Missile Demil Brief
Static Fire for Rocket Motors
to
National Academies of Sciences
Committee on Alternatives for the Demilitarization of Conventional Munitions (CMD Committee)

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OUTLINE

- Background for Missile Demil
- Review Static Fire of Rocket Motors
- Alternatives to Static fire
- Obsolete/Unique Items in Missile Demil
- Summary

Missile and Rocket Motor Approaches for Demil

- Missile demil is complex & requires multiple approaches to solve
  - Missiles are generally “wooden rounds”; never intended to be disassembled; many sub-assemblies and components
  - Numerous versions within the same missile family
  - Missile demil inventory varies from all up rounds (AUR) to individual components
  - Disassembly operations typically highest cost driver
- General Assessment/Approach to Missile Demil
  - Determine current capability for system (commercial and organic)
    - Quantity versus funding versus capability
    - Technology gaps
  - Asses reuse potential/interest from other organizations
  - Workload commercial and organic facilities
    - Commercial--closed disposal
    - Organic--combination of OB/OD and closed disposal

Recovery and Reuse

- Missile Demil has focused on recovery and reuse as much as practicable
  - Reuse of motors for sounding rockets, targets, sled tests, etc.
  - Reuse of missile components
    - Preferred method is for missile program offices to recover items from missiles prior to turning items into demil account
      - Majority of items recovered for reuse are hardware related (launch tubes, closure rings, seeker components, covers, etc.)
      - Rocket motors and other explosive items are reutilized as well
      - Reuse of items are driven by parts obsolescence, practice/trainer round conversions, cost avoidance, etc.
    - Missile demil funded TOW recycling facility
      - Operated ~2003-2013
      - Recovered launch tubes, shipping boxes, aft/forward covers-for new missile builds and trainer rounds
      - Significant cost savings for the Army
    - Reuse of energetics
      - No current missile demil energetics recycling
      - Discussed further in Alternatives to Static Fire portion of presentation

Static Fire

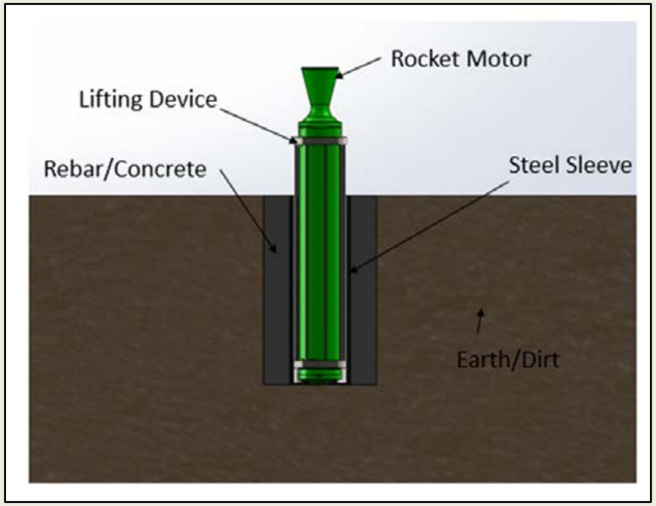
- Two main categories of motors that are static fired
  - Hazard class 1.3 Ammonium perchlorate (AP) based motors
    - Cross linked polymerized material that is slurry cast, case bonded into motor cases and cures into rubber like material
    - Most motors consist of AP as oxidizer and aluminum/rubber binder as fuel; specific formulations vary with percentages and binder types
    - Largest portion of the missile demil inventory
    - Typically very stable
    - Propellant safety risk from friction and electrostatic discharge (mass fire/ explosion)
    - Some formulations can have grain cracking/slumping issues
  - Hazard class 1.3/1.1 Double base motors
    - Extruded cartridge grain that is cured and then loaded into motor cases
    - Most motors consist of nitrocellulose and nitroglycerin with varying ballistic modifiers
    - Low quantities and tend to be oldest stocks in missile demil inventory
    - Typically stable but are monitored for stabilizer content
    - Propellant safety risk from impact (**mass detonating/explosion**); nitroglycerin diffusion to threads and seals (disassembly risk)

