DOE/ER-0335

Small Business Innovation Research

DOE/ER--0335

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Program Solicitation

Closing Date: January 22, 1988

SBIR Program Manager
Office of Energy Research
U.S. Department of Energy
Washington, D.C. 20545

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DOE PROGRAM SOLICITATION FOR SMALL BUSINESS INNOVATION RESEARCH

1. PROGRAM DESCRIPTION

1.1 Introduction

The Department of Energy (DOE) invites small business firms to submit proposals in this sixth annual solicitation for the Small Business Innovation Research (SBIR) program. Firms with strong research capabilities in science or engineering in any of the topic areas described in Appendix F are encouraged to participate. DOE will support high-quality research or research and development (R&D) on advanced concepts concerning important energy related scientific or engineering problems and opportunities that could lead to significant public benefit if the research is successful.

Objectives of this program include stimulating technological innovation in the private sector, strengthening the role of small business in meeting Federal R&D needs, increasing the commercial application of DOE-supported research results, and improving the return on investment from Federally funded research for economic and social benefits to the Nation.

1.2 Three-Phase Program

This program solicitation is issued pursuant to the Small Business Innovation Development Act of 1982, Public Law 97-219. Under Phase I, DOE anticipates making approximately 100 firm, fixed-price awards during fiscal year 1988 to small businesses in amounts up to $50,000 for a 6-1/2-month project period. Phase I is to evaluate, insofar as possible, the scientific or technical merit and feasibility of ideas submitted under the SBIR program. The proposal should concentrate on research that will contribute to proving scientific or technical feasibility of the approach or concept and would be a prerequisite to further DOE support in Phase II. DOE expects that the necessary Phase I studies will be completed within the 6-1/2-month project period. The successful completion of Phase I will be a prerequisite to a Phase II proposal, and the proposed Phase II studies must be in the same technical topic and subtopic as the Phase I studies.

Phase II awards are expected to be made during fiscal year 1989 to firms with approaches that appear sufficiently promising as a result of the Phase I effort. Phase II cost-reimbursable awards are expected to be in amounts up to $500,000 and to cover a period of up to 24 months. It is anticipated that one-third to one-half of Phase I awardees will receive Phase II awards, depending on Phase I results and availability of funds. Phase II is the principal research and development effort. Instructions for the preparation of the Phase II proposal will be provided to all Phase I contractors at the time of the Phase I award.

Under Phase III, it is intended that non-Federal capital be used by the small business to pursue commercial applications of the research or R&D. Also, under Phase III, Federal agencies may award non-SBIR funded follow-on contracts for products or processes that meet the mission needs of those agencies. The work proposed for Phases I and II, assuming that it proceeds successfully, should be suitable in nature for subsequent progression to Phase III.

Both Phase I and II contracts may include a profit or fee. This solicitation is for Phase I proposals only.

1.3 Follow-on Funding

In addition to supporting scientific and engineering R&D, another important goal of this program is the conversion of DOE-supported research into technological innovation by private firms. Therefore, on an optional basis, the DOE program includes an incentive for proposers to obtain a contingent commitment for private follow-on funding prior to Phase II to continue the innovation process where the research also has commercial potential. Federal funding pays for research meeting DOE objectives (Phases I and II); private capital provides for follow-on developmental funding to meet commercial objectives (Phase III).

Proposers who feel that their research has the potential to meet market needs, in addition to meeting the DOE objectives, should secure non-Federal follow-on funding to pursue the development phase. The commitment should be made prior to the Phase II proposal submission. This commitment will be contingent on the DOE-supported research meeting some specific technical objectives in Phase II, which, if met, would justify non-Federal funding to pursue further development for commercial purposes in Phase III. In the case of Phase II proposals of approximately equal merit, those that provide proof of such a commitment for follow-on funding will receive special consideration during the evaluation process.

The recipient will be permitted to retain commercial rights to any invention made in either Phase, subject to the patent policies as stated in this solicitation.

1.4 Eligibility and Limitations

A proposal must be limited to only one subtopic under one of the topics listed in Appendix F of this solicitation. It must fall within the description of the subtopic, and also satisfy whatever description, restrictions, and exclusions are contained in the introductory section of that topic. When a proposal has relevance to more than one subtopic, the proposer must decide which subtopic is the most relevant and submit the proposal under that subtopic only. However, there are no limitations on the number of different proposals that may be submitted under this solicitation. If a proposal that is substantially the same as the one submitted in response to this solicitation has been previously funded, or is pending at, or about to be submitted to another Federal agency, or to the DOE as a separate action, the proposer must so indicate and provide the information required by Section 3.4 (1).

Each concern submitting a proposal must qualify as a small business for research or R&D purposes as defined in Section 2.2. Also, for both Phase I and Phase II, the research or R&D work must be performed in the United States. "United States" means the several states, the territories and possessions of the United States, the Commonwealth of Puerto Rico, the Commonwealth of Northern Mariana Islands, the Trust Territory of the Pacific Islands, and the District of Columbia.

This solicitation does not obligate DOE to make any awards under either Phase I or Phase II. DOE is not responsible for any monies expended by the proposer before award of any contract.

1.5 Principal Investigator

The Principal Investigator (PI) should be knowledgeable in all technical aspects of the proposal and be capable of leading the research effort; a record of the PI's past accomplishments in the technical field related to the proposal is desirable because it strengthens the confidence in ultimate prospects for success of the proposed project.

The PI's primary employment must be with the small business at the time of award and during the conduct of the proposed research. Primary employment means that more than one-half of the PI's time, but no less than 20 hours (average) per week, is spent in the employment of the small business during the conduct of the project. Primary employment with a small business precludes full-time employment with another organization. In addition, the PI is expected to devote to the project a considerable part of his or her time, and in no case less than 5 hours (average) per week for the duration of the project. Before the contract is awarded, the PI will be required to sign a statement certifying adherence to all of the above requirements. In order to ensure appropriate technical guidance for the project, only one PI will be accepted per project; co-PIs will not be accepted.

Proposals will be evaluated against *all* of the criteria listed in Section 4.2, and the qualifications of the PI enter very importantly in Criterion 3. Accordingly, the following rules shall apply to any substitution in PI after the closing date of the solicitation: (1) After the closing date but prior to the award selection, no substitution in PI will be considered. (2) For proposals selected for award, but prior to contract execution, any proposed substitution in PI will be viewed as a substantial change in the original proposal, and no contract will be awarded unless the DOE expressly approves the substitution. (3) During the term of the contract, any change in the PI requires prior written approval by the DOE contracting officer.

1.6 Contact with DOE

Questions about the DOE SBIR program may be addressed to Mrs. Gerry Washington, Program Spokesperson, c/o SBIR Program Manager, US Department of Energy, Washington, DC 20545, telephone (301) 353-5867. Requests for copies of the solicitation may be addressed to the SBIR Program Office at the above address, telephone (301) 353-5707. For reasons of competitive fairness, communications regarding this solicitation are restricted during the proposal preparation period.

The selection of proposals for awards will be completed approximately four months after the closing date of the solicitation. Contract awards will be completed approximately two months thereafter. No information on proposal status will be available until the final selections have been made. However, if a proposal acknowledgement card with an assigned proposal number is not received from DOE within 3 weeks of the closing date, the proposer should telephone (301) 353-5867.

2. DEFINITIONS

The following definitions apply for purposes of this solicitation:

2.1 Research or Research and Development

Any activity which is (a) a systematic, intensive study directed toward greater knowledge or understanding of the subject studied; (b) a systematic study directed specifically toward applying new knowledge to meet a recognized need; or (c) a systematic application of knowledge toward the production of useful materials, devices, and systems or methods, including design, development, and improvement of prototypes and new processes to meet specific requirements.

2.2 Small Business

A small business is one that at the time of award of Phase I and, if appropriate, Phase II:

a. is independently owned and operated, is not dominant in the field of operation in which it is proposing, and has its principal place of business located in the United States;

b. is at least 51 percent owned, or in the case of a publicly owned business, at least 51 percent of its voting stock is owned by United States citizens or lawfully admitted permanent resident aliens;

c. has, including its affiliates, a number of employees not exceeding 500 and meets the other regulatory requirements found in 13 CFR Part 121. Business concerns, other than licensed investment companies or state development companies qualifying under the Small Business Investment Act of 1958, 15 U.S.C. 661 et seq., are affiliates of one another when either, directly or indirectly, (1) one concern controls or has the power to control the other, or (2) third parties (or party) control or have the power to control both. Control can be exercised through common ownership, common management, and contractual relationship. The term "affiliates" is defined in greater detail in 13 CFR 121.3-2(a). The term "number of employees" is defined in 13 CFR 121.3-2(t). Business concerns include, but are not limited to, any individual, partnership, corporation, joint venture, association, or cooperative.

2.3 Minority and Disadvantaged Small Business

A minority and disadvantaged small business concern is one that is:

a. at least 51 percent owned by one or more minority and disadvantaged individual(s), or, in the case of any publicly owned business, at least 51 percent of the voting stock of which is owned by one or more minority and disadvantaged individuals; and.

b. whose management and daily business operations are controlled by one or more such individuals.

A minority and disadvantaged individual is defined as a member of any of the following groups: Black Americans; Hispanic Americans; Native Americans; Asian-Pacific Americans; or Asian-Indian Americans.

2.4 Women-Owned Small Business

A small business that is at least 51 percent owned by a woman or women who also control and operate it. "Control" in this context means exercising the power to make policy decisions. "Operates" in this context means being actively involved in the day-to-day management.

2.5 Subcontract

A subcontract is any agreement, other than one involving an employer-employee relationship, entered into by a Federal Government funding agreement awardee calling for supplies or services required for the performance of the original funding agreement.

2.6 Joint Venture

An association between two or more firms to jointly participate in a single business enterprise. There must be a community of interests, a sharing of profits and losses, and, for the purposes of this solicitation, the new entity must qualify as a small business as defined in Section 2.2.

3. PROPOSAL PREPARATION INSTRUCTIONS AND REQUIREMENTS

3.1 Proposal Requirements

The purpose of a proposal to DOE under the SBIR program is to provide sufficient information to persuade DOE, and members of the research community who review the proposal, that it is responsive to the subtopic under which it is submitted and that the proposed work represents a sound approach to the investigation of an important scientific or engineering question and is worthy of support under the stated criteria. Experts at institutions such as colleges, universities, and DOE national laboratories may be consulted during the preparation of the proposal. The proposal should concentrate on research that will contribute to proving scientific or technical feasibility of the approach or concept and would be a prerequisite to further DOE support in Phase II. Where the scientific or technical merit, or the essential feasibility of the innovation, has already been established, the work will not be considered for SBIR funding.

The quality of the scientific or technical content of the proposal will be the principal basis on which proposals will be evaluated. The work proposed for Phase I, assuming that it proceeds successfully, should be suitable in nature for subsequent progression to Phases II and III. A proposal should be self-contained and written with the care and thoroughness accorded papers for publication. Each proposal should be reviewed carefully by the proposer to ensure inclusion of data essential for evaluation.

Appendix F lists 29 technical topics, in an arbitrary order, numbered 1 through 29. Each technical topic subdivides into no more than 4 subtopics; each subtopic is designated by a letter a, b, c, or d. **A proposal must respond to only one technical topic and, within it, to only one subtopic.** Both the topic number and the subtopic letter must be entered in the appropriate spaces on the cover sheet (Appendix A). Failure to identify the topic and subtopic will cause the proposal to be declined without further review. The same proposal may not be submitted under more than one subtopic. However, an organization may submit different proposals on different subtopics or different proposals on the same subtopic under this solicitation. Where similar research is discussed under more than one subtopic, the proposer should choose that subtopic whose description appears most relevant to the proposer's technical concept. DOE will not assign proposals to topics and subtopics other than those identified by the proposer.

The proposed R&D must be responsive to the DOE program objectives, but also can serve as the base for technological innovation and new commercial products, processes, or services that benefit the public. Proposals must be confined to advanced concepts in energy-related scientific or engineering research or R&D, which may be carried out through fabrication and evaluation of a laboratory prototype, where necessary. Specifically excluded from this solicitation are proposals principally for literature surveys, for compilations of the work of others, for technical assessments, and for technical status surveys. Proposals principally for the development of proven concepts toward commercialization or for market research should not be submitted, because such efforts are considered the responsibility of the private sector. Commercialization is the objective of the follow-on funding option, which is to fund development efforts in Phase III using non-Federal capital, as a continuation of the research supported by DOE under Phases I and II.

All consultants, instrumentation, and physical facilities identified in the proposal must be available for the research project. **The consultants who are identified in the proposal must have agreed to serve in the manner and to the extent described in the proposal, and the proposal must contain (in Section 3.4(k)) a specific statement to that effect.** If the instrumentation, equipment, and physical facilities to be used are not the property of the proposer and are not to be purchased or leased for this project, their source must be identified and their availability specifically confirmed in the proposal (Section 3.4(j)). Statements certifying to consultant availability and salary, national laboratory (or other source) facilities or instrumentation and rental terms must be signed by a principal and submitted with the proposal. If the proposal is selected for an award, the contract may not be awarded unless all of the above are available.

3.2 Protection of Proposal Information

DOE's policy is to use information (data) included in proposals for evaluation purposes only and to protect such information from unauthorized use or disclosure. While this policy does not require that the proposal bear a notice, protection can be assured only to the extent that the "Notice" printed at the bottom of the cover sheet (Appendix A) is applied to those data that constitute trade secrets or other information that is commercial or financial and confidential or privileged. Other information may be afforded protection to the extent permitted by law, but DOE assumes no liability for use and disclosure of information to which the "Notice" has not been appropriately applied.

In addition to government personnel, scientists and engineers from outside the Government are generally used in the proposal review process. Any decision to obtain outside evaluation shall take into consideration requirements for the avoidance of organizational conflicts of interest and the competitive relationship, if any, between the proposer and the prospective outside evaluator. Evaluation will be under agreement with the evaluator that the information (data) contained in the proposal will be used only for evaluation purposes and will not be further disclosed. Proposers are requested to specifically authorize external review, for evaluation purposes only, on the cover sheet of their proposals. The proposer should be aware that DOE might be unable to give the proposal full consideration if evaluation outside the Government is desired but external review is not authorized by the proposer.

3.3 General Content

This solicitation is designed to reduce the investment of time and cost to small firms in preparing a formal proposal. Those who wish to respond should submit a research proposal of no more than 25 consecutively numbered pages including cover sheet, project summary page, main text, references, resumes, budget, and any other enclosures or attachments. The pages must be of standard 8 1/2" × 11" size, and no type smaller than 12-pitch with no more than 6 lines per inch is allowed except as legends on reduced drawings, but not tables. The proposal should be direct, concise, and informative. Promotional and nonproject-related discussion is discouraged. To meet DOE requirements, all items listed in Section 3.4 are to be covered fully and in the order set forth, but the space allocated to each will depend on the problem chosen and the Principal Investigator's approach. In the interest of equity to all proposers, all information required by Section 3.4 must be included in the 25 pages; proposals in excess of 25 pages will not be considered for review or award.

It is not necessary to provide a lengthy discourse on the commercial applications in the Phase I proposal except to discuss them briefly as required by Section 3.4, subsections c and d as appropriate. The proposal must be principally directed at research or research and development on the specific topic and subtopic chosen.

To facilitate proposal processing, DOE employs automated optical devices to read and record proposal information wherever possible. Toward this end, it is desirable but not required that the proposal cover sheet (Appendix A) and the project summary (Appendix B) be typed without proportional spacing, and using one of the following type-styles:

Courier 10 and 12 Pitch
Letter Gothic 12 Pitch
Prestige Elite 12 Pitch
OCR A and B
Standard Elite
Standard Pica

Carefully align the forms in the typewriter using the underlines as a guide and begin typing at the vertical line.

3.4 Phase I Proposal Format

a. Cover Sheet—Complete one copy of the optical character readable form printed in red in Appendix A using the following instructions. Photocopy that form as page 1 of each copy of the proposal. One copy should be designated as the original and should contain signatures on the cover page and the budget form (Appendix D). The original optical character readable page should be included with the complete submittal package (see Section 6.1).

Detailed instructions follow:

1. Topic Number—Provide the appropriate numerical designator of the technical topic (one of the 29 listed in Appendix F) to which you are submitting your proposal.

2. Subtopic—Provide the appropriate alphabetical character designating the subtopic, within the technical topic, to which you are submitting your proposal.

3. Proposal Title—Should reflect the substance of the project and must be limited to 120 characters and spaces. Do not use the topic or subtopic title.

4. Firm Name—Enter name of the company submitting the proposal. If a joint venture, enter name of the company chosen to negotiate and receive the contract. If name exceeds the space provided, please abbreviate.

5. Address—Enter mailing address.

6. State—Enter two-letter state abbreviation.

7. Zip Code—Enter five-or nine-digit code.

8. Amount—Must not exceed $50,000. Proposals requesting more than $50,000 will be declined without further review.

9. Duration—All awards will be for a 6-1/2-month period of performance.

10. Certifications and Authorizations—Enter Y for yes and N for no in response to the statements or questions on the cover sheet and on the yellow statistical information card.

11. Endorsements—Must be completed for, and signed by, both the Principal Investigator and the Corporate/ Business Official, empowered to make contractual commitment on behalf of the firm. Both entries must be completed and signed even if the functions of the Principal Investigator and the Corporate/Business Official are performed by the same individual. Designate one photocopy of

the proposal as the original and have the original signatures appear on the cover sheet of that copy. It is not necessary to also sign the red-printed optical character readable form, as its sole purpose is to facilitate data entry.

12. **Proprietary Notice**—Should be completed, if applicable.

13. **Acknowledgment and Statistical Information**—The two-part yellow form enclosed with this solicitation should be completed on both sides and stapled to the cover sheet of the original (signed) copy of the proposal. The right portion of the form is a self-addressed postcard that will be detached by the DOE personnel and mailed to the proposer to acknowledge the receipt of the proposal. The left portion contains information required by the Small Business Administration for statistical purposes. The information will not be revealed to the reviewers and will play no role in the proposal award process. The acknowledgment and statistical information card will not be counted in the 25-page limitation of the proposal.

No other cover sheet is permitted.

b. **Project Summary**—Complete the optical character readable form printed in red and identified as Appendix B and photocopy for use as page 2 of your proposal. Also include the original (printed in red) optical character readable form plus three additional photocopies thereof with the complete submittal. **The project summary page must not contain proprietary information.** Detailed instructions follow:

1. **Name and Address of Proposer**—Enter firm name and mailing address as shown on the proposal cover sheet (Appendix A).

2. **Title of Proposal**—Enter the same title as shown on the proposal cover sheet (Appendix A).

3. **Technical Abstract**—Provide a summary of your proposed project. Limit to the space provided.

4. **Key Words**—Provide no more than eight key words descriptive of the project and useful in identifying the subject matter of the technology, research thrust, or application of the proposed effort.

5. **Anticipated Results/Potential Commercial Applications** —Summarize the anticipated results and potential applications if the project is carried over into Phase II and beyond. Limit to the space provided.

c. **Identification and Significance of the Problem or Opportunity**—Define the specific technical problem or opportunity addressed and its importance. (Begin on page 3 of your proposal.).

d. **Background, Technical Approach, and Potential Applications**

1. **Indicate the overall background and technical approach to the problem or opportunity and the part that the proposed research plays in providing needed results.**

2. **State the anticipated results of the approach if the** project is successful and is carried over into Phases II and III. This should address the technical, economic, and other benefits to the Nation. Identify any specific groups in the commercial sector, or the Federal Government, or other individuals, that might be expected to use the projected results. Please bear in mind that Phase III must address either the development of commercial applications or the development of products or processes for use by the Federal Government.

3. **Discuss the significance of the Phase I effort in** providing a foundation for the Phase II research and development effort.

e. **Phase I Technical Objectives**—State the specific objectives of the Phase I effort, including the questions it will try to answer to determine the feasibility of the proposed approach.

f. **Phase I Work Plan**—This section **must provide an explicit, detailed description of the Phase I research approach and work to be performed.** The plan should indicate not only what is planned **but how the work will** be carried out. The Phase I effort should attempt to determine the technical feasibility of the proposed concept, and if successful should provide a firm basis for the Phase II proposal.

The work plan should be linked with the objectives and the questions the Phase I effort is designed to answer. **The methods planned to achieve each objective or task should be discussed explicitly and in detail. This section should be a substantial portion of the total proposal.**

g. **Phase I Statement of Work**—The Statement of Work must summarize items e and f above by very briefly stating the principal project objective(s), identifying the tasks to be performed, and the performance schedule. It also should identify the final report as the only deliverable under Phase I. A sample Statement of Work is included as Appendix C.

h. Related Research or R&D—Describe significant research or R&D that is directly related to the proposal including any conducted by the Principal Investigator or by the proposing firm. Describe how it relates to the proposed effort and any planned coordination with outside sources. The proposer must persuade reviewers of his or her awareness of key recent R&D work conducted by others in the specific area of the proposed project.

i. Key Personnel and Bibliography of Directly Related Work—Identify the Principal Investigator and other key personnel involved in Phase I, including their directly related education, experience, and bibliographic information. When vitae are extensive, summaries that focus on the most relevant experience or publications are desired and such brevity may be necessary to meet the proposal size limitation (see Section 3.3). It is important that the requirements described in Section 1.5 concerning the PI be met explicitly.

j. Facilities/Equipment—Describe available instrumentation and physical facilities necessary to carry out the Phase I effort. Items of equipment to be purchased or leased (as detailed in Appendix D) shall be justified under this Section. If the equipment, instrumentation, and facilities are not the property of the proposer and are not to be purchased or leased, the source must be identified and their availability specifically confirmed in this section. A principal of the organization that owns or operates the facility/equipment must certify regarding the availability and cost of facilities/equipment and any associated technician cost; a copy of this certification must be submitted with the proposal.

k. Consultants—Involvement of university or other consultants in the planning and research stages of the project is permitted subject to Section 1.4 and 1.5 limitations. If such involvement is intended, it should be described in detail and included in Appendix D (if appropriate). If consultants are to be used and are identified, this section must contain a specific statement that they have agreed to serve in the manner and to the extent described in the proposal. A statement signed by the consultant certifying his/her availability and salary must be submitted with the proposal.

l. Similar Proposals or Awards—If a proposal, whether SBIR or not, substantially the same as the one submitted in response to this solicitation has been previously funded or is either funded, pending, or about to be submitted to another Federal agency, or to the DOE in a separate action, the proposer must provide the following information:

1. The name and address of the agency(s) to which a proposal was submitted, or will be submitted, or from which an award is expected or has been received.

