Researchers at the Air Force Research Laboratory in Edwards AFB California have achieved a breakthrough in polynitrogen chemistry that may allow future advances in high energy rocket propellants or explosives.

Although nitrogen (known to chemists as diatomic molecular nitrogen) makes up 80% of the earth’s atmosphere, polynitrogen molecules or ions, which contain only nitrogen atoms, are very rare and unique. The interest in these compounds for propellants is their ability to provide energy through the production of nitrogen molecules.

In 1772, the English chemists, Rutherford, Scheele, and Cavendish were able to isolate pure nitrogen from air. Since that time, only one polynitrogen compound, an azide anion, had ever been produced in bulk form. Curtis made that discovery in 1890.

The new discovery was made by Drs. Karl Christie and William Wilson of the Air Force Research Laboratory’s Propulsion Directorate located at Edwards. They announced their work on January 19, 1999 at the 14th Winter Fluorine Conference of the American Chemical Society held in Florida.

The discovery is a N5+ cation combined with the AsF6- anion or N5+AsF6-. Dr. Christie devised the synthesis of the compound and Dr. Wilson was able to produce macroscopic amounts of the compound with high yield and purity. Considering the cation’s calculated heat of formation of 353kcal/mol, the white solid compound is surprisingly stable. The discoverers are part of the Lab’s HEDM or High Energy Density Matter team. Their efforts are devoted to finding and producing new high-powered rocket propellants or additives that exceed current capabilities for use in future Air Force systems. Using the power of the world’s largest computers, team members can predict the properties of exotic yet-to-be-made compounds. Other scientists in the group work to turn the computer predictions into reality by making and testing the new high-energy materials in the laboratory. Promising propellant candidates are then made in larger quantities and transitioned to the aerospace industry for additional evaluation.

The Lab’s HEDM team, led by Dr. Pat Carrick, swung into action to validate and verify all aspects of the new and novel molecule. Efforts by Drs. Jerry Boatz, Jeffrey Sheehy, and Mario Fajardo provided important theoretical and spectroscopic data from lab tests. This data agreed with information from Dr. Kershaw at USC and Stanton at University of Texas, Austin. Previous calculations made by Drs. Pyykkoe and Runeberg of the University of Helsinki, Finland were also utilized.

The team also collaborated with the Loker Hydrocarbon Research Institute and Chemistry Department at the University of Southern California, where Dr. Christie guides a separate research group funded by the National Science Foundation. HEDM research at the lab is partially supported by Dr. Mike Berman of the Air Force Office of Scientific Research (AFOSR) and by the Defense Advanced Research Project Agency (DARPA).

continued on page 4
CPIA's Technical/Bibliographic Inquiry Service

CPIA offers a variety of services to its subscribers, including responses to technical/bibliographic inquiries. Answers are usually provided within three working days, and take the form of telephoned, telefaxed, electronic or written technical summaries. Customers are provided with copies of JANNAF papers, excerpts from technical reports, bibliographies of pertinent literature, names of recognized experts, propellant/ingredient data sheets, computer program tapes and instructions, and/or theoretical performance calculations. The CPIA staff responds to nearly 800 inquiries per year from over 180 customer organizations. CPIA invites inquiries via telephone, fax, e-mail, or letter. For further information, please contact Tom Moore at (410) 992-7306, or e-mail: tmoore@jhu.edu. Subjects covered in recent inquiries include:

Technical Inquiries

- JANNAF shotgun/relative quickness test history
- U.S. ground-based airbreathing test facilities
- Reaction of TNT with sodium hydroxide
- Chemical composition and heat of combustion data from RP-1, JP-4, and Jet-A fuels
- Dual stabilizer use in double-base gun propellants
- Hydrazine monopropellant additives
- Military specification for ammonium perchlorate

Bibliographic Inquiries

- Explosive hazards of hydrogen-air vapor clouds
- Compatibility of N₂O₄ and MMH with graphite/epoxy motor case
- Electric propulsion technology, performance, and power requirements
- Acoustic combustion instability
- Particle size distribution and characterization of rocket motor static firing exhaust

The Chemical Propulsion Information Agency (CPIA), a DoD Information Analysis Center, is sponsored and administratively managed by the Defense Technical Information Center (DTIC). CPIA is responsible for the acquisition, compilation, analysis, and dissemination of information and data relevant to chemical, electric, and nuclear propulsion technology. In addition, CPIA provides technical and administrative support to the Joint Army-Navy-NASA-Air Force (JANNAF) Interagency Propulsion Committee. The purpose of JANNAF is to solve propulsion problems, effect coordination of technical programs, and promote an exchange of technical information in the areas of missile, space, and gun propulsion technology. A fee commensurate with CPIA products and services is charged to subscribers, who must meet security and need-to-know requirements.

