

**Hugh J. McSpadden**  
**Consultant, Energetic Materials and Technology**

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## *Curriculum Vitae*

**Education:** Bachelor of Science in Chemistry, University of Tennessee, Knoxville, Aug. 1954.

**Citizenship:** USA.

**Security clearance:** Secret. Clearance is presently administratively terminated after completion of contract work with Goodrich/Aircraft Interior Products.

### **Overview of Experience: Product Engineering and Chemistry**

#### **R & D Experience**

- \* **Responsible for**, and directly involved with much of the work in creating unique, high-density impulse propellants, in developing improved thermal insulations, and in most other aspects of energetic materials and rocket motors.
- \* **Directed** work with, and participated in, the continuous processing of energetic materials on the state-of-the-art machines at Universal Propulsion Company (now Goodrich/Aircraft Interior Products/Propulsion Systems Arizona)..
- \* **Developed** a wide range of composite propellants with required burning rates and signature characteristics for use in various applications. Also developed, designed and invented ignition systems for ammonium nitrate propellants.
- \* **Co-inventor** and developer of a wide range of rubber-base rocket case insulations, and related materials, with patents issued.
- \* **Additional patents** have been issued on propellants, ignition systems, and insulation. Other patents are pending.

#### **Project Management Experience**

- \* **Direct involvement** on almost a daily basis from the conceptual stage to completion of the facility for state-of-the-art continuous processing of energetic materials. Closely involved with the use of this facility.
- \* **Responsible for** propellant production, as well as propellant R&D in a combined department.

#### **Program Management Experience**

- \* **Directed** Energetic Materials, including propellant production plus Research and Development. Work included selection of personnel, scheduling, budget creation, capital expenditure planning and performance to meet schedules.

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**Employment record**

**Sept. 1954 - Nov. 1955.** Phillips Petroleum Company, Rocket Fuels Division, McGregor, Texas, operating contractor for Air Force Plant 66. a GOCO (government-owned, contractor-operated) facility Analytical chemist doing chemical and analyses on raw materials using established procedures. Also developed new procedures for analyzing raw materials, and for special analyses on blends of materials. Created special sealed glass apparatus. Sampled raw materials in warehouses and in explosive bunkers.

**Nov. 1955 - Jul. 1957:** U. S. Army. Infantry basic training at Ft. Ord. CA, then advanced training as a AAA TPS-1D "Skysweeper" Gun-laying radar operator. Permanent assignment as Clerk Typist in Headquarters Battery, Anti-aircraft Artillery Replacement Training Center (AAA RTC), Ft. Bliss, Texas. Major duties included: interviewing trainees prior to assigning them to permanent stations; interviewing Officer Candidate School (OCS) applicants and assisting them in preparation of the Security Questionnaire. I was also involved in preparing the cumulative "Morning Report" (a daily accounting of all personnel present, on leave, etc.) for the entire AAA RTC. Separated from active duty in July 1957 to return to the civilian job in McGregor, Texas.

**July 1957 - Jan. 1962.** Air Force Plant 66. Development chemist. Phillips was the contractor until about Oct. 1957, when Astrodyne became the contractor. Astrodyne was a 50/50 joint venture of Phillips Petroleum Company, Rocket Fuels Division and the Rocketdyne Division of North American Aviation. Some time in the first half of 1959 Phillips sold their half and the contractor became Rocketdyne. My job in all this was Development Chemist, with particular emphasis on rubber-based insulations for the interior of solid propellant rocket motors. At least two insulation patents and one patent on ignition systems were issued based upon work I did. Processing was done using roll mills, Banbury mixers and molding presses. Other work included formulating and processing solid propellants, developing bonding techniques for propellant to composite materials, developing ignition systems, fabricating pilot production quantities of various solid propellant gas generators, visiting subcontractor for verification of processes used for critical components, plus providing technical assistance to the Manufacturing department for several different operations and items.

**Jan. 1962 - Jun. 1964.** Propellant Chemist, Rocket Power Inc., Mesa, AZ. Administrative offices were at Falcon Field airport, Mesa, with all other departments at the north end of Greenfield Road. Formulated a wide range of propellants for sounding rockets, rocket catapults for air crew escape systems, for small boost (JATO) rockets, and for various ballistic devices. Did 'hands-on' work in preparation of ingredients, and in mixing and casting the propellants into test motors. Analyzed results from test firings and derived burning rate data from the results. Applied the ballistic information to new formulations. Also formulated, mixed, and used various liner compositions. Polymers used included polysulfide, polyurethane, polybutadiene-acrylic-acid (PBAA) and polybutadiene-acrylic acid-acrylonitrile (PBAN) as well as experimental polymers. Wrote applicable reports and memorandums as required for work being done.

