PROCESS SAFETY EDUCATION LESSONS LEARNED

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USING CASE STUDIES AND RECEIVING ANCILLARY BENEFITS THROUGH INSTRUCTION AND USE OF WHAT-IF HAZARD REVIEWS IN AN ACADEMIC RESEARCH ENVIRONMENT

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PHR - TEAM REVIEWS IN A RESEARCH SETTING – A GOOD THING

- If planning and preparation for a review is conducted in a particular manner:
  - You could cancel the review at the last minute and still have derived benefits
  - Participants will be better prepared to spot and solve problems in the future.
- EH&S can be an effective facilitator rather than a a subject matter technical expert at the review table .

STEP 1 – ARRANGING THE REVIEW

- Either EH&S is contacted by the Principle Investigator (PI) or EH&S does the contact
- PI is directed to:
  - Arrange time for the review
  - Invite the engineer with primary responsibility for the process. This person will be responsible for having the review conducted and documented. EH&S will participate and facilitate if you would like.
  - Review team participants including maintenance
- Result – Accountability and Responsibility Verified – as well as realization that there may be other stakeholders with questions

CASH REGISTER STORY

A business man had just turned off the lights in the store when a man appeared and demanded money. The owner opened a cash register. The contents of the cash register were scooped up, and the man sped away. A member of the police force was notified promptly.

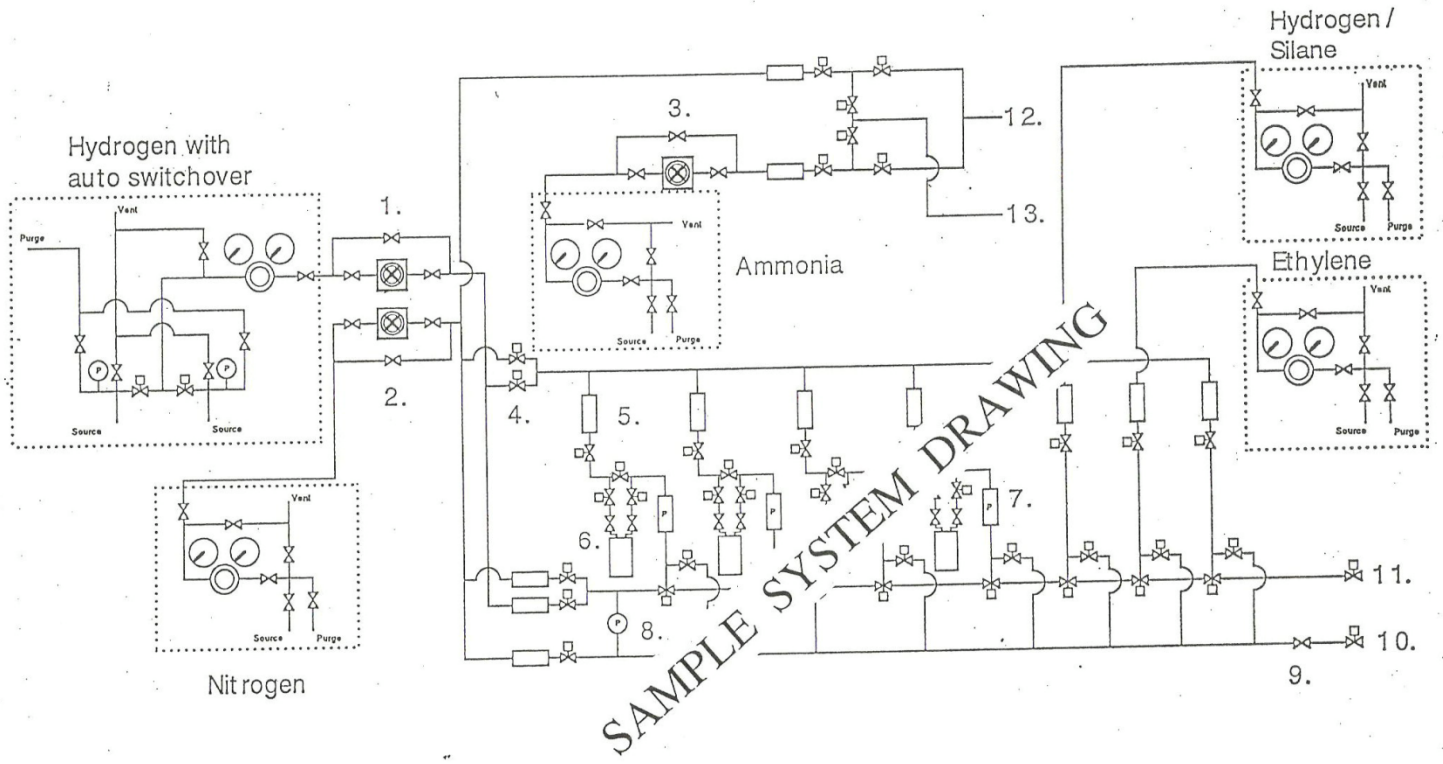
STATEMENTS	Command	Consultation	Consensus
1. A man appeared after the owner had turned off his store lights.	T F ?	T F ?	T F ?
2. The robber was a man.	T F ?	T F ?	T F ?
3. The man who appeared did not demand money.	T F ?	T F ?	T F ?
4. The man who opened the cash register was the owner.	T F ?	T F ?	T F ?
5. The store owner scooped up the contents of the cash register	T F ?	T F ?	T F ?
6. Someone opened a cash register.	T F ?	T F ?	T F ?
7. After the man who demanded the money scooped up the contents of the cash register, he ran away.	T F ?	T F ?	T F ?
8. The cash register contained money but the story does not state how much.	T F ?	T F ?	T F ?
9. The robber demanded money of the owner.	T F ?	T F ?	T F ?
10. The story concerns a series of events in which only 3 persons are referred to: The owner of the store, a man who demanded money, and a member of the police force.	T F ?	T F ?	T F ?
	_____	_____	_____
	Number of Correct Answers		

