in pressure in the equipment under these circumstances is approximately 2 inches water gauge.

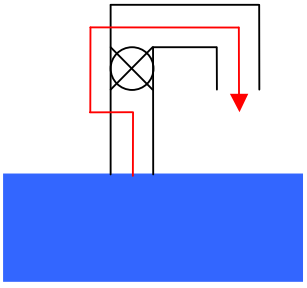
Air is introduced into the equipment through the bottom surface of each cabinet on the system. Where the recommended airflow volume may exceed the flow capabilities of the cleanroom environment, alternative facilities may be required, for example, by the manufacture of an enclosure over the grills and ducting air into this sealed enclosure from outside the main clean-room area. However, the input air should be at a constant temperature to maintain maximum stability of the components within the equipment, and of a suitable class of air purity.



Please note that there will be tubing for pressure switches and other items extending up into the extract duct. Dimensions for these protrusions may be found on the installation diagram e.g. →

In addition provision should be made in the extract for a further item:-

1. If the system is fitted with an optional Palladium Diffuser for Hydrogen purification, then attention needs to be be paid to the H2 Bleed line – this should be routed as follows: -



H2 bleed routed inside cabinet extraction duct, bypassing the fan.
Minimum pipe diameter ¼”

2.7 INSTALLATION – SYSTEM EXHAUST

The toxic exhaust from the system is supplied with a KF25 flange fitting inside the cabinet. This must be coupled to a suitable toxic treatment/waste system in accordance with local safety requirement. The exhaust line must be in stainless steel, and the connection between the equipment and the scrubber must be continuous, without separable connections in non-ventilated areas (i.e. any joints must be in a VMB). Consideration should be given to sheathing the line, dependent on its exposure to mechanical risk, and also purging the sheath, which may be mandatory according to local regulations or law.

To minimise deposition, the user should consider heating the interconnect line between the MOCVD system and the exhaust treatment plant.

The equipment exhaust line must be connected to an appropriate and functional scrubbing (detoxification) system. Note that:-

- There must be an individual Scrubber system for each reactor in operation.
- If it is intended to connect more than one system to a scrubber inlet port together with any AIXTRON MOCVD system, then it is mandatory to inform AIXTRON Group, and to mutually agree on necessary measures together with AIXTRON Group
- If the scrubber outlet is connected to the same extraction channel as the cabinet ventilation the distance of the point of connection shall be not less than 2 m downstream of the cabinet.
- Failure of air extraction from the scrubber will cause a safety alarm similar to scrubber failure.

However the exhaust is treated, it may be a mandatory safety requirement that the exhaust is monitored after treatment, according to local safety standards. The detection of hydrides passing through the scrubbing unit due to insufficient scrubbing, failure or any other malfunction of the scrubbing unit will activate a scrubber failure alarm and generates a safestate shut down of the AIXTRON system. The functionality of toxic monitoring device must be demonstrated to the AIXTRON Group engineer.
Local safety requirements must also be met in the treatment of the exhaust products, and on the details of installation of the exhaust line.

2.8 INSTALLATION – FACILITY SAFETY & TOXIC DETECTION

Emergency safety systems which are mandatory for system operation must include:

- Hydrogen detection (at least for room air control, within the MOCVD system exhaust and any spaces through which gas supply and exhaust lines are routed if separated from the room by walls, ceilings etc.)
- Toxic gas detection (at least for room air control, within the MOCVD system exhaust, within the scrubber exhaust and any spaces through which gas supply and exhaust lines are routed if separated from the room by walls, ceilings etc.)
- Fire detection
- Smoke detection
- For all the above indicated safety system alarms, potential free contacts must be provided to be connected to the AIXTRON system

The Hazardous and toxic gas handling system must comply with general safety requirements as stated below:

- Interlocked with facility safety system
- Fail safe shut off valves
- He-leak tightness < 10^{-9} mbar l/sec
- Plumbing quality complies with regulations for specified gases

	***Note that personal detection cannot be called upon as the primary (or only) means of hazardous / toxic detection*** *due to the introduction of German workplace safety laws that require personal detectors to be properly calibrated on a daily basis. This means that there must be a daily functional check of the respective hazards that are intended for detection, and that it is mandatory to carry test gases in order to assure compliance with safety regulations!* ***Therefore, personal toxic detection can only be allowed as an additional safety measure.*** ***Hence it is always mandatory for the customer to have full toxic monitoring****. Legally, we can no longer accept the use of AIXTRON personal detection as a temporary measure until the customer installs the "final and proper" detection system. Therefore the safety requirements detailed above are mandatory, and must be met by the customer prior to AIXTRON commencing any work – whether system levelling, 2nd or 3rd ATP.*

2.9 Recommended Tool List

For maintenance purposes the following tools are recommended:

1. Set of metric (mm) hex (Allen) keys
2. Set of imperial (inch) hex (Allen) keys
3. Set of flat blade and Pozidrive (crosspoint) screwdrivers
4. Inspection mirror
5. Digital Volt meter
6. Adjustable Grips (Slip Joint Pliers) 250mm
7. Set Open Ended Metric spanners 8-19mm
8. Imperial spanners :
   a. $^{5}/_{8}$ inch for ¼-inch VCR male
   b. ¾ inch for ¼-inch VCR female
   c. $^{15}/_{16}$ inch for ½-inch VCR male
   d. $1^{1}/_{16}$ inch for ½-inch VCR female
   e. $1^{5}/_{8}$ inch for 1-inch VCR/VCO male
   f. 1¾ inch for 1-inch VCR/VCO female
   g. $^{9}/_{16}$ inch for ¼ -inch Swagelok
   h. $^{11}/_{16}$ inch for $^{3}/_{8}$-inch Swagelok

This may be ordered as a complete kit from AIXTRON Ltd., please contact the Sales department for pricing.

2.10 Leak Detector

After any work on gas handling equipment (reactor, gas tubing or vacuum system) a system leak test must be performed to check and assure system safety, confirming that the leak rate of the system is better than $2x10^{-9}$ mbar l/s, to minimize any influences on the process, and to avoid toxic gas hazards.
In addition, on any production equipment with a high duty cycle, a monthly system leak test should be performed.

For performing a system leak test, a Helium Leak tester with a resolution of $1x10^{-10}$ mbar l/s or better should be used, such as a Leybold UL200 Leak tester, or any leak tester of equivalent or better performance – for use on a

production system containing toxics it is recommended that a system with a **liquid nitrogen cold trap** is used. Always ensure that the exhaust of the leak detector is connected to a working exhaust duct with toxic monitoring

	*If it is suspected that a MO source line is contaminated with MO material, then a **liquid nitrogen cold trap** should be placed between the system and the leak tester*

2.11 VACUUM PUMP

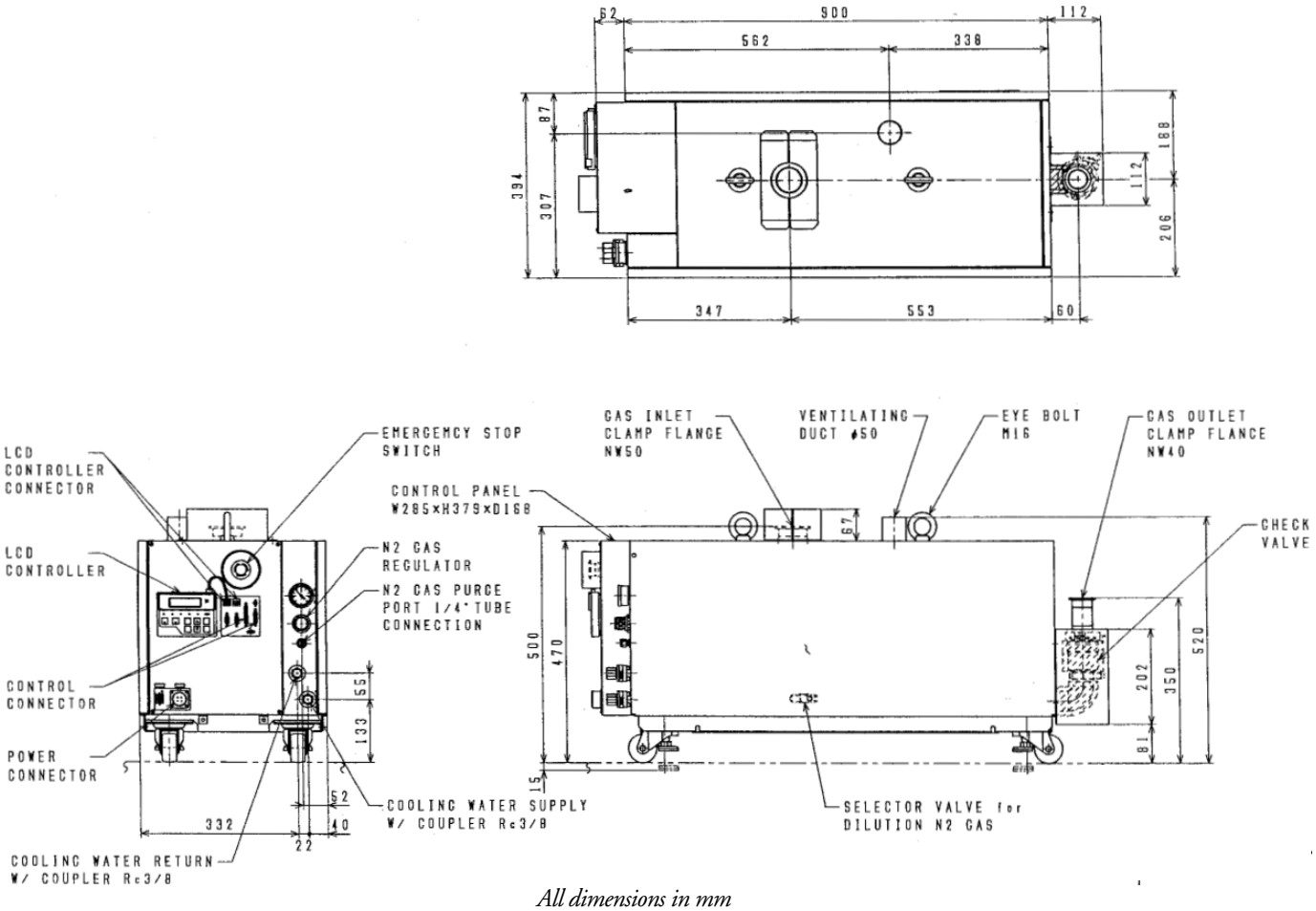
AIXTRON Ltd. specify the Ebara ESA25D Dry vacuum pump as standard equipment on all systems.

2.11.1 Specifications

		Ebara ESA25D
Nominal Pump Rate	CFM @ 60Hz	106
	m^3hr^{-1} @ 50Hz	148
	m^3hr^{-1} @ 60Hz	179
Ultimate Partial pressure		30mTorr
Connection	(Inlet)	NW50
	(Outlet)	NW40
Cooling Water	Max. pressure (psi)	58
	Diff. Pressure (psi)	14.5
	Max. temp. (°C)	30
	Flow Rate (slm)	3.5-8.0
N_2 Gas Purge	Pressure (psi)	14.5-101
	Flow rate (slm)	10-12
Weight	(kg)	240
Lubricating Oil	Capacity (litres)	0.4
	Type	Fomblin Y-L VAC 25/6 Barrierta J100 Demnum S-65 Krytox VPF 1525
Power	Rating (kW@50/60Hz)	3.7

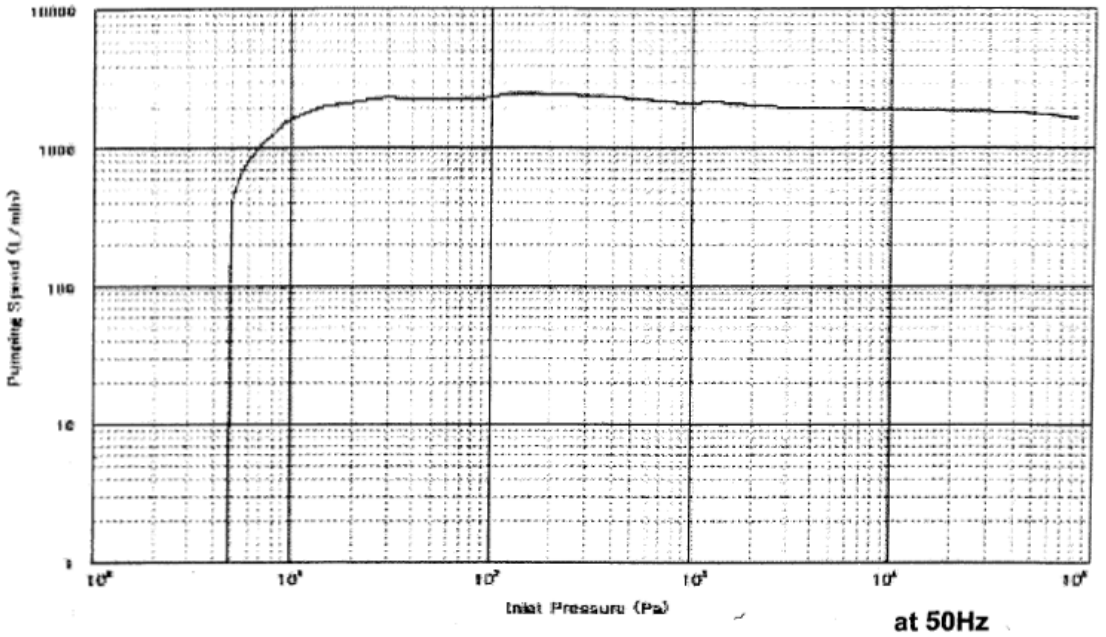
Shown on CCS6x2FT

2.11.2 Dimensions

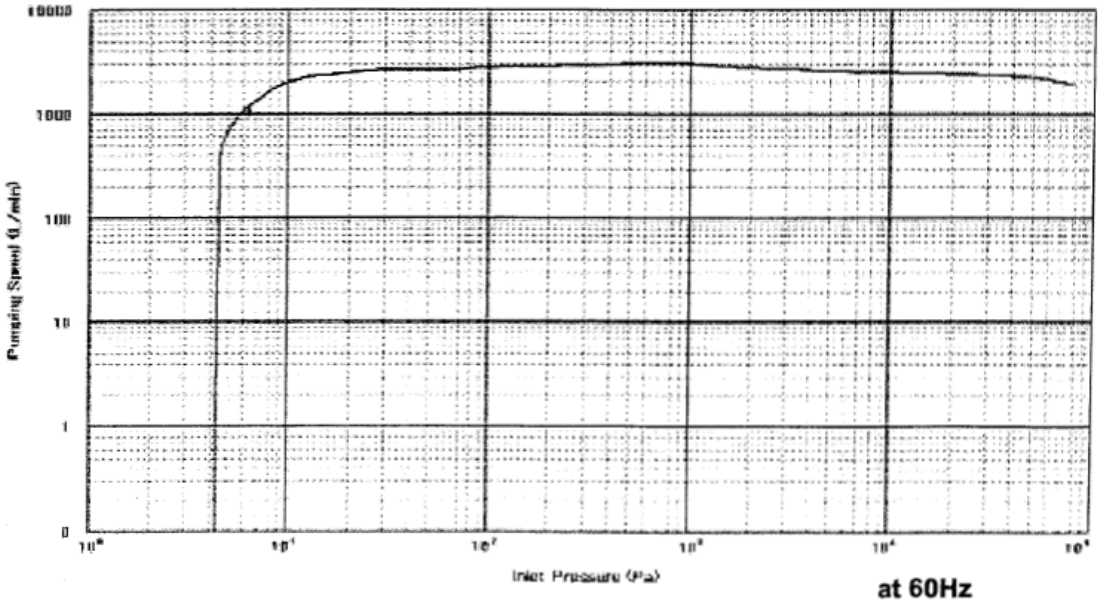


All dimensions in mm

2.11.3 Pump Rates



at 50Hz

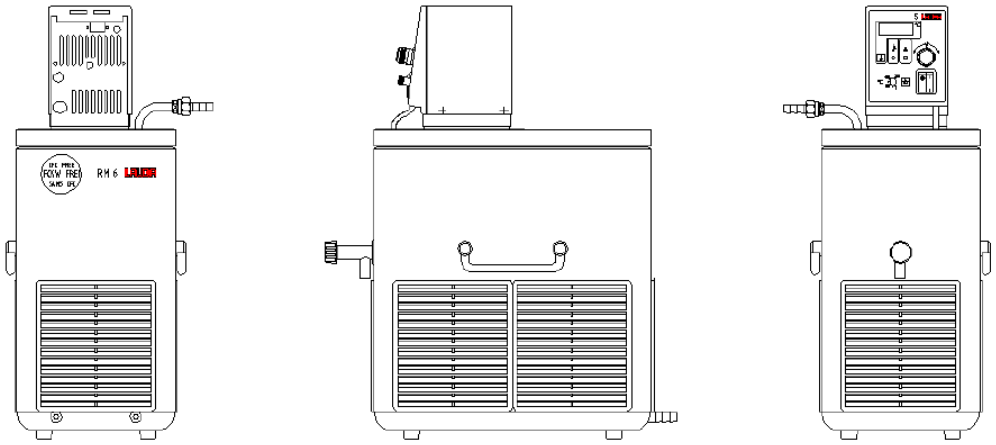


at 60Hz

3 BUBBLERS

3.1 LAUDA BATH

The CCS 3x2FT and 6x2FT Reactor systems use a number of Lauda RM6 S/H Thermostatic baths.