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The following are various meetings and events. We welcome all such announcements, so that the propulsion community can be better served with timely information. See CPIA's Homepage “Calendar of Events” link (URL=http://www.jhu.edu/~cpia/).

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AIAA = American Institute of Aeronautics and Astronautics, (703) 264-7500 or (800) 639-2422
*AIAA = American Institute of Aeronautics and Astronautics, Contact: Howard O'Brien, Jr., (703) 264-7555 or (800) 739-4424
ACS = American Chemical Society, Edward T. Urbansky (513) 569-7655 or fax: (513) 569-7658
Franklin Applied Physics, Inc. = (610) 666-6645
ICT = Fraunhofer-Institut fur Chemische Technologie, +49 - (0)721-4640 - 0
LANL = Los Alamos National Lab, (505) 665-6277 or fax: (505) 665-3407
NDIA = National Defense Industrial Association, (703) 247-2578 or fax: (703) 522-1885
NATO = North Atlantic Treaty Organization, fax: +33(1)5561 2298/99 or e-mail: tonnp@rta.nato.int
New Mexico Tech = (505) 835-5674 or fax: (505) 835 5630
Breakthrough In Polynitrogen Chemistry...continued from page 1

Dr. Christie and his fellow researchers envision additional molecules with greater stability and potential for the future. For example, the new cation might be combined with an energetic anion to yield a highly energetic propellant or explosive ingredients.

Led by Col. John R. Rogacki, The AFRL’s Propulsion Directorate is responsible for basic research, exploratory and advanced propulsion technology development. They develop propellant, lubricant, and propulsion technologies for future air and space vehicles in addition to aeronautical power technology. Their propulsion research includes turbine engines, rocket engines and motors, and hypersonic and advanced concept systems. The Air Force Research Laboratory consists of nine technology directorates with facilities across the nation and includes the Air Force Office of Scientific Research. The organization is led by Major General Richard R. Paul and is responsible for Air Force research ranging from propulsion, sensors, human factors, and electronics, to aircraft and spacecraft.

With focus, unique facilities, and modern research tools, the organization is conducting research and development on innovative, cost-efficient, and reliable rocket propulsion advances that will serve the Air Force and the nation well into the next millennium. This article was provided by the Edwards AFRL. For questions concerning this information please contact Ranney Adams (805) 275-5465.

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Plume Measurement Facility Opens at China Lake

The Plume Measurement Facility (PMF) at the Naval Air Warfare Center, China Lake, California, recently became operational. PMF was built and designed to gather comprehensive broadband measurements and signature-characterization data for rocket motor plumes. In fact, in the entire DoD this is the only static test facility built from the ground up for infrared (IR), electro-optical (EO), and radar-cross-section (RCS) measurement of motor plumes.

Thorough plume-signature characterization is vital from two perspectives: offensive, to minimize the detectability of current and developing U.S. missiles; and defensive, to identify threat missiles and assist sensors and countermeasures designers in detecting and defeating threat weapons.

Signature reduction has long been a concern to weapon developers and tacticians. Early efforts concentrated on reducing the visible signature (smoke trail) of rockets and missiles. However, the advent of more sophisticated sensors and countermeasure devices—both U.S. and foreign—expanded that concern to a broader segment of the electromagnetic spectrum. Sensors now exist that can detect IR and ultraviolet (UV) plume signature, and radar can detect the RCS of a rocket motor plume.

A 1993 survey in the Navy, Air Force, and Army revealed a requirement for IR, UV, EO, RCS, and millimeter wave (MMW) plume data for over 100 different missiles. The survey also found that although several temporary facilities were being used to gather bits and pieces of this data for research and development, there was no single facility that could meet the needs of all the services. In response to this need, DoD directed that a permanent, dedicated facility be built that would meet the requirements of both weapons and countermeasures designers.

A team of tri-service project managers looked at ten potential sites. Each site was evaluated for its operational support base, existing R&D facilities, technical infrastructure, environmental considerations, safety, and security. Another particularly important factor was clarity, since RCS measurements require an extremely low level of background clutter. The results of the evaluation showed China Lake’s Skytop propulsion area to be the best location for the new facility.

