

AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT

1. CONTRACT ID CODE

PAGE OF PAGES

2. AMENDMENT/MODIFICATION NO.

3. EFFECTIVE DATE

4. REQUISITION/PURCHASE REQ. NO.

5. PROJECT NO. (If applicable)

6. ISSUED BY

CODE

7. ADMINISTERED BY (If other than Item 6)

CODE

U. S. Nuclear Regulatory Commission
Division of Contracts
Washington, DC 20555

8. NAME AND ADDRESS OF CONTRACTOR (No., street, county, State and ZIP Code)

National Academy of Sciences
Office of Contracts and Grants
Attn: Mr. Dennis Miller, Executive Director
2101 Constitution Avenue
Washington, DC 20418

(X) 9A. AMENDMENT OF SOLICITATION NO.

9B. DATED (SEE ITEM 11)

10A. MODIFICATION OF CONTRACT/ORDER NO.

NRC-03-84-069

10B. DATED (SEE ITEM 13)

9/27/84

CODE

FACILITY CODE

11. THIS ITEM ONLY APPLIES TO AMENDMENTS OF SOLICITATIONS

☐ The above numbered solicitation is amended as set forth in Item 14. The hour and date specified for receipt of Offers ☐ is extended, ☐ is not extended.

Offers must acknowledge receipt of this amendment prior to the hour and date specified in the solicitation or as amended, by one of the following methods:

(a) By completing Items 8 and 15, and returning _____ copies of the amendment; (b) By acknowledging receipt of this amendment on each copy of the offer submitted; or (c) By separate letter or telegram which includes a reference to the solicitation and amendment numbers. FAILURE OF YOUR ACKNOWLEDGMENT TO BE RECEIVED AT THE PLACE DESIGNATED FOR THE RECEIPT OF OFFERS PRIOR TO THE HOUR AND DATE SPECIFIED MAY RESULT IN REJECTION OF YOUR OFFER. If by virtue of this amendment you desire to change an offer already submitted, such change may be made by telegram or letter, provided each telegram or letter makes reference to the solicitation and this amendment, and is received prior to the opening hour and date specified.

12. ACCOUNTING AND APPROPRIATION DATA (If required)

B&R No. 20-19-50-55-6

FIN B8686

Increase: \$93,800.00

13. THIS ITEM APPLIES ONLY TO MODIFICATIONS OF CONTRACTS/ORDERS, IT MODIFIES THE CONTRACT/ORDER NO. AS DESCRIBED IN ITEM 14.

(X) A. THIS CHANGE ORDER IS ISSUED PURSUANT TO: (Specify authority) THE CHANGES SET FORTH IN ITEM 14 ARE MADE IN THE CONTRACT ORDER NO. IN ITEM 10A.

B. THE ABOVE NUMBERED CONTRACT/ORDER IS MODIFIED TO REFLECT THE ADMINISTRATIVE CHANGES (such as changes in paying office, appropriation date, etc.) SET FORTH IN ITEM 14, PURSUANT TO THE AUTHORITY OF FAR 43.103(d).

X C. THIS SUPPLEMENTAL AGREEMENT IS ENTERED INTO PURSUANT TO AUTHORITY OF:
Mutual Agreement of Parties - FAR 43.103(a)(3)

D. OTHER (Specify type of modification and authority)

E. IMPORTANT: Contractor ☐ is not, ☒ is required to sign this document and return 2 copies to the issuing office.

14. DESCRIPTION OF AMENDMENT/MODIFICATION (Organized by UCF section headings, including solicitation/contract subject matter where feasible.)

This modification is being issued (1) to revise the scope of work to include a specific project entitled "Study on Hydrogen Combustion in Severe Light-Water Reactor Accidents, (2) to extend the period of performance, (3) to increase the total contract ceiling amount and (4) to raise the domestic travel ceiling. Accordingly, the following revisions are made.

1. Section B.3, Brief Description of Work, is deleted in its entirety and the following is substituted in lieu thereof:

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NRC-03-84-069 PDR

Except as provided herein, all terms and conditions of the document referenced in Item 9A or 10A, as heretofore changed, remains unchanged and in full force and effect.

15A. NAME AND TITLE OF SIGNED (Type or print)

PAUL L. SUTTON

Assistant to the President

15B. CONTRACTOR/OFFEROR

X Paul Sutton
(Signature of person authorized to sign)

15C. DATE SIGNED

JUN 28 1985

16A. NAME AND TITLE OF CONTRACTING OFFICER (Type or print)

Paul J. Edgeworth

16B. UNITED STATES OF AMERICA

BY Paul J. Edgeworth
(Signature of Contracting Officer)

16C. DATE SIGNED

6/17/85

"B.3, Brief Description of Work

The National Research Council, through the Commission on Engineering and Technical Systems and its Energy Engineering Board, proposes to conduct an evaluation to determine whether there is a sufficient body of technical data and analysis on the phenomena and safety significance of hydrogen conflagration in severe accidents involving light-water reactors to provide a basis for regulatory action on hydrogen control. The objective includes formation of considered judgments concerning such questions as: What conclusions do the facts support? How dependably? What are the gaps in knowledge? How much do they matter? How easily, if at all, can the missing information be developed? The study will be conducted over an eight month period."