The RM6 bath has the following specification:

Working temperature range	°C	-20 - 150
Condenser cooling		Air
Ambient temperature range	°C	5 - 40
Temperature setting/ resolution		Digital, using 10-turn potentiometer and numerical indication; resolution of indication 0.1°C, potentiometer approx. 0.03°C
Temperature indication /resolution		Incorporated digital thermometer; 0.1°C resolution, absolute accuracy better 0.2% of indicated value ±0.2°C
Temperature sensor/ control action		PT100 / PID
Temperature control (at -10°C)	±C	0,05
Heater power	kW	1,5 (230V), 1,0 (115V)
Cooling capacity eff. *(with Ethanol at 20°C ambient temperature, Temperature of cooling water 20°C)*	20°C; kW	0,2
	0°C; kW	0,15
	-20°C; kW	0,05
Safety features		Adjustable overtemperature protection and low-level protection to EN 61010
Flow rate	l/min	8
Discharge pressure	bar	0,15
Pump connections		M 16x1
Max. filling capacity	l	4 - 6
Bath opening (W x D)	mm	150 x 130

Bath depth	mm	160
Usable liquid depth	mm	140
Height top edge of bath	mm	400
Overall size (W x D x H)	mm	200 x 350 x 560
Weight, net	kg	24
Mains supply	V; Hz	230V; 50Hz/ 100V; 50Hz/ 115V; 60Hz
Power consumption	kW; 230V	1,8
	kW; 115V	1,3
CE Compliance	Units to EU-Directive 89/336/EWG (EMC) and 73/23/EWG (low-voltage) with CE-mark	

Should you use any non-standard size bubblers that may require a larger size bath (which has not been specified in the purchase order), then it may be possible to amend the purchase order and supply this at additional cost.

3.2 Bubbler Connections

All bubbler pipes are usually made in $^{1}/_{8}$ inch tubing with VCR connections. This allows the bubbler pipes to be carefully bent to suit all bubbler types. Bubbler lids are provided to fit either one of two bubblers into a bath. The single bubbler lid is shown below. Please ensure that your bubbler input, output and fill port connections conform to these dimensions.

3.3 Line Heaters

Line heaters will be fitted on solid sources only e.g. TMIn and Cp_2Mg, including Switching manifold, Vent and waste line as necessary. On GaN systems this extends to the Run/Vent stack, on GaAs/InP systems, this will extend to the Showerhead.

Please note:

- *It is not possible to guarantee an accurate temperature for all heated pipework and components*
- *A component such as an MFC or pressure controller should not be heated above 50°C*
- *It is still recommended that OM solid sources are operated as close to ambient as possible to minimise risk associated with source material condensing onto pipework and components.*

4 SUSCEPTOR

The system is provided with two susceptors as standard.

Please note that there can be as long as a **10-14 week** lead-time on custom design susceptors, so it is appropriate to finalise the susceptor specification at an early stage.

We can design susceptors to suit different wafer sizes, and to include ¼ test wafer pieces.
In order to design a custom susceptor, we will need to know:

1. Wafer material (e.g. Single crystal Sapphire (Aluminium Oxide) Wafer)
2. Wafer diameter and tolerance (e.g. 50.8mm ± 0.05mm)
3. Wafer thickness and tolerance (e.g 330nm ± 30 μm)
4. Orientation of flat if applicable (e.g [11-20] ± 0.5°)
5. Flatness, Warp, Bow TTV specification (e.g <25μm)
6. Configuration sketch if the proposed design includes wafer pieces.

Any changes to the standard 100μm Silicon Carbide coating should also be defined for GaN systems

5 SAFETY & INTERLOCKS

Control of the CCS 3x2FT and 6x2FT reactor system is organised to incorporate a number of interlocks for safety purposes.
The system uses the proven AIXTRON SCS (Safety Control System) to prevent unsafe system operation.
The 3x2FT system is equipped with a comprehensive Safety Control System preventing any unsafe state of the system. There are two parts to the safety system:-

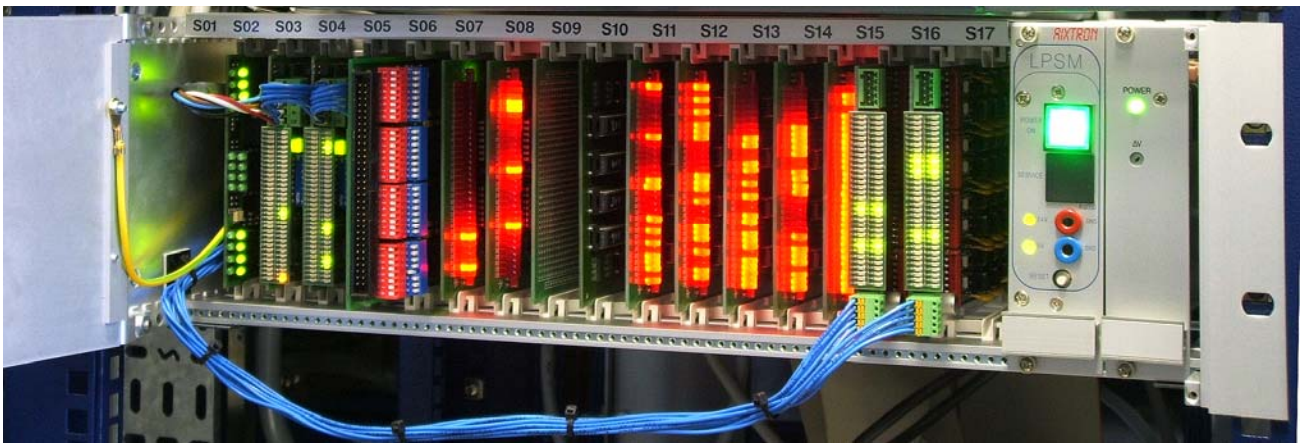
- Machine Safety, and
- Human Safety

Machine safety and digital control: -
Machine Safety is controlled by both Schmersal safety relays, and the AIXTRON Safety Control System (SCS).
High level safety is dealt with using Schmersal safety relays, which look at:

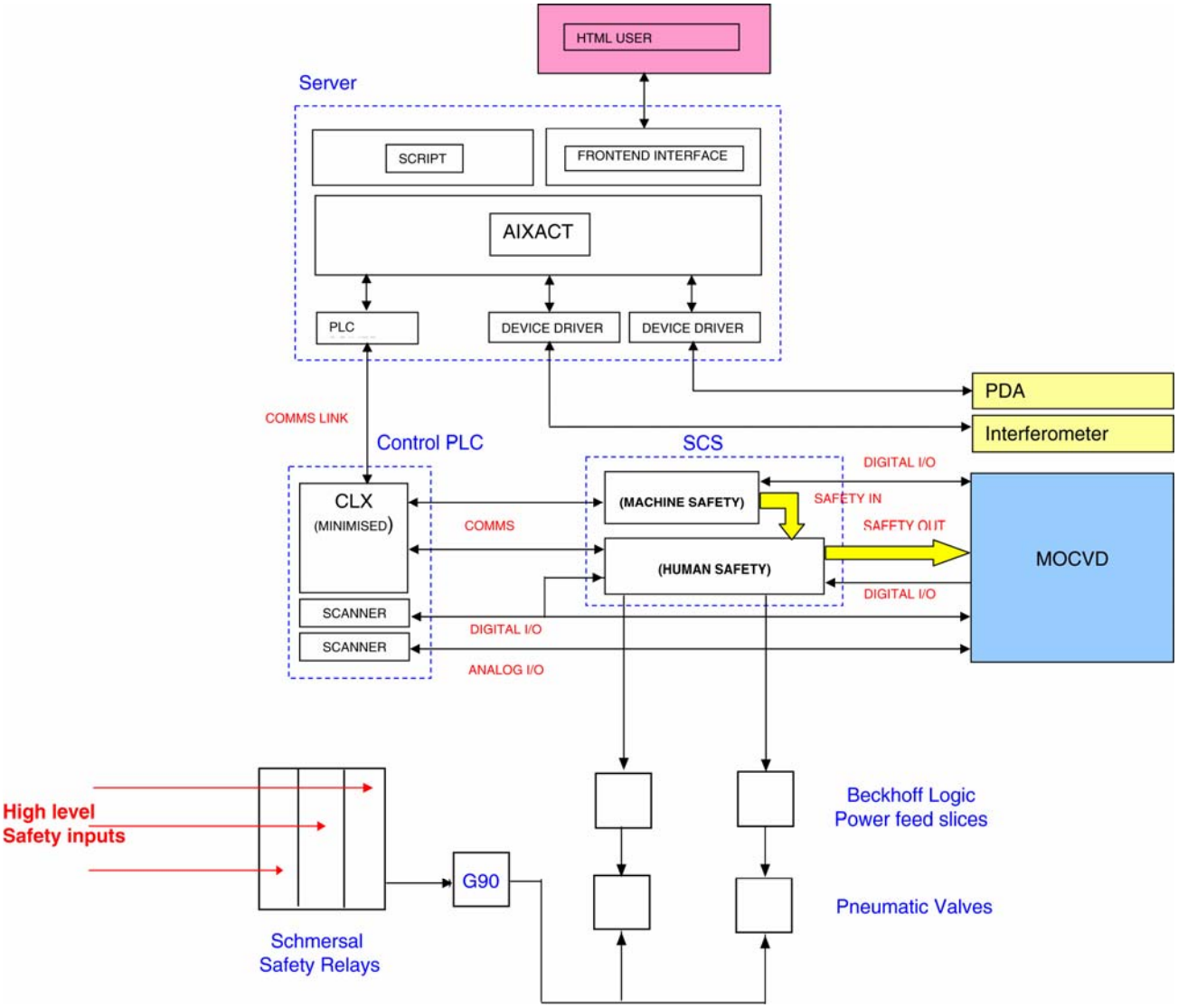
- Extract Flow
- Extract pressure
- Door Switches

In the event of a high level trip, pneumatic valve G90 is disabled, which interlocks the pneumatic supply to the system. The safety relay outputs are fed to the SCS which also monitors inputs from the MOCVD system, and provides safe outputs back to the MOCVD system. The Hazardous valves (numbered Hxx) are controlled by Beckhoff logic, which uses Power Feed slices to interlock individual Hazardous valves.

Human Safety
All of the Cause Effect functions that have been designated as Human safety are replicated within the AIXTRON Safety Control System (SCS).
The Safety Control System is a modular safety control system that monitors all signals, valve positions, sensors, and analog limit values. It operates stand-alone, and is superior in the control hierarchy to the control computers. The Safety Control System switches the system to a safe state if a dangerous situation occurs.
The Safety Control System is located in the electrical cabinet.



The control map is illustrated below.



- The system uses the AIXACT software as the system control software. This software is robust and has been proven on previous system designs.

- There are two DeviceNet networks on the system – a fast digital network for safety, and a slower analog network for device control e.g

- The Safety Control System or SCS releases all digital outputs of the AIXACT Process Controller and will interlock them according to the systems' Enable Table and Cause-Effect Diagram. The SCS prevents critical machine states. In case of an alarm, it will set the tool into a safe condition. Process Safety and Machine Safety interlocking can be dealt with in software within the AIXSAFE PLC. Examples of this are the prevention of associated H2 and N2 valves being opened at the same time.

A sample Interlock Cause – Effect table is given below:

AIXTRON — Safety and Interlock Description
Safety Diagram — System 3x2FT

Comission: Revision: 3

Prepared: Rfrohn Date: 14.05.2007

Released: Jmeyer Date: 14.05.2007

Cause \ Effect	N_2 Source Supply Off G01 - G04, H66	H_2 Rd Cell Off H67	N_2 Run Supply Off G05 - G08, G15	N_2 Inlet Supply Off G25	Process Pump SF01 / Cooling G19 Off	DOR Evac Valve Off G08	MO Vac Valve Off G10	IGS Valve Off G11	Control Off SF04 / Vac Valve G12 Off	Bypass Valve Off G13	Reactor Valve Off G14	Power Off Valves G24.1 - G24.2	Maintenan./Source Off G26-28	Hydride Source Valves Off H01 - H11	Run Vent Valves Off H200 - H229	MO Source Valves Off H16 - H28	Vac Vent Valve Off H40	H_2 Run Supply Off H41 - H46	H_2 Source Supply Off H50 - H65	Heater Contactor Off	Process Heater Off SF02	Reactor Cooling Close G16 - G18	Reactor Open Not Release	DOR Fill Valve Off G07	Recipe Not Allowed (PLC)	Control Not Allowed (PLC)	Alarm Buzzer On	Glovebox Control Not Release + G29	Thermostate Cooling Off G30	Pyro Furnace SF06 Off	Disable Gap Adjustment	Disable Main Rotation	Door Open Not Release	Laser On Not Release	Pneumatic Supply Off G90	dP Reactor 1)	Low Pressure Reactor	Reactor Pressure < Limit
Emergency Off (Red Button)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Main Power Fail	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
External Earth Quake	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
External Fire Alarm	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Process Stop (Yellow Button)	X		X		X				X	X				X	X	X	X	X	X	X	X	L	X		X	X	X											
H_2 Monitor (Customer)	X	X	X				X							X	X	X	X	X	X		X		X		X	X	X	X		X	X	X						
H_2 Monitor (Glovebox)	X	X	X				X							X	X	X	X	X	X		X		X		X	X	X	X		X	X	X						
Toxic Monitor (Customer)	X		X				X							X	X	X	X	X	X		X		X		X		X						X					
Access Panels	O		O											X	X	O	O	O	O		X				O		X				O	O		O				
Air Extraction Pressure	O		O											X	X	O	O	O	O						O		X							O				
Air Extraction Flow	X	X	X											X	X	X	X	X	X						X		X							X				
Pneumatic	X		X			X	X		X	X			X	X	X	X	X	X	X		X		X		X	X	X											
H_2 Pressure									X					X	X	X	X	X	X		X				X		X											
N_2 Pressure									X					X	X	X	X	X	X		X		X		X		X											
Scrubber	X		X				X		X					X	X	X	X	X	X		X		X		X		X											
Heater Fail														X	X	X					X				X		X											
Low Power Fuse	X		X						X	X	X		X	X	X	X	X	X	X		X		X		X	X	X											
Waterleak					X				X					X	X	X				X	X	L			X		X		X									
Excess Reactor Pressure				X						X				X	X	X	X	X	X		X		X		X		X											
dP Reactor 1)			X				X		X					X	X	X	X	X			X		X		X	X	X											
Waterflow Reactor > Limit False			H						H					H	H	H	H	H		X	X				H		H											
Excess Reactor Temperature			X						X					X	X	X	X	X		X	X		X		X	X	X											
Excess Watertemp Reactor			X						X					X	X	X	X	X		X	X		X		X		X											
Reactor Leak Monitor																									X		X											
Reactor Lid Down False			X			X			X					X	X	X	X	X			X														X			
Reactor Clamp Close False			X			X			X					X	X	X	X	X			X														X			
Reactor Chamber Close False			X			X			X					X	X	X	X	X			X																	
Heater Access Close False			X						X					X	X	X	X	X			X																	
P < Limit 1 DOR False 10mbar			X						X					X	X	X	X	X			X																	
P > Limit 2 Reactor False 960mbar							X				X													X														
Throttle Valve Close False							X				X													X														
Timer N_2 Purge Active			X											X	X	X	X	X																			
Excess Outlet Pressure				X	X			X	X					X	X	X	X	X	X		X		X		X	X	X											
P > Limit 1 Reactor False 30 mbar																																						
Main Rotation < Limit																						O																
Watchdog	X	X	X		X				X	X	X		X	X	X	X	X	X	X			X	L			X	X	X				X	X	X					
Device Net	X	X	X		X				X	X	X		X	X	X	X	X	X	X			X	L			X	X	X				X	X	X					
T < Limit 1 Reactor False 150°C																								X														
Heat Exchanger																												X										
dP Filter														X	X	X										X		X											
Maintenance Mode														X	X																								
PT1 Disconnected																																				X	X	X
Exhaust Filter Fitted			X											X	X	X	X	X			X																	
Exhaust Filter Cover			X											X	X	X	X	X			X																	
Pyro Furnace Limit																															X							
H_2 Excess Input Pressure	X	X																								X		X										
H_2 Purifier Fault	X	X																								X		X										
yellow marked = Not Part of the SCS																																						

6 INSTALLATION PROCEDURE

6.1 INSTALLATION REQUIREMENTS

The following text is intended to detail the general requirements for the external services that are needed for the CCS-MOCVD system.

