Resodyn™ ACOUSTIC MIXERS

96% Less Labor. 99% Less Solvent. A New Approach to Mixing Energetic Materials

Joint Military Research Shows ResonantAcoustic® Mixing Superiority in Safety, Throughput, and Cost in Military Illumination Flares

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OVERVIEW

Military illumination flares are among the most widely produced pyrotechnic items in the U.S. defense inventory. For decades, manufacturing the Magnesium/Sodium Nitrate/Epoxy compositions at their core has relied on mix-muller and impeller-based mixing — a slow, solvent-intensive process that exposes operators directly to hazardous materials. In 2002, an accident at the Crane Army Ammunition Activity (CAAA) during a mix-muller-based process caused extensive damage to equipment and the mixing room. [1]

A joint Army-Navy research program funded by SERDP set out to change this — and over three and a half years of rigorous testing, ResonantAcoustic® Mixing proved to be a safer, faster, and dramatically more cost-effective alternative, with projected annual savings of approximately $681,000 in labor and solvent costs. [1][2]

Solution

- ResonantAcoustic® Technology
- Sealed, Bladeless Mixing of Sensitive Pyrotechnics
- Elimination of In-Process Operator Exposure
- Scalable from LabRAM to RAM 5 H to RAM55

Achievement

- Labor Reduction up to 96% [1]
- 99%+ Reduction in Cleaning Solvent [1]
- ~$681,000 Projected Annual Savings vs. Mix-Muller [1][2]
- 92% Increase in Annual Production Capacity [1][2]

CHALLENGES

Conventional mix-muller and impeller-based mixing of pyrotechnic compositions requires metal-to-metal contact between moving parts, creating a genuine ignition risk. Personnel must repeatedly scrape blades and wheels during production-scale mixing of sensitive materials — exposing them to both the energetic composition and the volatile organic chemicals used for cleanup. In 2002, an accident at CAAA in a mix-muller-based process — thought to have been caused by pinching of material between moving parts — resulted in extensive damage to equipment and the mixing room. [1]

The waste and cost burden compounds the problem. Cleaning a mix-muller requires 1–2 gallons of acetone per batch regardless of batch size. According to CAAA personnel, up to 80% of all acetone at their illumination manufacturing facility is consumed on cleaning mixing hardware alone — a challenge that spans all three categories of energetic materials: explosives, propellants, and pyrotechnics. [1][3]

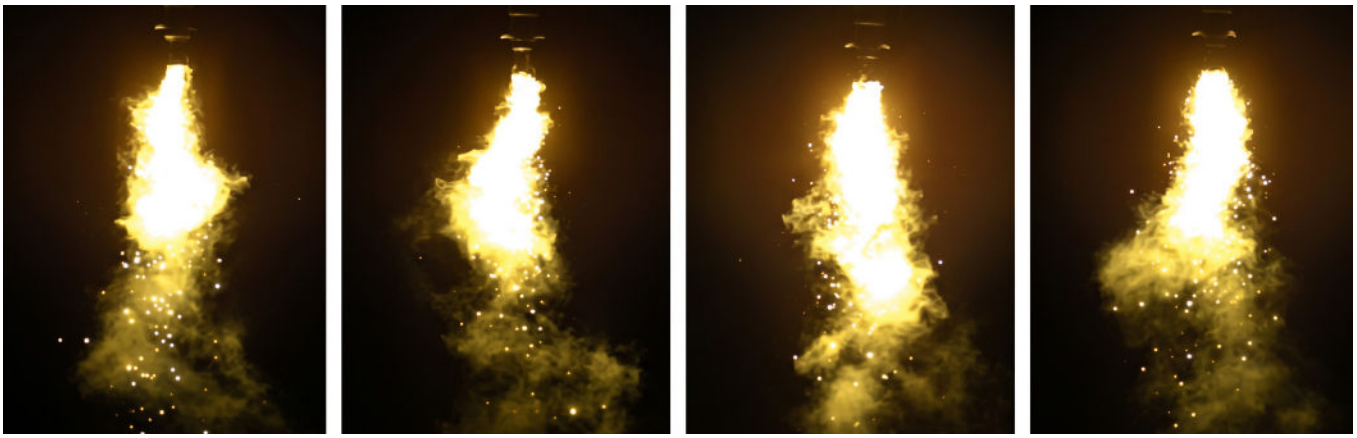
Scaled to a full production year, the numbers are striking. A mix-muller operating 8 hours per day over a 250-day annual schedule produces approximately 200,000 lbs of composition — at a labor cost of $600,000 per year and an acetone cleaning bill approaching $131,000. The defense manufacturing community needed a fundamentally different approach. [1][2]

A Decade of Coordinated Military Investment

ResonantAcoustic® Mixing is not an emerging or unproven technology in the defense sector. By the time the WP-2631 pyrotechnics program concluded, the U.S. military had simultaneously funded five SERDP and ESTCP research programs validating RAM across all three categories of energetic materials — explosives, propellants, and pyrotechnics. [3]

"Our five ongoing SERDP/ESTCP projects are related to RAM processing of energetic materials that span all three different energetic categories."

— Dr. Eric Beckel, U.S. Army ARDEC [3]



Mix-muller mixed | *Resodyn 1-step mixed* | *Resodyn 2-step mixed* | *Resodyn 3-step mixed*

WP-2631 illumnation flare testing.

SOLUTION

ResonantAcoustic® Mixing technology, pioneered by Resodyn Acoustic Mixers, uses low-frequency, high-intensity acoustic energy to homogeneously mix materials in a fully sealed container — without blades, impellers, or any moving parts contacting the composition. Containers can be customized to include temperature control, vacuum, and chemical compatibility to enhance safety and improve mix performance.