2. The date of proposal submission or the date of award.

3. The title of the proposal.

4. The name and title of the project manager or Principal Investigator for each proposal submitted or award received.

m. Budget—Complete the budget form in Appendix D for the Phase I effort only and photocopy for the required 10-copy submission. Incorporate the copy of the budget form bearing the original signature into the copy of the proposal bearing the original signatures on the cover sheet. Some items in the budget sheet form may not apply to the proposed project. If such is the case, there is no need to fill out each and every line in the form. What matters is that enough information be provided to allow DOE to understand how the proposer plans to use the requested funds if a contract is awarded. If the total budget exceeds the amount requested on the cover page, the proposal should contain information on who will contribute the difference.

Other budget considerations are as follows:

1. The budget should indicate the profit or fee if requested.

2. Under Phase I, a minimum of two-thirds of the research or analytical effort must be performed by the proposing firm. (Under Phase II, a minimum of one-half of the research or analytical effort must be performed by the proposing firm.)

3. Equipment budgets may be included under Phase I (and Phase II). The inclusion of equipment will be carefully reviewed relative to need and appropriateness for the research proposed. Equipment is defined as an article of nonexpendable, tangible, personal property having a useful life of more than one year and an acquisition cost of $500.00 or more per unit. Title to equipment will be vested with DOE unless it is determined that transfer of title to the contractor would be more cost effective than recovery of the equipment by DOE.

4. Budgets for travel funds must be justified and related to the needs of the project.

n. Checklist—Complete the checklist in Appendix E and attach one copy to the cover sheet of the original (signed) copy of the proposal. The checklist will not be counted against the 25-page limitation of the proposal.

4. METHOD OF SELECTION AND EVALUATION CRITERIA

4.1 Introduction

Phase I proposals will be judged on a competitive basis in several stages. All will be screened initially by DOE to ensure that they (1) meet stated solicitation requirements, (2) contain sufficient information for a meaningful technical review, and (3) do not duplicate other previous or current work. Proposals found to be in compliance with those requirements will be technically evaluated by scientists or engineers to determine the most promising technical and scientific approaches. Each proposal will be judged on its own merit. Final decisions will be made by DOE based on the evaluation criteria and consideration of other factors, such as program balance. In the evaluation and handling of proposals, every effort will be made to protect the confidentiality of the proposal and any evaluations. There is no commitment by DOE to make any awards on any topic, to make a specific number of awards, or to be responsible for any monies expended by the proposer before award of a contract. DOE may elect to fund several or none of the proposed approaches to the same topic or subtopic. Also, awards under the program are subject to the availability of funds.

If a written request for a debriefing is received by the SBIR Program Manager within 30 days after the announcement of the final selections, an oral debriefing of the offerer's proposal will be provided to the proposed Principal Investigator. Neither the identity of reviewers nor their verbatim comments will be disclosed.

Phase II proposals will be subject to a technical review process similar to Phase I. Proposals will be judged against Phase II criteria on a competitive basis. Final decisions will be made by DOE based on the scientific and technical evaluations and other factors, including the commitment for follow-on funding, the possible duplication with other research, program balance, and budget limitations.

4.2 Evaluation Criteria—Phase I

DOE plans to select for award those proposals offering the best value to the Government with approximately equal consideration given to each of the following criteria:

1. **The scientific/technical quality of the Phase I research proposal and its relevance to the proposal's stated objectives.**

2. **The innovation and originality** demonstrated by the proposal.

3. The **qualifications** of the Principal Investigator, other key staff, and consultants, if any, and the adequacy of available or obtainable instrumentation and facilities.

4. The **anticipated benefits**, technical and/or economic, of the proposed research (Phase I and Phase II), if successful, with special emphasis on the likelihood that the project will attract further funding for product or process development after the SBIR support expires.

5. The adequacy of the Phase I proposed effort to show progress toward proving the **feasibility** of the concept.

Technical reviewers will base their conclusions only on information contained in the proposal. It cannot be assumed that reviewers are acquainted with the firm or key individuals or any experiments referred to, but not described in refereed professional journals (i.e., those in which the articles have been subjected to peer review). Relevant journal articles should be identified in the proposal.

4.3 Evaluation Criteria—Phase II

Detailed instructions regarding Phase II proposal submission will be sent by DOE to all Phase I award winners. Listed below are some of the principles on which those instructions can be expected to be based.

A Phase II proposal can be submitted only by a Phase I awardee. It must contain enough information on progress accomplished under Phase I by the time of Phase II proposal submission to enable an evaluation of the project's promise if continued into Phase II. The Phase II proposal will be reviewed for overall merit based on the criteria below. Each item will receive approximately equal weight, except for item one, which will receive twice the value of any other item:

1. The scientific/technical quality of the proposed research, with special emphasis on its innovation and originality.

2. The qualifications of the Principal Investigator and other key personnel to carry out the proposed work and the adequacy of available or obtainable instrumentation and facilities.

3. The anticipated benefits, technical and/or economic, of the proposed research, with special emphasis on the likelihood that the project will

attract further funding for product or process development after the SBIR support expires.

4. The degree to which the Phase I objectives were met at the time of Phase II proposal submission.

5. The adequacy of the Phase II objectives to meet the problem or opportunity.

Phase II proposal evaluations may include on-site evaluations of the Phase I effort. The reasonableness of the proposed costs, vis-a-vis the effort to be performed, will be examined to determine those proposals that offer the best value to the Government.

In the case of proposals of approximately equal merit, the provision of a follow-on funding commitment for continued development from non-Federal funding sources will be a special consideration. **The follow-on funding commitment must provide that a specific amount of Phase III funds will be made available to or by the small business and must indicate the dates the funds will be made available. It also should contain specific technical objectives, which, if achieved in Phase II, will make the commitment exercisable by the small business.** The terms cannot be contingent on obtaining a patent because of the length of time this process requires. The commitment shall be submitted with the Phase II proposal.

5. CONSIDERATIONS

5.1 Awards

The DOE expects to award approximately 100 firm, fixed-price Phase I contracts ranging up to $50,000 to small businesses in fiscal year 1988. Awards are expected to be made no later than July 22, 1988. DOE will announce the names of those firms receiving awards, and successful proposers will then have six and one-half months after award to carry out their proposed Phase I effort.

It is anticipated that one-third to one-half of the Phase I awardees will receive Phase II awards, depending on the results of the Phase I effort and the availability of funds. Both Phase I and Phase II contracts may include a profit or a fee, but the amount requested must not exceed $50,000 for Phase I and $500,000 for Phase II.

Phase II is to further develop ideas originated under Phase I. Specific instructions for the preparation of Phase II proposals will be sent to Phase I awardees by the DOE at the time of award. Those Phase II proposers who wish to maintain project continuity must submit proposals no later than 45 days prior to the expiration of the Phase I contract. Successful Phase II proposers may then be issued a modification covering a four-month interim period of performance while the Phase II effort is being negotiated. This modification can be expected to become effective at the completion of Phase I or as soon thereafter as possible. Funding for this interim period is expected to be on a cost reimbursable basis, not to exceed a proration of the Phase II effort as recommended by the SBIR Program Manager; it is intended to cover the start-up costs of the Phase II effort. Phase II proposers will be requested to provide an estimate of the amount of funding required to cover this interim period as part of their Phase II proposal. Should the two parties fail to agree on terms covering the Phase II effort, allowable costs experienced during the four-month interim period, but excluding any fee, will be reimbursed in accordance with Federal and DOE commercial cost principles. (See FPR 1-15.2 and DOE PR 9-15.2)

The final date for receipt of Phase II proposals will be March 22, 1989. The period of performance under Phase II will depend on the scope of the effort, but normally will not exceed 24 months. Phase II award decisions will be based on the Phase II proposal and on the evaluation of progress attained under Phase I. Phase II awards will be in amounts up to $500,000, depending on the scope of research or research and development. Prior to Phase II, the DOE contracting officer may request certain organizational, management, and financial information for administrative purposes to assure that the applicant adheres to certain standards applicable to Federal cost-type contracts.

5.2 Reports and Payment Schedule

Six copies of a final report on the Phase I project must be submitted to DOE within 30 days after completion of the Phase I effort. The final report should include a single-page project summary as the first page (use form, Appendix B) identifying the purpose of the research, a brief description of the research carried out, the research findings, and the anticipated results/potential commercial applications of the research in a final paragraph. The summary may be published by DOE and should not contain proprietary information. The remainder of the report should indicate in detail the project objectives, work carried out, results obtained, and estimates of technical feasibility.

To avoid duplication of effort, language incorporated in a Phase II proposal to report Phase I progress may be used verbatim in the final report with changes only to accommodate results obtained after the Phase II proposal submission, and modifications required to integrate the final report into a self-contained, comprehensive, and logically structured document.

Payments on Phase I contracts will be made as follows: 45 percent at the time of award (after submission of an invoice), 45 percent at such time as the need is demonstrated and an invoice submitted, and 10 percent on receipt of the final invoice indicating that the final report has been submitted to and accepted by DOE.

5.3 Innovations, Inventions, and Patents

a. **Proprietary Information.** Information contained in unsuccessful proposals will remain the property of the proposer. The Government may, however, retain one file copy of each proposal. The Government will not return proposal copies to the proposer, but they will be destroyed. Public release of information in any proposal submitted will be subject to existing statutory and regulatory requirements.

If proprietary information is provided by a proposer in a proposal which constitutes a trade secret, proprietary commercial or financial information, confidential personal information, or data affecting the national security, it will be treated in confidence, to the extent permitted by law, provided this information is clearly marked by the proposer with the term "confidential proprietary information" and provided appropriate page numbers are inserted into the legend printed at the bottom of the cover sheet (Appendix A). The Government will limit dissemination of such information to within official channels.

Any other legend may be unacceptable to the Government and may constitute grounds for removing the proposal from further consideration and without assuming any liability for inadvertent disclosure.

b. **Rights in Data Developed Under SBIR Funding Agreements.** Rights in technical data, including software developed under the terms of any funding agreement resulting from proposals submitted in response to this solicitation, shall remain with the contractor or grantee, except that the Government shall have the limited right to use such data for government purposes and shall not release such data outside the Government without permission of the contractor or grantee for a period of 2 years from completion of the project from which the data were generated. However, effective at the conclusion of the 2-year period, the Government shall retain a royalty-free license for Government use of any technical data delivered under an SBIR funding agreement whether patented or not and shall be relieved of all disclosure prohibitions.

c. **Copyrights.** The awardee normally may copyright and publish (consistent with appropriate national security considerations, if any) material developed with DOE support. DOE receives a royalty-free license for the Federal Government and requires that each publication contain an appropriate acknowledgement and disclaimer statement.

d. **Patents.** Small business firms normally may retain the principal worldwide patent rights to any invention developed with Government support. The Government receives a royalty-free license for Federal Government use, reserves the right to require the patentholder to license others in certain circumstances, and requires that anyone exclusively licensed to sell must normally manufacture it domestically. Information regarding patent rights in inventions made with Federal funding by small business firms can be found in the Code of Federal Regulations, 37 CFR Part 401.

5.4 Cost Sharing, Joint Ventures, and In-House Work

Cost sharing is permitted for proposals under this solicitation; however, cost sharing is not required nor will it be an evaluation factor in the consideration of a proposal. Note, however, that the Government's Phase I contribution is limited to $50,000. **If the amount listed on line 15 of Appendix D exceeds the amount requested on the cover sheet, the proposer must explain who will contribute the difference. Similarly, if the total estimated cost shown in the Phase II proposal exceeds the amount requested on the cover sheet, the proposer must explain who will contribute the difference.**

Joint ventures are permitted, provided the entity created qualifies as a small business in accordance with the definition included in this solicitation.

Finally, a minimum of two-thirds of the research or analytical effort must be performed by the proposing firm during Phase I. A minimum of one-half of the research or analytical effort under Phase II must be performed by the proposing firm.

5.5 Contractor Commitments

On award of a contract, the contractor will be required to make certain legal commitments through acceptance of numerous provisions in the Phase I contract. The outline that follows is illustrative of the types of provisions that will be included in the Phase I contract. This is not a complete list of provisions to be included in Phase I contracts, nor does it contain specific wording of these clauses. Copies of complete general provisions will be made available on request.

a. **Standards of Work.** Work performed under the contract must conform to high professional standards.

b. **Inspection.** Work performed under the contract is subject to Government inspection and evaluation at all reasonable times.

c. **Examination of Records.** The U.S. Comptroller General (or a duly authorized representative) shall have the right to any directly pertinent records of the contractor involving transactions related to this contract.

d. **Default.** The Government may terminate the contract if the contractor fails to perform the work contracted.

e. **Termination for Convenience.** The contract may be terminated at any time by the Government if it deems termination to be in its best interest, in which case the contractor will be compensated for work performed and for reasonable termination costs.

f. **Disputes.** Any dispute concerning the contract, which cannot be resolved by agreement, shall be decided by the contracting officer with right of appeal.

g. **Contract Work Hours.** The contractor cannot require an employee to work more than 8 hours a day or 40 hours a week unless the employee is compensated accordingly (i.e., receives overtime pay).

h. **Equal Opportunity.** The contractor will not discriminate against any employee or applicant for employment because of race, color, religion, sex, or national origin.

i. **Affirmative Action for Veterans.** The Contractor will not discriminate against any employee or applicant for employment because he or she is a disabled veteran of the Vietnam era.

j. **Affirmative Action for the Handicapped.** The contractor will not discriminate against any employee or applicant for employment because he or she is physically or mentally handicapped.

k. **Officials Not to Benefit.** No member of or delegate to Congress shall benefit from the contract.

l. **Covenant Against Contingent Fees.** No person or agency has been employed to solicit or secure the contract upon an understanding for compensation except bona fide employees or commercial agencies maintained by the contractor for the purpose of securing business.

m. **Gratuities.** The contract may be terminated by the Government if any gratuity has been offered to any representative of the Government to secure the contract.

n. **Patent Infringement.** The contractor shall report each notice or claim of patent infringement based on the performance of the contract.

5.6 Additional Information

a. This Program Solicitation is intended for informational purposes and reflects current planning. If there is any inconsistency between the information contained herein and the terms of any resulting SBIR funding agreement, the terms of the funding agreement shall control.

b. Before award of an SBIR funding agreement, the Government may request the proposer to submit certain organizational, management, personnel, and financial information to assure responsibility of the proposer.

c. The Government is not responsible for reimbursing any monies expended by the proposer before award of any funding agreement.

d. This Program Solicitation is not an offer by the Government and does not obligate the Government to make any specific number of awards. Also, awards under this program are contingent on the availability of funds.

e. The SBIR program is not a substitute for existing unsolicited proposal mechanisms. Unsolicited proposals shall not be accepted under the SBIR program in either Phase I or Phase II.

f. If an award is made pursuant to a proposal submitted under this SBIR Program Solicitation, the contractor will be required to certify that he or she has not previously been, nor is currently being, paid for essentially equivalent work by an agency of the Federal Government.

6. SUBMISSION OF PROPOSALS

6.1 Number of Copies

Ten copies of the proposal are required. One copy must be signed as an original by the Principal Investigator and an official empowered to commit the proposing firm. In addition, one each of the completed red-inked cover page and project summary forms, three separate photocopies of the Project Summary (Appendix B of this solicitation which is to become page 2 of any proposal), one Checklist, and one Acknowledgement and Statistical Information form must be enclosed. The Acknowledgement and Statistical Information form should be attached to the original cover sheet.

Proposals submitted by U.S. Postal Service (First Class, Registered or Certified mail) must be addressed to:

SBIR Program Manager, ER-16
US Department of Energy
1000 Independence Ave., SW
Washington, DC 20545

Please use the following address when submitting proposals by any other mail delivery services:

SBIR Program Manager, ER-16
US Department of Energy
Routes 270 and 118
19901 Germantown Road
Germantown, MD 20874

Handcarried proposals may be delivered to: US Department of Energy, 1000 Independence Avenue, SW, Room 1J-005, Washington, DC. or 19901 Germantown Road, Germantown, MD.

Secure packaging is mandatory. The Department cannot be responsible for the processing of proposals damaged in transit. **All copies of a proposal must be sent in the same package.**

If a proposal acknowledgement card with the proposal number endorsed on it is not received from DOE within 3 weeks following the closing date of this solicitation, the proposer should telephone the SBIR Program Office promptly at (301) 353-5867.

6.2 Deadline for Proposals

a. **Any proposal received by mail after 5:00 p.m. EST on January 22, 1988, will be considered late unless it was sent by the US Postal Service's registered or certified mail not later than January 15, 1988.** Since the postmark will be the evidence on which the decision is made, it is incumbent on proposers to assure themselves that the postmark is clear and easily legible; hand cancellation is suggested. Express mail (including U.S. Postal Service Express Mail) proposals will be considered late if they are received after 5:00 p.m. EST on January 22, 1988. **Late proposals will not be eligible for award and will be declined without a review.**

b. Proposals that are carried by hand will not be accepted if delivered after 5:00 p.m. on January 22, 1988.

c. Modifications to proposals that are intended to be incorporated in the review/award process will be considered late on the basis set forth for proposals in items a and b immediately above.

d. Modifications by successful proposers during the process of negotiation will be considered only if it is determined that they make the proposal more favorable to the Government.

e. Proposals may be withdrawn by a written notice received at any time prior to award.

6.3 Physical Packaging

a. **Binding**—Please do not use special bindings or covers. Staple the pages in the upper left hand corner of each proposal.

b. **Packaging**—All 10 copies of a proposal, three additional copies of the project summary, the originals of the completed optical character readable forms identified as Appendix A and Appendix B, and the Checklist identified as Appendix E must be sent in the same package.

7. SCIENTIFIC AND TECHNICAL INFORMATION SOURCES

Sources of scientific and technical information are listed in the bibliographies of each topic in Appendix F. Wherever references are made to publications not commercially available, information on their availability is normally included following the reference.

7.1 National Technical Information Service

Reports resulting from DOE research and those received by DOE from exchange agreements with foreign countries and international agencies are available to the public in both paper copy and microfiche through the National Technical Information Service (NTIS). They may be obtained through regular mail from:

NTIS Energy Distribution Center
P.O. Box 1300
Oak Ridge, TN 37831
(615) 576-1301

For *expedited service*, call toll-free 1-800-336-4700. *Rush service* (dispatched within 24 hours by First Class Mail) costs an extra $10 per item and *express service* (dispatched within 24 hours by Federal Express) costs an extra $20 per item.

Microfiche of unclassified, unlimited DOE reports is available for use by the public free of charge in Government Printing Office depository collections. More than 1300 public, college, and university libraries around the country are designated as U.S. Depository Libraries. Check with your local public library.

7.2 Other Sources

Proposers may want to obtain scientific and technical information related to their proposed effort as background or for other purposes. Literature and database searches for abstracts, publications, patents, lists of Federal research in progress (the FEDRIP database), and names of potential consultants in the specific research area can be obtained at good technical libraries (especially those of universities), from some state organizations, and from the organizations listed below.

Documents should be ordered soon after receipt of the solicitation because they may take some time to be obtained. Most of the organizations listed can provide services at cost, including a rush or express service, which you may charge to a credit card in some cases. You may wish to call for information on costs and services offered.

ARAC
611 North Capital
Indianapolis, IN 46204
(317) 262-5003

Central Industrial Applications Center
Southeastern Oklahoma State University
Station A, Box 2584
Durant, OK 74701
(405) 924-6822

Florida Product Innovation Center
Box 7, Progress Center
1 Progress Boulevard
Alachua, FL 32615
(904) 462-3494

NASA/Industrial Applications Center
823 William Pitt Union
Pittsburgh, PA 15260
(412) 648-7000

NASA/UKy Technology Applications Center
University of Kentucky
109 Kinkead Hall
Lexington, KY 40506-0057
(606) 257-6322

NERAC
One Technology Drive
Tolland, CT 06084
(203) 875-1749

NIAC/University of Southern California
3716 South Hope Street, #200
Los Angeles, CA 90007
(213) 743-6132 or 1-800-642-2872 in CA
1-800-872-7477 outside CA

North Carolina Science and Technology Research Center
P.O. Box 12235
Research Triangle Park, NC 27709
(919) 549-0671

Southern Technology Applications Center
Box 24, Progress Center
1 Progress Boulevard
Alachua, FL 32615
(904) 462-3913

U.S. DEPARTMENT OF ENERGY
SMALL BUSINESS INNOVATION RESEARCH
SOLICITATION NO. DOE/SBIR 88-I
PROPOSAL COVER SHEET

APPENDIX A

DOE USE ONLY

88-I

NOTICE FOR HANDLING PROPOSALS. "This proposal is to be used only for DOE evaluation purposes. All Government and non-Government personnel handling this proposal shall exercise extreme care to ensure that the information contained herein is not duplicated, used, or disclosed in whole or in part for any purpose other than to evaluate the proposal, without the written permission of the offeror (except that if a contract is awarded on the basis of this proposal, the terms of the contract shall control disclosure and use). This is a Government notice, and shall not by itself be construed to impose any liability upon the Government or Government personnel for any disclosure or use of data contained in this proposal."