If there is any conflict between values in the installation diagram and those stated in this generic manual, then the installation diagram should be used as the authorative document.

6.1.1 Upon receipt of the system

- The system should be removed from the packing crates and sited in its final position in the lab. The two or more sections of the system should be levelled, using the adjustable levelling feet. The levelling feet will have been retracted for shipping and can be adjusted using a suitable wrench.

- In areas susceptible to earthquakes, it may be more appropriate to use shims instead of the leveling feet and then bolt the system to the floor using the anchor points provided.

- Once the system has been levelled the sections can be bolted together using the fixing bolts provided.
  Note: *This is not essential and can be left until the full installation takes place.*

- The Keys and the fixing bolts will be found in a bag attached to the outer load lock door in the reactor cabinet.

- All other spare parts supplied with the system can be left in their respective boxes until such time as the installation commences. If preferred the boxes can be emptied but care should be taken whilst doing this to ensure that none of the contents are discarded along with the packing materials. Secure storage must be provided for fragile items such as the reactor quartz.

6.1.2 Gas Connections (Gas Control Cabinet)

- The gas connections for the hydrides are located inside the roof of the gas control cabinet and are terminated with ¼" VCR connectors.
  Note: *The number of gas lines for systems can vary and the precise details of their location will be found on the installation diagram for the system.*

- The hydrides are normally supplied to the system regulated to 20psi (30 psi for NH3).

- The gas connections for the H_2 and N_2 are located inside the roof of the gas control cabinet and are terminated with ¼" VCR connectors.

- H_2 is normally supplied to the system regulated to 90psi (200 psi if a palladium diffuser is fitted).

- N_2 is supplied to the system regulated to 90psi.

6.1.3 Gas Connections (Reactor Cabinet)

- The gas connections for the glove box and load lock are located inside the roof of the reactor cabinet and are terminated with ¼" VCR connectors.

- N_2 is supplied to the glove box and load lock regulated to 90psi.
  Note: *This supply MUST be regulated separately from the supply to the gas system.*

- Forming gas (5% H_2 in N_2) is supplied to the regeneration unit regulated to ~5psi, terminated in a roof mounted ¼" VCR fitting. (The internal connection to the Glovebox controller if used is a 10mm Swagelok fitting)

- The connection for the system exhaust is located inside the roof of the reactor cabinet and is terminated with a KF25 fitting.
  Note: *This must be connected to a suitable scrubbing system.*

6.1.4 Pneumatic Supply

- The Pneumatic supply to the system must be pre-regulated to 120psi. The connection for the pneumatic supply is located on the roof of the gas control cabinet and is terminated with a ¼" Swagelok connector. The Pneumatic supply is recommended to be a low purity N2 supply, to prevent any oxygen entering the Hydrogen lines in the unlikely event of a valve leaking its pneumatic feed over the valve stem.

6.1.5 Water

- The connections for the separate water circuits are located on the roof of the reactor cabinet and are terminated using $^3/_8$ or ½ inch Swagelok connectors.
  Note: *The number of water circuits can vary from system to system and the precise location and size of the connections will be found on the installation diagram.*

- It is recommended that all water supplies are filtered and that each circuit is supplied via isolation valves.

6.1.6 Air Extraction

- There are a number of air extraction points that are located on the top of the system. There will be a minimum of two extraction points for the gas control cabinet and one for the reactor cabinet. The air extraction ducts must be fitted with dampers to enable the airflow through the system to be balanced. The damper for the reactor cabinet ducting should not be located too close to the system, as there are pipes which protrude into the ducting above the roof level of the system. The total airflow rate required for the system is 1550cfm ($2635 m^3 hr^{-1}$) with a minimum duct pressure of 1-inch water gauge. The gas control cabinet requires 800cfm ($1360 m^3 hr^{-1}$) and the reactor cabinet requires 750cfm ($1275 m^3 hr^{-1}$).

6.1.7 Electrical Supply

- The system requires a 3 phase power supply + neutral + earth.

- The system is configured for a 400V phase to phase input, giving 230V phase to neutral. Therefore for alternative input supply voltages a transformer will be required.

Note: *The precise details of the voltage and current and frequency requirement will be found on the installation diagram. Please confirm these details at the Design Review meeting.*

- Power is brought into the system through the roof of the Reactor cabinet. There is a plate located on the roof which has a pre-drilled 10mm pilot hole and which can be removed. This plate should be drilled to accommodate a suitable cable gland for the incoming mains cable.

- The incoming power is connected directly to the three-phase circuit isolator. The neutral and earth connection points are adjacent to the main isolator. Access to the isolator is gained by removing the side panel adjacent to it and by removing the panel on which the operating lever is mounted. In order to remove the front panel the operating lever must be in the off position.
  Note: *Care should be taken when removing this panel, as it has wiring attached to it.*

6.1.8 System Computer

- The system computer is an internally mounted server (Dell Poweredge). The system may be supplied with a **optional** remote Client PC for system operation (Dell Optiplex Workstation), which is connected by an Ethernet cable to the internally mounted VPN router – this PC will require mains power. A computer desk is supplied.

6.1.9 Ancillary Equipment

6.1.9.1 Leak testing

- During the early part of the installation a H_e (Helium) leak detector will be required. There is a leak test point sited behind one of the lower panels of the gas control cabinet which is terminated with a KF16 fitting. A suitable means of connecting this point to the leak detector should be provided. A supply of H_e (Helium) will also be required.

6.1.9.2 Temperature controlled baths

- Each of the temperature-controlled baths has a liquid capacity of 6 litres. Baths that are required to run at low temperatures require a 50% mixture of ethylene glycol (or equivalent) and water. Any baths that run at around ambient temperature can be filled with pure water.

6.1.9.3 Charcoal

- On systems that are intended for the growth of InP/GaAs materials, the filter downstream of the reactor contains activated charcoal. This charcoal will have to be changed periodically.
  Note: *The spent charcoal must be oxidised and disposed of in accordance with locally audited safety instructions.*

- Sufficient supplies of charcoal must be made available to enable the growth demonstration to be completed.

- Sufficient supplies of charcoal must also be available (at all times) to change the Glovebox Purge line after any toxic release incidents into the Glovebox that have been adsorbed by the Glovebox Purge line charcoal filter.

6.1.10 Preparation

- It is essential that all of the actions and services listed in this document are completed so that the main part of the installation can proceed smoothly.

- Contact with the regional GSO manager will be established prior to the shipment of the system from our facility. The installation will be scheduled based on a best estimate for the completion date for all of the external services once the system has arrived on site.

- AIXTRON GSO / AIXTRON Ltd. is aware that unforeseen delays to the installation of the external services can occur. During the period that the external services are being installed, regular contact with the regional GSO manager must be maintained, so that any such unforeseen delays can be notified and, if necessary, amendments to the installation schedule can be made in good time.

- AIXTRON GSO / AIXTRON Ltd. will be on hand to answer any queries that may arise during the period leading up to the completion of the external services, and may be contacted at the address below.

AIXTRON LTD.
ANDERSON ROAD, BUCKINGWAY BUSINESS PARK,
SWAVESEY, CAMBRIDGE,
CB24 4FQ, UNITED KINGDOM.
Tel: +44 (0)1223-519444
Fax: +44 (0)1223-519888.
E-mail: UK-Service@aixtron.com

6.2 Services Check List

Please complete and return to AIXTRON Ltd. at the address below, immediately after system arrival.

AIXTRON Ltd.
Anderson Road, Buckingway Business Park,
Swavesey, Cambridge,
CB24 4FQ, United Kingdom.
Tel: +44 (0)1223-519444
Fax: +44 (0)1223-519888.
E-mail: UK-Service@aixtron.com

The system is positioned and levelled:	Yes ☐	No ☐	N/A ☐
The system is bolted together:	Yes ☐	No ☐	N/A ☐
Extraction ducts are connected:	Yes ☐	No ☐	N/A ☐
Pneumatic Air connected:	Yes ☐	No ☐	N/A ☐
The electrical supply is connected:	Yes ☐	No ☐	N/A ☐
Cooling Water connected:	Yes ☐	No ☐	N/A ☐
Hydride gas lines connected:	Yes ☐	No ☐	N/A ☐
System N_2 connected:	Yes ☐	No ☐	N/A ☐
System H_2 connected:	Yes ☐	No ☐	N/A ☐
Glove Box N_2 connected:	Yes ☐	No ☐	N/A ☐
Ethylene Glycol available:	Yes ☐	No ☐	N/A ☐
Toxic & Flammable Detection operational:	Yes ☐	No ☐	N/A ☐
Leak Checker available:	Yes ☐	No ☐	N/A ☐
Leak Checker connection available:	Yes ☐	No ☐	N/A ☐
H_e and spray gun available:	Yes ☐	No ☐	N/A ☐
Metal Organic Sources available:	Yes☐	No ☐	N/A ☐
Wafers & cleaning materials.	Yes ☐	No ☐	N/A ☐

Gas Cylinder Cabinets
Model 1170 Series

Matheson Model 1170 is our standard gas cabinet series with a flat top design. The new construction is optimized for economy, without compromising safety or quality.

- **Automatic door closure** to ensure containment of leaks
- **Modular U-Channel Supports** make installation of gas control panels, cylinder supports, shelving, and other equipment easy.
- **Lockable access panel and wire reinforced safety glass viewing window** have steel frames and are fully gasketed.
- **Non-protruding paddle type latch** prevents accidental opening and snagging. It slams and latches at three points and is fitted with a lock for security.
- **Neoprene gaskets** fit snugly around door to ensure a positive seal
- **Standard inlet air louver or optional diffuser plate** fitted with an inlet filter (p/n VEN-0101-XX) lets air into the cabinet.
- **Flat-top design** with exhaust stack.
- **Fire sprinkler head**, for extra protection with a fuse rating of 155°F.
- **Cylinder restraints** to ensure that all cylinders are held securely in place during storage and operation
- **Rugged exterior construction** of 12-gauge cold rolled steel with welding seams.
- Interior and exterior is finished with gray **2-part polyurethane paint**.
- **Low profile, one-inch reinforced threshold** makes cylinder installation and removal easy.

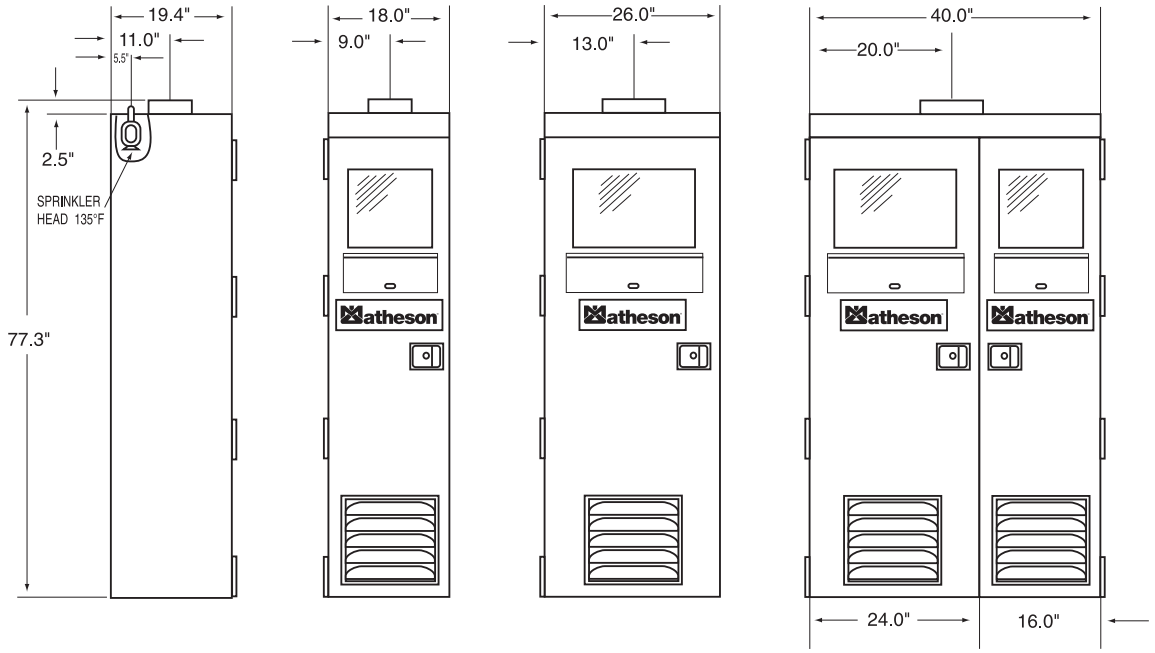
Specifications foe Model 1170 Series and Hard Hat Series
(Meet or exceed Article 80 UFC requirements)

Cabinet:	12 gauge cold rolled steel
Gaskets:	Neoprene with oil resistant adhesive
Window:	1/4" wire reinforced safety glass
Paint:	2-part polyurethane; interior and exterior – light gray
Cabinet Floor:	Zinc-plated steel
Doors:	1 and 2 cylinder cabinets – one door with left hand hinge 3 cylinder cabinet – double door with off-center post
Integral Sprinkler:	Fuse rating of 155°F and flow capacity of 35 GPM @ 40 psi
Water Pipe Connection:	1/2" NPT Female

Model No.	Cabinet Type	Overall Height	Depth	Width	Exhaust Flow Required (SCFM)	Exhaust Stack Diameter	Shipping Weight lbs
1177F	1 Cylinder	79"	19"	18"	175	4"	300
1178F	2 Cylinder	79"	19"	26"	250	6"	380
1179F	3 Cylinder	79"	19"	40"	450	8"	540

Gas Cabinet Dimensions and Options

Model 1170 Series



Gas Cabinet Options

- **Adjustable Cylinder Shelf (see table for part number)** – mounted on the U-Channel tracks. The shelf provides a convenient means of installing small cylinders. Perforations in the shelf allow cabinet air to sweep around the entire cylinder.

- **Fusible Link (see table for part numbers)** – installed in the center of the cabinet door. Offers immediate response in the event of a fire. Once the heat melts the fusible link, a guillotine damper blocks the inlet air supply.

- **Cylinder Scales** – recommended for use with all liquefied gases. Provides the weight of contents remaining in the cylinders. Manual and electronic cylinder scale models are available. (See pages 431 - 432)

Model No.	Description
1190-S	Adjustable cylinder shelf
1177F-6	Fusible link for Model 1177F
1178F-6	Fusible link for Model 1178F
1179F-6	Fusible link for Model 1179F
VEN-0101-XX	Optional diffuser plate with inlet air filter

Gas Cylinder Cabinets
"Hard Hat" Series

Matheson's new "Hard Hat" cabinet is designed for outdoor use and installation. It is ideally suited for handling gas applications in refinery environments. The cabinet incorporates several structural features making it weatherproof and is constructed from stainless steel materials to withstand harsh weather effects. The "Hard Hat" cabinet is available is standard sizes to accommodate up to three cylinders.

