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Food Processing Facility Decontamination Using Chlorine Dioxide Gas

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Chicago Section IFT
the First Section

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Why should there be interest in Food Facility Decontamination?

1. **Estimate of the immediate economic losses by the spinach industry due to *E. Coli* contamination of spinach in 2006 [GAO; Last Accessed 3.17.10]: $37 to $74 Million**

2. **Estimated cost to the nation's peanut producers from the 2009 salmonella contamination of peanut butter [Associated Press; Last Accessed 3.17.10]: $1 Billion**

3. **Estimated cost to *Florida's tomato industry* due to a mistaken salmonella finding in 2007 [Sarasota Herald Tribune; Last Accessed 3.17.10]: *$500 Million***

4. **… each year roughly 1 out of 6 Americans (or 48 million people) gets sick, 128,000 are hospitalized, and 3,000 die from foodborne diseases.**
   http://www.homefoodsafety.org/pages/media/safety_facts.jsp

5. **Foodborne illnesses cost an estimated *$152 billion* each year in health-related expenses.**
   Scharff, R.L., 2010. Health Related Costs from foodborne illness in the United States. Produce safety project at Georgetown University. Accessed at: http:// www.producesafetyproject.org /admin/assets/files/Health-Related-Foodborne-Illness-Costs-Report.pdf-1.pdf. Accessed on: 05/13/2010.

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Food Safety Modernization Act

The FDA Food Safety Modernization Act (FSMA) was signed into law January, 2011.

It aims to ensure the U.S. food supply is safe by shifting the focus of federal regulators from responding to contamination to *preventing.*

Effective July 2011

The first rule of this Act strengthens FDA's ability to prevent potentially unsafe food from entering commerce. It allows the FDA to administratively detain food the agency believes has been produced under insanitary or unsafe conditions. Previously, the FDA's ability to detain food products applied only when the agency had credible evidence that a food product presented was contaminated or mislabeled in a way that presented a threat of serious adverse health consequences or death to humans or animals.

http://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm253983.htm

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What to use?

Four (4) decontaminating techniques were considered for the space decontamination (3 fumigants and 1 liquid based)

1. **Manual fogging with liquid high level disinfectant**
2. **Ozone gas**
3. **Vapor Phase Hydrogen Peroxide (VPHP)**
4. **Chlorine dioxide gas (CD)**

Last three were known to be effective decontaminants to spore and non-spore forming bacteria under standard laboratory conditions.

i.e., clean flat surfaces lacking porous materials or potential dead-legs with which fumigant penetration might be hampered.

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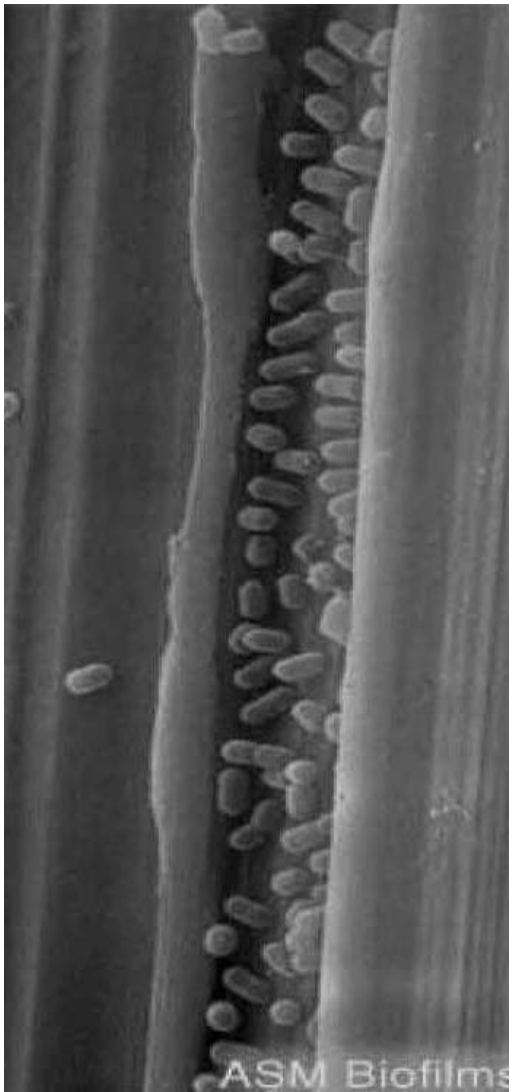
What is an Effective Decontamination?

- **All Decontamination methods can work based on the following:**
  - **Must reach ALL surfaces for a prescribed amount of time, which means you must have:**
    1. **Good and Complete Distribution**
    2. **Thorough and Total Penetration**
    3. **Sufficient Contact Time**
    4. **At specified concentration**
- **Any decontamination method requires a complete and thorough distribution of the sterilant or high level liquid disinfectant to get an effective decontamination**



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Fogging with liquid high level disinfectant

- **Fogging spray liquids around the room**
- **Foggers create small droplets that are affected by gravity**
- **Droplets do not reach the under side of equipment or components, behind equipment, inside ventilation grills, or cracks and crevices**
- **Large space decontamination is troublesome, not all surfaces can be realistically be sprayed and wiped**
- **The areas requiring decontamination were packed with equipment such that there was no easy access to walk through, so spraying would not be an option from an accessibility point of view**

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Ozone Gas Restrictions

- Generators do not generate enough for room decontamination (used mainly for odor control)
- Ozone is extremely volatile with short life span (20-30 min)
- Limited efficacy[1]
- Long cycle time (up to 36 hours)
- Requires high RH 80%-95%
- Issues with large volume (getting concentration to all areas due to short life span.
- Corrosive (high oxidation potential 2.07)
- Not US-EPA registered process
- Not NSF approved for BSC cabinets

1 Foarde, Karin and Eaton, Cary, Ph.D. "Ozone Antimicrobial Efficacy" EPA/600/R-08-137, Dec 2007 http://www.epa.gov/nrmrl/pubs/600r08137/600r08137.pdf
6 hours exposure 1000ppm 4.3log reduction of spores with high RH >80%

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Hydrogen Peroxide Vapor Restrictions

- **The areas that required decontamination had very tight spaces and lots of large equipment**
- **Difficult to distribute and maintain an appropriate concentration of vapor hydrogen peroxide within the many rooms and around all of the equipment and items**
- **Heat up liquid HP to boiling point (+109^{o}C) and inject into room**
- **High 90% RH during the cycle might have effect on materials**
- **Shadow Areas**
- **Material compatibility**
- **Not NSF approved for BSC cabinets**

