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Special Devices Inc. (SDI)
Moorpark, California, USA
Automotive Initiator Division

Inadvertent Ignition of Zirconium Potassium Perchlorate Associated With A Vacuum Collection System

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Abstract

Applied lessons learned from an inadvertent ignition of a highly electrostatic sensitive pyrotechnic material (zirconium potassium perchlorate) used in SDI's Automotive airbag initiators.

SDI - Moorpark, California Facility

Brief Process Description:

- Zirconium and potassium perchlorate (ZPP) are blended and dried at the H-1 blending facility
- ZPP is transported to automated high volume loading bays and pressed into subassemblies
- Subassemblies are tig or laser welded to create a gas tight seal and transferred to the production line for additional processing prior to shipment

Ignition Sensitivity Comparison

Zirconium potassium perchlorate (ZPP) a pyrotechnic material utilized in a wide variety of specialized, highly reliable, hermetically sealed pyrotechnic devices in Special Devices, Inc. Automotive, Defense & Aerospace and Mining & Blasting products.

Zirconium potassium perchlorate

	Lead azide	**Lead Styphnate**	**ZPP**
•Electrostatic Discharge:	0.007 Joules	0.0009 Joules	***0.00001 Joules***
•Impact:	2cm w/ 2kg Wt.	17cm w/ 2kg Wt.	65cm w/ 2kg Wt.
•Friction:	< 5 Newtons	< 5 Newtons	< 16 Newtons
•Auto-ignition:	340°C (635F)	280°C (535F)	350°C (660F)

Pyrotechnic Loading Process

Pyrotechnic Loading Machine

- Wearing appropriate personal protective equipment, Operators retrieve ZPP staged in conductive containers from a shielded storage fixture inside the bay
- Operators transfer ZPP from the storage fixture to the pyrotechnic loading machine.
- In the course of normal operations the Operators place ZPP inside the shielded workstation where automated systems and mechanisms transfer and press the ZPP into subassemblies
- Residual ZPP may accumulate on the dial table of the loading machine during the course of normal operations.
- Loading machines are equipped with a wet vacuum system to minimize the potential for pyrotechnic material accumulation.
- During processing, out of place pyrotechnic material is collected at multiple vacuum stations located through out the machine, and deposited into water filled containers.
- Operators monitor the vacuum collection containers. If the water level declines to a minimum point and/or pyrotechnic material accumulation in the vacuum flask exceeds 5 grams, the collection container is changed out.

Process Safety Controls – Pre-Mishap

Electrostatic Energy Controls

- Earth Grounding for Production Equipment
- Conductive Floor Surface
- Controlled Temperature Level (~22°C)
- Controlled Humidity Level (35% - 60%)
- Conductive Shoes and Wrist-Straps (Verified for continuity prior to start-up)
- Non-synthetic Clothing
- Non-conductive Vacuum Transfer Tubes and Wet Collection Container

Personal Protective Equipment

- Non-synthetic Clothing and Flame Resistant Shop Coat (PBI)
- Hearing Protection and Aluminized Hood (For Pyro material dry transfer)
- Flame Resistant (PBI/Leather) Gloves

Administrative Controls

- Equipment and Conductive Surface Grounding/Bonding integrity verification (Semi-Annual)
- Operator Wrist-Straps and Conductive Shoes Daily Validation Log
- Annual updating Of Operating Procedures and Operator re-certification Training

