Accelerometer-Based Reliability & Condition-Based Maintenance System For Firearms

By:

Howard D. Kent, Armor Development Group, LLC
Forward By:

Lt. Col. Shawn P. Lucas, Program Manager, Individual Weapons
US Army ARDEC, Joint Services Small Arms Program

Topic:

State Of The Art Maintenance For Firearms:

“A Synergy Of Cost Savings In Firearms Maintenance & Fleet Readiness Measures
Which Increase The Warfighter’s Confidence In Their Weapon.”
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The Problems:

Current Inventory Of War Weary Firearms In US Service >1.1 Million…
Knowledge Of Inventory Weapon Condition: Low

Costs To Replace Or Rehabilitate Entire Fleet Too High…

User Confidence In Weapon Function Varies From High To None…

But How To Increase Readiness Within Current Maintenance Budgets And Raise User Confidence In Their Weapon?

Answer: Adopt Commercial “Predictive Maintenance” Techniques…
Introduction:

“Who is this guy and why are we listening to this topic?”

Introduction:

“Look Toward The Weapon Because The ATK Ammo Is So Consistent”

“Thousands Of Instrumented Rounds Were Fired Using ATK Federal Ammunition In Preparation For This Presentation. The Ammunition Was So Consistent And Repeatable For Influence On The Vibration Waveform, That We Treated It As A Constant And Varied Other Components Of The Weapon System.”

And Introducing America’s ATK Federal & Lake City Ammunition Division To Address The Subject Of Quality Control For Military Ammunition…
Introduction:

“Who uses Predictive Maintenance (PDM) and why do it to weapons?”

- 100% Of Energy Production Companies
- Over 90% Of Fortune 500 Industrial Companies
- Over 80% Of All Public Utilities
- US Army Corps Of Engineers
- US Navy Naval Facilities Command
- US Navy Fleet Maintenance Command
- US Air Force Intermediate Maintenance
- US Department Of Energy

Who Should Practice PDM:

Any Operator Of Critical Or High Value Equipment…

PDM Tools Include: Vibration Analysis, Infrared Thermography, High Speed Videography, Lubricant Analysis, Ultrasonic Microphones, Electrical Diagnostics, Non-Contact Instruments, And Other Advanced Testing Methods Which Focus On Machinery In Operational Use.
Introduction:

The Three Basic Types Of Maintenance & Associated Costs:

**Preventative Maintenance:**
*Factory Scheduled Maintenance*
*Operating Hours Or Time Basis*

Prevents Many Faults By Inspection/Lubrication, Predicts None, Costs Very Little To Do…

**Reactive Maintenance:**
*Run Equipment To Failure*
*Repair/Replace What’s Left*

Prevents Or Predicts Nothing, Costs A Tremendous Amount Of Capital & Lost Production…

**Predictive Maintenance:**
*Run Until Performance Drops*
*Repair Only As Needed*

Prevents Majority Of Faults, Saves A Tremendous Amount Of Capital & Lost Production…

Recommendation:

**Preventative Maintenance:**
Use On Everything Regardless Of Cost Or Criticality

**Reactive Maintenance:**
Use On Low Cost & Non-Critical Equipment

**Predictive Maintenance:**
Use On Critical & High Value Equipment
Introduction:

“Why Vibration Analysis and how does it work?”

1) All Mechanical Components Of Firearms Are:
   * Different Sizes, Material Compositions And Weights
   * Mounted With Different Fasteners At Varying Orientations
   * Experiencing A Wide Range Of Stresses Over Time On Firing

2) All Mechanical Components Experience Wear With Use Differently

3) Damage And Wear Cause Easily Detectable Changes In Vibration
Example: Accelerometers & Their Output

All Photos Above DYTRAN, Except Stanford University B-Y-G Triaxial In Lower Left, Upper Center: CSi 2400 Vibration Analyzer, Upper Right: Azimadli Generic Accelerometer F-R Showing Usable Measurement Range.
Example: All Accelerometers Are Not Created Equal