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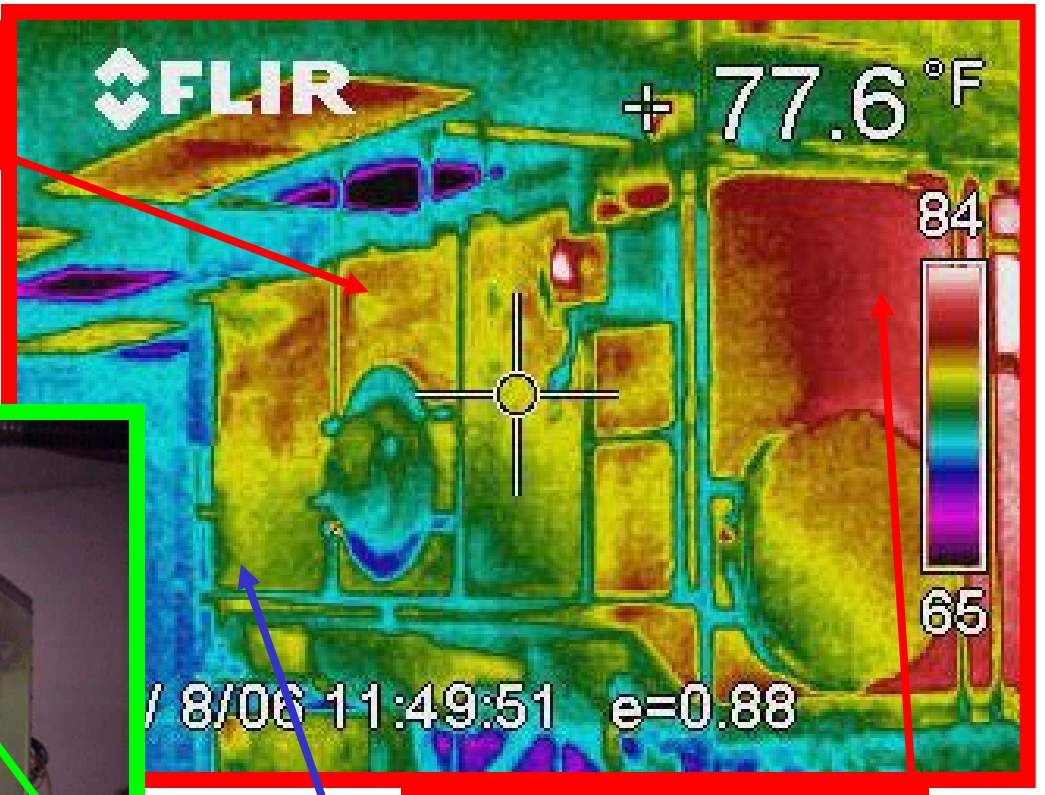
Decontamination Images

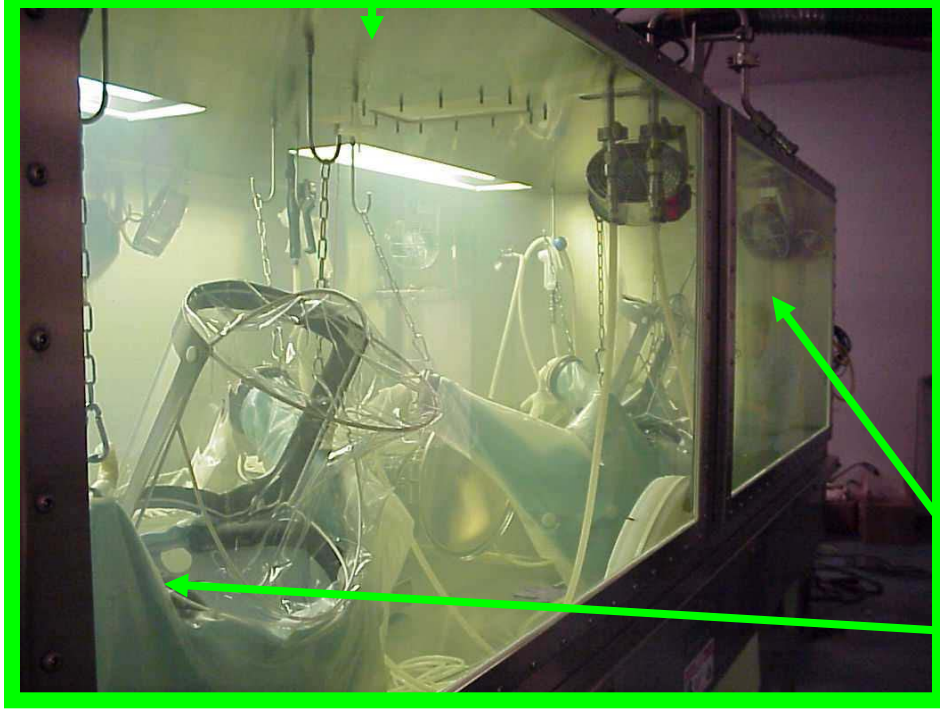
Thermal Image of a Vapor Phase Hydrogen Peroxide Cycle (Poor Distribution)



Warmer (more VPHP)

Cooler (Less VPHP)

Picture of a Chlorine Dioxide Gas Cycle (Excellent Distribution & Penetration



Chlorine Dioxide Gas Even Distribution & Penetration

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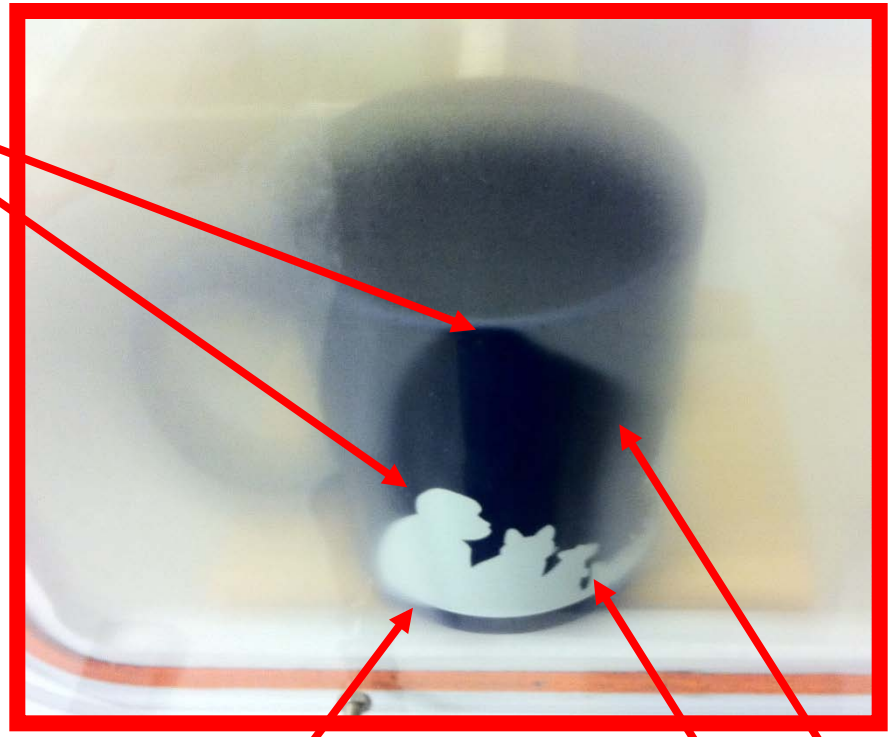
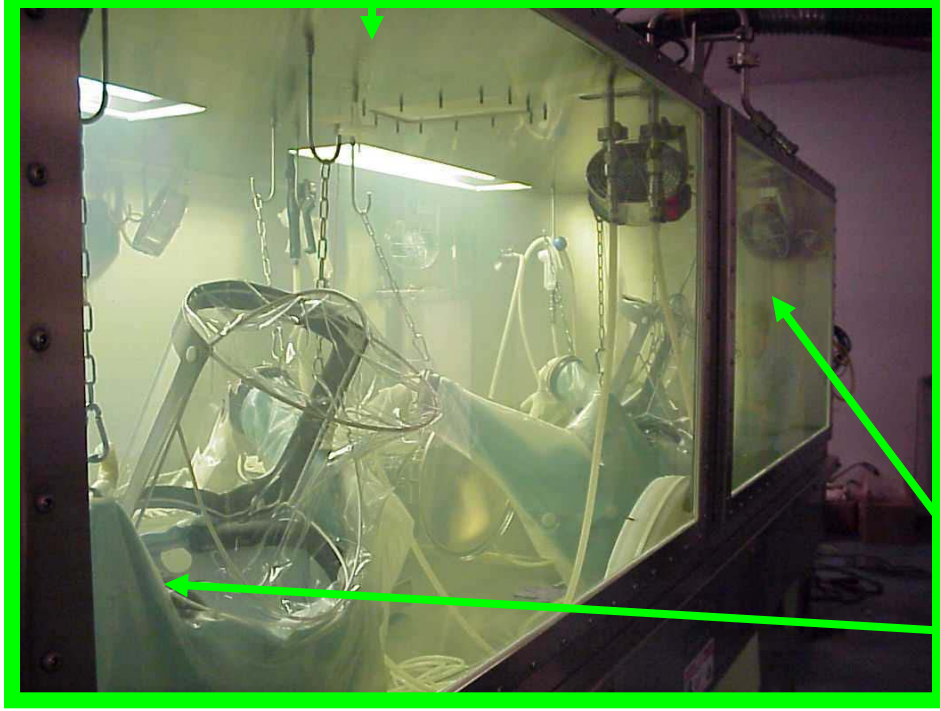
Decontamination Penetration Images

