

Continuous Production of Paste

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Project Overview

Objectives

- Design, Fabricate and Test an Energetics Rated Continuous Acoustic Mixing – Clean In Place (CAM-CIP) system
- Demonstrate Energetic PBX Production at NAWCWD China Lake Using the Energetics Rated CAM-CIP system

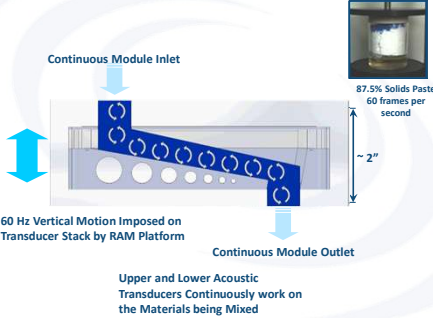
Results

- CAM-CIP Module Completed and Tested
- Testing of Energetics Rated Ancillary System Ongoing



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Continuous Acoustic Mixer - Paste



Continuous Module Inlet

60 Hz Vertical Motion Imposed on Transducer Stack by RAM Platform

Continuous Module Outlet

87.5% Solids Paste
60 frames per second

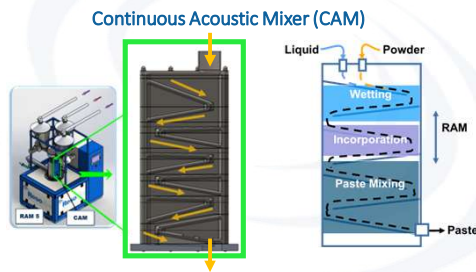
~ 2"

Upper and Lower Acoustic Transducers Continuously work on the Materials being Mixed



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Continuous Mixing Schematics



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Mixing Pastes Continuously

- CAM-CIP for RAM 5
- Paste Viscosities: >1,000,000 cP at Room Temperature
 - Tested at: 3.0 kg/min or 180 kg/hr



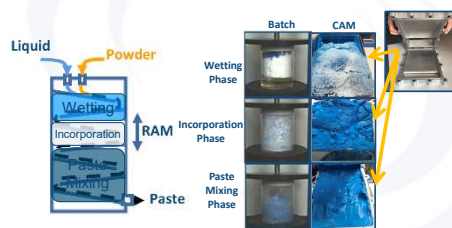
Continuous Mixing System



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Continuous Module Mix Regimes

Mix Regimes are the Same within the CAM as in Batch



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Characterization of the CAM-CIP

Test	Solids Loading %	Acceleration G	Flow Rate gm/min	Solids Loading Range %
1	92.6	60	932	0.4097
2	92.6	80	932	3.175
3	88.6	70	535	1.044
4	89.0	60	970	0.5808
5	89.0	80	970	0.6595
6	86.0	70	1,500	0.00989
7	87.5	60	1,760	0.1824
8	89.0	70	2,500	0.1230
9	87.5	80	2,500	0.5012
10	86.0	60	2,500	0.4531
11	87.5	70	1,250	0.1617

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Plastic Bonded Surrogate Explosive Paste

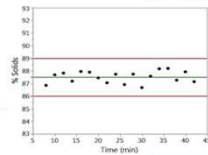
Regression Analysis:

- JMP Software was utilized
- All source interactions are statistically significant
- The interaction between solids loading and acceleration is the most significant

Mixed material was tested for consistency using:

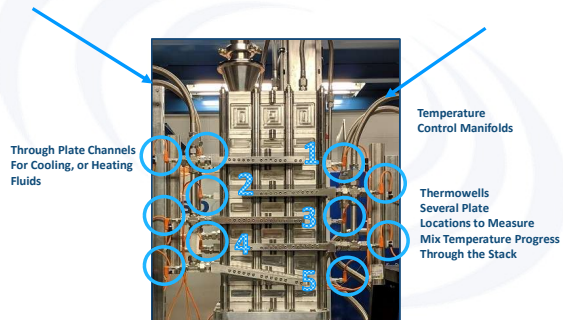
- Thermal Gravimetric Analysis

Source Interactions	p-value
Solids Loading (%)	0.0233
Acceleration (g)	0.0408
Flow Rate (gm/min)	0.0150
Solids Loading (%), Acceleration (g)	0.0016
Solids Loading (%), Flow rate (gm/min)	0.0236
Acceleration (g), Flow Rate (gm/min)	0.0264

