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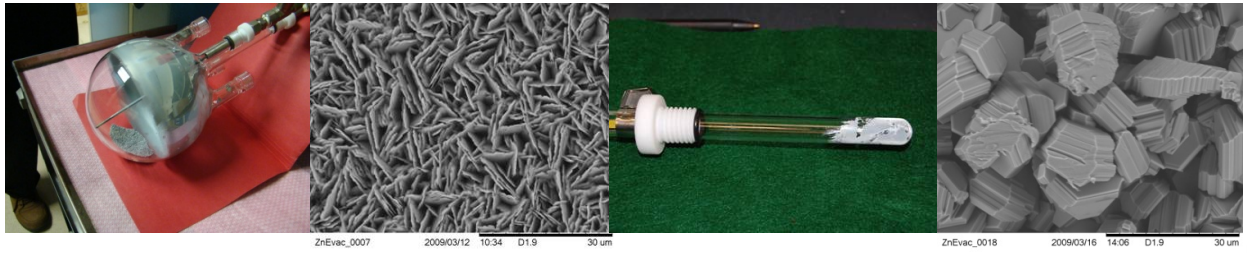
SAVANNAH RIVER NATIONAL LABORATORY
Operated by Savannah River Nuclear Solutions, LLC

We Put Science To Work

Implementation and Application of Integrated Safety Management to ^{65}Zn Simulation Study

A. Duncan, P. Korinko, R. Malstrom



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SRS Work Management ISMS Functions / Integration

ISM Guiding Principles:

1) Line Management Responsibility for Safety
2) Clear Roles and Responsibilities
3) Competence Commensurate with Responsibilities
4) Balanced Priorities
5) Identification of Safety Standards and Requirements
6) Hazard Controls Tailored to Work Being Performed
7) Operations Authorization

Supplemental High-Reliability Principles for Effective Safety Management System Implemention:

A) Highly Reliable Operational Performance
B) Individual Attitude and Responsibility
C) Performance Assurance
D) Organizational Performance Improvement

1 Define Scope of Work

- o Translate Mission into Work
- o Set Expectations
- o Priortize Tasks
- o Allocate Resources

2 Analyze Hazards

- o Identify Hazards
- o Analyze Hazards
- o Categorize Hazards

3 Develop / Implement Controls

- o Identify Standards & Requirements
- o Identify Controls to Prevent/Mitigate Hazards
- o Establish Safety Controls
- o Implement Controls

4 Perform Work

- o Confirm Readiness
- o Perform Work Safely

5 Feedback / Improvement

- o Collect Feedback Information
- o Identify Improvement Opportunities
- o Make Changes to Improve
- o Oversight & Enforcement

Continuous Improvement

PassPort
Work Management System

1Y Manual - Procedure 8.20
8Q Manual - Procedure 120 (4)
Safe Work Performance
o AHA / Work Authorization
(2) o Planning / Hazard I.D. / Hazard Controls
o PHR, RWP
o Qualified Personnel (3)

AIM / P3/ FMTS

Maintenance and Construction
Quality & Training
Human Resources & Info Technology
Projects, Vendors & Subcontracts
Operations & Program Mgmt
Procedures and Security
RadCon & Safety
Engineering and Procurement

Work Requests
Work Orders
Program Mission / Project Plans
P3 Scheduling
Facility Status
Technical Baseline
TRAIN / Qual Matrix
Document Control Register
Authorization Basis
Budget & Finance
IPI, Safety Equipment
RIE / CGD
Pressure Protection
Materials
Condition Tag Log
Procedure Index
Lockout Database
FEB Evaluations
Action Tracking / Corrective Action
Self Assessment
History / Trending
Worker Feedback & Closure Process
Lessons Learned

05/24/05

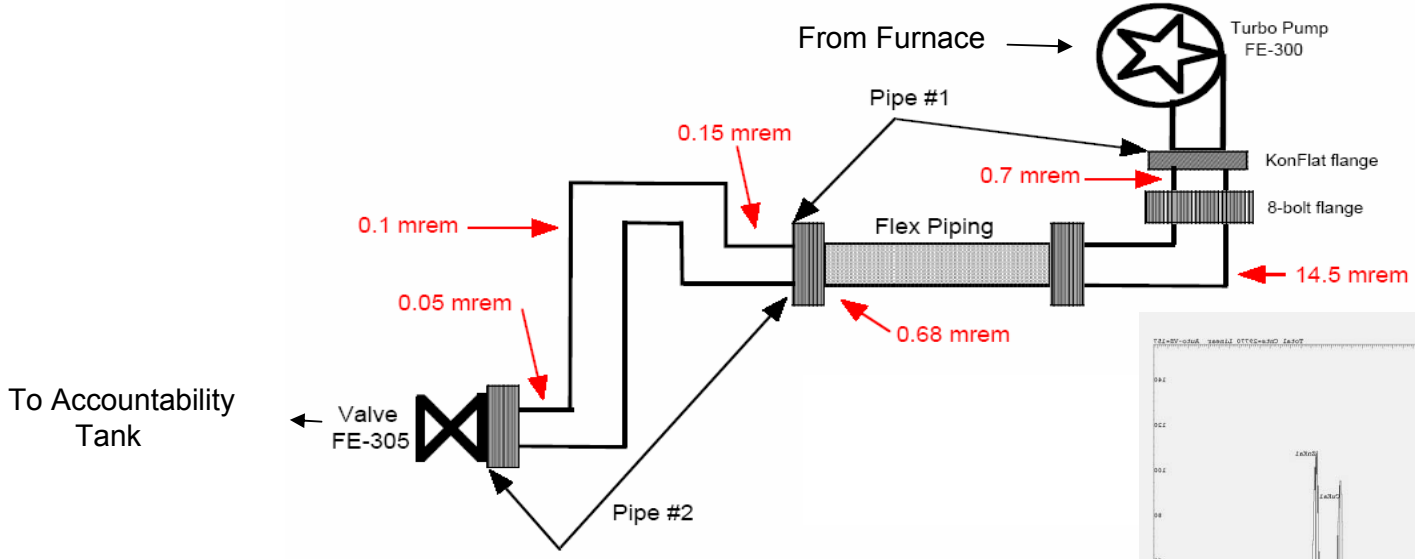
wheel... jrf

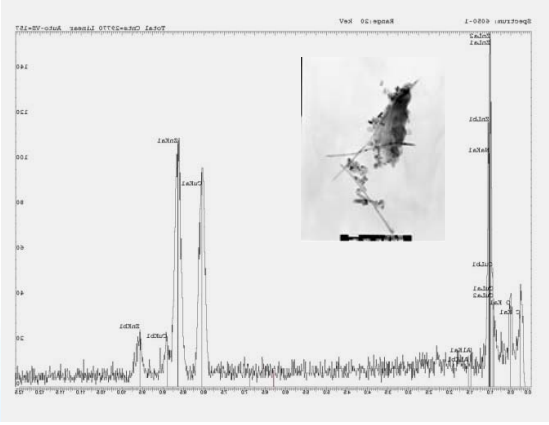
Print Close

Background

- **Applicable prior history**
  - TEF detected radioisotope ^{65}Zn after completing extraction
  - Plant Configuration

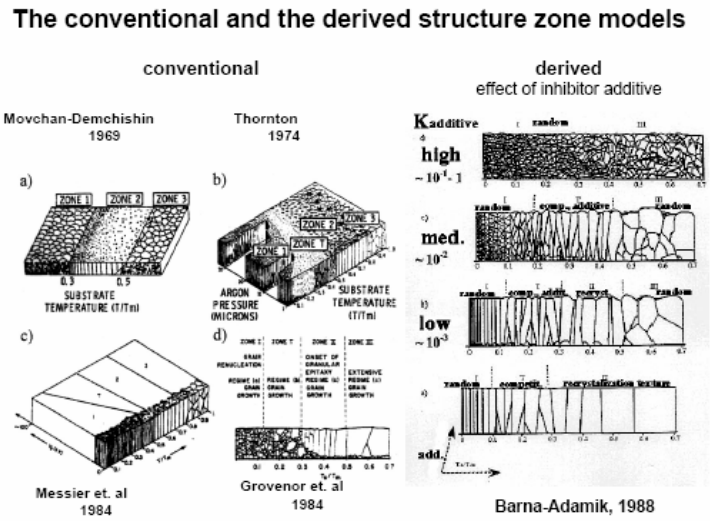
Piping Contaminated with Zinc65 in Glovebox-500





Principles behind research

- **Literature review indicates that substrate temperature affects deposit**
- **Desire adherent deposit to preclude formation of mobile species**



Physical Vapor Deposition, T. Parker, Ed., Temescal, 1976.