Isolator Image with Vapor (Poor Penetration)



Poor Penetration

Picture of a Chlorine Dioxide Gas Cycle (Excellent Distribution & Penetration



Chlorine Dioxide Gas Even Distribution & Penetration

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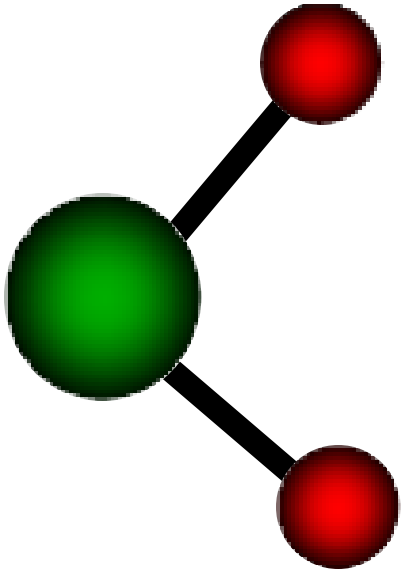
What is Chlorine Dioxide (CD) ?

Properties:

- **Yellow-Green Gas[1]**
- **Water Soluble[2]**
- **Boiling Point 11°C[3]**
- **Tri-atomic Molecule**
- **Molecular Weight 67.5**



1. **Ability to be monitored in real time with a photometric device. Not subject to condensation or affected by temperature gradients.**
2. **Ability to penetrate water (not all sterilants can penetrate water, *vapors can not*)**
3. **Chlorine dioxide is a "true gas" at room temperatures; which means excellent distribution and penetration.**

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Chlorine Dioxide Gas

- Chlorine Dioxide is a true gas at room temperatures
- True gasses distribute to reach even tightly packed areas
- Does not condense on surfaces
- Shortest cycle times
- Does not require post exposure wipe down or neutralization
- Effective at RH at 65%
- Non-Carcinogen (ACGIH – NO, OHSA – NO)
- Photometric sterilant concentration monitoring and control
- EPA approved as a sterilant
- NSF approved for BSC cabinets

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What to use?

Four (4) decontaminating techniques were considered for the space decontamination (3 fumigants and 1 liquid based)

1. ~~**Ozone**~~
2. ~~**Vapor Phase Hydrogen Peroxide (VPHP)**~~
3. **Chlorine Dioxide (CD)**
4. ~~**Manual fogging with liquid high level disinfectant**~~

Based on material compatibility, safety, efficacy, and cycle times, gaseous chlorine dioxide was chosen to perform the decontamination of the food processing facility.

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Decontamination Process

- Pre-Condition
  - Raise humidity to 65% RH
- Condition
  - Hold humidity at 65% RH
- Charge
  - Target Concentration 1 mg/L
- Exposure
  - Target 2 hour
- Aeration
  - Approximately 45 minutes until entry without PPE
- No measurable concentration outside facility
- No leaks detected inside facility

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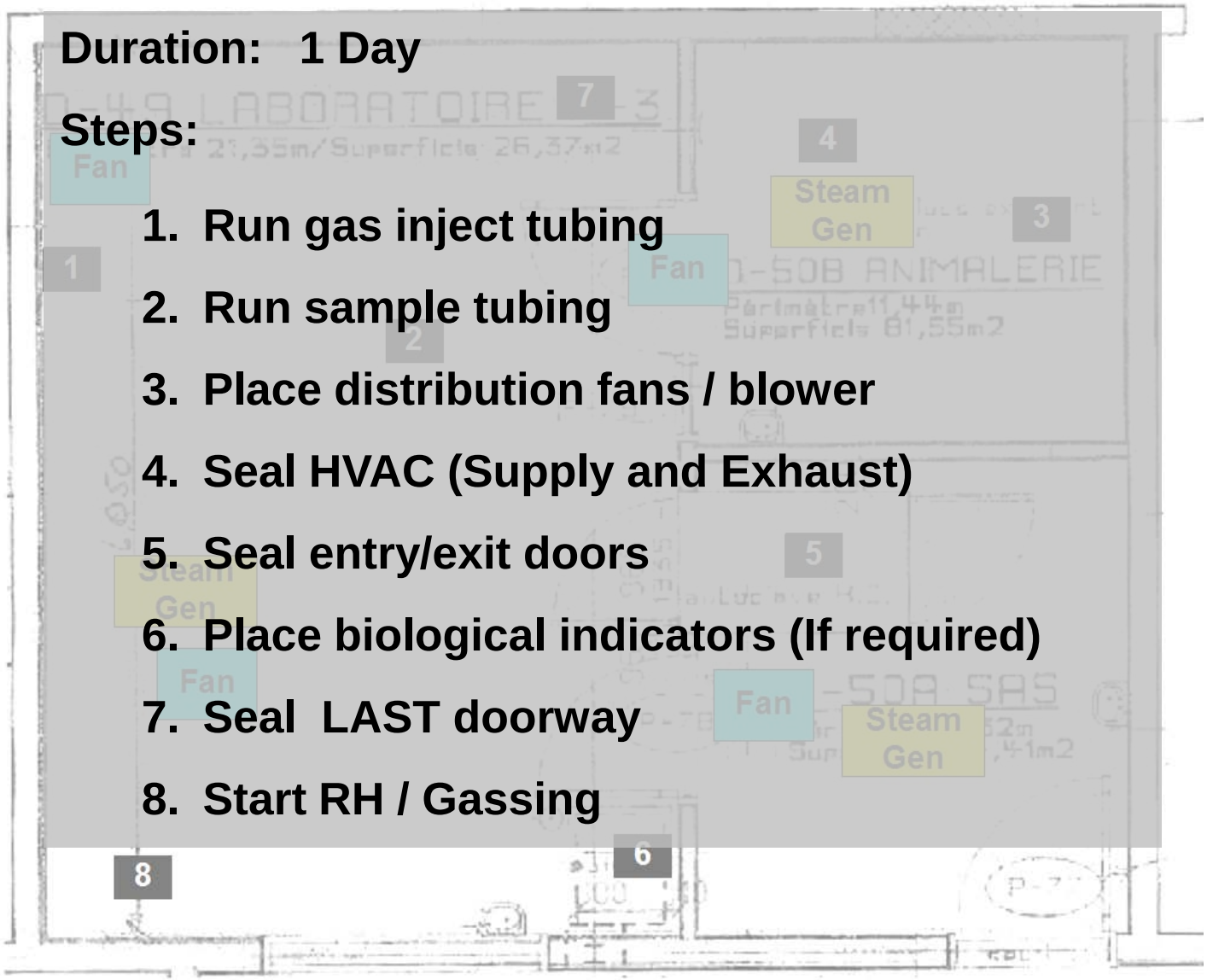
Decon Site Preparation (Set Up Equipment)