Static Fire

Recent history of static fire of rockets

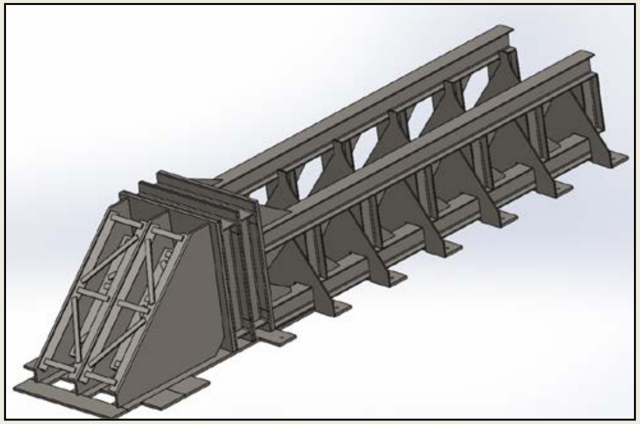
Motor	Hazard Class	Propellant Weight	QTY	Timeframe	Location
Honest John (H365)	1.1/1.3	~2,000	250	2015-2017	MCAAP
Maverick (PA33)	1.3	~65	660	2014-2017	MCAAP
Chaparral(V511)	1.3	~60	280	2014-2017	MCAAP
Phoenix (V885)	1.3	~360	400	2014-2015	LEMC
Standard (V284)	1.3	~385	180	2014-2016	LEMC
Sparrow (V378)	1.3	~135	1200	2015-2017	LEMC
Sidewinder (V888)	1.3	~60	2833	2015-2017	LEMC
Sidewinder (V888)	1.3	~60	285	2015-2016	MCAAP

Large Rocket Motor Static Fire Stands



ANMC Vertical Static Fire Stand Design

- New Static Fire Stands
  - Hazard Class 1.1 motors; double base propellants
  - Targeted for the ANMC; already installed at the MCAAP
- Workload Target
  - Honest John
  - Nike/HERC
  - MK12
  - Other large propulsion systems



