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Next-Generation Induction Melter Technology Development

DOE EM Waste Processing Technical Exchange, Nov 16-18, 2010, Atlanta, GA

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Presentation Outline

- Introduction
- CCIM Key Attributes
- CCIM Target Performance for Hanford WTP Applications
- EM Tank Waste R&D Plan Initiative 5.2.1
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- CCIM Project - Proposed LAW Tasks and Milestones
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- CCIM Project - Anticipated Near-term Outcomes
- CCIM Project - Summary - Focus Areas

Introduction

- **DOE EM radwaste vitrification processing challenges are addressed in the Tank Waste R&D Plan (June 2010)**
- **R&D Plan Initiative 5.2.1 "Develop Next-Generation Melters" includes 5 key R&D activities**

Ongoing

- **5.2.1.2 -** Glass Formulation for Next Generation Melters (NGM)
- **5.2.1.3 -** Next Generation Induction-heated Melter Bench-Scale Testing
- **5.2.1.4 -** Next Generation Melter Development and Engineering
- **5.2.1.5 -** Design, Fabrication, and Installation of Next Generation Test Melter

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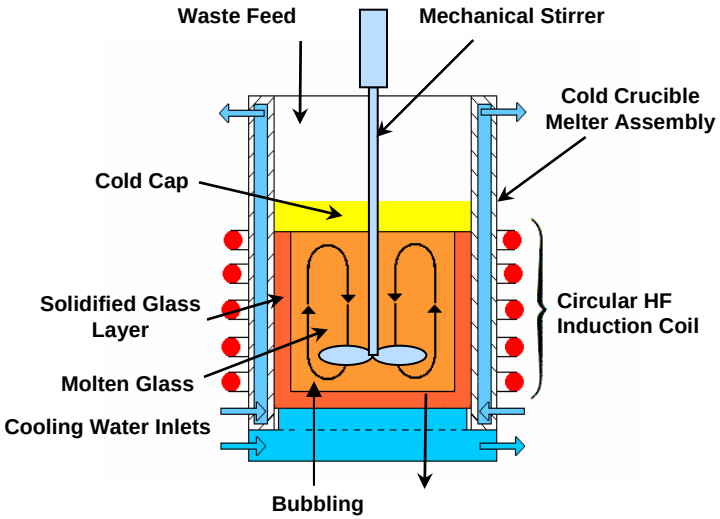
- **5.2.1.6 -** Next Generation Melter Testing and Component Improvement

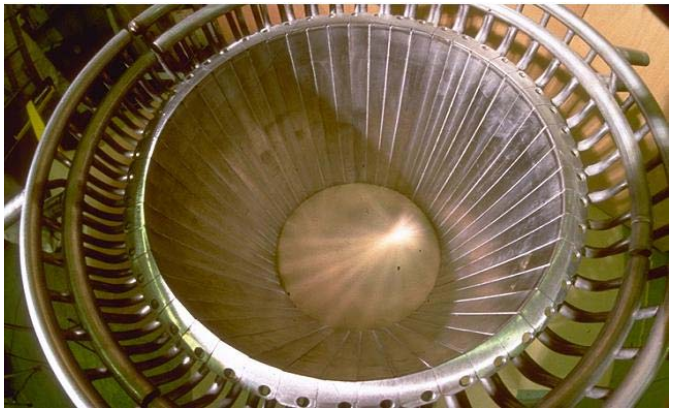
Future

- **AREVA is one of the two NGM technology providers identified for evaluation**
  - **Brings the CCIM technology successfully retrofitted into an existing HLW vitrification facility at La Hague**
- **AREVA participates in R&D activities funded through WRPS and PNNL**

