

Emergency Response Plan

For

Crystal Growth Facility

@

The University of New Mexico

1000 University Blvd.

Albuquerque, NM 87106

November 30, 2016

REVISION 4.0

TABLE OF CONTENTS

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1	Introduction to Crystal Growth Facility	4
1.1	PURPOSE AND USE	4
1.2	EMERGENCY CALL NUMBERS	5
1.3	DOCUMENT CONTROL	5
2	Hazard Analysis	5
2.1	CHEMICAL HAZARDS	5
2.1.1	<i>Toxic and Highly-Toxic Gases</i>	6
2.1.2	<i>Flammable Gases</i>	6
2.1.3	<i>Corrosive Gases</i>	7
2.1.4	<i>Dual-Hazard Gases</i>	7
2.1.5	<i>Flammable Liquids</i>	7
2.1.6	<i>Pyrophoric Liquids</i>	7
2.1.7	<i>Corrosive Liquids</i>	7
2.1.8	<i>Hazardous/Toxic Waste</i>	7
2.1.9	<i>Process Hazards</i>	7
3	The Safety System at CGF	7
3.1	SAFETY OF BUILDING OCCUPANTS	7
3.1.1	<i>Access Control</i>	7
3.2	SAFETY AWARENESS	8
3.3	SAFETY TRAINING	8
3.3.1	<i>Awareness Training</i>	8
3.3.2	<i>Chemical Safety Training</i>	8
3.3.3	<i>Emergency-Responder Training</i>	8
3.3.4	<i>Crystal Growth Training Matrix</i>	8
3.4	GENERAL SAFETY CONTROLS	8
3.4.1	<i>Ventilation System (both general ventilation and hazardous exhaust)</i>	8
3.4.2	<i>Security Alarm System (intruder detectors)</i>	9
3.5	GAS ALARM, DETECTION, AND NOTIFICATION SYSTEMS	9
3.5.1	<i>Toxic Gas Monitor (TGM)</i>	9
3.5.2	<i>Hydrogen Sensors</i>	9
3.5.3	<i>Local Alarm System</i>	9
3.5.4	<i>Remote Alarm System</i>	11
3.5.5	<i>Annunciator Panel</i>	11
3.6	AUTOMATIC INTERVENTION SYSTEMS	12
3.6.1	<i>Automatic Shutoff Valves</i>	12
3.6.2	<i>Fire Alarm, Detection, and Notification Systems</i>	12
3.6.3	<i>Fire Alarm System</i>	12
3.6.4	<i>Heat Detector</i>	13
3.6.5	<i>Automatic Fire Sprinklers</i>	13
4	Emergency Procedures	13
4.1	EVACUATION OF FACILITY	13
4.2	CGF EMERGENCY PERSONNEL	13
4.3	EXTERNAL RESPONSE AGENCIES	14
4.3.1	<i>UNM Police Department</i>	14
4.3.2	<i>Albuquerque Fire Department</i>	14
4.3.3	<i>UNM-RSHEA Department</i>	14
4.3.4	<i>Private Contractors</i>	15
4.3.5	<i>Post-Incident Critique</i>	15

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5	Standard Response Procedures	15
5.1	RESPONSE PROCEDURE FOR GAS DETECTOR ALARM.....	15
5.2	RESPONSE PROCEDURE FOR INTRUDER ALARM	15
5.3	RESPONSE PROCEDURE FOR AUTOMATIC SPRINKLER ALARM	16
5.4	RESPONSE PROCEDURE FOR SMALL OR INCIPIENT-LEVEL FIRES.....	16
5.5	RESPONSE PROCEDURE FOR LARGE OR STRUCTURAL FIRES.....	17
5.6	RESPONSE PROCEDURE FOR SPILLED LIQUID CHEMICALS	17
5.6.1	Definitions.....	17
5.6.2	What To Do In The Event Of A Chemical Spill.....	18
5.7	RESPONSE PROCEDURE FOR GAS/VAPOR RELEASES	21
6	Appendices 22	
6.1	APPENDIX A—LAYOUT MAPS AND FIGURES	22
6.1.1	Site Map of Crystal Growth Facility (1000 University Blvd, SE).....	22
6.1.2	Floor Plan of Crystal Growth Facility (Chemical Storage / Use).....	23
6.1.3	Floor Plan of Crystal Growth Facility (Emergency equipment locations) Error! Bookmark not defined.	
6.1.4	Layout of Toxic Gas Annunciator Panel.....	24
6.2	APPENDIX B—COMMON CHEMICALS IN USE AT CGF	25
6.3	APPENDIX C: FIRE/EMERGENCY EVACUATION PLAN	27
6.3.1	Egress Routes.....	27
6.3.2	Procedures for employees operating critical equipment	27
6.3.3	Headcount Procedures.....	27
6.3.4	Means of Notifying Occupants.....	27
6.3.5	Means of Notifying the Fire Department	27
6.3.6	Evacuation Route Map.....	27
6.3.7	Personnel who can be contacted to provide additional information: Error! Bookmark not defined.	
6.4	APPENDIX D: FIRE SAFETY PLAN.....	29
6.4.1	Procedure for Reporting a Fire, or other Emergency	29
6.4.2	Life-Safety Strategy.....	29
6.4.4	List of Major Fire Hazards	30
6.4.5	Personnel responsible for Fire Equipment	30
6.4.6	Personnel responsible for Fuel Hazard	30
6.4.7	Personnel responsible for Chemical Hazard	30
7	Document Control History	32

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1 Introduction to Crystal Growth Facility

1.1 Purpose and Use

Personnel at the CGF are faculty, staff, or students of UNM, or official visitors to UNM. The main process in operation at CGF is metal-organic chemical vapor deposition (MOCVD), used to produce thin layers of semiconductor materials such as gallium nitride. The MOCVD process uses toxic, pyrophoric, and flammable source materials.

An accident at CGF may impose a substantial risk to the life and health of CGF personnel and may impact the neighboring community. These hazards have been addressed by the Center for High Technology Materials in consultation with the local (campus and city) emergency services community, and a safety system has been implemented.

The most significant hazards at CGF are:

- accidental release of hydrogen (highly flammable gas)
- accidental release of a metal-organic material (pyrophoric fire hazard)
- accidental release of hydrogen chloride or ammonia (toxic gas)
- accidental spill of corrosive liquid (strong acids or bases)

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1.2 Emergency Call Numbers:

1. CHTM/CGF Operations Specialist ,Wes Denton: 228-0809 (cell)
2. CHTM/CGF Facilities Research Specialist, Joe Massey: 249-7464 (cell)
3. CHTM/CGF Master Electrician , Mark Villegas: 219-6966 (cell)

1.3 Document Control

The source document for this Emergency Response Plan, and the distribution of all copies, is strictly controlled by UNM's Center for High Technology Materials (CHTM). The document will be reviewed annually to ensure accuracy and timeliness. If revisions are necessary or desired prior to the annual review, the changes must be submitted in writing to the CHTM Document Control Manager, who will then circulate the proposed change through the list of controlling parties, each of whom will signify approval of the change by signing and dating the accompanying Change Form.