- **Rain gutter** above cabinet door prevents rain from entering cabinet
- **Stainless steel** hinges and hardware
- **Rain hat** to cover stack
- **Special Zinc Chromate primer** to prevent rust and corrosion
- **Removable top panel** for service access
- **Automatic door closure** to ensure containment of leaks
- **Lockable access panel** and wire reinforced safety glass viewing window have steel frames and are fully gasketed
- **Non-protruding paddle type latch** prevents accidental opening and snagging. It slams and latches at three points and is fitted with a lock for security
- **Neoprene gaskets** fit snugly around door to ensure positive seal
- **Standard inlet air louver** or optional diffuser plate fitted with inlet filter (p/n VEN-0101-XX) lets air into the cabinet
- **Fire sprinkler head** for extra protection with a fuse rating of 155°F
- **Cylinder restraints** ensure all cylinders are held securely during storage and operation
- **Low profile, one-inch reinforced threshold** makes cylinder installation and removal easy

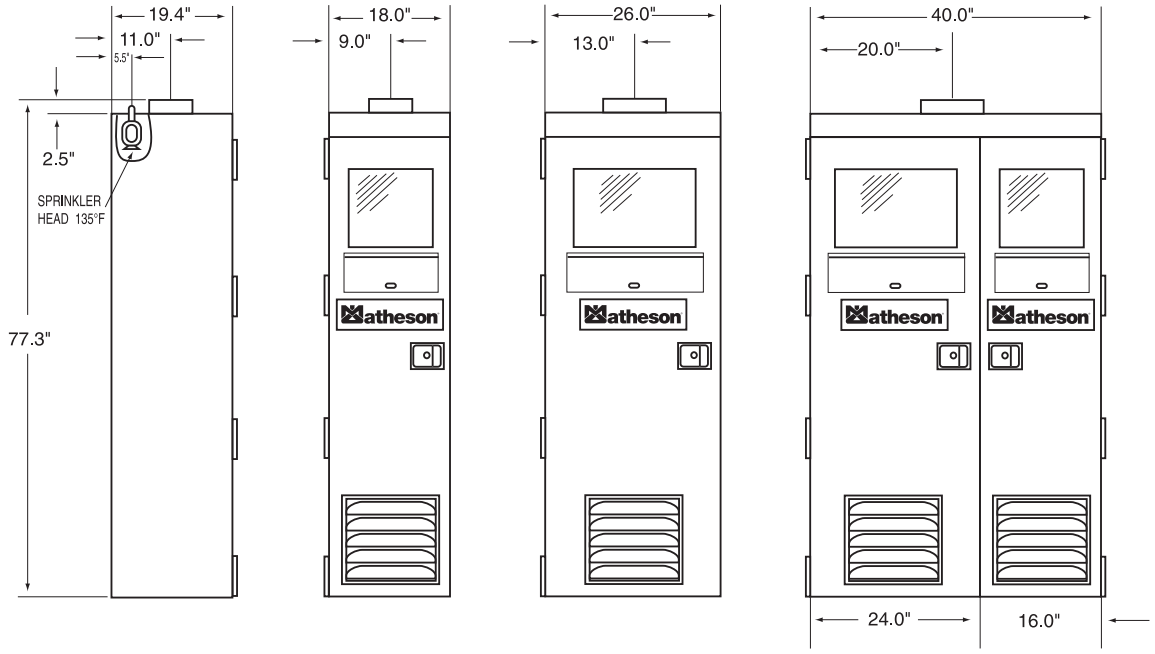
Specifications for Hard Hat Series
(Meet or exceed Article 80 UFC requirements)

Cabinet:	12 gauge cold rolled steel
Gaskets:	Neoprene with oil resistant adhesive
Window:	1/4" wire reinforced safety glass
Paint:	2-part polyurethane: interior and exterior – light gray
Cabinet Floor:	Zinc-plated steel
Doors:	1 and 2 cylinders cabinets – one door with left hand stainless steel hinges 3 cylinder cabinet – double door with off-center post
Integral Sprinkler:	Fuse rating of 155°F and flow capacity of 35 GPM @ 40 psi
Water Pipe Connection:	1/2" NPT Female

Model No.	Cabinet Type	Overall Height	Depth	Width	Exhaust Flow Required (SCFM)	Exhaust Stack Diameter	Shipping Weight lbs
1177-HH	1 Cylinder	79"	19"	18"	175	4"	300
1178-HH	2 Cylinder	79"	19"	26"	250	6"	380
1179-HH	3 Cylinder	79"	19"	40"	450	8"	540

Gas Cabinet Dimensions and Options

Hard Hat Series



Gas Cabinet Options

- **Adjustable Cylinder Shelf (see table for part number)** – mounted on the U-Channel tracks. The shelf provides a convenient means of installing small cylinders. Perforations in the shelf allow cabinet air to sweep around the entire cylinder.

- **Fusible Link (see table for part numbers)** – installed in the center of the cabinet door. Offers immediate response in the event of a fire. Once the heat melts the fusible link, a guillotine damper blocks the inlet air supply.

- **Cylinder Scales** – recommended for use with all liquefied gases. Provides the weight of contents remaining in the cylinders. Manual and electronic cylinder scale models are available. (See pages 431 - 432)

Model No.	Description
1190-S	Adjustable cylinder shelf
1177F-6	Fusible link for Model 1177-HH
1178F-6	Fusible link for Model 1178-HH
1179F-6	Fusible link for Model 1179-HH
VEN-0101-XX	Optional diffuser plate with inlet air filter

saes group

SAES Pure Gas

The Technology of Pure Gas

AMMONIA GAS PURIFIER SPECIFICATION

0 - 1,600 slpm Automatically Regenerable Ammonia Gas Purifiers.
For consistent gas quality and impurity removal to pptV levels

SAES Pure Gas
The Technology of Pure Gas

Automatically Regenerable Ammonia Purifier (10-100 Nm3/hr)

The MegaTorr MGS Series Ammonia Gas Purifiers are enhanced, optimized designs providing sub-ppb performance in small footprints. SAES Pure Gas has drawn on years of experience in Ultra-High Purity (UHP) piping design, advanced process material analysis and state of the art integrated control systems to develop this family of purifiers to meet the needs of low capital cost, high reliability and high performance.

Purifier uses dual adsorption vessels that alternate between purify and regeneration modes, providing continuous purification. Adsorber regeneration is accomplished by back-flushing with purified process gas at an elevated temperature.

Safety Features

- **Hydrogen and Ammonia sensor**s
  Placed inside the cabinet to detect hydrogen and ammonia giving a control system alert.
- **Over Pressurization Safety System**
  Provides over-pressurization protection for purifier vessels and piping. NOTE: This is not a full flow relief system - this is an internal relief system to accommodate blocked valve heating.
- **High Temperature Hardware Interlock**
  For over-temperature protection independent of the control system

Standard Features

- Microprocessor PLC
- Color Touch Screen Human Machine Interface (HMI)
- Electric Gas Preheaters
- Closed-Loop Temperature Controls
- Alarm and Gas relay customer connections
- Vented Cabinet Purge with low airflow warning
- Inlet and Outlet Isolation Valves for manual purifier isolation.
- Regen Blending Station provides hydrogen regeneration gas mixture blending and control.
- Ground Fault Protection (GFI)
- Emergency Off Button (EMO)

Optional Features

- Auto or Manual Bypass allows process gas flow to bypass the purifier vessels.
- Separate Control Power allows purifier control system to be powered by an external, customer supplied power source or UPS.
- Particle Filter provides purified gas filtration.
- MODBUS Data communication port provides operational data output.
- Purifier Hold Down Brackets provide means for securing purifier to floor.
- Inlet/Outlet Pressure transducers provide process gas pressure indication.
- Inlet Mass Flow Meter provides process gas flow rate and total flow indication.

Applications

- Semiconductor
- Flat Panel Display
- LED / Compound Semiconductor
- Fiber Optic
- Research
- Solar
- Fuel Cell

Model	Rated Flow
PS21-MGS10- NH	10 Nm3/hr (~166 slpm)
PS21-MGS20- NH	20 Nm3/hr (~333 slpm)
PS21-MGS30- NH	30 Nm3/hr (~500 slpm)
PS21-MGS40- NH	40 Nm3/hr (~665 slpm)
PS21-MGS50- NH	50 Nm3/hr (~833 slpm)
PS21-MGS60- NH	60 Nm3/hr (~1,000 slpm)
PS21-MGS80- NH	80 Nm3/hr (~1330 slpm)
PS21-MGS100-NH	100 Nm3/hr (~1,660 slpm)

Product Specifications (for all models)

Gas Purified	NH_3
Inlet Requirements (Process Gas)	NH_3: 5.0 N Inlet Purity*, 20 micron max particle size 10-35ºC (50-95ºF), 4.5-10.4 barg (65-150 psig)
Inlet Requirements (Regen Gas)	H_2: 5.0 N Inlet Purity, 20 micron max particle size 5-35ºC (41-95ºF), 6.9-8.3 barg (100-120 psig) N_2: Purified Gas (5.0 N minimum), 20 micron max particle size 5-35ºC (41-95ºF), 6.2-7.6 barg (90-110 psig)
Impurities Removed	H_2O, O_2, CO_2, NMHC, metals to < 1 ppb*
Particle Filtration	2 micron (standard) 0.003 micron (optional)
Pressure Drop	< 0.7 bard (~10 psid) (Without options at maximum flow, 6.9 barg inlet)
Instrument Air	Clean dry air or nitrogen filtered to 10 μm Min-Max Pressure: 6.6 – 9.7 barg (~95 – 140 psig)
Applicable Codes & Standards	ASME Pressure Vessel Standards Section VIII US National Electric Code CE Marking (Must be specified on order) Manufacture License of Pressure Vessels, Peoples Republic of China (Must be specified on order)

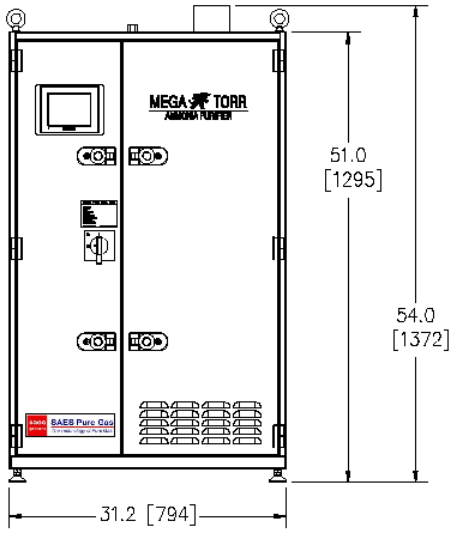
*Analytical specification certified at greater than 10% of the max flow. The certification is carried out in N2 or Ar at shipment. Consult factory for non-standard inlet or outlet purity requirements.

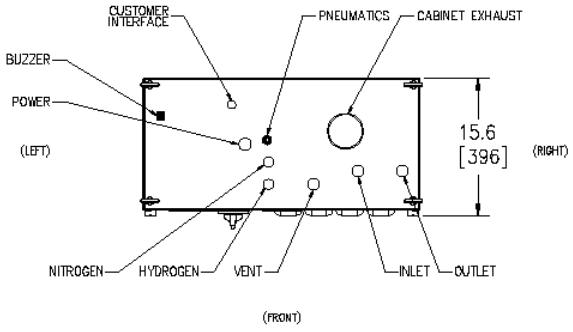
Facility Specifications

Purifier Model	PS21-MGS10-NH	PS21-MGS20-NH
Dimensions	Height: 1375 mm (~54 in) Width: 800 mm (~31 in) Depth: 400 mm (~15 in) Weight: < 160 Kg (< 352 lbs.)	
Purifier Clearance	1 meter (~3 feet) in front; 150 mm (~6 inches) left and right sides	
Mechanical Connections	Feed Inlet: ½" MVCR Purified Outlet: ½" MVCR Regeneration/Relief Vent: ½" MVCR H_2 Inlet: ¼" MVCR N_2 Inlet: ¼" MVCR Cabinet Vent: 4" duct Instrument Air Inlet: 3/8" FNPT	
Regeneration Vent Temp.	Ambient air + 30°C (+ 54°F)	
Purify Time	Programmable	
NH_3 Consumed Per Regen	0.184 m^3 (184 liters)	0.37 m^3 (370 liters)
H_2 Consumed Per Regen	1.5 m^3 @ 5 slpm	3.0 m^3 @ 5 slpm
N_2 Consumed Per Regen	60 m^3 @ 30 slpm	60 m^3 @ 30 slpm
Main Power	208 or 230 VAC, 1 Phase, 50/60 Hz Installed Power: 1.2 kW Power Consumption during Purification: 0.1 kW Power Consumption during Regeneration: 0.6 kW	
Separate Control Power (Option)	110 or 230 VAC, 1 Phase, 50/60 Hz Power Consumption: 0.1 kW	
Cabinet Ventilation	170 Nm^3/hr (100 scfm) [@ Facilities Vacuum - 0.2 inches H_2O]	
Installation	Indoor, Ambient Temp (min – max) 5° – 35°C (41° – 95°F)	

Dimensions

PS21-MGS10-NH (10 Nm3/hr) through PS21-MGS20-NH (20 Nm3/hr)



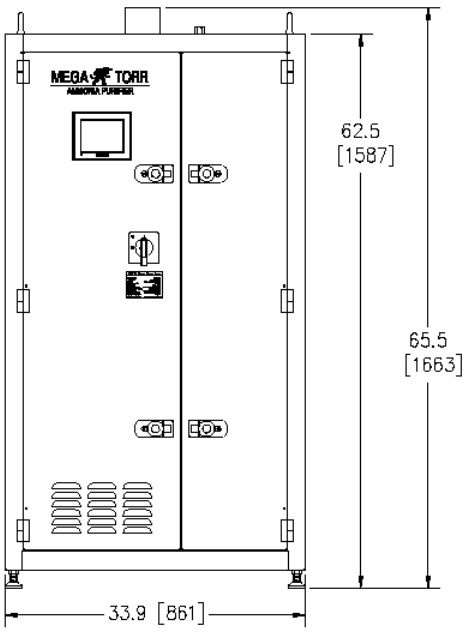


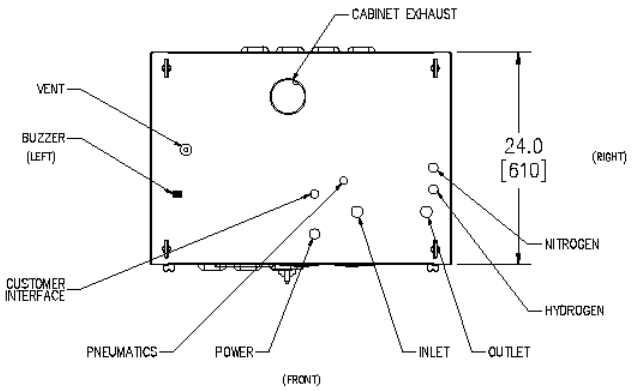
Facility Specifications

Purifier Model	PS21-MGS30-NH	PS21-MGS40-NH	PS21-MGS50-NH	PS21-MGS60-NH
Dimensions	Height: 1675 mm (~66 in) Width: 865 mm (~34 in) Depth: 610 mm (~24 in) Weight: < 350 Kg (< 770 lbs.)			
Purifier Clearance	1 meter (~3 feet) in front and back			
Mechanical Connections	Feed Inlet: ½" MVCR Purified Outlet: ½" MVCR Regeneration/Relief Vent: ½" MVCR H_2 Inlet: ¼" MVCR N_2 Inlet: ¼" MVCR Cabinet Vent: 4" duct Instrument Air Inlet: 3/8" FNPT			
Regeneration Vent Temp.	Ambient air + 30°C (+ 54°F)			
Purify Time	Programmable			
NH_3 Consumed Per Regen	0.55 m^3 (550 liters)	0.74 m^3 (740 liters)	0.92 m^3 (920 liters)	1.1 m^3 (1100 liters)
H_2 Consumed Per Regen	4.6 m^3 @ 10 slpm	6.0 m^3 @ 10 slpm	7.7 m^3 @ 10 slpm	9.2 m^3 @ 10 slpm
N_2 Consumed Per Regen	100 m^3 @ 70 slpm	120 m^3 @ 70 slpm	140 m^3 @ 70 slpm	160 m^3 @ 70 slpm
Main Power	208 or 230 VAC, 1 Phase, 50/60 Hz Installed Power: 2.4 kW Power Consumption during Purification: 0.1 kW Power Consumption during Regeneration: 1.2 kW			
Separate Control Power (Option)	110 or 230 VAC, 1 Phase, 50/60 Hz Power Consumption: 0.1 kW			
Cabinet Ventilation	260 Nm^3/hr (150 scfm) [@ Facilities Vacuum - 0.2 inches H_2O]			
Installation	Indoor, Ambient Temp (min – max) 5° – 35°C (41° – 95°F)			

Dimensions

PS21-MGS30-NH (30 Nm3/hr) through PS21-MGS60-NH (60 Nm3/hr)



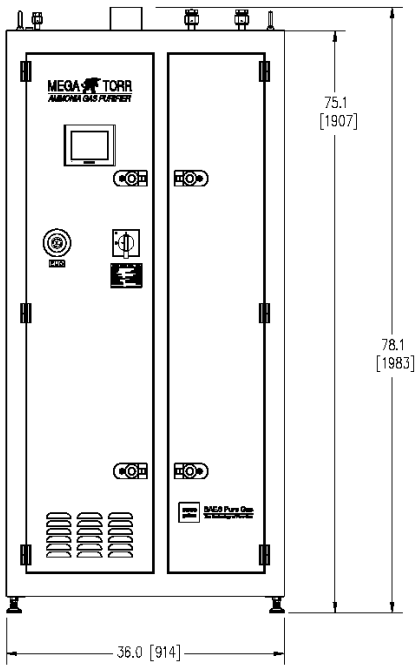


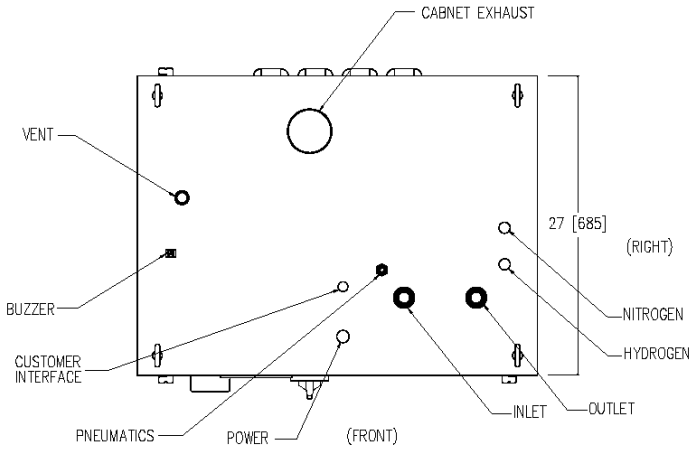
Facility Specifications

Purifier Model	PS21-MGS80-NH	PS21-MGS100-NH
Dimensions	Height: 1985 mm (~78 in) Width: 915 mm (~36 in) Depth: 700 mm (~28 in) Weight: < 450 Kg (< 990 lbs.)	
Purifier Clearance	1 meter (~3 feet) in front; 150 mm (~6 inches) left and right sides	
Mechanical Connections	Feed Inlet: 3/4" MVCR Purified Outlet: 3/4" MVCR Regeneration/Relief Vent: ½" MVCR H_2 Inlet: ¼" MVCR N_2 Inlet: ¼" MVCR Cabinet Vent: 4" duct Instrument Air Inlet: 3/8" FNPT	
Regeneration Vent Temp.	Ambient air + 30°C (+ 54°F)	
Purify Time	Programmable	
NH_3 Consumed Per Regen	1.6 m^3 (1600 liters)	1.8 m^3 (1800 liters)
H_2 Consumed Per Regen	14 m^3 @ 10 slpm	16 m^3 @ 10 slpm
N_2 Consumed Per Regen	200 m^3 @ 70 slpm	200 m^3 @ 70 slpm
Main Power	208 or 230 VAC, 1 Phase, 50/60 Hz Installed Power: 2.9 kW Power Consumption during Purification: 0.1 kW Power Consumption during Regeneration: 1.4 kW	
Separate Control Power (Option)	110 or 230 VAC, 1 Phase, 50/60 Hz Power Consumption: 0.1 kW	
Cabinet Ventilation	260 Nm^3/hr (150 scfm) [@ Facilities Vacuum - 0.2 inches H_2O]	
Installation	Indoor, Ambient Temp (min – max) 5° – 35°C (41° – 95°F)	