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**Jun. 1964 – Sept. 1965.** Aero Dyne, Inc. Tempe, AZ. Located on Kyrene Road, 1.5 miles south of Williams Field Road, Chandler. Technical director and one of 4 founders of this company that was formed to supply 3.0-inch diameter sounding rockets of the LOKI type and size to Space Data Corp., Phoenix, AZ. Founders of Space Data and of Aero Dyne were all employed at Rocket Power at one time. Limited formulation work here, because the major products the first year used polysulfide/ammonium perchlorate propellants based on well known formulations. Designed, built and used tensile testing apparatus. Designed and used molds for making igniter components from aluminum filled epoxy resins. Loaded igniter systems. Participated in test firings and in data reduction.

**Oct. 1965 – Feb. 1996.** Universal Propulsion Company (UPCO), 3400 Pyrite St., Riverside, CA 92507 (to July 1978); Universal Propulsion Company, A Talley Industries Company, 1800 W. Deer Valley Road, Phoenix, AZ 85027 and 25401 N. Central AV, Phoenix, AZ 85027-7899. UPCO was incorporated in 1959, but did not become an active company until the summer of 1965. I joined the privately held company in October 1965 as the third active employee, and did a very wide range of jobs associated with all phases of solid propellant development, manufacturing, testing, purchasing, receiving, quality assurance, and shipping of products. I also did propellant grain design for some of the products, plus the design of casting tooling and some machinery design for the earlier products.

Polymers used included polysulfide, carboxyl-terminated polybutadienes and hydroxyl-terminated polybutadienes. Oxidizers used included ammonium perchlorate, potassium perchlorate, strontium nitrate, ammonium nitrate, and lead nitrate. Explosives such as PETN were also evaluated. Propellant billets were fabricated into test motor grains using normal machine shop and assembly practices.

Other work included development of intumescent insulation systems for protection of ordnance, such as bombs, from external flames. The work also included insulation for the interior of small rocket motors.

Also did work on pyrotechnic delay systems and on ignition systems. One application of ignition concepts was the successful development and demonstration of mid-air explosive dispersal and simultaneous, near-total ignition of the contents of Napalm B fire bombs when traveling at 600 knots.

Several patent applications were submitted and patents were granted on insulations and on unique high-density propellant formulations.

Company growth, partly done by the 1968 licensing of a ballistic device product line from Space Ordnance Systems, led to the establishment of an "Arizona Division" at 117 N. Hayden RD, Scottsdale, AZ. The continued growth of this division led to its relocation to 1800 W. Deer Valley RD, Phoenix, AZ. UPCO relocated me to the Deer

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Valley Road address in July 1978, leading to closing the Riverside operations in May 1980. Eventually all operations were relocated to the 25401 N. Central AV., Phoenix site, which is at the corner of Happy Valley Road and Central Avenue.

Note that UPCO became one of the Talley Industries Companies at about the time I relocated to Arizona. Also note UPCO has never been a subsidiary of Talley Defense Systems (TDS); rather UPCO and TDS were at equal levels within the Talley Industries structure.

Increased facilities and staffing at the Arizona facilities permitted more emphasis on propellants and liners for existing and new applications, while simultaneously doing the creation of the production propellant processing paperwork and the oversight of the ballistic, physical and mechanical properties of the propellants and of the products in which they were used. Basic monitoring techniques and spreadsheet formats are still used at UPCO.

My title developed into Chief Chemist, then into Chief Scientist, reflecting the increasing support of engineering and of manufacturing. For about 2-1/2 years I led both R&D, reporting to the President, and led the propellant manufacturing work, reporting to the Exec. V.P./Director of Manufacturing.

At various times, and for various applications, I provided ballistic design recommendations to Product Engineering. I have participated in an uncounted number of post-test evaluations of rocket motors, as to the degree of success, and as to the reasons for unsuccessful tests. The work included coordination with purchasing, with receiving inspection, with Manufacturing Engineering for tooling and equipment design, with the test department for rocket motor firings, with the various aspects of rocket motor assembly, including propellant machining, and with the X-ray operations for inspection of the rocket motors and propellant grains.

