RDECOM

PEO Ammunition

Joint Lethality

BAE SYSTEMS

GENERAL DYNAMICS
Ordnance and Tactical Systems–Canada

IMX-104 High Explosive (HE) Loading of 60/81/120mm Mortars

Joint U S Army & U S Marine Corps

Department of the Army
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TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

PROGRAM OBJECTIVE

- Support PM CAS effort to develop an IM Comp B replacement for the 60/81/120mm mortar.
- Utilize ARDEC’s melt pour pilot plant facility to rapidly develop and document loading process parameters while supplying acceptable mortars for IM testing.
- Transition developed loading process parameters to the Industrial Base.

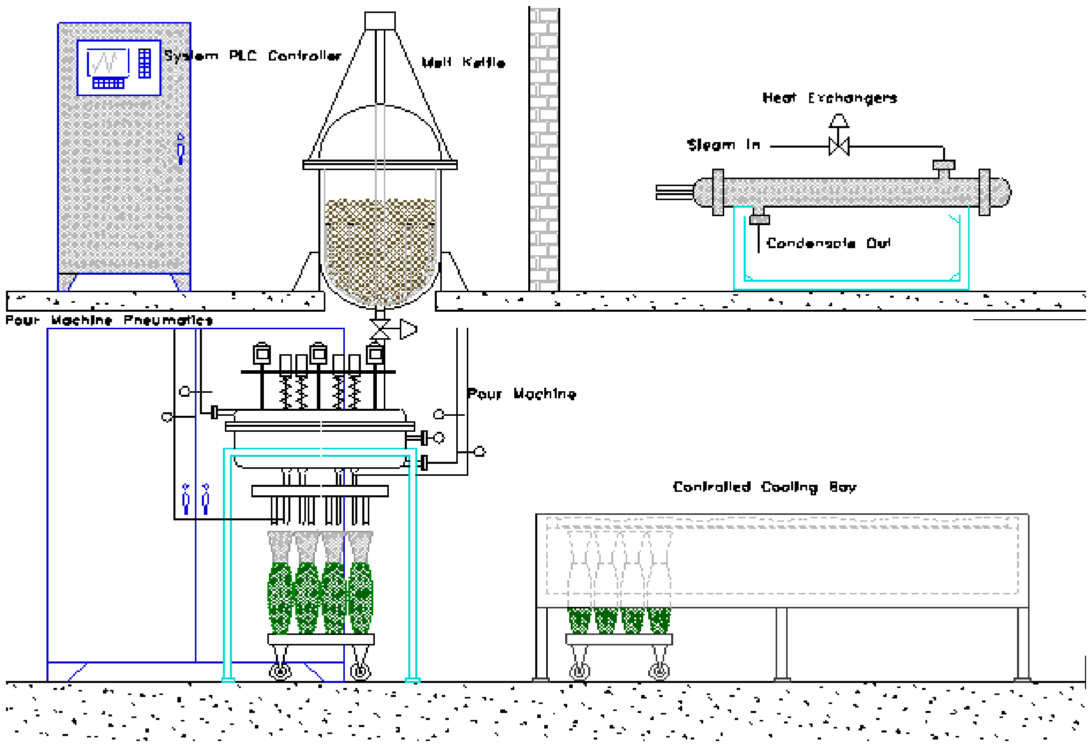
BACKGROUND

- IMX-104 is a DNAN based explosive which also contains RDX and NTO and selected by PM CAS as the IM replacement for Comp B.
- In order to provide 60/81/120mm mortars with new HE, the ARDEC pilot plant loading facility was utilized.
- Tight controls over equipment and processes are necessary to meet cast quality specification requirements for mortar rounds
- The state-of-the-art melt pour equipment at ARDEC is well suited to execute the development of a process for this multi-component explosive.
- The ARDEC pilot plant facility has provided several hundred 60/81/120mm mortars for IM and performance tests.