Goals

- **Develop understanding of Zn capture mechanisms**
- **Provide data to operations group so a solution to contain Zn can be implemented**

R&D Integrated Safety Management & Work Control System

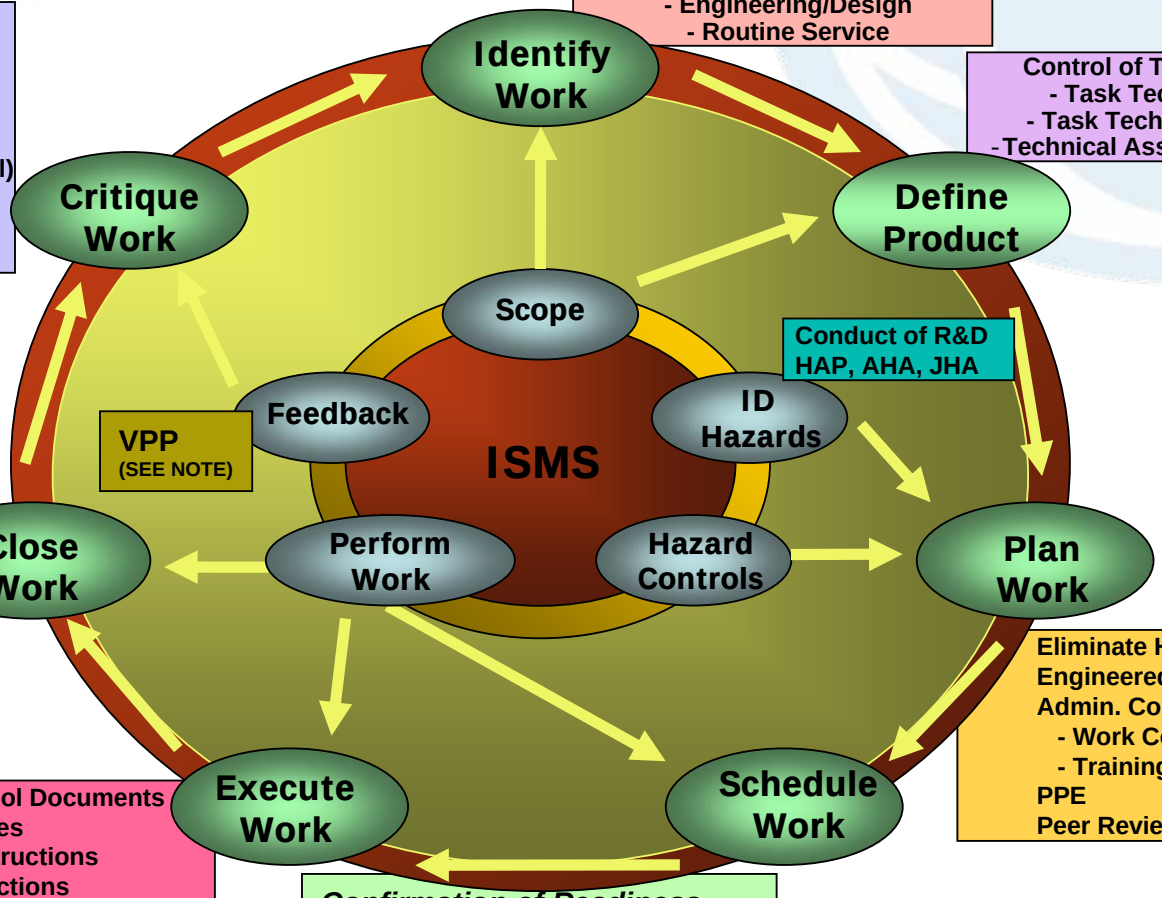
April 16, 2009

Categories of Technical Work:
- R&D
- Engineering/Design
- Routine Service

Self-Assessments
Management Observations
BBS Observations
Monitored Evolutions
Performance Indicators
Issue Investigation (HPI Tool)
- Fact Finding
- Post Job Review

Corrective Action

Control of Technical Work:
- Task Technical Plans
- Task Technical Requests
- Technical Assistance Requests



Conduct of R&D
HAP, AHA, JHA

VPP
(SEE NOTE)

Document results
Disassemble apparatus
Dispose of waste

Eliminate Hazard
Engineered Controls
Admin. Controls:
- Work Control Documents
- Training

PPE
Peer Review (HPI Tool)

Work Control Documents
- Procedures
- Work Instructions
- R&D Directions

"Time-out" (HPI Tool)
BBS Observations

Confirmation of Readiness
Pre-job briefing (HPI Tool)
- Enhanced situational awareness
  - Critical steps
  - Error-likely situations
  - Potential consequences
  - Flawed defenses

NOTE: Savannah River Site is a DOE Voluntary Protection Program (VPP) site

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Define Scope of Work

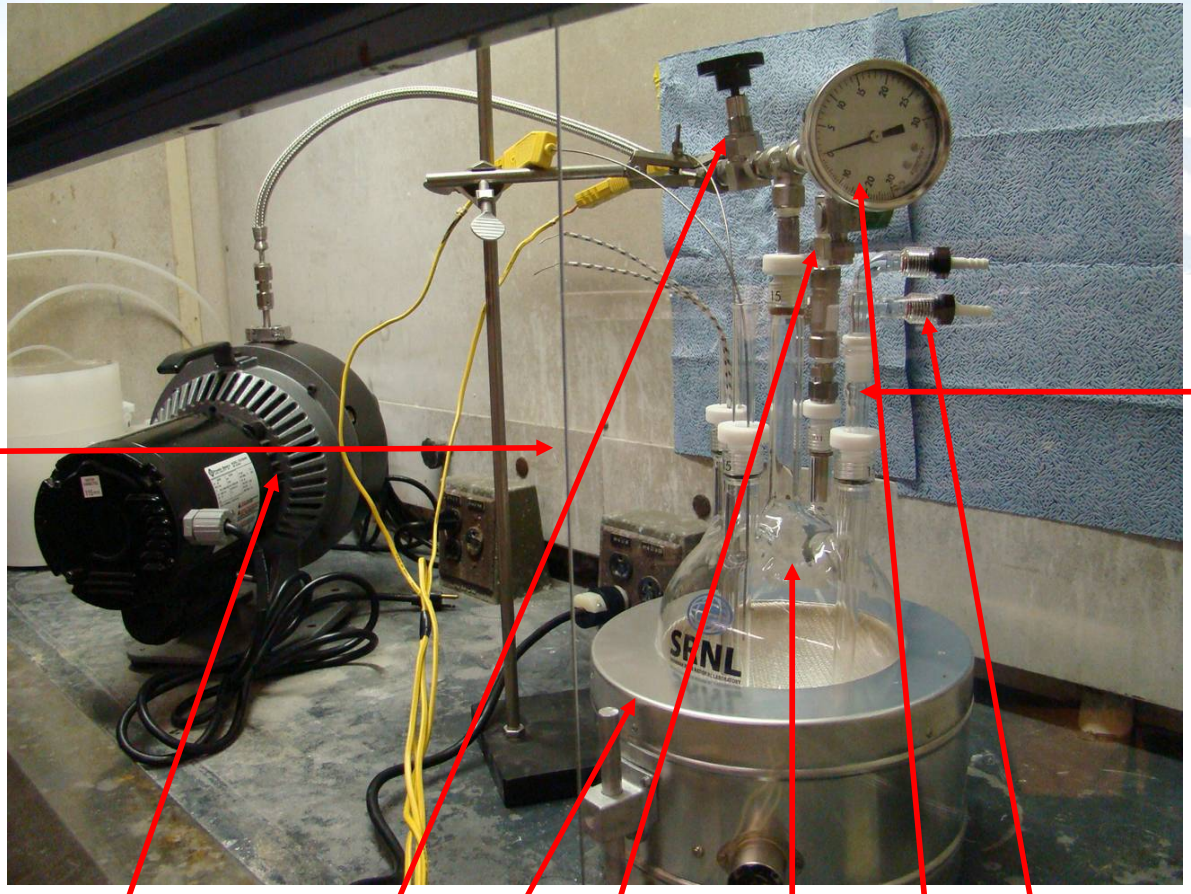
- **TEF project management -- ^{65}Zn mitigation team**
  - Team – Test Zn trapping strategy
    - 2 phase proposal defining the scope of work for testing deposition characteristics of Zn
      - *Phase 1 -- scoping study – thermal conditions to contain Zn vapors*
      - *Phase 2 -- effectiveness of strategy*
- **TEF project manager authorized work via e-mail**

