



Expeditionary Systems Evaluation Division



NSWC Crane Division

Detachment Fallbrook

Mechanical Properties Characterization and Accelerated Aging of Composition C-4 Explosive

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*Distribution approved for Public Release; distribution unlimited,
per DoD 5230.24 and OPSEC/Security Review conducted 6 OCT 10*





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Mechanical Properties Characterization and Accelerated Aging of Comp C-4 Explosive

- **Background**
- **Objective**
- **Test Methods**
 - **Mechanical Properties Testing**
 - **User Evaluation**
 - **Accelerated Aging**
- **Test Results**
- **Summary and Conclusions**



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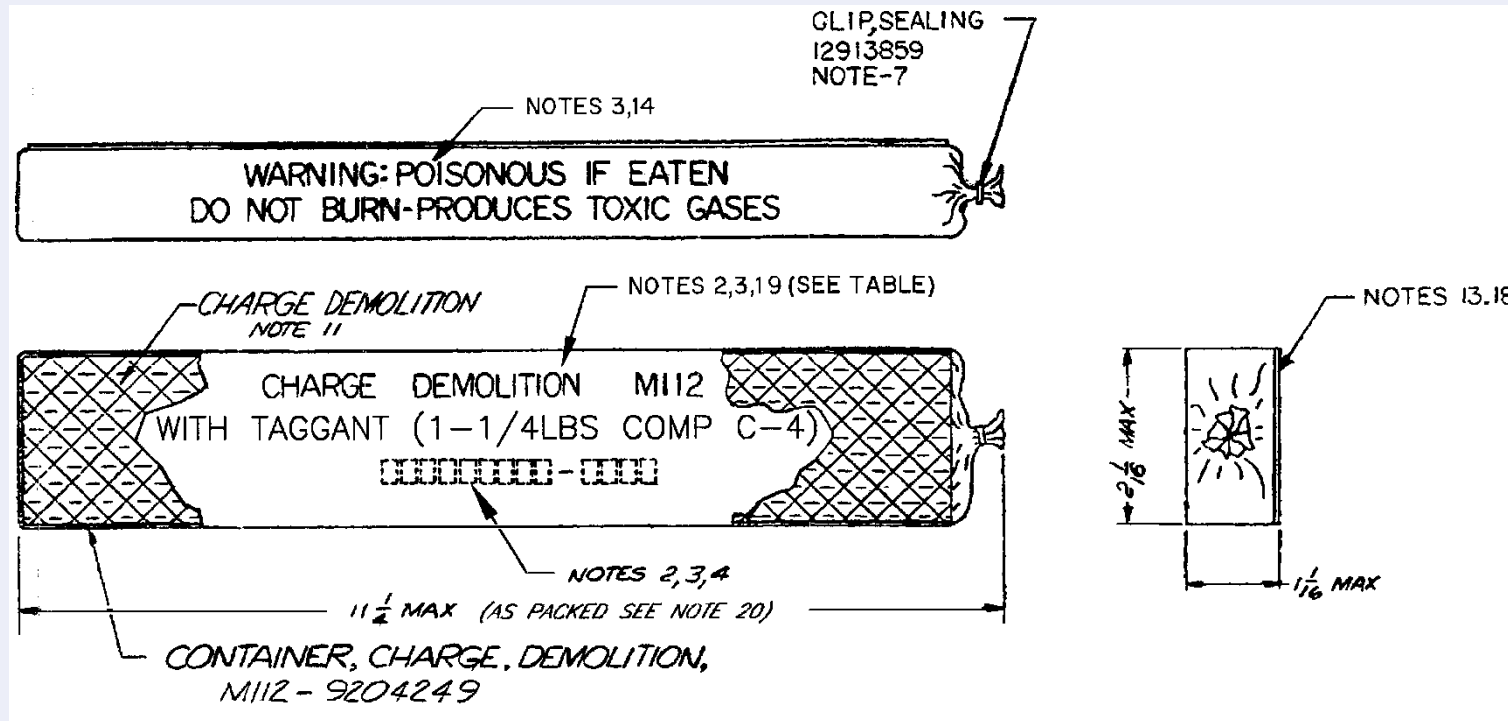