I prepared and taught in-house classes on the basics of rocket motor design, including showing how the choice of propellants affects the possible ballistic designs for any set of requirements.

I was extensively involved in 1979-1980 with the demonstration training of Daicel personnel, plus creation of tooling drawings and of technical documentation for the training of Daicel Chemical Industries personnel in the appropriate propellant manufacturing processes (Harima Plant near Himeji, Hyogo Pref., Japan) as part of the Technology Transfer related to the F-15J aircraft and their manufacture in Japan. I spent two weeks on-site in Japan as part of this process, with continuing contact with Daicel people for many years.

UPCO jointly established with Werner-Pfleiderer, of Ramsey NJ, a state-of-the-art facility for manufacture of propellants via an innovative continuous process with a machine described as a "twin-screw, co-rotating compounder". I was closely involved with all phases of the acquisition of, and training in the use of, the machinery because it was assigned to Research and

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Development for several years before being transferred to propellant manufacturing. A wide variety of formulations were successfully processed, covering both castable and extrudable solid propellants and pyrotechnic formulations.

Historically the product line at UPCO has included rocket motors, propellant actuated devices (PAD), cartridge actuated devices (CAD), explosive actuated devices and ejection seats. This range of products continues.

**Feb. 1996 – Dec. 2000.** Self-employed consultant with Universal Propulsion Company as one of my clients. As a consultant, I was removed from management responsibilities, and instead focused on the specific tasks assigned to me. These tasks related, in one way or another to solid propellants and to the use of those propellants. For example, rocket motor design in support of proposal efforts was a significant component of my work. Another sector of my work was that of supporting the automotive products group in the development of air bag inflation systems.

During this time, Talley Industries was purchased by Carpenter Technology, and ceased to exist. The individual companies were then either retained by Carpenter, or offered for sale. The BF Goodrich Company purchased UPCO, placing it into BF Goodrich Aerospace. A few years later, BF Goodrich sold all non-aerospace operations, and renamed itself “Goodrich Corporation”.

**Dec. 2000 – Apr. 2002 (approx.).** Senior Staff Scientist on the Goodrich payroll, supporting Engineering (particularly New Product Engineering), and starting in February 2002, heavily involved with the daily activities related to propellant production. I continued to provide support to proposal efforts, particularly when new propellant chemistry was involved. I also taught a 20-plus lesson on rocket motor design and propellant selection (second time for such a class.) Support of the automotive group’s activities continued.

**Apr. 2002 (approx.) – Dec. 2004.** Contract employee at Goodrich through PDS Tech, Tempe, AZ.. There was a restructuring in late 2003 and early 2004 of various activities within Goodrich. UPCO as an entity was repositioned and renamed as: Goodrich Corp. / Aircraft Interior Products / Propulsion Systems – Arizona. Its product line did not change. My work responsibilities included continuing support of the propellant production, training of new hires in formulation work, and support of New Product Engineering. I also taught an abbreviated eight lesson class on rocket motors (third such class).

**Fall 2003 – present.** Consultant, failure analysis with Augspurger Komm Engineering, Inc. 15455 Greenway-Hayden Loop, C-14, Scottsdale, AZ 85260-1611. Highly varied work requiring good observational and analytical skills to identify the probable cause for the failures.

Please see the following pages for a listing of most of my patents and also of my publications over and beyond the many internal reports and formal reports written for each employer.

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**Additional Information**

\* **In-depth knowledge** of rocket motor design and ballistics. In-depth experience in analysis of measured performance. Experienced in many methods of propellant processing – extrudable, castable, compression moldable.

\* **One of three International Co-chairs** of the 2003 IASPEP (International Autumn Seminar on Propellants, Explosives and Pyrotechnics) meeting in Guilin, China. Scheduled to be one of two co-chairs at IASPEP 2005, in Beijing, China, 25-28 Oct. 2005. International Advisory Committee member for IASPEP 2001. Co-chair of sessions in the 1999 and 2001 IASPEP meetings in Chengdu and ShaoXing, China, respectively.

\* **Participant** in 80% of the ICT (Institute for Combustion Technology) meetings in Karlsruhe, Germany since 1985.