Developed IM Processes

- Processes for several IM candidates have been developed utilizing ARDEC’s melt pour equipment.
  - TNT Replacement Candidates
    - IMX-101
      - Qualified TNT replacement in 155mm M795 projectile
    - IMX-102
    - IMX-103
    - PAX/AFX-196
  - Comp B Replacement
    - IMX-104
    - PAX-21
    - PAX-41

Melt Pour Process Diagram



Initial Loading Equipment

- Initial loading effort was performed using the pilot mortar loading system in Bldg 810 at ARDEC
  - 75 gallon melt kettle
  - 16 Nozzle pour machine
  - Mortar Oven (Air cooled process)
- This mortar system did not provide an environment that would yield quality cast.
  - Insufficient heating of the funnels
  - Inadequate temperature gradient.

IM LOADING EQUIPMENT

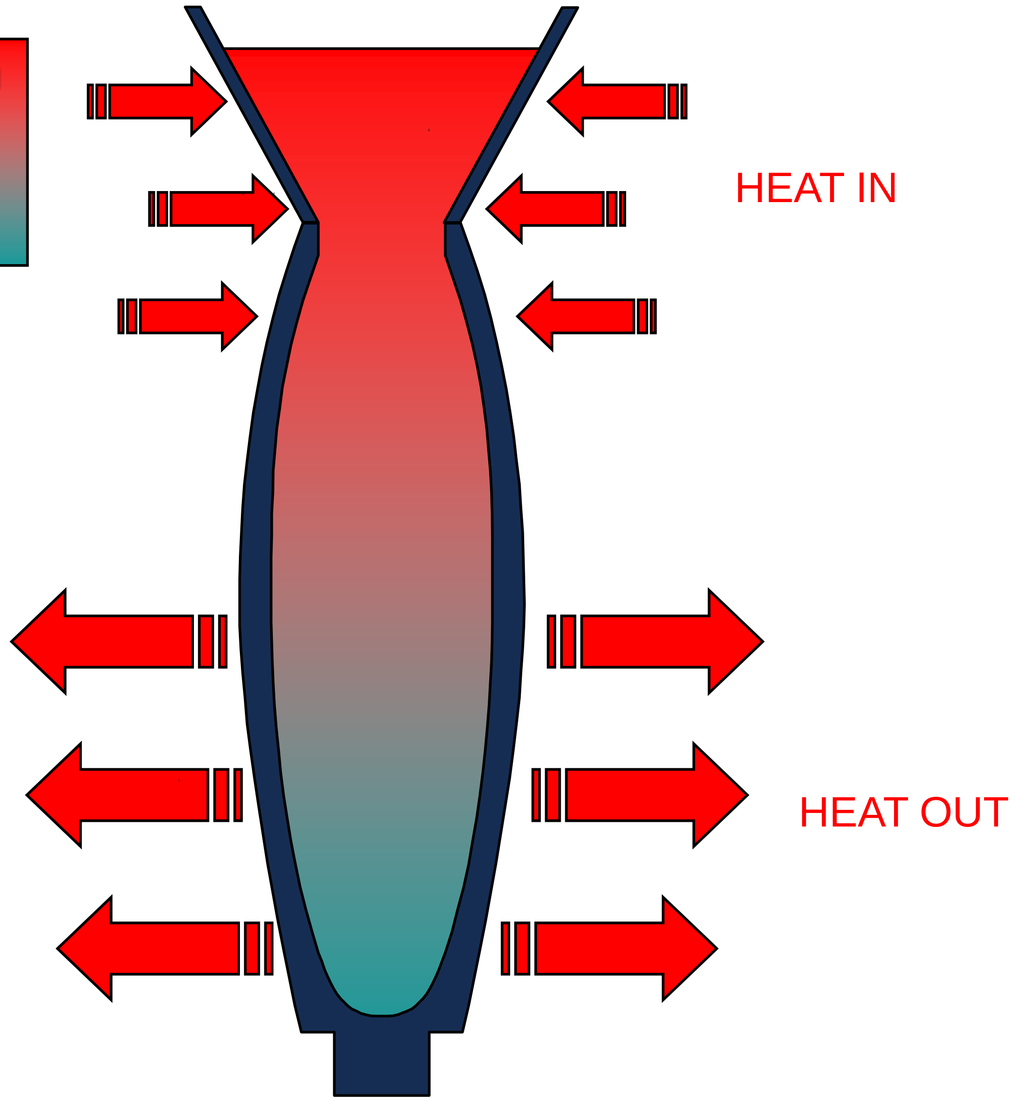
4 Nozzle Pour Machine

50 Gallon Melt Kettle

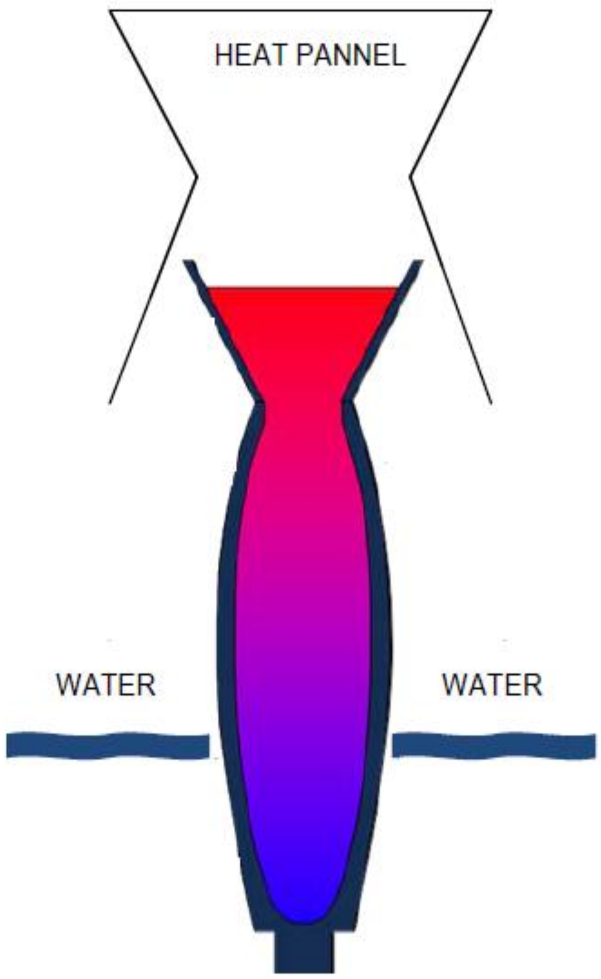
Controlled Cooling Oven
with Load Cart

Bottom Up Cooling Method

Active heating of the funnel and neck is required in order to maintain molten explosive in the funnel and upper portion of the shell while heat is removed from the lower portion of the shell in a controlled manner resulting in a bottom-up solidification cast profile.