(Over)

STEP 2 – PREPARATION FOR THE REVIEW

- PI is provided in advance with review forms, checklists, and brief description of how review is to be conducted.
- Instructions include requirement for:
  - P&ID of the process
  - Process description using P&ID of the process to the review team
  - List of Materials and Potential Hazards
  - Bring any SOPs
  - Startup Checklist

SAMPLE SYSTEM DIAGRAM



1. Hydrogen purifier
2. Nitrogen purifier
3. Ammonia purifier
4. Carrier gas selection valves
5. Metalorganic carrier gas MFC
6. Metalorganic bubbler
7. Metalorganic bubbler pressure regulator
8. Run/vent differential pressure gauge
9. Vent pressure regulation valve
10. Vent line, diluent and metalorganics
11. Run line, diluent and metalorganics
12. Vent line, ammonia
13. Run line, ammonia

Overview of Process and Equipment

Principal Investigator: _____

Qualified Operator(s): _____

Lab Location: _____ Phone: _____

Office Location: _____ Phone: _____

Brief Description of Process: _____

_____

_____

Brief Description of Equipment: _____

_____

_____

List the Chemicals Used:

Gases

Chemical Name	Max. Flow Rate	Typical Flow Rate	Typ. Flow Duration	# of Runs / Week

Liquids

Chemical Name	Max. Flow Rate	Typical Flow Rate	Typ. Flow Duration	# of Runs / Week

Solids

Chemical Name	Quantity in System	Quantity Consumed per month (year)

System Basics

What is the normal operating pressure of the system?_____

List the types of alarms (audible, visible) on the system._____

_____

Does the system have the following: **EPO** (Em. Pwr. Off), **EGO** (Em. Gas Off), Gas Monitoring, Exhaust Flow Monitoring?_____

_____

_____

Can the following hazards exist?

___ Explosion
___ Implosion
___ Electrocution
___ Electric Shock
___ Electric Burn
___ Thermal Burn (hot)
___ Thermal Burn (cold)
___ RF Exposure
___ RF Burn
___ Radioactive Exposure
___ Allergic Reaction
___ Exothermic Reaction
___ Excessive Noise
___ Intense Light
___ Laser
___ Pinch Points
___ Falls
___ Struck By
___ Caught Between
___ Sharps / Cuts
___ Air Contamination
___ Water Contamination
___ Soil Contamination
___ Muscle Strain
___ Eye Strain