Duration: 1 Day

Steps:

1. **Run gas inject tubing**
2. **Run sample tubing**
3. **Place distribution fans / blower**
4. **Seal HVAC (Supply and Exhaust)**
5. **Seal entry/exit doors**
6. **Place biological indicators (If required)**
7. **Seal LAST doorway**
8. **Start RH / Gassing**



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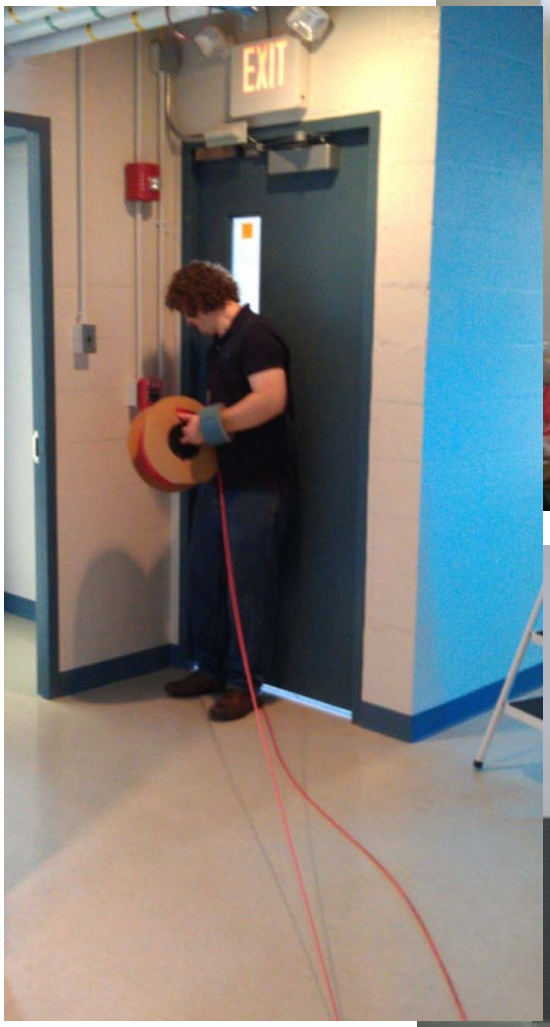
Gassing Preparation – Run Tubing



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Gassing Preparation – Seal Doorways

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Gassing Preparation – Seal Mouse holes

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Gassing Preparation – Seal Main Supply

Surface to Seal to eliminate leakage

Area may be filled with gas and pull cord eliminates the need to enter area.

Pull cord to remove tape.

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Gassing Preparation – Seal Roof Exhaust

Surface to Seal

Access Door

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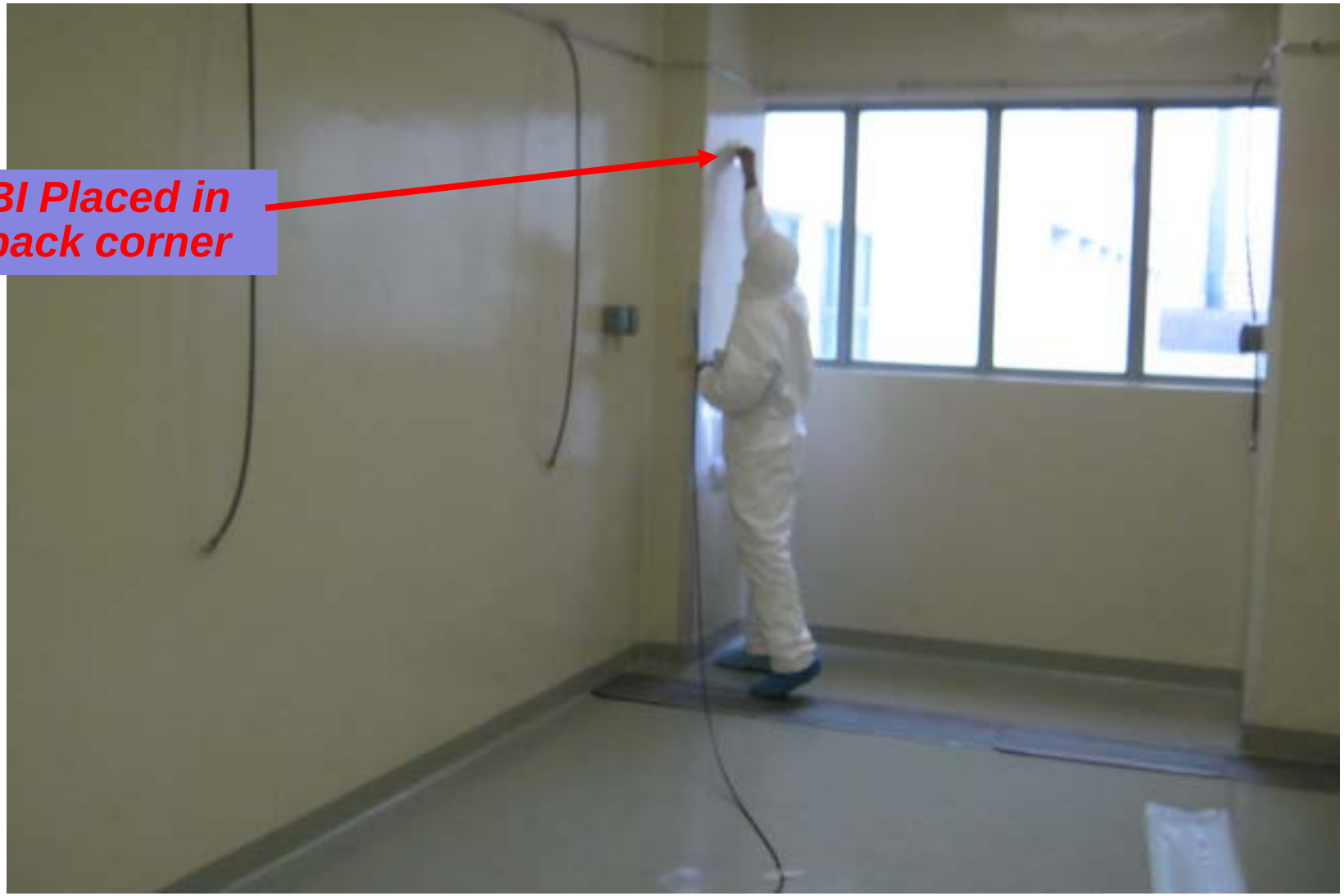
Gassing Preparation – Place BI's