At the heart of the facility is a hill that rises about 140 feet above the floor of a small valley. Atop the hill is the base pad for the rocket motor test stand. The stand will accommodate motors up to 39 inches in diameter, 14 feet in length, and with a maximum thrust of 80,000 pounds. Motors can be statically fired in horizontal through nozzle-up attitudes, and the stand returns only a minimal signal when illuminated by radar. Because of the size of the motors tested, all operations are remote controlled from Skytop’s Bay Four, a mile from the test stand.

PMF can also be used to measure motor thrust performance. The test stand incorporates a six-degrees-of-freedom force-measurement system produced by Integrated AeroSystems of Costa Mesa, California. Located between the stand and the concrete base pad, the system can resolve the motor-force vectors in any direction—especially for thrust-vector-control motors.

Figure 1 shows the site layout. On the valley floor are 19 instrumentation sites arrayed in concentric half-circles at distances of 300 to 3,280 feet from the test stand. The sites are located at viewing angles of -90 degrees to +150 degrees from the plume axis. Each site has power and communications hook-ups, and provides angle and distance options for the instrumentation vans that observe the motor firings.

Two radar systems are fixed a the 800- and 1500-foot pads on the -15 degree axis. The Fast Linear Plume Radar (FLPR) is a frequency-modulated homodyne system that can run from 0.1 to 18-gigahertz. The other specially modified Lintek Elan is a pulsed Doppler system that covers the 8.2 to 18-gigahertz range. IR/UV/EO vans can be located at any of the instrumentation pads. China Lake personnel or the customer can perform data gathering, recording, and analysis.

For more information on capabilities or testing at the Plume Measurement Facility, contact the Project Manager, Paul Gorish, at (760) 939-7381 (DSN 437-7381), or by e-mail at gorishPS@navair.navy.mil.
SPIRITS
AC Computer Code

CPIA has just received for distribution a CD-ROM version of the SPIRITS-AC1r1 computer code, which replaces SPIRITS-AC1r0. This new version of SPIRITS-AC1r1 includes many bug fixes, updated SIRRM-II input defaults, and the PC-DOS version of SPIRITS-AC1 that can run in a Windows DOS shell. This update will automatically be mailed to SPIRITS-AC1r0 computer code users who received their original SPIRITS-AC1r0 version within the past two years.

Three target modules that can be loaded to run under SPIRITS-AC1 have also been delivered to CPIA for distribution. They are available to current SPIRITS-AC1 users at the cost of $240.00 each and are also available on CD-ROM. Instructions for loading the CDs are included in text files in the root directory. Full manuals for SPIRITS-AC1 and the target modules are present under the docs directory as explained in the root directory files. Please contact Dorothy Becker, CPIA, at (410) 992-7302, x204 for additional information on any of the above materials.

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The CPIA in collaboration with Technology Applications, Inc. (TAI) of Boulder, Colorado has re-constructed and updated the former National Bureau of Standards (NBS) Cryogenics Database. The NBS maintained a database of cryogenic technical documents that served the national need well up until the early 1980s. The database was a highly specific bibliography of cryogenic literature and thermophysical property data. However, since then, the database has not been maintained for use. CPIA and TAI have undertaken a project to convert the NBS database to a PC platform and to backfill the database with citations of cryogenic literature from the present to 1980. This release of the re-constituted and updated Cryogenics Information Retrieval System (CIRS) contains about 125,000 citations; 115,000 represent citations from the former NBS database with over 10,000 new citations from the recent literature. As part of the activities on this project, defective and duplicate entries were removed from the former NBS database and the NBS bibliography was converted into a Windows-based, searchable database with formatted printing capabilities. Literature citations from the Defense Technical Information Center (DTIC) technical report database, the NASA/RECON technical report database and CPIA’s in-house Propulsion Information Retrieval System have been added. In addition abstracts were added from volumes 23 through 44 of Advances in Cryogenic Engineering (1978 – 1998), volumes 1 – 9, Proceeding from Cryocoolers (1981 – 1995), and volumes 1 – 4, Interagency Cryocooler Meetings (1986 – 1990). An additional database consisting of computer codes for generating thermophysical properties of cryogens is planned for mid-1999.

Support for this project is being provided by the Air Force Research Laboratory, Propulsion Directorate, EAFB, CA and the Space Vehicles Directorate, Kirtland AFB, NM; NASA Ames Research Center, Moffett Field, CA, and the NASA Kennedy Space Center, Cape Kennedy, FL; the Naval Research Laboratory, and the Chemical Science and Technology Laboratory of the National Institute of Standards and Technology, Boulder, Colorado.

