Primary Prevention for Occupational Health:

The Effects of Pollution Prevention (P2) Interventions on Worker Safety and Health in Massachusetts

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Objectives - Research Aims & Goals

- To evaluate first-hand the relationship between P2 and occupational health at 3 Massachusetts PWB facilities.
- To discover what effects P2 intervention programs have had on worker safety and health at these three facilities.
- To determine if P2 interventions at the facility level actually promote or force real primary prevention.
- To identify what might drive or motivate industry to embrace prevention as the key to integrating OHS and EHS.
- To utilize the knowledge gained from working with the three PWB facilities to make future recommendations to integrate OHS and EHS at the plant level.

Methodology

Case Studies: Three printed wire board (PWB) manufacturers in Massachusetts.

Retrospective / Contemporary

Tools: Qualitative/Semi-Quantitative

- OSHA Program Evaluation Profile (PEP) - General Occupational Safety and Health (OSH) Evaluation
- The Pollution Prevention Options Analysis System (P2 OASys)
- “Open-Ended Interview” with key informants at each facility.

OSHA's PEP
(Program Evaluation Profile)

- **Management Leadership & Employee Participation**
- Survey & Hazard Analysis
- Accident & Record Analysis
- Hazard Prevention & Control
- Emergency Preparedness & Response
- Safety & Health Training

Scoring

- (5) Outstanding Program
- (4) Superior Program
- (3) Program Implemented
- (2) Developmental Program
- (1) No Program Implemented

P2 OASYS - - The Pollution Prevention Options Analysis System

- Acute Human Effects * (10)
- Chronic Human Effects * (8)
- Physical Hazards * (5)
- Aquatic Hazards (5)
- Bioaccumulation (5)
- Atmospheric Hazard (4)
- Disposal Hazard (4)
- Chemical Hazard * (13)
- Energy and Resource (3)
- Product Hazard * (3)
- Exposure Potential * (1)

** Elements that directly measure worker health.*

Open-Ended Interview - Identification of opportunities and barriers to integration

Key Elements

- Positive effects of the P2/TUR interventions on worker safety and health
- Barriers or limitations of P2/TUR interventions to positively impact worker safety and health
- Additional opportunities for improving workplace safety and health when considering P2 or TUR interventions
- Methods to achieve integration of EHS and OHS
- EHS/OHS team
- Performance measurements of an integrated approach
- What would make an integrated EHS/OHS intervention successful ?

Company Profiles – Company # 1

- International PWB manufacturing firm
- Multi-layer circuit boards (9,000 panels per week)
- 200,000 sq.ft.
- Approximately 550 employees
- Sales > $200 M annually
- Zoned industrial area with houses approximately 600 feet away
- EHS Manager and Risk/Safety Manager
- ISO 14000
- Participated in two EPA DfE projects
- TUR Team – mostly managers and engineers, with solicitation for worker input
- Regular EHS and OHS audits
- In-house Emergency Response Team
- Formal approval process for new chemicals
- No formal safety incentive program

P2/TUR Interventions –
Company #1

- Eliminated Freon 113 (1992) – Replaced with aqueous cleaning unit
- Eliminated 1,1,1 trichloroethane degreaser (1991) – Drop-in replacement with terpene solvent
- Eliminated use of glycol ethers in O/L Resist Processing and O/L Developing (replaced with aqueous dry film developed with potassium carbonate - resulted in reduction of 37,000 pounds glycol ethers in one year)
- Replaced Tin/Lead Etch Resist with Tin (1995) – resulted to reduction of 33,000 pounds of lead over three year period
- Maintenance, fine-tuning processes (Continuous Improvement – overall reduction in toxics)

Total pounds of toxic chemicals per layer adjusted panel decreased by 39.8% in 3 years (1993 to 1996)

Company Profiles – Company # 2

- 10 facilities in the U.S., Case - Prototype Shop – military applications
- Located in industrial park with other industries
- 1,500 multi-layer cores/day, shipping about 250/day
- 3 shifts per day
- Planned ISO 14000 by 2002
- EHS Manager and Safety Manager
- In-house Emergency Response Team
- TUR Team – managers (EHS & OHS), engineers, technicians, waste treatment operators, with solicitation of worker input
- Comprehensive annual EHS audit with 38 indicators designed to promote “beyond compliance”
- Monthly safety audits
- Formal Chemical Approval Process for new chemicals
- No formal safety incentive program

P2/TUR Interventions – Company #2

- Eliminated 1,1,1 trichloroethane
- Nitric Acid recycling and recovery for solder strip line (tin-lead strip) – reduction in chemistry usage, recovery of 95% free acid, reduction in waste treatment and disposal costs
- Plasma Etchback – replaced sulfuric acid system with plasma gas (O2, H2, CF4, and N2)
- Waste Treatment - 90% ion exchange- reduces dependency on waste treatment chemicals
- Ammoniacal etch (inner and outer layer) – higher free ammonia etching - tighter equipment maintenance and control – resulted in reduction in ammonia use and elimination of anhydrous ammonia
- Maintenance, fine-tuning processes (Continuous Improvement – overall reduction in toxics)