Melt Cast Cooling Oven



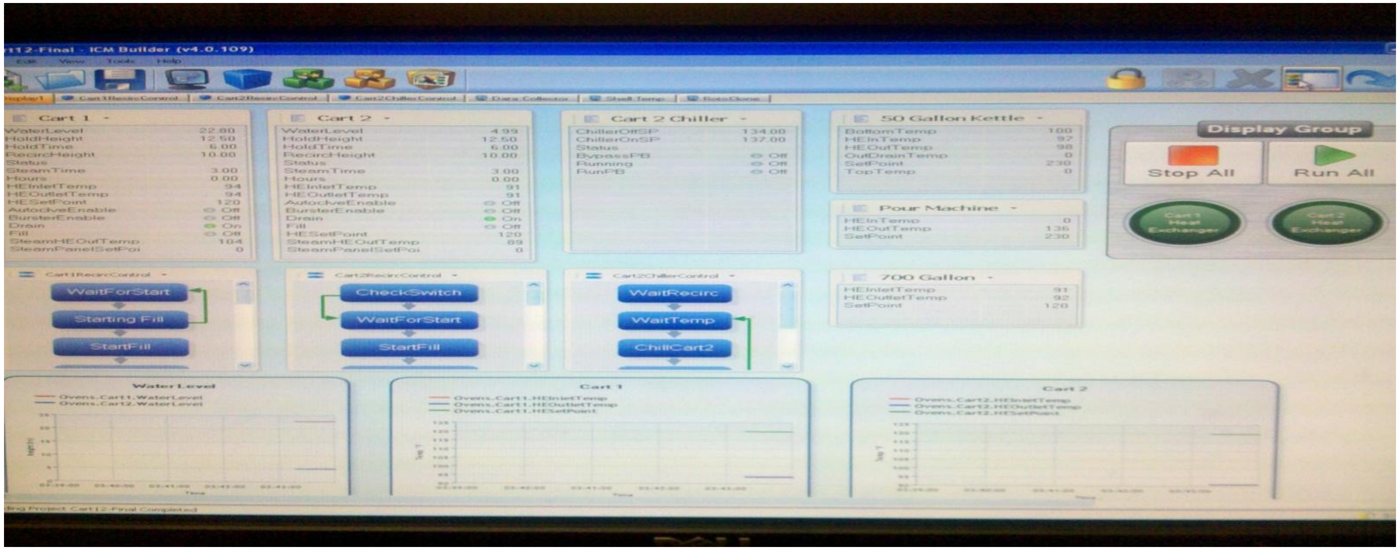
Water Cooling Oven

Water Cooling System

- The loading effort was preformed using the water cooling system
  - 50 gallon melt kettle
  - 4 Nozzle pour machine
  - Water Cooled Carts (for projectile body)
  - Water Heated Pannels (for riser)