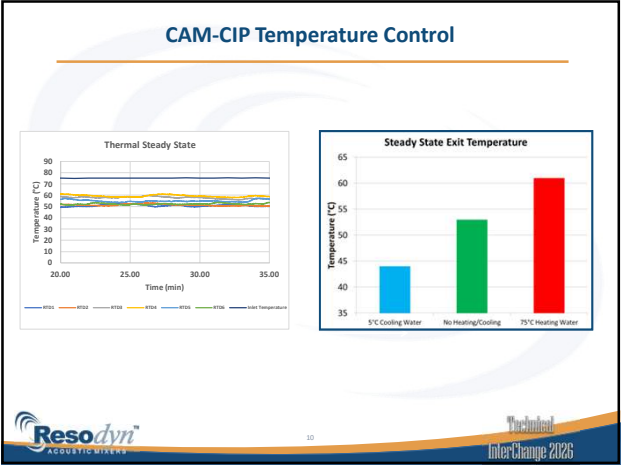


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Temperature Control – Heating or Cooling



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Clean-in-Place (CIP)

Current Typical Batch Cleaning

- Uses Organic Solvents
 - Hazardous Air Pollutants (HAP)
 - Exposure source for workers
- Creates Waste
 - Residual material ≈ 5% by mass
 - Cleaning supplies and PPE ≈ 10% by mass

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Clean-in-Place (CIP)

Prototype CAM Processing Water and Air

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CAM Clean in Place (CIP)

- Cleaning Inert PBX Surrogate from CAM using Clean-in-Place
- 5 kg of Material Wasted
- Less than 9 L of Aqueous Waste
- 100% Removal Efficiency Achieved

After Runout
Before Cleaning




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Transition to an Operational Environment