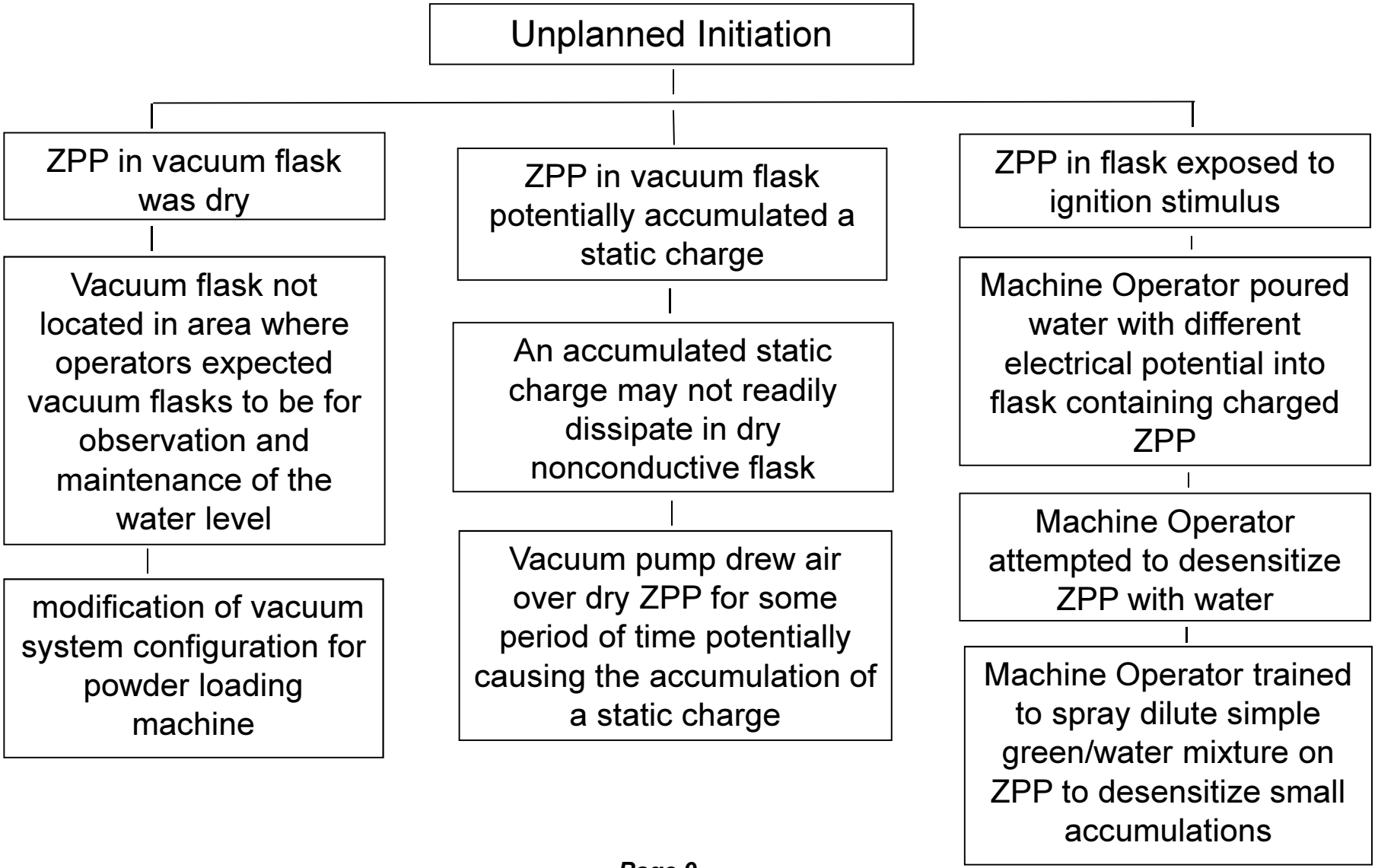
Mishap Summary

- Machine Operators inadvertently discover an out of place vacuum container, containing approx. 100 grams of ZPP.
- The container was still connected to the vacuum system at a collection point that had been eliminated 2 months prior. The container was under the machine and not visible during normal operating conditions.
- The large volume of dry ZPP was an unusual condition and not described in the safety operating procedures (SOP) or an operating condition the workers had been trained to safely correct.
- One Operator disconnected the flask from the vacuum system and placed it on the machine control panel, while the other operator retrieved water to wet the ZPP.