Topic No. (1-29) ____ Subtopic (a-d) ____

PROPOSAL TITLE: ____________________

FIRM NAME: ____________________

MAILING ADDRESS: ____________________

CITY: ____________________ STATE: ________ ZIP: ________

AMOUNT REQUESTED: $ ____________ PROPOSED DURATION (PHASE I): 6½ months
(Not to exceed $50,000.)

Please staple acknowledgment and statistical information form here.

CERTIFICATIONS AND AUTHORIZATIONS

ANSWER Y (YES) OR N (NO)

☐ 1. The above organization certifies that it is a small business and meets the definition stated in Section 2.2.

☐ 2. The above organization certifies that a minimum of two-thirds of the research and/or analytical effort will be performed by the proposing firm. (See Section 3.4.)

☐ 3. External review of this proposal is hereby authorized. (See Section 4.1)

☐ 4. If the proposal does not result in an award, is the Government permitted to disclose the title and technical abstract page only of your proposed project, and the name, address, and telephone number of the official of the proposing firm to any inquiring parties? (If you answer No, the Government may still be required by applicable laws to release such information.)

ENDORSEMENTS

Principal Investigator (See Requirements in Sec. 1.5)

TYPE NAME, Indicate Mr., Mrs., Ms., Dr.

____

Title: ____________________

Telephone No. ____________________

Signature of Principal Investigator ____________________ Date ________

Corporate/Business Official

TYPE NAME, Indicate Mr., Mrs., Ms., Dr.

____

Title: ____________________

Telephone No. ____________________

Signature of Corporate/Business Official ____________________ Date ________

PROPRIETARY NOTICE (IF APPLICABLE, SEE SECTION 5.3)

For any purpose other than to evaluate the proposal, this data shall not be disclosed outside the Government and shall not be duplicated, used, or disclosed in whole or in part, provided that if a funding agreement is awarded to this proposer as a result of or in connection with the submission of this data, the Government shall have the right to duplicate, use, or disclose the data to the extent provided in the funding agreement. This restriction does not limit the Government's right to use information contained in the data if it is obtained from another source without restriction. The data in this proposal subject to this restriction is contained on pages:

____

APPENDIX A

DOE USE ONLY

88-I

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SMALL BUSINESS INNOVATION RESEARCH
SOLICITATION NO. DOE/SBIR 88-I
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FIRM NAME: ____________________________________

MAILING ADDRESS: ______________________________

CITY: ____________________ STATE: ________ ZIP: ________

AMOUNT REQUESTED: $ ____________ PROPOSED DURATION (PHASE I): 6½ months
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Principal Investigator (See Requirements in Sec. 1.5)

TYPE NAME, Indicate Mr., Mrs., Ms., Dr.

____

Title: ___________________________

Telephone No. ____________________

Signature of Principal Investigator ______________ Date ________

Corporate/Business Official

TYPE NAME, Indicate Mr., Mrs., Ms., Dr.

____

Title: ___________________________

Telephone No. ____________________

Signature of Corporate/Business Official ______________ Date ________

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SMALL BUSINESS INNOVATION RESEARCH SOLICITATION NO. DOE/SBIR 88-I

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PROPOSAL TITLE: ______________________________

FIRM NAME: ______________________________

MAILING ADDRESS: ______________________________

CITY: ______________ STATE: ______ ZIP: ______

AMOUNT REQUESTED: $ ______________ (Not to exceed $50,000.)

PROPOSED DURATION (PHASE I): 6½ months

Please staple acknowledgment and statistical information form here.

CERTIFICATIONS AND AUTHORIZATIONS

ANSWER Y (YES) OR N (NO)

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Principal Investigator (See Requirements in Sec. 1.5)

TYPE NAME, Indicate Mr., Mrs., Ms., Dr.

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Title: ______________________________

Telephone No. ______________________________

Signature of Principal Investigator ______________ Date ______________

Corporate/Business Official

TYPE NAME, Indicate Mr., Mrs., Ms., Dr.

____

Title: ______________________________

Telephone No. ______________________________

Signature of Corporate/Business Official ______________ Date ______________

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U.S. DEPARTMENT OF ENERGY

SMALL BUSINESS INNOVATION RESEARCH PROGRAM

PHASE I - FY 1988 - I

PROJECT SUMMARY

APPENDIX B

DOE USE ONLY

88 - I

Topic No. (1-29)

Subtopic (a-d)

FIRM NAME, ADDRESS, TELEPHONE NUMBER:

TITLE OF PROPOSAL:

NAME AND TITLE OF CORPORATE/BUSINESS OFFICIAL:

TECHNICAL ABSTRACT (Limit to space provided.):

KEY WORDS (8 maximum):

ANTICIPATED RESULTS/POTENTIAL COMMERCIAL APPLICATIONS as described by the awardee. (Limit to space provided.)

APPENDIX B

U.S. DEPARTMENT OF ENERGY
SMALL BUSINESS INNOVATION RESEARCH PROGRAM
PHASE I - FY 1988 - I
PROJECT SUMMARY

DOE USE ONLY

88 - I

Topic No. (1-29)

Subtopic (a-d)

FIRM NAME, ADDRESS, TELEPHONE NUMBER:

TITLE OF PROPOSAL:

NAME AND TITLE OF CORPORATE/BUSINESS OFFICIAL:

TECHNICAL ABSTRACT (Limit to space provided.):

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ANTICIPATED RESULTS/POTENTIAL COMMERCIAL APPLICATIONS as described by the awardee. (Limit to space provided.)

APPENDIX B

DOE USE ONLY

88-I

U.S. DEPARTMENT OF ENERGY
SMALL BUSINESS INNOVATION RESEARCH PROGRAM
PHASE I-FY 1988-I
PROJECT SUMMARY

Topic No. (1-29)

Subtopic (a-d)

FIRM NAME, ADDRESS, TELEPHONE NUMBER:

TITLE OF PROPOSAL:

NAME AND TITLE OF CORPORATE/BUSINESS OFFICIAL:

TECHNICAL ABSTRACT (Limit to space provided.):

KEY WORDS (8 maximum):

ANTICIPATED RESULTS/POTENTIAL COMMERCIAL APPLICATIONS as described by the awardee. (Limit to space provided.)

SAMPLE STATEMENT OF WORK

1. **Project Objective**

The contractor shall investigate the electrocatalytic production of styrene from ethylbenzene in solid electrolyte fuel cells. The effort is directed toward defining optimal operating conditions for achieving high yields of styrene with simultaneous electric energy generation.

2. **Scope of Work**

The work to bé performed consists of the following tasks:

2.1 Construction of tubular stabilized zirconia fuel cells with a platinum cathode and an iron oxide or platinum anode. Both anode materials are quite promising and a decision between the two will be made after preliminary runs.

2.2 Measurement of the styrene cell activity and yield as a function of velocity, temperature, and inlet concentration of ethylbenzene and external resistive load.

2.3 Measurement of the cell electric power output and overpotential as a function of the operating parameters described in 2.2

2.4 Preliminary engineering and economic analysis according to the results of 2.2 and 2.3.

2.5 Final Report Preparation.

3. **Performance Schedule**

Task 2.1 completed two months after start of work.

Task 2.2 and 2.3 completed four months after start of work.

Task 2.4 completed five months after start of work.

Task 2.5 completed six months after start of work.

4. **Deliverable**

The contractor shall provide a Final Report containing the data from the experiments performed according to Tasks 2.2 and 2.3 along with analyses and conclusions based on these data.

APPENDIX D

CONTRACT PRICING PROPOSAL (RESEARCH AND DEVELOPMENT)		Office of Management and Budget Approval No. 29-R0184	
This form is for use when *(i)* submission of cost or pricing data (see FPR 1-3.807-3) is required and *(ii)* substitution for the Optional Form 59 is authorized by the contracting officer.		PAGE NO.	NO. OF PAGES
NAME OF OFFEROR	SUPPLIES AND/OR SERVICES TO BE FURNISHED (Title of Proposed Effort)		
HOME OFFICE ADDRESS			
DIVISION(S) AND LOCATION(S) WHERE WORK IS TO BE PERFORMED	TOTAL AMOUNT OF PROPOSAL $	GOV'T SOLICITATION NO. DOE/SBIR 88-I	

DETAIL DESCRIPTION OF COST ELEMENTS

			EST COST *($)*	TOTAL EST COST[1]	REFERENCE[2]
1. DIRECT MATERIAL *(Itemize on Exhibit A)*			EST COST *($)*	TOTAL EST COST[1]	REFERENCE[2]
a. PURCHASED PARTS					
b. SUBCONTRACTED ITEMS					
c. OTHER–*(1)* RAW MATERIAL					
(2) YOUR STANDARD COMMERCIAL ITEMS					
(3) INTERDIVISIONAL TRANSFERS *(At other than cost)*					
TOTAL DIRECT MATERIAL					
2. MATERIAL OVERHEAD[3] *(Rate %X$ base =)*					
3. DIRECT LABOR *(Specify)*	ESTIMATED HOURS	RATE/ HOUR	EST COST*($)*		
Principal Investigator					
TOTAL DIRECT LABOR					
4. LABOR OVERHEAD *(Specify Department or Cost Center)*[3]	O.H. RATE	X BASE =	EST COST *($)*		
TOTAL LABOR OVERHEAD					
5. SPECIAL TESTING *(Including field work at Government installations)*			EST COST *($)*		
TOTAL SPECIAL TESTING					
6. SPECIAL EQUIPMENT *(If direct charge) (Itemize on Exhibit A)*					
7. TRAVEL *(If direct charge) (Give details on attached Schedule)*			EST COST *($)*		
a. TRANSPORTATION					
b. PER DIEM OR SUBSISTENCE					
TOTAL TRAVEL					
8. CONSULTANTS *(Identify–purpose–rate)*			EST COST *($)*		
TOTAL CONSULTANTS					
9. OTHER DIRECT COSTS *(Itemize on Exhibit A)*					
10. *TOTAL DIRECT COST AND OVERHEAD*					
11. GENERAL AND ADMINISTRATIVE EXPENSE *(Rate % of cost element Nos.*					
12. ROYALTIES[4]					
13. *TOTAL ESTIMATED COST*					
14. FEE OR PROFIT					
15. *TOTAL ESTIMATED COST AND FEE OR PROFIT*					

OPTIONAL FORM 60
October 1971
General Services Administration
FPR 1–16.806
5060–101

This proposal is submitted for use in connection with and in response to *(Describe RFP, etc.)*

and reflects our best estimates as of this date, in accordance with the Instructions to Offerors and the Footnotes which follow.

TYPED NAME AND TITLE	SIGNATURE

NAME OF FIRM	DATE OF SUBMISSION

EXHIBIT A—SUPPORTING SCHEDULE *(Specify. If more space is needed, use reverse)*

COST EL NO.	ITEM DESCRIPTION *(See footnote 5)*	EST COST *($)*

I. HAS ANY EXECUTIVE AGENCY OF THE UNITED STATES GOVERNMENT PERFORMED ANY REVIEW OF YOUR ACCOUNTS OR RECORDS IN CONNECTION WITH ANY OTHER GOVERNMENT PRIME CONTRACT OR SUBCONTRACT WITHIN THE PAST TWELVE MONTHS?

☐ YES ☐ NO *(If yes, identify below.)*

NAME AND ADDRESS OF REVIEWING OFFICE AND INDIVIDUAL	TELEPHONE NUMBER/EXTENSION

II. WILL YOU REQUIRE THE USE OF ANY GOVERNMENT PROPERTY IN THE PERFORMANCE OF THIS PROPOSED CONTRACT?

☐ YES ☐ NO *(If yes, identify on reverse or separate page)*

III. DO YOU REQUIRE GOVERNMENT CONTRACT FINANCING TO PERFORM THIS PROPOSED CONTRACT?

☐ YES ☐ NO *(If yes, identify.)*: ☐ ADVANCE PAYMENTS ☐ PROGRESS PAYMENTS OR ☐ GUARANTEED LOANS

IV. DO YOU NOW HOLD ANY CONTRACT *(Or, do you have any independently financed (IR&D) projects)* FOR THE SAME OR SIMILAR WORK CALLED FOR BY THIS PROPOSED CONTRACT?

☐ YES ☐ NO *(If yes, identify.)*:

V. DOES THIS COST SUMMARY CONFORM WITH THE COST PRINCIPLES SET FORTH IN AGENCY REGULATIONS?

☐ YES ☐ NO *(If no, explain on reverse or separate page)*

See Reverse for Instructions and Footnotes

OPTIONAL FORM 60 (10-71)

INSTRUCTIONS TO OFFERORS

1. The purpose of this form is to provide a standard format by which the offeror submits to the Government a summary of incurred and estimated costs *(and attached supporting information)* suitable for detailed review and analysis. Prior to the award of a contract resulting from this proposal the offeror shall, under the conditions stated in FPR 1–3.807–3 be required to submit a Certificate of Current Cost or Pricing Data (See FPR 1–3.807–3(h) and 1–3.807–4).

2. In addition to the specific information required by this form, the offeror is expected, in good faith, to incorporate in and submit with this form any additional data, supporting schedules, or substantiation which are reasonably required for the conduct of an appropriate review and analysis in the light of the specific facts of this procurement. For effective negotiations, it is essential that there be a clear understanding of:

a. The existing, verifiable data.
b. The judgmental factors applied in projecting from known data to the estimate, and
c. The contingencies used by the offeror in his proposed price.

In short, the offeror's estimating process itself needs to be disclosed.

3. When attachment of supporting cost or pricing data to this form is impracticable, the data will be described *(with schedules as appropriate)*, and made available to the contracting officer or his representative upon request.

4. The formats for the "Cost Elements" and the "Proposed Contract Estimate" are not intended as rigid requirements. These may be presented in different format with the prior approval of the Contracting Officer if required for more effective and efficient presentation. In all other respects this form will be completed and submitted without change.

5. By submission of this proposal the offeror grants to the Contracting Officer, or his authorized representative, the right to examine, for the purpose of verifying the cost or pricing data submitted, those books, records, documents and other supporting data which will permit adequate evaluation of such cost or pricing data, along with the computations and projections used therein. This right may be exercised in connection with any negotiations prior to contract award.

FOOTNOTES

1. Enter in this column those necessary and reqsonable costs which in the judgment of the offer will properly be incurred in the efficient performance of the contract. When any of the costs in this column have already been incurred (e.g., on a letter contract or change order), describe them on an attached supporting schedule. Identify all sales and transfers between your plants, divisions, or organizations under a common control, which are included at other than the lower of cost to the original transferror or current market price.

2. When space in addition to that available in Exhibit A is required, attach separate pages as necessary and identify in this "Reference" column the attachment in which the information supporting the specific cost element may be found. No standard format is prescribed; however, the cost or pricing data must be accurate, complete and current, and the judgment factors used in projecting from the data to the estimates must be stated in sufficient detail to enable the Contracting Officer to evaluate the proposal. For example, provide the basis used for pricing materials such as by vendor quotations, shop estimates, or invoice prices; the reason for use of overhead rates which depart significantly from experienced rates (reduced volume, a planned major re-arrangement, etc.); or justification for an increase in labor rates (anticipated wage and salary increases, etc.). Identify and explain any contingencies which are included in the proposed price, such as anticipated costs of rejects and defective work, or anticipated technical difficulties.

3. Indicate the rates used and provide an appropriate explanation. Where agreement has been reached with Government representatives on the use of forward pricing rates, describe the nature of the agreement. Provide the method of computation and application of your overhead expense, including cost breakdown and showing trends and budgetary data as necessary to provide a basis for evaluation of the reasonableness of proposed rates.

4. If the total cost entered here is in excess of $250, provide on a separate page the following information on each separate item of royalty or license fee; name and address of licensor; date of license agreement; patent numbers, patent application serial numbers, or other basis on which the royalty is payable; brief description, including any part or model numbers of each contract item or component on which the royalty is payable; percentage or dollar rate of royalty per unit; unit price of contract item; number of units; and total dollar amount of royalties. In addition, if specifically requested by the contracting officer, a copy of the current license agreement and identification of applicable claims of specific patents shall be provided.

5. Provide a list of principal items within each category indicating known or anticipated source, quantity, unit price, competition obtained, and basis of establishing source and reasonableness of cost.

CONTINUATION OF EXHIBIT A–SUPPORTING SCHEDULE AND REPLIES TO QUESTIONS II AND V.

OPTIONAL FORM 60 (10-71)

CHECKLIST

Proposer:

Proposal Title:

Please complete this checklist and paper clip (one copy only) to the cover sheet of the original (signed) copy of the proposal.

DOES THE PROPOSAL SATISFY THE FOLLOWING REQUIREMENTS?

Requirement		DOE USE ONLY
• One, and only one, topic from Appendix F identified on cover sheet.	[ ]	[ ]
• One, and only one, subtopic from Appendix F identified on cover sheet.	[ ]	[ ]
• Proposal, including all attachments, not more than 25 pages.	[ ]	[ ]
• Abstract contains no proprietary information and does not exceed space provided on the Project Summary Sheet.	[ ]	[ ]
• Amount requested not in excess of $50,000; if amount listed on line 15 of Appendix D exceeds amount requested on cover sheet, proposal contains explanation of who will contribute the difference.	[ ]	[ ]
• No pages other than size 8 1/2" × 11".	[ ]	[ ]
• No type smaller than elite (except as legend on reduced drawings, but not tables).	[ ]	[ ]
• Both endorsements on cover sheet completed and signed.	[ ]	[ ]
• All certifications on cover sheet marked YES or NO.	[ ]	[ ]

ATTENTION: PROPOSALS NOT MEETING ALL OF THE ABOVE REQUIREMENTS WILL BE DECLINED WITHOUT FURTHER ACTION.

TECHNICAL TOPIC DESCRIPTION

The technical topic descriptions for this solicitation are given below. The text in the first section of each topic gives general and background information for the topic. Within a topic, where there are subtopics, a proposal must respond specifically to the description given in one subtopic and not just to the general description at the beginning of the topic; it must comply, however, with whatever restrictions and exclusions might be contained within that general description.

1. GEOTHERMAL INSTRUMENTATION

Economic utilization of geothermal resources depends in part on a knowledge of conditions deep in the reservoirs. The physical and chemical conditions encountered in geothermal wellbores place special demands on instruments that measure the critical parameters. Such instruments are required to operate at high temperatures (up to 350 °C), low pH (down to 2), pressures up to 10,000 psia, and depths to 20,000 ft. The economics of geothermal powerplants depend in part on a knowledge of conditions in the hot brine flowing through the plant. Changes (sometimes abrupt) in fluid characteristics may cause plugging of wells, corrosion failure, and scale buildup, and lead to extended plant downtime. Fluid conditions in plants are similar to those in wellbores, except that the pressures range only up to 300 psia, and acidity is the one critical parameter lacking a practicable measurement technique.