Company Profiles – Company # 3

- One facility - 63,000 square feet
- Approximately 130 employees (70% have been there for over 30 years)
- 3 shifts per day
- Sales > $12 M annually
- Single and Double Sided, Multi-layered, Rigid Printed Circuit Boards
- Prototype to Production Volumes
- EHS Manager – does both environmental and occupational safety and health
- TUR Team – includes managers, engineers, technicians and operators – there is solicitation for worker input

P2/TUR Interventions - Company # 3

- Eliminated 1,1,1 trichloroethane (1993)
- Ammoniacal Etching - New machine – reduction of 6,000 pounds of ammonia (etch) in one year
- Replaced Tin/Lead Etch Resist with Tin
- Wastewater / Recycling
- Product Change – New chemistry uses poly ferrisulfate (not reportable) instead of ferrous sulfate at 1/16th the amount
- Maintenance, fine-tuning processes (Continuous Improvement – overall reduction in toxics)
- Dry Film Development - Chemical Substitution (went to feed and bleed system) - replaced sodium carbonate with potassium carbonate

OSHA PEP Scores

- **Company # 1 Managers**
  - All 4 scored: *superior program*
- **Company # 1 Workers**
  - 3 scored : *superior*
  - 1 scored : *program implemented*
- **Company # 2 Managers**
  - 3 scored : superior
  - 2 scored : program implemented
- **Company # 2 Workers**
  - 2 scored : superior
  - 3 scored : program implemented
  - 1 scored : developmental program
- **Company # 3 Managers**
  - 1 scored : superior
  - 3 scored : program implemented
- **Company # 3 Workers**
  - 3 scored : program implemented

P2 OASys Results with PEP Scores

Company 1 PEP Ave 3.875		Company 2 PEP Ave 3.4		Company 3 PEP Ave 3.125	
Glycol Ether	52	Sulfuric-Permang	86	Ferrous Sulfate	61
Potassium Carbonate	38	Plasma Desmear	33	Polyferric Sulfate	30
Difference	**14**	**Difference**	**53**	**Difference**	**31**
1,1,1 Trichlor	63	Old solderstrip system	40	Sodium Carbonate	50
Terpene	48	New solderstrip System	14	Potassium Carbonate	28
Difference	**15**	**Difference**	**26**	**Difference**	**22**

Open-Ended Interviews - Key Statements

Company #1

- *Positives:* TUR (reduction or elimination of chemicals) leads to less exposure to employees.
- TUR options must include aspects of worker safety & health; should be check system for all chemical, process or equipment changes in plant to evaluate both EHS and OHS risks; should include all employees involved in the change.
- Integrated approach can be measured by toxic chemical use, IH monitoring, injury/illness reports, and employee feedback.
- Successful integrated approach must include consistent participation of all employees, from process engineers to operators on the floor. Must be top management support.

Open-Ended Interviews - Key Statements

Company #2

- Consider EHS and OHS to be equally important, therefore do not associate positive or negative impacts of one over the other.
- Costs associated with each P2/TUR option (both EHS and OHS) is important, where anticipation of *potential* problems must be considered (environmental and occupational health impacts).
- Successful integrated approach must incorporate a system where the P2/TUR option is evaluated by all employees affected by the change, including project managers, process and product engineers, department supervisors, operators, quality control, purchasing, the controller, the business unit manager (GM), and even suppliers of the equipment.
- Need to be aggressive with SOP's that spell out internal requirements for evaluating P2/TUR options.

Open-Ended Interviews - Key Statements

Company #3

- Some TUR options actually lead to increased risk to the employees and should not be considered.
- Generally TUR positively impacts worker safety and health, but cost is always a large part of the decision.
- An integrated approach can be measured by tracking toxics reductions, but more importantly, by talking to the operators and getting feedback on how the process is working.
- Successful integrated approach must be “preventive” in that both EHS and OHS risks are considered up front, and all stakeholders are involved in the process (both management and employees).
- Integrated approach must include EHS and OHS equally, i.e. not driven by one over the other. Must be preventive, not just reactive. TURA alone is not enough. It is driven by the pollutant and only at large amounts. Companies must act in good faith to reduce both EHS and OHS risks but don’t get credit for doing the continuous improvements. Needs to address small business needs with being able to go “beyond compliance” in both EHS and OHS areas.

Results: P2/TUR and OHS at the Corporate Level

- P2/TUR interventions not driven by OHS needs.
- P2/TUR does have positive impact on OHS – but difficult to measure.
- Missed opportunities to jointly affect EHS and OHS.
- Conscious integration of EHS and OHS due to foresight and “preventive” approach and philosophy of the company (and its management).

Benefits in Occupational Health of Integrating both Disciplines

- Allows for full participation by all members/representatives of the facility.
- Provides an integrated approach to identification of specific interventions to decrease or eliminate potential harm to workers and the environment.
- Provides opportunity to practice primary prevention - avoid reliance on “end-of-pipe” solutions.
- Prevents risk shifting to workers by evaluating more than one media at a time.