MCAAP Static Fire Stand Design

MCAAP Static Fire Stand

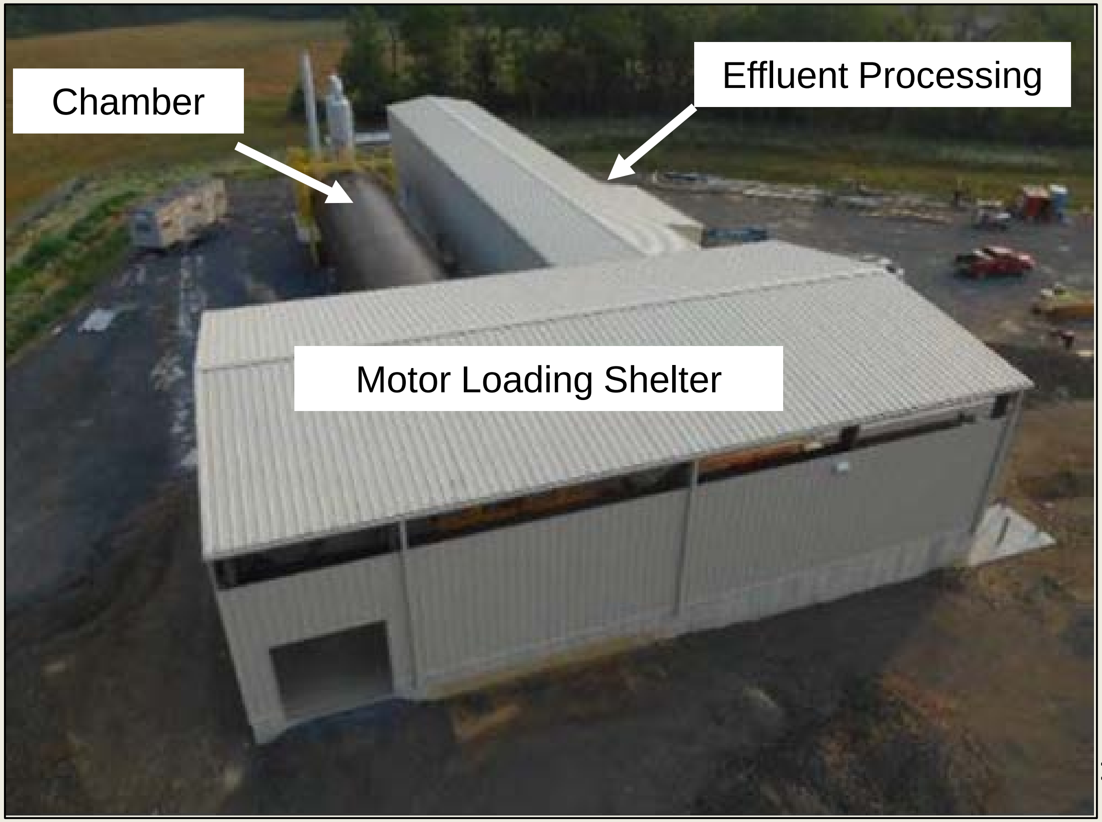
Large Rocket Motor Static Fire Stands

Static fire of Honest John

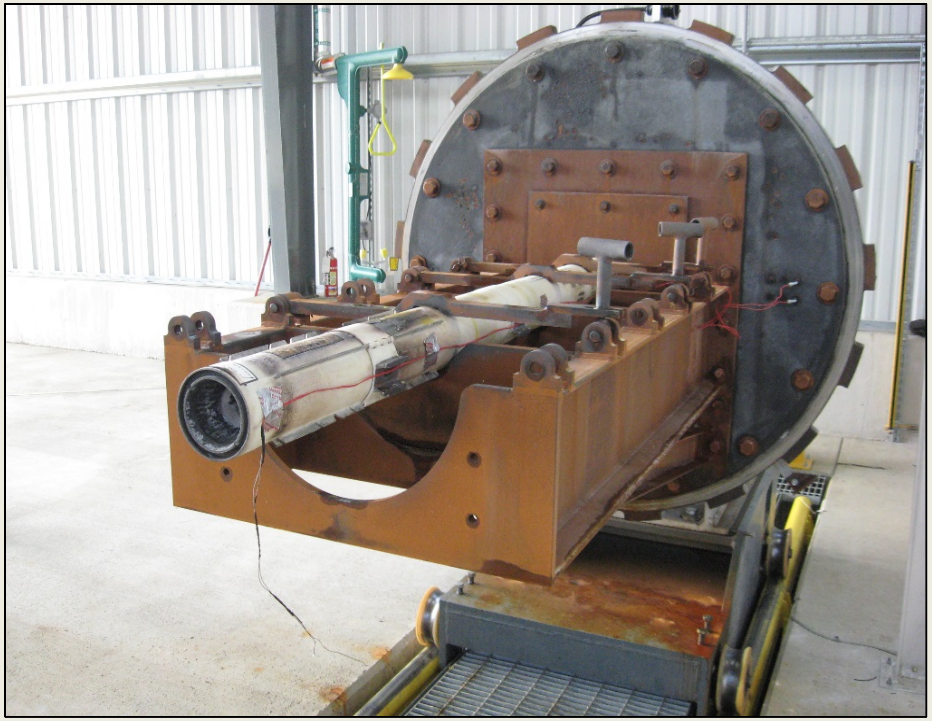

Static fire of MK12

Letterkenny Munitions Center (LEMC) Ammonium Perchlorate Rocket Motor Destruction (ARMD) Capability

- Establishing a closed, thermal destruction capability for tactical solid rocket motors that contain HC 1.3 Ammonium Perchlorate (AP) based propellants
- Designed to address demilitarization of a wide range of Army and other service rocket motors (~28 different rocket motors)
- Current design is 10,000 cycles per year
- Target largest intact motor ~680 pounds NEW; Motor segments up to ~800 pounds NEW
- Currently in acceptance testing phase
- Completed small motor family testing
- Low Rate Initial Production (LRIP) operations scheduled for FY18



Letterkenny Munitions Center (LEMC) Ammonium Perchlorate Rocket Motor Destruction (ARMD) Capability



Motor loading/unloading shelf

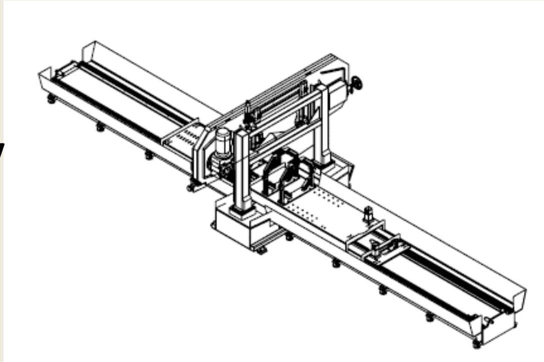
Pollution Abatement System

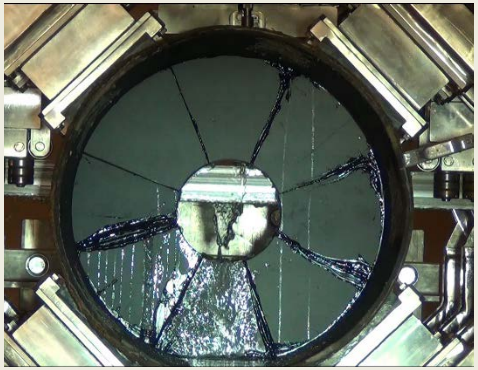
Alternatives to Static Fire

Rocket Motor Segmenting

- Segmentation of solid propellant rocket motors for feedstock to the Letterkenny Munitions Center (LEMC), Ammonium Perchlorate Rocket Motor Thermal Treatment Capability.