\* **Active member and frequent participant** in International Pyrotechnic Society, AIAA (American Institute of Aeronautics and Astronautics), NDIA (National Defense Industrial Association), CMEUG (Continuous Mixer and Extruder Users' Group) and CPIA/JANNAF meetings as attendee, speaker/author, session chair or session co-chair, meeting co-chair, meeting organizer, etc.

I maintain an active USA passport.

Please see the following pages for a listing of most of my patents and also of my publications over and beyond the many internal reports and formal reports written for each employer.

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**Partial listing of patents**

- US 6,726,788 Preparation of Strengthened Ammonium Nitrate Propellants.
- US 6,394,975 Ammonium Nitrate Propellants
- US 6,069,906 Method for Preparing Age-stabilized Propellant Compositions
- US 5,583,315 Ammonium Nitrate Propellants
- US 5,419,118 Multi-Stage Rocket Motors
- US 5,149,384 Propellant Material
- US 4,619,722 Propellant material with reduction to lead oxide
- US 4,001,126 Heat Protective Material and Method of Making the Material
- US 3,945,202 Rocket Containing Lead Oxidizer Salt-High Density Propellant.

Additional patents include one on the ignition system for a gas generator propellant grain, another on rubber-based combustion inhibitors for propellant grains, and another on rubber-based rocket case interior insulations.

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**Papers presented at meetings**

- 1. Development of Rubber-Based Insulation Materials for Solid Propellant Rocket Motors.** Originally classified CONFIDENTIAL. Authors: O. D. Ratliff, H. J. McSpadden. Joint Army-Navy-Air Force Propulsion Meeting, Washington D.C., May 1959. Published in *Bulletin of the 15<sup>th</sup> Meeting Joint Army, Navy, Air Force Solid Propellant Group, Volume V*. Available in **AD 324 049**, from the Defense Technical Information Center..
- 2. An unclassified version of paper number 1** (above) was presented at the Spring 1959 meeting of the Rubber Division of the American Chemical Society (probably held in Akron, Ohio). Presenter was O. D. Ratliff. Exact title of paper and of journal is unknown at this time.
- 3. High Density Impulse Propellants.** Hugh J. McSpadden. Presented at the 1981 JANNAF Joint Propulsion Meeting. Published in CPIA Publ. 340, Volume I, May 1981, pp. 357-374. Availability: NTIS.
- 4. Lead Nitrate Particle Size Using the Sedigraph,** J. D. Levantino, H. J. McSpadden. *Joint International Symposium on Compatibility of Plastics and Other Materials with Explosives, Propellants, Pyrotechnics and Processing of Explosives, Propellants and Ingredients*. American Defense Preparedness Association, 11-13 March 1985, Mariner's Inn at Hilton Head, SC.
- 5. Removal of Lead Ion Interference in Water Analysis Using Karl Fischer and Eugen Scholz Reagents,** H. J. McSpadden and J. D. Levantino. *Joint International Symposium on Compatibility of Plastics and Other Materials with Explosives, Propellants, Pyrotechnics and Processing of Explosives, Propellants and Ingredients*. American Defense Preparedness Association, 11-13 March 1985, Mariner's Inn at Hilton Head, SC.
- 6. Improvements In Particle Size and Moisture Analysis Methods for Lead Nitrate.** Presented at, and published in: **PYROTECHNICS. Proceedings of the 16<sup>th</sup> Internationale ICT\_Jahrestagungs 1985** combined with **10<sup>th</sup> International Pyrotechnics Seminar**. July 2 - 5, 1985, Karlsruhe, Germany.
- 7. Accelerated Aging Tests of Cast Composite Propellants, Batch Versus Continuous Processes.** Dr. James J. Baker & Mr. Hugh J. McSpadden. *Environmental Testing in the 90's*. 20<sup>th</sup> International Annual Conference of ICT, 18<sup>th</sup> Annual Technical Meeting of GUS, June 27 - 30, 1989. Karlsruhe, Germany.
- 8. Continuous Production of Composite Propellants,** J. J. Baker, H. J. McSpadden. 14<sup>th</sup> International International Pyrotechnics Seminar, July 11 - 15, 1989, Jersey, Channel Islands, UK.

