API RP 67 Recommended Practice for Oilfield Explosives Safety: Development of Proposed Changes to the Third Edition

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INTRODUCTION

• Background and historical perspective.

• Steering Committee and Task Group concept.

• Overview of 11 Task Groups and key additions to the 3rd edition.

• Industry incident database.

• Future industry meetings.

• Questions.
HISTORICAL PERSPECTIVE

• First Edition – 1994 ...
  – Purpose: “...to prevent inadvertent detonation of explosives”
  – Conveyance technologies: primarily e-line and tubing.
  – Transportation and security: sparse, pre-9/11 era
  – Mainstay safety outcomes:
    • 50-ohm resistorised detonators.
    • 30-ft drop test for downhole firing systems.
    • 0.25 V as a stray voltage limit.
    • Responsibilities of Explosive User in Charge.
    • Formalization of electrical before ballistic arming.
HISTORICAL PERSPECTIVE, continued…

• Second edition – 2007 …
  – Recognized technical advances and incidents since 1994.
  – Key additions and changes:
    • Special handling of HMX after elevated thermal exposure.
    • Safety for TCP firing heads exposed to surface pressure.
    • Downhole electric tractors as a new conveyance method.
    • Stray voltage limit increased to 5 V using some detonators.
    • Surface pressure control equipment has been introduced.
    • Wellsite safety meeting by Explosive User in Charge.
  – Reaffirmed January 2015.
HISTORICAL PERSPECTIVE, continued…

• Third edition – started 2011 to present.
  – Recognized continued technical advancements.
  – Emphasized global safety/security aspects for explosive control.
  – Used Steering Committee concept with Task Group SMEs.
  – Active engagement program with feedback from:
    • 19B Subcommittee on Perforating – biannually.
    • Institute of Makers of Explosives (IME) – biannually.
    • Association of Energy Service Companies (AESC) – annually.
    • Perforating Safety Forums – biennially.
    • International Perforating Symposia (US) – biennially.
STEERING COMMITTEE AND TASK GROUP ORGANIZATION

Steering committee (23 members)

11 Task groups formed to address specialized subject matter

Subsequent team formed to create incident reporting database

1. Detonators, surface firing panels, interrupts, selective fire
2. Time delays
3. Downhole tractors
4. Temperature management
5. Firing heads on bottom of guns, slickline firing heads
6. Coil tubing operations
7. Storage, transport, and security of explosives
8. Pipe recovery operations
9. Surface pressure control equipment
10. Special categories of explosive devices
11. Personnel, training, and audits
STATUS

• Approved by API ballot 20 Feb 2017

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<th>Negative</th>
<th>Abstain</th>
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| Total Responses:  | 14          |           |         |              |
| Total Ballots:    | 18          |           |         |              |
| Response Rate ((Affirmative + Negative + Abstain) / Total Ballots): | 78% | Must be > 50% |
| Approval Rate (Affirmative / [Affirmative + Negative] ): | 86% | Must be >= 66.66% |
| Consensus:        | YES         |           |         |              |

• Steering Committee / Task Groups resolving comments.
  – 351 total, 200 complete, 151 remaining.
• Publish circa 4Q17.
Task Group 1
Detonators, Firing Panels, Interrupts, Selective Fire Systems

• Characteristics and features for electric detonators.
  – Group 1:
    200 mA no-fire, 50 ohm resistance, may contain primary explosive.
  – Group 2:
    25 V no-fire, evaluated for safe RF distance, may contain primary explosive.
  – Group 3:
    120 V no-fire, immune to RF, do not contain primary explosives.

• Expanded language for selective firing systems.
  – Mechanical and electronic switches.

• Interrupts.
  – Barrier design validation.

• Lightning.
  – Guidelines for stop an restart of field operations before/after storms.