Research proposed for support should specifically address novel approaches to these measurements that have potential for use by commercial well logging companies or by designers of plant monitoring equipment. Proposals are solicited in only the four subtopics below. These subtopics represent areas of research critical to the successful development of many high-temperature geothermal reservoirs. Development of reliable instruments for operation in geothermal wellbores and plants will assist the geothermal industry in obtaining reliable well-field data and plant operators in achieving effective process control. Scientific researchers in the oil, gas, and mining industries will also benefit from access to such instrumentation.

a. Measurement of Downhole Fluid Velocity—Flow measurement deep in geothermal wells provides information on fluid entry zones during production and on fluid outflow zones during injection. The location of the flashpoint or of casing leaks also may be obtained from flow measurements. Commonly, flow in a wellbore is measured with a downhole tool employing an impeller or turbine. In geothermal environments, such devices have been found to malfunction or fail completely. Impellers and bearings may be damaged by corrosive fluids and by very high fluid velocities. In addition, particulates in the fluid can lodge in impellers, causing erratic measurement of flow velocity. Thus, better techniques are required to obtain reliable estimates of flow rates in the severe conditions present in geothermal wells. Other flow measurement approaches used in surface ducting, such as ultrasonic, thermal, or magnetic methods, may be found suitable for downhole geothermal applications. Flow conditions in the wellbore may not be constant with depth because of inflow or outflow at various permeable zones in the formation. Proposals are solicited that are directed toward new flow-rate measurement methods in deep wellbores or toward improvements on existing technologies.

b. Measurement of Downhole Pressure—Pressure measurements deep in the wellbore provide some of the most valuable data for measuring the productivity of geothermal wells and for assessing reservoir characteristics. However, application of these measurements in boreholes with temperatures greater than 150 °C is hindered by lack of borehole instruments with adequate pressure resolution, accuracy, and reliability. The lack of instrumentation can be attributed directly to the lack of electronic pressure transducers that operate adequately at temperatures in the range of 150° to 300 °C (Lamers, 1979). Although a handful of manufacturers sell "high-temperature" pressure transducers and some prototype downhole pressure instruments, the currently available transducers are not well suited for application in a borehole environment because the calibration coefficients of the transducers are temperature sensitive, and they tend to drift with thermal cycling, prolonged exposure to high-temperature environments, and age. Use of such instruments usually requires application of temperature corrections to pressure measurements. These techniques often result in attempts to resolve small differences between two large quantities. Thermal stability of calibration and minimal time drift are desirable characteristics. Reliability of current transducers is also of major concern. A high failure rate was observed during a set of bench tests on a number of the currently available high-temperature pressure transducers (Reference 5). Proposals are solicited for instruments and techniques that can measure downhole pressures and meet the stringent requirements discussed above.

c. Measurement of Fluid Acidity—The fluid in most geothermal wells contains large quantities of dissolved solids that can be extremely corrosive. The problems of scaling (i.e., the precipitation of dissolved solids on surfaces under particular physical and chemical conditions) and corrosion are severe, both in the wellbore and in geothermal powerplants. Both of these problems are sensitive to concentration of the hydrogen ion in solution, that is, the pH of the fluid. A knowledge of the relationship between the pH of the fluid and well depth would indicate regions where scaling and/or corrosion of drill pipe and casing could be problems. In-line measurement of pH in brine flowing through geothermal powerplants would enable plant operators to react to changes that could threaten plant operation. Measurement of pH in geothermal brines is complicated by high temperature and high salinity. Several attempts have been made to develop a successful high temperature pH electrode, using conventional glass, advanced ceramics, and advanced semiconductors. While a great deal has been learned from these attempts, the effectiveness of these approaches is still unclear. None of the current state of the art approaches have been reliable enough for service in hot, hostile, geothermal conditions. Proposals are invited for the development of a downhole pH measurement system and/or an in-line plant system that will accurately and reliably function in the geothermal environment.

d. Downhole Spectral Gamma Ray Measurement—Spectral gamma logging is common in oil and gas wells. Typically a downhole tool measures gamma rays emitted by potassium (K-40) at 1.46 MeV, the uranium series nuclide bismuth (Bi-214) at 1.76 MeV, and the thorium series nuclide thallium (Tl-208) at 2.61 MeV. In geothermal wells, measurement of natural gamma radiation has the potential for use in detailed stratigraphic correlation, recognition of rock types, location of fracture zones, and examination of heat-producing elements. Currently, spectral gamma tools are not readily available to the geothermal industry, primarily because of the temperature limitations of existing tools. Proposals are sought for the development of a spectral gamma tool that can be used for logging geothermal wells at the operating conditions stated above.

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General

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a. Measurement of Downhole Fluid Velocity

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3. Doebelin, E. O. Measurement Systems Application and Design, 3rd edition. McGraw-Hill Book Co., 1221 Avenue of the Americas, New York, NY 10020, 1982.
4. Durgin, W., Ed. Flow - Its Measurement and Control in Science and Industry. Instrument Society of America, P.O. Box 2277, Research Triangle Park, NC 27709, 1981.

b. Measurement of Downhole Pressure

5. Berkeley Group Inc. A Survey of Pressure Transducers That are Suitable for Use in Geothermal/Geopressured Wells, 1982 February.**
6. Koehler, D. R. Quartz-Resonator Pressure Gauges: Temperature Performance, 1981 September; SAND-81-0130, 22 p. [NTIS Order No. DE82000790/CAZ]
7. Veneruso, A. F. and T. D. McConnell. Pressure Measurements in Low Permeability Formations, 1980; CONF-800344, 19 p. [NTIS Order No. SAND-80-0705C/CAZ]

c. Measurement of Fluid Acidity

8. Development of High Temperature Instruments for Measuring Water Chemistry in Geothermal Systems. "In: High Temperature Electronics and Instrumentation Seminar Proceedings, G. A. Jensen et al, Eds; Houston, TX; 1979 December 3; pp. 219-226." [NTIS Order No. SAND-80-0834C/CAZ]
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10. National Materials Advisory Board. Assessment of the Characterization (In Situ -Downhole) of Geothermal Brines: Final Report, 1978 January; NMAB-344, 74 p. [NTIS Order No. PB-276-399/3/CAZ]
11. Shannon, D. W. et al. In-Line Process Instrumentation for Geothermal Power Plants, 1985 May; PNL-SA-13195, 29 p. [NTIS Order No. DE85012457/XAB/CAZ]

d. Downhole Spectral Gamma Ray Measurement

12. Belnap, W. B. API Standards for Nuclear Logs. *Log Anal.* 4: 7-10, 1963 Aug-Sept.
13. Lock, G. A. and W. A. Hoyer. Natural Gamma Ray Spectral Logging. *Log Anal.* 12(5): 3-10, 1971.

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2. ADVANCED INDUSTRIAL SENSORS AND CONTROL SYSTEMS

Fundamental research in certain areas of advanced sensors and control systems, specified below, will be considered under this topic. Research and development is sought on appropriate on-line sensors to provide more accurate readout and efficient control systems for energy-intensive industrial processes. The lack of appropriate sensors that will operate in the environmental extremes (i.e., corrosion, temperature, pressure, moisture, etc.) of many industrial processes is a major limitation on the capability of automatic control systems. Proposals are sought for innovative and new concepts in advanced on-line sensors for application in control systems leading to decreased energy consumption and increased material productivity in U.S. industry. Proposals should have a significant research component aimed at mitigating one or more technical barriers to widespread adoption of the technology. Major potential industrial applications of a successful development should be identified, but proposals that deal solely or predominantly with development will be rejected. The proposers are expected to be thoroughly familiar with the current research literature relevant to the subtopic in which work is proposed.

Subtopics of interest are limited to the following:

a. Advanced Sensors—DOE presently supports limited research on advanced sensors in several industries. However, there are many areas of critical need for sensors not yet researched or developed. Research is sought that employs high technology methods to enhance image processing and pattern recognition in the automatic detection and categorization of material defects; to provide an accurate and rapid quantitative analysis; and, in general, to advance the development of sensors that are simple to operate, durable, and reliable when functioning in an extremely hostile industrial environment. Many energy-intensive industrial processes (for instance, various furnaces, lime kilns, digesters, distillers, evaporators, dryers, etc.) are not controllable in real time for lack of appropriate sensors and control systems.

b. Hierarchical Control—DOE presently supports research in several hierarchical control systems and in application of artificial intelligence for improving productivity of manufacturing processes. However, at this time there does not appear to be adequate generalized knowledge of design and implementation considerations. Proposals are solicited for research to identify the critical factors that bear on structural design of hierarchical control systems, algorithms descriptive of relationships among unit processes, and development of "expert" or "consultative" systems embodying the knowledge necessary to design hierarchical process controls.

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4. Emerson, D. B. Process Sensor Availability and Needs: A Review of Equipment Available to the Pulp and Paper Industry: Final Report, 1986 June; DOE/CE/40715-tl, 106 p. [NTIS Order No. DE86012858/XAB/CAZ]
5. Energetics, Inc. A Plan For the Assessment of Department of Energy, Office of Industrial Programs Roles in Industrial Sensors R&D, 1986 May.*
6. Energetics, Inc. Long-Term Research and Development Needs Assessment: Final Report, 1984 September.*
7. Hunt, S. E. Automated Energy Control of Integrated Pulp and Paper Mills: Final Report, Phase I, 1983 April; DOE/ID/12136-T1, 220 p. [NTIS Order No. DE83013888/CAZ]
8. Kusik, C. L. et al. Assessment of Selected Conservation Measures for High-Temperature Process Industries, 1981 January; DOE/CS/40015-T3, 216 p. [NTIS Order No. DOE/CS/40015-T3/CAZ]
9. Looze, D. P. Research Initiation-Aggregated Hierarchical Control: Final Report, 1983 January; NSF/ECS-83002, 78 p. [NTIS Order No. PB83-226761/CAZ]
10. Presser, C. and H. G. Semerjian. Evaluation of Industrial Combustion Control Systems: Final Report, 1984 October; DOE/CS/40521-T1, 254 p. [NTIS Order No. DE85016803/XAB/CAZ]
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Automated Manufacturing Systems. *Comput. & Ind. Eng.* 7 (3): 241–255, 1983.
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*Available from Energetics, Inc., 9210 Route 108, Columbia, MD 21045.

3. ADVANCED BUILDING ENVELOPE MATERIALS TECHNOLOGIES

Reduced energy consumption in buildings can result from improving the energy efficiency of building envelopes (as long as market acceptability is not compromised), or from increased use of more energy-efficient materials in building envelopes. Unique challenges are associated with these approaches depending on whether the application is for new or for existing buildings. Improving the energy efficiency of building envelopes can be accomplished through better control of thermal conductivity, radiant energy flux, visible light flux, thermal capacitance, air flow, and moisture permeability. The materials used in building envelope systems offer one avenue of approach to improving the control of one or more of these factors. Proposals are solicited on only the following subtopics:

a. Multipurpose Features of Building Materials—A significant challenge for energy conservation is to maintain market interest in times when energy is not a major national issue and significant investment in energy conservation measures has already occurred. One way to maintain interest and investment in energy conservation is to build attractive non-energy characteristics into conservation products. Combining several functional advantages into a single system, device or material could happen in several ways, and proposals are requested in only the following areas:

1. Combining Energy Functions—Thermal conductivity and moisture permeability are two highly interrelated energy functions of building envelopes. If a single material could both insulate and restrict moisture flow, the current practice of separately installing vapor barriers and insulation materials could be made more efficient.

2. Combining Functions of Envelopes and Other Building Energy Systems—Other building energy systems must operate interactively with building envelopes. HVAC and lighting systems must be designed and operated to provide appropriate levels of comfort and light in relation to the performance of the building envelope. Innovative envelope systems or materials may offer energy conservation advantages in the operation of these other systems, while improving the thermal or visual comfort, or providing an additional useful function. One example currently in the marketplace is the use of foamglass structural walls for warehouses that both insulate and act as structure. Another example might be smart windows or shutters that adjust the amount of daylight entering the building and that could maintain view, minimize lighting energy, and minimize cooling loads due to solar gain and to electric lighting.

3. Combining Energy and Other Building Functions—People use and enjoy buildings for reasons other than energy efficiency. Features that enhance fire safety, structural integrity, privacy or aesthetics could be combined with energy efficiency measures to increase market appeal.

b. Mitigating Secondary Effects of Building Materials—Achieving thermal performance standards or objectives often means compromising other design or cost considerations. Innovative materials are sought to enable the achievements of energy efficiency without compromising secondary effects. An example involves the design strategy of limiting the glazed area to increase the thermal efficiency of the envelope. A secondary effect is the limited view of the outdoors. Innovative window systems, such as glazings with high thermal resistance, are sought to limit the heat loss from the exposed glazed area while maintaining a wide view.

c. Improving the Performance of Building Envelopes—Proposals are solicited for improving the performance of building envelopes through innovative materials that increase energy efficiency or increase control responsiveness.

Increasing energy efficiency might be achieved through the development of new materials, or new combinations of materials, the control of air flow, moisture permeability, thermal resistance, etc. For example, a transparent material with better insulating values than glass might be used in windows.

Increasing control responsiveness might be achieved through envelope systems that are more responsive to seasonal and short term weather conditions and demands, allowing for operational adjustments that could save energy. An example might be an exterior structure that would allow for easy panel changes from summer to winter, with panels designed to optimize the envelope performance in combination with other building systems like the HVAC system. This would provide an element of control over R-values for the building envelope. Another example might be window glazings that can automatically control the amount of light entering the interior space.

Specific ideas that might be considered are as follows:

1. **Building Materials Incorporating High Thermal Mass**—Advanced material used for interior finish of buildings could incorporate phase-change materials or other materials that increase heat storage capacity. These materials might be used in the finish of permanent walls or partition walls in office-type buildings. Massive partition walls have the added advantage of reduced sound transmission. Advanced materials and associated design/construction are desired.

2. **Glazings with Integrated Means of Re-directing Solar Radiation**— In passive solar buildings it is typically desirable to maximize the solar radiation transmitted by the glazing on the massive heat storing elements of the structure. Similarly, many daylighting schemes rely on light reflected onto light-colored ceilings for effective re-distribution. A glazing material with an integrated means of directing solar radiation through diffraction, reflection, or other such means could serve to direct solar radiation to heat absorbing or light reflecting surfaces on the floor or ceiling.

3. **Glazings with Directional Admittance of Solar Radiation**—Overhangs, light shelves, and window setbacks have been used to seasonally control unwanted solar heat gains, but still admit daylight and permit views. Application of all three techniques are limited by architectural constraints. A glazing material with an integrated means of selectively rejecting solar radiation as a function of direction could be used to control undesirable heat gains. Such a glazing material would have an equivalent built-in overhang (or side fin), and as such would add another light control strategy to the architectural options.

4. **Glazing Materials with Controllable Light Transmission Characteristics**—Glazing materials that have adjustable daylight transmitting characteristics can be used to control solar heat and light gains. Optical control of such glazings could be both passive (based on room air temperature or light level) and active (external electronic or other control). Most existing research is on electro-, thermo-, and photo-chromic glazings. Additional technically advanced, commercially viable concepts for glazings with controllable light transmission characteristics are desirable.

d. Increasing the Feasibility of Retrofitting Energy Efficient Materials into Building Envelopes—Much of the energy consumed in U.S. buildings is used inefficiently because the envelopes were designed and constructed during a time of cheap fuel. A barrier to increasing the energy efficiency of these buildings is the trouble and expense involved in correcting the inefficiencies. Innovative products and techniques are sought for improving the energy efficiency of existing building envelopes. These might include easy-to-apply coatings or non-destructive ways for accessing envelope interiors. Also the energy conservation level in retrofit applications is often limited by the available cavity width for insulation. The development of high R-value (greater than R4 per inch) loose-fill insulation would eliminate this restriction.

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4. INDOOR RADON

Because of increasing societal concerns over radon health effects, arising largely from energy conservation measures that reduce building ventilation, DOE is substantially expanding its radon research program. The goal is to develop the quantitative data and broadly applicable principles that will allow accurate assessment of indoor radon exposure and associated lung cancer risk under environmental conditions. For the purposes of this research topic, proposals are desired on measuring the physical and chemical properties of radon and its progeny, and must be limited to the following subtopics:

a. Passive Measurement of Radon Progeny in Indoor Air—Innovative proposals are invited on research to develop an inexpensive passive device to measure radon decay product concentration in indoor air. Devices exist for measuring radon gas, but health experts generally agree that it is the decay products, not the gas, that present the health concern. Although one can estimate the decay product concentration from a measurement of the gas, it would be better to measure the decay products directly. The design goals for a decay product monitor/dosimeter can be taken from the characteristics of existing radon gas monitors/dosimeters. The device should be: (1) capable of measuring the true average concentration over a period of no less than 3 days and no longer than 3 months with a sensitivity of 0.005 working levels and an accuracy of +/-20 percent; (2) small enough to be easily shipped via mail; and (3) capable of making measurements, including deployment and read-out, for less than about $50 each in quantities of thousands.

b. Measurement of Radon Concentration—Proposals are sought for a portable instrument capable of measuring radon gas concentration in indoor air with a recycle time of between 5 and 15 minutes. This device could be used to "sniff out" areas of high radon gas concentration, which would be helpful in identifying radon entry points in a building. The design goals for a radon sniffer can be taken from common radiological instruments such as a Geiger counter or gamma survey meter. Ideally, the unit should weigh less than 5 kg and should be battery-operated (although operation from 110 volt, 60 Hz is also acceptable). It should have a sensitivity of 0.2 pCi/l and respond in less than 5 minutes (possibly less at high concentrations of radon gas), and yield a measurement accurate within 10 percent.

c. Methods for Measuring Activity Size Distribution for Ultrafine Particles—Improved techniques are sought for measuring the properties of radon decay products, particularly the activity size distribution of the "unattached" fraction and of particles with diameters below 10 nm. Interpreting the ultrafine particle size activity is important both for understanding the indoor air chemistry of radioactivity immediately following the radon decay and for assessing dose and lung tissue effects following inhalation. The most important aspect of particle-daughter product interactions is perhaps that involving tobacco smoke. Fundamental studies of the binding potential of radon daughter products with smoke and other organic constituents of ordinary household air would help considerably in developing models to describe health effects from inhaled radon with ambient conditions. Such measurements require precision that may only be attained using equipment developed for the purpose.

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5. HUMAN GENOME

DOE supports research to stimulate the rate of acquisition of knowledge regarding the molecular structure of the human genome and to make this information, and related physical resources, readily available to interested users. Such knowledge would markedly improve the Department's ability to estimate risks to humans exposed to low levels of radiation and chemicals by clarifying the basis for variation in human susceptibility to such exposures and would form the basis for individualizing radiation protection and monitoring needs. There is also the potential to diagnose early disease correlates years before clinical symptoms appear. Areas of interest include improvements in techniques for mapping the entire human genome by establishing the linear order of DNA fragments for each chromosome, developing more efficient DNA-sequencing technologies, and improving computational capabilities for acquiring and storing human chromosome DNA-sequence data as well as development of algorithms for high-speed sequence comparisons. Proposals are invited in only the following subtopic areas:

a. Improvement in Techniques for Mapping Human Chromosomes—To date, the only organism for which a complete physical map exists is Escherichia coli (E. coli), and the development of this map was a time-consuming task. As the human genome is almost a thousand times as large as that of E. coli, there is clear value to development of techniques that will significantly reduce the cost and time to construct physical maps of human chromosomes. Proposals are sought that will make substantial improvements in chromosome mapping technology.

Improvements are sought in the ability to produce and handle fragments of DNA in the size range from 100 to 1000 kilobases, including chromosome separation, sequence-specific DNA chain scission, separation and purification of large fragments, and large insert cloning.

b. Development of Improved DNA Sequencing Technology—Increased use is being made of DNA sequencing in biotechnology, cancer research, genetic toxicology, and molecular genetics. Data derived by DNA sequencing have wide application in a variety of research areas including: design of improved vectors for gene cloning and expression, analysis of the genetic organization of eukaryotic chromosomes, and assessment of environmentally induced DNA damage. Proposals are sought for improvements in techniques and instrumentation to substantially increase current capabilities. Innovative new approaches to increasing the speed of sequencing by orders of magnitude, error-free performance, and low cost per base are of particular interest. Developments might include: (1) new automated instrumentation for DNA preparation, cloning, and mapping (physical, restriction fragment, and genetic mapping); (2) improved base-selective labeling; (3) new approaches to sequencing (chemical, enzymatic, or physical).

c. Improvement in DNA Sequence Information Storage and Processing—Current methods of entering DNA sequence data into computer databases require human involvement and are costly. The amount of sequence data, already growing rapidly, is expected to rise sharply when low cost automated sequencing technology is available. Innovative proposals are sought for significant improvements of cost-effective sequence data management. Developments might include immediate data entry with uniform notation and efficient searching with cross-referencing to other data banks. Also of interest are algorithms developed expressly for high-speed comparisons, analysis, and interpretation of DNA and protein sequences; for example, to identify homologies and near-homologies within and between species.

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6. ENVIRONMENTAL BIOTECHNOLOGY AND ANALYSES

The DOE research program in the environmental sciences covers a wide spectrum of activities. These range from atmospheric measurements near the ground and upper levels, to oceanographic measurements, to ecological studies from genetic levels, to holistic ecosystem functioning. All relate to the production of energy and its environmental effects.

Complex gaseous and fluid emissions and solid residuals are released to atmospheric, terrestrial, and marine environments by many energy activities. Organic and inorganic compounds are dispersed and transformed by and to biota. Improved detection and identification systems are needed to locate and to quantify these contaminants, as well as to develop biological mechanisms that can be exploited to reduce bioavailability and potential adverse impacts of the substances. Biotechnological methods of interest to improve ecosystem tolerance of both natural and man-induced stresses include, but are not limited to, development of organisms for removal and recovery of contaminants, identification and manipulation of gene-controlled responses for enhanced tolerance of environmental stress, and biosensors for increased sensitivity and detection of specific compounds. Remote sensing and in situ techniques are needed to monitor the chemistry and biology of atmospheric, terrestrial, and aquatic components of the biosphere.

Research within this topic is directed to developing innovative biological and geochemical technologies and approaches for environmental applications. Literature searches or general scientific assessments are excluded.

Proposals must be limited to the following areas:

a. Biotechnological Applications to the Environment—Innovative research is sought for the identification and development of biological systems that represent new approaches to current and foreseeable environmental needs associated with energy development. Emphasis is placed on biological mechanisms for biotechnological uses such as contaminant removal, recovery of economically valuable compounds or metals, degradation of compounds to more environmentally acceptable forms, and increased tolerance of energy-generated stresses. The DOE has special interest in developing an understanding of gene-regulated responses to environmental stress, including controlling factors for their induction and enhancement.