Laboratory Equipment Startup Checklist

- Clearances all appropriate
- Emergency systems (sprinkler, smoke alarms, gas alarms, etc) all functional from lab to Public Safety
- All items from applicable hazard reviews are resolved
- Lab Safety plan completed and approved
- Emergency procedures, including evacuation are in place
- All applicable employee / student training has been conducted
- All equipment interlocks have been tested and are operational
- Equipment using hazardous chemicals or gases have been tested with low hazard materials (baths filled with water, aspiration systems tested, inert gases used for hazardous gas equipment) with all systems found to be functional - no leakage,etc.
- Ventilation systems have been balanced and labeled, with ventilation alarm devices in place
- Appropriate electrical inspection has been performed
- Key work practices and procedures are understood (chemical/gas receiving, transport, disposal, gas cylinder changes, equipment troubleshooting and maintenance)

Comments

_____

_____

_____

_____

Both Signatures Required for Approval for Startup

Lab Principal Investigator _____ Date:_____

Env. Health and Safety_____ Date:_____

STOP HERE – WHAT HAS RESEARCH GROUP LEARNED BEFORE REVIEW HAS EVEN STARTED ?

- Step 1 Result – Accountability and Responsibility Verified – as well as realization that there may be other stakeholders with questions
- Step 2 Result – Have schematic for use with review and for posterity – mgt of change. Understand what will need to be in place prior to startup. Have understanding of equipment operation and materials to describe process and hazards

STEP 3 – CONDUCT REVIEW

- Establish Ground Rules – Example - Won't Accept Procedural Controls only For High Severity Events – MOCVD example
- Facilitate by Allowing Sufficient Discussion for Process Owners (Grad Students, Post Docs) to Reach Appropriate Conclusions - "Muzzle the Experts" - "It's the Process Stupid"
- Document, Assign Follow Up Action – Reference Startup Checklist

LESSONS FOR THE TEAM MEMBERS (LESSONS LEARNED)

- Process Safety Review with Maintenance Input – "I won't do that" Involve Maintenance Early – Pre-review is useful
- Safety Review with Post Doc and Graduate Student – "I'm leaving, she will manage this equipment" – Knowledge transition – Management of Change
- Process Safety Review including Cylinder Change Procedure – "you never closed the gas supply valve" – Benefit of Drawings and written SOPs
- Blue Collar Input on Silane Review – "There's that V-2 again"
- Lockout / Tagout on Silane Review – "Not sure we addressed this adequately on our installation" – Benefits to the reviewers as well as those reviewed
- Hydrogen Fire in Glove Box Article (How Not to Write a Lessons Learned)

SOME COMMON INCIDENT CAUSES

- Inadequate Understanding – Chemical, Physical Properties of Products / Byproducts
- Inadequate Engineering Controls
- Reliance on Work Practices in Lieu of Engineering Controls
- Inadequate Selection / Use of PPE
- Failure to Practice Lockout/ Tagout
- Human Factors Problems Not Recognized
- Inadequate Attention to Management of Change

HORROR STORIES (LESSONS LEARNED FOR EXPERIMENTAL PLANNING)

- Lockout / Tagout - Disilane Fire in Cluster Tool
- Human Factors - Clean Hood Hotplate
- SOPS Instead of Engineering Controls - MOCVD Purge Sequence
- Failure to Examine / Test Systems - Silane Scrubber Alarms
- Lack of Redundant Controls -Clean Room Immersion Heater
- Failure to Read the Label - Cylinder Stencil vs Label - Arsine
- Management of Change - Hydrogen Fire in Glove Box

DRIERITE COLUMN EXPLOSION

- Disilane Fire (lockout / tagout)
- Clean Hood Hotplate (human factors)
- MOCVD Purge Sequence (engineering controls in lieu of work practices)
- Silane Scrubber (don't make assumptions)
- Clean Room Immersion Heater (redundant controls and devastating business interruption)
- Hydrogen Fire in Glove Box (Mgt of Change)

DRIERITE COLUMN EXPLOSION INCIDENT CAUSE (S) ?