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**9. Continuous Production of Composite Propellants.** Dr. James Baker and Mr. Hugh J. McSpadden. *Joint International Symposium on Compatibility of Plastics and Other Materials with Explosives, Propellants, Pyrotechnics and Processing of Explosives, Propellants and Ingredients.* American Defense Preparedness Association, 23-25 October 1989, Virginia Beach, Virginia.

**10. Continuous Processing of Composite Propellants: What We Have Learned.** Dr. James J. Baker and Mr. Hugh J. McSpadden. *Technology of Polymer Compounds and Energetic Materials.* 21<sup>st</sup> International Annual Conference of ICT 1990. July 3 – 6, 1990, Karlsruhe, Germany

**11. ZSK-58E Compounder and ZSK-58 Extruder at Universal Propulsion Co., Inc.** Hugh J. McSpadden. *Fourth Annual Continuous Mixer and Extruder Users Group*, 4 - 6 December 1990. Hosted by Thiokol Corporation Ordnance Operations, Shreveport, LA

**12. Update: Results of Testing the Werner-Pfleiderer Compounder and Systems.** Dr. J. J. Baker, H. J. McSpadden and E. F. Schukrafft. *Joint International Symposium on Compatibility of Plastics and Other Materials with Explosives, Propellants and Pyrotechnics and Processing of Explosives, Propellants and Ingredients.* American Defense Preparedness Association. 22-24 April 1991, San Diego, CA.

**13. Continuous Processing of Propellants,** H. J. McSpadden, J. J. Baker, E. Schukrafft. 16<sup>th</sup> International Pyrotechnics Seminar, Jönköping, Sweden, June 24-28, 1991

**14. Continuous Processing of Propellants,** H. J. McSpadden, J. J. Baker, E. F. Schukrafft. 22<sup>nd</sup> Jahrestagungs, Institut für Combustion Technologie (ICT), Karlsruhe, Germany, Jun-Jul 1991.

**15. Demixing. Weld-line Formation in Casting, and Ramifications on Ballistic Properties.** Hugh J. McSpadden. 9<sup>th</sup> Continuous Mixer and Extruder Users Group Meeting, Stevens Institute, Weehawken, New Jersey, 2-4 June 1997.

**16. Reminiscences. Over 45 Years in the Solid Propellant Industry.** Hugh J. McSpadden. 26<sup>th</sup> International Pyrotechnics Seminar, Nanjing University of Science and Technology, Nanjing, Jiangsu Province, China. October 1-5, 1999.

**17. Comparison of Propellants and the Processing Methods.** Hugh J. McSpadden. 3<sup>rd</sup> International Autumn Seminar on Propellants, Explosives and Pyrotechnics, Chengdu, Szechuan Province, China, 5-8 October 1999.

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**18. Phase Stabilized Ammonium Nitrate Propellant.** W. C. Fleming, H. J. McSpadden, Donald E. Olander. **AIAA 2000-3179.** 36<sup>th</sup> AIAA / ASME / SAE / ASEE Joint Propulsion Conference, 16-19 July 2000, Huntsville, Alabama.

**19. A History of Universal Propulsion Company,** Hugh J. McSpadden. **AIAA 2000-3689.** 36<sup>th</sup> AIAA / ASME / SAE / ASEE Joint Propulsion Conference and Exhibit, Huntsville, Alabama, 17-19 July 2000.

**20. Goodrich 244. A Fire Extinguishing Propellant.** Dr. Donald E. Olander and Mr. Hugh J. McSpadden. Presented at the 33<sup>rd</sup> Jahrestagungs, Fraunhofer Institut für Combustion Technologie (ICT), Karlsruhe, Germany Jun. 2002.

**21. Goodrich/Universal Propulsion Company's California Operations.** Hugh J. McSpadden, **AIAA 2002-3565.** 38<sup>th</sup> AIAA / ASME / SAE / ASEE Joint Propulsion Conference & Exhibit, 7-10 July 2002, Indianapolis, Indiana.

**22. The History of Hurricane Mesa Test Facility.** Hugh J. McSpadden and Richard R. Higgins. **AIAA 2004-3336.** 40<sup>th</sup> AIAA / ASME / SAE / ASEE Joint Propulsion Conference & Exhibit, 17-19 July 2004, Huntsville, Alabama.

**23. An Overview of Solid Rocket Propellant Evolution Within the USA.** Hugh J. McSpadden. **AIAA -2005-3807.** To be published in July 2005, following the AIAA Joint Propulsion Conference, Tucson, Arizona.