Composition C-4 and M112 Demolition Charge

- Most common demolition material used by USMC
 - Designed to be flexible to facilitate molding into specific charges
 - Consists of RDX plus polyisobutylene, dioctyl adipate and process oil
 - M112 Demolition Charge: 1 ¼ lb Extrusion Molded C-4 Blocks



M112 Demolition Charge Design





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Test Program Objectives

- **As Composition C-4 ages it experiences significant changes in its material properties**
- **Physical manifestation of these changes is material “hardness” with ability to mold samples as life limiting characteristic**
- **Objective of test program was to quantify material hardness using both traditional and newly developed test methods and relate these to serviceability**



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Penetrometer Test Method

- C-4 in the as molded M112 Demolition Charge is characterized using the “Penetrometer” method per MIL-DTL-50523, paragraph 4.3.3.1
 - Measures the max compressive force required to press a 0.26 inch diameter conical steel tip into the material at a rate of 6 in/min to a depth of 0.25 inches
 - Allowed range at production is 3-9 lbs, 4 measurements taken for each block
 - Performed using Instron Model 3342 Single Column Materials Tester at 73°F
- Testing of aged items using this technique failed to accurately characterize the harder material due to the propensity of the explosive to crack under loading in the region surrounding the penetrometer tip



Plasticity Test Method

- C-4 in bulk form is characterized using the “Plasticity” method per MIL-STD-650, Procedure 211.2
 - Prepare a molded sample 2 inches in diameter by 0.75 inches thick
 - Measure sample thickness before and after being subjected to a constant load of 5 kg for 20 minutes
 - Plasticity = $(A-B)/1.3$, where A is Log_{10} of original sample thickness and B is Log_{10} of final sample thickness
 - Performed using Instron Model 3342 Single Column Materials Tester at 70°F
- Primary drawback is the time required to prepare material samples and perform test



Compressive Load/Deflection Test Method

- New test method developed to address issue of localized cracking under tip in penetrometer test
 - Prepare molded sample 1 inch diameter x 1 inch thick
 - Measure max compressive load during compression of sample at a rate of 6 inch/min
 - Performed using Instron Model 3342 Single Column Materials Tester at 73°F
- Primary drawback is the time required to prepare the material samples



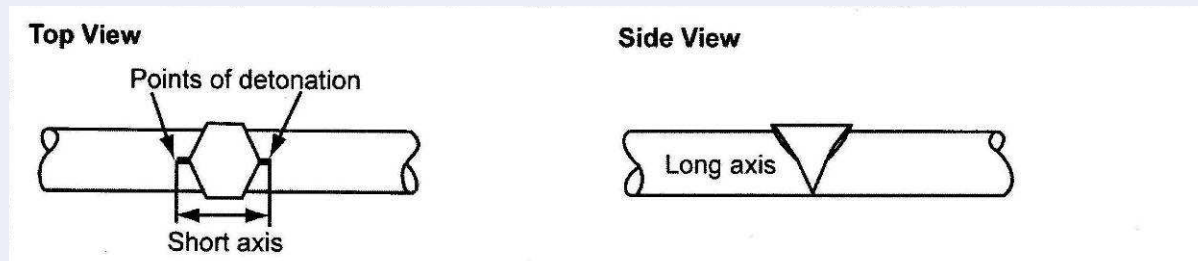
Ultrasonic Velocity Test Method

- New test method developed to leverage relationship between material sound velocity and modulus
 - Performed on complete M112 Demolition Charges at four locations
 - Determined by measuring the time of flight of longitudinal sound waves through a measured material thickness
 - Performed using Olympus NDT EPOCH XT Ultrasonic Flaw Detector and 0.5 MHz transducers at 73°F
- Non-destructive and can be performed quickly on test samples in the original charge configuration