1.4 Table of Acronyms

Acronym	Text
8-5	0800 hour to 1700 hours
AFD	Albuquerque Fire Department
CPMG	Bis-cyclopentadienyl magnesium
BOE	Buffered Oxide Etch
CGF	Crystal Growth Facility
CGM	Combustible Gas Monitors
CHTM	Center for High Technology Materials
DCM	Document Control Manager
EOHS	Employee Occupational Health Sciences (part of UNM School of Medicine)
ERP	Emergency Response Plan
ERT	Emergency Response Team
GaAs	Gallium Arsenide
HF	Hydrofluoric Acid (liquid acid or gas)
IDLH	Immediately Dangerous to Life and Health
LEL	Lower Explosive Limit

2 Hazard Analysis

2.1 Chemical Hazards

Due to the nature of the processes utilized at Crystal Growth, there are a variety of hazardous chemicals* stored and used at the CGF, generally falling into the following categories:

*A more detailed list of the most-common hazardous chemicals used at CGF can be found in Appendix B of this Plan. An actual listing of the chemistry on-site can be located in the Safety Kiosk located next to the back (west) entrance to the facility.

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2.1.1 Toxic Gases

Gases having certain harmful effects on human health (both acute and chronic) are called toxic gases. Currently, only ammonia would be included in this category of the gases in use at CGF. Cylinders of ammonia are contained in gas cabinets like the ones pictured below.



2.1.2 Flammable Gases

Gases that ignite easily and burn vigorously, like hydrogen, are in use at CGF; generally, hydrogen cylinders are located in the exterior (south) yard, arranged in groups of six connected cylinders (aka: 6-packs), as pictured below. Gas cylinders containing mixtures of gases that are mostly hydrogen are contained in gas cabinets inside the facility.



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2.1.3 Corrosive Gases

Gases, like liquids, can be corrosive—destructive to human tissues and metals—and can be either acidic or basic (like Ammonia).

2.1.4 Dual-Hazard Gases

Many gases exhibit more than one of the above characteristics: that is, corrosives can also be flammable, pyrophorics can also be toxic, toxics can also be corrosive. Ammonia is a gas in use at CGF that is toxic, corrosive, and flammable.

2.1.5 Flammable Liquids

Certain liquids having a flash point below 100 degrees F and which will burn when ignited are used at CGF, often for cleaning and other maintenance purposes; some common flammables used are acetone, methanol, and isopropyl alcohol.

2.1.6 Pyrophoric Liquids

Some of the liquid chemicals used at CGF, especially the metal-organics used in the MOCVD process, are also pyrophoric, meaning they will self-ignite in air at temperatures below 130 degrees Fahrenheit.

2.1.7 Corrosive Liquids

Many liquid chemicals commonly used in labs are corrosive—destructive to human tissues and metals, and can be either acidic (like Nitric Acid or Phosphoric Acid) or basic (like Ammonium Hydroxide).

2.1.8 Hazardous/Toxic Waste

Some of the chemicals used in the processes at CGF remain hazardous after the process is complete, and require further controls while remaining on-site. The storage and disposal of these wastes is strictly controlled according to the requirements of UNM's SRS Department.

2.1.9 Process Hazards

In addition to the chemical hazards illustrated above, other CGF processes utilize certain hazardous operations and equipment, including lasers (class-4).

3 The Safety System at CGF

3.1 Safety of Building Occupants

3.1.1 Access Control

Access to the Crystal Growth Facility is strictly limited to persons having legitimate business there. The facility is normally locked at all times, and only those with access privileges and keys can enter the building. Motion detectors are activated outside of normal business hours, and any activity in the building during those times initiates an alarm, both locally and at the UNM police station.

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3.2 Safety Awareness

Signs and posters are displayed at several locations throughout the Crystal Growth Facility to advise building occupants as to emergency procedures. This includes evacuation procedures in general, evacuation routes to follow in case of emergency, and a simple explanation of the alarm-system warning devices (which color indicates which hazard). Also, as part of the Hazard Communication program in place at the CGF, chemical containers and storage apparatus are labeled using a standardized, informative, and easy-to-understand system; this allows CGF staff to quickly understand and evaluate the hazards associated with the individual chemicals that they may encounter. For more detailed information regarding chemical hazards, an MSDS collection (3-ring binder style) and an up-to-date chemical inventory can be found at the Safety Kiosk near the rear (west) entry into the facility.

3.3 Safety Training

All authorized users of the CGF hazard areas are trained in general safety policies/procedures, chemical and fire hazards at the CGF, and emergency procedures. This training occurs prior to the authorization of access to CGF, and refresher training is required annually. Training is aimed at three distinct levels:

3.3.1 Awareness Training (Level 1 Training)

This level of training is for casual or infrequent users of the facility, including janitorial and maintenance (UNM Physical Plant or outside contractors) personnel.

3.3.2 Chemical Safety Training (Level 2 Training)

This level of training is required for anyone handling chemicals or gases, or working in the clean rooms, service room, or laser rooms.

3.3.3 Emergency-Responder Training (Level 3 Training)

For anyone assigned to specific duties in the event of an emergency incident at the CGF.

3.3.4 Crystal Growth Training Matrix

Refer to the CGF Training Matrix for a complete listing of training requirements for all three levels [see Appendix F].

3.4 General Safety Controls

3.4.1 Ventilation System (both general ventilation and hazardous exhaust)

- There are two ventilation systems at Crystal Growth, one is for general ventilation or conditioning of the building air, while the other system exhausts hazardous gases (or potentially-hazardous air) through one or more scrubbers before exhausting to atmosphere.
- Under emergency conditions (such as a high-level alarm on the toxic-gas monitoring system), the general ventilation system is shut off, at the same time as the hazardous (or "scrubbed") exhaust is ramped up to twice normal speed. In this way, all building air is treated through the scrubbers before being released to atmosphere.
- Because of the action of these two systems, the building is always under slight negative pressure, which may become noticeably negative in emergency conditions. This negative pressure helps prevent any leakage of hazardous products to the exterior of the CGF.

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3.4.2 Security Alarm System (intruder detectors)

- To detect the presence of unauthorized persons or “intruders” in the Crystal Growth Facility, several motion detectors are in place.
- During normal business hours (M-F, 8-5), the Security System is disarmed, and people can come and go if they have been granted Access to the building. After hours, when the system is armed, the motion of a person in the facility will set off the alarms. UNMPD also receives the alarm and will dispatch an officer to investigate the cause.
- Persons having authorized access to the CGF who must enter the building when the intruder-alarm system is armed must input their individual access code number into the Alarm Control Panel (within the allowed time period) in order to disarm the motion sensors.

3.5 Gas Alarm, Detection, and Notification Systems

3.5.1 Toxic Gas Monitor (TGM)

High-sensitivity continuous gas monitoring is in operation in the Crystal Growth Facility, utilizing a Sierra Monitor IT Series catalytic bead gas sensor system. Air Samples are drawn from several locations with a risk potential and tested for the presence of target toxic gases. Air samples are drawn from locations that are considered to be either open or closed.

- Closed-system indicates sampling is restricted to areas using engineered containment such as gas cabinets, exhaust lines, equipment enclosures, etc. This type of monitoring uses a Sierra Monitor IT Series monitor, which monitors 16 separate sampling points. The Sierra Monitor IT Series System activates alarms at two distinct levels: the low-level or Warning Alarm (set at 12 ppm of ammonia) and the high-level or Evacuation Alarm at 50ppm.
- Open system or Ambient Air Sampling indicates sampling occurs in areas of normal human occupation (commonly referred to as the “breathing space”). The open system also utilizes the Sierra Monitor IT Series analyzer for continuous monitoring of the ammonia.
- The Veeco MOCVD also has an internal gas sensor designed to detect the presence of gas within the tool itself.