Note: this presentation addresses Phase 1 scoping studies (non-baseline work) prepared under the L1 manual using Conduct of R&D

Define the Scope – Phase 1 Scoping Experiments

- **Work Conditions**
  - Laboratory tests to determine temperature regime for vaporization and deposition
  - Design apparatus – identify hazards: vacuum pump, instrumentation, temperature controllers, vacuum chamber, and piping
  - Selected 735-11A Laboratory 110 since it has available chemical fume hood
- **Acceptance Criteria**
  - Temperature, pressure, and deposition morphology data that show variations in coating adhesion
  - Vessel temperature data that indicate sufficient Zn vapor formation
- **Final Deliverable Phase 1**
  - Information / data to ^{65}Zn mitigation team to guide phase 2

Test Apparatus – Initial Configuration



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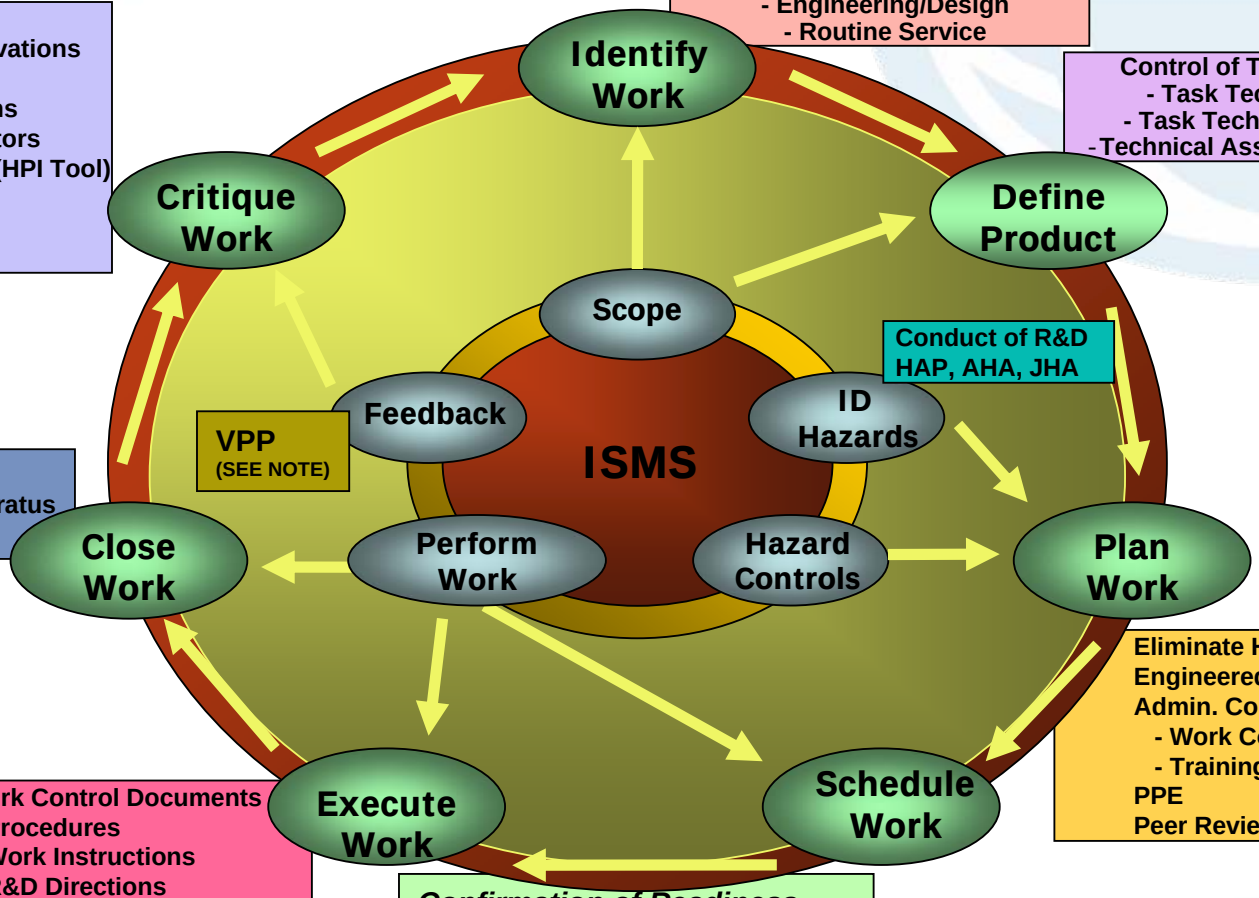

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Identify and Analyze the Hazards

- **Analyze and document hazards that could impact workers, facility, public, or environment**
  - Personnel involved in work planning activities have the appropriate technical and operational backgrounds and expertise
    - PIs well educated (all have PhDs) and have 49+ years combined in R&D environment
    - PIs trained in ISM and the work planning and control process
  - Subject Matter Experts (SMEs) and system engineers (SEs) are consulted where appropriate
    - Industrial Hygiene, Fire Protection, Pressure Protection, Safety, and Environmental Controls personnel were all involved in HAP package preparation

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Identify and Analyze the Hazards

- **Hazard assessment used eHAP system**
- **SME consultation used to address specific hazards**
  - Industrial Hygiene, Pressure Protection, Fire Protection, Safety Engineer
- **Team approach used to systematically identify and analyze work hazards and significance**
  - The HAP package, JHA, and 8Q-51 safety inspection were all done as a group effort by the PIs
- **Workers are involved in hazard identification where possible**
  - PIs will conduct work and wrote Job Hazards Analysis (JHA)
- **Walk-downs are used where appropriate to identify hazards associated with both the work tasks and the work environment**
  - Several reviews for management were given and the final 8Q-51 safety inspection was performed with representation from Industrial Hygiene, Pressure Protection, Fire Protection, Safety and Management
- **Hazard analysis considers "what if" scenarios and error-likely situations to determine if additional protective measures are appropriate**
  - Jobs Hazards Analysis (JHA) was performed and signed off by all workers
  - The JHA is included in the HAP package

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Identify and Analyze the Hazards

- **Work planning effectively coordinates work activities**
  - Laboratory has multiple users
    - Advanced rad worker practical & other MS&T researchers
  - Efforts were made to ensure other work didn't impact our experiments and vice versa.
- **Primary hazards identified**
  - Over-temperature
  - Over-pressurization if flask not evacuated during heating