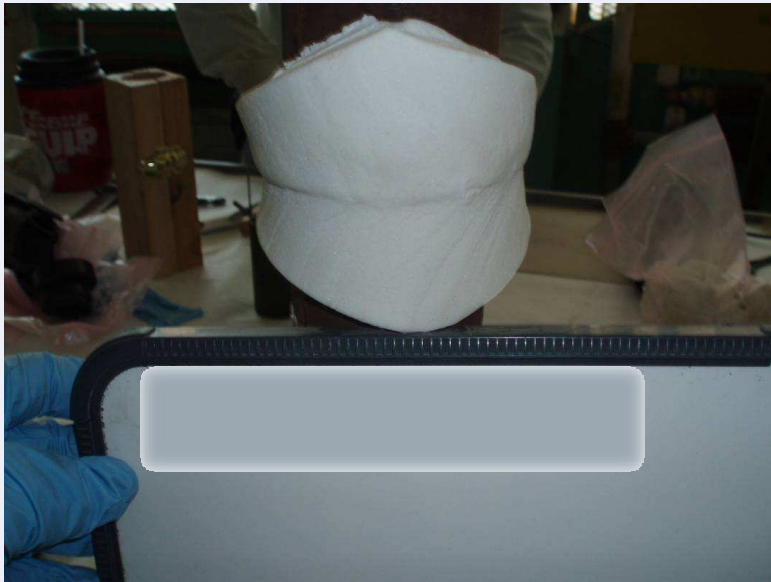


User Evaluation

- Performed by retired USMC personnel with demolition experience
- Consisted of hand shaping C-4 into various configurations per FM 3-34.214
- Task which demonstrated most clearly mechanical properties of C-4 was construction of diamond charge:



User Evaluation



Successful Diamond Charge



Failed Diamond Charge



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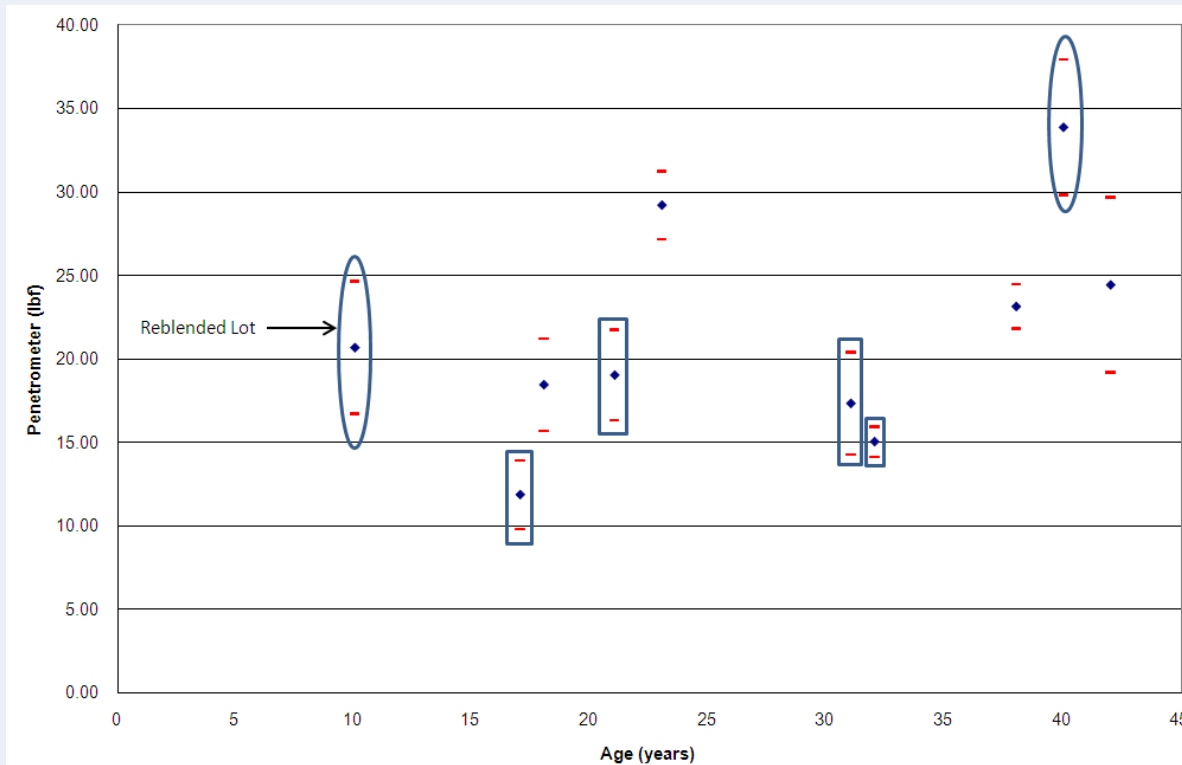
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Accelerated Aging