3.5.2 Hydrogen Sensors

Because of the use of highly-flammable hydrogen gas in the CGF, hydrogen sensors are also located at strategic points around the facility. These Combustible Gas Monitors work on a different operating principle than the TGM, but also provide continuous sampling of the air at suspect points and evaluate the samples for the presence of hydrogen. Again, the system activates at two distinct levels: the low-level or warning alarm at 20% of LEL (Lower Explosive Limit), and the high-level alarm or Action Alarm at 40% of the LEL.

3.5.3 Local Alarm System

Visual and audio notification devices are activated to warn occupants of the CGF of the potential hazards when detected. A dual-light rotating/flashing beacon provides visual indication that the gas monitoring system has detected a problem:

- Red beacon indicates the presence of hydrogen
- Blue beacon indicates the presence of ammonia

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Beacons are activated when the low-level point is reached, and continue to operate at all concentrations above warning level—there is no change in the visual signal when the high-level is reached/exceeded. The audible warning sound does change, however, emitting a chime sound at the low-level alarm point and a very loud klaxon sound when the alarm is at or above the high level. There is no distinction in the audible warning between hydrogen and ammonia.

Example of colored beacons in central hallway with visibility from either clean room



Example of amber light located in central hallway for differential building pressure issues



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Example of colored beacon alarm located on Veeco reactor for differential building pressure issues



3.5.4 Remote Alarm System

The gas detection systems automatically send information to the remote alarm station at the UNM police station. This feature allows timely response to emergencies at CGF at times when no personnel are in the facility.

3.5.5 Annunciator Panel

Inside the Main Entry, indicator lights provide information about the nature of the alarm, the location of the specific sample-point that is detecting the gas, and the concentration levels of the gas (see layout in Appendix A4). This location also provides indication from the facility's sensors related to the fire alarm system: pull stations, heat detectors, and activation of the fire-sprinkler system.

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3.6.4 Heat Detector

A heat detector is installed in the south electrical room (Room 130), providing early detection of fire in that location.

3.6.5 Automatic Fire Sprinklers



Are installed throughout the CGF (and in each gas cabinet inside the facility). Activation of any sprinkler head will initiate an alarm at the Annunciator Panel (Main Door of the CGF), will cause the Water Gong (on the exterior wall of the building outside the Main Sprinkler Valve) to ring, and will activate the Local Fire Alarm system (pictured at right)—including the notification and automatic dispatch features at the UNMPD.



Note: All fire alarm, detection, and intervention systems are tested on a regular schedule, at least annually and more often where indicated. Extinguishers and Fire Sprinklers are inspected and maintained by UNM-SRS Fire Safety office.

4 Emergency Procedures

4.1 Evacuation of Facility

When indicated by the gas detection system's warning devices, or by the fire-alarm system, or by the local alarm system (pull-stations), all building occupants shall evacuate the Crystal Growth Facility by immediately proceeding to the nearest exit and leaving the building. Once outside the building, they shall proceed to the evacuation grouping point and remain there until accounted for and released by emergency personnel. [see site map in Appendix A1 for location, and also see Appendix C for the site-specific Evacuation Plan for the Facility].

There are several exits from the Crystal Growth Facility, and every building occupant is personally responsible for becoming familiar with their locations. Occupants should also take the time to plan both a primary and a secondary evacuation route from their normal work location. Hazardous areas in the facility have at least two exits from them, in case one is blocked by the emergency condition. [see Evacuation Route Map on page 24]

4.2 CGF Emergency Personnel

If it can be done safely, emergency personnel in the facility at the time of an emergency evacuation should exit the building via the main entry, so that they can check the status board regarding the number and names of people in the building. The main entry also contains the annunciator panel for the various detection and alarm systems. Only when it can be safely done, emergency personnel can check the panel to find out the nature and location of the emergency condition, and whether the condition is improving, remaining static, or deteriorating. Strategically, the priorities of the emergency personnel are as follows:

- life safety, including building occupants, response personnel, and the public.
- the environment and the community
- the continued functionality of the crystal-growth facility
- university and/or private property

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Tactically, this translates into attention to the following list of items for the emergency personnel to concentrate on during the initial response:

- determine if everyone is out of the facility in an evacuation
- names on the status board?
- headcount of people at evacuation grouping point
- long-term status of the evacuees
- establish control of the facility and location of command post
- determine nature of emergency
- determine the need for any additional outside-agency response, establish status of response, prepare to meet incoming emergency personnel

4.3 External Response Agencies

4.3.1 UNM Police Department

Outside of normal business hours at CGF, the UNMPD is the primary response agency to an alarm or other hazardous condition. Until the nature of the emergency is determined, they should always proceed with extreme caution. In general, police will not enter the building regardless of the type of alarm. Initially, they should respond to the Main Entrance (unless contraindicated by apparent hazardous conditions) and view the Annunciator Panels from a safe position outside the building.

- If the panel is showing a high-level toxic-gas alarm, the PD officer should call for CGF Emergency-Response Personnel and AFD (including HazMat Team) to be notified and respond to the facility.
- If the panel is showing a high-level hydrogen alarm, the PD officer shall leave the immediate area without delay and call for the Albuquerque Fire Department (including HazMat Team) to respond.
- If the panel is showing an alarm on the fire panel (heat detector or automatic-sprinkler operation), the officer shall call for the Albuquerque Fire Department to respond.
- If the panel is showing less than a high-level alarm (on either the toxic or the flammable gas monitors), the PD officer should contact CGF Emergency-Response Personnel before entering the Facility. If entry is made, the “buddy system” must be adhered to, meaning at least two people entering and working together at all times.

4.3.2 Albuquerque Fire Department

Under some circumstances, the AFD will become the primary responding agency, and will assume command of the emergency utilizing the Incident Command System. This would include fires (either active, extinguished, or smoke-only), hazardous material incidents involving significant threat to life-safety, and medical emergencies. Note: in case of a bomb threat, the Police will be the Incident Commander.

4.3.3 UNM-SRS Department

In emergency conditions, vital technical support at times may be obtained from the University's, Safety and Risk Services Department (UNM-SRS). Post-emergency, they will also play an important role in recovery and cause-determination.

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4.3.4 Private Contractors

In some emergency situations, outside contractors will be engaged to perform certain specific tasks. The current contractor for most chemical spills is Clean Harbors. Air Products or other gas suppliers may be involved in operations designed to contain gas leaks.

4.3.5 Post-Incident Critique

In order to promote continuous improvement of the Safety and Emergency Response Systems at CGF, a formal Critique shall be conducted of each Emergency Incident. This Critique will be officiated by senior management of the CHTM as soon as practicable following the conclusion of the incident. A report will be issued summarizing the findings of the Critique, including corrective actions or changes necessary to optimize the Emergency Response procedures and/or related documents.

5 Standard Response Procedures

5.1 Response Procedure for Gas Detector Alarm

- Determine if Alarm is for Flammable Gas or Toxic Gas
- Determine if Alarm Level is Low- or High-Level
- If Flammable Gas is High-Level, have AFD respond to site (contact made via UNMPD); Shut off supply of both Hydrogen and Natural Gas from exterior main control valves.
- If Toxic Gas is High-Level, ensure building is evacuated, and deny entry to building, call for ERT or equivalent to respond to site, and continue to monitor gas concentration levels to identify trend.
- If Alarm (either system) is Low-level, monitor gas levels from exterior of building and determine need for entry. The Low-level or Warning alarm allows for intervention or additional monitoring while the threat level is still relatively minor. Generally, low-level alarms either continue to build, resulting in a high-level alarm; or they drop back towards zero. If the level remains stable in the low-level area, some sort of intervention (by ERT or similar) is probably warranted.
- If a High-Level Toxic Gas Alarm subsequently drops down to a low-level alarm (or below), CGF Personnel, *trained* and wearing appropriate PPE can make entry into the building, following all safe-operating procedures, in order to determine the cause of the problem and take corrective actions. At a minimum, this training would be to level 3 as specified in paragraph 3.3.3 of this document.