Biosensors are desired that will provide increased sensitivity, extended operation, and precise emplacement for use in detecting extremely low levels of specific compounds occurring in mixtures or singly. Innovative methods for developing the biosensors from enzymes, antibodies, and novel sources, and for localizing the biosensor on membranes, filaments or other devices for emplacement, are of special interest. Also sought is the development or improvement of automated systems for high-speed sorting, isolation, and identification of microbial populations.

b. Technology for Plant Genetics Research—Plants have historically provided breakthroughs in genetic research, from Mendelian genetics to the identification of transposons. DOE seeks to build on this strong base of knowledge in plant genetics and solicits proposals that develop methods and/or instrumentation leading to increased understanding of genetic structure/function relationships. The research may include but is not limited to: (1) identification of the molecular processes by which the environment affects multigene traits, with special interest in gene-regulated responses to environmental stress such as salt, drought, and chemicals; (2) methodology for rapid identification and comparison of gene DNA sequences coding for common functions in different species, such as sucrose production; (3) determination of the role of repetitive DNA sequences in genes; and (4) contributions to understanding the processes by which environmental factors affect gene regulation of cell differentiation and development.

c. Instrumentation for Detecting and Analyzing Environmental Contaminants—DOE seeks proposals to develop new chemical, physical, and biological instrumentation, including techniques to monitor, detect, and analyze organic and inorganic contaminants using ground, aerial, and satellite remote technologies.

Methods to make improved predictions on the transport and fate of organic and inorganic contaminants in surface waters, ground water, and terrestrial ecosystems are included. Special emphasis is on subsurface ecosystems, specifically the aqueous transport and fate of contaminants in soils and deep subsurface ecosystems. DOE's interests in this area are motivated by increased concern about the effects from disposal of liquid and solid wastes generated from energy development and production. Specific DOE interests within this subtopic also include the following: field methods to evaluate the complex environmental chemistry of organic and inorganic contaminants and mixtures; computer processing of remotely sensed data; advanced systems for sampling subsurface ecosystems; and innovative methods to remotely detect stressed ecosystems and identify the stressor.

Remote sensing instruments and techniques for obtaining improved meteorological and atmospheric chemical data are sought. Weather variables that can be sensed by remote techniques are temperature, wind shear, wind speed and direction, and humidity. The remote sensing of atmospheric chemical constituents such as SO_x, NO_x, NH_3 and metals such as Na, K, Ca, or Mg are of importance.

d. Acid Rain and Aircraft Measurements—DOE is devoting a substantial effort to measuring the components of both wet and dry acid deposition. An improved instrument for measuring the dry deposition of gases or particulates of the common compounds associated with acid deposition such as SO_x or NO_x is sought. Also of interest are proposals for instruments that will measure atmospheric particle sizes and distribution in the range of 10 angstroms to 8 mm. Another instrument needed in acid rain investigations is a sequential rain sampler. The composition of precipitation in succeeding 10-minute intervals may differ substantially. To provide an understanding of the atmospheric processes involved, a sequential sampler to provide samples for successive constant time intervals or successive precipitation amounts (e.g., sequential 1.25 mm or 0.05 inches) is sought.

In studying atmospheric processes such as dispersion over complex terrain, long-range dispersion, or acid precipitation, measurements are made by instruments mounted on aircraft. Such equipment must be extremely sensitive with a small time constant. Proposals are invited for aircraft instruments to measure the common pollutants, e.g., SO_x, NO_x, metals, or chlorides, as well as relevant meteorological variables, e.g., temperature, humidity, rainfall rate, icing, and particle size and distribution.

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7. BOTANICAL RESEARCH TECHNIQUES AND INSTRUMENTATION

Work under this topic should focus on analytical techniques and instrumentation for use in research in the botanical sciences aimed at understanding basic plant growth processes (e.g., root-soil and leaf-atmosphere interactions), as well as improving capabilities for predicting responses to environmental variables affecting plant growth. Advanced and innovative techniques and instrumentation are sought that are conceptually different from those now in use; their availability should offer an advantage for providing measures of productivity and yielding information on resistance to stress and the direct effects of variable CO_2 or other important environmental influences on plant growth. The advantage might be in terms of new capability to measure a previously unmeasurable parameter or significant improvement in precision, sensitivity, rapidity, or nonambiguity, or in economic superiority. While unique plant materials or test systems can be used to demonstrate concepts and principles, proposals are sought to develop techniques that have application with different genotypes and diverse botanical groups, and which correlate responses at different levels of plant organization. Modeling methods are acceptable for organizing and interpreting data; however, research on predictive models per se is beyond the scope of this topic. The emphasis is with basic plant processes, including responses to CO_2 enrichment. Screening or dose-response type studies of pollutant effects from SO_2, acid rain, O_3, etc. are beyond the scope of this research topic.

Measures of response should clearly demonstrate an unambiguous relation of an effect to the causing variable that can be evaluated at different levels of plant organization. The proposals must present a convincing case for potential application of the technique to testing varieties and/or correlating different plant processes. Areas of interest for which proposals are solicited under this topic are limited to the following subtopics:

a. Productivity Measures—Proposals are sought that will identify, develop, and demonstrate measures or new instrumentation concepts that correlate productivity-type responses at different levels of plant organization, including cellular, tissue, whole leaf, whole plant, and plant populations. The developed techniques would be expected to show correlation of a productivity measure among different plant processes (e.g., photosynthesis, growth, yield) as well as provide a basis for comparison of productivity among diverse botanical groups. Devices to measure the influence of several variables simultaneously affecting productivity are sought.

b. Measures of Stress in Plants and Plant Response to Stresses—Proposals are invited that will develop analytical techniques for quantifying relative stress among varieties or in comparative species. New measures of physiological response to stresses of drought, salinity, CO_2 level, diseases, and pests are desired. As with subtopic a., above, the technique or instrumentation should be suitable for application to comparisons and/or correlations of stress among different botanical groups.

c. Measurement of CO_2 Effect with Plants—Proposals are solicited that will develop novel concepts and techniques for field research of plant response to CO_2 enrichment and for screening varieties of principal crop species (agronomic, forest) and/or native species for response to increasing atmospheric CO_2. Diagnostic measures with emphasis on photosynthesis, organ growth, and harvestable yield would provide the basis for comparing relative response among plant materials, varieties, and botanical groups. Technique development should also emphasize rapid and non-destructive determination of cell, tissue, and whole plant effects.

d. Concepts and Instrumentation for Enhanced Understanding of Basic Plant Functions—Proposals are invited that will devise innovative approaches and equipment to investigate how roots function in situ. Methods are sought for ascertaining the internal reactions regulating growth at any one time. Other techniques for providing totally new insights into key basic biochemical and biophysical mechanisms of plants will be considered.

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8. CHEMICAL SCIENCES RESEARCH

Chemical sciences research can contribute to the advancement of virtually all areas of energy generation, conversion, and storage. This topic singles out and is limited to four specific subtopics in this broad field: analytical instrumentation, chemical separations, combustion diagnostics, and photoelectrochemical energy conversion. The first three subtopics are technique oriented and might be expected to affect many different chemical processes. The fourth is specifically aimed at the possible ultimate development of a new energy conversion technology.

a. Advanced Sensors for Analytical Chemical Measurements—Determination of chemical composition is being done increasingly on line, in real time, without removal of samples of a material for subsequent analysis. The components of interest may be unstable, or immediate feedback on changes in composition may be required to keep a manufacturing or waste stream under control. Progress has been made in developing a variety of optical and electrochemical sensing devices for analytical purposes. However, these only allow measurement of a small number of chemical species and often are limited to a restricted range of operating conditions.

Advanced sensors are sought that will provide one or more of the following capabilities: highly localized sensing (micron-size scale, if possible), remote measurements, operation in extreme temperature and/or pressure environments, and very rapid response. In all of the above cases, the interest is in the sensing or analysis of chemical species. While such devices will undoubtedly have applications in energy technologies, the proposed research should not be targeted to a specific application, but should seek understanding of principles of operation and the broadest possible range of operating capabilities. Particular interest is in novel types of sensors, instead of research leading to incremental improvements in existing devices. Specifically excluded from this subtopic are proposals aimed at sensors or diagnostic techniques in the combustion area which would fall under subtopic c.

b. New Polymers for Enhanced Selectivity and Efficiency in Chemical Separations—A variety of polymeric substances are currently used in membrane or particulate form for separation of raw materials or waste streams into their chemical components. Substances are sought that utilize novel concepts for obtaining greater selectivity and/or higher fluxes than can presently be achieved for the isolation of valuable components from complex mixtures. This subtopic is limited to new chemical compositions and/or new macro-or micro-structures of polymers. Plans for testing the new materials for selectivity and efficiency should be incorporated into the proposal. Proposals should not emphasize a specific separation, but should describe fundamental research into the relationship between the novel chemical or physical structures and their separation properties, leading to potential applications in the separations field, possibly in Phase II and/or III.

c. Diagnostics for Combustion Systems—The accurate description of a chemically reacting combustion system requires qualitative and quantitative knowledge of the chemical species present at the temperatures and pressures characteristic of flames. The components of interest include both stable and transient species.

This subtopic is directed to proposals involving novel techniques and methods that will augment existing capabilities and approaches to identification of chemical species under combustion conditions involving gaseous fuels. Examples of needs under this subtopic are: new non-intrusive optical diagnostic methods, sensitive rapid-response detectors, and new high spatial resolution techniques. Of particular interest is research that is not restricted to incremental improvements in existing techniques. The Phase I proposal should emphasize understanding of the processes and phenomena involved, although a specific device based upon the concepts explored in Phase I could be a portion of a Phase II proposal.

d. Photoelectrochemical Energy Conversion—Novel processes are sought for photoelectrochemical energy conversion in which sunlight will be the sole or a primary source of the energy needed to generate fuels (for example, hydrogen from water; alcohols or hydrocarbons from carbon dioxide) or other chemicals whose production is energy intensive. This subtopic requests proposals for new processes, materials, and configurations that will lead to stable, efficient energy conversion.

The proposal should primarily be aimed at exploration of new concepts that may lead to development of a specific device in Phase II and/or III.

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9. MATERIALS SCIENCES

Research supported under this topic must be aimed at new scientific knowledge on fundamental properties of materials. Because materials and materials-related phenomena are of underlying importance for a broad range of scientific and technological needs, several other topics in this solicitation may provide opportunities for other types of materials research. Before submitting a proposal on materials sciences, a proposer should examine carefully other technical topic descriptions in the solicitation to make sure that the best match is found for the research effort. If its objective matches a topic and subtopic under a specific energy system, it should be submitted under that topic. Construction and building materials, and materials such as wood and pottery, are excluded from this topic. Literature searches and evaluation, data compilation, and analytical analyses are also excluded from this topic.

Areas of interest for which proposals are solicited under Materials Sciences are limited to the two subtopics listed below. Proposals under both subtopics must represent sound, scientifically based studies and not simply multiparameter materials processing or developmental exercises.

a. Research on New and Improved Materials—A proposal should be submitted for consideration under this subtopic *only if the research represents significant materials advances* **of a general nature** ***and not simply incremental improvements*** **for utilization in a restricted application.** This subtopic solicits research in only the following areas: preparation and characterization of nonequilibrium materials; surface and bulk modification by ion implantation and laser or electron-beam treatment; intermetallic compounds with potential gains in mechanical and environmental stability over conventional alloys; the synthesis, forming, or consolidation of structural ceramics aimed at achieving fully dense, homogeneous, flaw-free microstructure and significant improvements in high temperature, long term mechanical behavior and corrosion resistance; high field, ductile superconductors; and ceramic superconductors with high current-carrying capacity at or above liquid nitrogen temperatures and with fracture toughness and mechanical durability.*

b. Techniques and Instrumentation—New materials and concepts are sought to advance the current state of the art in reflecting and diffracting elements and

*Particular note should be taken of the mention of high-temperature, ceramic superconductors under three separate topics: Materials Sciences (9), High Temperature Superconducting Materials: Processing and Devices (10), and High Energy Physics Technology and Research (16). Proposals of a fundamental nature should be submitted under Topic 9; those aimed at fabrication and processing as well as component or device design should be submitted under Topic 10; and developmental proposals aimed specifically at high energy physics applications should be submitted under Topic 16.

detectors for use with high-intensity sources of ultraviolet radiation, x-ray radiation, and both thermal and epithermal neutrons. Present monochromators, mirrors, and detectors are often the limiting factors in forefront materials research at advanced scientific facilities such as synchrotron radiation facilities and neutron sources. The proposed techniques, instruments, components, or systems should advance present materials characterization capabilities by improving spatial, angular, or energy resolution, or by improving endurance in the high-intensity environment. New methods and concepts for specimen preparation and specimen environment control in electron microscopes are sought. Examples of needs under this subtopic are: improved electron microscope specimen preparation, improved instrumentation for sensing contamination and cleaning in the high current accelerator high vacuum environment, improved cooled optical systems for very intense beams, instrumentation to determine the finish and figure (shape) of mirrors, and improved high resolution, man-made, diffracting structures such as Fresnel zone plates and multilayer coatings.

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10. HIGH TEMPERATURE SUPERCONDUCTING MATERIALS: PROCESSING AND DEVICES*

The recent discovery of ceramic materials with superconductivity transition temperatures above 90 K, well above the boiling point of liquid nitrogen (77 K), has excited both scientific and practical interest. Applications requirements fall into two major categories: (1) wires, tapes, and other geometries, which can be formed into multifilament cables or other structures for use in electric power transmission lines, electromagnets, electric generators, motors, propulsion systems, and storage systems, (2) films of various thickness for use in electronic devices such as interconnects and Josephson junctions, in accelerator cavities, and possibly in other devices. These types of applications require considerable technological development. The goal of this topic is to develop methods of processing and fabricating materials into forms that can be used in components and devices based on this new discovery and to develop innovative designs that take full advantage of materials whose T_c exceeds 90 K. Literature searches and economic analyses as stand-alone activities are excluded from this topic. Proposals are solicited for work involving already-identified superconducting materials with T_c greater than 90 K, in only the following areas:

a. Fabrication and Processing—Innovative research and development is sought to produce one or more of the following: superconducting filaments, wires, multifilament cables, tapes, films. Proposed projects may include the development of novel and improved ceramic fabrication processes, the bonding of ceramics to other materials, the production of multifilament cables in practical lengths, and the development of

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*Particular note should be taken of the mention of high-temperature, ceramic superconductors under three separate topics: Materials Sciences (9), High Temperature Superconducting Materials: Processing and Devices (10), and High Energy Physics Technology and Research (16). Proposals of a fundamental nature should be submitted under Topic 9; those aimed at fabrication and processing as well as component or device design should be submitted under Topic 10; and developmental proposals aimed specifically at high energy physics applications should be submitted under Topic 16.

appropriate electrical contacts between cables, terminals, and devices. Fabrication development must include characterization. It may also include the measurement and achievement of mechanical properties (fracture toughness, tensile strength, etc.) and integrity that will be required for the ultimate application of these materials.

b. Component or Device Design—Innovative designs and/or fabrications of components or devices, but not large systems, are sought which utilize the unique properties of ceramic superconductors. There will need to be a close coupling between the design and fabrication activities, whereby the design will define the size, geometry, and properties of the fabricated material, and the physical and mechanical properties and behavior achievable with superconducting ceramics will define the range of possible applications. Promising designs should, where possible, be subjected to proof-of-concept tests.

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Since this field is developing rapidly, it is impossible to provide a complete bibliography. However, the proposer is expected to be aware of the relevant literature published by the time of proposal submittal. A partial bibliography follows:

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11. TWO-PHASE FLOW INSTRUMENTATION

DOE presently supports research in the area of two-phase flow—in particular, flows with two fluid phases as with liquid-vapor, liquid-gas, or two immiscible liquid systems. In contrast to single-phase flow, a broad understanding of the thermo-fluid dynamic behavior of two-phase systems has not yet been attained. Although there is a substantial effort in progress on an international scale, reliable experimental data are still needed to evaluate the important parameters used in describing and predicting two-phase flow behavior.

a. Instrumentation for Fluid/Fluid Two-Phase Systems—Proposals are solicited that will identify and apply innovative instrumentation and measurement concepts to the evaluation of such important variables as local phase concentrations (local void fraction in gas-liquid and vapor-liquid systems); distribution of bubble and droplet sizes; local phase velocities; interfacial features such as wave structure, area concentration, flow-pattern transition, liquid film thickness in annular flows, and other pertinent features. This subtopic is limited to fluid-fluid systems. Proposals concerned primarily with product development with little or no research component will not be considered. Proposers are expected to be familiar with the relevant current research literature in the area of two-phase flow.

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12. PLASMA DIAGNOSTICS

DOE is currently supporting many magnetic-fusion-related plasma experiments that require diagnostics for measurement of plasma parameters and analysis of plasma observations. The goal of this topic is to develop and demonstrate novel techniques and instrumentation that provide reliable, multidimensional spatial and temporal resolution for critical plasma parameters.

Areas of interest to DOE under this topic include complete diagnostic systems for measuring plasma parameters, individual components of these systems, and improved capability for data analysis. Excluded from this topic are concepts and systems pertaining mainly to inertially confined plasmas. If, during Phase I or Phase II, the proposer intends to use resources other than his own, he should ensure prior to proposal submission that the needed resources will be made available for the project. Innovative proposals are sought in only the following subtopics:

a. Plasma Parameter Measurement Techniques—Major parameters to be measured include plasma density and plasma current, plasma impurity density, electron and ion temperature, and magnetic field strength. All of these measurements should be accompanied by spatial distribution information. In addition, measurement of energy confinement times and auxiliary plasma heating properties also is desired. Proposals to develop techniques for making these measurements should include not only absolute values, but small variations in those values in space and time. Equipment must be capable of a large dynamic range and be sensitive to small variations.

Other areas in which innovative research is solicited include measuring the velocity of fast, nonthermal particles (product alphas, injected particles, fast, rf-heated particles) and determining the energy spectra, spatial position, and time evolution of plasma thermal particles, including impurities.

b. Diagnostic Components—Under this subtopic, the development of new diagnostic components or major enhancement of capability by modification of existing components is sought.

With the advent of tokamak operation with ignited plasmas, there is a growing requirement for radiation-hardened components and techniques for diagnostic instrumentation. Thus, emphasis should be placed on hardware that can be used in a harsh fusion environment characterized as follows: high vacuum, high radiation, high temperature, and high magnetic field.

Vacuum components, optical components, fiber optics, detectors, etc., can be considered together with techniques to make measurements in the soft x-ray and vacuum ultraviolet spectral ranges possible. In those instances where equipment does not have a long lifetime in a harsh radiation environment, the hardware should be designed to be handled remotely.

In particular, innovative approaches to the following are sought:

1. Detector Systems—The parameters of existing components and systems such as those required for detecting ions, neutrons, photons, plasma current, and ambipolar potentials require improvements to increase accuracy (e.g., increasing the signal-to-noise ratio in instrumentation or extending the range over which measurements can be made). Improvements in detector resolution are needed while making the detectors compatible with the harsh fusion environment. For example, in the area of spectroscopic devices, improvements in diffracting elements, gratings, spectrometers, windows, and monochromators are needed to ensure radiation resistance and ruggedness.

2. Diagnostics for Ultra-High Vacuum Environments (10^{-8}torr)—Most diagnostic devices currently used require improvement in resistance to magnetic and electric fields, temperatures, and vacuum. Representative areas for improvement include coatings, probes, radiation-hardened encoders, spectrometers, monochromators, gratings, and windows. In addition, surface treatment, repair techniques, and in-situ calibration techniques also are needed.

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13. PLASMA CONFINEMENT SYSTEMS TECHNOLOGY

DOE supports the operation of several different fusion plasma confinement devices. Many common problems are encountered in these various devices. Thus, it is possible to identify specific technology areas where innovative research and development would benefit the entire fusion experimental program. Excluded from this topic are concepts and systems pertaining mainly to inertially confined plasmas. Also excluded are theoretical studies and computer code development unless specifically associated with the design of components.

Proposals pertaining to technology development are sought in only the following subtopics:

a. Plasma Production and Control—This subtopic solicits proposals for plasma heating, fueling, magnetic divertors, and other subsystems that directly produce or control the plasma. All subsystems must be compatible with appropriate plasma conditions of temperature, radiation, stress, allowed impurity level, etc.

In plasma heating, both radio frequency (rf) and neutral beam injection methods are used. The activities and needs for rf heating are of particular interest. The relevant frequency ranges are 0.05-0.3, 1-4, and 30-600 GHz, and the required power levels are 0.5-5 MW. Many rf sources and components in this range of frequencies and power levels are not available, especially those at millimeter wavelengths. Many components such as transmission lines, circulators, vacuum feedthroughs, electron guns, power supplies, magnet systems, launching structures, Faraday shields and insulating coatings compatible with a plasma environment are candidates for innovative development. The application of heat pipes to solve special cooling problems of components is an example of possible innovative development.

The rf heating method chosen for near term and future large and mid size fusion applications is the Ion Cyclotron Resonance (ICR) range of frequencies of 50-300 MHz. These systems are expected to operate at very high powers for long pulse lengths. Total system powers of 10 to 50 MW and pulse lengths of from 30 seconds to continuous operation are under discussion. Because of the limited number and size of access ports and the need to shield feed and antenna ports, antenna systems capable of launching 5 MW through a 1/4 square meter area port need to be developed. Other components of the system, many of which do not exist in the necessary parameter ranges, such as tuning capacitors, feed-through devices, coaxial cable, stub tuners, and rf power amplifiers and tubes, need to be developed for this application.