- The water cooling oven provided an environment that would yield quality cast.
  - Sufficient heating of funnels
  - Water as the cooling media to establish a temperature gradient that promoted bottom up cooling.

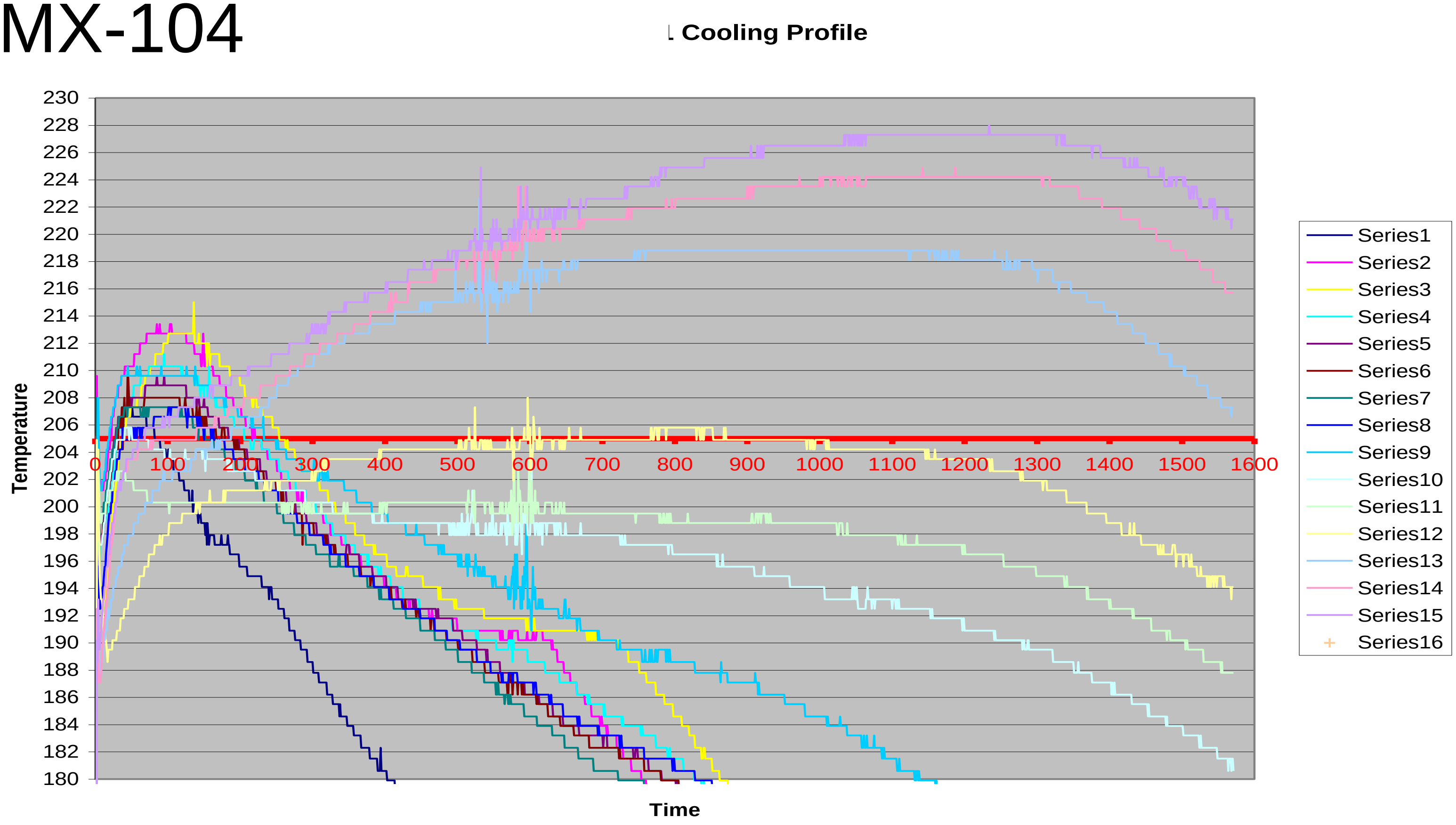
Intelligence Control Modeling (ICM)