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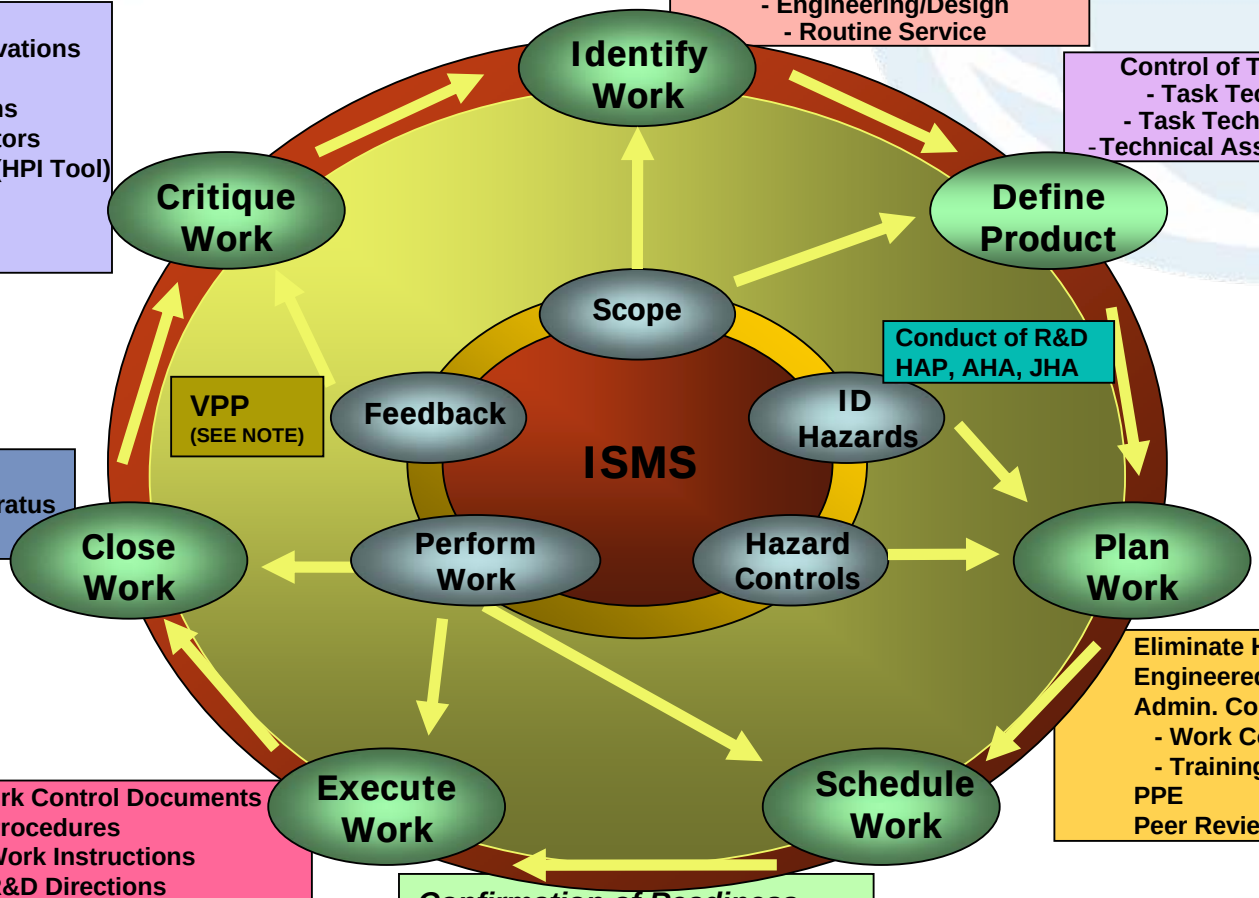

Conduct of R&D
HAP, AHA, JHA

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(SEE NOTE)

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Implement Controls

Controls are implemented that effectively protect against identified hazards.

- **A hierarchy of controls methodology is employed**
  - Apparatus will be placed in chemical hood
  - Commercially available UL listed components will be used when available
  - Glassware will be assembled and built by professional glassblowers and annealed
  - A polycarbonate safety shield will be used
  - R&D Directions will be used and proper PPE will be worn by researchers

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Implement Controls

- **Appropriate controls are identified for all hazards associated with the work activity**
  - Over Temperature accident scenario avoided by
    - Over-temperature controllers with separate thermocouples
    - Heating mantle sized with maximum temperature of 450°C
  - Pressure protection device not needed after SME evaluation
    - Determined vessel would withstand worst case pressure
    - Decision documented in M-PAR-A-00060
    - Engineering Standard 15061(WSRC-TM-91-1)
      - *Stored energy calculated 1200 ft-lbs (less than the 10000 ft-lbs specified in ASME Boiler and pressure vessel code so relief device not needed)*
    - Additional Controls
      - *Experiment continuously monitored with duplicate pressure gauges*
      - *Lexan safety shield utilized*
  - R&D Directions will be used

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Implement Controls

- **The hazards and controls are clearly identified in the R&D Directions**
  - R&D Directions will be used for each experiment
  - Primary action in the event of a problem is to power off mantle heater
    - Eliminates pressure source
- **Work Directions clearly identify warnings, precautions, hold points, independent verifications, and other measures to ensure personnel and environmental safety, equipment protection, and continuity of operations**
  - The system will be continuously monitored during the entire mantle heat cycle and cool down
    - Experiment will terminated when mantle temperature is below 100°C

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eHAP Summary

SLNL-NB-2007-00018
89

Hazards and Controls Summary

HAP Number: SRNL-L2000-2008-00019-0	**Correspondence Number:** SRNL-L2000-2008-00019
Title of R&D Activity: Zinc trapping experiments	
Name of PI: Paul Korinko	**HAP Lead (If not PI):** Robert Malstrom
Description: see attached	

Hazards and Controls

Pressure Protection

Hazards:	Controls:
Hazardous Energies - Compressed gas cylinders? Hazardous Energies - Cryogenic liquids and dewars? Hazardous Energies - Potential pressure differences in excess of the lowest rated component of the system (All pressurized system components must be considered. See checklist in...for guidance.)? Hazardous Energies - Systems under vacuum or at a pressure between 0 and 15 psig?	see M-PAR-A-00060

Industrial Hygiene & Chemical Control

Hazards:	Controls:
Hazardous Energies - Temperatures > 40ºC (104ºF)? IH - Does your work activity involve the use of compressed gases or liquids or cryogenic liquids?	proper PPE will be used when handling cryogenic liquids proper PPE will be used when handling compressed gases proper PPE will be used when handling chemicals proper PPE will be used when handling hot articles, a "HOT" sign will be placed near apparatus to warn others of potential hazards

Environmental Protection & Waste Management

Hazards:	Controls:
Worksite Environmental - Airborne mists, dusts, or vapors? Environmental Compliance - Is this a new activity?	only gas released will be helium, liquid nitrogen, and potentially extremely small quantities of zinc vapor (<10 gms total) into a hood *see attached documentation*

eHAP Summary cont.

Fire Protection

Hazards:	Controls:
Hazardous Energies - Temperatures > 40ºC (104ºF)? Hazardous Energies - Compressed gas cylinders? Hazardous Energies - Cryogenic liquids and dewars? Worksite Environmental - Airborne mists, dusts, or vapors?	Heating mantle and cartridge heaters will be used Equipment will be attended at all times during the heating

MSB

Hazards:	Controls:
Worksite Environmental - Work performed in 723-A, 730-A, 774-A, 735-A, 735-11A, 736-A, 738-A, 748-A, 749-A, 774-A, 781-A, 786-A, 999-1W, or 999-2W?	Screening MSB # SRNL-MSB-09-0004 showed no MSB Evaluation is required

Final Acceptance Inspection

Hazards:	Controls:
Step 2 - Does the activity involve the installation or modification of experimental R&D equipment or systems?	see attached pdf for 8Q51 inspection report

Hazardous Electr. Energy Isolation

Hazards:	Controls:
Step 2 - Does the activity involve the installation or modification of experimental R&D equipment or systems?	new experimental apparatus will be installed but all electrical components will be commercially available and no hazardous

8Q-51

IH
Fire Protection
Pressure Protection
Safety Engineer
Management

OSR 20-22 (Rev 8-21-2006)

Proc. Ref. 8Q, 51

SRS Final Acceptance Inspection

Work Request or Project Order No.	Problem No. or Job File No.	Building and Area	Date of Inspection
SRNL-L2000-2008-00019		735-11A	2/25/2009

Scope of Inspection

Zn Trapping Experiments. The experiment will show the best range of temperatures for trapping the zinc vapor. A 2 liter Pyrex boiling flask (figure 1) containing zinc metal would be evacuated. Three (or more) fingers would stick into the top of the flask to act as 'condensers'. The flask system would be evacuated to 10 microns or lower pressure using a vacuum pump. Using a heating mantle with temperature control the zinc concentration in the vapor phase could be adjusted.

Instructions

The FA initiates this form in accordance with Manual 8Q, Procedure 51.