5.2 Response Procedure for Intruder Alarm

Activation of the Intruder Alarm is the only alarm condition that allows police responders to enter the CGF alone.

When the Intruder Alarm is activated, CGF personnel are not to enter the CGF building unless expressly directed to do so by the police officer.

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5.3 Response Procedure for Alarm Conditions on the Fire Alarm Panel.

Once building has been evacuated, determine the type of alarm if possible (preferably from outside).

- If Alarm is due to heat detector, Room 130 is the location. Do not attempt to make entry into the room, wait for AFD to arrive.
- If Alarm is due to smoke detector activation, determine the location of the detector.
- If detector is in ductwork, further investigation may be necessary to determine the actual source of the smoke.
- If detector is an area detector, caution should be used to investigate, and only if there is no visible smoke or other potential hazards.
- If smoke or other products of combustion are visible, discontinue the investigation and proceed to the Fire Response listed below.

5.4 Response Procedure for Automatic Sprinkler Alarm

- Determine location of sprinkler which is in operation
- Sprinkler may be in hidden area (such as inside a gas-cabinet, making it difficult to determine exactly where the water is flowing.
- If any signs of a fire in progress or any visible smoke conditions are noticed while trying to locate the operating head, move immediately to Fire Procedure (below) and discontinue emergency operation inside the Facility.
- If operating sprinkler head is inappropriately flowing water (due to mechanical damage or to material failure), the system should be shut down as soon as all possibility of fire/heat has been positively eliminated.
- If the Main Sprinkler Valve must be closed to stop the flow of water, only the following personnel/agencies are authorized to close the Main Sprinkler Valve:
 - Albuquerque Fire Department
 - UNM SRS – Fire Safety Office
 - Western States Fire Protection (contractor)
- When closed, the valve shall be tagged as Closed by UNM Fire Safety Office and the sprinkler system identified as Out-of-Service, with the appropriate authorities notified of the out-of-service condition.
- The system will be returned to service as soon as possible, and in no case shall it be left out-of-service for periods longer than 24 hours. System outages of more than one hour require a fire watch on the facility during the outage. Fire watch personnel are provided by the building or department occupying the facility.

5.5 Response Procedure for Small or Incipient-level Fires

- Evacuate the building. The easiest, quickest mechanism is to activate a pull station, which not only sounds the local alarm, but also notifies the UNM police department and the fire department.
- Incipient Fires, by definition, are small, approachable, and confined to the object/immediate area of origin. This does not mean they should be treated lightly! If heat and/or smoke conditions make approaching the fire difficult, it has evolved beyond the incipient stage and has become a structural fire (whether or not the structure is involved yet).
- A portable fire extinguisher can be used to extinguish the fire, only when all of the following conditions are met:

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- Ensure you have an escape route. There is at least one route of exit that will remain open even if the fire spreads during the extinguishing phase. Rule-of-thumb: have the exit at your back when you approach the fire with the extinguisher.
- The extinguisher is the type and size appropriate for the fire conditions at hand.
- The person operating the extinguisher has been trained in proper procedures for operating the device.
- The person operating the extinguisher feels comfortable making an attempt to extinguish the fire.

5.6 Response Procedure for Large or Structural Fires

[These procedures would apply regardless of whether the Fire was already large on discovery, or had expanded from a small/incipient-stage fire]

- Immediately evacuate the building using the nearest pull-station to activate the local alarm. Make sure all occupants have left the building and deny entry until the arrival of the AFD.
- Notify the UNM Police of the location, circumstances, and condition of the fire for an immediate response.
- Make sure that the water gong is sounding (exterior of building on the east wall), indicating that the sprinkler system is in operation.
- If possible to safely do so, shut off all gas systems from the exterior main control valves on the outside of the CGF.

5.7 Response Procedure for Spilled Liquid Chemicals

The UNM Safety Risk Services manual, section 4.02 (Chemical Spill Response Program) provides comprehensive instructions in dealing with chemical spills and is used as a model for spill-response. The following paragraphs are extracted from that document, dated 1-12-07.

5.7.1 Definitions

Chemical Spill – Any unplanned or uncontrolled release of any solid, semi-solid, liquid, or gaseous hazardous chemical that can pose a potential safety or health risk to people or the environment.

Facilities - Facilities covered under this program include all UNM-owned and all UNM-leased structures and property.

Hazardous Chemical - Any solid, semi-solid, liquid, or gaseous chemical that may pose a physical hazard or a health hazard. This would include the following:

- corrosives (acids, bases)
- paints
- petroleum products (gasoline, diesel fuel, oil)
- poisons
- oxidizers
- reactives
- solvents (paint thinners, alcohols)

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Health Hazard – Chemicals that may cause various acute or chronic adverse health effects such as corrosives, carcinogens, irritants, mutagens, teratogens and sensitizers.

Major Spill - Any hazardous chemical spill that involves highly toxic, highly reactive, explosive or life-threatening chemicals. Any spill situation that presents significant fire, explosion, or other physical or health hazard risks, particularly if a person may be or has been significantly exposed, contaminated or injured to such an extent that medical or other outside assistance is required. Any spill situation that may adversely impact the external environment whether or not the spill occurred internal or external to a building. **Note: If any chemical is present that, when spilled, could present a situation that meets this definition, then emergency procedures for spill response, including cleanup, must be included as part of the workplace's Standard Operating Procedures.**

Safety Data Sheet (SDS) – A document prepared by the manufacturer of a hazardous chemical that contains information about the hazards of the chemical and the appropriate work practices required for safe use and spill response.

Minor Spill - Any hazardous chemical spill that does not involve highly toxic, highly reactive, or explosive chemicals in a situation that is not life threatening. This type of spill presents a manageable physical or health hazard to personnel who, when wearing proper Personal Protective Equipment (PPE), will not be exposed to any chemical at a level that exceeds any recognized OSHA action level or permissible exposure limit.

Physical Hazard - A hazardous chemical with physical characteristics that make it combustible, flammable, explosive, reactive, a compressed or cryogenic gas, an organic peroxide or an oxidizer.

5.7.2 What To Do In The Event Of A Chemical Spill

Personnel can safely clean up the vast majority of chemical spills that occur. **Whoever is most knowledgeable about the spill is responsible for prompt notification and proper clean-up, if safe to do so.** It is the responsibility of the supervisor and/or Chemical Safety Officer to have spill clean-up materials and personal protective equipment, which are appropriate for the chemicals being handled, readily available for emergency use. They are also responsible for ensuring that spills are cleaned up as soon as possible.

The various types and quantities of hazardous chemicals used at UNM require preplanning in order for accidental chemical spills to be handled in a safe manner. Use the flow chart in Attachment A to plan an appropriate response to any spill. Two categories of chemical spills and response procedures are identified for the purposes of this plan.

1. Minor Spill

Evaluate the spill situation before making any decisions.

- ✓ What chemicals are involved?
- ✓ Where is the SDS for this chemical and what does it say about spill clean-up?
- ✓ Is the appropriate spill kit available?
- ✓ Do you need to isolate the spill area (barrier tape or safety watch)?
- ✓ If the chemical is flammable, do you need to turn off any equipment, heat sources, electrical panels, or other potential ignition sources?