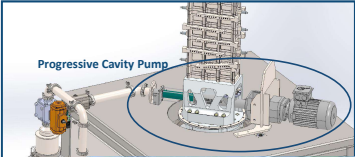


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Material Transport

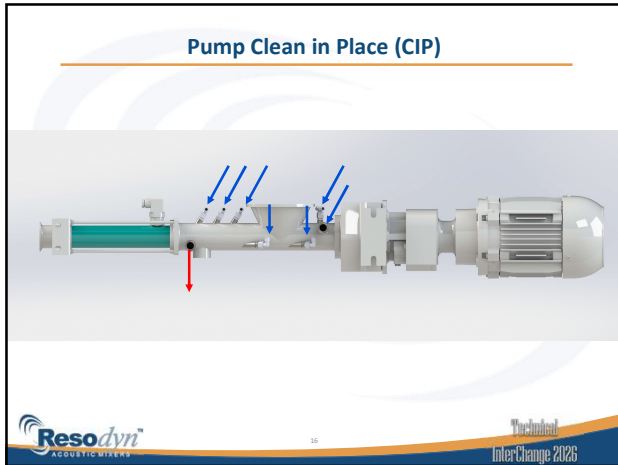




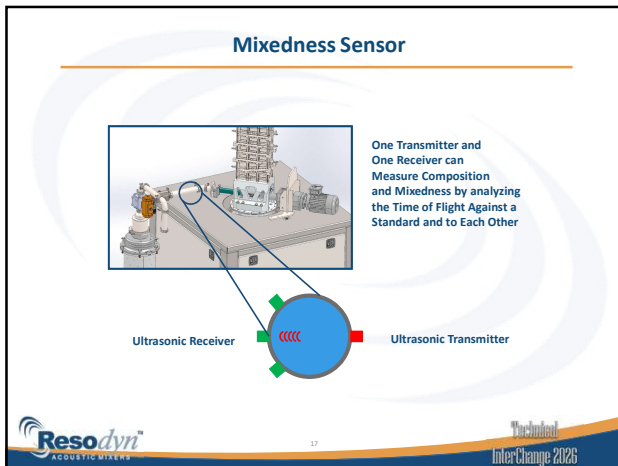
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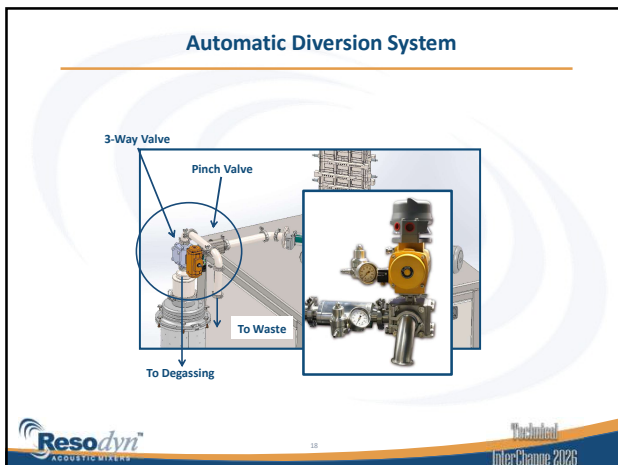
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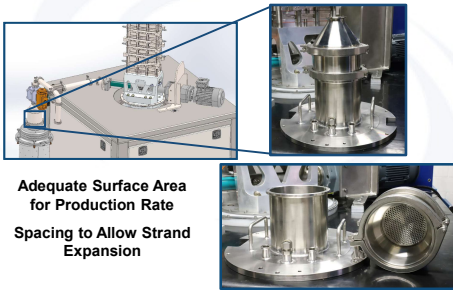


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Continuous Degassing System



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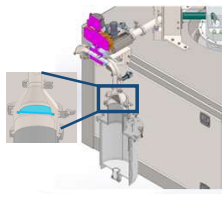
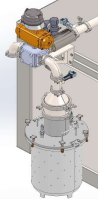
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Continuous Degassing System Assembly

View of Degas Assembly



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Continuous Mixed Material Degassing System in Operation

Degas Strainer Assembly



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Degassed Mixed Material Collection at End of Run

Mixed and Degassed
Material Production Rate
60 kg/hour



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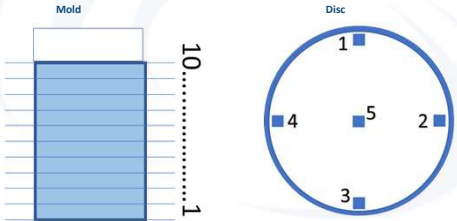
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Energetic Rated System Testing

Mold

Disc

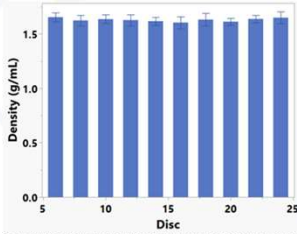


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Energetic Rated System Testing

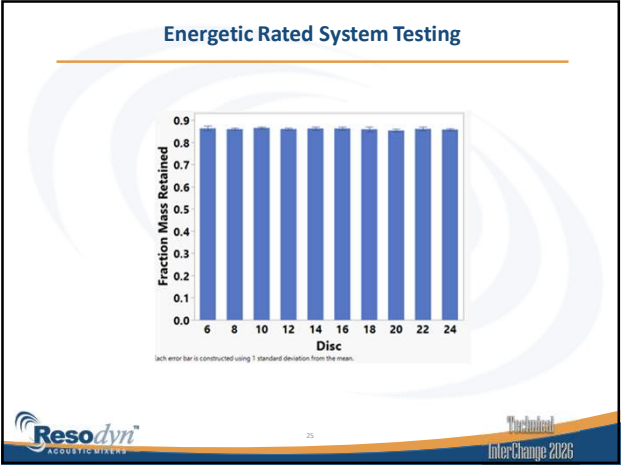


Each error bar is constructed using 1 standard deviation from the mean.