Dimensions

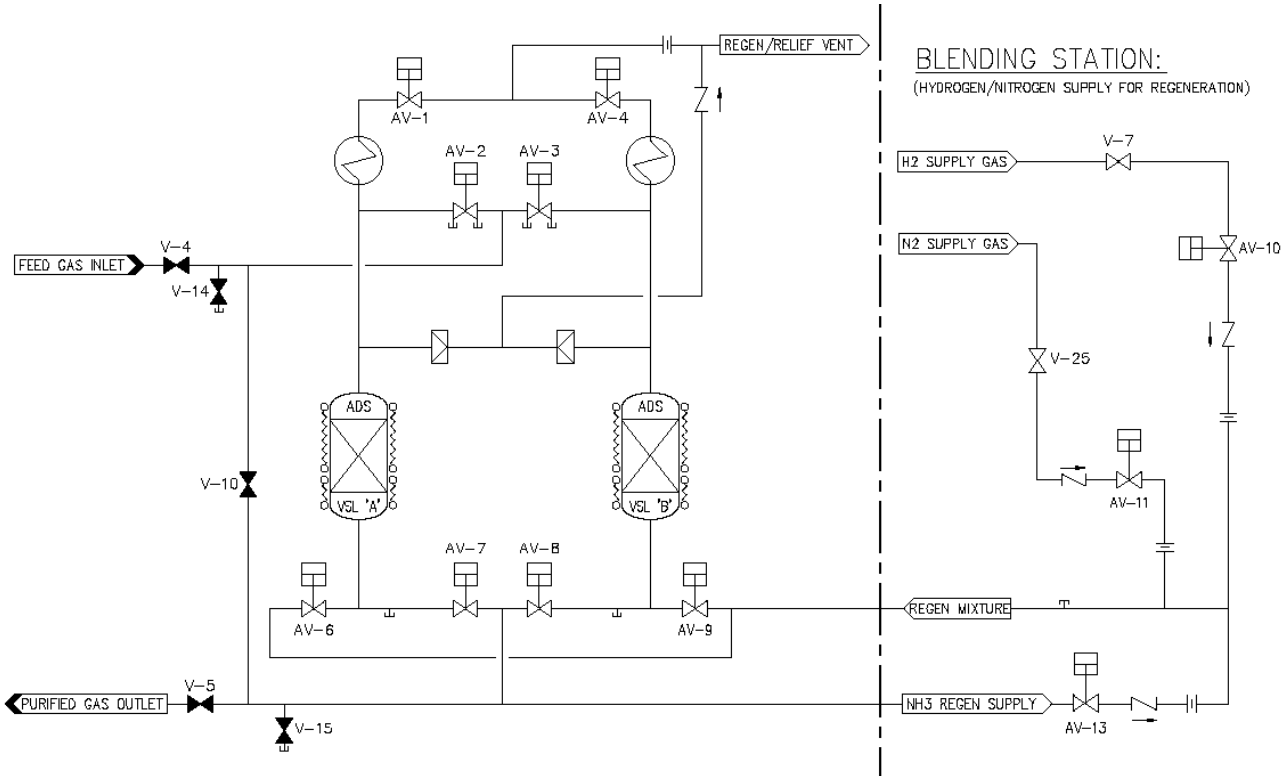
PS21-MGS80-NH (80 Nm3/hr) through PS21-MGS100-NH (100 Nm3/hr)





Piping Diagram

For all models



Contact Information

SAES Pure Gas
4175 Santa Fe Road
San Luis Obispo, CA, USA, 93401
Phone: +1 805 541 9299
Fax: +1 805 541 9399
E-mail: spg@saes-group.com
Website: www.saespuregas.com

Customer Service / Field Service Engineers
24 Hours, 7 days/week
Phone: + 1-805 781-2392 International
+ 1-800 934-3628 USA
Email: spg.fse@saes-group.com

SAES Pure Gas, Inc.
The Technology of Pure Gas
4175 Santa Fe Road, San Luis Obispo, CA 93401
Tel: 1 (805) 541-9299 | Fax: 1 (805) 541-9399

MICRO TORR® Specifications

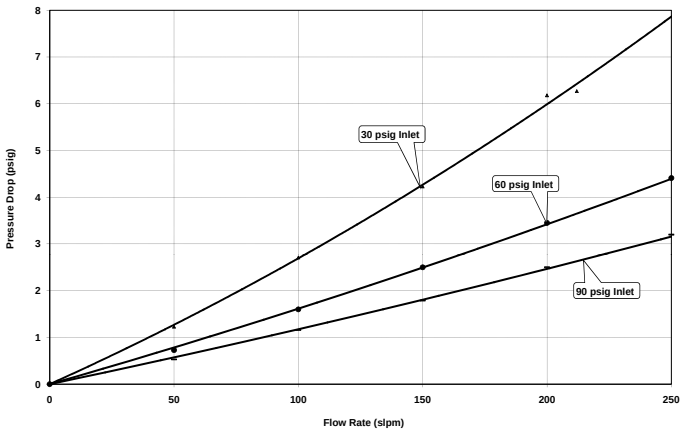
MC1500

MicroTorr purifiers are the most complete and reliable solution for Point-of-Use (POU) gas purification. Combining model size with a selection of gas-specific purification materials, MicroTorr purifiers can be tailored to many different customer applications, while maintaining impurity removal to Part-Per-Billion (ppbV) levels or better. Optional valves and a 0.003 micron particle filter are available as well as custom subsystem configurations.

Competitive Advantages and Benefits:

- **Reliability.** Uncompromised process consistency and yield improvement.
- **Performance.** State-of-the-art purification technology, low pressure drop, and long lifetimes.
- **Regenerability**. Most MicroTorr media are factory regenerable, minimizing potentially hazardous waste.
- **Quality.** 316L stainless steel, Helium leak checked, pressure tested, and analytical testing to Part-per-Trillion (pptv) levels.
- **Support.** Lifetime estimation and regeneration service available through SAES Pure Gas Sales Network.

Pressure Drop vs. Flow Rate
MC1500, 0.003 µm Particle Filter, tested in N2



Ordering Information

MC1500 - XXX XX

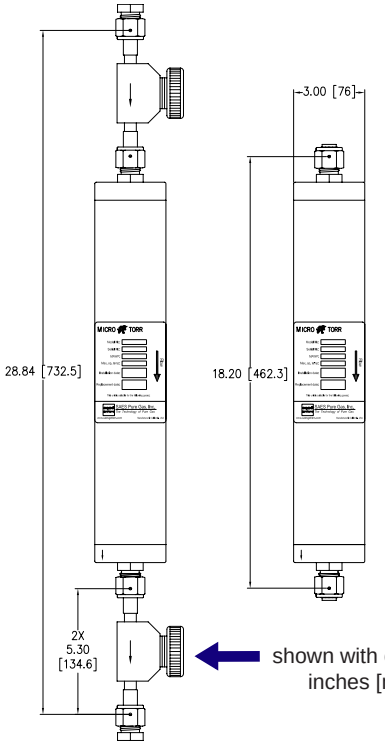
Model	Media	Options
MC1500	202, 203, 302, 403, 404, 502, 602, 702, 703, 804, 902, 904, 905, 906	No options F 0.003µm Particle Filter V Inlet/Outlet Valves FV Filter and Valves

Example: MC1500-902F
Model: MC1500 Media: 902 Options: 0.003µm Particle Filter

MC1500

- Lifetime
  Consult factory for specific lifetimes
- Maximum Flow: 250 slpm†
- Nominal Flow: 40 slpm†
- Maximum Pressure: 250 psig

† See reverse for Arsine & Phosphine flowrates



shown with optional valves
inches [millimeters]

Install Vertically with flow downward in direction of arrow. Consult factory for other mounting options.

SAES Pure Gas, Inc.
The Technology of Pure Gas
4175 Santa Fe Road, San Luis Obispo, CA 93401
Tel: 1 (805) 541-9299 | Fax: 1 (805) 541-9399

MICRO TORR® Specifications
MC1500

Mechanical Specifications

Model	MC1500-*F	MC1500-*FV
Maximum Flow	250 slpm†	250 slpm†
Nominal Flow	40 slpm†	40 slpm†
Material	Body-316L Stainless Steel	
Filter (Outlet)	Integrated 0.003 micron, metal	
Valves	N/A	1/2" manual
Max Operating Pressure	250 psig (17.3 barg) @ 40°C	
Max Temperature Rating	40°C (104°F)	40°C (104°F)
Inlet	1/2" MVCR	1/2" FVCR
Outlet	1/2" MVCR	1/2" FVCR
Length (Face to Face)	18.20"±.03 [462.3mm±0.8]	28.84"±.05 [732.5mm±1.3]
Outside Diameter	3.00" [76.2mm]	3.00" [76.2mm]
Electropolish	Yes	Yes
Leak Rating	$1x10^{-9}$ atm cc/sec of He	$1x10^{-9}$ atm cc/sec of He
Weight	8 lbs (3.6 kg)	12.7 lbs (5.8 kg)

*The 3 digit number found in the model number equates to the "Media" row in the table below.
†Flowrates with 502 media: Arsine/Phosphine max= 70.0 slpm, nominal= 40.0 slpm·

MC1500 Purification and Removal Capabilities

Media	Gases Purified	Impurities Removed	Outlet Performance	Regenerable	Dangerous Goods (DG) Classification
202	Ar, CDA, H_2, He, Kr, N_2, Ne, O_2, Xe, CO_2, N_2O, D_2, NO	H_2O	< 1 ppbV	YES	Non-DG
203	Ar, CDA, H_2, He, Kr, N_2, Ne, O_2, Xe, N_2O, D_2	H_2O, CO_2	< 100 pptV	YES	Non-DG
		Volatile Acids, Organics, Refractory Compounds*	< 1 pptV		
		Volatile Bases*	< 5 pptV		
302	B_2H_6, BCl_3, BF_3, $CClH_3$, Cl_2, CO_2, $GeCl_4$, GeH_4, H_2S, H_2Se, HBr, HCl, N_2O, NF_3, NO, $SiCl_4$, SiF_4, SiH_2Cl_2, $SiHCl_3$, SO_2, $CHClF_2$	H_2O, Metals	< 1 ppbV	NO	Non-DG
403	Ar, CDA, H_2, He, Kr, N_2, Ne, O_2, Xe, CO_2	Volatile Acids, Organics, Refractory Compounds*	< 1 pptV	NO	Non-DG
		Volatile Bases*	< 5 pptV		
404	Ar, CDA, H_2, He, Kr, N_2, Ne, O_2, Xe, CO_2, C_2H_2, C_3H_6, C_2H_4, NH_3	Organics*	< 1 ppbV	YES	Non-DG
502	PH_3, AsH_3	H_2O, O_2	< 1 ppbV	NO	Non-DG
602	CO	H_2O, O_2, CO_2, Acids, Bases, Organics, Refractories*	< 1 ppbV	NO	DG - UN3089 Class 4.1
702	NH_3, C_2H_7N, $C_2H_8N_2$, C_2H_4, C_3H_6, CH_3SiH_3, GeH_4, H_2-SiH_4 mix, SF_6	H_2O, O_2, CO_2, Metals	< 1 ppbV	YES	DG - UN3089 Class 4.1
703	NH_3	H_2O, O_2, CO_2, NMHCs, Metals*	< 1 ppbV	YES	DG - UN3089 Class 4.1
804	CO_2	H_2O, O_2, CO, H2	< 1 ppbV	YES	DG - UN2881 Class 4.2
		Volatile Acids, Refractories, Condensable Organics (>100amu), Volatile Base	< 5 pptV		
		Non-Condensable Organics (>45 amu)	< 100pptV		
902	Ar, He, Kr, N_2, Ne, Xe	H_2O, O_2, CO, CO_2, H_2	< 100 pptV	YES	DG - UN2881 Class 4.2
		Volatile Acids, Organics, Refractory Compounds*	< 1 pptV		
		Volatile Bases*	< 5 pptV		
904	H_2, H_2 -Inerts Mix, D_2	H_2O, O_2, CO, CO_2	< 100 pptV	YES	DG - UN2881 Class 4.2
		Volatile Acids, Organics, Refractory Compounds*	< 1 pptV		
		Volatile Bases*	< 5 pptV		
905	C_2F_6, C_2H_6, C_3F_8, C_3H_8, $C_2F_4H_2$, C_4F_8, C_4H_{10}, CCl_4, CF_4, CH_4, CHF_3, SF_6	H_2O, O_2, CO, CO_2, H_2 NMHCs*	< 1 ppbV	YES	DG - UN2881 Class 4.2
906	CDA, O_2, N_2O	H_2O, CO, CO_2, NMHCs*	< 1 ppbV	YES	Non-DG

*NMHCs = Organics (C>4); Volatile Acids are compounds including SO2, NOx, HCl, H2S, etc; Volatile Bases are basic compounds including NH3 and amines; Refractories are hydrocarbons with etheroatoms such as Si,

Other Sizes Available

Model Number	MC1	MC50	MC190	MC200	MC400	MC450	MC500	MC700	MC1500	MC2525	MC2550	MC3000	MC4500	MC9000
Maximum Flow (slpm)	5	10	50	50	60	75	100	120	250	300	500	500	1000	1000
Average Flow (slpm)	0.5	1.5	5	5	9	10	12	25	40	80	80	80	200	300

Piping Options Available: Dual Purifier Manifold, 3 Valve Bypass, 5 Valve Bypass

SAES Pure Gas, Inc.
The Technology of Pure Gas
4175 Santa Fe Road, San Luis Obispo, CA 93401
Tel: 1 (805) 541-9299 | Fax: 1 (805) 541-9399

MICRO TORR® Specifications

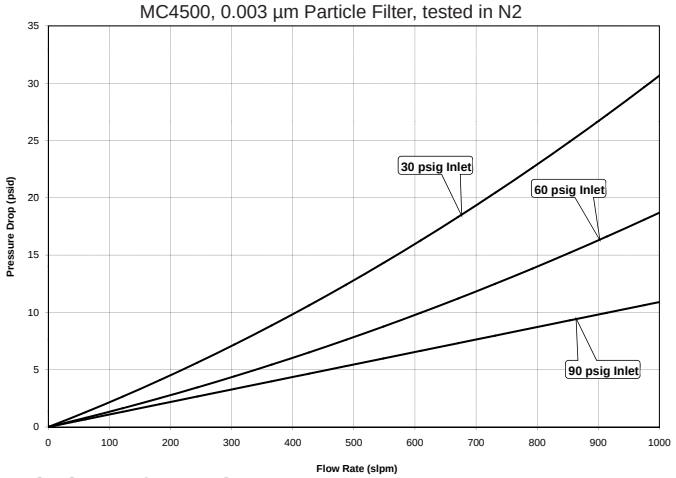
MC4500

MicroTorr purifiers are the most complete and reliable solution for Point-of-Use (POU) gas purification. Combining model size with a selection of gas-specific purification materials, MicroTorr purifiers can be tailored to many different customer applications, while maintaining impurity removal to Part-Per-Billion (ppbV) levels or better. Optional valves and a 0.003 micron particle filter are available as well as custom subsystem configurations.