- Target: Solid propellant rocket motors
  - Greater than 18” diameter
  - Smaller than 24” diameter
  - Above 805lbs NEW
  - Ferrous or non ferrous casings





Segmenting 18” rocket motors

NEW ~1500 lbs per motor

Segmenting 24” rocket motors

NEW ~1605 lbs per motor

Commercial Closed Disposal of MLRS

- Commercial facility at Joplin, MO
- Operating since ~2008
- Closed disposal of all energetic items from MLRS
- Recycling of scrap metal
- Processed ~175,000+ rockets (~35M+ pounds of propellant)
  - Segment motors into 8 sections
  - Thermally process in tunnel furnace; process ~25-30 pounds in semi-continuous process
  - Dry/Wet scrubber for HCl; bag house for particulates
- Segmenting required due to permit limits/sizing of equipment
  - Motor completely submerged in water
  - Numerous fires during cutting operations; mostly in the first few years of operations
  - Saw design has been modified over the years based on lessons learned
  - Designed facility for fires; typically repaired and back to operations within 1-2 weeks

Alternatives to Static Fire

Reuse of energetics

- Currently no missile/rocket energetics are being recovered for recycle/reuse from the missile demil office
- Multiple government R&D efforts conducted in the past 10-20 years for recovery & reuse of missile and warheads energetics (AP, warhead material reuse, slurry explosive manufacture)
  - Sounds great in theory but difficult to implement and justify
  - Recycle in commercial applications
    - Customer/market demands vs government funding for recovery operations
    - Just in time vs storage (speculative accumulation)
    - Future environmental liabilities/traceability for the government
    - Total quantities available versus market needs
    - Variation in energetics formulations
    - Cost of operations vs benefits
  - Recycle/Reuse in new missile/ammunition items
    - Same issues as above
    - Program office buy in
    - Costs for requalification in new systems

Alternatives to Static Fire

Reuse of energetics (continued)

- Rocket motor industry has been performing water washout and recovery/reuse of AP from rocket motors
  - Recovery of rocket motor cases has been a significant driver
  - Large motors or strategic systems yield more consistent product
  - Years past the reuse was in slurry explosives and specialty chemicals/conversion
  - Cost of manufacturing new AP has been increasing; recent qualification of recovered AP for use in space lift platform
  - Cost of recovery typically higher than static fire/closed disposal
- Government researched liquid ammonia recovery of AP for many years
  - Environmentally advantageous –no water processing
  - Costly to operate
  - Required pre-processing to access propellant (ammonia washout or dry propellant machining)
  - AP demand vs availability at time of research/development
  - Inherent safety risks considered to challenging to mitigate

Alternatives to Static Fire

Reuse of energetics (continued)

– Government researched reuse of double base propellants in slurry explosives
  - Multiple issues with ATF & DDESB concerning ownership transfer/shipping liabilities
  - Product suitable for bagged slurry explosive for “wet” field (specialized application)
  - Cost vs availability vs market demands
  - Future liability/traceability to Government once in the commercial market
  - No longer pursued after 2007 economic downturn in construction market
  - Requires pre-processing of propellants
    - Motor disassembly
    - Mechanical size reduction of propellants(machining, grinding, cryofracture, etc)
    - Handling/processing risks with detonation hazard

Alternatives to Static Fire

Chemical processing of energetics

– Industry research/development of chemical destruction processes using base hydrolysis for double base type propellants
  - Conversion to fertilizer
    - Demonstrated at pilot scale level (for double base type propellants; not demonstrated at production scale
    - Issues with heavy metals
    - Cost of operations
    - Requires pre-processing (previously discussed)
    - Not considered feasible for rocket motors
  - Base hydrolysis as destruction
    - Successful conventional ammo program for cartridge actuated devices with similar propellants
    - Requires pre-processing or major changes in processing equipment for full up rocket motor grains
    - Cost vs stockpile of double base type motors

Alternatives to Static Fire

Other Processes

- Super critical water oxidation
  - Heavily researched in 1990’s to early 2000’s for propellants
  - Requires pre-processing
  - Process too costly; engineering processing issues never fully resolved

- Closed disposal (incineration or enclosed chamber burning) for double base motors
  - Internal discussions/reviews for facility similar to LEMC ARMD
  - Many of motors too large for current LEMC ARMD; requires pre-processing
  - Requires modification to pollution abatement system
  - Cost of new facility to process full up motors vs stockpile

Obsolete/Unique Items in Missile Demil Inventory

SPARTAN First Stage Demilitarization






<u>SPARTAN First Stage Rocket Motor Demilitarization</u>

- Forty-Six (46) units, ADMC, RRAD
- TIER-II Demilitarization SOP DEVELOPED
- 46 Units COMPLETE by OB/OD at Anniston and Red River Army Depots

