DEVELOPMENT & OPTIMIZATION OF A PRODUCTION SCALE PROCESS FOR THE MANUFACTURE OF IMX-101 AT HSAAP

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Briefing Outline

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Background

- IMX-101 Formulation
  - Developed at Holston Army Ammunition Plant (HSAAP) as a replacement of TNT
  - Contains non-traditional ingredients such as DNAN & NTO
    - Ingredients manufactured and/or processed at HSAAP
  - Superior IM performance than TNT in 155mm M795 projectiles
    - Passed all IM Engineering Tests (Bullet Impact, Fragment Impact, Slow Heating, Fast Heating, Sympathetic Reaction & 81mm Shaped Charge Jet Impact)
    - IM test results presented at IMEMTS 2007
  - Down-selected as the prime candidate as TNT replacement filling in 155mm M795 projectiles
  - BAE Systems OSI was contracted to manufacture IMX-101 in full production scale
    - Explosive Qualification
    - Projectile Loading Process Development

Passed SCJI

Passed Bullet Impact

Background (cont)

- IMX-101 successfully Loaded, Assembled & Packed (LAP) at US Army RDECOM ARDEC in the 155mm M795 projectile
- Qualification of IMX-101 explosive near completion
  - Aging trials result pending
- Qualification testing of IMX-101 explosive in M795 projectile also underway
  - Formal IM testing scheduled CY09
- IMX-101 filled M795 projectiles survived gun-launched ambient, hot & cold at max charge (M198 howitzer, Yuma Proving Ground)
- IMX-101 also being considered for the next generation 105mm M1 cartridge and the 155mm M107 training ammunition

Program Objectives

- OSI and ARDEC to jointly establish a reproducible manufacturing process of IMX-101 at HSAAP under optimum operating conditions
  - Baseline parameters established (un-optimized)
  - Conduct experiments in production facility and compare results
    - Provide supporting information for material specification
    - Generate consistent material for loading trials at ARDEC
  - Desire to use Design of Experiment (DOE) approach to optimize processing parameters
  - Manufacture explosives using optimized processing parameters
- Finalize SOP, Material Specification and Manufacturing Instruction for the manufacture of IMX-101