For beam heating, research on components for negative-ion neutral beam injectors also is invited. These injectors typically operate at 400 kV and 1-10 A of neutral current. Other areas requiring further research include high velocity deuterium or tritium pellet injectors and direct energy recovery/conversion devices. In each case, improved performance and reliability is desired, preferably at reduced cost.

b. Power Conditioning—Fusion research facilities require the use of electrical power conditioning equipment capable of handling 10s and 100s of megawatts. Typical operating parameters are centered in two ranges: 1–2 kV at 10–100 kA, 50–100 kV at 0.1–1 kA, and ~500 kV at 10–20 A. The required waveforms are frequently neither AC nor DC, but rather follow a complex time history. Response times of order 0.5 ms are needed. Innovative research is solicited for microprocessor controllers for thyristor power supplies, gate-turn-off thyristors that exceed present performance, and indicating fuses for thyristors. Also sought are fast-opening breaking switches that can interrupt hundreds of kiloamperes and withstand tens of kilovolts. Switching power-supply technology appears ready for several of these applications that have heretofore used conventional transformer-rectifier systems.

c. Vacuum Technology—Plasma research facilities depend on reliable high speed vacuum pumps, associated valves, and other hardware for continuous pumping as well as rapid evacuation of the chamber between pulses. Components for which proposals are sought specifically include specialized seals designed to withstand unusual thermal and/or electrical stresses, water-cooled bushings for high power feedthroughs, electrically conducting, quick disconnects for vacuum application, remote-leak detection systems, and improved ultra-high vacuum valves.

d. Superconducting Magnets and Materials—This subtopic addresses the design and development of new or advanced concept magnets for plasma fusion confinement systems. Proposals are sought in this area for very high field magnets (B >16 T) and low loss pulse magnets for tokamak systems and alternative concepts. Innovative and advanced materials and processes that have a high potential for attractive conductor performance and low fabrication costs are sought. Cryogenic superconductor materials with high critical current density, low sensitivity to strain degradation effects, and radiation resistance are needed for future applications. Development of superconducting joints is needed for high field and pulse applications. Other needs for advanced magnet systems include development of weldable structural case materials with high strength and toughness at 4 K and radiation-resistant insulators. Low-cost, efficient, and reliable cryogenic support components, such as liquid helium pumps and cryogenic dewars, that are compatible with these systems are required for the long term.

Bibliography

See reference list at the end of Topic 12.

14. FUSION ENERGY SYSTEMS

The achievement of practical power production from fusion energy will require operation of large plasma confinement devices and eventual operation of prototypical reactors. The long-range technical problems posed by these challenges generate many research opportunities. Excluded from this topic are concepts and systems pertaining mainly to inertially confined plasmas. Proposals must address only one of the following subtopics:

a. Materials—Proposals are sought in materials research directed toward the development of (1) new metallic structural and low activation alloys, ceramic materials, carbon/carbon composites, and polymers very resistant to the damage and swelling produced by the nuclear irradiation environment that will be found in a fusion reactor; (2) radiation-resistant copper alloys for high heat-flux components and first-wall structures; (3) copper/epoxy composites; (4) brazing techniques for graphites and carbon/carbon composites; and (5) techniques for increasing thermal conductance at mechanical joints for components under high thermal loading.

Proposals also are sought on first-wall protection materials for a fusion reactor. The first wall experiences an extremely harsh environment, necessitating considerable development and specialization of materials for in-vessel components. Surface heating conditions span the range from long-pulse heat fluxes (0.1 to 1 MW/m^2) on surface areas characteristic of first-wall heat rejection components to short-pulse heat fluxes (50–300 MW/m^2) on surface areas appropriate to plasma disruptions (1 to 10 cm^2) in tokamaks. Heat-dissipating materials and techniques are sought.

Permeation of materials by tritium must be minimized by the development of permeation-resistant coatings and materials. Research directed toward the development of such tritium-impermeable materials and coatings is invited.

Plasma/wall interactions that produce plasma poisoning and erosion are a general problem. Materials research on low Z (atomic number), self-regenerating materials, thick (1 cm) coatings, and control of eroded material redeposition is invited for limiters, wall armor, and liners. In addition, innovative methods are sought together with novel techniques and components for particle control.

b. Fusion Nuclear Technology—Development is sought of the technology involved in the extraction and conversion of fusion energy to produce electrical power. R&D is required to develop concepts for tritium breeding blankets cooled by high-temperature coolants that are used to generate electricity. Lithium-bearing materials are being considered in many different solid and liquid forms. Liquid metals, molten salts, water, and helium are being considered for coolants. Among the technical issues to be addressed are liquid-metal magnetohydrodynamics effects, materials compatability/corrosion, tritium recovery, solid breeder thermomechanical behavior, and tritium breeding neutronics performance.

Additional R&D is required in the areas of tritium extraction from water, the permeation of tritium through various structural materials and double-walled heat exchangers, and the effects of tritium on materials properties.

c. Site Operations—Ideas are sought for potential applications of robotic and remote-handling technology to fusion reactor maintenance problems, including: (1) internal/external reactor inspection; (2) removal/replacement of bolts, seals, and port covers; (3) cutting/welding operations; (4) repair/replacement of pipes and valves; (5) radiation monitoring; and (6) decontamination of reactor components.

d. Systems Studies—Systems design studies are sought that will lead to improved tokamak reactor designs. Only tokamak studies will be considered. Improved subsystem conceptual designs including breeding blankets, impurity control, fueling, heating, current drive, and magnets are the most likely areas for these improvements. These improved subsystem designs must include systems engineering assessments of the impact of the designs on operational parameters such as availability/reliability/maintainability, environmental impact, cost, and health and safety. The control of reactor and near-reactor tokamak fusion devices will require a significantly more sophisticated feedback control system than is used in present experiments. Studies are sought to develop a comprehensive, state-of-the-art, control methodology utilizing modern optimal control theory. The control objectives include plasma current, horizontal and vertical position, shape, and burn control. Since these variables are related, the control concept must handle them all in a simultaneous coupled manner. Questions to be addressed in the study include: the minimum number of measurements required for adequate control, the use of indirect (not plasma parameters) system measurements, and distributed control procedures for burn control. The feedback control must be verified in a time-dependent tokamak systems code that incorporates all of the major engineering systems and physics effects expected in reactor grade devices. Studies are also sought that will define instrumentation requirements to perform various tests on nuclear components (e.g., blankets and high heat-flux components) in a tokamak engineering test reactor environment, including appropriate safety tests. Also, assessment of the state of the art of the required instrumentation is sought.

Bibliography

See reference list at the end of Topic 12.

15. TECHNOLOGY FOR THE SUPERCONDUCTING SUPER COLLIDER

DOE supports a nation-wide research and development program for the Superconducting Super Collider (SSC). The SSC is a high luminosity proton-proton collider designed to provide center-of-mass energies twenty times higher than those available at existing facilities. This capability will allow exploration of matter in an unprecedented realm where new, fundamental phenomena are expected. The R&D program is in its fourth year and the project is well into the conceptual design stage. When completed, the heart of the SSC will be two rings of superconducting magnets in a 10-ft diameter tunnel that is 53 miles in circumference.

The implementation of this ambitious undertaking depends on superconducting magnet and cryogenics technology. Though recent advances in these areas have been impressive, further improvements can be expected, and several aspects of this effort should be well suited to the capabilities of small businesses. A technology crucial to the success of the experimental physics program at the SSC once it is operational is that of particle detection and data processing. Though much of the development of the large scale equipment must rely on the capabilities of the large national labs, there are many opportunities for contributions by small businesses.

The technology requirements of the SSC are also extensions of generic needs of the High Energy Physics Program, as represented under Topics 16, 17, and 18. The scope of Topic 15 includes only work addressing the specific requirements of the SSC, with its unusual size and complexity. Generic high energy physics R&D which does not address specific SSC requirements should be submitted under Topics 16, 17, or 18, as appropriate.

Proposals are solicited in this topic for the following subtopics only to the extent that the proposed work is relevant to the SSC:

a. Superconducting Magnets and Materials, and Precision Magnetic Field Measurements—The ductile alloy Nb-Ti will be used for the main SSC dipoles and quadrupoles. Proposals for improving the characteristics of the alloy Nb-Ti and further development of Nb-Ti-Ta are solicited.

The SSC design calls for two classes of superconducting dipole, quadrupole, sextupole and octupole correction coils. One type is within the bore of the dipoles "distributed" around the ring. The other type is "lumped" in elements called spool pieces located periodically around the machine. Conductor and multipolar configurations meeting SSC requirements and cost-effective methods for conductor and magnet fabrication are sought.

The SSC also requires a large number of special magnets such as large aperture dipoles and quadrupoles and very high gradient quadrupoles. Concepts exist for these magnets, but innovative approaches and detailed designs are sought.

All the magnets for the SSC have magnetic field requirements that are particularly strict due to the small bore size. Variations in the field must be measured to a few parts per million to assure magnet quality and to determine the operation of the correction magnets. These measurements must be made at fields ranging from 0.1 to 7 T in a 32-mm diameter tube that may be up to 17-m long. Measurements are to be made at ambient temperature and at 4 K. New instrumentation approaches that will give an accurate and rapid determination of specific overall field and field quality are invited.

b. Cryogenics Technology—Helium must be pumped over distances of kilometers through the SSC accelerator magnets. Helium pumps with high efficiency, variable flow rates (over a range of 5 to 1, and independent of pressure differential), and capacities in the range up to 0.2 kg/s at a pressure differential of 2 atmospheres are sought. The flow of liquid and gaseous helium must be measured at approximately 4 K. Flow meters with output proportional to the flow rate are solicited for this application.

Also sought are radiation resistant temperature sensors that cover the range from 4 K to 80 K, have good accuracy, hold calibration, and can be installed in an industrial working environment where the magnets and cryogenics are assembled.

c. Detector Electronics and Materials—Large scale experiments at the SSC will require electronics systems that are well beyond the current scale in high energy physics. Both analog and digital integrated circuits that combine high speed, low power dissipation, and radiation resistance will be widely used in SSC detectors. Proposals are invited for all phases of electronics systems development, from design tools and processes to the manufacturing of specific circuits.

Silicon microstrip detectors are an established technology in high energy physics for the detection of charged particles. Significant advances in the following areas are sought in these devices to meet the challenge of utilizing the full capability of the SSC: (1) increased yield and lower cost per unit area, (2) larger arrays, (3) radiation resistance, (4) integrated production of detector and readout electronics, and (5) development of fast, two dimensional (pixel) devices and electronics.

Large area silicon diodes may also be used in sampling calorimeters. The cost of producing good quality, high resistivity silicon in large sizes (few cms by few cms) is the major barrier to their large scale use. Development is solicited for new methods or additional sources, which will have a significant impact. Another approach invited is to investigate the use of large area amorphous silicon.

Large area, complicated printed circuits may be required for some SSC detectors. Innovative research leading to fabrication on flexible media is solicited.

Small diameter glass and plastic scintillating optical fibers will have a variety of uses in SSC experiments. Glass fibers 20 to 50 microns in diameter (including cladding) and typically 10 cm long may be used as precision charged particle detectors. Improvements in the attenuation lengths and speed of response are sought. Plastic fibers up to 1 mm in diameter (including cladding) and several meters long can be used as particle detectors or as the sampling medium in calorimeters. Substantial improvement in the radiation resistance is required for some applications.

Research and development is sought on warm liquid calorimeter materials and the electronics associated with these detectors. The goal of this effort should be to demonstrate the feasibility of a large scale prototype calorimeter. DOE is interested in liquids with high free electron yield, and high mobility and lifetime at room temperature that can be produced and maintained with impurity levels less than a few parts per billion. Promising materials include, for example, tetramethylsilane (TMS), hexamethylethylenedisilane (HEDS or DTMS), and tetramethylpentane (TMP).

Proposals are invited for the development of very high density transparent media as alternatives to lead glass for hadronic energy resolution. Candidate glasses or other materials must be radiation resistant, have a fast response time, and be capable of being produced in large enough quantities for prototype demonstration. Cerium glass is one possibility. Development of the readout methods is also sought.

Methods are sought for obtaining large quantities of high grade BaF_2, which is fast and radiation hard, at a reasonable price. Also needed are techniques for calibration of electromagnetic calorimeters made of this material.

SSC experiments will require computing resources beyond that presently in place within the high energy physics community. In particular, massive parallel processing systems, in which each processor acts independently, will be required. The development and fabrication of such systems based on available microprocessors presents excellent opportunities for development by a variety of businesses.

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16. HIGH ENERGY PHYSICS TECHNOLOGY AND RESEARCH

DOE supports research and development in a wide range of technologies essential to the DOE's program in high energy physics. Principal areas of current interest include advanced superconducting magnets and related materials, superconducting radio frequency (rf) technologies, cryogenic technology, high speed electronic instrumentation, data acquisition and analysis systems, and special computer systems.

DOE also supports research to explore the basic constituents of matter, the forces between these constituents, and the transformation of matter and energy at the most elemental levels. Although the dominant mode of experimental research is to use large, collaborative efforts at major national particle accelerator facilities, there are experimental and theoretical endeavors in collaborative or stand-alone efforts where small businesses can make creative and innovative contributions.

The areas relevant to high energy physics in which proposals are solicited are limited to the following subtopics:

a. Superconducting Magnets, Materials, and RF Technology—This subtopic addresses the design and development of new or advanced concept dipole and quadrupole magnets for use in accelerators, storage rings, and charged-particle beam transport systems. Innovative research is sought in this area for dipoles and quadrupoles with various combinations of magnetic field shapes and field-quality specifications, but low manufacturing cost. Other multipole magnets are also sought.

New or improved materials and related processing techniques for high critical-current, high critical-field conductors to produce low stabilizer (Cu, Al) to superconductor ratio multifilamentary wire for use in very high-field magnets (B >8 T) are sought. Examples include niobium titanium, high tantalum-content niobium titanium, niobium tin (Nb_3Sn), and tertiary and quaternary alloys.

Innovative proposals are invited for development of the newly discovered class of high temperature superconductors (e.g., the ceramic Y-Ba-Cu-O) and other new materials into practical conductors (i.e., high current density, fine filaments, and potential for use in magnets) that can possibly lead to future advances in accelerator beam transport and detector performance and reduced operating complexity and cost.*

Superconducting alloys are sought for radio frequency application (L, S, and higher frequency bands) with

*Particular note should be taken of the mention of high-temperature, ceramic superconductors under three separate topics: Materials Sciences (9), High Temperature Superconducting Materials: Processing and Devices (10), and High Energy Physics Technology and Research (16). Proposals of a fundamental nature should be submitted under Topic 9; those aimed at fabrication and processing as well as component or device design should be submitted under Topic 10; and developmental proposals aimed specifically at high energy physics applications should be submitted under Topic 16.

particular emphasis on alloys with high critical temperature, low secondary-emission coefficients, and correct stoichiometry.

b. Cryogenic Technology—New and significantly improved cryogenic devices and systems for helium service in the temperature range 2 to 20 K are sought. Examples include new or significantly improved heat exchangers, rotating machinery (turboexpanders, circulating pumps, compressors), transfer lines, interconnects and cold seals (in pressure ranges from hard vacuum to 20 atmospheres), low heat-leak valves, and computer-compatible instrumentation (temperature, pressure, flow, etc.). Note that cryogenic R&D appropriate mainly to the Superconducting Super Collider should be proposed under that topic (Topic 15).

c. Theoretical and Experimental Physics—This subtopic invites proposals for theoretical or experimental research exploring new or novel concepts for elementary particle physics and its relationship with other sciences (e.g., applications of elementary particle physics to nuclear physics and astrophysics); novel experimental techniques and systems, or materials that either extend basic experimental capabilities or result in less costly and less complex apparatus (e.g., less costly calorimeters, vertex detectors, etc.).

Many particle detectors use special combinations of gases as ionization media. Advances are sought in gas purification and gas monitoring technologies.

Proposals with a major emphasis on digital instrumentation, digital processing or data triggering, handling or analysis techniques or hardware should be considered for Topic 17.

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17. HIGH ENERGY PHYSICS DATA PROCESSING AND DETECTOR INSTRUMENTATION

DOE supports research and development in a wide range of technologies essential to experiments in high energy physics at the three major DOE high energy accelerator laboratories. These technologies involve the processing and analysis of experimental data and the development of particle detectors. The DOE program also includes the development of advanced technologies for novel particle detectors and for the recording, processing, and analysis of experimental data at future facilities such as the proposed Superconducting Super Collider (SSC), (see Topic 15). Principal areas of current interest include high-speed electronics instrumentation, data acquisition and analysis systems, special computer systems, computer networks, computer peripherals, and particle detectors and associated data readout systems.

Although particle physics detector instrumentation and data processing equipment development and construction is usually centered in a large, collaborative effort at a major national particle accelerator center, there are many developmental endeavors in collaborative or stand-alone efforts where small businesses can make creative and innovative contributions to the further development of the required advanced technologies.

The areas in which proposals are solicited are limited to the following subtopics:

a. High-Speed Electronic Instrumentation—This subtopic includes:

1. Electronics—Innovative research is solicited for circuits and systems for rapidly processing data from particle detectors such as proportional wire chambers, scintillation counters, Cerenkov counters, etc. Representative processing functions and circuits include high-speed counters (>300 MHz), time-to-amplitude converters, fast preamplifiers, etc. Systems of these devices compatible with the international CAMAC standard, the FASTBUS instrumentation standard, the VMEbus standard, and/or other widely used standards are of particular interest. Low noise field-effect transistors are also needed for use in particle detectors.

2. Systems—Research is invited on advanced, high speed logic arrays and microprocessor systems for fast event identification, event trigger generation, data preprocessing, etc., with very high throughput capability. Such systems should be compatible with or implemented in the international CAMAC standard or FASTBUS.

3. FASTBUS—A new instrumentation standard for interfacing modern computers to physics experiments has been developed by the US NIM/CAMAC Committee under the sponsorship of the DOE at the request of the high energy physics community. Known as FASTBUS, this is a flexible, multiprocessor-compatible and modular electronic instrumentation system with wide application for data acquisition, data processing, and equipment control. Research and development is solicited for development of new FASTBUS logic modules, including segment interconnects, segment extenders, fast buffer memories, counter modules (64 or more counters per module, f >300 MHz), segment display modules, microprocessor modules, and diagnostic modules.

b. Special Computer Systems—Proposals are invited for a wide variety of innovative software and hardware for applications in high energy physics experiments, data processing, and theoretical computations, including, for example, distributed microprocessor systems, pattern-recognition systems, database management systems, code development systems, emulators for high-speed computation, large scale parallel processors (x100 to x1000 Cray-1 or IBM 3090 computational power) for large scale simulation, and cost-effective, multiple-access, large-memory systems.

c. Computer Peripherals and Communications—Proposals are invited for hardware and/or software for local and wide area computer to computer networks, cost-effective alternatives to magnetic tape or disk online storage, new approaches to very long scale online data storage (e.g., optical disk), smart terminals, scientific work stations, and graphics display units.

d. Data Handling Techniques and Systems for Novel Particle Detectors—This subtopic invites innovative research in data handling including, but not limited to: (1) mathematical and computer algorithms providing improved approaches to data handling and analysis, and (2) novel experimental techniques and devices that result in more cost-effective and/or less complex systems for digitizing, handling, or recording detector outputs.

Proposals with a major emphasis in novel detector materials, detection techniques, and/or fabrication techniques, as opposed to digital instrumentation or data processing, should be considered for Topic 16.

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18. ACCELERATOR TECHNOLOGY FOR HIGH ENERGY PHYSICS

DOE, through its programs in High Energy Physics and Heavy Ion Fusion Accelerator Research, supports a broad research and development effort in the science, engineering, and technology of charged-particle accelerators, storage rings, and associated apparatus. Advanced research and development is sought in support of these programs, particularly with respect to new concepts of acceleration, advanced theoretical studies, and device development that will contribute to overall advances in accelerator technology applicable in the High Energy Physics and Heavy Ion Fusion Research programs. Proposals are invited in only the following subtopics:

a. Theoretical Studies—This subtopic includes physical phenomena and principles underlying the design, operation, and performance of accelerators, storage rings, linear colliders, and beam transport systems. Innovative research is solicited in effects of space charge, collective phenomena, beam-beam interaction in storage rings, polarization/depolarization mechanisms, nonlinear beam dynamics, and phase-space cooling processes.

b. Advanced Accelerator Concepts—Proposals are sought for new or improved acceleration concepts to provide very high gradient (>100 MeV/m for electrons and >5 MeV/m for ions) acceleration of intense beams of particles. Stageability, beam stability, manufacturability, high wall plug-to-beam power efficiency, and cost-effectiveness are of particular concern. Also sought are induction accelerators to obtain kiloampere ion beams, including the use of multiple beams; new or improved storage ring concepts and technology; and new or improved concepts for linear colliders.

c. Radio Frequency Acceleration—Proposals are invited for research on very high gradient (>100 MeV/m for electrons and >5 MeV/m for ions) accelerating structures (superconducting or room temperature), particularly for wavelengths of 0.1 to 10 cm. There is particular interest in new concepts for producing high peak power (P >150 MW), narrowband, low duty-cycle, low pulse repetition frequency (~1 kHz) pulsed radio frequency (rf) sources operating at L-band or higher and in high average-power continuous wave (cw) narrowband rf sources (P >1 MW, Δf <5 MHz) operating at 300 MHz or higher. Potential electrical efficiencies >45 percent are considered essential for these rf sources. Also sought are high repetition rate switching tubes (80 kHz, 3 to 5 kA, and about 30 to 40 kV) that have very long lifetimes and are capable of operating in a burst mode, and fast, high power solid state switches capable of handling 10 to 100 kA at 50 kV with switching speeds of a few picoseconds.

d. Special Devices and Techniques—Novel devices and techniques are sought in the areas of high repetition rate lasers, collective-effect beam monitors, ion optics, and phase-space cooling.