The inspection is for safety items only that may include the following:

1. Falling Hazards	10. Grounding	19. Warning Signs	28. Stored Energy
2. Tripping Hazards	11. Warning Devices	20. Ventilation	29. Component Individual Lockout Capability
3. Clearances	12. Lighting and Emergency Lighting	21. Temperature	
4. Sharp Edges	13. Safety Shower/Eyewash Unit	22. Noise Level	30. Drawings Updated
5. Guards	14. Emergency Exit, Means of Egress	23. Operating Procedures	31. PPE Needed
6. Cleanliness	15. Fire Protection Equipment/Systems	24. Domestic Water Cross Connection	32. Public Address System
7. Accessibility to Controls	16. Painting (Color Coding, etc.)	25. Pinch Points	33. Chemical Hazards
8. Overload Protection	17. Identification	26. Pressure Relief Device	34. Ergonomics Factors
9. Exposed Wiring	18. Radiation Hazards	27. Pressure Vessel	35. Repetitive Motion/Failure Points

Status of Facility, Equipment, Structure or Component

- [x] Satisfactory for Safe Operation, Occupancy or Property Dispositioned - no further action necessary.
- [ ] Conditionally Satisfactory for Safe Operation, Occupancy or Properly Dispositioned provided the following unsatisfactory Conditions/Issues are addressed or corrected.
- [ ] Unsatisfactory for Safe Operation, Occupancy or Not Properly Dispositioned until the following conditions/Issues are corrected.

Label chemical reactor PI name chemical name "Hazards" Water Reactive
"Hot" sign

Inspection Team

Print Name	Signature	Organization	Location
Sherolyn Bishop	Sherolyn Bishop	SRNL IH	773A
Jamak B. Patel	[illegible]	SS & ES/FPE	773-42A/116
Michael Mitchell	Michael Mitchell	ROD/FE	773-A
Henry King	[illegible]	SRNL/WTG	773-A
R.R. Battues	Ray Battues	SRNL S&H	773A A116

The FA/FM documents successful closure of all findings and completion of any applicable testing by signing the Inspection form: thus authorizing use, occupancy or closure of the applicable facility, equipment, structure or component. Copies of the completed OSR form shall be forwarded to all inspection team members.

Andrew R. [illegible] Custodian/FA/FM

2/25/09 Date

A copy must be retained in the file.

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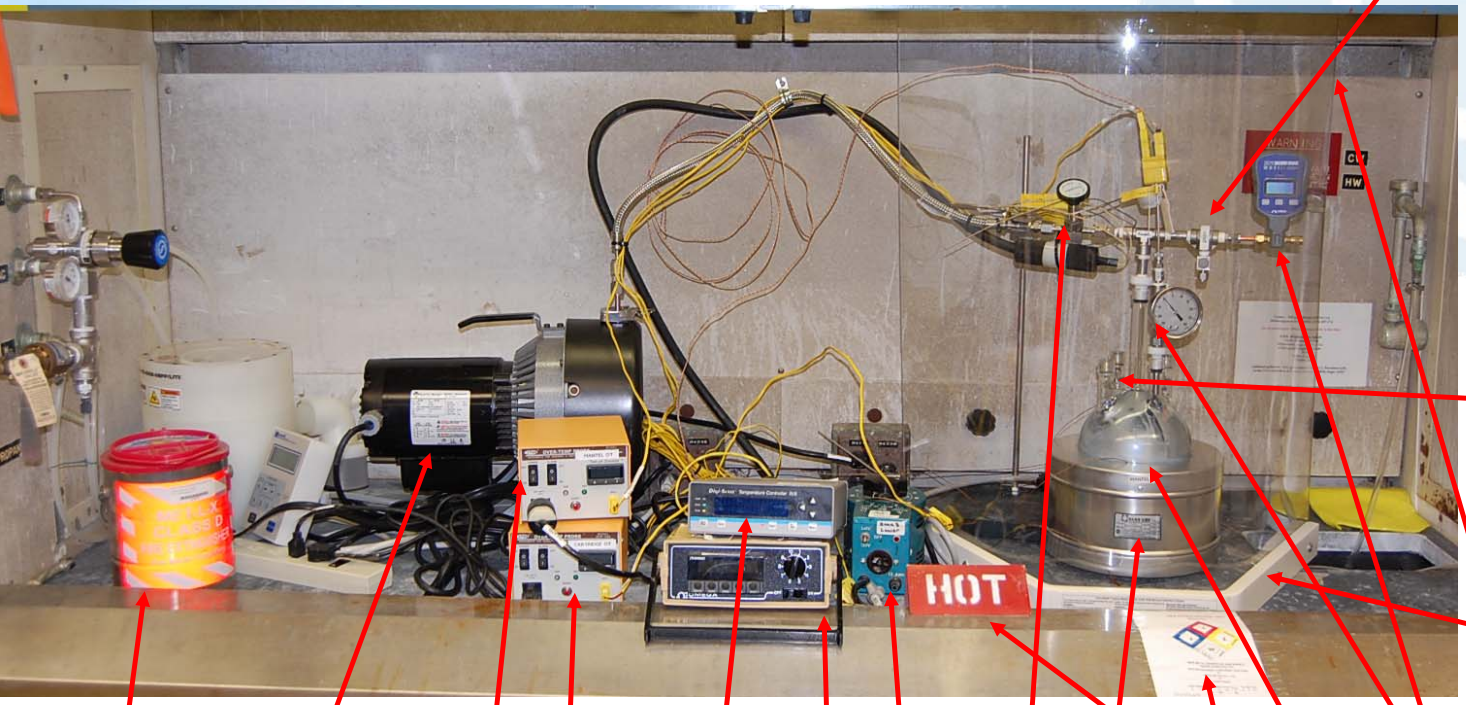
Test Apparatus – Final Configuration



Vent valve

1 of 3 Sample cells (hot, cold, & Ambient)

Protective Shield

Vacuum gauges

Requested Signage

Vessel

Heater Mantle

Isolation valve

Mantle Variac

Cartridge Controller

Thermocouple Reader

Cartridge OT cont

Mantle OT cont

Scroll Pump

Metal-X

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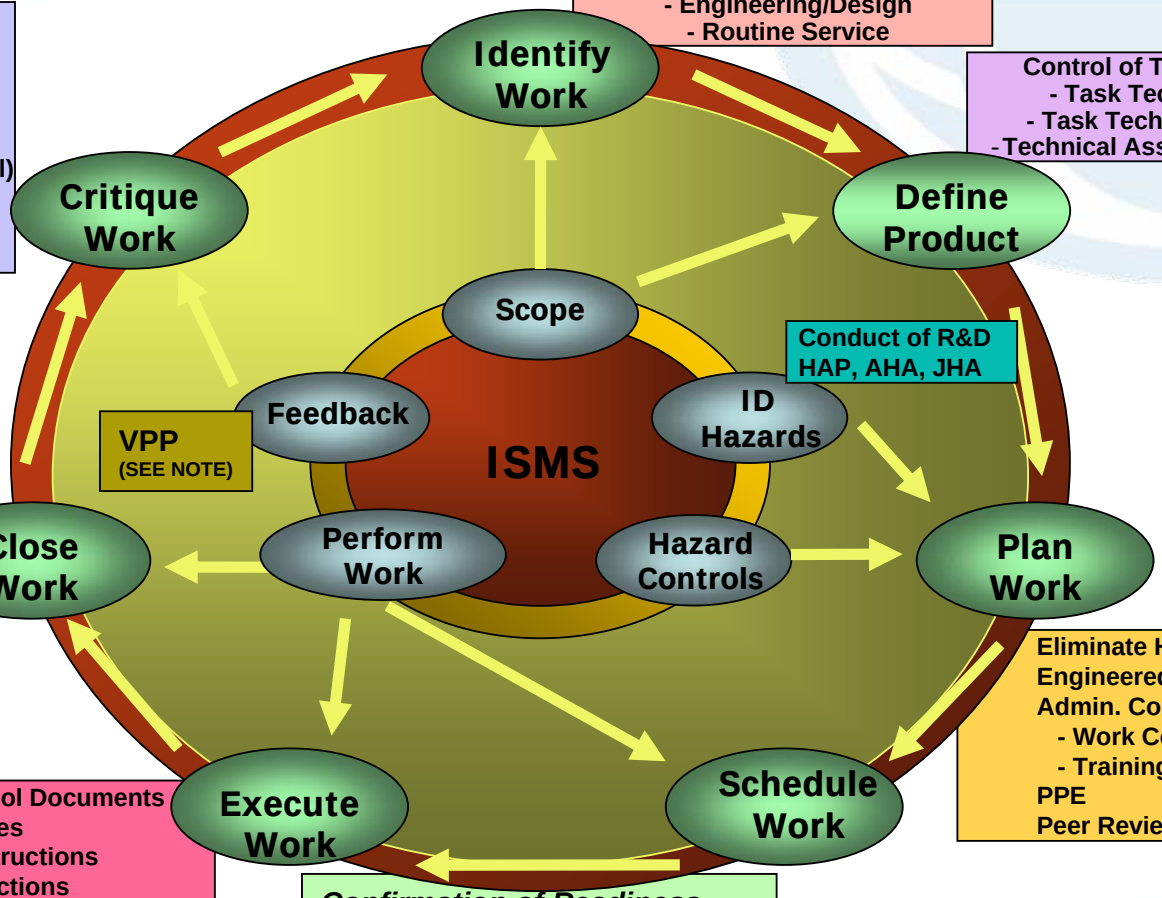