- The ICM System utilizes cart water level sensors, thermocouples, data collectors, and real time control screens to develop loading processes.
- The ICM system allows for changes to be made to cooling parameters in real time or by analyzing the results of previous test runs.
- The ICM uses these tools to control the Bottom Up Cooling Method



PROJECTILE COOLING PROFILES

IMX-104



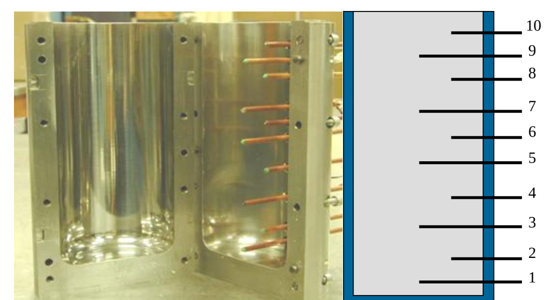
Conclusion

- The use of data acquisition and tightly monitored process controls allows for a Science Based approach toward process development.

- ICM is capable of tracking and recording large quantities of process data outputs enabling the documentation of process parameters for analyzing and sharing with the industrial base for smooth transition to production.

GD-OTS Canada Pilot Plant development

– Characterization of IMX-104 material lots
  - Viscosity and rheological behavior
  - Study clean scrap material re-use
  - Casting behavior
  - Thermal characterization
  - Standardized methods used at GD-OTS Canada
  - Comparison with previous lots of this material



GD-OTS Canada Pilot Plant development

GENERAL DYNAMICS
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- Casting parameters for both 60 and 81 mm
  - Preliminary batches
    - 1 batch in the pilot plant (instrumented shell)
    - 1 batch in production
  - Baseline batch (instrumented shell)

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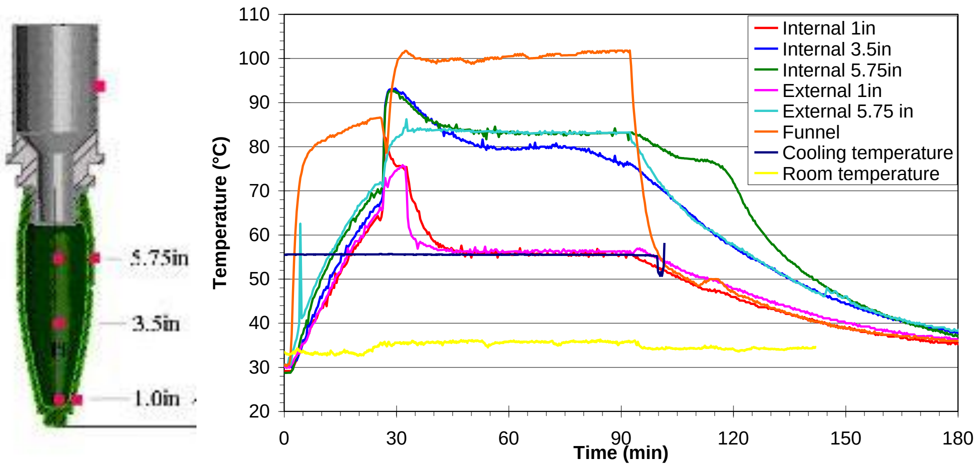
GD-OTS Canada Pilot Plant development