Novel low output power, high pulse repetition rate lasers operating in the near infrared or visible spectrum are sought that can be either externally modulated or run cw to produce 10 to 50 GHz trains of 5 to 30 picosecond pulses.

Novel charged-particle beam monitors are sought to measure the transverse or longitudinal charge distribution in small radius (<5 mm diameter), short (<10 mm) relativistic electron or ion beams. Also sought are devices capable of measuring and recording the Schottky spectrum of these beams. Both diagnostics should be nondestructive to the beams monitored and have computer-compatible readouts.

In the area of electron and ion beam optics, novel, cost-effective devices are sought that use electromagnetic, electrostatic, or plasma techniques to manipulate high-momentum, high-intensity charged particle beams.

The technology of phase-space cooling of ion beams is relatively new. New concepts, devices, and techniques are sought particularly for application to electron and stochastic cooling of proton and antiproton beams. Areas of special interest are low dispersion, high beta wave guides (1 to 10 GHz); high frequency, low noise large-bandwidth rf power amplifiers (>2 kW, >2 GHz bandwidth at center frequencies of 1 to 10 GHz); high voltage (1 to 5 MV); high current, low emittance electron and positron beam sources; and high power electron-beam collectors.

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19. ACCELERATOR TECHNOLOGY FOR NUCLEAR PHYSICS

Support sought under this topic of the DOE Nuclear Physics Program is aimed at research and development activities related to the science, engineering, and technology of heavy-ion, electron, and proton accelerators and associated systems. Research and development is sought that will permit optimum support of charged-particle acceleration and provide apparatus that will significantly contribute to overall accelerator technology and applications specifically tailored to the Nuclear Physics Program. In this effort, there is an interest for electron beam energies of up to 16 GeV; and heavy-ion energies from a few MeV/AMU up to collider energies of 100 + 100 GeV/AMU. Proposals are invited in only the following subtopics supporting the Nuclear Physics Program:

a. Superconducting Radio Frequency Techniques—Design and development of new or advanced concept superconducting materials are sought, especially as applied to radio frequency accelerating cavities used in particle accelerators. Included in this area of interest are accelerating structural elements and cavities, and peripheral components such as terminations and cryogenic radio frequency windows. The avoidance of inclusions in the superconducting material and contamination on the surface of the superconductor is of extreme importance in minimizing field emission, quenches due to localized heat sources, and excessive global heat dissipation. Innovative concepts and designs addressing these performance improvements are solicited.

b. Ion Sources—Particle beam ion sources are sought having improved intensity, emittance, and range of species. Included are high-charge-state sources for heavy ions, sources for negative, light, and heavy ions, and polarized sources for hydrogen ions, heavy ions, and electrons.

c. Beam Diagnostics—Advanced beam diagnostic concepts and devices are solicited that provide high speed computer-compatible measurement and monitoring of particle beam intensity, position, emittance, polarization, luminosity, momentum, and energy. It is especially of interest to develop techniques that are nondestructive to the beams being monitored.

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20. NUCLEAR PHYSICS INSTRUMENTATION AND TECHNIQUES

DOE seeks innovative approaches to technical problems encountered in basic research in nuclear physics. Measurements in this field are typically performed at the limit of technical feasibility. Hence, new capability will often generate important advances in scientific knowledge. DOE is particularly interested in supporting projects that may lead to advances in detection systems for nuclear physics experiments. Opportunities exist for developing equipment beyond the present state of the art and outside the usual scope of research and development activities at the national accelerator facilities. Proposals are invited in only the following subtopics:

a. Particle Detectors and Detector Materials—Devices are sought for detecting charged particles (such as electrons, protons, heavy ions, and mesons), photons, neutrons, neutrinos, and single atoms, with improved resolution, sensitivity, stability, dynamic range, durability, and background suppression. These include solid-state detectors such as silicon strip detectors, silicon detectors with high position resolution and multihit capability, and charged-coupled devices; photosensitive devices such as photodiodes, photomultipliers, and microchannel plates; gas-filled detectors (e.g., proportional, drift, streamer, and Cerenkov chambers); liquid argon and xenon ionization chambers; single-atom detectors using laser techniques; and magnetic spectrometer components and systems. Materials are sought for the construction of devices that detect particles of interest to nuclear physics research such as electrons, protons, heavy ions, mesons, photons, neutrons, and neutrinos. Examples include scintillating materials such as bismuth germanate, barium fluoride, scintillating optical fibers, and lead glass.

b. Special Nuclear Targets—Special targets are sought for nuclear physics research where experiments require the interaction of particle beams with unconventional targets, such as polarized targets (with nuclear spins aligned) which might include high density, highly polarized gas targets or polarized solid targets (for neutron studies). Other special targets include those required when very low energy charged particle beams are used, e.g., windowless gas targets, supersonic jet targets, etc. There is also an interest in new technology for the production and use of films for targets, strippers, and detector windows.

c. Electronics for Nuclear Detectors—Instrumentation is sought for processing analog and digital signals from nuclear detectors with significantly improved speed, resolution, counting rate, and noise suppression (e.g., large scale digitization and time-to-digital conversion coupled with rapid scan and compression techniques, low noise amplifiers with good resolution and high counting rate, stable low threshold discriminators, monolithic-flash analog-to-digital convertors, and fast stable light pulsers with less than 1 ns rise time).

d. Nuclear Data Acquisition and Analysis—Proposals are solicited for research and development of devices and systems, including generalized software packages, for the acquisition and analysis of data used in nuclear physics research. Significant improvements are sought in speed, flexibility, transportability of software, storage capacity, and convenience (e.g., novel front-end processors for CAMAC, FASTBUS, or VME crates; multimicroprocessors for filtering, compression, and preanalysis; multidimensional, bulk-memory histogramming systems; and microprocessor-based systems for the display of data).

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21. COAL UTILIZATION AND CONVERSION

Coal is abundant and inexpensive compared to oil and gas. Greater use of coal is impaired by the difficulties of using a solid fuel and of cleaning up the products of combustion, which contain ash and gaseous pollutants. The results of innovative research could contribute to coal utilization by enabling users to handle coal with a level of convenience and reliability approaching that of liquid and gaseous fuels and by developing methods to remove sulfur and ash in an economic manner. Significantly improved technology also is needed to use the reserves of coal for the production of synthetic fuels to lessen dependence on imported petroleum. (*Note:* Proposals involving Biotechnology should be submitted under Topic 25). Proposals are sought on only the following subtopics:

a. Clean Utilization of Coal and Coal-Based Fuels.—Direct utilization of coal in production of heat is of interest because it is a more efficient use of the heat energy than can be achieved with processes which convert the coal to liquids or gases. Recent technological advances can allow direct combustion of coal in fluidized beds or pulverized coal burners with significantly reduced emissions. Innovative research is sought in the direct combustion of coal leading to (1) new applications of recent developments to industrial, commercial, and residential coal combustion, (2) further reduction in emissions of particulates and noxious gases, (3) new and improved systems for using coal-water slurries in combustion processes, and (4) innovative flue gas cleanup processes.

Direct utilization in turbines and internal combustion engines is possible and is also of interest because of the higher efficiency in use of the basic energy content. Proposals for turbine use are sought for (1) alternative turbine hot gas path configurations for reducing deposition and erosion, and (2) alternative combustor designs for increased combustion efficiency at shorter residence times.

In using coal-based fuels (e.g., micronized coal, coal slurries, and minimally cleaned, coal-derived gas) in internal combustion engines, proposals are sought for new approaches to (1) anti-sludge, reduced wear lubricants, (2) combustion control (e.g., location of initial combustion and flame propagation, including novel head, chamber, and crown designs for combustion control, and injector technology improvements), and (3) methods for preparing, handling, and injection of alternative fuel forms which include powders, pyrolysis fuels, and coal distillates.

Innovation in the direct conversion of fossil fuels to electrical energy, via fuel cells, is invited particularly in the areas of (1) new high temperature ceramics possessing strength, porosity, electronic or ionic conductivity, and stability to thermal cycling, corrosion, and dissolution; (2) polymers with ionic or electronic conductivity suitable for use as electrolytes, electrodes, or wetting control agents; and (3) new cell concepts for the co-production of chemicals and electricity.

b. Coal Cleaning, Coal Slurry Technology, and Coal Size Reduction.—The objective is to derive a method of developing a cleaned coal product that can be used interchangeably with fuel oil or natural gas, with minimum retrofit.

Cleaned coal presents fewer problems with respect to slagging and mineral sulfur content. The specific aim is to develop improved coal cleaning technology through chemical or physical studies that will enhance the cleaning process. Research investigations could include the study of materials that would enhance fine coal separation, improved energy recovery, wetting, dispersing, flocculating behavior, reactivity, and toxicity reduction.

Cleaned coal may be transported, stored, and burned in a liquid suspension. Water, alcohols, and combinations thereof in conjunction with stabilizing agents are the fluids used to obtain stable suspensions. Proposals are sought that will lead to a better understanding of coal surface chemistry and that will provide more predictable slurry behavior from the stand-points of slurry stability and controlled viscosity over extended time periods (of the order of 6 months) without the need for constant monitoring and control.

In order to clean coal or to prepare a coal slurry for combustion, the mineral fuel itself must be reduced in size. Most grinding processes now known and practiced are energy intensive, particularly for the smaller size ranges. Efficient particle reduction methods are solicited for coal size reduction to the 5 to 20 micron size range.

c. Innovative Coal Conversion Technology—The objective in this area is to initiate or advance the development of novel approaches to the derivation of fuel gas, synthesis gas, or liquid fuels from American coals. Proposals are invited with emphasis on significant process cost improvements by way of innovative process chemistry, reaction concepts, and catalyst systems, rather than on incremental improvements to conventional gasification and liquefaction processes.

A fruitful approach might be to correlate the characterization of coals with respect to the chemical reactivity that contributes to liquefaction and gasification, in terms of donatable hydrogen, the ease with which donatable hydrogen is transferred, the ratio of weak to stable bonds, the relative tendency to go to gaseous or liquid products, the product distribution in terms of molecular weight and polarity, the tendency to undergo retrogressive reactions, and the relative susceptibility to catalysis.

d. Hot Gas Cleanup—The objective of this subtopic is to develop innovative, effective, and economic processes for high temperature, high pressure cleanup devices for coal-fueled gas turbine systems. Research is solicited that addresses techniques for removing contaminants to levels that are compatible with gas turbine systems and reducing emissions to levels below the promulgated standards for pulverized coal boilers.

DOE has particular interest in proposals for the development of a high temperature, high pressure membrane system for the separation or concentration of selected contaminants. As this membrane system would need to operate in a pressurized system (above 100 psi) and at temperatures above 1200 °F, the gas separating membranes would probably be made from an inorganic material such as a ceramic.

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22. FOSSIL ENERGY INSTRUMENTATION

Future, large scale, advanced fossil energy processes, such as coal gasification, liquefaction, combustion, and oil shale retorting, will require reliable process instrumentation to assure plant safety, to control product quality and plant efficiency, and to protect the environment. The instruments will measure important process variables and monitor the integrity of critical equipment within the processes. Existing fossil energy processes, including large, pulverized coal-fired systems, could be similarly improved through the use of more reliable, more accurate process instrumentation. Accurate noninvasive instrumentation is also required for basic coal research and new process development.

In fossil energy processes, sensor reliability is adversely affected by exposure to high temperatures, high pressures, and corrosive conditions, such as hydrogen sulfide and particle erosion. Durability limitations on normal sensor construction materials in these environments favor the development of more sensitive, nonintrusive techniques of measurement. The time response required for safe process operation or for adequate understanding of a particular chemical phenomenon may be in the millisecond to second range. In addition, because of the multiple-phase nature of the process media, often more than one sensing technique is required for a unique measurement of the process variable desired.

DOE is interested in supporting advanced, applied research that will explore new scientific concepts and approaches to instrumentation, particularly those that pursue applications that are an outgrowth of fundamental research. Support will be confined to high risk, advanced, applied research. Obvious applications of well-known instruments or instrumental techniques are not appropriate for this topic. Potential for ultimate use in commercial-scale processes will be a major consideration. Proposals should concentrate on: (1) the possibility of measuring important variables not currently measurable and (2) areas where major improvements can be made in sensitivity, accuracy, or response time by using new scientific principles or techniques, or made in reliability by employing new material advances for sensor construction.

Proposals will not be funded that are mainly for product development; that is, such that the original research component is minimal and the problem is essentially one of design or packaging into a new format, or testing some product for commercialization.

To be eligible for support under this topic, a proposal must address one of the following subtopics:

a. Instrumentation for Combustion Research— Innovative research in instrumentation and diagnostic techniques, leading to greater understanding of the combustion process and the combustion of solid and coal-derived fuels in particular, would enable combustors to be designed with such improved features as greater fuel flexibility and reduced emissions. Diagnostics are sought that can measure particle dynamics, gas phase kinetics, and turbulent mixing. The measurement of kinetic parameters at combustion conditions is essential for understanding the coupling between chemical kinetics and the turbulent mixing process.

b. Flow Instrumentation—Measurement of key variables in the flow of multiphase process streams involves direct measurement of the mass flow or measurement of variables such as density and velocity at temperatures to 480 °C (900 °F) and pressures up to 13.8 MPa (2000 psi). For some applications, such as transport of solid-bearing streams (e.g., coal-oil or coal-water) where phase separation is possible, techniques are sought capable of monitoring the solid phase flow to anticipate upset process conditions. For systems in which some deposition can be tolerated, measurement of the existence and the extent of the deposits is sought. Also sought are instruments for monitoring spatial flows in larger process components and vessels such as pumps, compressors, separators, and reactors (including entrained, fluidized, and ebullating beds).

c. **Hot Reaction Zone Control Systems**—Instruments and control systems having essentially instantaneous response to process variables of interest must be developed to permit integrated automatic control of advanced fossil energy processes. Measurements must be taken in the hot reaction zone where process control must be effected; downstream measurements introduce excessive time lag and the possibility of altered relationships giving rise to faulty measurement. Process conditions involve a mixture of solid matter with liquids or gases or an undefined mixture of the two types of fluid. Instruments for on-line measurement and control of the concentration of solids in solid/fluid flow are sought.

d. **On-line Analysis of Gas Streams**—Gas streams, such as product gas streams, are composed of a mixture of gases carrying a mixture of solid particulates and condensate particulates (droplets) which form and grow as stream temperature drops. Knowledge of the composition of both gases and solids is essential to process control. Instrumentation is sought for the essentially instantaneous measurement of the molecular composition, absorptivity, and specific heat of gas streams as well as monitoring of harmful species, especially in optically dense flows. In addition to solid particles, it is necessary to measure condensate particulates and their vapor sources, since downstream changes in temperature and pressure will encourage growth of existing condensate particulates and formation of additional condensate particulates of differing composition. Instruments for measurement of the number, density, size distribution, and composition of the particles are sought.

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23. FOSSIL ENERGY MATERIALS

Materials, materials properties, and materials performance are of interest and importance to all fossil energy technologies. Research supported under this topic should specifically address materials needs of fossil energy systems where the corrosive and erosive aspects of coal conversion and utilization limit system operability and reliability. Research emphasis should be on novel materials-processing techniques and new scientific knowledge about the properties of materials.

Topics for which proposals are solicited are limited to the three subtopics listed below. These subtopics represent areas of materials research that have been identified as critical to the successful deployment of certain fossil energy technologies. Proposals under all three subtopics should be based on sound fundamental principles. Of particular interest is proposed research that will lead to an understanding of the structure-properties/performance relationships of materials in fossil energy environments.

a. Nucleation and Growth of Protective Alumina Scales—α-Alumina is one of several metal oxides that can be effective in providing protection for alloys against sulfidation attack under certain environmental conditions. Under thermodynamically favorable conditions, protective oxides can form and extend the useful lives of alloys. In operating fossil energy systems, conditions are not always conducive to the formation and regeneration of protective α-alumina scale. Also, the α-alumina scale usually has poor adhesion. Thus, a need exists for a fundamental understanding of the nucleation and growth processes of α-alumina. Such an understanding would improve our ability to properly design and specify alloys for applications in corrosive environments. Proposals are sought for research directed toward obtaining a fundamental understanding of the nucleation and growth processes of protective α-alumina. Alloys to be studied will include Fe-18Cr-6Al and Fe-25Cr-4Al, although other alumina-forming alloys may be included.

Novel approaches by which the protective scales are formed and regenerated may be included. Although similar considerations may be made for other protective oxides such as chromia, this subtopic specifically relates to alumina, and proposals should address alumina only.

b. Protective Coatings for Structural Alloys— Many high-strength alloys that are candidate structural materials in fossil energy systems do not have the requisite corrosion resistance for these applications. Coatings of materials that are more resistant to corrosion, such as aluminum and chromium are frequently used to provide corrosion protection. Although coatings are often successful in providing this protection for specific systems, it is presently not possible, in a general way, to specify properties of a coating that will ensure good and continued corrosion protection. A fundamental and systematic study of the properties of aluminized and chromized, coatings and their relationship to protection provided is desired. Properties to be considered include, but are not limited to: aluminum or chromium content of coating as a function of depth; thickness of coating diffusion zone; variations in coating thickness and aluminum or chromium content; and microstructural and micromechanical properties of coating and substrate materials. The proposed research should be structured to lead to the development of specifications for coatings that, if met, will assure their protective ability.

c. Development of Ceramic Fiber Preform Processing Techniques—Ceramics are generally considered to have good potential for use in the hot (up to 1000 °C) gas streams of coal conversion and utilization systems. Techniques are being developed to form toughened ceramics by infiltrating and depositing a ceramic matrix in ceramic fiber preforms. These fibrous preforms serve to form the structural skeleton of the final ceramic structure. Several types of preforms have been and are being studied. Mats of ceramic fibers, cloth layups, and wound structures are among the many types of preforms that have been studied. Innovative research is needed to develop and prove other techniques for processing ceramic fibers into disks and tubes as well as more complex shapes. Proposals for research are solicited that will lead to the development of novel techniques for producing ceramic fiber preforms.

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24. ENHANCED OIL AND GAS RECOVERY AND TAR SANDS

DOE seeks innovative methods and concepts that will allow more efficient, effective, economical, and environmentally acceptable enhanced oil recovery (EOR) and recovery of syncrude (bitumen) from tar sands. Of the 481 billion barrels of crude oil discovered in the United States, over 300 billion barrels will not be recovered by conventional techniques (primary or secondary recovery). Also, recent estimates of domestic tar sand resources reported by the US Geological Survey and others are far greater than were previously reported. Tar sand bitumen is representative of the type of heavy hydrocarbon remaining in many petroleum reservoirs after some primary, secondary, and tertiary production methods have been applied. While commercial tar sands operations have been initiated in Canada, US resources have not been commercialized because of different reservoir characteristics, generally greater depth of burial, and host material.

The current depressed gas prices make it desirable, on the one hand, to reduce the cost of finding new gas and recovering it from marginal wells and, on the other hand, to increase demand by enhancing the value of gas as a fuel or raw material in new areas of usage. Novel recovery techniques could lead to lower costs through extended life (at lower production costs) for marginal wells and by increasing the number of productive wells located during exploratory operations. Improved diagnostic tools for better identification of fracture trends would further improve the productivity of exploratory efforts.

Research is sought in only the following subtopics:

a. New Processes for Fluid Diversion—In recovery processes for oil and tar sands, one of the major problems is the preferential flow of injected fluids through high permeability layers causing the bypassing of lower permeability, oil containing zones, thus reducing recovery efficiency. Novel processes are sought that will effectively alter relative permeabilities and direct the injected fluids toward low permeability, oil containing regions. These processes should control injected fluid without plugging zones of low or medium permeability. In addition, proposals are invited for development of techniques that modify and control the relative permeabilities surrounding producing wells so as to increase oil production relative to the efflux of brine and injected fluids.

b. Innovative Tracking of Flood Fronts in Recovery Processes—Methods are sought that will enable tracking of injected fluids in chemical, miscible, and thermal recovery processes. Tracking may be accomplished through measuring properties of reservoir fluids to detect injected fluids or through measurements of saturation changes (oil, water, gas, or additives). Presently, the means of detecting flood fronts is through sampling of produced fluid and/or logging at observation wells drilled at intervals from the injection wells. Methods or processes that can make these measurements at the surface, without drilling additional wells, are especially desirable.

c. Improved Recovery Effectiveness in Heavy Oil and Tar Sand Reservoirs—Two of the most difficult problems in the recovery of heavy oil and tar sand bitumen from reservoirs through the use of injected fluids are: (1) low displacement efficiency and (2) low volumetric sweep efficiency (areal and vertical) when a low-miscibility fluid, such as steam in steam flooding or air in in-situ combustion, is used. New approaches such as a combination of steam flooding and in-situ combustion with other processes are sought to accomplish more effective displacement of the heated heavy oil or bitumen. Also, new ideas are needed for surface extraction processes for the recovery of tar sand bitumen or heavy oil.

d. Natural Gas Technology—Generally, a need exists for diagnostic tools and improved interpretations of areal and vertical extent of tight, fractured gas reservoirs. New geoscience approaches/methods are sought for locating and characterizing the fractured reservoir prior to drilling. The methods could be applied to an existing borehole through the strata of interest. In addition, better directional drilling diagnostic tools/methods are sought to maintain directional control using air drilling techniques so that wells can be designed to cross the natural fracture network that is determined to be present in situ. Such information could reduce directional drilling time to reach the production target and improve directional drilling economics. Also sought is diagnostic tool development for operating through medium-and short-radius wellbores into long, horizontal wellbores.