CCIM Key Attributes

- **Direct induction heating by a high-frequency electromagnetic field through a sectorized cylindrical structure maintains high operating temperatures**
  - **Allows high thermal power release to the melt and high specific throughput rates (~2.92MTG/day.m^2)**
  - **No immersed electrodes**
  - **Melter is interruptible - Capable of restart, even after extended shutdown**
- **Water-cooled stainless steel crucible**
  - **Creates a protective inner glass layer ("Cold Crucible")**
  - **No direct contact with corrosive glass**
  - **No refractory lining**
  - **Increased equipment service life**
- **Improved mixing and glass product homogeneity**
  - **Mechanical stirrers**
  - **Bubblers**
- **Bottom discharge for complete draining**
- **Compact metallic structure**
  - **Easily replaceable, and readily disposable**





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CCIM Target Performance for Hanford WTP Applications

- **Key throughput requirement for accelerated HLW processing**
  - **Increase HLW design processing rate to 7.5 MTG/day at 38% waste loading and 70% TOE with 2 NGMs = consume 1,430 Kg of waste oxides per day per melter**
  - **A 1.4 m diameter CCIM can consume up to 1,450 Kg of waste oxides per day**
    - Demonstrated during ART CCIM Phase II-A testing using high-alumina SB4 tank waste slurry
    - Supports throughput requirement for accelerated completion of HLW mission
    - Increased waste loading also reduces the number of HLW canisters to be poured
      - 14,111 HLW canisters are planned (RPP System Plan, ORP-11242, Rev 4) – increasing waste loading to 50% on average can reduce this count to less than 9,000 (46% waste loading achieved with SB4)

- **Key throughput requirement for accelerated LAW processing**
  - **Increase LAW processing rate to 42 MTG/day at 70% TOE using 2 NGMs**
  - **Alternate geometries can be applied to achieve the high throughput necessary**
    - Advanced Cold Crucible Induction Melter (ACCIM) - Heating by an induction coil below the bottom slab has been demonstrated at scales to 1.4 m diameter
    - In this approach, a much larger melter surface area can be considered

EM Tank Waste R&D Plan Initiative 5.2.1 Scope & Objectives – CCIM Project

AREVA R&D activities funded through WRPS:

- **Leads 5.2.1.4 – CCIM Development & Engineering**

FY2010

- Define preliminary designs for CCIM technology fitted into WTP HLW and LAW Vitrification Facilities

FY2011 & outyears

- Study Key Technical Issues related to technical feasibility of HLW and LAW retrofits
- Define process flowsheets for key HLW and LAW streams to allow determination of the impact of CCIM and ACCIM deployments on the WTP mission
- Update pre-conceptual designs based on results from studies and large-scale CCIM tests (5.2.1.6), identify cost & schedule for deployment, and issue consolidated report

• OUTCOME

Engineering design studies verify that CCIM retrofit into WTP is technically feasible, and provide sufficient data to forecast cost and schedule to deploy the technology

- **Supports 5.2.1.2 – Glass Formulations & 5.2.1.3 – CCIM Bench-scale Testing**

FY2010 & beyond

- Provide technical support to principal investigators (PNNL, SRNL, and INL)
- Ensure results can be integrated with later large-scale CCIM testing

EM Tank Waste R&D Plan Initiative 5.2.1 Scope & Objectives – CCIM Project (cont.)

AREVA R&D activities funded through PNNL:

- **Leads 5.2.1.5 – Design, Fabrication, and Installation of CCIM Test Melter**

FY2010

- Develop pre-conceptual design of a large-scale (~1 m dia) US-based CCIM process demonstration platform

FY2011 & outyears

- Definitive design, procurement of long-lead material, and site preparation
- Fabrication, installation, and acceptance testing
- Commissioning and test operations

CCIM pilot-scale test platform
CEA Marcoule

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EM Tank Waste R&D Plan Initiative 5.2.1 Scope & Objectives – CCIM Project (cont.)