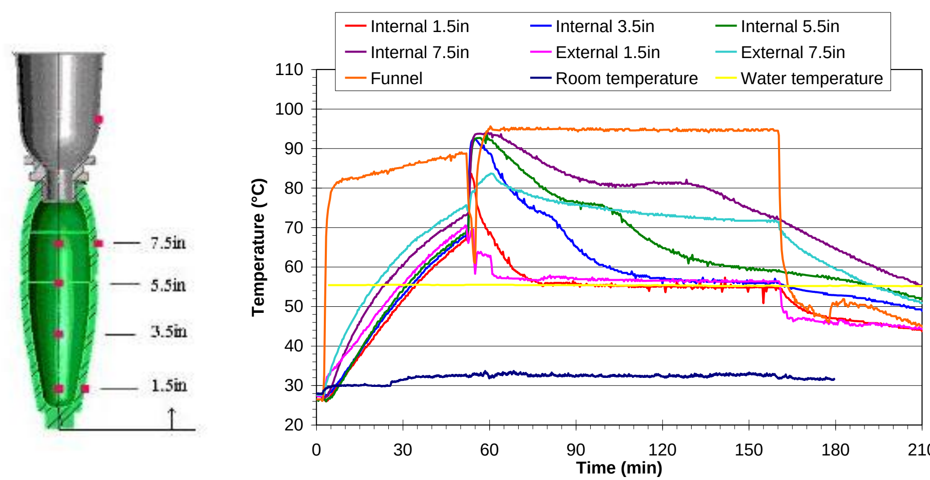
GENERAL DYNAMICS
Ordnance and Tactical Systems–Canada

- Method for both 60 and 81 mm



60 mm

81 mm



GD-OTS Canada Pilot Plant development

- Design of experiments
  - Input: DFMEA, process mapping, previous batch results
  - Selection of input variables (X's)
  - Output variables:
    - Porosities/cavities; cracks
    - Development of quantitative variable based on x-rays
  - Logistic regression (discrete variables)
  - 3 input variables selected for each caliber
  - 2^3 full factorial design
  - 2 confirmation batches

GD-OTS Canada Production

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- 60 mm mortar
  - Confirmation batch in the production facilities and final adjustments
  - 2504 cartridges to be delivered for qualification
    - 1288 M720A2 (HF-1 steel)
    - 376 M768 (HF-1 steel)
    - 840 M888 (AISI1340 steel)
  - 2864 projectiles cast (3.7% reject)
    - 1904 M720A2/M768
    - 960 M888

GD-OTS Canada Production

GENERAL DYNAMICS
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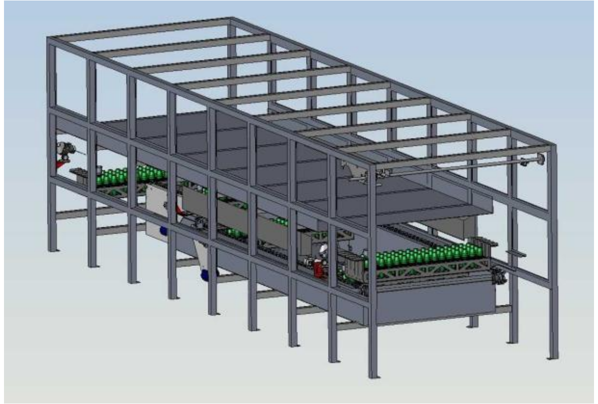
- 81 mm mortar
  - Confirmation batch in the production facilities and final adjustments
  - 2100 cartridges to be delivered for qualification
    - 699 M821A2 (HF-1 steel)
    - 1401 M889A2 (HF-1 steel)
  - 2304 projectiles cast (7.8% rejects)



GD-OTS Canada Conclusion

- Use of IMX-104 material characterization and DOEs to develop robust method in production
- Combined reject rate in first production of 5.5% (The rate was going down and was concentrated to some batches)
- Improve on logistic regression and DOEs preparation.
- Additional work to reduce cavities/porosities