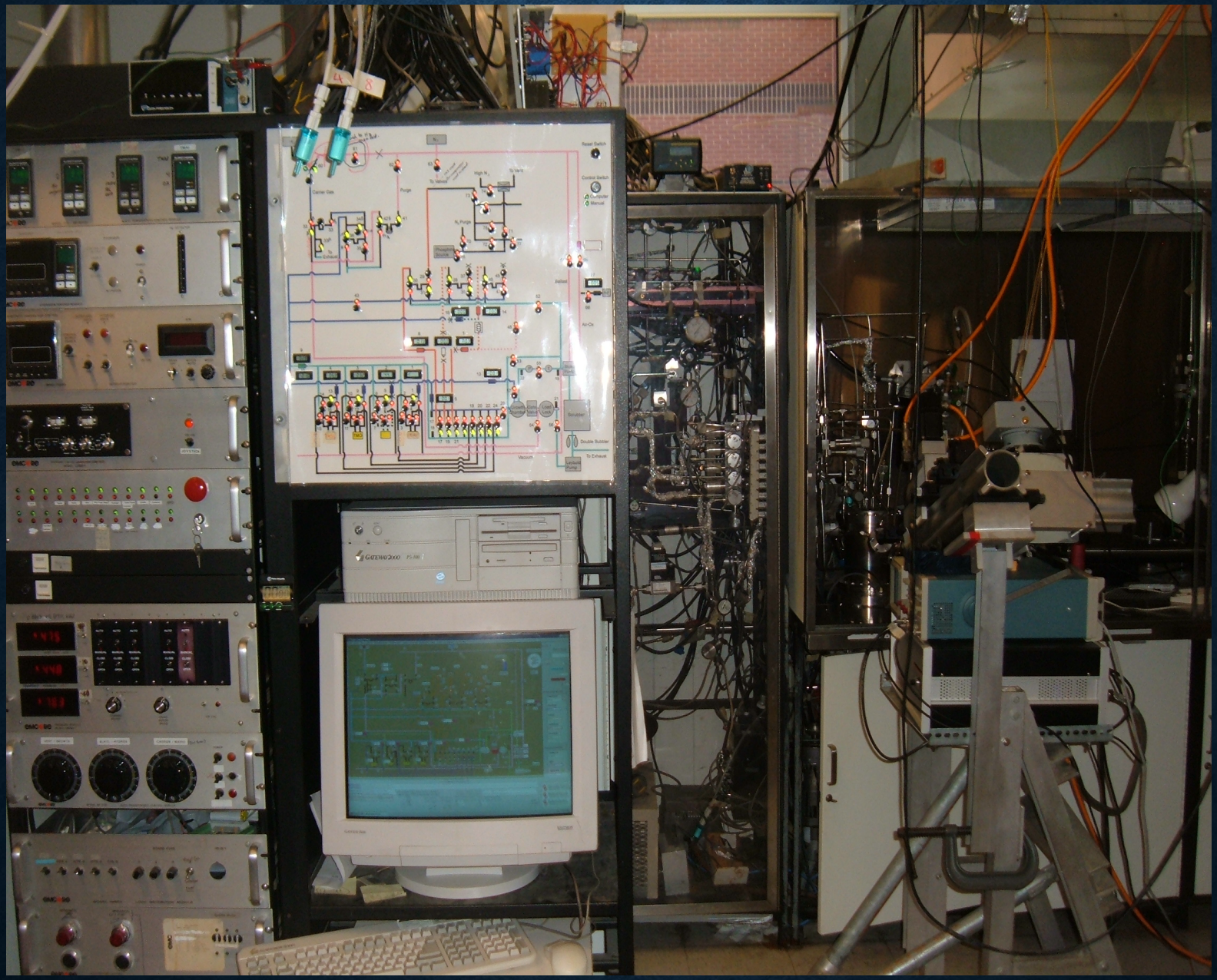
- Inadequate Understanding – Chemical, Physical Properties of Products / Byproducts
- Inadequate Engineering Controls
- Reliance on Work Practices in Lieu of Engineering Controls
- Inadequate Selection / Use of PPE
- Failure to Practice Lockout/ Tagout
- Human Factors Problems Not Recognized
- Inadequate Attention to Management of Change
- Other ?

HUMAN ERROR
TREVOR KLETZ - "WHAT WENT WRONG"

"They know what they should do, want to do it, and are physically and mentally capable of doing it. But they forget to do it. Exhortation, punishment, or further training will have no effect. We must either accept an occasional mistake or change the work situation so as to remove the opportunities for error or make errors less likely."