Competitive Advantages and Benefits:

- **Reliability.** Uncompromised process consistency and yield improvement.
- **Performance.** State-of-the-art purification technology, low pressure drop, and long lifetimes.
- **Regenerability**. Most MicroTorr media are factory regenerable, minimizing potentially hazardous waste.
- **Quality.** 316L stainless steel, Helium leak checked, pressure tested, and analytical testing to Part-per-Trillion (pptv) levels.
- **Support.** Lifetime estimation and regeneration service available through SAES Pure Gas Sales Network.

Pressure Drop vs. Flow Rate
MC4500, 0.003 µm Particle Filter, tested in N2



Ordering Information

MC4500 - XXX XX

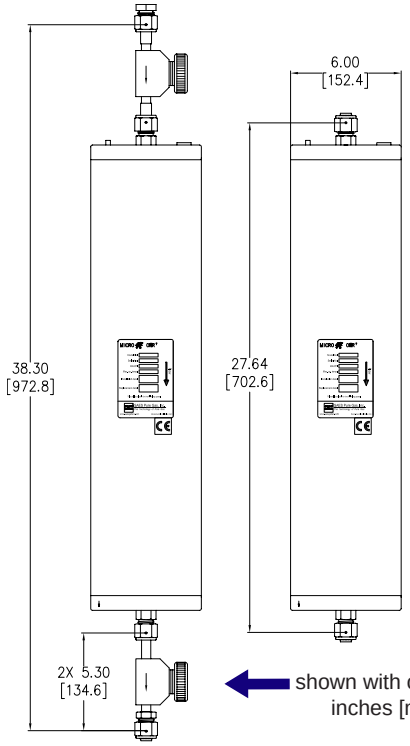
Model	Media	Options
MC4500	202, 203, 403, 404, 702, 703, 804, 902, 904, 905, 906	No options F 0.003µm Particle Filter V Inlet/Outlet Valves FV Filter and Valves HF 0.003µm Filter/High Flow HFV 0.003µm Filter/High Flow/With Valves

Example: MC4500-902F
Model: MC4500 Media: 902 Options: 0.003µm Particle Filter

MC4500

- Lifetime
  Consult factory for specific lifetimes
- Maximum Flow: 1000 slpm†
- Nominal Flow: 200 slpm†
- Maximum Pressure: 250 psig

†See reverse for Filtered Options



shown with optional valves
inches [millimeters]

Install Vertically with flow downward in direction of arrow. Consult factory for other mounting options.

SAES Pure Gas, Inc.
The Technology of Pure Gas
4175 Santa Fe Road, San Luis Obispo, CA 93401
Tel: 1 (805) 541-9299 | Fax: 1 (805) 541-9399

MICROTORR® Specifications
MC4500

Mechanical Specifications

Model ( )=Option	MC4500-*	MC4500-*V	MC4500-*HF	MC4500-*HFV
Maximum Flow	1000 slpm			
Nominal Flow	200 slpm			
Filter (Outlet)	2.0 micron outlet metal		Integrated "High Flow" 0.003 micron, metal	
Material	Body-316L Stainless Steel			
Valve (Option)	N/A	1/2" manual	N/A	1/2" manual
Max Operating Pressure	250 psig (17.3 barg) @ 40°C	250 psig (17.3 barg) @ 40°C	250 psig (17.3 barg) @ 40°C	250 psig (17.3 barg) @ 40°C
Max Temperature Rating	40°C (104°F)	40°C (104°F)	40°C (104°F)	40°C (104°F)
Inlet	1/2" MVCR	1/2" FVCR	1/2" MVCR	1/2" FVCR
Outlet	1/2" MVCR	1/2" MVCR	1/2" MVCR	1/2" MVCR
Length (Face to Face)	27.64"±.06 [702.6mm±1.5]	38.30"±.08 [972.8mm±2.0]	27.64"±.06 [702.6mm±1.5]	38.30"±.08 [972.8mm±2.0]
Outside Diameter	6.0" [152.4mm]	6.0" [152.4mm]	6.0" [152.4mm]	6.0" [152.4mm]
Electropolish	Yes	Yes	Yes	Yes
Leak Rating	$1x10^{-9}$ atm cc/sec of He	$1x10^{-9}$ atm cc/sec of He	$1x10^{-9}$ atm cc/sec of He	$1x10^{-9}$ atm cc/sec of He
Weight	43.1 lbs (19.5 kg)	48.7 lbs (22.1 kg)	43.1 lbs (19.5 kg)	48.7 lbs (22.1 kg)

*The 3 digit number found in the model number equates to the "Media" row in the table below.
†"HF" = High Flow Filter option.

Purification and Removal Capabilities

Media	Gases Purified	Impurities Removed	Outlet Performance	Regenerable	Dangerous Goods (DG) Classification
202	Ar, CDA, H_2, He, Kr, N_2, Ne, O_2, Xe, CO_2, N_2O, D_2, NO	H_2O	< 1 ppbV	YES	Non-DG
203	Ar, CDA, H_2, He, Kr, N_2, Ne, O_2, Xe, N_2O, D_2	H_2O, CO_2	< 100 pptV	YES	Non-DG
		Volatile Acids, Organics, Refractory Compounds*	< 1 pptV		
		Volatile Bases*	< 5 pptV		
403	Ar, CDA, H_2, He, Kr, N_2, Ne, O_2, Xe, CO_2	Volatile Acids, Organics, Refractory Compounds*	< 1 pptV	NO	Non-DG
		Volatile Bases*	< 5 pptV		
404	Ar, CDA, H_2, He, Kr, N_2, Ne, O_2, Xe, CO_2, C_2H_2, C_3H_6, C_2H_4, NH_3	Organics*	< 1 ppbV	YES	Non-DG
502	PH_3, AsH_3	H_2O, O_2	< 1 ppbV	NO	Non-DG
702	NH_3, C_2H_7N, $C_2H_8N_2$, C_2H_4, C_3H_6, CH_3SiH_3, GeH_4, H_2-SiH_4 mix, SF_6	H_2O, O_2, CO_2, Metals	< 1 ppbV	YES	DG - UN3089 Class 4.1
703	NH_3	H_2O, O_2, CO_2, NMHCs, Metals*	< 1 ppbV	YES	DG - UN3089 Class 4.1
804	CO_2	H_2O, O_2, CO, H2	< 1 ppbV	YES	DG - UN2881 Class 4.2
		Volatile Acids, Refractories, Condensable Organics (>100amu), Volatile Base	< 5 pptV		
		Non-Condensable Organics (>45 amu)	< 100pptV		
902	Ar, He, Kr, N_2, Ne, Xe	H_2O, O_2, CO, CO_2, H_2	< 100 pptV	YES	DG - UN2881 Class 4.2
		Volatile Acids, Organics, Refractory Compounds*	< 1 pptV		
		Volatile Bases*	< 5 pptV		
904	H_2, H_2 -Inerts Mix, D_2	H_2O, O_2, CO, CO_2	< 100 pptV	YES	DG - UN2881 Class 4.2
		Volatile Acids, Organics, Refractory Compounds*	< 1 pptV		
		Volatile Bases*	< 5 pptV		
905	C_2F_6, C_2H_6, C_3F_8, C_3H_8, $C_2F_4H_2$, C_4F_8, C_4H_{10}, CCl_4, CF_4, CH_4, CHF_3, SF_6	H_2O, O_2, CO, CO_2, H_2 NMHCs*	< 1 ppbV	YES	DG - UN2881 Class 4.2
906	CDA, O_2, N_2O	H_2O, CO, CO_2, NMHCs*	< 1 ppbV	YES	Non-DG

*NMHCs = Organics (C>4); Volatile Acids are compounds including SO2, NOx, HCl, H2S, etc; Volatile Bases are basic compounds including NH3 and amines; Refractories are hydrocarbons with etheroatoms such as Si,

Other Sizes Available

Model Number	MC1	MC50	MC190	MC200	MC400	MC450	MC500	MC700	MC1500	MC2525	MC2550	MC3000	MC4500	MC9000
Maximum Flow (slpm)	5	10	50	50	60	75	100	120	250	300	500	500	1000	1000
Average Flow (slpm)	0.5	1.5	5	5	9	10	12	25	40	80	80	80	200	300

Piping Options Available: Dual Purifier Manifold, 3 Valve Bypass, 5 Valve Bypass

HOGEN® H Series

Hydrogen Generation Systems

	H2m	H4m	H6m
DESCRIPTION			
	On-site hydrogen generator in an integrated, automated, site-ready enclosure. Load Following operation automatically adjusts output to match demand.		
ELECTROLYTE			
	Proton Exchange Membrane (PEM) - caustic-free		
HYDROGEN PRODUCTION			
Net Production Rate: Nm^3/hr @ 0°C, 1 bar SCF/hr @ 70°F, 1 atm SLPM @ 70°F, 1 atm kg per 24 hours	 2 Nm^3/hr 76 SCF/hr 35.8 SLPM 4.31 kg/24hr	 4 Nm^3/hr 152 SCF/hr 71.7 SLPM 8.63 kg/24hr	 6 Nm^3/hr 228 SCF/hr 107.6 SLPM 12.94 kg/24hr
Delivery Pressure - Nominal	15 barg (218 PSIG) / 30 barg option (435 PSIG)		
Power Consumed per Volume of H_2 Gas Produced	7.3 kWh/Nm^3 19.2 kWh/100ft^3	7.0 kWh/Nm^3 18.5 kWh/100ft^3	6.8 kWh/Nm^3 17.8 kWh/100ft^3
Purity (Concentration of Impurities)	99.9995% (Water Vapor < 5 PPM, -65°C (-85°F) Dewpoint, N_2 < 2ppm O_2 < 1 PPM, All Others Undetectable)		
Turndown Range	0 to 100% net product delivery (Automatic)		
Upgradeability	Field upgradeable to a maximum of 6 Nm^3/hr (228 SCF/hr)		N/A
DI WATER REQUIREMENT			
Rate at Max Consumption Rate	1.83 L/hr (0.50 gal/hr)	3.66 L/hr (0.96 gal/hr)	5.50 L/hr (1.42 gal/hr)
Temperature	5°C to 50°C (41°F to 122°F)		
Pressure	1.5 to 4 barg (21.8 to 58.0 PSIG)		
Input Water Quality	ASTM Type II Deionized Water required, < 1 micro Siemen/cm (>1 megOhm-cm) ASTM Type I Deionized Water preferred, < 0.1 micro Siemen/cm (>10 megOhm-cm)		

PROTON
THE LEADER IN ON SITE GAS GENERATION.

www.protononsite.com | T 203.949.8697 | F 203.949.8016 | Proton OnSite 10 Technology Drive Wallingford, CT 06492 | customerservice@protononsite.com

	H2m	H4m	H6m
HEAT LOAD AND COOLANT REQUIREMENT			
Cooling[1]	Liquid-Cooled; Anti-freeze, non-fouling; 5°C to 35°C (41°F to 95°F) *25°C cooling water maximum for ambient temperatures above 40°C		
Max. Heat Load (Cooling Requirement)	8.1 kW / 27,368 BTU/hr / (2.3 tons refrig)	16.1 kW / 54,936 BTU/hr / (4.6 tons refrig)	23.7 kW / 80,868 BTU/hr / (6.8 tons refrig)
ELECTRICAL SPECIFICATIONS			
Recommended Breaker Rating	22 kVA	40 kVA	58 kVA
Electrical Specification	380 to 480 VAC, 3 phase, 50 or 60 Hz		
INTERFACE CONNECTIONS *Consult Installation Manual for details*			
H_2 Product Port	1/4" Parker CPI™ compression tube fitting, SS		
H_2/H_2O Vent Port	1/2" FNPT, SS		
DI Water Port	1/4" FNPT, SS		
Calibration-Gas Port	1/8" FNPT, brass		
Coolant Supply Port	1" FNPT, brass		
Coolant Return Port	1" FNPT, brass		
Drain Port	3/8" FNPT, brass		
Electrical	Connect to on-board circuit breaker		
Communications	Ethernet		
CONTROL SYSTEMS			
Standard Features	Fully automated, push button start/stop. E-stop. On-board H_2 leak detection. Automatic fault detection and system depressurization		
Remote Alarm	Form C relay, 5A, 250V, 150W Max. rated switch		
Remote Shutdown	Safety circuit trip		
ENCLOSURE CHARACTERISTICS			
Dimensions, W x D x H (Product / Est. Shipping)	71" x 32 " x 75" (180 cm x 81 cm x 191 cm) / 81" x 41" x 85" (206 cm x 104 cm x 216 cm) Note: add 8 cm (3") to height for installed lifting brackets		
Weight (Product / Est. Shipping)	1500 lbs (682 kg) / 1776 lbs (807 kg)	1600 lbs (727 kg) / 1887 lbs (858 kg)	1700 lbs (773 kg) / 1998 lbs (908 kg)
Rating	IP66 for electronics compartment. IP43 for fluids compartment; Upgradeable to IP56.		
ENVIRONMENTAL CHARACTERISTICS *Do Not Freeze*			
Standard Siting Location	Indoor, level ± 1°, 0 to 90% RH non-condensing, Non-hazardous/non-classified environment		
Storage / Transport Temperature	5°C to 60°C (41°F to 140°F)		
Ambient Temperature Range	5°C to 50°C (41°F to 122°F)		
Altitude Range - Sea Level to:	2400 m (7874 ft)		
Ventilation	Proper ventilation must be provided from a non-hazardous area, at a rate in accordance with IEC60079-10, Zone 2 NE		
SAFETY AND REGULATORY CONFORMITY			
Maximum On-board H2 Inventory at Full Production	0.040 Nm^3 @ 15 barg; 0.08 Nm^3 @ 30 barg 1.5 SCF @ 15 barg; 2.9 SCF @ 30 barg 0.0036 kg @ 15 barg; 0.0069 kg @ 30 barg		
Cabinet Ventilation with Environment	NFPA 69 and EN 1127-1, Clause 6.2. Vent fan draws fresh air up to 28 Nm^3/min (1000 ft^3/min)		
Noise dB(A) at 1 Meter	<83		
Approvals	cTUVus (UL and CSA equivalent), CE (PED, ATEX, LVD, Mach. Dir., EMC), NYFD		
OPTIONS			
Proton Onsite offers a wide range of options to tailor your HOGEN hydrogen generation system to meet your specific operational requirements. Please contact your local representative to discuss the current list of options available to best fit your needs.			

[1]Consult Proton Onsite Applications Department for proper installation guidelines. Specifications subject to change.

PROTON ON SITE™

PD-0600-0062 Rev. D

Certified to ISO 9001:2008

Edwards Vacuum LLC
6400 Inducon Corporate Drive
SANBORN NY 14132

Date: Wednesday, July 01, 2015

QUOTATION REFERENCE
Quote No: 0020337009_3

Robert Farrell
University of Wisconsin-Madison
433 Babcock Drive
MADISON WI 53706

External Sales Contact:
Rep Vacuum One
SDIX@VACUUMONE.COM
Direct Dial: 773-244-3102

Internal Sales Contact:
Joel Tuck
JOEL.TUCK@EDWARDSVACUUM.COM
Direct Dial: 800-848-9800

RE:

All amounts quoted in currency USD

Item No.	Item Description	Qty	Unit List Price	Disc%	Unit Net	Total	Availability	L
100	A55321020	1.00	30,469.00		30,469.00	30,469.00	Out of Stock	

M150 S Leak

Important Notes:

1-It is important that the customer assure that the system is properly leak checked prior to operation.

2-It is important that the customer inform Edwards of the gas flows to the system in order to determine suitability.

3- Max flow of gas listed to the system NH3 - 20slm, H2 - 40 slm, Total flow - 60 slm.

4. GRC 'A' Cartridge requires a minimum of 15 slm of gas flow at all times during operation to prevent overheating. This may be achieved with vacuum pump purge.

5. Hydrogen will not be abated in 'A' Cartridge and must be properly handled and vented in the exhaust of the GRC.

6. NH3 is abated into N2 and H2. Therefore customer should be aware that the Ammonia content in the exhaust will be standard H2 flow, plus 1.5 times the NH3 flows when these materials flow together.

7. Cartridge life also depends on time factor. On the shelf can be as much as 6 years, but at temperature is only 9- months. We recommend customers change their cartridges at 9 month intervals even if capacity has not been reached.

8. Ammonia detectors should be installed on exhaust of GRC to determine if and when cartridge has been spent, however, customer should be aware that typical cartridges begin to show degradation of the catalyst used for abatement after 5 kg of metal organic have passed over the material.