The CIRS CD-ROM can be purchased from CPIA at a cost of $180 for CPIA Subscribers, $270 for non-subscribers and $360 for foreign purchases. Please contact Ms. Dorothy Becker at (410) 992-7302 (x204) or e-mail at dlbecker@jhu.edu.
JANNAF Welcomes New Chairman

Mr. David S. Siegel is serving his second term as chairman of the JANNAF Executive Committee. During his first term, from November 1990 to October 1992, new policies and procedures were adopted that greatly improved the operations of the JANNAF IPC and its ten technical subcommittees. Siegel has been with the Office of Naval Research for over 35 years, and has extensive experience in science and technology program management in the areas of aerodynamics, guidance and control, materials technology, and ordnance technology. He has a B.S. in Physics from the City College of New York and an M.S. in Physics from The American University located in Washington, D.C. Siegel also has completed graduate courses in Aerospace Engineering from the University of Maryland. He is currently Director, Strike Technology Division within the Weapons, Marine Corp, Special Programs Department. This division is structured into two major programs, weapons technology and aircraft technology. These programs directly support Navy S&T requirements for Joint Strike Warfare and Joint Littoral Warfare. In support of these mission area requirements, the division conducts basic and applied technology and advanced development programs in the areas of aerodynamics, flight control, avionics, structures, air vehicle and weapon propulsion, missile and gun projectile guidance and control, warheads, fuze, safe and arm devices, fire control and targeting.

Panels and Committees:

- Navy member, Joint Army, Navy, NASA, Air Force (JANNAF) Interagency Propulsion Executive Committee.

New CPIA COTR Named

CPIA is pleased to welcome Mr. Stuart R. Blashill as its new Contracting Officer’s Technical Representative (COTR). Mr. Blashill heads the Propulsion and Energetic Systems Division within the Weapons and Targets Department at the Naval Air Warfare Center Weapons Division (NAWCWPNS) in China Lake, California. He received a master’s degree in Electrical Engineering from California State University, Northridge in 1990 and a bachelor’s degree in Physics from UCLA in 1971. He has been employed at NAWCWPNS since 1985 and has primarily supported propulsion programs during his tenure, with particular emphasis on Insensitive Munitions and Thrust Vector Control.

Stuart is a graduate of the NAVAIR Senior Executive Management Development Program, and received the NAWCWPNS Research and Engineering Award in 1996. He is the national lead for the Integrated High Payoff Rocket Propulsion Technology (IHPRPT) program Control Systems technology area and is very active in international programs, serving as the U.S. Navy point-of-contact for The Technical Cooperation program (TTCP) Energetic Materials and Propulsion Technology Panel. Stuart was appointed to the JANNAF Executive Committee in 1998, following a two-year stint as chairman of the Rocket Nozzle Technology Subcommittee (RNTS) and its nozzle control systems panel.

Stuart is married, has two sons, and is very active in youth and church organizations.
The 37th American Institute of Aeronautics and Astronautics (AIAA) Aerospace Sciences Meeting took place January 11-14, 1999 at the Reno Hilton, Reno, Nevada. The conference was well attended with approximately 1700 preregistered from over 25 countries. CPIA participated in this year's meeting and conducted a JANNAF Modeling & Simulation Workshop and M & S Subcommittee TSG meeting. Over 900 papers were presented in over 145 sessions, with approximately 15% foreign paper participation.

Fluid dynamics was again strongly represented at the Aerospace Sciences Meeting, with papers in over 25 sessions. Aerodynamics, including applied, aeroacoustics and measurement technology also had over 25 sessions. Propellants and combustion, thermodynamics and solid rockets combined to provide over 20 sessions. Atmospheric environment and atmospheric flight mechanics comprised over 15 sessions. Wind energy exhibited an increasing presence. Other topics covered at the meeting included microgravity and space processing, air breathing propulsion and hypersonics, ground test, plasmadynamics and lasers, education, and finally aerospace power systems, artificial intelligence, aircrew-centered system design, interactive computer graphics, multidisciplinary design optimization, terrestrial energy applications, liquid propulsion, Mars pathfinder and weapon system effectiveness.