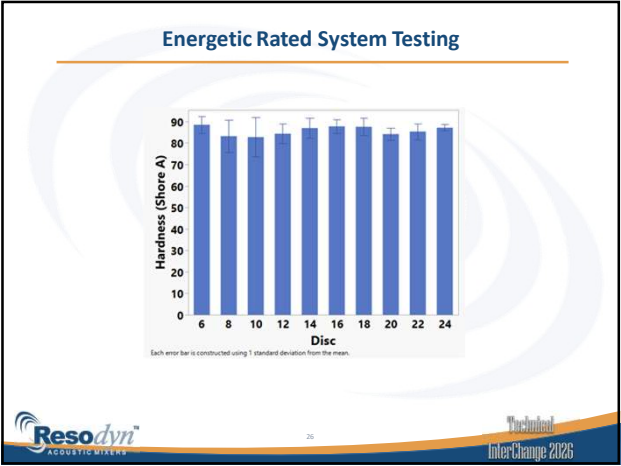
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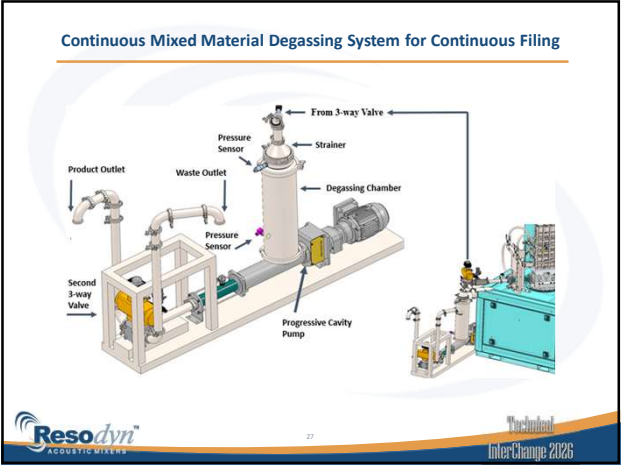
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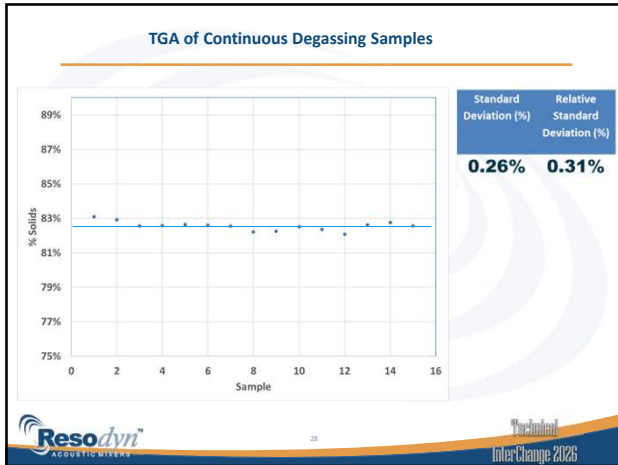
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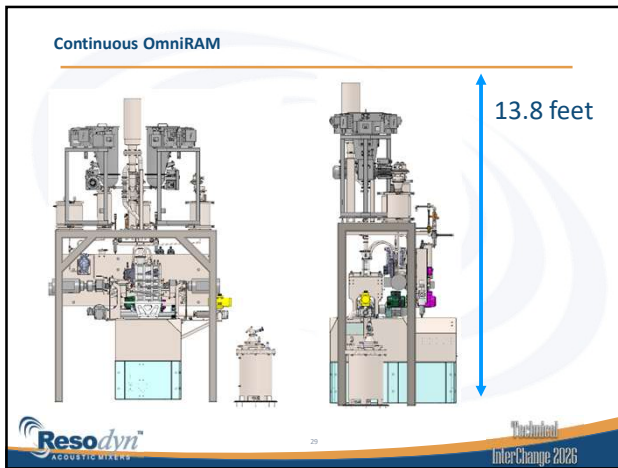


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Summary

Accomplishments

- Energetics Rated CAM-CIP Ready for Energetics Testing
- CAM-CIP Demonstrated with 100% Efficiency
- Temperature Control, Degassing

Next Steps

- Production of Mixed Energetic Material from this System at NAWC WD China Lake
- Development of Inline Mix Quality Sensor
- Testing of the OmniRAM Continuous system
- Installation of Continuous OmniRAM at DSTG

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