Powder Loading Machine – Post Ignition

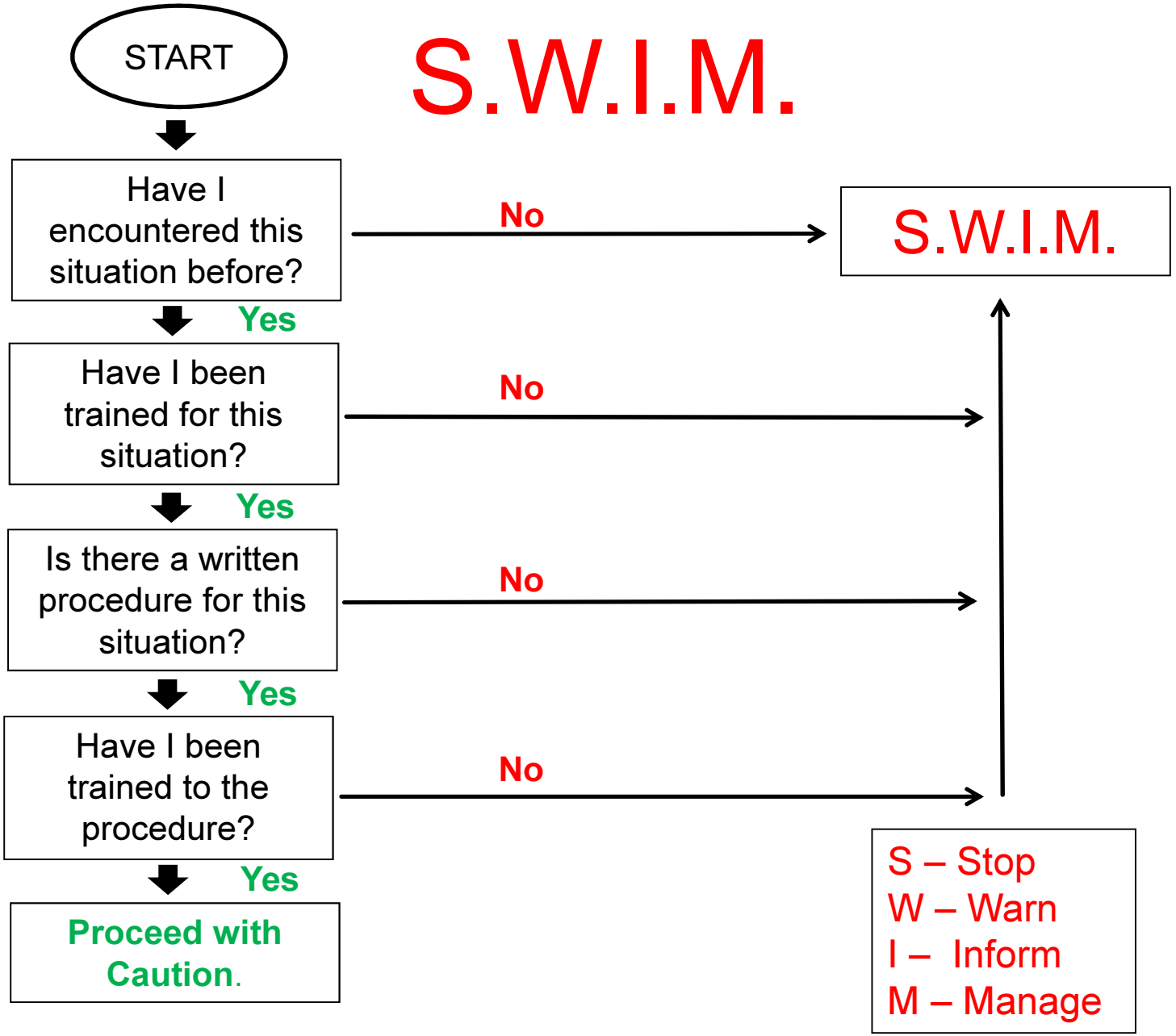
- The Operator then began to rewet the ZPP in the container by pouring water from a plastic container into the plastic vacuum container when the ignition occurred.
- Both Operators received serious, non-fatal, injuries
- The machine control panel was destroyed, the facility was damaged and some debris exited the bay as a result of the ignition
- No other equipment and no subassemblies were impacted by the ignition