The newly forming JANNAF Modeling & Simulation Subcommittee conducted a successful workshop during the week at Reno, NV. The workshop entitled “Modeling & Simulation Workshop 1999: Millenium Computers: How They Will Affect Modeling & Simulation?” was the third of a new series devoted to a broader scope of modeling and simulation issues. A summary of key findings includes:

1) All participants considered the workshop productive, and urged a continuing forum.
2) The continuing involvement of private industry driving Modeling & Simulation is needed.
3) Upcoming technical sessions related to this JANNAF activity will include:
   a) Technical sessions at the 18-22 Oct 1999 Joint CS/PSHS/APS Meeting in Cocoa Beach, FL on Interoperability and Validation & Verification of Propulsion-Related Modeling & Simulation Codes.
   b) Workshop at the 14-16 Dec 1999 JANNAF Propulsion Meeting in Tucson, AZ on Interoperability and Validation & Verification of Propulsion-Related Modeling & Simulation Codes.

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**SPP SHORT COURSE**

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  - 3-D and Axisymmetric Grain Design, Internal Ballistics and Motor Stability
- Introduction to Basic Concepts in SRM Nozzle Performance
  - Two-Phase Flow Expansions, Nozzle Flow Loss Mechanisms
- Familiarization of SPP/SRM Modeling Techniques
  - Modeling Techniques, Recommended Practices
- User-Oriented Training
  - SPP Input/Output Usage's and Interpretation
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The workshop consists of three sections: a two day course on Nozzle Performance, a two day course on Motor Performance, and a one day course on Motor Combustion Stability. The course level covers novice through expert for all topics. The three sections will be held sequentially to allow participants to enroll in all sessions. The sections include a computer laboratory session.

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The 1998 meetings of the JANNAF Combustion Subcommittee (CS), the Propulsion Systems Hazards Subcommittee (PSHS), and the Airbreathing Propulsion Subcommittee (APS) were jointly held on 7-11 December 1998 at the Raytheon Systems Company and the Marriott Hotel in Tucson, Arizona. Raytheon Systems Company provided excellent support for this year’s meeting, with Mr. Mike Kaiserman serving as meeting site host. Mr. Thom Boggs of the Naval Air Warfare Center, China Lake, California, served as the joint Meeting Chairman. The technical program chairmen were: Dr. David Downs (TACOM/ARDEC), Dr. Harold Sandusky (NSWC/IH), and Lt Col David Hazelton (WL/WPAFB) for the CS, PSHS, and APS, respectively. Overall, the joint meeting was judged to be a great success by the participants, which totaled over 350 engineers, scientists and program managers. The technical interchanges and networking were viewed as particularly valuable activities this year. The meeting opened with a Welcoming Address by Mr. Jerry Lockard, Vice President of Missile Systems and Dr. Colin G. Whitney, Technical Director of Raytheon Systems Company. Opening ceremonies included the presentation of CS recognition awards to Dr. Arpad Juhasz, ARL and Dr. Dick Miller, Consultant; a PSHS recognition award to Ms. Alice Atwood of the Naval Air Warfare Center/China Lake; and APS recognition award to Mr. David Stallings of Sverdrup Technology for their outstanding contributions to JANNAF and their respective subcommittees.

Over 220 papers were presented in 38 technical sessions, which included 3 CS/PSHS and 10 APS/CS jointly sponsored sessions and 2 jointly sponsored workshops.

The CS technical program had over 135 papers presented in 28 technical sessions. Technical topics included advanced ingredients; kinetics, fundamentals and instability of solid propellant combustion; combustion & combustion instability fundamentals and applications in solid rocket motors; liquid & hybrid rocket combustion; measurement techniques; molecular modeling, kinetics, formulation, ignition, combustion, and interior ballistics associated with solid gun propellants; modeling & simulation, diagnostics and charge concepts for electro-thermal guns; liquid propellant gun topics; hypersonic technology program overviews; Hyper-X & HyTech system & technology; scramjet engine design studies and test results; dual-mode scramjet development & analysis; current & advanced hypersonic fuels; aerothermodynamic problems in high speed flows; and advanced engine cycle and small expendable turbopropulsion. Two CS town meetings were conducted in the areas of solid and gun combustion to discuss topics of current interest and to select future workshop topics.

The meeting of the Solid Rocket Combustion Instability Panel discussed conducting FY1999 workshops in the areas of motor flow and propellant response testing. Topics of discussion for the Kinetics Panel focused upon further understanding condensed phase kinetics.

The PSHS technical program included presentation of 34 papers in seven sessions. These technical sessions covered projectile impact penetration induced reactions of energetic materials and munitions, thermal decomposition and cookoff phenomena; detonation phenomena with propellants and explosives; damage and initiation studies with energetic materials; design and test of high explosive and energetic materials and munitions; and kinetic modeling and simulations of high explosives and energetic materials and munitions.