The sealed container design greatly reduces the risk of accidental ignition by impact, friction, or pinching of material between moving parts. As the SERDP report states directly:

> "*Resonant acoustic mixers offered by Resodyn Corporation are fundamentally different than the traditional impeller and mix-muller-based mixing techniques while simultaneously offering several significant safety advantages.*" [1]

The Naval Surface Warfare Center, Crane Division and U.S. Army Armaments Center research team spent three and a half years developing, refining, and validating RAM processes specifically for high-volume Mg/NaNO3/Epoxy pyrotechnic manufacturing across laboratory, concept, and full pilot scale. [1]

Homogeneity and Performance — Equivalent or Better

All RAM-mixed compositions were observed to be more homogeneous than mix-muller produced materials, with similar or slightly lower ignition sensitivity. Performance testing showed RAM material produced similar burn times and similar or increased luminous efficiency. Where the mix-muller typically produces large hard chunks of binder-rich material, the refined RAM processes produce material with the consistency of wet sand. [1]

Custom mixing container illustration for scaling analysis on LabRAM II H. [1]

Full-Scale Pilot Demonstration — Tested and Passed

RAM-mixed illumination composition was delivered to CAAA where three M485A2 155-mm Illumination candles were manufactured using standard production hardware and tested alongside standard mix-muller candles at the NSWC Crane photometric light testing facility — passing all light intensity performance requirements. [1] Leslie Thompson, Commodity Manager for Pyrotechnics at CAAA's Manufacturing & Engineering Directorate, confirmed in a formal letter of support:

> "*The material appeared homogeneous, with equal or better pot life, and pressed well using our production tooling. In comparison to the currently used mixed muller, the RAM mixer has several safety advantages and also mixes these types of compositions faster.*" [1]

Safety by Design — Eliminating the Ignition Risk

RAM's sealed, bladeless operation eliminates every major ignition hazard associated with the mix-muller process — no metal-to-metal contact, no scrape-down, no operator exposure

to composition during mixing, and full remote operation capability. For energetics facilities requiring hazardous location compliance, Resodyn offers the RAM 5 H, certified for Class 1 Division 1 environments. As Dr. Andrew Nelson of the Naval Air Warfare Center Weapons Division confirmed:

> "*The machines themselves are coming from Resodyn and for our industry as Class 1 Div 1 machines.*" [3]

Projected Annual Savings of ~$681,000

To produce approximately 1,000 lbs of illumination composition, the mix-muller requires three technicians for 10 hours. The RAM 5 H accomplishes the same output in 5 hours — a 61% labor cost reduction — while the RAM55 completes a 924-lb batch in just 1.5 hours, a 96% reduction. [1] Projected across a standard 8-hour, 250-day operating year, a RAM 5 H produces approximately 384,000 lbs annually — nearly double the mix-muller's 200,000 lbs on the same schedule. To match that output, a mix-muller facility would require approximately $1,152,000 in annual labor versus $600,000 for the RAM 5 H, a saving of $552,000. [1][2]

On solvent alone, the mix-muller would consume approximately 4,608 gallons of acetone annually to match RAM 5 H output — versus approximately 44 gallons for the RAM 5 H — a saving of approximately $129,617 and a reduction in hazardous solvent waste of over 99%. [1][2] Combined, a production facility replacing a mix-muller with a RAM 5 H could project annual savings of approximately $681,000, based on the cost assumptions documented in the SERDP report. Actual savings will vary based on facility labor rates, production volume, and operational configuration. [1][2]

Two soldiers launch illumination candles to enhance the nightime operation capabilities. [1]

Image credit: U.S. Dept. of War

CONCLUSION

The three and a half year joint research program documented in SERDP Project WP-2631 represents one of the most rigorous independent validations of ResonantAcoustic® Mixing technology in the defense sector. From laboratory scale through full pilot production of fielded M485A2 illumination candles — tested and passed at a U.S. military lot acceptance facility — RAM proved safer, faster, and dramatically cleaner than the legacy mix-muller process it is designed to replace.

The projected economics make a compelling case: approximately $681,000 in annual labor and solvent savings, a 92% increase in production capacity, and a greater than 99% reduction in hazardous acetone waste — all from a single RAM 5 H operating on a standard production schedule. [1][2]

The quality of the research was recognized beyond the program itself. Based directly on the WP-2631 findings, the U.S. Navy filed a patent for the three-part RAM mixing process for energetic materials — now issued as US11746068B2, assigned to the United States Government, and available for commercial licensing. [5] With five simultaneous government programs independently validating RAM across all three categories of energetic materials, the research team's conclusion stands on solid ground: RAM is a viable alternative to mix-muller mixers — and a strategic long-term advantage for any energetics manufacturer. [1][3]

Contact Resodyn Acoustic Mixers, Inc. to discuss revolutionizing your mixing process for advanced energetics manufacturing.

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CITATIONS

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2. Annual savings projections derived from Table 13 cost analysis in Citation 1, applied to a standard 8-hour/day, 250-day/year operating schedule. Report assumptions: labor rate $100/hour, acetone $150/20L. Actual results will vary.
3. Beckel, E. and Nelson, A.P. "Environmentally Sustainable Manufacturing for Energetic Formulations." SERDP/ESTCP Webinar Series, Webinar #72. May 31, 2018. https://serdp-estcp.mil/resources/details/dd31eb15-b719-4d96-a980-67cceed4b116
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5. Yamamoto, C.M. and Shaw, A.P. "Three Part Mixing Process for Energetic Materials and Epoxy Binder." U.S. Patent US11746068B2. Issued September 5, 2023. Assignee: United States Department of the Navy. Available for commercial licensing. https://patents.google.com/patent/US11746068B2/en

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