Conduct of R&D
HAP, AHA, JHA

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(SEE NOTE)

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Perform Work Safely Within Controls *(time frame)*

- **Integrated work with ongoing work activities and authorized to proceed *(1 month prior)***
  - Met with line management and laboratory custodian to gain access to laboratory space in a chemical hood
  - Briefed them on proposed path forward and obtained approval
- **Readiness to conduct work confirmed *(1-2 weeks prior)***
  - Setup apparatus and controls, conducted 8Q-51 safety inspection, walked down laboratory with line management
- **Pre-job briefing to ensure hazards and controls are understood, staff is trained and qualified *(1 day before)***
  - Conducted informal pre-job briefing among research staff to review of JHA, *HAP* and R&D Directions for conducting the work
- **Confirm pre-requisites/limitations, hold points and immediate actions in R&D Directions with PIs (workers) *(day of test)***

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Perform Work Safely Within Controls *(time frame)*

- **Workers utilized R&D Directions**
  - Conducted 2 tests following the R&D Directions
    - Constant monitoring & recording test parameters (temperatures & pressure vs. time)
  - Recorded data in laboratory notebook
- **The acceptability of work product or outcome is verified *(after test)***
  - Used SEM to characterize morphology of films produced
  - Recorded condition / appearance with digital camera
- **Work documents are closed in a timely manner *(project end)***
  - Project will be summarized and end with report
  - Laboratory notebook will be closed and stored in records at end of project

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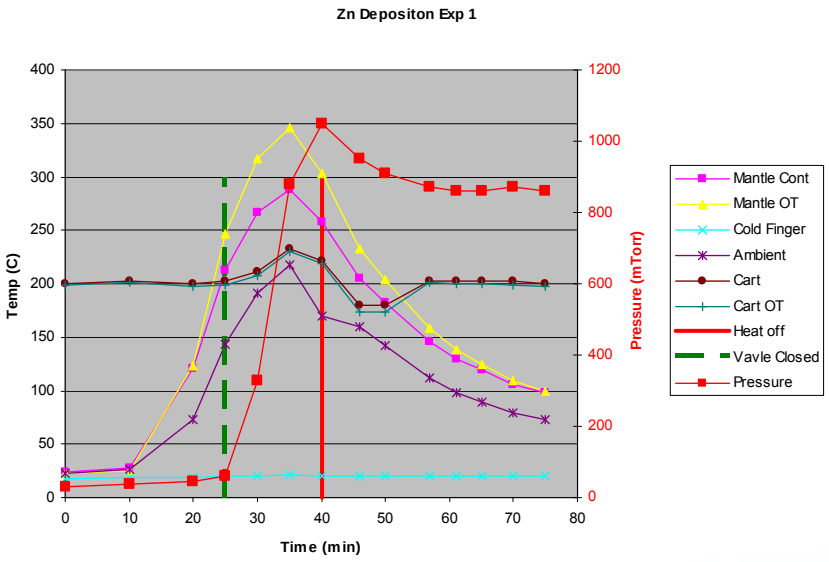
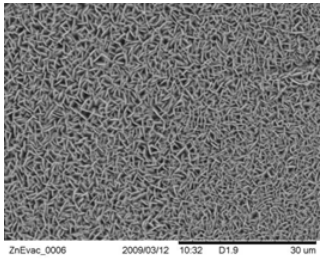
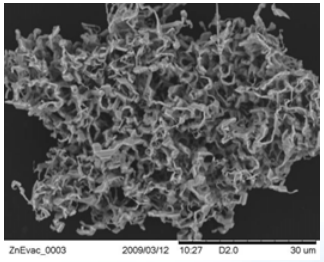
Test 1 Results

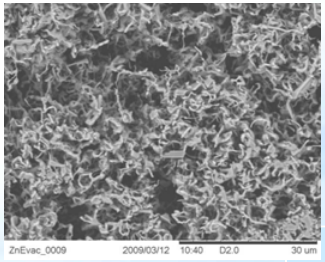




Cold Finger
Nearly continuous film
Lenticular deposit



Ambient Finger
Discontinuous film
Sponge deposit



Hot Finger
Discontinuous film
Sponge deposit

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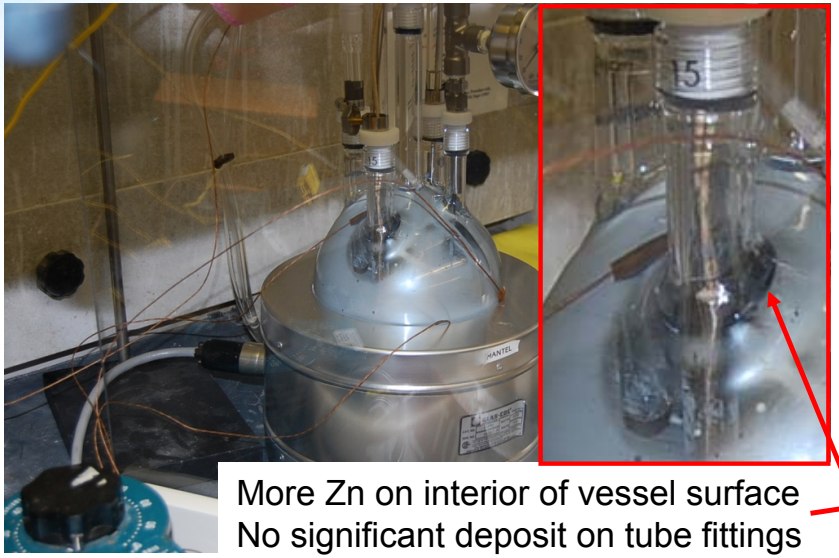
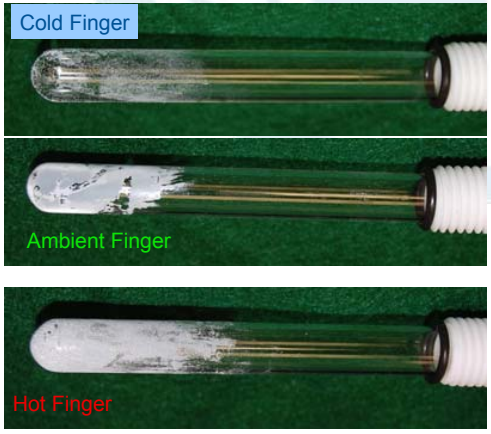
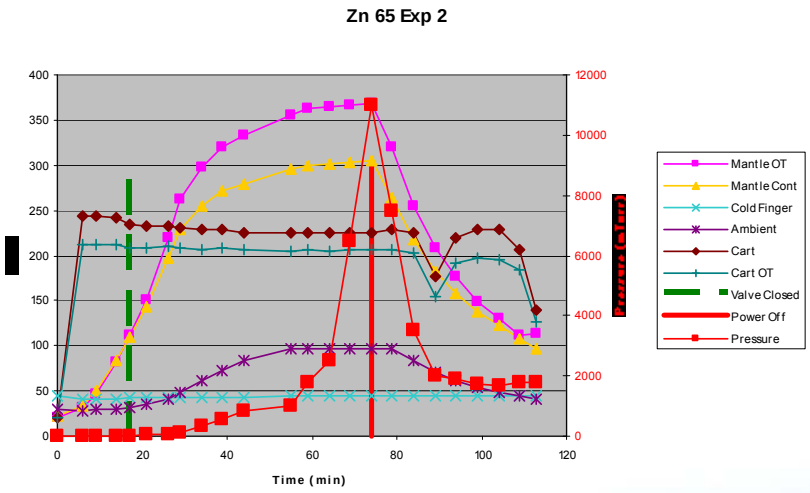
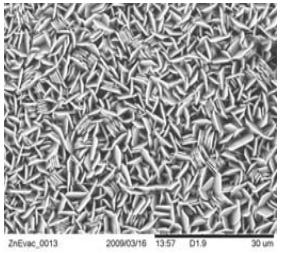
Test 2 Results