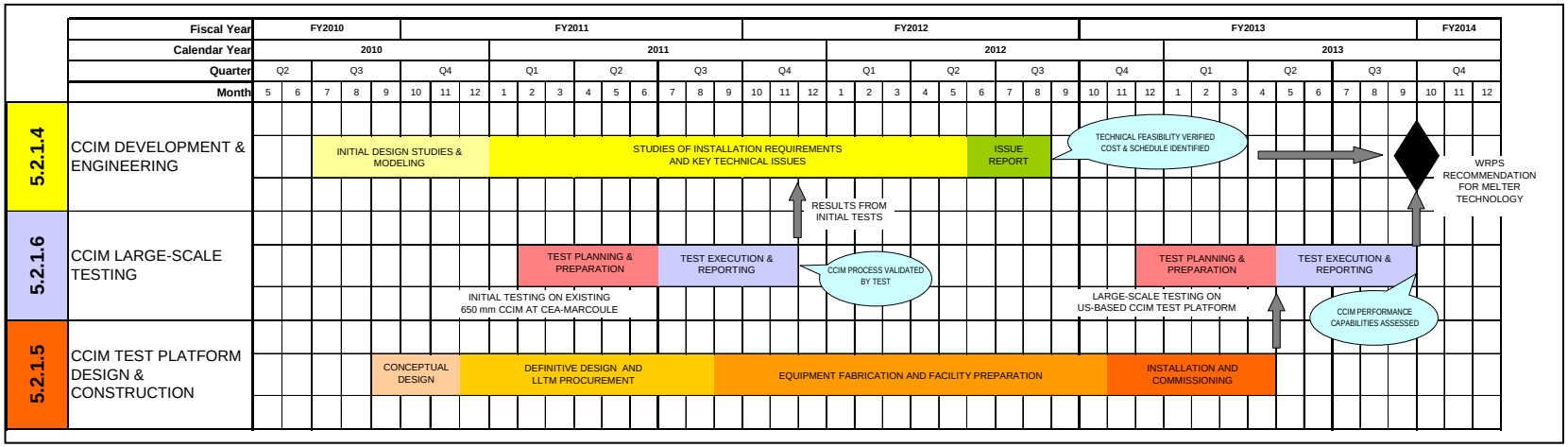
AREVA has proposed to participate in FY11 and outyear R&D activities

- **5.2.1.6 – Next Generation Melter Testing - CCIM**
  - **Initial system demonstration tests – at existing CEA pilot-scale test platform in Marcoule**
    - Provides early verification of design assumptions in 5.2.1.4 engineering studies
  - **Process variability tests on large-scale US-based CCIM demonstration platform**
    - CCIM performance capabilities for processing Hanford waste assessed

• OUTCOME

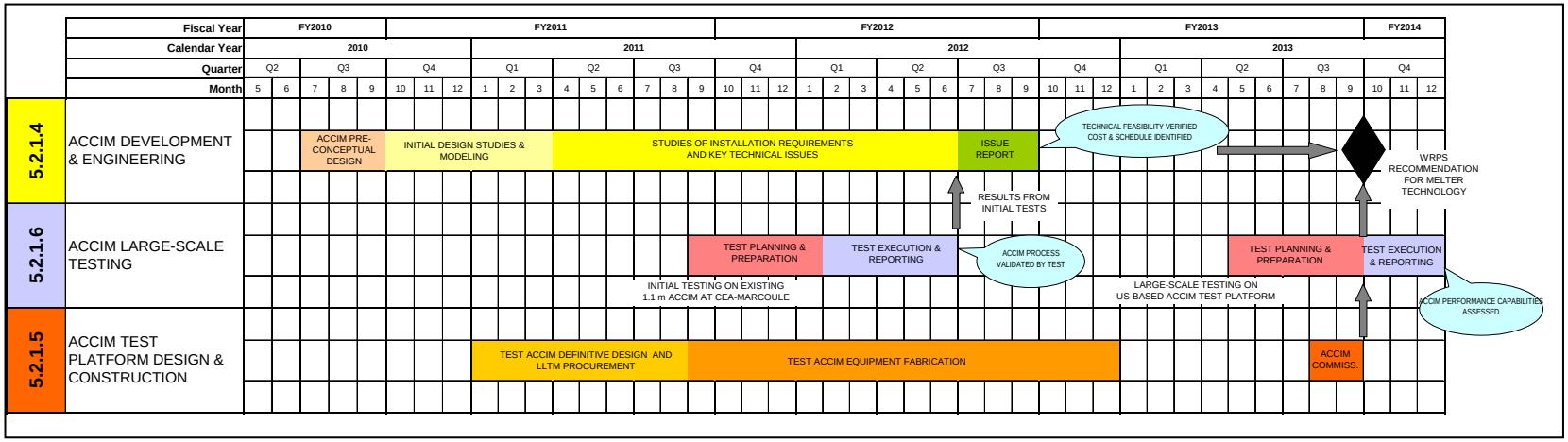
Testing on a US-based process demonstration platform demonstrates CCIM throughput capacity when treating key Hanford wastes at large-scale

