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Visual Inspection Reliability Study

Interagency Manufacturing Operations Group (IMOG)

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Purpose and Background

- Study overview
- Phase 1 results
- Phase 2 experiment
- Status and path forward
- Preliminary observations

Visual Inspection Study Overview

Sandia National Laboratories

- Nuclear Safety Research & Development (NSR&D) special project funded through NNSA
- Phase 1 completed in 2012
  - Conducted literature review
  - Observed NSE inspection processes
  - Designed experiment to address NSE inspection
- Phase 2 (March 2013 – October 2014)
  - Conduct experiment
  - Analyze data
  - Report and apply results

Phase 1 Results

- Literature review of inspection research from 1950s+
  - Error rates of 20% to 30% are common
  - Omissions occur more frequently than commissive errors
  - Inspection performance is influenced by task, environmental, individual, organizational, and social factors
  - Large individual differences exist
    - No defect is detected by all inspectors
    - Defect detection is not stable over time
  - Primary methods to improve inspection
    - Training (both procedural and cognitive aspects of the task)
    - Inspection procedures (search strategies, vigilance effects)
    - Apparatus (equipment calibration, overlays)
- Review published in SAND2012-8590

Phase 1 Results

- Reviewed Specification Exception Releases (SXR) that involved inspection
  - Equipment issues—calibration, holding fixtures
  - Procedural issues—misinterpretation or lack of clarity, reliance on historical guidance, or incorrect procedure used
- Observed implementation of many recommended practices at KCP
  - Standards for direct comparison
  - Inspector collaboration and communication
  - Search for one defect at a time for optimal performance
  - Working breaks to avoid vigilance effects
- Observed typical equipment and procedural issues

Phase 2 Purpose

Conduct a signal detection theory analysis of a visual inspection task to document reliability of current NSE visual inspection processes.

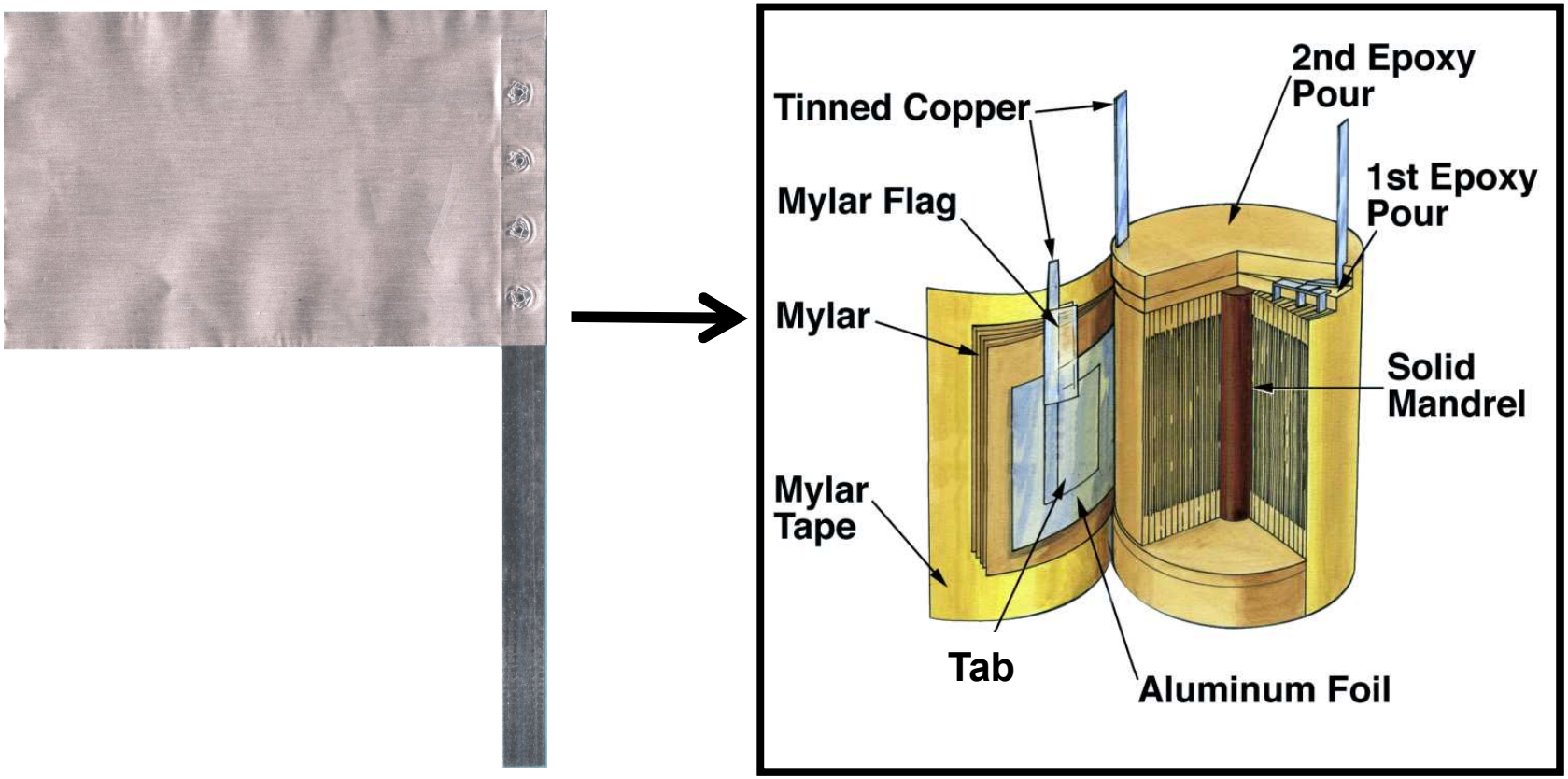
- Three primary objectives
  - Document performance accuracy for products of interest within NSE to determine whether reliability estimates typically reported in the literature apply
  - Evaluate efficacy of a phased approach in which a second inspector re-evaluates items the first inspector rated with low or medium confidence
  - Document workload and stress associated with completion of visual inspection tasks