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- ✓ Will you need to notify the Principal Investigator or your supervisor about the spill?
- ✓ Is personal protective equipment needed and is it available?
- ✓ Will you need to have another person to stand by or assist during the clean-up?
- ✓ Will you need to wear a respirator during the clean-up?
- ✓ Will you need to wear other protective equipment, such as gloves, face shield, etc.?
- ✓ Does the ventilation to the area need to be improved, or the windows opened?
- ✓ Will the spill have consequences in other areas and to other people?

Safe clean-up of a spilled chemical may include following several of these guidelines:

- ✓ Notify others in the immediate area that a spill has occurred;
- ✓ Advise other lab occupants and supervisor of the spill;
- ✓ Isolate the area so that nobody unknowingly walks into the contaminated area, by closing doors, posting other individuals at doors or hallways to warn others, barrier tape, etc.;
- ✓ Increase area ventilation, if needed, by turning on hoods and opening windows;
- ✓ Review the spill clean-up procedures recommended in the MSDS sheet;
- ✓ Procure and open the chemical spill kit, and evaluate the contents;
- ✓ Plan the clean-up procedures you will follow;
- ✓ Wear protective equipment as needed, including safety goggles or face shield, gloves, Tyvek suit, apron, respirator, and/or long-sleeve lab coat;
- ✓ Avoid breathing vapors/fumes from the spill;
- ✓ Confine spill to small area with absorbent materials;
- ✓ Absorb spill with absorbent pads or paper towels;
- ✓ Acid and base spills should be neutralized prior to clean-up;
- ✓ Use the appropriate UNM-SRS Spill Response Guide in Attachment C;
- ✓ Clean up spill area using other appropriate procedures as recommended in the MSDS;
- ✓ Collect residue, place in disposal container, and label waste container;
- ✓ Decontaminate reusable cleanup supplies such as scoops, rubber boots, etc.;
- ✓ Place all contaminated PPE (gloves, Tyvek suits, etc.) into a plastic bag for disposal;
- ✓ Restock the chemical spill kit and return it to the normal storage location;
- ✓ Contact SRS at 277-2753 for waste pickup and proper disposal;
- ✓ In event of personal contamination, remove affected clothing and flush contaminated skin with water for fifteen minutes, and seek medical attention at EOHS (or equivalent); and,
- ✓ Complete the Chemical Spill Report Form and forward it to UNM-SRS.

2. Major Spills

If an area contains large quantities of any chemical, emergency procedures for spill clean-up must be included as part of the Standard Operating Procedures for that chemical in the UNM workplace. **Employees should only attempt to clean up large or major spills after special training has been received, and when appropriate spill clean-up materials, and personal protective equipment are readily available and are properly utilized.** Otherwise, in the event of a major spill for which personnel are not properly prepared, and particularly if any person has been significantly exposed, contaminated or injured to such an extent that medical or other outside assistance is needed, follow the **E.A. R.** steps:

Evacuate affected area and close doors.

Alert Campus Police by calling 911 from a campus phone and a safe location, or 277-2241 from a non-campus phone.

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Remain close to the phone, if requested to do so, until contacted by emergency responders.

Be prepared to provide more information about the spill, including MSDS information. Assist emergency personnel upon arrival. For any chemical spill that occurs outside a building, with potential for adversely impacting the physical environment, call Campus Police at 277-2241 and request that appropriate UNM-SRS staff be contacted.

All 911 calls, dialed on campus phones are routed to UNM Campus Police, which is staffed 24-hours/day and 7-days/week. All 911 calls to Campus Police that are related to a chemical spill will be routed by Campus Police to the Albuquerque Fire Department's (AFD) dispatch center and to the appropriate UNM-SRS staff. The AFD, including the Hazardous Materials Incident Task Force (AFD-HazMat), will then be sent to the spill site.

In the event of a major chemical spill, Campus Police will work with AFD-HazMat and UNM-SRS to secure the affected chemical spill area. AFD-HazMat is responsible for responding to major chemical spills on campus. Specifically, AFD-HazMat is responsible for:

- Assessing the nature and extent of the chemical spill with assistance from UNM-SRS, Campus Police, and appropriate personnel from the spill location.
- Evacuating and securing the affected area of the chemical spill with assistance from Campus Police and appropriate personnel from the spill location.
- Removing injured personnel and transporting them to appropriate medical facilities.
- Containing the chemical spill.
- Notifying the New Mexico State Police, if appropriate.

The New Mexico State Police, as directed in the New Mexico State Emergency Management Act, has overall authority over all HazMat related emergency events and will be the Incident Commander when on the scene, unless otherwise delegated.

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5.8 Response Procedure for Gas/Vapor Releases

5.8.1 Determine the type of gas involved, if possible:

- Hydrogen and ammonia releases should be detected by the gas monitoring systems, which will indicate the type of gas and the concentration levels.
- Nitrogen and Argon are inert gases and are not detectable; the main hazard with these gases would be oxygen-exclusion/asphyxiation.
- Silane (100ppm mixture), Carbon Tetrachloride, and Disilane (200ppm mixture) are not monitored by gas detection.

5.8.2 Immediate Course of Action. Regardless of the gas involved, the immediate course of action is to ensure building is evacuated, and deny entry to building, call for ERT or equivalent to respond to the site, and notify the UNM Police of the event (as per UNM-SRS policy). In the case of ammonia or hydrogen, this should happen automatically once the gas is detected by the monitoring system. An incident involving the other gases in use at CGF will require these steps to be manually initiated.

5.8.3 Shut off the flow of gas if possible:

- Exterior shutoffs should be closed from a safe position.
- Automatic shutoffs (tied to the gas-monitoring system) should close, causing the gas levels to drop back to zero in a short period of time. In cases where the gas-monitoring system is not in alarm, the automatic shutoffs can be activated by tripping a fire pull station.
- If gas continues to leak from the system, the cylinder may need to be closed manually. Although a simple operation, such entry into the hazardous atmosphere involves a certain level of risk, and can only be accomplished with the highest mobilization of the ERT (and, in most cases, the involvement of the AFD HazMat Unit or privately-contracted gas specialist teams).
- In a situation where the cylinder cannot be shut off, even manually at the cylinder-head, or cannot be shut off safely with personnel at hand, the gas provider should be contacted to bring specialized technical equipment (such as a “gas coffin”) and personnel to the CGF site for final determination of the incident (Air Products has a “gas-coffin” located at its Rio Rancho facility).