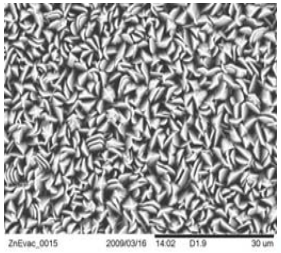


More Zn on interior of vessel surface
No significant deposit on tube fittings



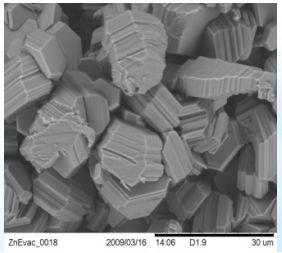






Cold Finger
discontinuous film
Lenticular deposit

Ambient Finger
Nearly continuous film
Lenticular deposit



Hot Finger
Continuous Film
Hexagonal Crystals

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Close

Intermediate Deliverable – Data for team

- **Data Presented to**
  - Tritium Readiness Campaign team
  - TEF facility manager and ^{65}Zn mitigation team
  - TEF project manager
  - Parties expressed interest in results to date
    - Concurred with continuing experiments
    - Suggested initiating Phase 2
- **Results**
  - Colder Temperatures not effective in developing tightly adherent deposit
  - Need to establish temperature range to produce adherent coating
    - 220°C produces good coating
    - 100°C does not

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R&D Integrated Safety Management & Work Control System

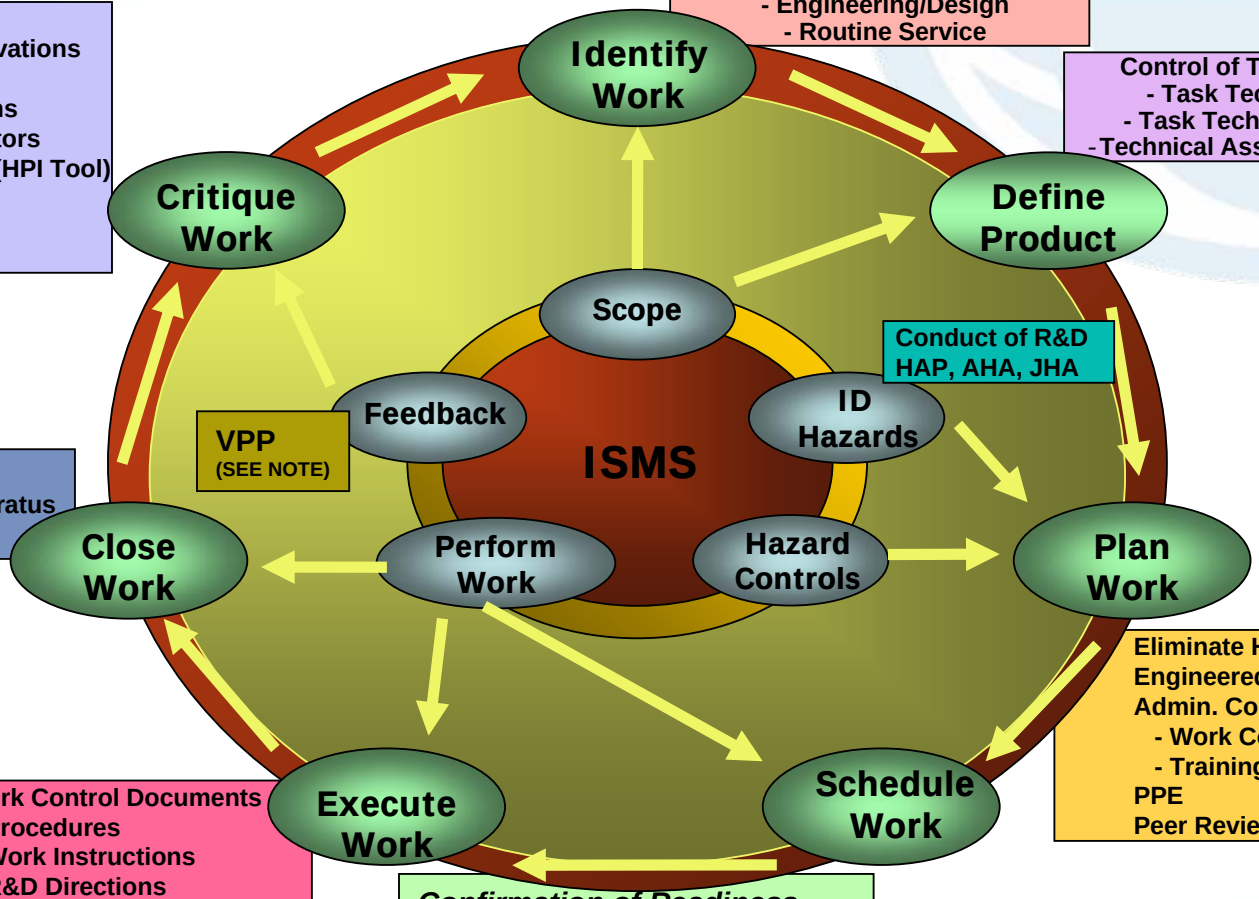
April 16, 2009

Categories of Technical Work:
- R&D
- Engineering/Design
- Routine Service

Self-Assessments
Management Observations
BBS Observations
Monitored Evolutions
Performance Indicators
Issue Investigation (HPI Tool)
- Fact Finding
- Post Job Review

Corrective Action

Control of Technical Work:
- Task Technical Plans
- Task Technical Requests
- Technical Assistance Requests



Conduct of R&D
HAP, AHA, JHA

VPP
(SEE NOTE)

Document results
Disassemble apparatus
Dispose of waste

Eliminate Hazard
Engineered Controls
Admin. Controls:
- Work Control Documents
- Training

PPE
Peer Review (HPI Tool)

Work Control Documents
- Procedures
- Work Instructions
- R&D Directions

"Time-out" (HPI Tool)
BBS Observations

Confirmation of Readiness
Pre-job briefing (HPI Tool)
- Enhanced situational awareness
  - Critical steps
  - Error-likely situations
  - Potential consequences
  - Flawed defenses

NOTE: Savannah River Site is a DOE Voluntary Protection Program (VPP) site

VPP is certification/recognition by DOE that SRNS and WSRC are providing excellent safety and health protection to all employees.