Mishap Analysis
Thought Process Map



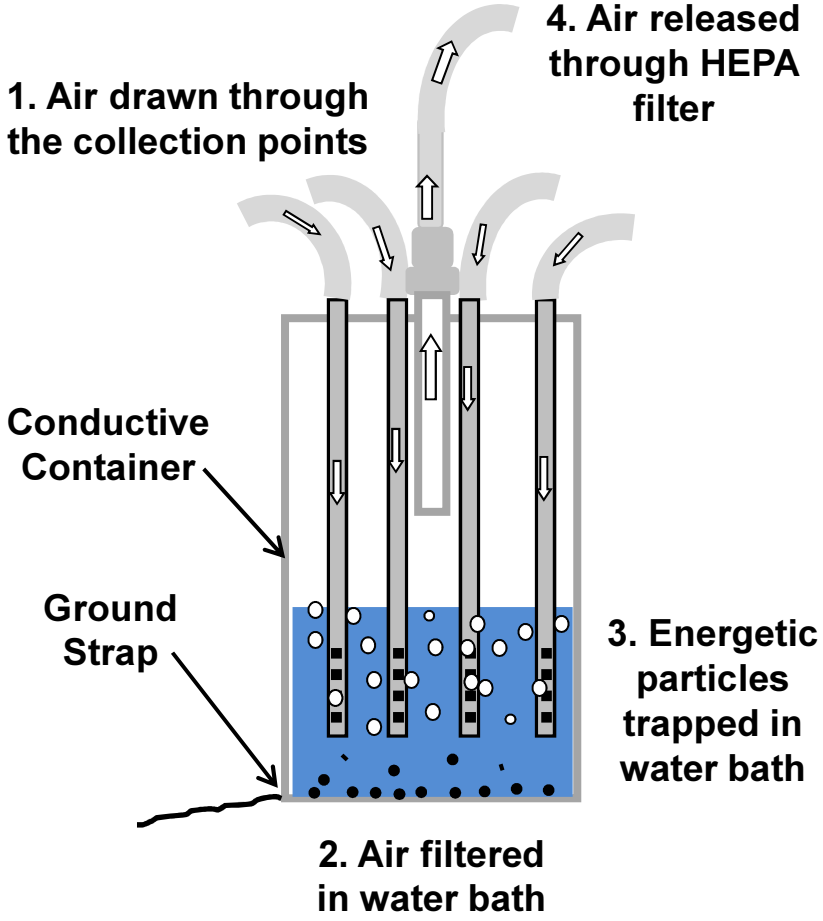
Corrective Measures For Global Operations
Post-Event Lessons Learned

1. Redesign energetic vacuum collection systems to be continuous electrically conductive and use only conductive materials and/or features designed to eliminate potential static discharges.
2. Re-emphasize that workers should perform only those tasks that are described in written safety operating procedures and for which they have been qualified to task-specific training.
3. Modify Safety Operating Procedures to include specific instructions to handle abnormal non-routine operating conditions.
4. Modify SOPs for operations using vacuum systems to include continuous electrically conductive collection containers, sight glasses for operators to observe water levels, automated low-level fail-safe water detector and train and qualify the operators to:
   A. The procedures for adding water and changing out vacuum containers
   B. The safe handling of the removed vacuum containers.
   C. Limiting operator dry pyro material wetting to 5 grams or less. (Created a Pryo Response Team (PRT) to safely dispose out of place dry pyro material over 5 grams)
   D. Developed a Hazard Response program S.W.I.M. then trained all levels of management and employees.


START
S.W.I.M.
Have I encountered this situation before?
No
S.W.I.M.
Yes
Have I been trained for this situation?
No
Yes
Is there a written procedure for this situation?
No
Yes
Have I been trained to the procedure?
No
Yes
Proceed with Caution.
S – Stop
W – Warn
I – Inform
M – Manage

Re-Designed Vacuum System Function

Electrically Continuous Vacuum System



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Questions, Answers and Discussion