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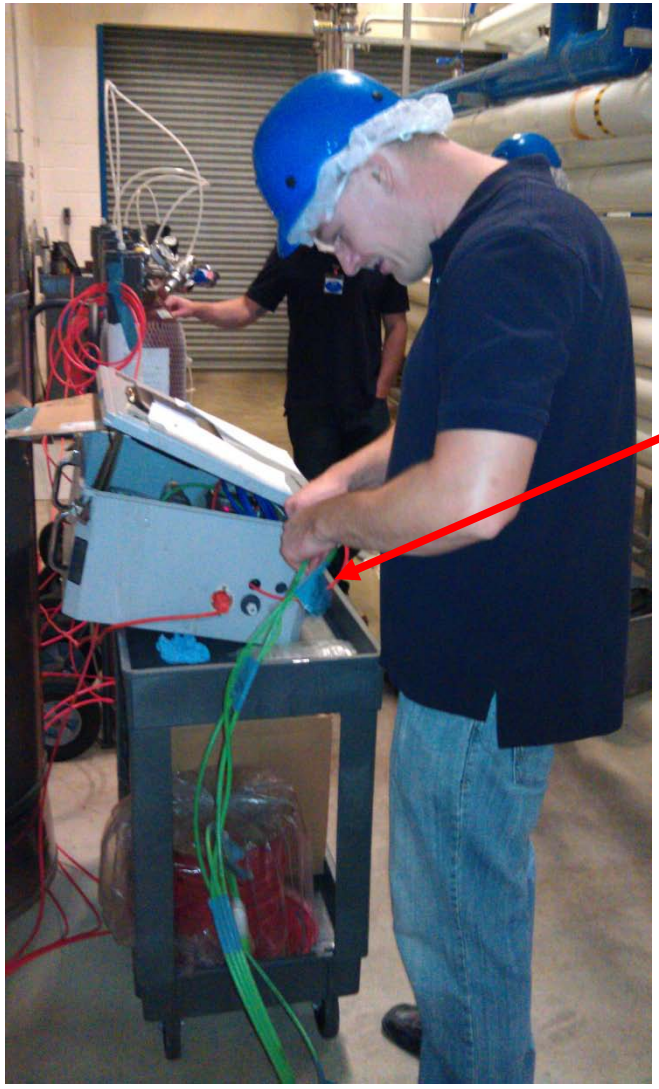
Start Gassing



Make Connections

And

Document Readings

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Decontamination Gassing Complete

Clean Up

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Gassing Complete – Unseal Doorways

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Gassing Complete – Remove BI's

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Gassing Complete – Remove Tubing and Fans

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Gassing Complete – Remove Generators

Purge Regulators

Disconnect and Remove Generators

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Applications at Food Processing Facilities

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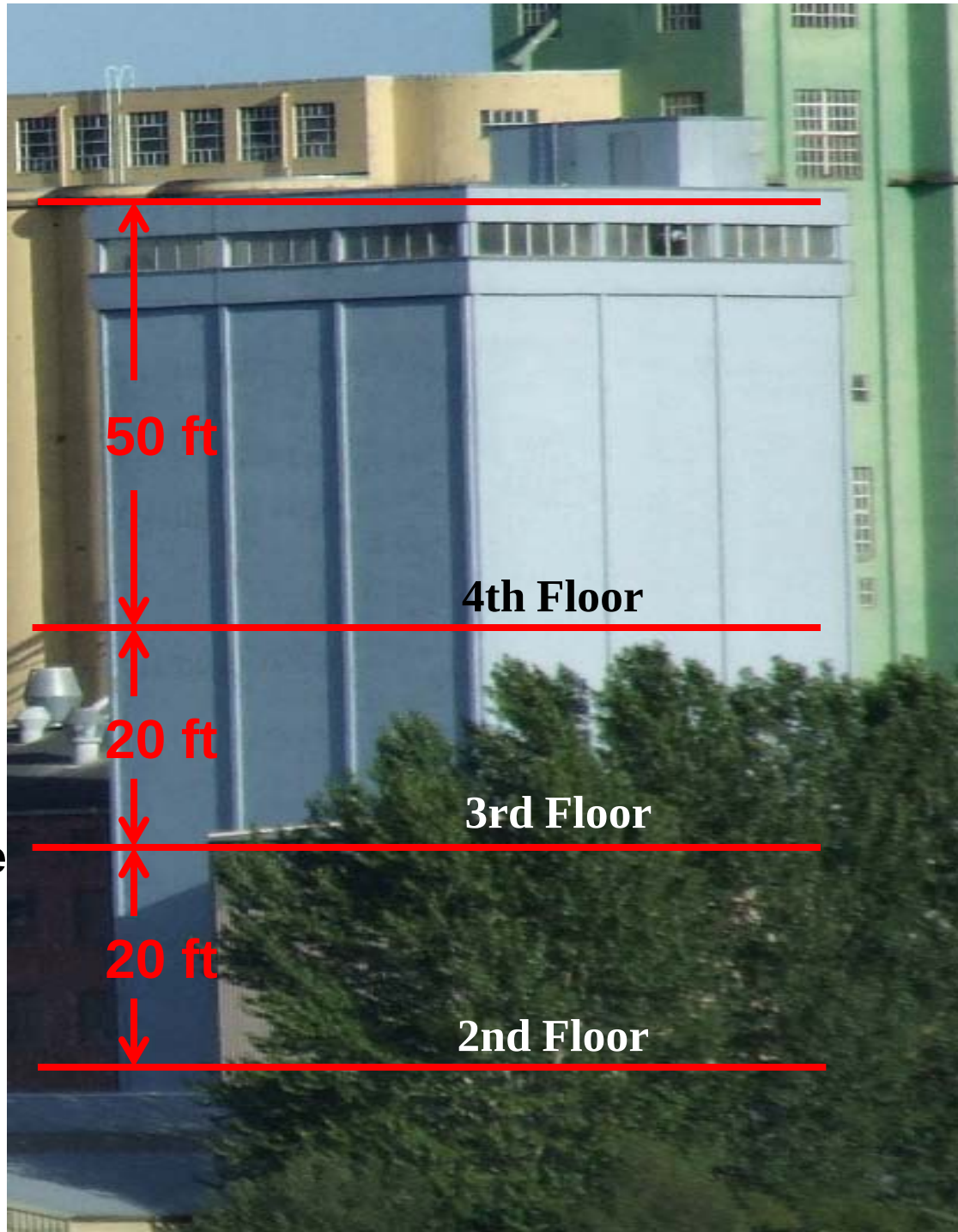
Decontamination Area Photo