The APS technical program included presentation of 34 papers in seven sessions. These technical sessions covered propulsion concepts and design criteria; advanced combustion concepts; blowout and instability of liquid rocket engines; liquid rocket engines; gas gun propulsion; and hybrid propellants and systems.
Meetings...continued from page 10

Materials; and vulnerability and systems safety issues with propulsion systems, munitions, and energetic materials. In addition, a very interesting plenary session on insensitive munitions and hazard classification technical and policy issues was held. This included a briefing by Mr. Anthony Melita, OSD, on policy-making activities of the DoD Insensitive Munitions Integrated Product Team. Also included was an interesting technical paper examining the hazards (both real and perceived) of Class 1.1 versus Class 1.3 solid rocket propellants. Finally, the session included an informal briefing on benefits of integration of insensitive munitions and hazard classification test policy, as well as an overview presentation of a recent Department of Defense Explosives Safety Board effort to revise explosives safety standards covering liquid propellants.

Meetings of the PSHS Impact/Shock Induced Reactions Panel and Safety & Hazard Classification Panel were also held during the week. The Impact Shock Induced Reactions Panel discussed new areas of technical focus, including a new thrust concerning response of energetic materials to low amplitude/long duration impact or shock loading. The Safety & Hazard Classification Panel met to kick-off a new task to review DoD hazard classification test procedures, particularly with respect to examining the integration of hazard classification and insensitive munitions test requirements.

The APS technical program increased from last year with over 55 papers in 11 sessions. Technical session topics included overviews of Hyper-X, HyTech and other high speed missile technology programs, Hyper-X & HyTech design issues, Hyper-X & HyTech sub-system & component development, hypersonic engine design, scramjet engine testing, hydrocarbon fuel & fuel system development, aerothermodynamic problems in high speed flow, dual-mode scramjet development, and advanced combined engine cycle & expendable turbopropulsion. A joint APS/CS airbreathing town meeting was held to discuss topics of current interest and to select future workshop topics. Two jointly sponsored APS/CS workshops were conducted on "Hypersonic Technology Roadmap Development" and "Scramjet Engine Test Standards."

Proceedings covering the CS, PSHS and APS meetings will be published separately by CPIA and will be available in March 1999. All proceedings will include the papers presented in joint sessions. To order the proceedings, call CPIA, Dorothy Becker at (410) 992-7302 x204.

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The JANNAF Standard for Liquid Engine Performance Prediction

The TDK 97 code analyzes and summarizes Liquid Engine performance loss mechanisms into four categories: Combustion Chamber, Boundary Layer, Chemical Kinetics, and Divergence losses.

New Features:
- Planar or Axially Symmetric Flow
- Transpiration or Tangential Mass Injection
- Scarfed, Plug, and Scramjet Nozzle Configurations
- Treats Internal/External Flow Interaction (Plug Nozzle)

Improved Usability
- Graphics Post Processor
- Runs on PC's under DOS, Win/95 & Win/NT

The price is just $5995.

Special Upgrade Offers Available to Current Owners of TDK/NAV.

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Telephone: (775) 882-1966 FAX: (775) 882-1827
Visit our website at: http://www.seainc.com
### JANNAF MEETING CALENDAR

<table>
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<tr>
<th>1999</th>
<th>Meeting</th>
<th>Type</th>
<th>Location</th>
<th>Abstract Deadline</th>
<th>Paper Deadline</th>
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<tr>
<td>Mar 23-26</td>
<td>JANNAF Structures and Mechanical Behavior Subcommittee Service Life Workshop</td>
<td>Workshop</td>
<td>Hill AFB, UT</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>Apr 26-30</td>
<td>1999 JANNAF Propellant Development and Characterization Subcommittee and Safety and Environmental Protection Subcommittee Joint Meeting</td>
<td>Conference/Workshop</td>
<td>San Diego, CA</td>
<td>N/A</td>
<td>Apr 9, 1999</td>
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<td>Dec 14-16</td>
<td>49th JANNAF Propulsion Meeting</td>
<td>Conference</td>
<td>Tucson, AZ</td>
<td>Apr 5, 1999</td>
<td>Nov 8, 1999</td>
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</table>

Attendance at JANNAF Conferences and Workshops is by invitation only.

MEETING CALENDAR SUBJECT TO CHANGE. FOR LATEST DETAILS, CONTACT CPIA AT (410) 992-7304.

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