Obsolete/Unique Items in Missile Demil

– Obsolete working group was formed in response to Spartan Motor demil
– Reviewed the missile inventory and identified motors that were considered obsolete with challenges/restrictions on disposition
– Challenges
  - Motors with hypergolic liquids
  - Too large to static fire and/or too low quantities to develop new capability/process
  - Throughput limits

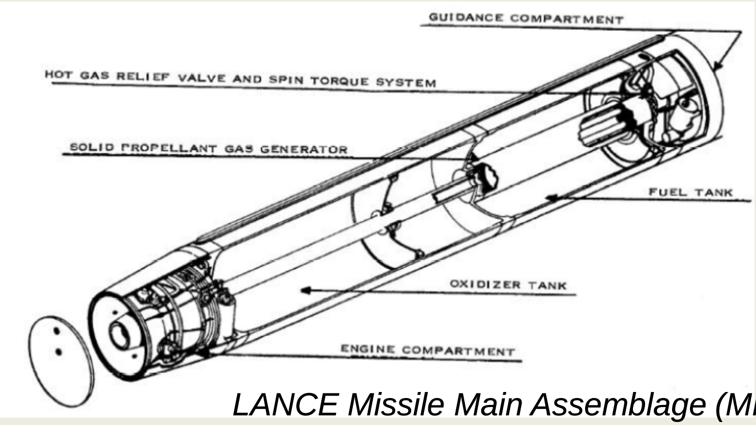
Obsolete/Unique Items in Missile Demil

Current list of Obsolete Motors

System (Total QTY B5A+)	Capability	Demil Location	Lbs	Issue/Challenge	Notes
Bomarc (2)			~6,000	Very large	2018 effort
Bullpup (253)	Detank	ANMC	varies	Hypergolic w/ no drain	2018 effort
Firebee (39)	Closed disposal/static fire		~150	Very little tech data	2019 effort
Genie (613)	Closed disposal/static fire		~300	Mag-Thor component	2019 effort
Honest John (1,074)	Static fire	MCAAP	2,000	Large	Need addt'l capacity; ANMC stands
~~Lance (0)~~		~~ANMC~~		~~Hypergolic~~	~~Trainers in process~~
Little John (124)	Static fire	MCAAP	~250		After Honest John et al.; ANMC stands
Nike Herc (372)x4	Static Fire	MCAAP	~750x4	Clustered, and large	Need addt'l capacity; ANMC stands
Sergeant (MGM-29) (16)			5,900	Very large	2018 effort
SRAM (1)	Static fire		~1000	Large	
Standard Mk12 (2,342)	Static Fire	MCAAP	<2,000	Large	Need addt'l capacity; ANMC stands
Talos (42)			~2,800	Large	2018 effort

Good to Go	Still Requires Work

LANCE Demilitarization



LANCE Missile Main Assemblage (MMA)

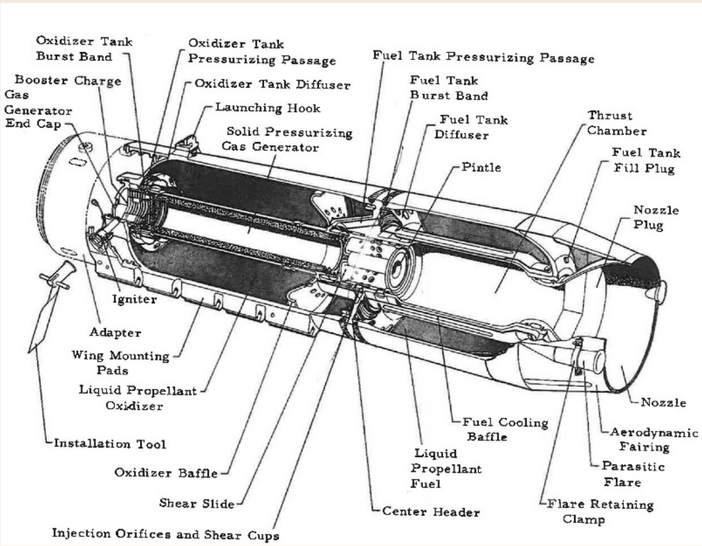
- 52 gal Unsymmetrical Dimethyl Hydrazine (UDMH)
- 80 gal Inhibited Red-Fuming Nitric Acid (IRFNA)
- *46 lbs Solid Propellant Gas Generator (SPGG)*
- *Thermal Batteries (Ca-CaCrO_4)*