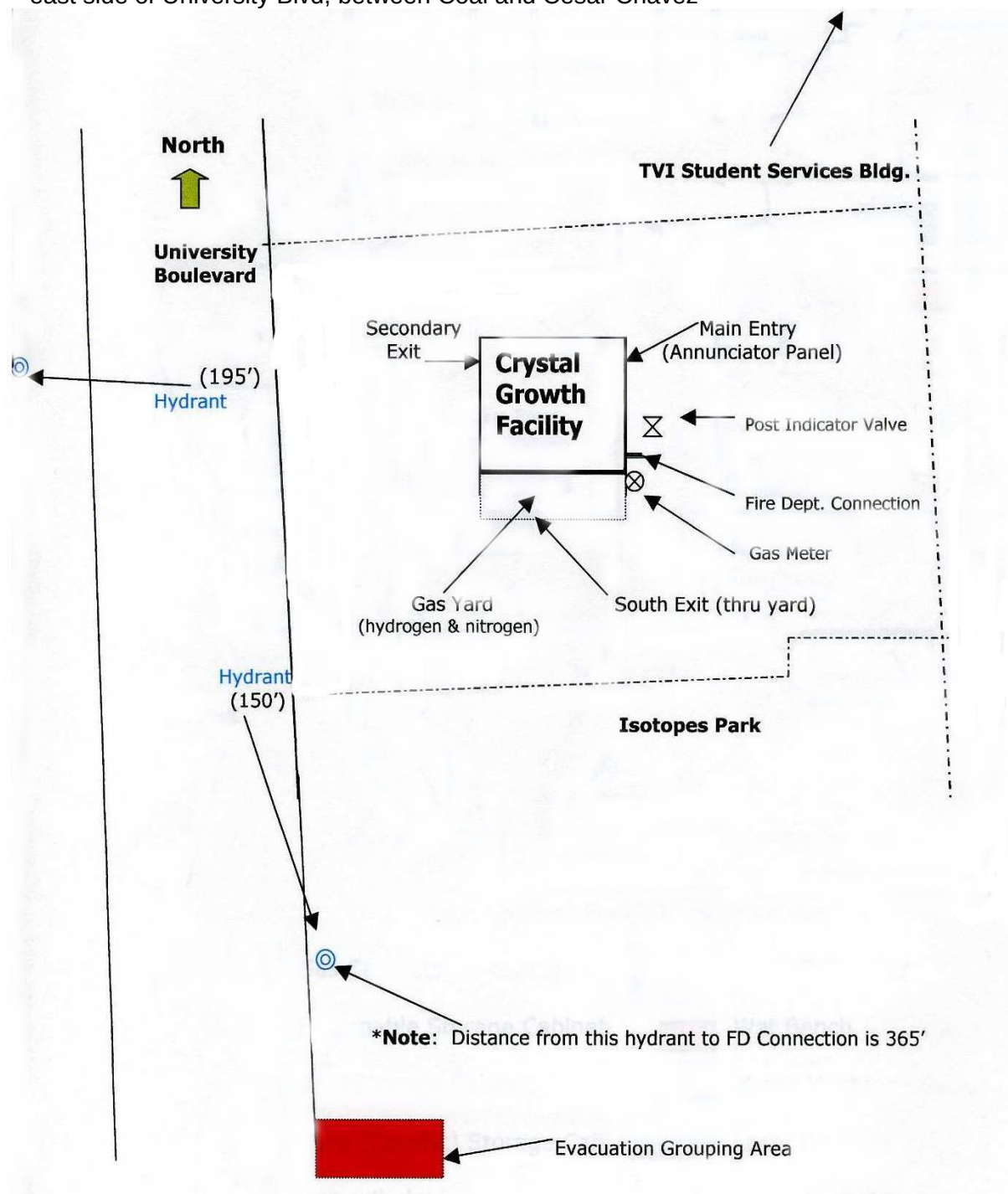
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6 Appendices

6.1 Appendix A—Layout Maps and Figures

6.1.1 Site Map of Crystal Growth Facility (1000 University Blvd, SE)

- east side of University Blvd, between Coal and Cesar Chavez



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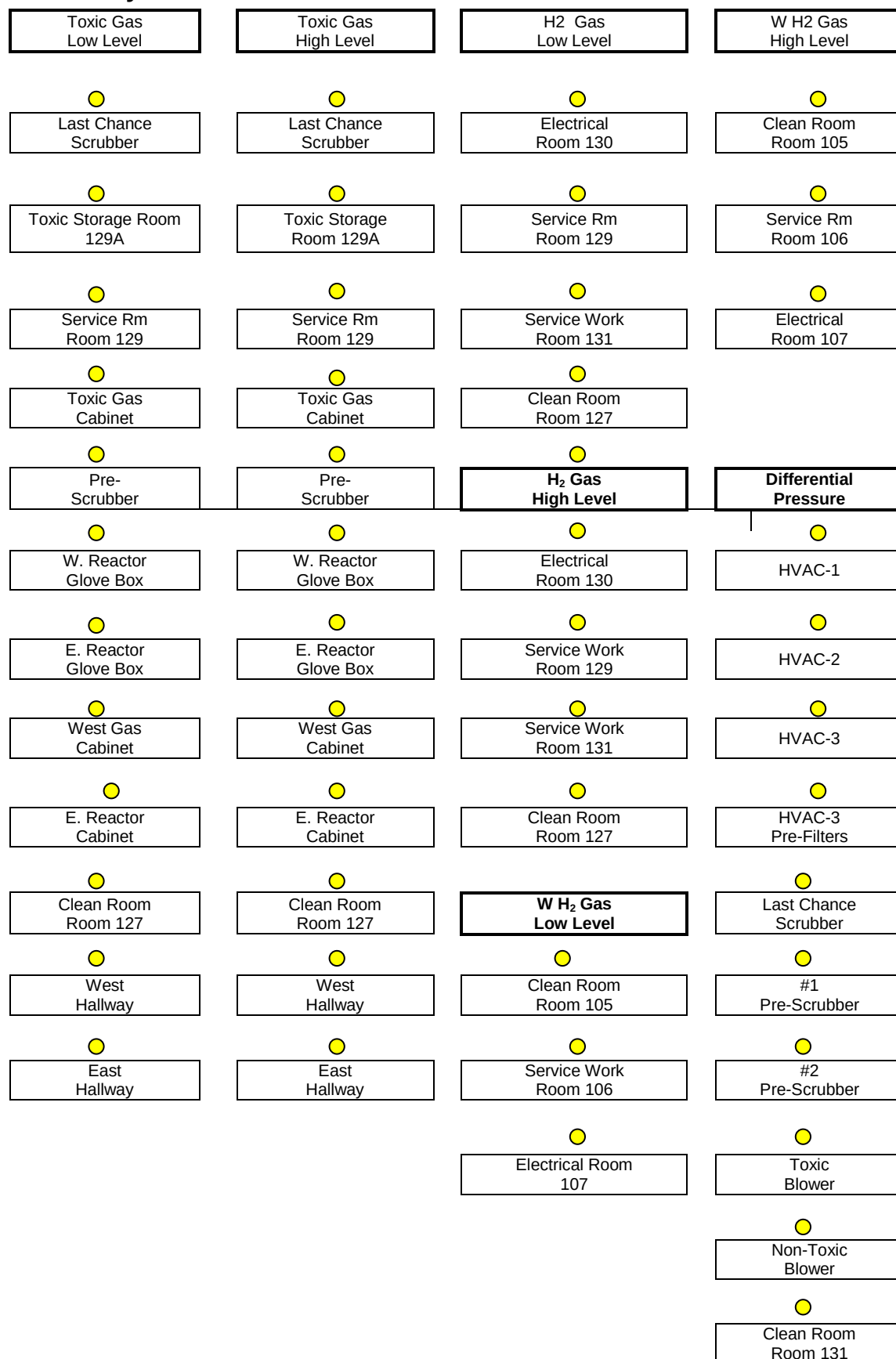
6.1.2 Floor Plan of Crystal Growth Facility

Showing locations of gas sensors, alarm devices, fire/life safety equipment, exit paths:



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6.1.3 Layout of Toxic Gas Annunciator Panel



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6.2 Appendix B—Common Chemicals in use at CGF

[a complete listing of the chemicals is kept at the Safety Kiosk near the west door]

Silane—in sufficient concentrations, this flammable/pyrophoric gas will self-ignite on contact with air, or may oxidize to siloxane, which is also pyrophoric and potentially explosive.

