BYU Safety & Ethics Conference 2022 – Case Study

ESD Sensitive Electronic Board made using Acetone

Sponsored by Boyd Hill
Who is a Hazards Analyst at Northrop Grumman and AIChE Great Salt Lake Section Chair

Cash Prizes Offered to Winning Teams

1st Place - $600 2nd Place - $400 3rd Place - $200

Safety is a Life Cycle Concern from Concept, Design, Operation to Disposal of product and equipment. This Case Study is at the Concept Phase.

Company XYZ has a promising new electronic computer board (~8" square x ~0.5" thick) that it would like to manufacture. The concept plan is to have

1) Operator(s) bring in a full box of blank boards in front of a robot
2) Robot removes one computer board and places it in a fixture on a conveyor belt
3) Conveyor belt moves the fixture to Black Box where several processes convert the blank board into a computer board. One of the process steps involves acetone a flammable liquid
4) Conveyor belt then continues where the next step is to heat the computer board to 150°F.
5) Final step is to have an operator remove the finished computer board and place it into a plastic package and box for shipping to a computer manufacture.

As a Hazards Analyst, you need to prevent or greatly mitigate – Personal Injury, Damage to Product and Damage to Equipment and Damage to the Facility. Enclosed is a Failure Modes and Effects Analysis (FMEA) Table with the minimum required columns to document hazards and methods for mitigating them. To help you get started and see what is expected, I performed a line for you.

As your Hazards Analysis Supervisor, I have identified the following hazards that must be addressed.

1) Electronic computer board is sensitive to Electro-Static Discharge (ESD) from a human spark
2) Robots used are electronically driven and thus should meet industry standards for use with acetone a flammable liquid. Specify as best you can the industry standard requirements
3) Personnel injury from interfacing with robot during normal operations including maintenance and during abnormal operations such as trouble shooting when the robot goes down
4) Flammable liquid (Acetone) generates a flammable vapor when mixed with air that is sensitive to a human ESD spark. NOTE: I completed a line to get you started on this failure mode.

Your job is to be creative in failures (assume worst case), solutions and prioritize solutions as follows:

a) Engineer out the Hazard. As an Engineer – best if you can engineer or design out the hazard (i.e. buy the right equipment), add or eliminate process steps as needed for safety. This is best done during the Concept/ Design Hazards Analysis and is your main job here.
b) Administrative which is done primarily during the Operational Hazards Analysis. When hazard cannot be adequately mitigated by design, then operator procedure step is used to mitigate the hazard. For example, through Procedural WARNING stating "Failure to comply with this step could result in …. (State the hazard that you are trying to mitigate against such as – "ignition of a flammable vapor and personnel injury from exposure to a fire"). OSHA (look up osha.gov and see what it does) requires warnings stated in this manner since operators are more likely to comply when told why they need to comply.

Extra points for coming up with possible equipment pieces that could work and mitigate the identified risks. In this sense you would then be jump starting the next effort the Design Hazards Analysis.

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) for ESD Sensitive Electronic Board made using Acetone

Line #	Failure Mode	Failure Cause	Potential Effects	Design Safety	Recommendation
1	ESD initiation of flammable Acetone from human spark **NOTE:** This FMEA line was generated by the Hazards Analysis Supervisor	Acetone in flammable concentration • Acetone leak from processing inside the Black Box AND Human spark due to being highly charged person • Wearing non-conductive shoes • Standing on floor that is non-conductive or non-static dissipative • Wearing synthetic clothing that readily charges AND not wearing ESD/ Flame rated coveralls	Local flash fire that propagates to large fire burning acetone Severe Personnel injury resulting in third degree burns and hospitalization Other personal requiring medical attention from exposure to flash fire	Unknown at time of recommendation **NOTE:** Acetone is flammable in air between 2.6% and 12.8% and has minimum ESD ignition of 0.0006 Joules or 0.6 mJ **NOTE:** Human can generate electro-static energy in a dry environment walking across carpet for example an ESD spark containing up to 0.015 Joules of energy or 15 mJ. Which means humans can easily ESD ignite Acetone and thus there is currently no known design safety given to prevent a human ESD sparking to Acetone vapor.	Design building with conductive or static dissipative floors (Recommendation 1) Design Black Box operation where acetone is processed to do the following: • Minimize amount of acetone being processed • Alarm and shut down process if acetone leaks out in sufficient quantity to create a flash fire (Recommendation 2) Develop Procedure for “Manufacturing XYZ computer board” and add the following: • Wear conductive shoes • Wear ESD/ Flame rated coveralls or lab coat • WARNING Failure to wear conductive shoes and ESD/ Flame rated coveralls or lab coat could result in ESD initiation of flammable acetone vapors and personnel injury (i.e., skin burns) (Recommendation 3)
2	Propagation of fire	Excessive quantity of acetone			

HINT: If you can think of the hazard put down the hazard and if it is adequately mitigated put “None” in the recommendation column or if no Design Safety state “Unknown at time of recommendation”.

HINT: Develop a Process Flow and organize your FMEA Lines in order of your process flow. Think of your customer (in this case I am your customer) and make it understandable. You will need to make assumptions at the Concept Phase. Please explain your assumptions. Be creative and explain what process clarifications, additions or changes you would make and why.

Good Luck, you are going to learn a lot and get to practice your Engineering Skills for this Case Study.

Project Requirements and Scoring Rubric

After finishing the analysis, you are expected to create a presentation that details all the potential hazards of the process and your recommendations to mitigate those hazards. The presentation will take place on Saturday afternoon, January 8, 2022.

The presentation should have a maximum length of 8 minutes, and a subsequent Q&A session will also take place for the judges to ask questions.

The judges will give you scores using the rubric below, which you are encouraged to refer to as you prepare your presentation. A score will be given for each row and will be weighted as shown in the table. The team with the highest total score will be our winner.

JUDGING CRITERIA	Points	Points Possible
FMEA - Documentation of Hazards		
Identifying Failure Modes & Causes		25
Potential Effects & Design Safety		5
Recommendations - Effective & Practical		40
FMEA Total Points		**70**
Power Point Summary		
Power Point Slides - Organized and Clear		10
Verbal Presentation		10
Team Answers to Judge's Questions		10
Power Point Total Points		**30**
Extra		
Propose Vendor Equipment to Mitigate Risk		**25**
Total		**125**