200	A22304115	1.00	2,898.00		2,898.00	2,898.00	In Stock
	C150A Cartridge For Ammonia						
300	Y04210027	1.00	593.00		593.00	593.00	In Stock
	TPU/TCS Bypass Bellow Conn Kit						
400	A55107000	1.00	6,397.00		6,397.00	6,397.00	Out of Stock

Dual GRC Change Trolley

GRC Performance				
Process Flow (sccm)	**Chemical Symbol**	**Chemical Name**	**GRC max flow per gas (sccm)**	**DRE**
100	TMGa	TriMethylGallium	100	99%
100	TMA	TriMethylAluminium		99%
40000	H2	Hydrogen	400000	No Reaction
10000	NH3	Ammonia	20,000	99%
50,000	N2	Nitrogen (pump purge+ process)	60000	No Reaction

Total for goods ex works	40,357.00
Incoterms	FCA Free Carrier Factory, Collect
Total	**40,357.00**
Shipment Method	Normal Frght Ground

Longest Typical Lead Time for the items listed above is currently 8-9 Weeks. Current Availability and Typical Lead Time as shown in this quotation are subject to change and will be confirmed when your order is placed.

The quoted prices are valid until Wednesday, July 29, 2015 to ensure that we process your order exactly to the stated prices and terms please refer to our quotation number 0020337009 in any communication with us.

Payment terms have been quoted without final credit review and are based on the number of items indicated. Edwards reserves the right to revise the quoted payment terms prior to shipment should credit review indicate an increased level of credit risk or should the number of items ordered differ from the number quoted

CONDITIONS OF SALE

This quotation is subject to our standard conditions of sale attached.

Prices are exclusive of sales taxes

Payment Terms: Net 30 days

See your order history online, shop online and get our newsletters by registering at edwardsvacuum.com

Edwards Service Organisation

For any further information regarding Contracts, Field Service, Equipment Repairs and Technical Advice, please contact us on 1-800-848-9800

Joel Tuck
Customer Care Coordinator
Tel: 800-848-9800
Fax: 866-484-5218
JOEL.TUCK@EDWARDSVACUUM.COM

TERMS AND CONDITIONS OF SUPPLY OF GOODS AND SERVICES ("Conditions") – US VERSION

1. SCOPE
1.1 In these Conditions: "Supply" means any supply by Supplier to Buyer including the supply of Goods and/or Services; "Buyer" means the party buying Goods or procuring Services and shall include, if the context so permits, its agents or sub-contractors; "Supplier" means the Edwards Group Company named on the Purchase Order; "Purchase Order" means an order placed on Supplier by Buyer; "Product" means a product owned by Buyer to be the subject of a Service; "Purchase Price" means the price to be paid by Buyer to Supplier for the Goods and/or Services; "Goods" means products, consumable materials, equipment, equipment components, spare parts, software and other goods and materials supplied by Supplier to Buyer (including any exchanged products supplied by Supplier as part of providing Services); "Services" means any services supplied by Supplier to Buyer; and "Service Exchange" means the exchange of a product shipped by Buyer to
Seller with a new or refurbished Good of the same type.
1.2 These Conditions apply to and are deemed to be incorporated in all contracts for Goods and Services and, save where Supplier and Buyer have agreed to specific terms, shall apply to and prevail over all conditions endorsed on, delivered with or contained in Buyer's purchase terms, or any Purchase Order, or other documentation. No modification to these Conditions shall be valid unless in writing and duly signed by a person authorised by Supplier. All Purchase Orders are
subject to a $40 minimum order level and are subject also to acceptance by Supplier.
1.3 Once accepted the Purchase Order and these Conditions shall constitute the contract ("Contract") between Buyer and Supplier for the Supply and shall constitute the entire agreement between the Buyer and Supplier in relation to the
Supply.
2. PRICE QUOTATIONS
2.1 Prices quoted for (a) standard Goods and Services remain valid for 30 days unless otherwise specified; and (b) non-standard Goods and Services are estimates and may be increased without notice in the event of increases in Supplier's costs of: (i) transport, labor and materials; (ii) handling of, and compliance with laws and regulations concerning hazardous materials; (iii) handling, delivery and shipping; (iv) energy or fuel; and/or (v) any other costs of supply or of Supplier's performance arising between the time of quotation and the time of Supply.
2.2 Prices quoted are exclusive of all applicable taxes, including but not limited to, any value added tax, Federal, state and/or municipal excise, sales and/or use taxes, levies and duties of any nature whatsoever ("Taxes") applicable to the Goods and Services. All Taxes shall be paid by Buyer unless Buyer provides Supplier with an exemption certificate
acceptable to the relevant taxing authority.
3. INSPECTION AND TESTING

3.1 All Goods are inspected by Supplier before supply to Buyer and tested where appropriate.
3.2 An additional charge will be made for tests or trial runs carried out at Buyer's request. In the event that Buyer does not attend such tests after 14 days' notice Supplier will perform the tests and the Goods will be deemed accepted
in Buyer's absence.
4. SUPPLY AND TRANSPORT
4.1 Supplier will use reasonable efforts to supply Goods and Services within the time requested in the Purchase Orderand in any event within a reasonable period.
4.2 Unless otherwise agreed in writing all shipments shall be made FCA (Incoterms 2010) Supplier's production and/or distribution facilities and/or repair centers. Unless other delivery arrangements are agreed, Supplier may, at Buyer's request and expense, arrange carriage and insure Goods against normal transit risks to the value of the Purchase Price. Risk of damage to or loss of Goods shall pass to Buyer on Supplier's delivery of the Goods to the carrier. Should Buyer carry out the transport of the Goods Buyer shall have in place all adequate transit insurance with insurers of good reputation to the value of the Purchase Price, and Buyer shall ensure that Supplier is noted as additional insured on this insurance Risk of damage to or loss of Goods shall pass to Buyer in accordance with the agreed terms and Buyer
shall indemnify Supplier against all loss of, or damage to, Goods.
4.3 Buyer shall take delivery of the Goods in accordance with the delivery date specified in the Contract or at the latest 5 days from Supplier's notification that the Goods are ready for delivery, whichever is the latest (the "Delivery Date") Buyer will supply Supplier with delivery instructions promptly on notification to Buyer that Goods are ready for shipment. 4.4 Buyer's obligation to take delivery of the Goods as provided in this Contract constitutes a material
obligation of Buyer.
4.5 Where the Goods to be supplied are new, Buyer may request a deferral of the Delivery Date provided this request is in writing and made at the latest 6 weeks prior to the due date of shipment. Edwards may accept or refuse, at its sole discretion, a request for deferral. Notwithstanding any other remedies available under these Conditions should deferral of delivery be for a period longer than 14 days from the Delivery Date, Supplier shall be entitled to charge Buyer compensation amounting to at least 2% of the Purchase Price per month of delay, to be paid by Buyer within 30 days of issuance of the corresponding invoice. Deferral of the Delivery Date shall not in any case be for longer than 3 months from the initial Delivery Date. Without prejudice to Condition 12 at the expiry of the 3 month period Supplier shall be entitled to make arrangements for storage of the Goods at a place of its choice. In such case, Supplier's obligation to deliver the Goods will be deemed satisfied and Buyer will be responsible for the risk of loss of, or damage to, the
Goods, and for paying the Purchase Price.
4.6 Where the Goods to be supplied are not new, or where Supplier is to return a Product after it is serviced, Buyer will supply Supplier with delivery instructions promptly on notification to Buyer that the Good or Product is ready for shipment. Should shipment or collection be postponed for more than 14 days after such notification, (i) Supplier shall be entitled to make arrangements for storage of the Good or Product at Buyer's risk and expense at a place of its choice, (ii) to charge Buyer a compensation at the rate of 2% of the Price per 14-day period or part thereof from the date of such notification and Buyer shall pay such amount within 30 days of invoice, and (iii) Supplier' obligation to deliver the Good or Product will be deemed satisfied and Buyer will become responsible for the risk of loss of or damage
to the Good or Product and for paying the Purchase Price.
4.7 In the case of Service Exchange Buyer must ship at its costs the product to be exchanged to Supplier within thirty (30) days of the date of the relevant Purchase Order. Should Buyer not comply with this obligation (i) Supplier may charge a non-return compensation which shall be calculated at the rate of two per cent (2%) of the Purchase Price for each 14 day-period during which Supplier has not received the product to be returned, with the non-return compensation being payable within thirty (30) days of the date of invoice by Supplier and (ii) should delay in returning the product exceed 3 months from the date of the relevant Purchase Order, Supplier shall be entitled to terminate the Purchase Order or that part of the Purchase Order related to the service exchange and Buyer shall pay the price which would be due against the supply of a new Good of equivalent specification, less any amount already paid towards the Service Exchange.
Buyer shall pay within 30 days of the date of invoice.
4.8 The parties agree that compensation and other expenses payable under the Conditions above are a genuine pre-estimate of the costs and losses which Supplier would suffer from Buyer not taking delivery of the Goods and/or for non-return of
a Service Exchange product on the Delivery Date.
4.9 In cases where a Product is received by Supplier in respect of which no Purchase Order, or other written authority, is given to Supplier to carry out Services within 60 days of receipt by Supplier, Supplier may, at its option, either return the Product to Buyer or dispose of the Product as Supplier thinks fit and Supplier may charge Buyer for, and
Buyer agrees to pay, all storage, return and/or disposal costs.
4.10 Buyer shall ensure and warrant that it shall comply with any applicable export or import laws, regulations or guidance and that it shall not import, export or re-export, directly or indirectly, the Goods, or other item related to the Goods, in or to (1) any country subject to an embargo under the laws of any country or under any international laws, including, but not limited to, Cuba, Iran, North Korea, Sudan and Syria and/or (2) any country for which an import or export/re-export licence or approval or certificate is required, without obtaining such licence or approval or certificate prior to importing or (re)exporting. Buyer shall attach to all Purchase Orders the necessary information to permit Supplier to commence its work, together with any import licence and/or permits or certificates, which may be necessary. Supplier shall not be liable for delay in delivery or non-delivery of the Goods or any associated item due to (1) any restriction on the import or export of the Goods or any associated items or (2) non-compliance by Buyer with this clause or with the law, or (3) delay or refusal of export or import licence or approval by any relevant authority. Supplier may request, and if so Buyer shall provide, in advance and as a condition of delivery, a signed statement providing information related to the use of the Goods and any associated items and/or the full identity of the end-user or any intermediary in the transaction. Notwithstanding any other provision of the Contract Supplier shall be entitled to terminate the Contract with immediate effect and without liability if it has reasonable grounds to suspect that Buyer has breached or intends to breach this clause.
4.11 Goods will be supplied and paid for as available unless Buyer specifically requests "one consignment". Each shipment shall be considered a separate and independent transaction. Supplier may suspend shipment of any unfulfilled Contract between the parties in the event of any act or omission on the part of Buyer or if Buyer is in material breach
of Buyer's obligations under a Contract, whether separate or not.
4.12 All Goods and Services supplied in accordance with the Contract will be deemed accepted unless Buyer promptly notifies Supplier in writing that the Goods or Services are not in compliance with the Contract. Any damaged Goods and
packaging must be kept for inspection by Supplier.
4.13 Supplier may modify the specification of Goods without notice provided that the modification does not materially
affect the performance, form or fit of the affected Goods.
4.14 Services, installation and commissioning are not included in the purchase price for the Goods.
4.15 Buyer shall be responsible for de-installing, de-commissioning and shipment of any Product. Supplier shall notify
Buyer following discovery of any such Product as unsuitable for the performance of Services
5. PAYMENT
5.1 All amounts are stated and payments are to be made in US Dollars unless otherwise agreed in writing. If Buyer specifies a different currency, Supplier reserves the right to amend the quoted price by any amount to cover movements in the exchange rate between the relevant currency and US Dollars arising between the time of quotation and acceptance of the Purchase Order. Unless purchased via Supplier's website (www.edwardsvacuum.com), orders paid by credit card are
subject to a $25.00 minimum.
5.2 Full payment without any deduction whatsoever must be made to Supplier within 30 days of the date of invoice unless otherwise agreed in writing. Invoices will normally be issued on the date of delivery of the Goods (or the date of deemed delivery) or completion of the Services. Any invoice disputes must be raised by Buyer within 15 days from date of
invoice, or the invoice shall be considered to be accepted by Buyer. Time for payment shall be of the essence.
5.3 All Purchase Orders are subject to credit approval before shipment. If, in Supplier's judgment, Buyer's financial condition does not at any time justify payment terms as previously specified, Supplier may cancel or suspend any unfulfilled Contract. Supplier may require Buyer to furnish Supplier with a confirmed irrevocable letter of credit drawn
on a bank acceptable to Supplier.
5.4 If any payment is overdue Supplier shall be entitled, without prejudice to any other right or remedy, to suspend all further deliveries to Buyer without notice and/or to charge interest on any amount overdue at the applicable statutory
default interest rate, or if none, at the rate of 8% per annum over the JP Morgan Bank N.A. base rate.
5.5 Any sum due by Buyer may be offset by Supplier against any sums due by Supplier to Buyer under any Contract
6. RETENTION OF TITLE 6.1 Subject to clause 6.2 Goods shall remain Supplier's property until Buyer has made full and unconditional payment to
Supplier of all sums due to it in respect of the Goods
6.2 Title to Product remains with Buyer unless it becomes the subject of Service Exchange in which case title passes to
Supplier upon receipt of the Product at the Service Centre.
6.3 Any consignment stock, inventory or materials held at Buyer's site and owned by Buyer for the use of Supplier in
carrying out the Services shall be at the risk of the Buyer
6.4 Until payment in full by Buyer, Goods shall be held by Buyer as bailee for Supplier and will be kept, unaltered and in good condition (at no cost to Supplier) separately from all other goods of Buyer or any third party in such a way
that they remain readily identifiable as Supplier's property.
6.5 If payment becomes overdue, or on the occurrence of any termination event referred to in Condition 12 below, Supplier may, where permitted by law, and after giving notice to Buyer, enter upon any premises where Supplier
reasonably believes Goods to be, or otherwise take action, to recover Goods.
6.6 From delivery and prior to full payment of the Purchase Price, Buyer shall maintain the Goods in satisfactory condition and keep them insured under adequate insurance policies with insurers of good reputation, covering the
Purchase Price.
7. INTELLECTUAL PROPERTY AND CONFIDENTIALITY
7.1 Supplier shall retain all right, title and interest in and to, and possession of, any know-how, technical information, drawings, specifications or documents, ideas, concepts, methods, processes, techniques and inventions developed or created by or on behalf of Supplier and supplied by Supplier under any Contract. All such information shall be kept confidential by Buyer and shall not be disclosed to any third party unless and until the same is or becomes public knowledge nor shall any such information be used by Buyer for any purpose other than for the purpose of using any
Goods supplied under the Contract without Supplier's prior written consent.
7.2 Ownership is retained by Supplier of any patent, copyright, trade secret, design right or other intellectual property right in or relating to the Supply and Buyer shall acquire no rights in or over such intellectual property rights save as expressly set out herein including, but not limited to, any technical information, know-how, drawings and
specifications supplied by Supplier or relating to the Supply.
7.3 Supplier's trademarks and names and those of its associated companies shall not be used by Buyer otherwise than as
aprited by Supplier to Goods, Services or associated documentation.
8. WARRANTY
8.1 In respect of supply of Goods comprising equipment and related components, spares and parts:
A. Supplier hereby undertakes to repair or replace at Supplier's option, or to arrange repair or replacement by Supplier's representative of, any Goods supplied to Buyer if a defect in materials or workmanship arises under conditions of normal and proper use and maintenance (fair wear and tear, and consumables excepted) provided that (i) the Goods were purchased and used for a purpose for which they were suitable; (ii) were operated and maintained in accordance with the operating instructions; (iii) unless otherwise agreed by Supplier, in writing, the defect occurs
within 12 months from the date of shipment of the Goods; and (iv) Condition 8.3 is satisfied.
B. Any repaired or replaced Goods (including Goods the subject of service exchange) will continue to be warranted for
the unexpired period of the warranty referred to in Condition 8.1 A above.
C. Supplier may charge Buyer for the cost of shipping Goods to and from a Supplier service centere if the Goods to be
repaired or replaced are located in a country in which Supplier does not have a service center.
D. The warranty under this clause does not cover the costs of installation or removal of the Goods to be repaired or
replaced which shall be at Buyer's cost.
8.2 In respect of supply of Services:
A.Supplier warrants that Services shall be performed in a workmanlike manner using reasonable skill and care and in accordance with Supplier's service policy and practice. Unless otherwise agreed in advance, Supplier shall provide such Services, including repair and replacement, as are in Supplier's reasonable opinion necessary in order to provide the
Service.
B. If subsequent to the performance of Services failure or breakdown (fair wear and tear and consumables excepted) occurs: (a) during the warranty period notified to Buyer at the time the Services are performed (or if no such period is notified to Buyer, and unless otherwise agreed, within 90 days of the date that the Services are completed); (b) during normal usage; and (c) shown by Buyer to Supplier's reasonable satisfaction (after a reasonable opportunity for Supplier to inspect the allegedly defective Services and to review documentation pertinent to the failure or breakdown) to have been caused by Supplier's failure to perform the Services in accordance with this Condition: Supplier, at its option, shall correct or re-perform the Service or replace the serviced product or refund the cost of the Services; provided that: (i) the failure or breakdown was not caused, or contributed to, by Buyer's act or omission, breach of contract, negligence, process reactions, excessive process build ups or accidents or by Buyer's failure to observe Supplier's recommended maintenance schedules and activities; and (ii) Condition 8.3 is satisfied.. For the avoidance of doubt any components of a Product not replaced in the course of the Product being serviced will not be covered by the Service
warranty on the Product.
C. Buyer is responsible for shipping Products to the designated Supplier service center at Buyer's risk and cost. Supplier may charge Buyer for the cost of shipping Product from a Supplier service center back to Buyer if the Product is located in a country in which Supplier does not have a service center. If Buyer requires a more expensive method of
freight than Supplier's standard shipping then the extra cost shall be paid by the Buyer.
D.The Warranty under this Condition does not cover the costs of installation or removal of the Product which shall be at
Buyer's cost.
E. Except as expressly warranted above, Services are provided "as is" and Buyer assumes the entire risk as to the results of the Services. Nothing stated in these Conditions implies that the operation of any serviced Product will be uninterrupted or error-free or that errors will be corrected. Other written or oral statements by Supplier, its
representatives, or others do not constitute warranties of Supplier.
8.3 The following provisions must be satisfied in respect of all claims under Conditions 8.1 and 8.2: a) the claim must first be notified promptly in writing to Supplier; b) the Goods or any Product must not have been repaired or modified by anyone other than Supplier or at Supplier's direction; c) in the case of equipment and related components, spares and parts not of Supplier's own manufacture, unless otherwise required by law, Supplier's responsibility shall be limited to passing on to Buyer the benefit of any guarantee or warranty given to Supplier by the manufacturer of such Goods or part; d) in the case of a replacement, Buyer returns at its cost the defective Goods to Supplier within 10 days of delivery of the replacement Goods by Supplier; e) the defect does not arise from Buyer's specification or instructions;
and g) Buyer has paid the purchase price in full or paid in accordance with agreed payment schedule.
8.4 Supplier may satisfy Supplier's liability under this Condition 8 by reducing the Purchase Price or refunding the
Purchase Price and retaking the Goods or issuing a credit note.
8.5 EXCEPT AS EXPRESSLY WARRANTED ABOVE, GOODS AND SERVICES ARE PROVIDED WITHOUT OTHER REPRESENTATIONS, WARRANTIES OR CONDITIONS OF ANY KIND, INCLUDING IMPLIED WARRANTIES AND CONDITIONS OF MERCHANTABILITY, FITNESS FOR A PARTICULAR
PURPOSE, TITLE OR NON-INFRINGEMENT OF THIRD PARTY'S RIGHTS.
9. LIABILITY AND INDEMNIFICATION
9.1 Subject to Condition 8, the following provisions set out the entire liability of Supplier (including any liability for the acts or omissions of its employees, agents, or subcontractors) to Buyer in respect of: a) any breach of these Conditions; or (b) any representation, statement or tortious act or omission, including negligence, arising under or in
connection with these Conditions.
9.2 Nothing in these Conditions excludes or limits the liability of Supplier for: (a) death or personal injury caused by Supplier's negligence or (b) fraud or fraudulent misrepresentation or (c) any other liability that cannot be excluded or
limited by law.
9.3 Subject to Condition 9.4 Supplier shall be liable for physical damage to property to the extent that it results from breach of Contract or Supplier's negligence in connection with the performance of the Contract, subject to an overall
limit of the amount received by Supplier from Buyer under the Contract.
9.4 Supplier shall not be liable to Buyer for pure economic loss, loss of profit, loss of business, depletion of good will, loss of anticipated savings, injury to reputation, loss of revenue, interruption of production, any damages claimed by Buyer by third parties, or otherwise, in each case whether direct, indirect or consequential, or any claims
for consequential compensation whatsoever (howsoever caused) which arise out of or in connection with the Contract.
9.5 If Buyer fails to perform any of its obligations pursuant to these Conditions, Buyer shall pay Supplier all costs and expenses incurred by Supplier, including all attorney's fees, in enforcing Supplier's rights relating to such
obligation, whether by formal proceedings or otherwise, in addition to any other remedy available to Supplier.
9.6 For the avoidance of a doubt save as provided in this clause Supplier shall have no liability in contract, tort, misrepresentation, restitution, or otherwise arising as a result of the performance or contemplated performance of the
Contract.
9.7 Buyer will indemnify and keep indemnified Supplier from and against any costs, claims, demands, liabilities, damages or losses and all interest, penalties and legal and other professional costs and expenses arising out of or in connection with Buyer's use of Goods or Buyer supplying Goods to any party who is not a party to these Conditions and the Goods' subsequent use. This indemnity shall cover (but is not limited to) Supplier's liability to third parties
arising out of the use or sale of the Goods, except to the extent caused by Supplier's negligence.
10. FORCE MAJEURE
10.1 Neither Buyer nor Supplier shall be liable for failures in performance, including delay or non-shipment, resulting
from acts or events beyond its reasonable control.
10.2 In the event of such delay, the date of shipment or performance shall, at the request of Supplier, be deferred for
a period equal to the time lost by reason of the delay and otherwise for a reasonable time.
11. CANCELLATION
11.1 Buyer may request a cancellation of the Contract to the extent it relates to the sale of Goods, provided such request is done in writing and at the latest six (6) weeks prior to the due date of shipment. Edwards may accept or refuse, at its sole discretion, a request for cancellation. Without prejudice to any other rights Supplier may have, upon cancellation Buyer shall pay Supplier a compensation equivalent to 15% of the Purchase Price for standard Goods and
30% of the Purchase Price for non-standard Goods within thirty (30) days from issuance of the corresponding invoice.
11.2 Unless agreed otherwise in writing by Supplier, should Buyer cancel any Contract to the extent it relates to the sale of Services, Buyer shall pay to Supplier the costs of all work done and materials purchased or provided in connection with the Services up to the time of cancellation, plus a compensation for all costs and losses equivalent to
15% of the Purchase Price
11.3 The parties agree that such sums payable to Supplier under this clause are a genuine pre-estimate of the costs and
losses which Supplier would suffer from Buyer cancelling all or part of the Contract
12. TERMINATION
12.1 If Buyer is subject to any act of bankruptcy or, being a company, has a receiver appointed or an administration order made against it or goes into liquidation or if a similar event occurs under applicable insolvency laws (except for the purpose of reconstruction or amalgamation) then all sums due to Supplier under the Contract shall immediately become due and payable and Supplier may, notwithstanding any previous waiver, terminate the Contract forthwith by written
notice.
12.2 Supplier may terminate the Contract with immediate effect in the event of a failure by Buyer to comply with any material provision of these Conditions if the failure continues for more than 14 days after Buyer has been given written
notice of such failure.
12.3 If Buyer fails to collect or take delivery of the Goods within 3 months of the Delivery Date, Supplier shall be entitled, without prejudice to its other rights, to terminate all or part of the Contract and to dispose of the Goods, and to charge Buyer a compensation of 15% of the Purchase Price (Standard Goods) or 30% of the Purchase Price (Non-Standard Goods), to be paid by Buyer within 30 days of issuance of the corresponding invoice. The parties agree that such sums payable to Supplier under this clause are a genuine pre-estimate of the costs and losses which Supplier would
suffer from Buyer not taking delivery of the Goods.
12.4 Termination shall be without prejudice to any prior right of either party or any provisions (including but not
limited to clauses 6, 7 and 9) which by nature shall survive termination
13. BUYER'S DUTIES AND RESPONSIBILITIES WHEN SERVICES ARE PROVIDED
13.1 All Products and environments (whether at Supplier' or Buyer's or Buyer's customer's premises) must be free from risks to health and safety (save to the extent notified to, and specifically accepted by, Supplier in writing). Supplier may decline, without incurring any liability, to service any Product, or work in any environment in which, in Supplier's
opinion, the risks to health and safety are not managed satisfactorily by Buyer.
13.2 Buyer will permit Supplier prior to commencement of any Services to assess the condition of the Products and the working environment. Supplier shall be under no obligation to service any Product which, in Supplier's reasonable opinion, has been used in a way or for a purpose for which it was not suitable, has not been operated and maintained in accordance with the manufacturer's operating instructions, is too old or in too poor a condition to be serviced
economically or is in any way unsafe.
Supplier shall have the right and Buyer shall provide all necessary access and cooperation to enable Supplier to carry
out a risk assessment.
13.3 Buyer will provide Supplier with all available operating documentation, drawings, test certificates and maintenance
inspection reports relating to any Product.
13.4 Buyer will indemnify and hold Supplier harmless against any loss, claim or damage suffered by Supplier or its employees, agents or sub-contractors suffered on the Buyer's site or Buyer's customer's site except to the extent caused
by Supplier's own negligence.
14. MISCELLANEOUS
14.1 Buyer may neither assign nor transfer nor deal in any other manner with any or all of its rights or obligations
under the Contract without the prior written consent of Supplier.
14.2 Save as expressly provided, no term or provision of these Conditions shall be enforceable by a third party (being
any person other than the parties and their permitted successors and assignees).
14.3 No waiver by either party of any breach of any of these Conditions by the other party shall be deemed to constitute a waiver of any other breach nor shall any delay or omission on the part of either party to exercise or avail itself of any right or remedy hereunder operate as a waiver thereof. A waiver given by a party hereunder shall be binding upon such party only if in writing and signed by such party. In the event that any term or provision of the Contract is declared null and void or unenforceable by any court of competent jurisdiction, the remainder of the provisions of these
Conditions shall remain in full force and effect to the fullest extent permitted by applicable law.
14.4 Nothing contained in these Conditions shall be deemed to require Supplier to take any action that would constitute, directly or indirectly, a violation of any laws of any applicable jurisdiction, and Supplier's failure to
take any such action shall not be deemed a breach hereunder.
14.5 All drawings, descriptive matter, technical specifications, capacities, performance rates, descriptions and other particulars given in respect of Goods (whether in catalogues or advertisements or accompanying or referred to in the Contract) are stated by Supplier in good faith based on Supplier's experience as being correct within acceptable tolerances but are not binding in detail and do not form part of the Contract unless specifically stated to do so. Unless agreed otherwise in writing, it is Buyer's responsibility to ensure that Goods are sufficient and suitable for
Buyer's purposes.
14.6 Buyer hereby acknowledges that relevant safety and training literature relating to the Goods and Services will be supplied by Supplier to Buyer free of charge and may be photocopied by Buyer as required. Buyer shall be fully responsible for the implementation of the contents of all safety and training literature provided by Supplier. Buyer shall ensure persons who use, maintain or otherwise handle Goods or receive Services receive adequate safety and
training literature.
14.7 Buyer shall comply at all times with Supplier's code of conduct which can be found at www.edwardsvacuum.com/corporate and with all applicable laws, statutes and regulations relating to anti-bribery and anti-corruption including but not limited to the UK Bribery Act 2010 and the US Foreign Corrupt Practices Act as amended from time to time (the "Requirements"), and Buyer shall have in place and shall maintain at all times its own policies and procedures to ensure compliance with the Requirements by Buyer's employees, officers, representatives, subcontractors and customers and shall enforce them where appropriate. Supplier shall be entitled to terminate the Contract immediately upon written notice to Buyer if Buyer or any person employed by it or acting on its behalf commits or may be deemed or is suspected to have committed or intends to commit a breach of the Requirements. If Buyer suspects or knows that there is any breach or intended breach of the Requirements by Buyer or any person employed by it or acting on its behalf, Buyer will notify
Supplier immediately.
15. GOVERNING LAW AND DISPUTE RESOLUTION
15.1 The Contract and any claim arising out of or in connection with it shall be governed by and construed in accordance
with the laws of the State of Delaware.
15.2 Buyer and Supplier agree that the State and Federal courts residing in the State of Delaware shall have the
exclusive jurisdiction to settle any disputes, which may arise in connection with the Contract.
15.3 Supplier shall have the option to bring suit before the Courts of the domicile of Buyer when the claim is for or
related to payments due from Buyer.