ARDEC Picatinny Arsenal

Holston Army Ammunition Plant

IMX-101 Manufacturing Process Overview

Load Ingredients

Melt and Mix

Molten IMX-101

Cast onto flaker belt

Molten IMX-101 in thin strip

Cool/solidify and break-up

IMX-101 flakes

Pack and ship

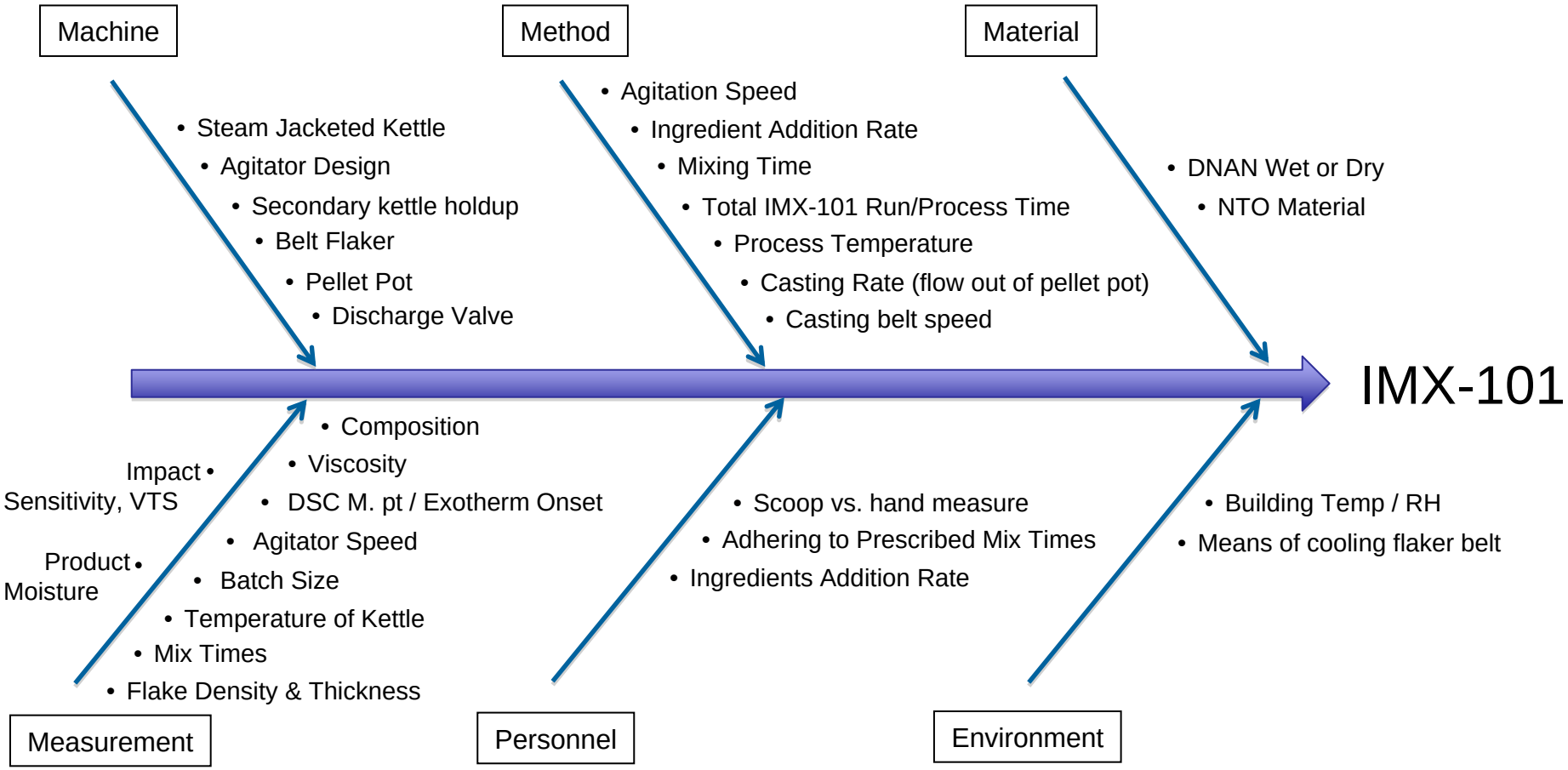
Images shown are from the PAX-21 production

IMX-101 Manufacturing Process Overview (video)

Baseline Processing Parameters

- Baseline Processing Parameters identified from 1,200 lb production-scale batches of IMX-101 made in 2006
  - Processing temperatures at various stages
  - Ingredient Feed Rate & Order of Addition
  - Use of dry/wet ingredients
  - Final Incorporation (mixing) Time
  - Agitator Speed
- Material Processibility indicated by Efflux Viscosity and consistent Product Homogeneity
  - Composition, sensitivity and other physical/chemical properties testing
- Close interaction with ARDEC EM and LAP Producibility Teams
  - Immediate feedback on LAP

IMX-101 Producibility Parameters Considered



IMX-101 Producibility – Phase 1

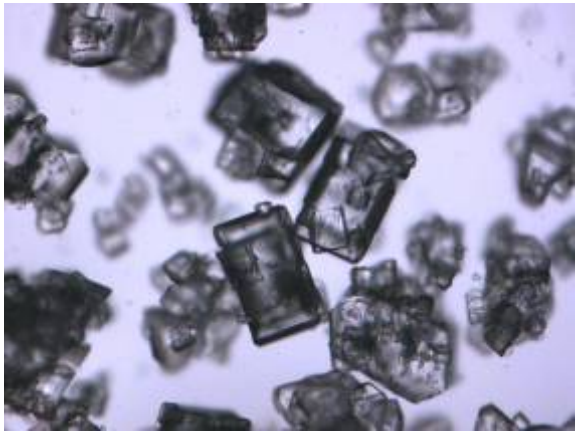
- Leverage lessons learned from previous melt-pour and IM explosive development activities (e.g. PAX-21, PAX-41, PAX-196, etc)
  - All products utilized same production equipment
- Established nominal composition and tolerances based on user feedback on earlier production-scale batches
  - Attempted to optimize
    - ingredient addition rate
    - final incorporation time
    - agitator speed
    - intermediate holding vessel retention time