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Feedback

- **Materials Science & Technology staff conducted self assessment**
  - Reviewed HAP, R&D Direction, pressure protection documents (2009-SA-002572) No findings for LOI
- **Experiment and HAP package was discussed and walked down with DOE facility representatives**
- **Post experiment meetings held to determine next experiment**
  - Determined deposition temperatures and duration
- **Data consolidated and entered into laboratory notebook**
- **Recommend starting Phase 2**
- **R&D Directions were revised for future tests based on independent review**

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Feedback – Initiate Phase 2

- **Assess defined scope – determine if changes are needed**
- **Reassess hazard assessment**
  - Revise to address new / different hazards
  - Assemble new apparatus
  - Utilize appropriate instrumentation
  - Draft appropriate task and quality plans if needed
- **Design new apparatus**

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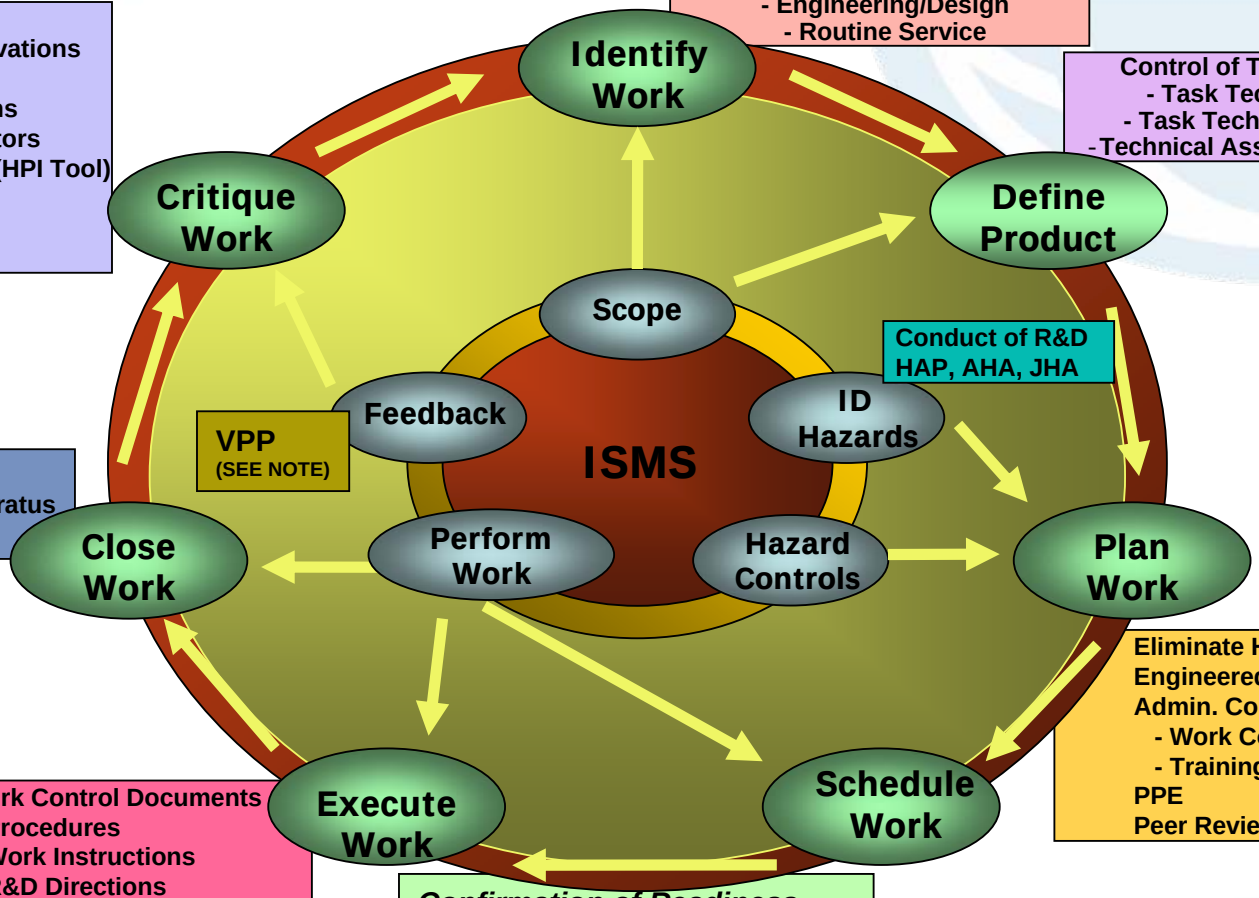

Conduct of R&D
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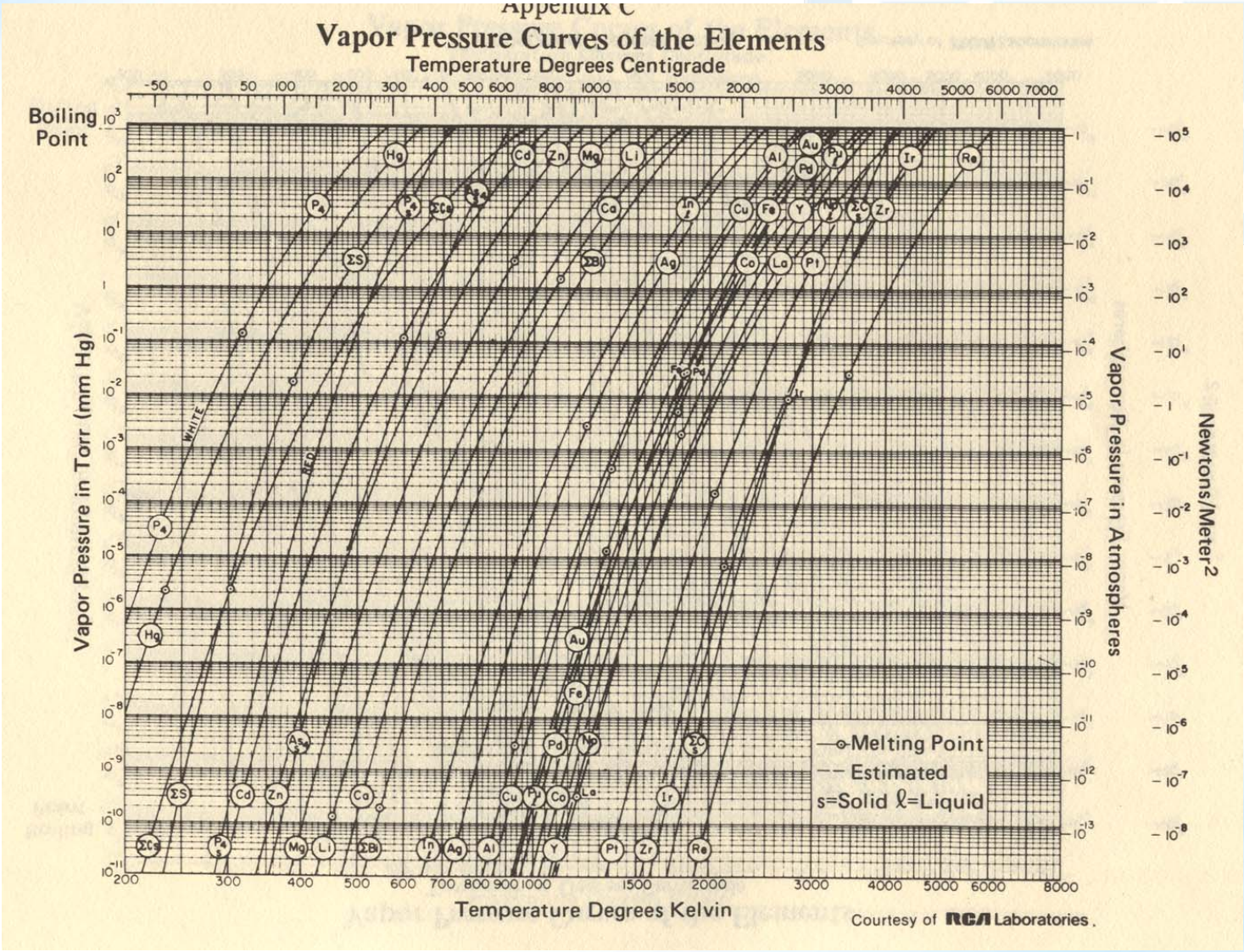
Questions?

Vapor Pressure of the Elements



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1Q 2-3 Scoping versus Task

Task Activity – R&D work is designated a task if it produces information for any one of the following purposes

- become part of or to establish a Technical Baseline as defined in Procedure Manual E7, "*Conduct of Engineering and Technical Support* "
- establishes the technical basis in documents formally transmitted to regulatory or licensing agencies, for example, Nuclear Regulatory Commission (NRC), South Carolina Department of Health Environmental Control (SCDHEC), Environmental Protection Agency (EPA), that are subject to become public records
- it is designated as a task by the requestor or R&D Management.
- All other R&D activities shall be considered scoping activities, which do not require a Task Technical Plan or a Task QA Plan.

Scoping Activity – those R&D activities that do not meet the criteria for a Task Activity.

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Define Scope of Work

- **The work requested, deliverables, and customer requirements are understood**
  - L1 Procedure 7.23 Conduct of R&D – Work Planning and Control
    - Proposal defined work to be accomplished and expected outcome
    - Must meet 1Q manual (Scoping and Task)
    - Funding status – defined from TEF project manager
    - Work location identified – 735-11A room 110

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