- 11 year old re-blended lot of C-4 was used to perform this test
- Samples were subjected to thermal aging at three temperatures and various times:
 - 165°F: 35, 45, and 55 days
 - 185°F: 10, 15, and 20 days
 - 210°F: 2, 4 and 6 days
- User evaluation results of the baseline samples from the re-blended C-4 lot failed to meet user moldability requirements as was the case with all of the accelerated aged samples

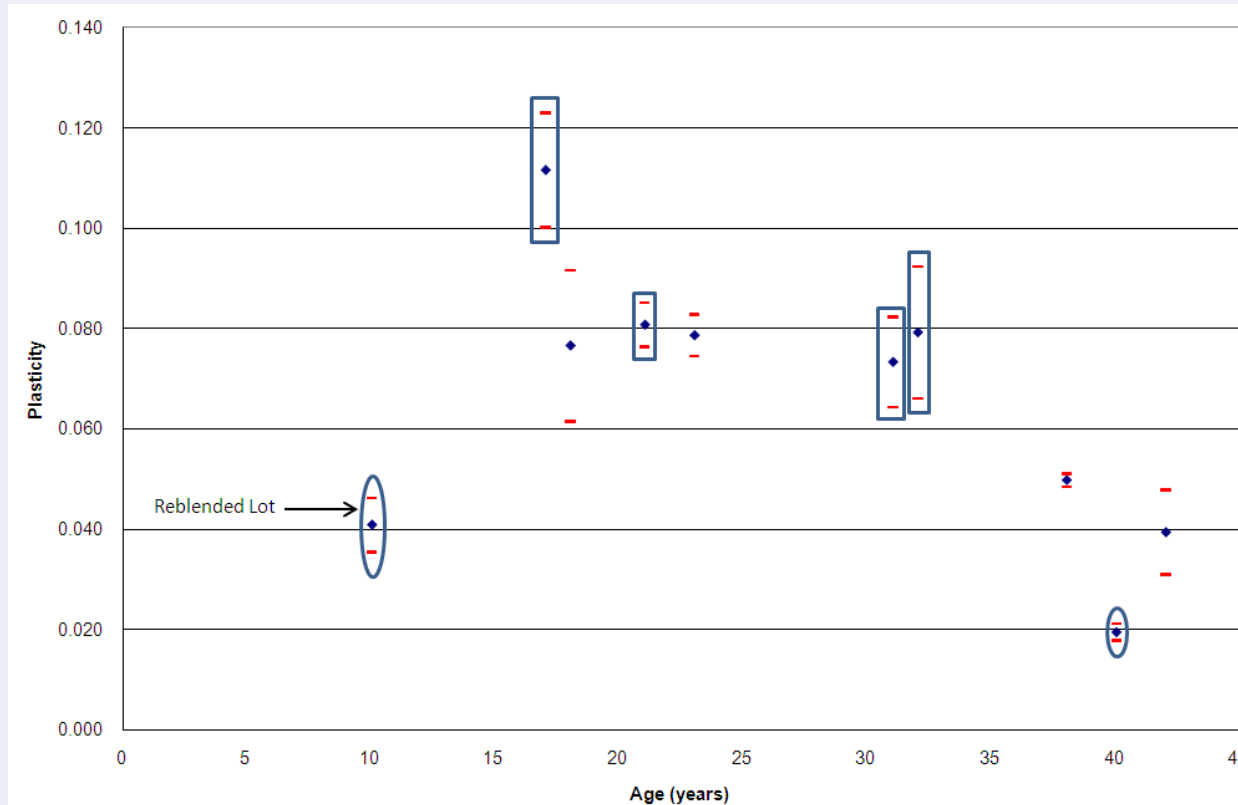


Test Results – Penetrometer



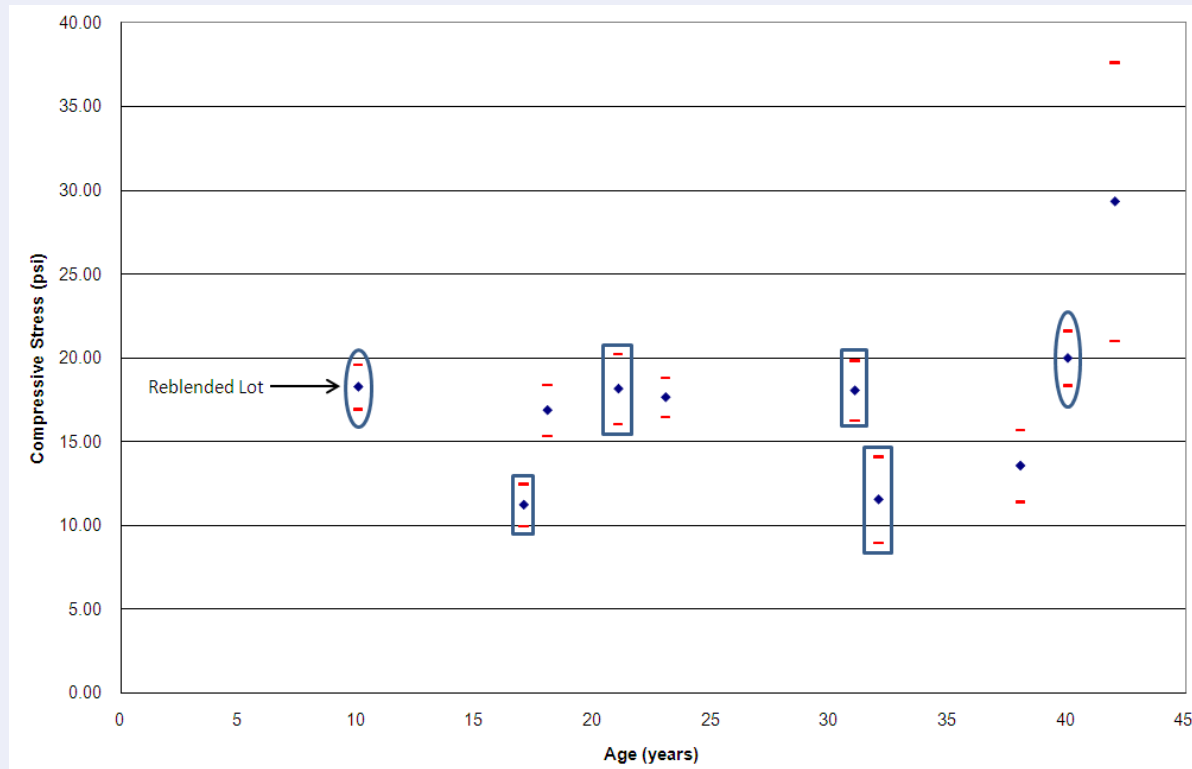
The two lots with the lowest user evaluation success ratios are outlined with ovals and the four lots with the highest user evaluation success ratios are outlined with rectangles.

Test Results – Plasticity



The two lots with the lowest user evaluation success ratios are outlined with ovals and the four lots with the highest user evaluation success ratios are outlined with rectangles.

Test Results – Compressive Load Deflection



The two lots with the lowest user evaluation success ratios are outlined with ovals and the four lots with the highest user evaluation success ratios are outlined with rectangles.



