NEXT GENERATION FIRE SUPPRESSION SYSTEM TECHNOLOGY: A NATIONAL RESEARCH PLAN

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This is an in-progress presentation of a plan whose goal is to develop and demonstrate, by 2004, environmentally-friendly, user-safe processes, techniques, and fluids that meet the operational fire extinguishment and explosion suppression requirements currently satisfied by halon 1301 systems in aircraft, ships, ground combat vehicles, and critical command and control facilities. The plan is being formulated at the direction of the Office of Advanced Technology, Director of Defense Research and Engineering (DDR&E).

CURRENT ACTIVITY

The present DDR&E Technology Development Plan (TDP) is aimed at identifying near-term alternatives to CFCs, halons, and other ozone-depleting substances, mostly by 1996. The TDP does not include comprehensive long-term research to find optimal replacements. Within the TDP, the search for halon 1301 replacements (*i.e.,* total flooding fire suppressants) has been focussed on testing similar, available fluids, with some exploration of mists and gas generators. None of the current replacement fluids matches halon 1301. A different type of effort is needed to find halon 1301-like fire suppression capability.

THE NATIONAL RESEARCH PLAN

The plan was developed with the collaboration of experts from government, industry, and academia. It has been improved following review by 15 entities within DoD, as well as the EPA.

The principal application of the research is to both new and existing Department of Defense weapons systems and facilities. An indication of the fire types to be addressed was obtained by surveying DoD experts on the fire protection in current weapons systems and facilities. While preliminary, the feedback shows that the fire locations vary in size, shape and occupancy; the fuels are solids, vapors, and liquids (pools and sprays); the needed fire suppression times run from 0.01 to 10 seconds; "cleanliness" of the fire suppressant in needed only sometimes. The hazards to be avoided include: harm to people, thermal damage to equipment, post-fire corrosion, loss of visibility, and overpressure. The storage and delivery system must usually be compact, and the suppressant and its hardware must be compatible with the existing host, if for retrofit. "One size" fire suppression will not fit all.

Addressing this range of fires and meeting the goal of the plan will require *ca.* $50 million and **nine** years. It is expected that collaboration with existing programs will reduce the need for "new" funding. The beneficiaries of the results and the participants in the research will also be expected to contribute resources. Because there are many similar fires types in non-Defense venues, there should be additional impacts and opportunities for cost-sharing.

The plan consists of 6 thrusts, in turn composed of 32 technical elements, to be carried out synergistically:

1. **RISK ASSESSMENT** AND **SELECTION METHODOLOGY:** Development of a process for choosing among alternative technologies by applying modem decision-making concepts.

 1.a **DoD Fire Data:** Characterization of the nature, frequency, consequences, and severity of fires previously and currently attacked using halon 1301; includes new weapons systems for which halon 1301 was intended; identification of the limits of acceptable damage and the threats to people.

 1.b. **Ullage Inerting In-Flight Data:** Obtaining accurate data on ullage conditions on which to base a valid fire protection strategy.

 1.c. **Relative Benefit Assessment of Fire Protection System Changes:** Means to evaluate the desirability of alternate changes to fire protection systems.

2. **FIRE SUPPRESSION PRINCIPLES:** Establishment of mechanisms of flame extinguishment using detailed experimental studies and computational models.

 2.a. **Mechanisms of Ultra-High Efficiency Chemical Suppressants:** Determine how chemicals that are as or more efficient than halon 1301 quench flames characteristic of those identified in Thrust 1.

 2.b. **Suppression Dynamics of Fine Droplets and Particles:** Obtain the data and understanding required to engineer improved heterogeneous agent dispersion systems with enhanced fire-extinction capability.

 2.c. **Flame Extinguishment Model:** Develop the ability to "design" a flame suppressant chemical.

 2.d. **Stabilization of Flames:** Understanding of the extent to which flame stabilization can impact the observed effect of a suppressant.

 2.e. **Explosion Inhibition Processes:** Develop basis for "designing" explosion inhibitors.

3. TECHNOLOGY TESTING METHODOLOGIES: Selection, adaptation, or development of test methods and instrumentation to obtain data on the effectiveness and properties of new suppression approaches.

3.a. Suppression System Effectiveness Screening: Develop test methods to obtain inexpensive fire suppression efficiency information on a diversity of suppression technologies.

3.b. Agent Compatibility with People, Materials, and the Environment: Develop test methods on the toxicity, environmental impact, and materials compatibility of new suppressants and their principal decomposition products.

3.c. Instrumentation for Gaseous Fuels, Oxygen, and Suppressant Concentration Measurements During Suppression of Flames and Explosions: Develop measurement methods needed for characterization of suppression performance and for determining combustion conditions in lab-scale apparatus.