US Standard Terms and Conditions of Sale Rev August 15, 2013

POU Abatement Bid Specifications for abatement of materials from MOCVD tool

Preferred Vendor and Product:

July 2, 2015
System: Edwards Vacuum LLC
M150 GRC System with (C150A) cartridge, exchange trolley, and an NW40 installation kit.

General Requirements

The following specification outlines a point of use abatement device that is required by X. The unit should allow for abatement of high flows of ammonia and abate metal organic materials as described in the process recipes. Ammonia (NH3) will have flows of up to 20 slm, and the following other low flow deposition materials may be flowed simultaneoulsly including Trimethyl Galium ($Ga(CH_3)_3$) Trimethyl Indium ($In(CH_3)_3$) and Trimethyl Aluminium ($Al(CH_3)_3$). During deposition, flows of Hydrogen (H2) at rates as high as 30 slm will also be used. The unit shall be capable of either eliminating the H2 gas through conversion to H2O vapour, or by passing the H2 gas safely through the system without abatement or treatment or contamination by oxygen from air. Materials will be delivered to the device as an exhaust from a pumping system which is purged at approximately 20 slm of N2, so the total flow to the abatement device will have a minimum total flow of 20 slm, and maximum total flow at approximately 70 slm.

The preferred method of treatment shall be via electrically heated, hot bed reaction of these materials. The hot bed reactor shall include a catalyst type, as well as other reaction materials specifically designed to meet the flows and materials listed . Wet scrubbing technologies by themselves, are not acceptable since the formation of Ammonium ions (NH4+) in the waste water, results in too high of dissolved nitrogen content, and this waste water cannot be appropriately adjusted and/or eliminated prior to dumping to drain. In addition, wet scrubbing would result in uncontrolled mixing of air to the gas stream rendering it flammable before proper release is possible. System shall have a demonstrated ammonia abatement performance of better than 99% destruction removal efficiency.

Vendor shall also provide a connection kit to connect NW40 exhaust line to the system. Vendor shall provide all other specialized tools, carts, cartridges and any other item required to make the unit a fully working device once facilities have been connected on site.

Along with the bid, the vendor shall provide an electronic copy of their operational instructional manual. The manual must include appropriate process and facilities connections, piping and instrumentation diagrams, as well as height weight and other details of the product clearly defined.

Once the unit has been connected to the required facilities on site, vendor shall provide a trained technician for at least one day on site. The purpose of a technician will be to start-the unit up, and give brief instructions on operation maintenance and other issues surrounding abatement by the system.

Main system hardware

The unit shall be less than (540 X 450 mm or 25 ¼ X 17 ¾ inches) floorspace 30 by 48 inches of front access service area to fit into space allotted for the installation. It shall operate at 208V 60Hz power, with 3 phases, neutral and earth ground.

The main components of the system shall be enclosed in a metal extractable cabinet that will allow each subcomponent in the unit to be extracted to exhaust at a rate of ~55-60 CFM. Extraction shall meet safety standards for flammable gases used. These measures ensure that any leak inside the cabinet does not fill the room with toxic and/or flammable gases. Connectors provided will allow for safe connection to facilities, and safe operation at all times.

The exhaust process line will include bypass valve as well as method to isolate the cartridge that are required for abatement The inlet bypass valve will be intimately associated with a pressure switch that does not allow a blockage in system flow to overpressure the cartridges. The entire system will feed-back to system controller and shall provide a closed contact warning to the tool that the abatement facility is or is not available.

The unit will use heated cartridges with catalyst beds to provide catalytic decomposition of the ammonia into nitrogen and hydrogen. The cartridge will also convert metalorganics such as TMA (trimethyl-aluminium), TMG (trimethyl-gallium) or TMI (trimethyl-indium) into inorganic carbon and metal oxides, so minimising the contamination of the catalyst bed and prolonging cartridge life. Abatement shall be capable of abatement of this material as well without exchange of the main abatement cartridge.

A number of individual heaters for the cartridges shall be supplied to drive the cartridges to operational temperatures. These heaters shall be integral to the system and not part of the disposable cartridges. These heaters shall be controlled through thermocouple readings that are taken at appropriate points on the system cartridges. The heaters shall be removable and repairable as needed. While the thermocouples themselves can be in the gas path, the heaters must be supplied as an independent component.

Cartridges shall include be easy to remove, and maintain. A mechanical removal cart is required that allows for easy movement of the spent cartridges.

A pressure switch will deploy and warning light will be lit on the unit if the cartridges obtain an over-pressure condition (indicating blockage). A manual or automated pressure relief valve shall be supplied that allows the pressure on the cartridge to be relieved in the event of over-pressure condition exists.

Wet scrubbers alone are not an acceptable method of abatement since large volumes of hydrogen gas could result in fire.

System abatement performance:

Vendor must have demonstrated performance of NH3 abatement to better than 99.%, and metal-organic materials should be at non detectable levels at the outlet of the system.

It is understood that the quantity of hydrogen will increased with catalytic destruction of ammonia, however this will be diluted and released in an controlled fashion at the system exhaust duct.

Service and Maintenance:

Low maintenance operation is sought. Vendor should have acceptable levels of technical support (both service and applications support) in the USA, along with warehousing of primary replacement parts.

END.