Two Basic Types: Piezo-Crystal Scientific & MEMS For Basic Control Sensing

Example: Signature Analysis Or “Deviations From Baseline Measures”

It Is Easier To See Changes In Machine Condition In Time Series…

Example: Time Series Analysis Cascade Comparison Or “Trending”

Example: Individual Weapon Firing Measurement

Overlay Of Multiple M4 Carbine Buffers With Cycle Rate Variations Due To Weight, Construction, Presence Or Absence Of Springs, Pads & Hydraulic Fluid Operation Shown…
Example: Single Case Comparative Cost Structure

M4 Upper With PDM Work Order:

Diagnosis: Identified Rough Chamber
Shipped By User
Received By Armory
Disassembly
Replacement Of Parts
  Barrel Assembly
  Barrel Extension
  Barrel Extension Pin
Reassemble
Inspection
Test Fire
Automatic Reporting
Clean & Package
Ship To User

Cost = $ “X”

M4 With Unknown Function Problems:

Diagnosis: None, Overhaul
Shipped By User
Received By Armory
Inspection
Test Fire
Disassembly
Gauging
Replacement Of Parts
  Barrel Assembly
  Barrel Extension
  Barrel Extension Pin
Bolt Assembly
Extractor, Spring, Pin
Ejector, Retainer
Firing Pin, Retainer
Carrier Assembly
Reassemble
Inspection
Test Fire
File Report
Clean & Package
Ship To User

Cost = $ “X” Times 2-3 !!!

And Remember, Sometimes Those Unnecessary Repairs Introduce New Faults To The Weapon!
Proposed Model Of Centralized Weapon Maintenance For Firearms:

- Concentrating Highly Trained Armorer Personnel & Specialized Equipment

**Major Repairs Performed At Depot Level**
- Test Fire
- Return To Inventory

**Anniston Army Depot Firearms Maintenance**

**Minor Repairs Performed At Armory Level**
- Operational Unit Armory
- Time Series Measurements

**Practice Range Firing Line**

Above: US Army Photos
Proposed Model Of PDM Weapon Survey For Firearms:

- Hundreds Of Readings May Be Taken Each Day On Firing Ranges By Non-Armorer Personnel With Condition And S/N Data Uploaded To Anniston
- Weapons Diagnosed And Work Orders Are Issued Centrally By Army Master Armors
- Issue Work Orders
- Repair Weapons
- Ship Weapons
- Return To Inventory
- Test Weapons On Range And Return
- Above: US Army Photos

Operational Unit Armory
Field Sweep Team
Anniston Army Depot Firearms Maintenance
Proposed Measurement Procedure Of PDM Weapon Survey For Firearms:

1) Scan Weapon Serial Number With OCR Gun
2) Attach QD Picatinny Mount Triaxial Accelerometer
3) Activate Data Collection Function & Fire Rounds
4) Verify Recording & Remove Triaxial Accelerometer

SAMSON RAM Advanced Adjustable QD Mount
Conclusion:

Initiate *Value Engineering Change Programs For Weapon Maintenance*:

- The Various Services Can Increase Fleet Weapon Readiness Affordably…
- The Individual Weapon User Can Increase Confidence In Their Weapon…
- DoD Can Have A Weapon Knowledge Base & Retain Armorer Capacity…
- Existing Maintenance & Inventory Structures Can Remain Unchanged…

…All Through The Use Of *Predictive Maintenance*.
Credits:

POC: Howard D. Kent, CEO, Phone: 818-314-8636, e-Mail: HDKent@socal.rr.com

With Special Thanks To:

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With Problem Identification & Definition Co-Authored By:

MSgt. Craig LaMudge, USAF-Ret., JSSAP Special Projects Office & NDIA Hathcock Award Winner

“He Who One Day Will Find Fault In Heaven”