CCIM Project
Proposed HLW Tasks & Milestones



MILESTONES – CCIM FOR HLW	
5.2.1.4 - Complete pre-conceptual design of CCIM installation for Hanford HLW	12/2010
5.2.1.5 - Complete large-scale US-based CCIM demonstration platform design	8/2011
5.2.1.6 - Complete initial system performance demonstration tests (at Marcoule)	11/2011
5.2.1.4 - Issue design for CCIM applied to Hanford HLW	8/2012
5.2.1.5 - Perform initial US-based CCIM demonstration platform shake-down tests	4/2013
5.2.1.6 - Complete process variability tests (on US-based demonstration platform)	9/2013

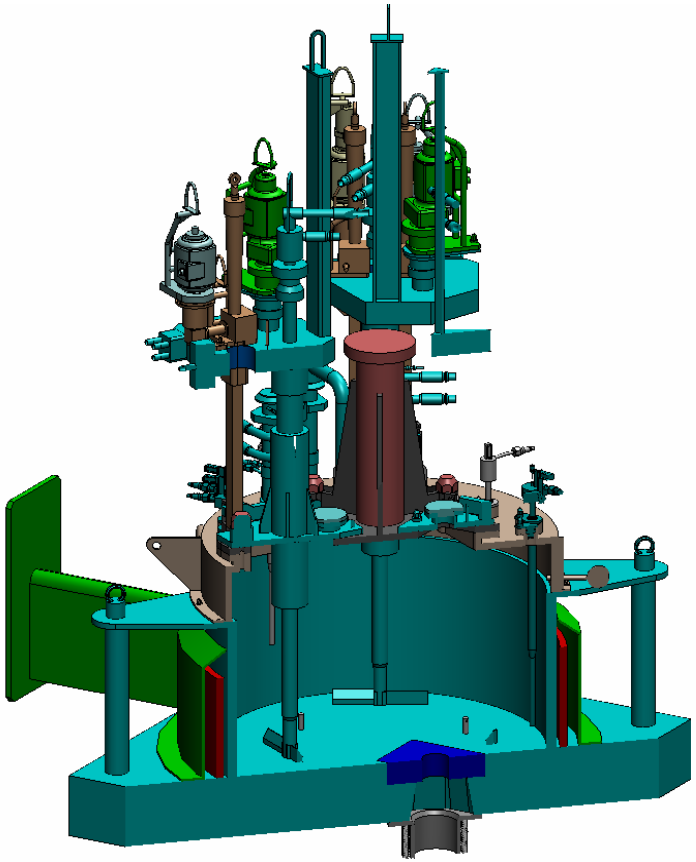
CCIM Project
Proposed LAW Tasks & Milestones



MILESTONES – CCIM FOR LAW	
5.2.1.4 - Complete pre-conceptual design of CCIM installation for Hanford LAW	3/2011
5.2.1.5 - Complete large-scale US-based CCIM demonstration platform design	8/2011
5.2.1.6 - Complete initial system performance demonstration tests (at Marcoule)	6/2012
5.2.1.4 - Issue design for CCIM applied to Hanford LAW	9/2012
5.2.1.5 - Perform US-based CCIM demonstration platform shake-down tests	10/2013
5.2.1.6 - Complete process variability tests (on US-based demonstration platform)	12/2013