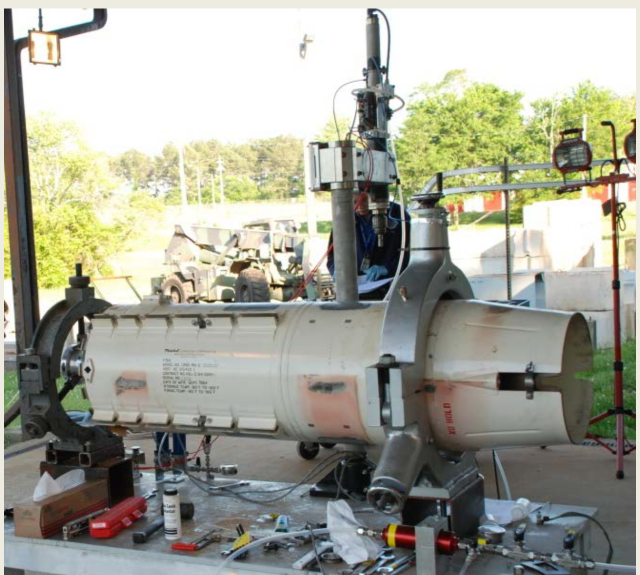
30 NOV 14 – IRFNA Leak at ANMC

Air Sampling around LANCE motors stored in ANMC Magazine K701

30 JUN 15 – LANCE De-tanking / DEMIL operations on RSA

Rapid Teaming to respond to DCG, LTG McQuistion’s direction to dispose of excess 27 LANCE MMAs at RSA by 30 SEPT 15





MAF-1 Analysis

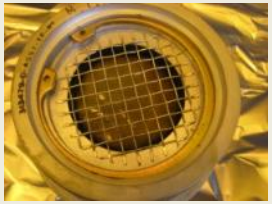
	3084	4222	1204
UDMH	49.44%	49.05%	47.39%
Acetonitrile	16.14%	15.69%	16.12%
Water	0.49%	0.44%	0.59%
DETA	32.69%	34.17%	35.04%

IRFNA Analysis

Sample	Bullpup IRFNA 3084	Bullpup IRFNA 1204	Bullpup IRFNA 4222	Specification (Domestic)
% Total Acid	102.53	103.66	102.82	N/A
% NO_2	15.64	16.46	15.49	13.0-15.0
% HF	**0.19**	**0.13**	**0.20**	0.6-0.8
Specific gravity (60°F)	1.576	1.582	1.578	1.564 - 1.575
% Residue	0.031	0.036	0.032	0.10 max
% Metallic Nitrate	0.129	0.149	0.135	N/A
% HNO_3	**80.41**	**80.57**	**80.84**	81.7-84.9
% Water	**3.64**	**2.69**	**3.33**	1.5-2.5

- **Safety and Condition Assessment (SCA) of the AGM-12 BULLPUP liquid rocket engine.**
- **Procedures & tooling developed and demonstrated to remove the solid propellant explosive train, extract *IRFNA* oxidizer and *Mixed Amine (MAF-1)* fuel, including toxic Unsymmetrical Dimethylhydrazine *(UDMH)*.**
- **Visual inspection of solid propellant, motor case evaluation, and analysis of the liquid propellants for three LR-62 engines.**
- **Determine subject motors condition, safe-to-store, transportability, and disposal recommendation for approximately 188 of these 1960 units remaining**

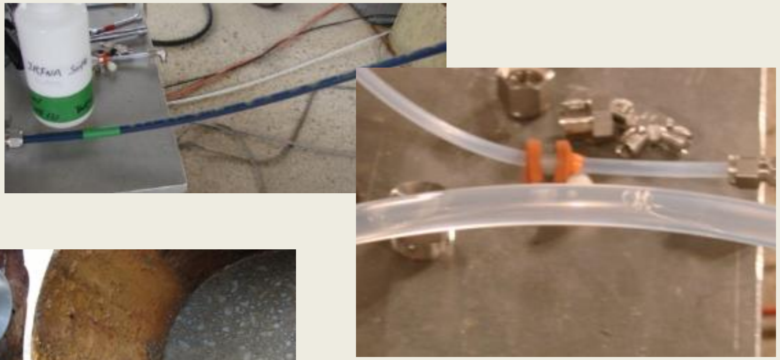
BULLPUP LR-58
Safety and Condition Assessment