Methodology - Subjects

- Recruit participants from multiple NSE sites where visual inspection is performed
  - SNL/NM
  - Y-12
  - Pantex
  - LANL
  - KCP
- Identify inspectors who meet the following criteria:
  - Perform visual inspection routinely and frequently as part of their normal jobs
  - Have performed visual inspection on the job for 1+ years
  - Have management approval to participate

Methodology – Test Articles

- 100 foil tabs used in components that are both detonation-critical and safety-critical



Methodology – Test Articles

- Four categories of potential defects
  - A. Creases, wrinkles near stake marks that might lead to a crease or fold over, or fold overs in foil beyond lead
  - B. Tears, cuts, or punctures in foil
  - C. Stake mark deformations or excursions beyond lead edge
  - D. Questionable visual observations
    - D1. Contamination (fingerprints)
    - D2. Ragged or uneven edges on foil
    - D3. Puffiness around stake marks (quilting)
    - D4. Misalignment or misplacement of foil
    - D5. Extra stake marks

Methodology – Test Articles

- Fold overs in foil beyond lead are a potential defect, depending on size

Methodology - Approach

- Demographic survey
- Orientation and training to 90% accuracy
- Part 1 – inspect all 100 test articles
- Part 2 – inspect subset of 40 test articles rated by a previous inspector with *low* or *medium* confidence
- For both parts, each inspector:
  - Decides whether tab is defective or not
  - Rates confidence in that decision
  - Identifies all defects present
  - "Thinks aloud" to clarify thought processes during inspection
  - Provides workload and stress ratings after each part

Status and Path Forward

Activity	Approximate Time Frame
Collect Data ✓ SNL/NM ✓ Y-12 ✓ Pantex ✓ LANL ❑ KCP	September 2013 – July 2014 ✓ September 2013 (N = 4) ✓ November 2013 (N = 12) ✓ December 2013 (N = 15) ✓ January 2014 (N = 14) ❑ June – July 2014 (N = 30)
Analyze Data	August – September 2014
Publish SAND Report	October 2014
Submit Manuscript to *Human Factors* Journal	October 2014
Present Results at IMOG	October 2014

Only aggregate data for the NSE will be reported. Data will not be reported by site or by individual.

Preliminary Observations

- Visual inspection of rolled foil tabs is not easy
  - Average 1 min per tab for inspection and decision making
  - Performance measures indicate a moderately difficult task
  - Accuracy for defect types varies widely from ~10% to 90%
- A second *independent* review of low/med confidence items may improve overall inspection accuracy
- Visual inspection of rolled foil tabs imposes moderate workload demands
  - Workload dominated by mental demand and effort
  - Daily inspection job reported to be more demanding

*These trends are **preliminary** and are subject to change after all data have been collected and analyzed.*

Contact Information

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