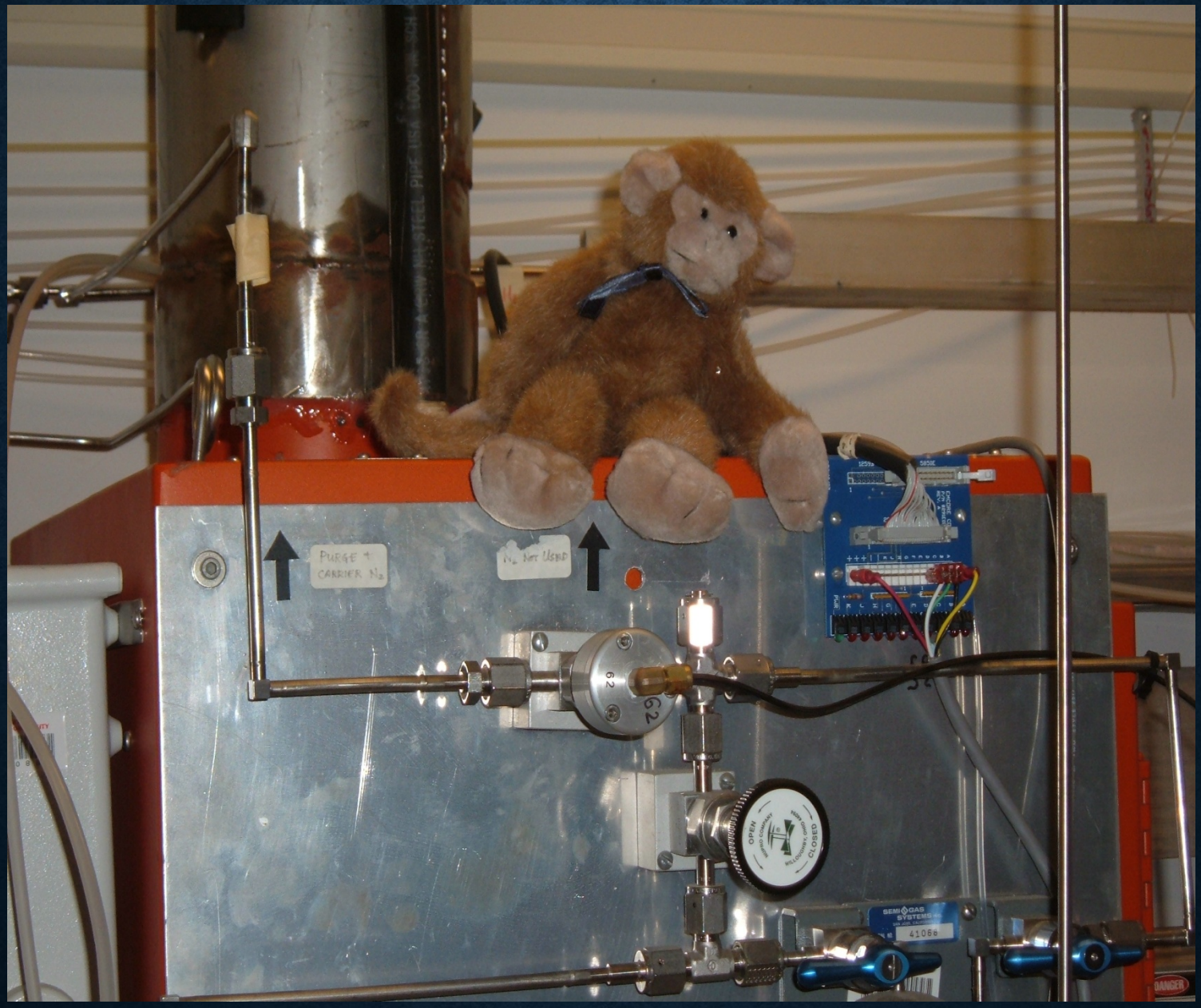
ADDITIONAL BENEFITS FROM REVIEW

- Participants Learn and Remember Expectations – Useful for Future Projects
- Procedural Controls are Rolled Into SOPs (also could test SOPs during review)
- Participants Learn the Process
- PHR itself is documented for future reference
- Can apply to non research applications – Lab Exhaust / HVAC, etc



MAKING / LEAVING AN IMPRESSION AND CONCEPTS TO KEEP

- http://www.youtube.com/watch?v=B2ZeIoLz8FE&feature=player_embedded


PURGE 1
CARRIER N_2
N_2 Not Used
OPEN
CLOSED
SEMIGAS SYSTEMS
41086
DANGER