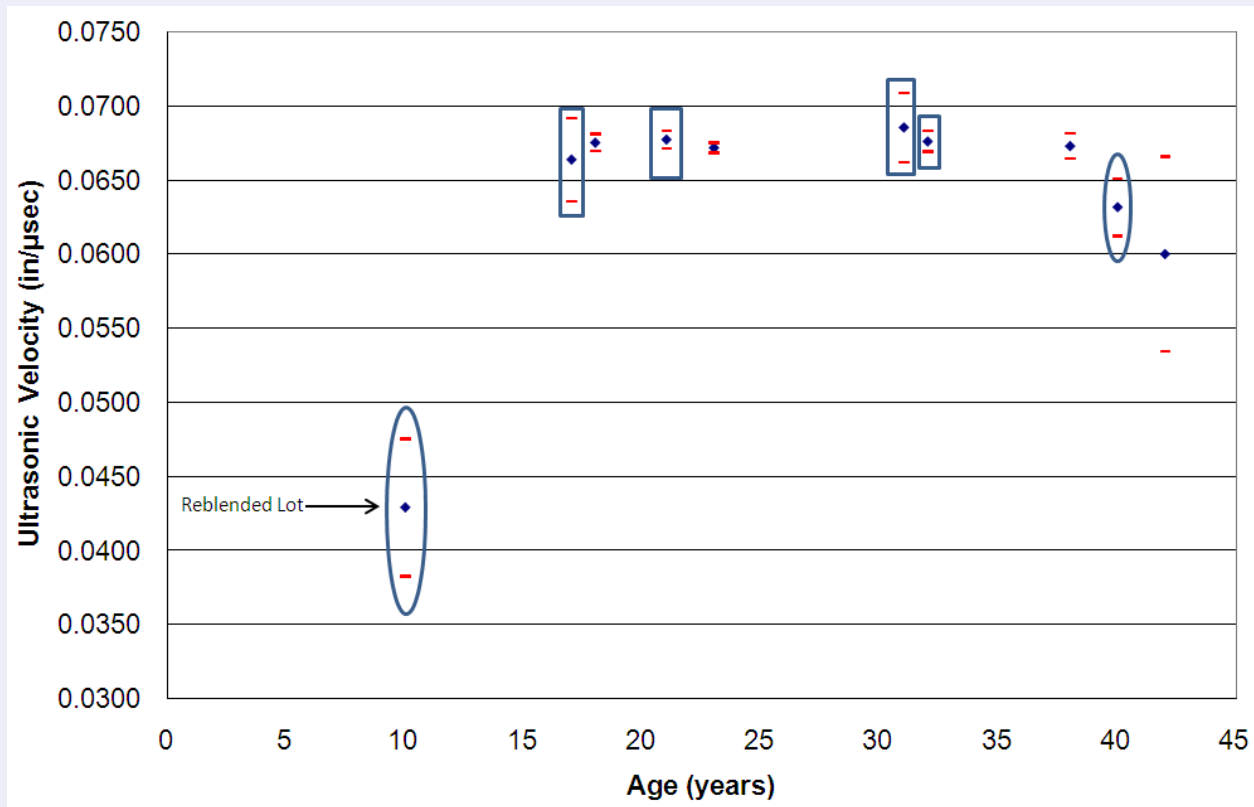
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Test Results – Ultrasonic Velocity



The two lots with the lowest user evaluation success ratios are outlined with ovals and the four lots with the highest user evaluation success ratios are outlined with rectangles.





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Summary and Conclusions

- **Penetrometer testing failed to distinguish the re-blended material as unacceptable.**
- **Plasticity testing successfully identified both the 40 year old lot and the re-blended material as unacceptable.**
- **Compressive Load Deflection testing failed to distinguish any material as being unacceptable.**
- **Ultrasonic Velocity testing successfully identified both the 40 year old lot and the re-blended material as unacceptable.**
- **More work needs to be done with ultrasonic velocity technique to investigate optimum transducer frequency, attenuation effects, and shear velocity**