- 280,000 ft^3
- 9 Stories (90ft)
- 3 Floors
- *Salmonella spp.* Contamination
- Decontaminated 2 times
- Decontamination 1
  - Raw uncoated concrete
- Decontamination 2
  - After painting/sealing concrete



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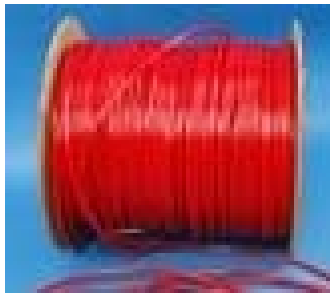
Equipment Used

- 31 manual generators used
- 2 EMS CD Gas Sensor Modules
  - 13 Sensor points
- 25 - 12” Distribution Fans
- 12 Blowers
- Extension Cords
- Duct Tape
- 1/4” gas inject tubing
- 1/4” gas sample tubing
- Biological Indicators (BI’s)
  - *Bacillus atrophaeus* (10^6 log/CFU)



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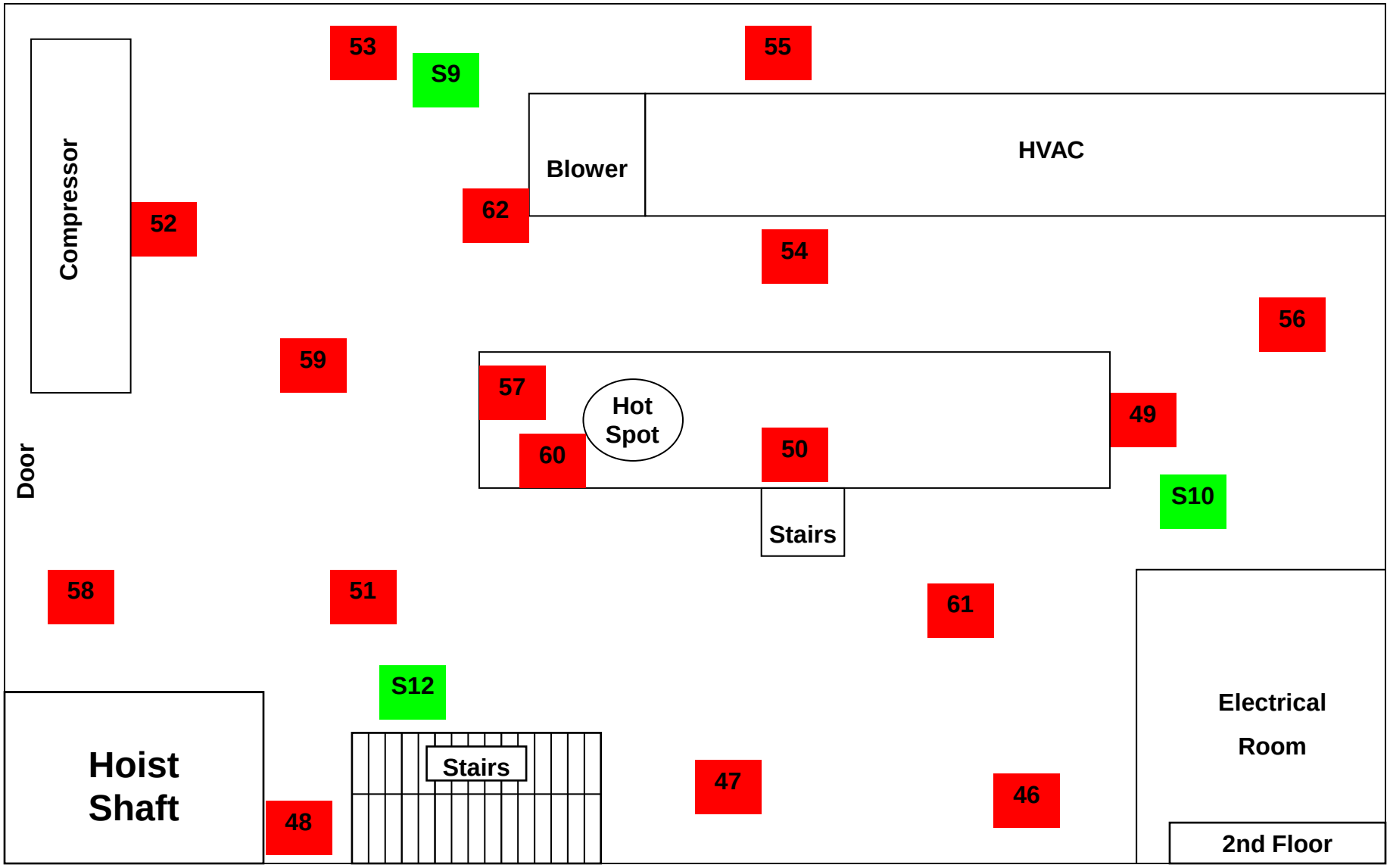
2nd Floor

Gas Inject

Gas Sample



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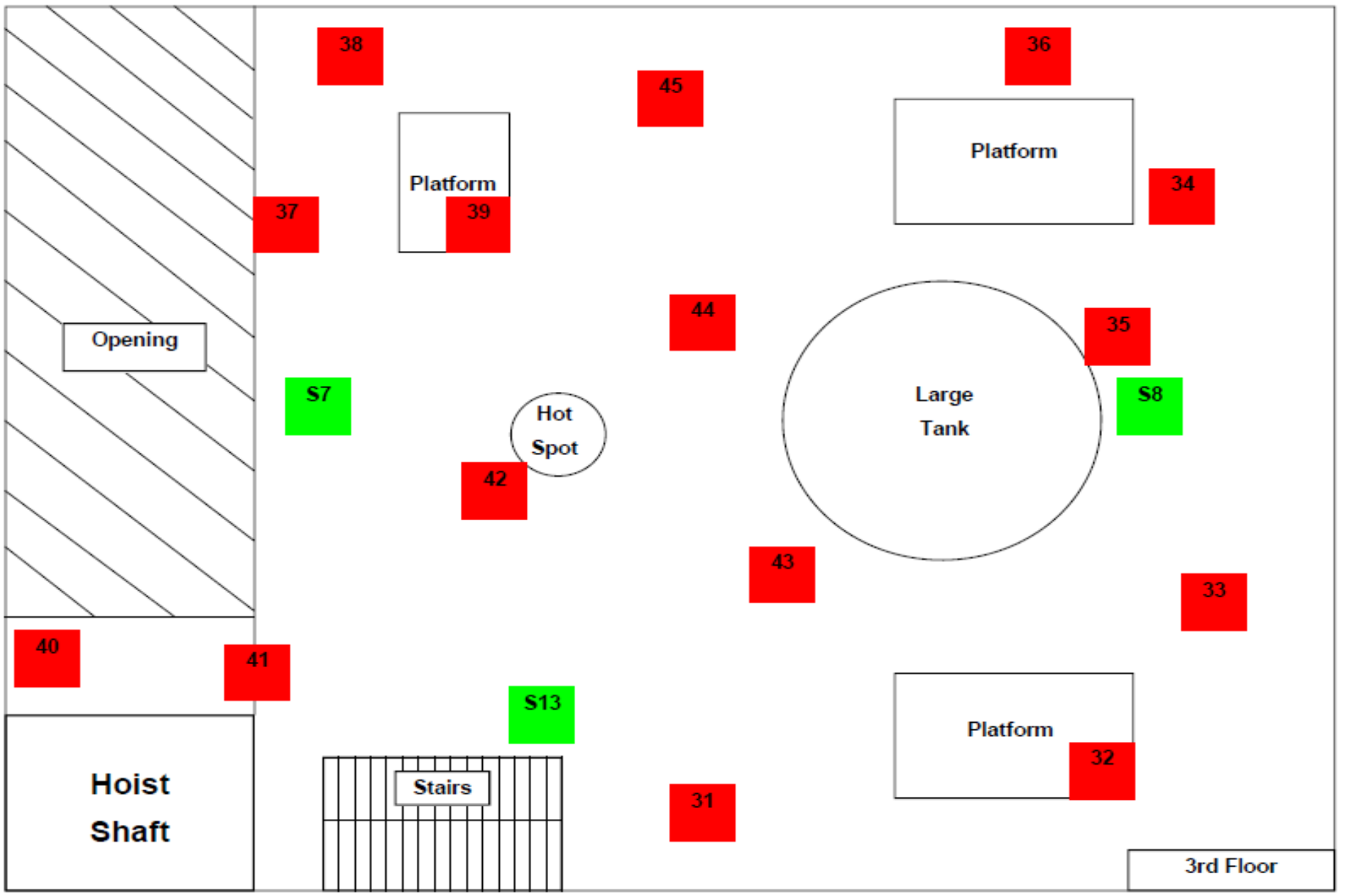
3rd Floor