• Gun loading shop recommendations.
Task Group 2
Time Delays

• Task Group 2 originally commissioned for ballistic interrupts.
• Distinctions between e-line and TCP interrupts prompted reassignment.
  – E-line interrupts moved to Task Group 1.
  – TCP interrupts moved to Task Group 5.
• Task Group 2 recommissioned to address time delays.
  – Pyrotechnic.
  – Electronic.
• Design requirements set forth for both types.
• Established a safety margin of 5 times the max. expected delay time when retrieving an accidentally initiated device.
Task Group 3
Downhole Tractors

• Two purposed-designed isolation barriers required between the tractor electrical circuitry and explosive device.
• No single-point failure will cause or permit voltage to be applied to explosives.
• Isolation barriers required to block at least 110% of the power supply voltage.
• Tractor and associated equipment to undergo a Failure Modes and Effects Analysis (FMEA).
• FMEA requires validation by an Independent Third Party Organization (ITPO).
Task Group 4
Temperature Management

- Thermally Stressed HMX.
  - More sensitive crystal structure forms after exposure to temp. above 300 F.
  - Phase change is irreversible.
  - UN Test 4(b) (ii) 12m drop tests were conducted to evaluate transportation safety of thermally overexposed shaped charges that were repackaged for return shipment to gun loading shops. All passed.

- Thermal Runaway Event.
  - Based on actual known events.
  - Results from a partial low order detonation, incubation time, and then runaway reaction.
  - Typically shallow wells when guns are run/retrieved in around 30 minutes.
  - Retrieval protocol established including standard wait times and process safety steps.
  - Logic flow chart created to guide field operations.
Guideline Flow Chart for retrieval of misfired guns

- Guns misfired or thermally overexposed.
  - Conduct a safety meeting and review safety procedures.
  - Record $t_o$, (time of the last attempt to fire or start POOH), and POOH up to 200 ft below wellhead/sea floor.
  - Wait at the 200 ft until 30 minutes has elapsed from $t_o$.
  - Has 30 minutes elapsed from $t_o$?
    - Yes: Continue POOH to surface.
    - No:
      - At surface, confirm: did the gun fire?
        - No: Use the IR thermometer or perform "water test": splash water over the gun.
        - Yes: Leave gun where it is. Clear the area, and wait 2 hours. Notify your manager of a potential ongoing thermal event.
          - Does water bubble or boil off, or IR thermometer read $>100^\circ\text{C}$ or $>212^\circ\text{F}$?
            - Yes: Measure the temperature with an IR thermometer; record temp $T_1$ and time $t_1$.
              - Does $T_1$ exceed $T_2$?
                - Yes: Proceed with disarming/disassembly procedures. End.
                - No: Clear the area and wait for 15 minutes (i.e., $t_0-t_1$). Take another temperature measurement and record temp $T_2$ and time $t_2$.
                  - $T_2 > T_1$?
                    - Yes: Proceed with disarming/disassembly procedures. End.
                    - No: Proceed with disarming/disassembly procedures. End.
Task Group 5
Firing Heads on Bottom of Guns / Slick-line Firing Heads

- Firing Heads on Bottom of Guns.
  - Unchanged from 2\textsuperscript{nd} edition.
  - Demonstrated safe design before and after exposure to downhole conditions.
  - Prior review and agreement by service company and operator.
- Slick-line Firing Heads.
  - Three types addressed:
    - All require two independent safety features or barriers.
    - Battery-operated systems also require FEMA by an ITPO.

<table>
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<tr>
<th>Initiation Technology</th>
<th>Initiator Type</th>
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<td>Mechanical or Pressure</td>
<td>Percussion</td>
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<tr>
<td>Battery-operated electronics</td>
<td>Percussion</td>
</tr>
<tr>
<td>Battery-operated electronics</td>
<td>Electric</td>
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Task Group 6
Coiled Tubing Operations

• Risk of multiple services: Pumping, CT, Perforating.
• Job agreement between operator & service co.: CWOP, SIT.
• Trip/Pop-off valves: Set for equipment ratings/job parameters.
• Absolute and differential pressure firing heads: Communication/weep ports
• Test of pressure-activated firing heads: Not with attached guns.
• During deployment: Monitor pressure to ensure equalization.
• Descent rate: Agreed between service company and operator.
• Second ball drop: Provision included if no alternatives available.
• For misfire recovery: Considerations for trip/pop-off valves, guns in hole, pressure bleed down.
Task Group 7
Storage, Transport, and Security of Explosives

• Security language strengthened, now including global emphasis.
• Storage.
  – Packaged Explosives and Loaded Perforating Guns.
  – Key Control / Recordkeeping.
• Transportation.
  – Role of HAZMAT employee outlined.
  – Considerations for route, comms, breakdowns / incidents.
  – Safety Permits from govs, Common Carrier evaluation.
  – Return of excess explosive material.
• Disposal / Recycling of Spent Perforating Guns.
Task Group 8
Pipe Recovery Operations

• Unchanged from 2\textsuperscript{nd} edition.