However, the mixture at CGF is 100ppm silane in nitrogen, considered **non-pyrophoric**.

Disilane—flammable and pyrophoric gas in pure form, it is used at CGF as a mixture of 200ppm of Disilane in Nitrogen, so it is essentially an inert gas.

Hydrogen—highly flammable gas with a flammable range of 4-75% in air, burns vigorously but flame is almost invisible under normal lighting conditions, gas is very light and will accumulate at upper levels in confined area, flame propagates so rapidly a deflagration explosion is likely; the gas is not actually toxic, but can be a simple asphyxiate in enclosed areas.

Ammonia—corrosive gas that can cause damage to lungs, eyes, and other soft tissues; somewhat toxic in its affect on people (PEL/TLV = 25ppm and IDLH = 300ppm); pungent, distinct odor detectable as low as 0.04ppm; technically, ammonia is also a flammable gas, although its flammable range is high and narrow at 16-25% in air.

Metal-Organic Reactants—chemical products used in the MOCVD (*metal-organic chemical vapor deposition*) process, which are generally low vapor-pressure liquids that are pyrophoric, and their oxides are carcinogenic. Chemically, they can be represented as RCH_3 , where R represents a Group III metal like gallium, aluminum, zinc, magnesium, or indium. Under normal operation the MO reactants are never exposed to air; however, if accidental release occurs, it should be assumed that they would spontaneously ignite. When combined with hydrogen the pyrophoric nature of the Metal-Organic Reactants can create a dangerous fire situation. Metal-organics currently in use (or anticipated for future use):

- trimethylgallium (TMG)
- trimethylindium (TMI)
- tertiarybutylarsine (TBA)
- bis-cyclopentadienyl magnesium (CPMG or CPM2)
- trimethylaluminum (TMA)
- triethylgallium (TEG)

Gallium Arsenide—present only as wafers, harmless under most conditions.

Nitrogen—inert gas with low hazard potential, although it could be a simple asphyxiate, displacing oxygen in an enclosed environment.

Argon—inert gas with low hazard potential, although it could be a simple asphyxiate, displacing oxygen in an enclosed environment.

Hydrofluoric Acid—corrosive liquid which presents not only the typical hazards associated with strong acids, but is also a special health hazard, due to its characteristic of deep tissue/bone damage and potential death; also, pain/burning and tissue damage may not be immediately noticeable—can be delayed up to 24 hours.

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Hydrochloric Acid—corrosive liquid with characteristic odor, can result in destruction of living tissues and metals on contact, and even dilute solutions can cause skin rashes and burning.

Phosphoric Acid—corrosive liquid with no odor, can result in destruction of living tissues and metals on contact, and high concentration solutions can cause eye and lung burning, erosion of teeth.

Sulfuric Acid—corrosive liquid with characteristic odor, can result in destruction of living tissues and metals on contact, and exposure can cause skin rashes, discoloration of the teeth, and chronic bronchitis.

Nitric Acid—very active corrosive liquid which can cause destruction of living tissues and metals on contact; must be stored in glass containers, stains many materials yellow. At concentrations above 40%, nitric acid is also classified as an oxidizer and will react violently with many fuels, as well as bases. Can also be formulated as fuming nitric acid.

Ammonium Hydroxide—corrosive liquid but basic rather than acidic (high pH), characteristic odor similar to ammonia, can result in destruction of living tissues and metals on contact, and even dilute solutions can cause skin rashes and burning, especially of the eyes.

Buffered Oxide Etch—mixture of ammonium fluoride and hydrofluoric acid used to etch the oxide layer, commonly referred to as BOE, it is a corrosive liquid and also presents similar hazards to HF.

Hydrogen Peroxide—powerful oxidizer, can be extremely hazardous at high concentrations, causing burning of the skin/lungs/respiratory tract, and can react violently with many substances, generating heat and possibly reaching ignition temperatures.

Methanol—flammable liquid (with a flash point of 52F) which is structurally polar, meaning common firefighting foams will not work to extinguish; also known as methyl alcohol or wood alcohol, methanol is somewhat toxic and a sensitizer/irritant to the skin.

Propanol—flammable liquid, but structurally polar, meaning common firefighting foams will not work to extinguish; this is essentially an alcohol, similar to isopropyl alcohol.

Acetone—flammable liquid (with a flash point at about 1.4 degrees F) which is organic in structure and a ketone with a very characteristic odor; commonly used as a solvent/cleaning agent, acetone is somewhat toxic and a sensitizer/irritant to the skin, requiring PPE.

Trichloroethylene—generally regarded as a toxic (IDLH = 1000ppm) and a carcinogen, TCE is usually found in liquid form and administered via a bubbler; TCE vapors are moderately flammable, and often are associated with a chlorine-type odor.

Carbon Tetrachloride—usually in liquid form, this halon is a skin and eye irritant; in vapor form it is toxic below the odor threshold (IDLH = 200ppm), and carcinogenic; at CGF, carbon tetrachloride is a very dilute mixture, of 200ppm in hydrogen, so it should be considered flammable.

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6.3 Appendix C: Fire/Emergency Evacuation Plan

6.3.1 Egress Routes

See Evacuation Route Map on the following page.

- from north office area—leave area to the east, exit from the main door, once outside the building, proceed south to the Evacuation Grouping Area. A secondary route (when the primary is blocked for some reason) would be to go west and exit from the West Door.
- from the west office area and the west corridor: go to the West Door and exit from there, walk south to the Evacuation Grouping Area or go south to the new Southwest Door and exit from there, then walk south to the Evacuation Grouping Area.
- from the central corridor: go to the north lobby area and exit from the main Entry Door; once outside the building, walk to the Evacuation Grouping Area. A secondary route would be to the south, exiting into the gas delivery yard—which could be an area of higher hazard.

Once outside the building, proceed to the **Evacuation Grouping Area**, south of the CGF property, near the third base entrance to Isotopes Park. If indicated by conditions, evacuees can then be moved to a safer, final location.

6.3.2 Procedures for employees operating critical equipment

Shut down equipment as soon as possible (using EMO's), only if it can be done safely and will not delay the safe evacuation of the facility.

6.3.3 Headcount Procedures

All employees, contractors, visitors, and other building occupants are to gather at the Evacuation Grouping Area (south of the CGF property, at the Isotopes Park) for headcount to be established.

The CGF Evacuation Warden establishes the headcount, using the list of names provided at the Main Entry board. When the Warden is not available for headcount, the Back-up Warden will fill the role:

- Primary Warden— Ashwin Rishinaramangalam (573-6070)
-
- **Important Note: there is no person on our staff to back up the Primary Warden. It is understood that the Primary Warden, Ashwin Rishinaramangalam, is not to enter the facility without an Albuquerque Fire Department person accompanying him.**

6.3.4 Means of Notifying Occupants

Activate the nearest Fire Alarm pull station: there is one located near every exterior exit door.

6.3.5 Means of Notifying the Fire Department

Activate the Fire Alarm pull stations (same as above), which automatically signals the UNMPD alarm & dispatch center, who will then notify the Albuquerque Fire Department. The secondary method of notifying the Fire Department—which should be used in addition to the pull stations—is to call the 9-1-1 center from a telephone in a safe area. [Refer to the procedure as specified in Appendix D, Paragraph 1, on page 25] To call directly to the UNMPD dispatch center from a cell phone or other non-campus telephone, call 277-2241 (a *non-emergency* number).