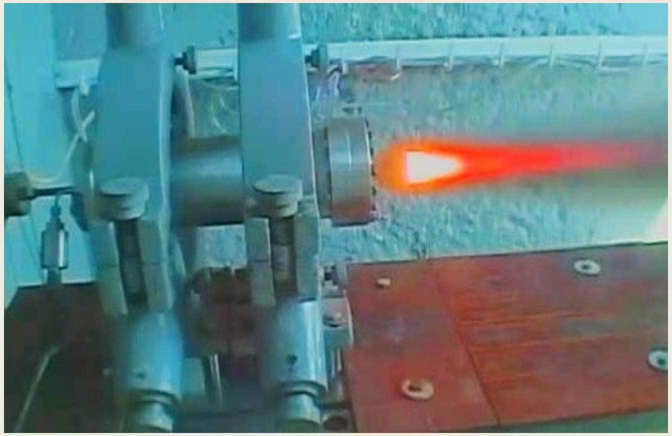
Igniter Boost Pellet Test

Static Fire


De-Tanking (Oxidizer / Fuel Contamination)



Gas Generator Extraction and Test Fire

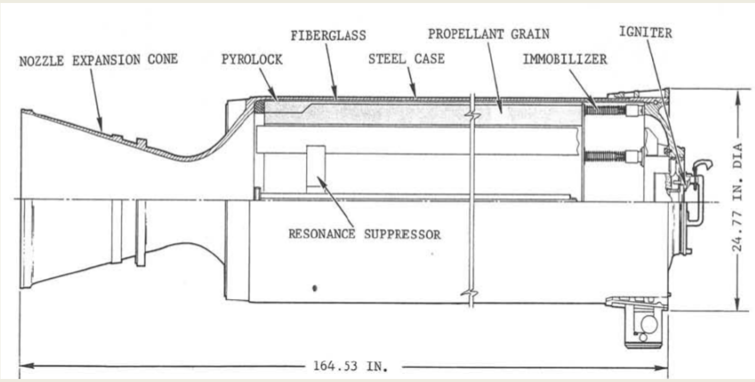


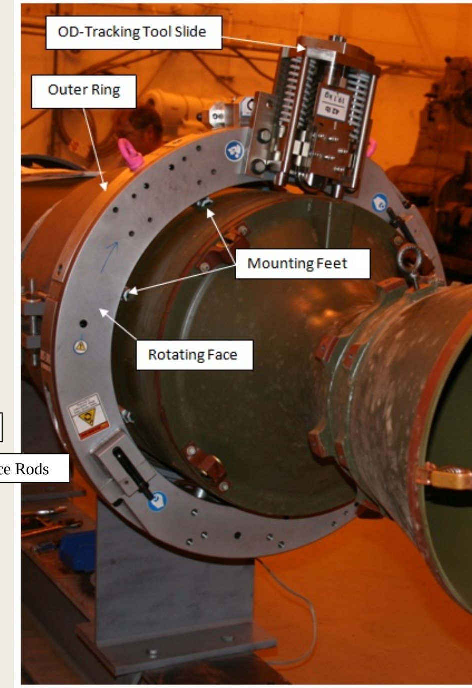
Oxidizer Injector Orifices (Corroded and Restricted)

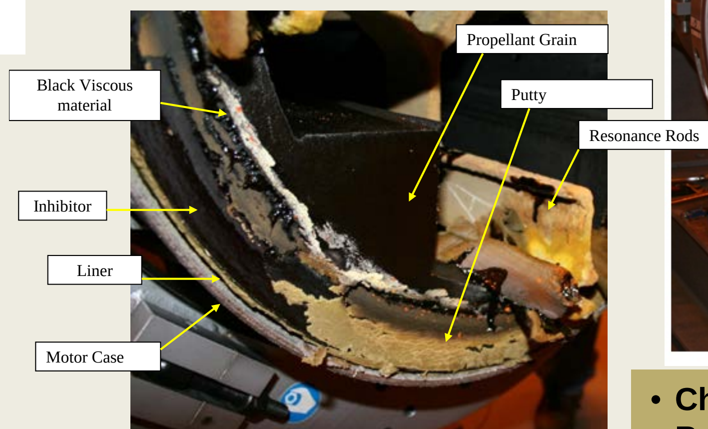

Motor Dissection and Evaluation (OX and Fuel Tanks)