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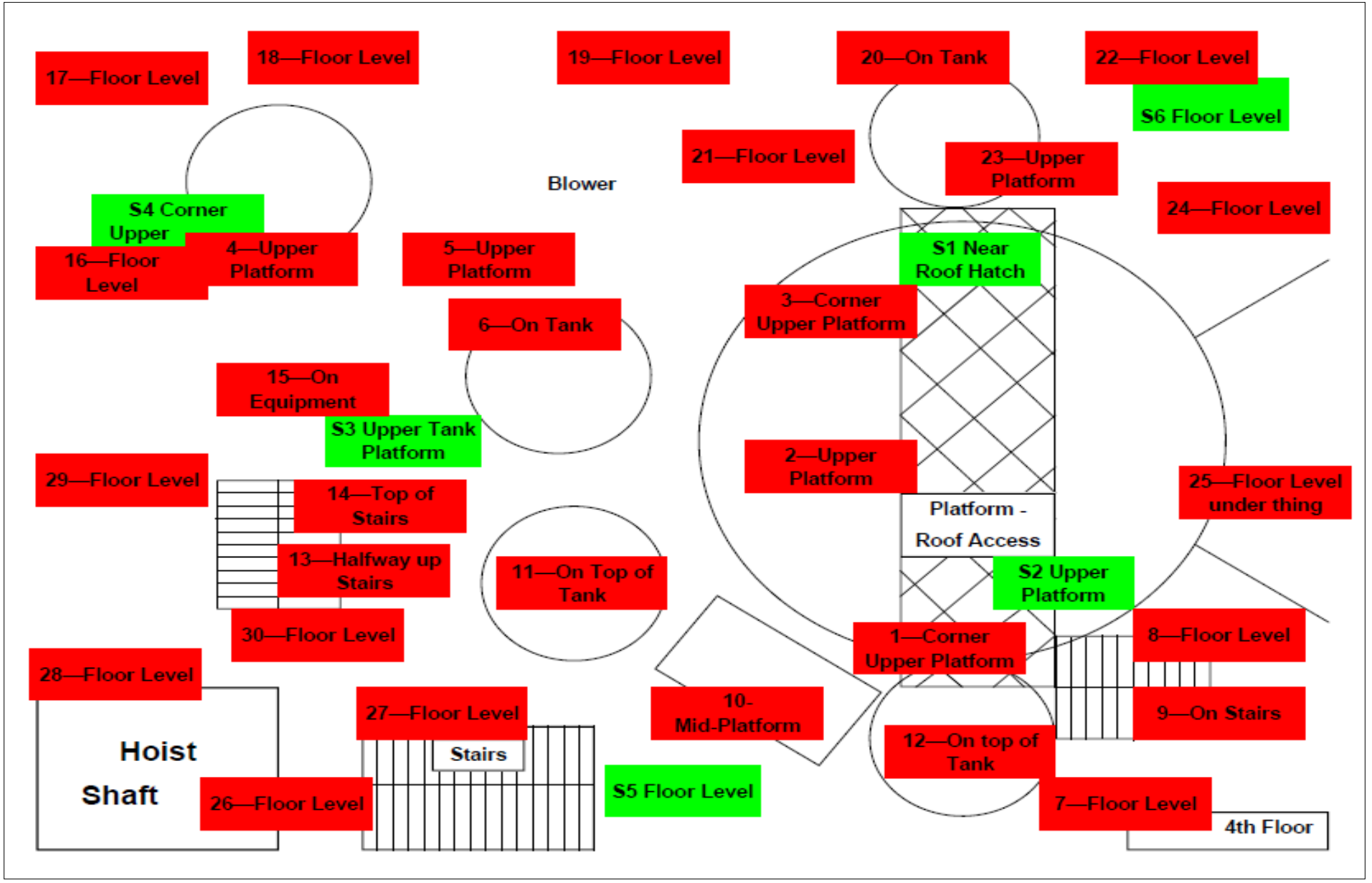
4th Floor