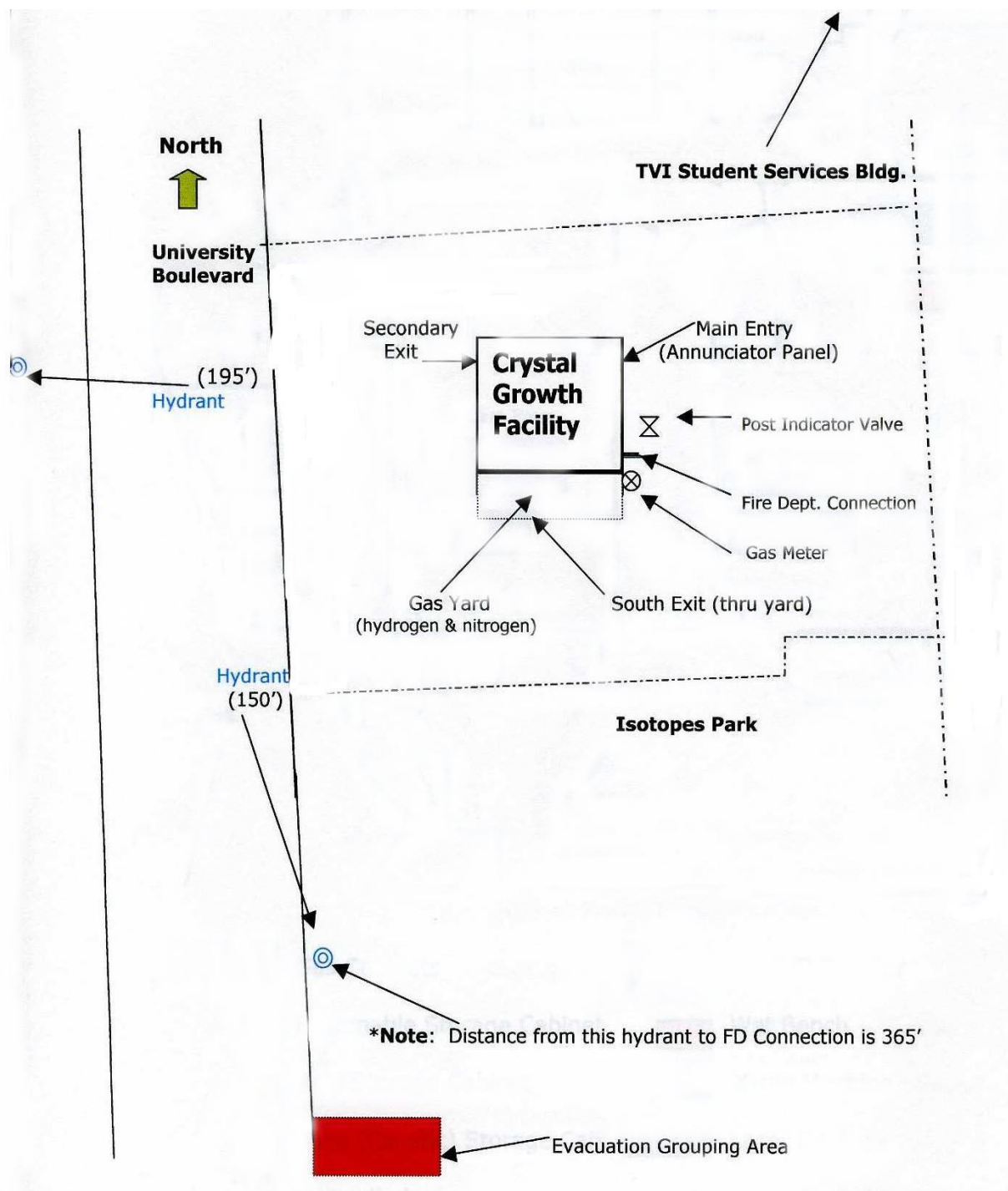
6.3.6 Personnel who can be contacted to provide additional information:

- Daniel Feezell (220-3899)
- Ashwin Rishinaramangalam (573-6070)

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6.3.7 Evacuation Route Map

Red Arrows signify the Primary Exit Route – Blue Arrows signify Secondary.



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6.4 Appendix D: Fire Safety Plan

6.4.1 Procedure for Reporting a Fire, or other Emergency

Call the UNM **9-1-1** Center, using a telephone in a safe area:

- When connected to the 9-1-1 dispatcher (at the UNMPD Emergency Center), you will be asked, "What is your emergency?" You should answer with the following information:
- "This is the Crystal Growth Facility—we have a [state the type of emergency, such as fire, gas leak, chemical spill, medical emergency, etc.] on the premises."
- "We are located at 1000 University Boulevard, SE, in the UNM Science & Technology Park (south campus)."
- Activate a Fire Alarm pull station, located at each exterior exit door.

6.4.2 Life-Safety Strategy

Procedures for notifying building occupants:

- Activate a fire alarm pull station (same as above).
- Make oral announcement, stating in a calm but loud voice: "Emergency! Emergency! Everyone must evacuate the building immediately."

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6.4.3 List of Major Fire Hazards

Hydrogen

- Hydrogen is a highly-flammable gas, meaning it will ignite across a wide range of mixtures with air, when exposed to an ignition source
- Hydrogen cylinders, ganged in 6-packs of cylinders, are kept in the gas yard on the south side of the facility
- The Carbon-Tetrachloride/Hydrogen mixture is almost pure hydrogen, and should be treated as such for fire-planning purposes

Pyrophoric Metal-Organics, used in the MOCVD reactors

- trimethylaluminum (liquid)
 - trimethylgallium (liquid)
 - trimethylindium (solid)
 - tertiarybutylarsine (liquid)
 - bis-cyclopentadienyl magnesium (solid)
 - triethylgallium
- Flammable Liquids (Typically used for maintenance/cleaning purposes)
 - methanol and isopropanol (IPA)
 - acetone
 - toluene

Electrical Hazards

6.4.4 Personnel responsible for Fire Equipment

- Wes Denton, CHTM/CGF Program Specialist 228-0809
- SRS/Fire Safety Division—contact can be made through the UNM Police Department.
- Western States Fire Protection (sprinkler system) @ 884-1844 (Note: may be contacted directly ONLY if UNM-SRS cannot be contacted first.)

6.4.5 Personnel responsible for Fuel Hazard

(for both flammable and combustible liquids, and for flammable/pyrophoric gases):

- Wes Denton, CHTM/CGF Program Specialist 228-0809

6.4.6 Personnel responsible for Chemical Hazard

- Wes Denton, CHTM/CGF Program Specialist 228-0809

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6.5 Appendix F – CGF Training Matrix

Position/Job	Safety Orientation	Chem Safety	HazWoper	Resp. Protection
Janitorial	X			
Lab Operator	X	X		
MOCVD Tech	X	X		X
ER Personnel	X	X	X	X
CGF Faculty	X	X		
Support Staff	X			
Contractors	X			

6.6 Appendix G – Contact Details

Title	Name	Office or Pager	Home Phone	Cell Phone
CHTM/CGF Program Specialist	Wes Denton	272-7009		228-0809
UNM-SRS/ Fire Safety Office	SRS Duty Officer	277-2753		
Western States Fire Protection*	Sprinkler System	884-1844		
Toxic Gas Monitor Engineer	TBD			710-4888
Gas Supplier (CRLS)	Kriss Stanley	277-5109		249-6689
Chemical Clean-up Contractor	Clean Harbors	800-645-8265		
Power Outage	UNM PPD Standby Manager via UNM Police	277-2241		

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7 Document Control History

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