Inexpensive new approaches or concepts are sought to restore the flow rate of old gas wells, including unconventional gas sources, whose production has declined to the point where they are no longer worth maintaining at current gas prices. Such concepts could be applied to individual wells to remove or overcome formation damage or to increase the surface area linked to the boreholes as in near wellbore stimulation. Alternatively, new or improved methods to drain more effectively much of the gas that has been bypassed in past drilling ventures are sought to sustain the life of existing gas fields. In both cases, wells and field, there is a need to recover more of the available gas in place from low risk reservoirs. New methods to obtain slim/slant hole drilling could be used to augment production from existing boreholes. New work-over equipment techniques to remove formation damage near the wellbore should be investigated. New treatment fluids to overcome paraffin and salt buildup that reduces flow capacity in low pressured reservoirs are sought.

Improved gas-to-liquids processing is sought using either catalytic or noncatalytic reaction (with special interest in the latter), better methods to separate desired products from the process, and efficient, higher conversion rates to reduce recycling. Processes of interest would produce specialty chemicals directly or higher hydrocarbons as precursors of refined liquid products.

Note: Biological methods for processing fossil fuels will be considered only under Topic 25, not under this subtopic.

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25. BIOTECHNOLOGY FOR FOSSIL ENERGY

DOE currently supports a wide range of research projects for utilizing the unique abilities of microorganisms (including their enzymes or other products) in the several phases of the preparation for use of fossil energy resources. Resources of interest in this topic include coal, natural gas, heavy oils, tar sands, and oil shale. Releasing the resource from its original location, removing undesirable contaminants, and converting the resource into different, more usable forms are all under study. Proposals under this topic must be scientifically sound and novel, and must have a specific type of fossil-processing technology as a principal goal. A minor change or extension of existing or currently developing technology will not be considered sufficiently novel.

Proposals are solicited in only the following subtopics:

a. Beneficiation of Fossil Energy Resources—Novel microorganisms or their products are sought to remove organic and inorganic contaminants from typical U.S. resources at mild operating conditions. Areas of interest include desulfurization, nitrogen removal, and ash removal. Microorganisms or their products may be employed in aqueous or nonaqueous systems; nonaqueous systems are especially attractive.

Development and characterization of such new microorganisms, understanding of the biochemistry involved in their activity, and methods for enhancing their activity are also sought. Particularly of interest under this subtopic is the exploration for new types of microorganisms or their products which have the ability to (1) selectively modify the surface properties of the contaminants, thereby enhancing the effectiveness of physical beneficiation with minimal Btu loss, (2) degrade sulfur-containing molecules in the resource followed by release of the sulfur as sulfate or other disposable residue, or (3) solubilize or release ash-forming materials.

b. Conversion of Fossil Energy Resources—Types of resource modifications may include, but are not limited to, conversion of fossil energy resources to liquid or gaseous fuels, viscosity reduction of high viscosity materials, and release of organic materials bound in inorganic matrices, such as kerogens bound in oil shales. All fossil energy resources are of interest under this subtopic; i.e., coal, natural gas, heavy oils, tar sands, and oil shale. Microorganisms, enzymes, or other products of microorganisms that have the ability to modify the structure of fossil energy resources and result in a fuel form that is more amenable to processing or utilization are sought. Biocatalysts in nonaqueous systems are especially interesting. Proposals are solicited for research on the biochemical mechanisms by which these conversions occur.

c. Fossil Energy Resources Processing—Improved approaches are sought for processing fossil resources through use of microorganisms or their products. Processes, processing systems, and processing equipment are all of interest under this subtopic. It is desired to develop a microbially-produced surfactant or stabilizer that can be used to prepare stable suspensions of a variety of solid-liquid combinations, and to lower the cost of stabilizers for such suspensions. Evidence must be shown that such microbially-stabilized solid liquid suspensions provide acceptable viscosity and are stable over time periods of the order of 6 months. Methods based on nonaqueous systems are of particular interest. Processing equipment must be able to handle finely divided solids suspended in water or organic solvents without becoming plugged or having to operate at low solids loading. Bioreactors must have the ability to process mixtures containing filamentous microorganisms. Reactor subunits should cost-effectively separate organisms having the desired processing ability and remove all other undesirable organisms.

d. Enhanced Oil and Gas Recovery—Development of processes using microorganisms or their products in the recovery of light and heavy oils or natural gas from low producing fields is sought. Research supported under this subtopic should specifically address new microorganisms capable of growing in underground reservoirs of oil or gas, and should examine their metabolic and biochemical characteristics. Of primary but not sole interest are microorganism systems that will produce biosurfactants, biopolymers, gases, or materials that release the oil or gas from the rock or sand matrices, with particular interest in systems that are effective in low porosity strata. Both laboratory and field testing are needed.

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26. ADVANCED ROBOTIC SYSTEMS AND CONCEPTS FOR NUCLEAR FACILITIES

Operators and manufacturers of nuclear facilities are making increased use of robotic systems to improve operations and maintenance, lower costs, increase plant availability and equipment reliability, enhance worker safety, and reduce radiation exposures to workers. Teleoperated remote vehicles and programmed robots are being employed for specific tasks. Future systems must use the experience and knowledge gained from use of these systems to integrate the two methods being employed into more advanced telerobotic systems. Telerobotic systems can make more effective use of human operators, expert systems, and intelligent machines. Design of future nuclear powerplants and supporting nuclear fuel cycle facilities should incorporate considerations for effective use of these advanced robotic systems.

Proposals must address one of the following four subtopics:

a. Real-Time Expert Systems in Robotics—Expert systems in robotics offer unique opportunities to use large amounts of process input data and perform rapid analysis and diagnosis of plant operating status, both technical and administrative. The rapid manipulation of available data and decision-making from it can be especially helpful to human operators in emergency situations; in some instances process commands can be issued directly to robots for corrective action before human operators are informed of the action taken. Effective and efficient use of expert systems can reduce the critical time response of robots during emergencies. Numerous capable, user-friendly, expert system shells are becoming commercially available, but very few have incorporated time-dependent variables that will give the system true real-time capability.

Proposals are sought that will identify specific tasks and examples and develop methods to assure that the expert system will operate in the real-time environment, using on-line knowledge to directly control intelligent robots to perform tasks. These systems should run on relatively small computers.

b. Intelligent Robots—Various models of commercial robots include sensor options that are operated from peripheral input/output controllers or a general-purpose programmable controller. In many applications (e.g., mobile robots with integrated navigation sensors or industrial robots using vision or force sensing), a distributed control system is desirable, whereby sensory data are compressed and evaluated in real time to provide useful information to the robot. Proposals are sought for intelligence research in different control processors for faster, more efficient decision-making during telerobotic tasks. The ease of interfacing the intelligent robot controllers to other control computers is of prime importance. Proper consideration must be given to operating and maintaining these machines reliably in a nuclear radiation environment. Development and demonstration of prototype equipment performing specific tasks should be included in the overall work proposal.

c. Application of Robotics and Remote Systems Technology to Advanced Nuclear Powerplants and Fuel Cycle Facilities—Use of advanced robotics and remote systems technology should be part of the initial considerations for nuclear powerplants and fuel cycle facilities of the future in order to maximize the potential benefits. The consideration of the facility/equipment/robotic interfaces early in the design phase recognizes the interactions and allows for optimization of the overall system.

Proposals are solicited for research to assess (1) changes in the current plant or plant system design to maximize the use of robotics and remote systems to increase safety, reduce radiation exposure, and lower operating costs; (2) robotic and remote systems to be used; (3) potential benefits in safety and operating costs; and (4) the potential cost for implementing the changes.

d. Reliability, Availability, and Maintainability (RAM) Assessment of Servomanipulators—A RAM assessment is needed to assure that a force-reflecting servomanipulator system meets its availability requirements. A failure modes and effects analysis (FMEA) is sought to identify all significant component failure modes and the effects of the failures on operation. A reliability model (e.g., a fault tree) is required to enable a quantitative assessment of the system's availability. The basis of the model will be the collection and analysis of failure rates and maintenance times, combined with the failure modes and effects that relate system and equipment failures to environmental, fabrication, testing, and operation and maintenance factors. The prediction of the system's availability will then be compared to its design criteria to determine whether design requirements and objectives are met. An analysis is sought to compare the relative reliability and maintainability of the various viable alternative configurations of the force-reflecting servomanipulator system. Component failure rates and restoration times will be assessed to determine the effects on the system's reliability and availability. Then, the weakest elements can be identified and critical item lists can be developed. An assessment of the maintainability of the system is needed to assure that all required maintenance actions are complete and do not negate the reliability or availability characteristics of the system.

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27. SENSORS AND MONITORING FOR ADVANCED NUCLEAR REACTORS

Technological advances that can improve the economy and operability of nuclear electric generating plants and also provide greater assurance of safety are sought. Sensor development activities proposed in the following areas may provide new capabilities for effective and comprehensive monitoring of advanced reactors:

a. Sodium Leak Detection—The early detection of a sodium leak in the reactor vessel of the pool-type Liquid-Metal Cooled Reactor (LMR) is important to the safe operation of the plant. The reactor vessel is surrounded by a guard or containment vessel with a space between the vessels of 4 to 8 inches. This gas space may be pressurized and sealed at a low positive gauge pressure. A simple, reliable system to positively detect sodium leakages in this gas space is sought. The system should be passive in nature, with no necessity for removing gas samples or mechanical devices for analysis. It also must be able to differentiate sodium from any other element and to operate in an argon atmosphere at gas temperatures up to 800 °F (430 °C).

b. Mechanical Measurements—Improved means for measuring (1) pressure, (2) post-yield strain, and (3) seismic displacements in advanced reactor power plants are important for safe, efficient operation, and for fault analysis. Proposals are solicited for research that is specialized to any of these measurements. Further development of "smart" pressure measuring transducers that could result in significant benefits is sought. Present units allow remote changing of pressure range, correction for temperature variation, linear or non-linear scaling, and diagnostic tests. In addition to these capabilities, new development is sought to provide in-place calibration verification (electric simulation of a known pressure change), a technique for establishing a known zero or pressure reference value, and a direct digital fiber optic interface. Similar principles may hold for measuring pressures in fluids such as sodium, steam, argon, and lubricating oil, but selection of sensor materials might vary depending on application. Capability for measuring differential pressures up to 300 psig with up to 3000 psig line pressure is sought. Accurate gauge pressure measurements across the range from 50 to 3000 psig are also sought. The pressure measuring transducers must be capable of operating at temperatures up to about 230 °F (110 °C).

The capability of measuring post-yield strains is sought for assuring adequacy of LMR designs to withstand earthquakes. Testing of components and systems under simulated seismic conditions subjects the materials to localized strains of 10% to 30%. To measure these large post-yield strains, foil-type strain gauges have been adhesively bonded to structure in areas where high strains are predicted. However, state-of-the-art techniques have been unsatisfactory. The primary limitation at present appears to be in the attachment of the gauge to the structure. This may be in part because strain-induced transient heating occurs during the seismic testing, and this alone may increase the temperature by at least 200 °F (~100 °C). New strain gauge adhesives and/or installation techniques that can provide accurate measurements up to 30% strain at 350 °F (~180 °C) throughout seismic event tests are sought.

Displacement information from tests of nuclear plant components and piping will lead to safer and more cost-effective design standards. However, seismic testing of piping structures presents instrumentation problems.

As examples, seismic test inputs may be uniaxial, but resultant motions are amplified and occur in all three axes. Photograhic techniques so far have been difficult to use and inaccurate, and double integration of accelerometer data has introduced unacceptable errors. Displacement requirements of at least ±25 inches in a frequency range of 0 to 35 Hz are foreseen. Noncontacting techniques would be preferred to avoid influencing the test structure. However, if a test-mounted sensor is employed, its mass should be minimized for the same reason. Proposals are invited that address any of these concerns.

c. Fiber Optic Adaptation for Nuclear Plants—The nuclear power industry has developed standards and criteria for pressure boundary penetrations and in-line connectors for hard-wired systems. The boundaries may be those of, for example, high pressure steam systems, containment, or material control zones. Compared with hard-wiring, fiber optics offers expanded capabilities for data acquisition and control especially if space limitations are imposed. With this potential, there is a need to develop penetrations and connectors for fiber optics that correspond to those existing for hard-wiring, and can meet similar standards and criteria. Successful concept definiton and feasibility demonstration for penetrations and connectors would be a reasonable goal for the first phase of work proposed.

d. Corrosion Sensing in Powerplant Cooling Systems—Nuclear powerplants contain many miles of piping carrying water (and steam) at wide ranges of temperatures and pressures. The powerplant safety and lifetime can seriously be impacted through corrosion of these piping networks. Efforts to mitigate corrosion have not been totally successful, as witnessed by several recent pipe breakage accidents. Corrosion detection techniques are sought to augment other approaches by providing: (1) early indicators that corrosion is in progress, (2) the rates of corrosion, and (3) sites where the corrosion is occurring. Potential approaches include sensing the by-products of the corrosion process or sensing corrosion related changes in the electrical or chemical make-up of the water/steam mixture. Detection methods need to be identified and their feasibilty demonstrated.

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28. COMPUTER APPLICATIONS TO NUCLEAR POWERPLANTS

Nuclear powerplant safety and operating efficiency require advanced control systems based increasingly on computer technology. Specific functions now within reach are automated computer-assisted diagnostics, fault-tolerant control and safety systems, and plant maintenance and reconfiguration management.

The candidate systems should include smart sensor technology, fault tolerance, sensor validation, analytic redundancy, local digital controllers, plant networks, integrated diagnostics capable of being coupled to control, and advanced presentation interfaces. Artificial intelligence and other related techniques may be considered, but systems must operate on line in real time and be based on plant control needs.

Proposals should be limited to the following subtopics:

a. Advanced Computerized Control Systems—Advanced digital computer control systems are sought that provide the reactor industry with more intelligent, more robust, and more versatile controllers in order to make a substantial improvement in plant availability. Innovations can best be accomplished by demonstrating advanced control concepts, software, and hardware on subsystems crucial to reactor operation and availability. In particular it is suggested that proposals detail the assumed control system requirements and describe how the proposed controller is to accomplish the tasks. It would be helpful if the descriptions include the hardware, software, and hardware-software integration requirements, a software development plan, and validation and verification plans.

New technology areas of interest include self-testing and verification schemes, fault-tolerant systems, computer security, and parallel processor (distributed computers) systems. Verification tests using simulators, and eventually real processes, would be desirable.

b. Fault-Tolerant Computer Systems Development—Many systems within a nuclear powerplant could benefit from verifying the truth of both data and conclusions. Proposals should provide means of demonstrating "proof-of-correctness" for fault-tolerant hardware and software in a novel way that avoids the practical problems characteristically encountered in process fault tolerance. These means, which should be system-specific, would require integration of the hardware and software in a manner that can be defended at license applications against all challenges to their adequacy of control or safety.

c. Development of Expert Systems for Process Monitoring and Operations Administration—Plant complexity requires handling of control, diagnostics, etc., at the lowest level possible with only the important information passed to the operator or other control system modules.

As a subset of the main plant control and diagnostics systems, innovative research is sought for the development of local modular control and diagnostics of, for example, emergency core-coolant systems. This control might include fault-tolerant controllers, smart sensors, sensor validation, analytic redundancy, diagnostics (possibly using expert systems or other AI techniques) and capability of communications to the control system hierarchy. Specific tasks need to be identified and the appropriate programs need to be developed. Validation and verification is required in order that the resulting systems can be assured to perform successfully.

d. Reactor Diagnostics and Analytic Redundancy—Methods of incorporating information about the plant process through the use of process signals available in the plant data base will be developed to allow validation of normal and permit recognition of off-normal plant behavior, as well as to provide alternative signals and pathways where possible when sensors and signal pathways become inoperative. The diagnostic tasks for which proposals are sought include the development of methods such as noise analysis and cross-correlation techniques to validate dynamic system performance and the establishment of a data base for determining trip causes from post-trip data analysis. This will allow an expeditious system restart following a scram and provide other post-accident evaluation needs. Another area of interest in diagnostics, for which innovative proposals are sought, is the development of techniques to enhance the quality of the information obtainable by using the plant computational capability.

Some techniques of interest are algorithms that: (1) extend the useful range of flowmetering to include two-phase conditions, (2) allow the use of non-linear sensors, (3) permit on-line calibration and time response measurement, and (4) promote applications where real-time, on-line calculations can provide enhanced data to improve plant operation. The principles of analytic redundancy should be investigated to determine where redundancy might be applied to avoid plant shutdowns on loss of certain sensors and signal pathways. There is a need to provide process information by utilizing unfailed sensors and signal pathways having sufficient reliability to continue plant operation. Techniques for both diagnostic methods and analytic redundancy must be capable of being implemented on a conventional commercially-available computer, using program security and access-denial features to prevent unauthorized changes in programming. Extensive hardware and software validation and verification are required to ensure that proper system responses will result from off-normal behavior and component or system failures. Proposals are invited for innovative research that addresses any of these concerns.

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29. FUEL CYCLE PROCESSES

The nuclear fuel cycle includes ore beneficiation, isotopic enrichment, and decontamination and decommissioning of no-longer needed facilities. Areas of interest in this topic are an economical means of moving directly from ore to fuel, improved methods of concentrating the fissionable isotope of uranium, and efficient means of removing and handling waste. In many cases, candidate technologies are routinely used in non-nuclear projects. However, the need to work dependably in nuclear environments imposes additional developmental requirements. Small businesses are encouraged to submit proposals for research or R&D specifically in support of the technologies below.

a. Atomic Vapor Laser Isotope Separation Engineering

The atomic vapor laser isotope separation (AVLIS) process utilizes precisely tuned red-orange laser light, generated from copper vapor laser (CVL) pumped dyes, to selectively separate uranium isotopes from an atomic beam. As AVLIS proceeds through engineering development activities to full-scale process demonstration, subsystem development and engineering will be emphasized. Several specific areas in which innovative R&D is sought are power systems, switching equipment, pulse-forming techniques, and materials handling.

Plant laser requirements call for CVLs to operate for thousands of hours in the 0.1 to 1 kW average power range at a nominal pulse repetition rate of 5 kHz. Innovative R&D is sought for fast switching, high current, solid-state diodes (30 kV inverse, 2 kA forward, turn-on time less than 30 nanoseconds, recovery time less than 2,000 nanoseconds); high voltage silicon controlled rectifiers with a recovery time of less than 1 microsecond and di/dt greater than 10 amps/second; and high frequency (about 100 MHz), high permeability ferrite core materials and amorphous ferromagnetic core materials with low loss for use as magnetic switches in high di/dt service.

Collector surfaces in AVLIS equipment operate at elevated temperatures so that deposited material will condense and flow as liquid to receptacles. Heating or cooling methods are sought that will provide continuous and reliable liquid flows of product and tails material.

The present uranium fuel cycle imposes a cost penalty on an implemented AVLIS enrichment plant. Innovative proposals are solicited on ways to process uranium ore concentrate directly to metal feed.

b. Remote Analytical Methods for Pyrometallurgical Reprocessing

An emerging method for reprocessing spent fuel is pyrometallurgy. Proposals are invited for innovative methods of analysis for solids, liquids, or vapors under conditions for which the material to be analyzed is inaccessible (except visually through shielding windows in "hot cells"). The needed data can only be obtained by instrumentation and sensors insensitive to high levels of radiation and temperature.

Interrogation of surfaces of metals and salts by remote techniques should result in quantitative analytical signals for determination of major constituents that include actinides (e.g., uranium, plutonium), alloying agents (e.g., zirconium), fission products (e.g., rare earths, noble metals), and process impurities (e.g., cadium). Proposals are sought for similar analytical techniques that can determine anionic impurities (e.g., chloride) at low concentration.

c. Stabilization of Zirconium Spent-Fuel Cladding

Many reactor fuels are clad with zirconium or zirconium alloy. During reprocessing, pieces, chips, or dust of potentially pyrophoric zirconium cladding are created, introducing a possible fire hazard. A remotely operable means of chemically stabilizing these zirconium fragments is sought so that such waste material may be subsequently handled and disposed of safely. The volume of such waste tends to be small compared to the volume of high level waste. The low level waste form must meet the requirements of 10 Code of Federal Regulations Part 61.

d. Decontamination Methods for High Volume Radioactive Waste

There are many locations where uranium-, thorium-, and radium-containing materials have been processed over the past eight decades. Many of these processing operations produced radioactive sludges and solutions that were put into open pits in the ground. Environmental laws and regulations have changed, and these old processing sites and the surrounding contaminated areas must be cleaned up. Often, the volume of such wastes is very large. In order to avoid the cost of moving large amounts of earth, proposals are sought for developing an economical method to separate the radioactive materials, thus producing a small volume of "radioactive" waste and a large volume of "clean" product that is below regulatory guidelines for unrestricted use. This limit is about 15 picocuries/gram of soil for radium and thorium below 15 centimeters of soil depth; in the upper 15 cm of soil, the limit is 5 picocuries/gram. The beginning concentrations are usually in the range of hundreds to thousands of picocuries per gram of soil. (1 picocurie = 10^{-12} curie)

In the past, some separation has been achieved by (1) mechanical means based upon differences in radioactivity emissions, (2) differences in specific gravity of the materials and the rate of settling in a liquid, and (3) differences in magnetic susceptibility. Proposals are invited on other techniques to apply these principles or on methods based upon different principles.

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