CCIM Project
Summary FY10 Accomplishments

- **Under R&D Activity 5.2.1.4**
  - **Started implementing the multi-year Task Plan for WP-4.1.4 CCIM engineering studies**
  - **Defined the preliminary CCIM design sized for WTP HLW treatment**
  - **Prepared preliminary CCIM flowsheet modeling tool for studying key Hanford wastes**
  - **Defined key design elements and scope of modeling required to determine preferred ACCIM configuration for accelerating LAW treatment**
  - **Prepared work plan for CCIM retrofit engineering studies and funding requirements for engineering and technology demonstrations through FY2013**



Sectional view of a 1.4 m diameter CCIM fitted with mechanical stirrers for HLW processing

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CCIM Project
Summary FY10 Accomplishments (cont.)

- **Under R&D Activities 5.2.1.2 and 5.2.1.3**
  - **Participated in WP-4.1.2 glass formulation studies and WP-4.1.3 bench-scale CCIM test planning**
  - **Provided suggestions for glass formulations (including iron phosphate glass) and bench-scale test plan that fully optimize the benefits of the CCIM technology being studied**
    - High operating temperatures (~1,350 deg C)
    - Not sensitive to corrosive glass and crystal-forming species)

CCIM Project
Summary FY10 Accomplishments (cont.)

- **Under R&D Activities 5.2.1.5**
  - **Held kick-off meetings with project participants SGN, AREVA NC, and AREVA NP Richland engineering staff**
  - **Established baseline resource-loaded schedule by updating proposed schedule to reflect actual start date of technical work (Oct 25) and milestone and completion dates specified in contract SOW**
  - **Prepared and submitted Project Quality Assurance Plan**
  - **Developed initial draft Functional Requirements and Technical Design Criteria for the US-based large-scale CCIM demonstration platform**

CCIM Project
Anticipated Near-term Outcomes

- **From CCIM HLW Studies**
  - **Lab and Demonstration Outcomes**
    - CCIM glass formulations optimized for HLW oxides
    - CCIM capabilities using alternate glass forms studied
    - Throughput and waste loading capabilities identified
    - CCIM off-gas performance with WTP waste forms assessed
  - **Engineering Outcomes**
    - 1.4 m diameter CCIM configuration for HLW processing at WTP defined
    - CCIM HF power supply configuration defined
    - Preliminary design of WTP HLW Melt Cell modifications completed
    - Initial WTP flowsheet and confirmation of sizing for CCIM processing prepared
    - Performing engineering studies of CCIM at WTP, sufficiently detailed to support an accurate estimate of cost and schedule for such a deployment
  - **US-based large-scale CCIM process demonstration platform operational near Hanford**

CCIM Project
Anticipated Near-term Outcomes (cont.)

- **From ACCIM LAW Studies**
  - **Lab and Demonstration Outcomes**
    - Glass formulations optimized for LAW constituents of interest studied
    - Capabilities and limitations of alternate glass formulations studied
    - Cost and schedule for rehabilitating and upgrading the Marcoule ACCIM platform defined
    - Technical feasibility of process LAW glass with ACCIM technology verified
    - Initial data on waste loading and throughput capabilities identified
    - Areas for further lab and demonstration study defined
  - **Engineering Outcomes**
    - Hanford LAW melter configuration and accessories studied
    - Initial flowsheets and sizing studies prepared
    - Areas for further engineering study defined

CCIM Project Summary – Focus Areas

- **Successful progress of the NGM program to support the DOE EM down-select decision by the end of FY2014 will require increased focus on the following areas**
  - **Consistent funding at required levels**
  - **Access to WTP HLW and LAW baseline design inputs**
  - **Continued participation of AREVA and CEA in R&D activities 5.2.1.2 and 5.2.1.3 for efficient planning of larger scale CCIM tests**
  - **Conduct early pilot-scale CCIM tests on the existing CEA Marcoule platform**
  - **Deploy near Hanford a large-scale CCIM platform for process demonstration and qualification, and operator training**