Gas Inject

Gas Sample



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Decontamination Area Photo

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Decontamination Area Photo

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Decontamination Area Photo

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Decontamination Area Photo

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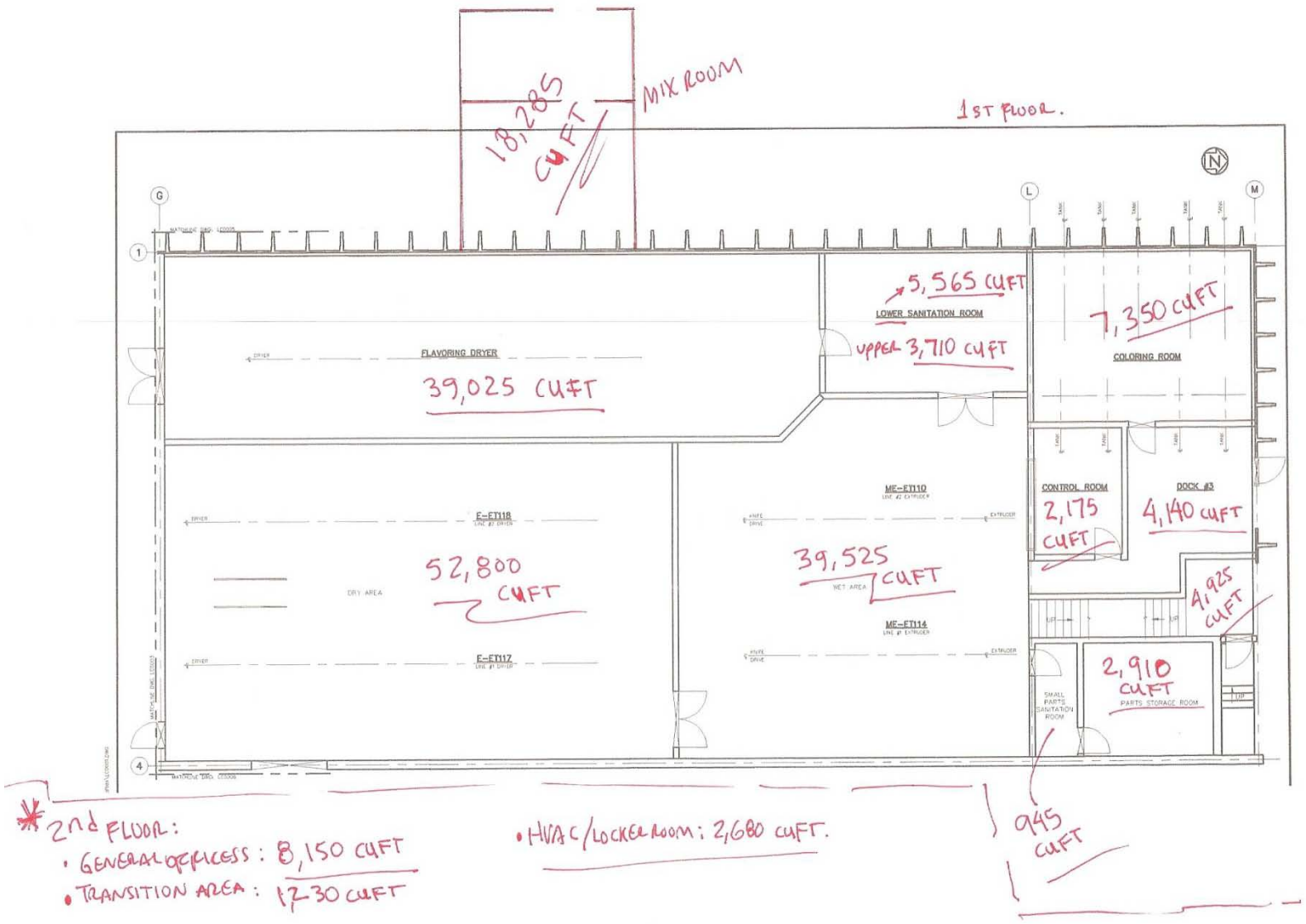
Decontamination of Protein Powder Grinding, Drying, and Packaging Facility *(6796 cu m - 240,000 cu ft)*



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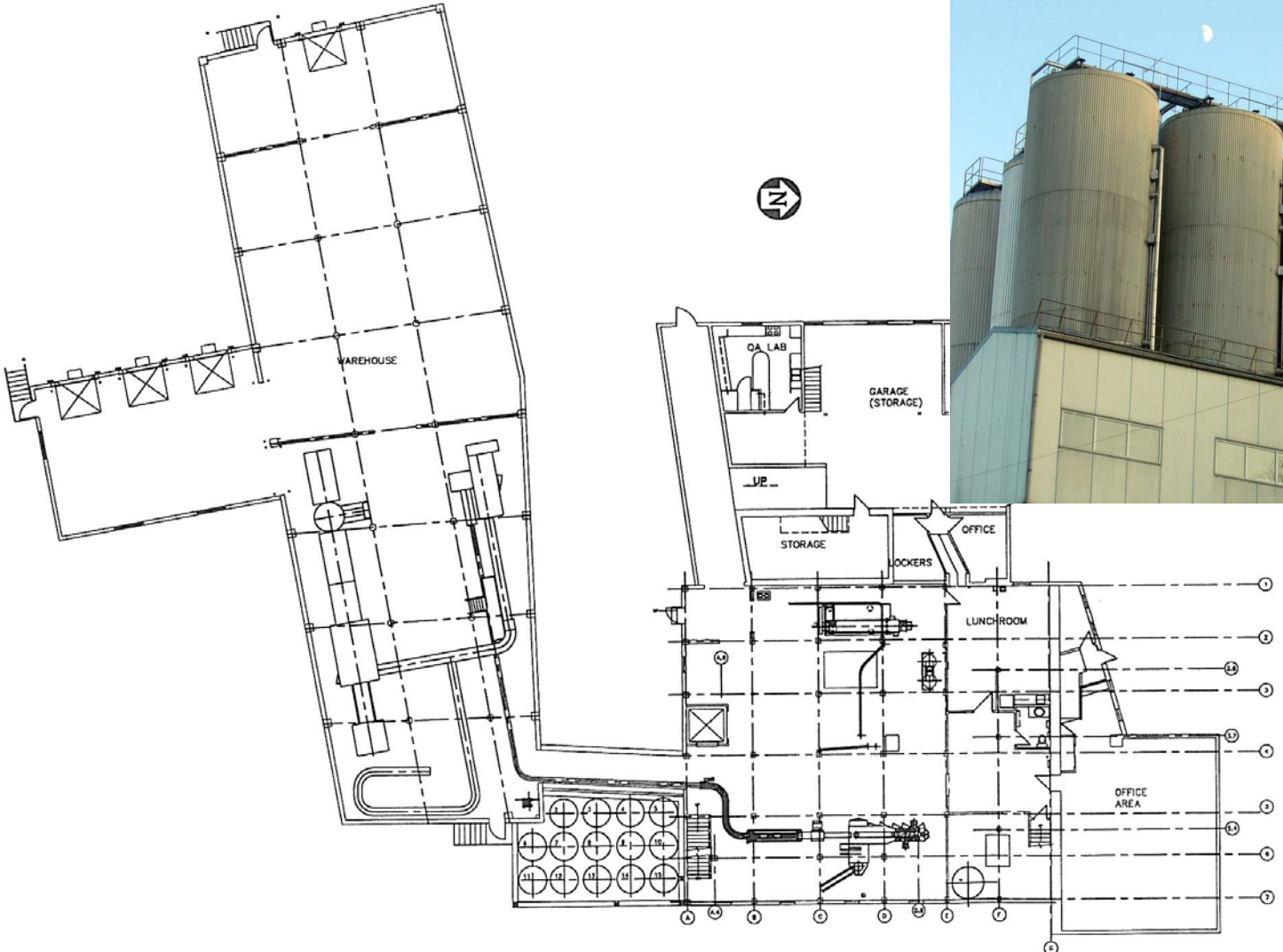
Decontamination of Grain Refining and Packaging Facility *(6512cu m - 230,000 cu ft)*



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Sterilization of Juice Storage Tank with Piping

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Sterilization of Intermodal Transportation Containers

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Conclusions

- **Complete kill of all Biological Indicators in each application**
- **Rapid decontamination cycles**
- **No physical residue observed as would be if formaldehyde or fogging was used.**
- **No indication of material degradation on any electronics or machinery**
- **CD has proven itself to be a practical and effective method for decontaminating full food processing facilities**

Questions?

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