IMX-101 Producibility – Phase 1

- Desire by the customer (PM-CAS) to manufacture using set operating conditions to establish process parameters for LAP of the M795 projectile
  - Utilize nominal formulation and consistent IMX-101 production parameters to manufacture multiple batches
    - 24 batches delivered to the customer for LAP process development operations

IMX-101 Producibility – Phase 1 Result

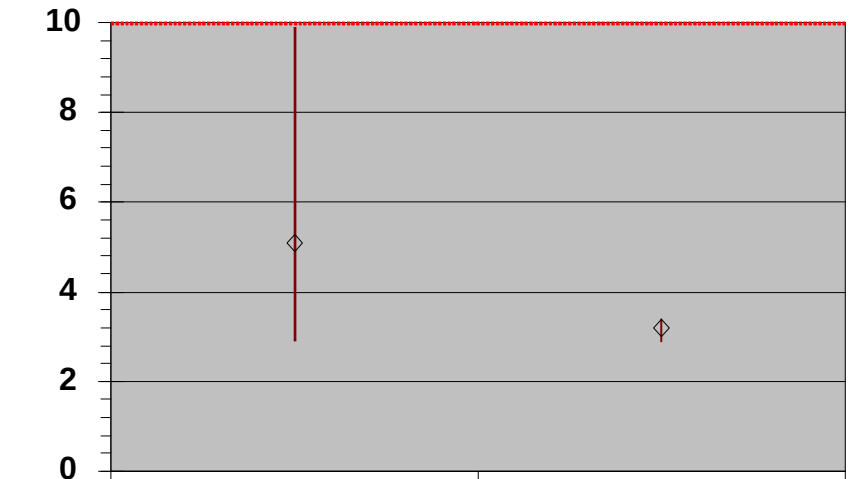
- Discovered variation of ingredients (particle size / shape) going into IMX-101 explosive led to independent evaluation
  - Extensive laboratory support for analysis and process optimization (e.g. NTO)
  - Obtained better understanding of product



IMX-101 Producibility – Phase 1 Result

- Product appeared to be consistent, as measured by efflux viscosity, and other draft specification requirements
  - Occasionally, end user experienced difficulties in LAP operation even with what was believed to be consistent material
    - LAP producibility DOE was also conducted
  - There are likely other parameters that affect the quality of the M795 cast (porosity, cracking, etc)
    - It is recommended to conduct Phase 2 of the IMX-101 Producibility Study

IMX-101 Consistency Improvement (efflux viscosity)



	Viscosity Pre-DOE	Viscosity Post-DOE
max	9.9	3.4
min	2.9	2.9
average	5.1	3.2
Cp k	0.8	5.7

IMX-101 Producibility – Phase 2 Follow-on Work

- Utilize Six Sigma Tools as a follow on to the LAP DOE and Conduct Explosive Producibility DOE to improve overall product
  - Work concurrently with ARDEC LAP Producibility Team to provide consistent explosive for LAP operation with no defects
- Investigate formulation ingredients (high/low)
  - Evaluate existing tolerance
- Optimize Processing Parameters
  - Final incorporation time
  - Ingredient addition rate
  - Agitator Speed / Design

Conclusion

- Over 20,000 lbs of IMX-101 have been manufactured
  - Still relatively “young” explosive, compared to Comp B, RDX, HMX & TNT
- Successful LAP and Gun Launch
- Explosive Qualification Nearing Completion
- Producibility of Explosive Demonstrated
- Qualification Testing in the M795 Underway
- Efforts underway for Large Scale Production Volumes in CY10