3.d. Instrumentation of Real-Scale Fire Test Facilities: Instrument the existing real-scale fire suppression testing facilities, as needed, making them research-capable.

4. NEW SUPPRESSION CONCEPTS: Definition of new ideas for fire suppression based on chemical and physical principles.

4.a. Powder-Matrix Systems: Investigate agents dissolved in an inert matrix so that it will be released rapidly at a temperature near or below the ignition point of the combustible mixture.

4.b. Organometallic Suppressants: Determine whether there are organometallic suppressants that are effective and sufficiently low in toxicity and residue.

4.c. Super-Effective Thermal Suppressants: Determine whether there are practical physical suppressants of efficiency comparable to halon **1301.**

4.d. Fire Suppression by Electric Fields: Determine whether electrical field of practical strength can couple with turbulent airflow to enhance flame lift-off.

4.e. New and More Effective Fire-Suppression Technologies that are Presently Conceptual: Introduce new and innovative approaches to fire suppression at the onset of the program.

5. EMERGING TECHNOLOGY ADVANCEMENT Acceleration to maturity of fluids, processes, and techniques that are already under development.

5.a. Liquid Mist Systems: Improve small droplet suppression systems.

5.b. Advanced Flame Arresting Foams for Fuel Tank Inerting: Develop foams that are lighter, retain little to no fuel, do not degrade or statically discharge, and offer explosion suppression at a weight equivalent to current halon 1301 fuel protection systems.

5.c. Active Suppression for Fuel Tank Explosions: Determine the viability of previously-developed systems.

5.d. Advanced Propellant/Additive Development for Gas Generators: Develop new types of chemically-generated gaseous suppressants.

5.e. Enhanced Powder Panels: Advanced protection against penetrating shells.

6. SUPPRESSION OPTIMIZATION: Development of the knowledge to obtain the highest efficiency of each candidate technology.

6.a. Injection of Suppressant into the Fire Compartment: Provide the technology needed to develop optimal physical injection systems for advanced fire suppression methods.

6.b. Suppressant Flow Through Piping: Develop and validate calculation methods for flow in pipes of single-and 2-phase fluids with widely varying properties and flow conditions.

6.c. Effects of Atmospheric Composition and Flow Conditions on Flame Extinction: Understand the effects of the fire atmosphere and flow field on suppressant distribution and the concentration needed for extinguishment.

6.d. Mechanism of Unwanted Accelerated Burning: Characterization of the mechanisms of the enhanced burning sometimes observed when agents are first applied to flames.

6.e. Development and Evaluation of Automatically Actuating Pre-Dispersed Agent Storage Containers: Develop new technology for minimizing the quantity of agent needed, while enhancing the delivery efficiency.

6.f. Hot Surface Reignition Suppression: Minimize autoignition of remaining fuels after suppression.

6.g. Pressure Effects on Engine Fire Suppression: Determine the extent to which agent testing must be conducted over a range of pressures.

6.h. Study of Fuel Flow Characteristics on Engine Fire Suppression: Understand the effects of fuel discharge properties on the ease of suppression.

6.i. **Operations Procedures for Improved Use of Fire Suppression Capability:** Identify changes in fire suppression procedures that would enhance the efficiency of the suppression system.

6.j. **Real-Scale Optimization of Advanced Fire Suppression Technologies:** Obtain verification of the factors affecting real-scale fire suppression performance; demonstrate the effectiveness of selected new fire suppression technologies.

This is a living plan, representing the best current thinking for achievement of the goal, but adaptable as our knowledge grows. It is designed to begin producing a steady flow of ideas quickly. The plan is directed at demonstrating and documenting new technologies, but not to develop them to readiness for each application. In this context, the major milestones are:

- Tabulation of the broad classes of fires to be suppressed and the best current laboratory-scale test methods for obtaining data on the performance and compatibility of new suppressants and their principal degradation products during the fire extinguishment process. [1996]

- Improved laboratory-scale test methods for obtaining suppressant performance and compatibility data. [1997]

- Selection for further R&D of first set of new technologies resulting from broad public solicitation of ideas. [1998]

- Completion of core methodology for DoD managers to evaluate the impact on each weapons system of selecting alternative fire suppression systems. [1999]

- Demonstration of a suite of computer models of the fire suppression process, based on the critical physical and chemical principles, for creating new suppression approaches and optimizing current ones. [1999]

- Completion of new generations of mist, inert gas generator, and powder technologies. [2001]

- Engineering models of an array of techniques for optimizing the use of new fire suppression technologies. [2003]

- Demonstration of effectiveness of new technologies. [2004]

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