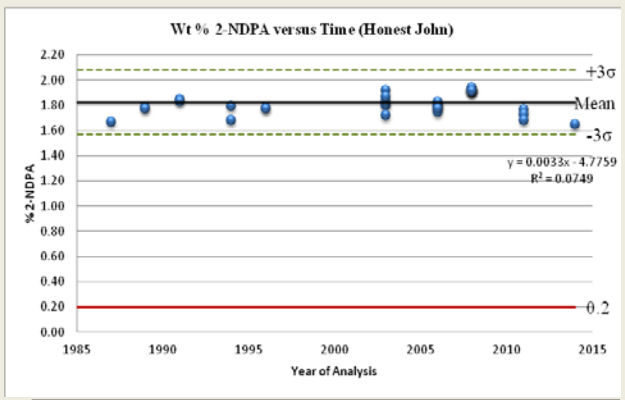
Water Expulsion Test

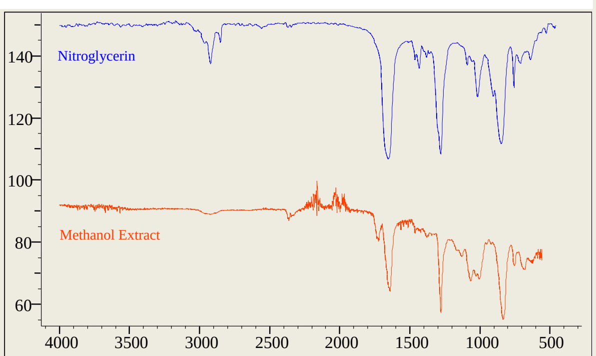
HONEST JOHN ROCKET MOTOR DISASSEMBLY AND CHEMICAL ANALYSIS





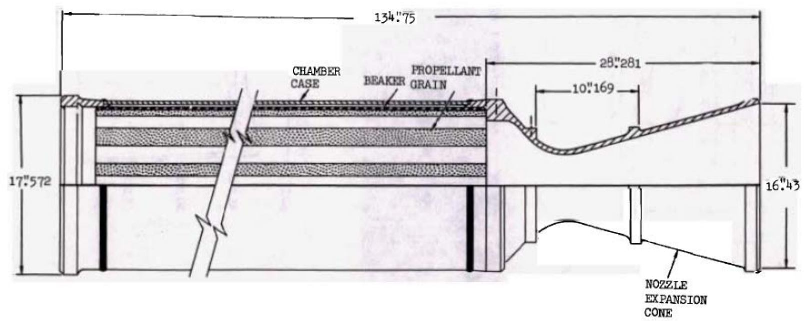






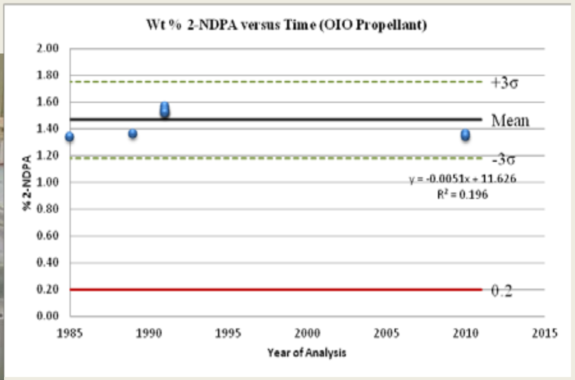
- **Chemical Analysis of Booster Propellant for Stabilizer Depletion**
- **Chemical Analysis of Residues for Energetic Content**
- **Analysis of 2008 Static Tests**
- **Development of Path Forward for Demilitarization**

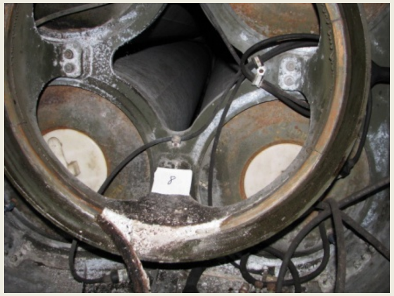
Nike Hercules Boost Motor Drager Test



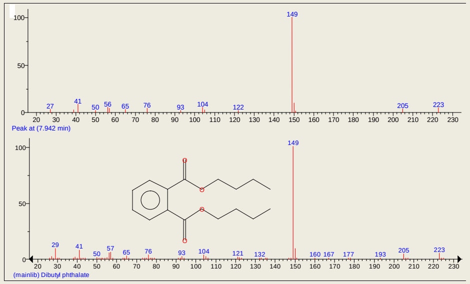
Nike Hercules Boost Motor Cross Section

- **System research, safety and risk assessment conducted by AMRDEC in 2009-2014**
- **Chemical Analysis of Booster and Igniter Propellants for Stabilizer Depletion**
- **Chemical Analysis of Residues for Energetic Content**





Nike Hercules Igniter
Dissection and Chemical Analysis



Summary

- Demilitarization of DoD (Army, Navy & AF) tactical missiles in a safe, cost effective, and efficient manner
- Maximize organic and commercial capability/capacity
- Focus on closed disposal processing where applicable
  - 35M+ pounds of AP propellants through commercial contract
  - When implemented, LEMC ARMD will provide closed disposal solution for ~90% of rocket motor propellants (by net explosive weight)
- Utilize permitted static fire operations as required