  – For jet cutters: follow the same procedures as when using perforating guns.

  – For chemical cutters: use securely-attached open-ended aluminium protective sleeves to cover the anchor body and severing head.
Task Group 9
Surface Pressure Control Equipment

• Pressure testing should be completed prior to inserting any explosive device.
• Recommends Quick Test Safety Subs, Wireline Safety Valves, and Vent Subs.
• Lubricator string not to be tested above its max working pressure.
• If the surface pressure control equipment must be tested with an explosive device inside, special precautions shall be taken.
  – Non-volatile liquid, typically a 50 / 50 mix of glycol and water.
  – Low volume / high pressure pump equipped with over-pressure protection.
  – Warning about adiabatic heating with high volume, high pressure pumps
  – Test pressure shall not exceed 80% of the pressure rating of the explosive device.
• Exception does not apply to exposed charge guns or cutters. These devices shall never be exposed to a pressure test.
Task Group 10
Special Categories of Explosive Devices

• Several recommendations unchanged from 2\textsuperscript{nd} edition.
  – Setting tools.
  – Cased hole formation testers.
  – Sidewall sample takers (core guns).
  – Bullet perforating guns.

• Primary change was inclusion of propellant stimulation tools.
  – Field safety considerations, especially friction.
Task Group 11
Personnel, Training, and Audits

• Updated minimum qualifications for three tiers of explosives personnel.
  – Explosive trainee.
  – Explosive User.
  – Explosive User in Charge.

• Created five informative annexes for operational and auditing purposes.
  – Annex B: Recommended Safety Equipment and Processes.
  – Annex D: Wellsite Audit Checklist.
  – Annex E: Stray Voltage Worksheet.
Safety Incident Database

• Database now implemented to track explosive incidents and near misses related to oil and gas industry.
  – Captured events dating back to 1970.
  – Over 100 entries now in database.
  – Located at www.perforators.org website.

• Additional related topic: Gaseous byproducts from perforating
  – Not included in any previous RP 67 edition.
  – Now included in 3rd edition as a result of recent instances of carbon monoxide (CO) production.
  – Important for plug abandonment and long perf intervals.
SUMMARY

- 3rd edition of RP 67 nearing completion; goal to publish Q4 2017.
- 6 year effort involving over 120 SMEs representing over 50 organizations.
- Steering Committee and Task Group concept used.
- Key additions and updates to the 3rd edition:
  1. Introduction of FMEA and ITPO to evaluate new technologies.
  2. Global perspective for transportation and security.
  3. Safety categories for electric detonators.
  4. Gaseous byproducts from perforating, particularly CO.
  5. Handling thermally overexposed explosive systems.
  6. Coil tubing, slickline, and tractor conveyance recommendations.
  7. Selective fire perforating, time delay firing, ballistic interrupts.
  8. Surface pressure control equipment, field operations, gun loading shops.
  9. Safe handling of propellant stimulation systems.
 10. Five informative annexes, industry safety incident database.
Future Industry Meetings and Updates for RP67

• International Perforating Safety Forum (PSF) 04 May 2017
  – Houston, TX

• Association of Energy Service Companies (AESC) 04 Oct 2017
  – Ft Worth, TX

• API Subcommittee on Perforating 11 Oct 2017
  – San Antonio, TX

• Institute of Makers of Explosives (IME) 12 Oct 2017
  – San Antonio, TX
## Acknowledgements

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<tr>
<th>Task Group Experts</th>
<th>Companies and Organizations</th>
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<tbody>
<tr>
<td>Over 120 people</td>
<td>Over 50 entities</td>
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