Total Estimated Cost: \$93,800.00

2. Section B.4, Level of Effort, is deleted in its entirety and the following is substituted in lieu thereof:

"B.4, Level of Effort

The following level of effort will be required by the contractor for performance of the work specified herein:

<u>Labor Category</u>	<u>Man-Hours</u>
Executive Director	130
Senior Staff Officer	940
Administrative Secretary	975
Total	2,045

It is recognized and agreed that the level of effort for each labor category may vary and that personnel will be utilized only to the extent necessary to perform the required work; however, full performance shall be accomplished by the expenditure of approximately the number of man-hours of effort specified above.

3. C.2, Work Requirements, is revised to include the specific issue involving the study of hydrogen conflagration/detonation. This study shall be performed in accordance with standard National Research Council procedures as directed by the Board, within the level of effort and cost estimates set forth in Section B.3 and B.4.

C.2.1, Background

Since the earliest period of commercial application of LWR technology, there has been an engineering concern regarding the possible threat of hydrogen generated during severe accidents. It has long been acknowledged that hydrogen poses a possible threat to the integrity of a reactor during certain conceivable accidents. There is the possibility that hydrogen generated from metal-water reactions (principally from metal-zirconium reactions in LWRs of modern design)

might combust, either by deflagration or explosion, and thereby threaten the reactor containment structure and engineered safety systems.

Many experts have believed that the likelihood of accidents involving hydrogen as a threat is extremely small; in practice, this conventional wisdom has manifested itself in reactors designed, built and operated without significant engineering attention paid to the possibility of such accidents. For example, the design basis of most current LWRs, both those operating and those still under construction, does not consider the issue of hydrogen in a general way, either in terms of designs to limit its generation, or in terms of equipment or procedures to remove hydrogen generated in large quantities in severe accidents. The containments are not designed to withstand a hydrogen deflagration or explosion, nor are the hydrogen removal systems (recombiners, etc.) sized for hydrogen generation from the severest accidents. It would be an exaggeration to state that the hydrogen issue was completely ignored in earlier design: it was not, but the accidents considered were significantly less severe in terms of their hydrogen threat than those currently under consideration.

There has been a dramatic change in thinking on this subject and related subjects in recent years, stemming mostly from the experiences during and after the Three Mile Island (TMI) accident in 1979. The TMI accident included a significant hydrogen combustion event (not an explosion, however) about ten hours into the accident sequence. In post-accident reconstructions of the phenomena, it has been widely accepted that a reasonable fraction of the zirconium cladding probably oxidized, releasing large amounts of hydrogen.

After study of the TMI accident, the issue of accidents more severe than the present design basis became generally recognized as one where important research was needed. A large research program was undertaken both in the U.S. (principally under sponsorship of U.S. Nuclear Regulatory Commission but with major support by the Electric Power Research Institute) and overseas (mainly in Japan, Germany, and France). While this research program covers a spectrum of issues much broader than that of hydrogen, the technical questions involving hydrogen have been one important element of the recent and ongoing research.

Concurrent with this research effort have been a number of changes in hardware, operating procedures, and regulations that are intended to cope with issues related to hydrogen generation and combustion. A few reactors have made important changes, and all have been affected in one way or another.

The central technical issues are few in number, but difficult to resolve in technical detail. This is because, in part, there are a very large number of possible accidents involving hydrogen and, in part, because there are many different reactor configurations (differences in design, operation, regulation). The technical issues include understanding the chemical and physical processes whereby hydrogen is generated in severe accidents; determining the likely

accident scenarios for these accidents once hydrogen is generated; working out the circumstances under which hydrogen deflagration or even explosion might occur; understanding what design and operational changes might reduce or eliminate the threat either by reducing hydrogen generation or removing it before it can ignite; and working out how present containments and their engineered systems will respond to a hydrogen combustion event, both as presently built and operated and after incorporating any of several proposed 'improvements.'

The research carried out since the TMI accident, including work now underway, has cast light on most of these issues. The Nuclear Regulatory Commission staff has reached the stage that they are now seriously considering a variety of possible changes to their regulations to deal more effectively with the hydrogen question. Some experts believe that the body of information now available, or soon to be available as the current generation of experiments and analyses are completed, will be adequate to provide an acceptable technical basis for modifying the NRC's regulations. However, because there is substantial pressure within the regulatory community to resolve the issue of what the future regulations will contain, the NRC is now moving toward a possible new regulatory position. The schedule for any new regulatory changes is not clear now, but will probably occur within the next two or three years.

The time is ripe for a thorough, independent technical review and evaluation of this subject. The central issue is whether the information now in hand, or anticipated very soon, provides an adequate basis to support regulatory decision-making in this area. If it does not, the question arises as to what additional technical information is needed to provide such a technical basis.

C.2.2, Scope of the Study

The Energy Engineering Board will assess the technical issues related to the fate and control of hydrogen generated in severe LWR accidents in order to determine the degree to which current knowledge may support regulatory decision-making; however, no attempt will be made to suggest the nature or extent of such regulations. To carry out the study, the Board will establish a committee of approximately six experts requiring expertise in reactor safety engineering, chemical engineering, effects of combustion (fire damage), combustion, and related disciplines.

C.2.3, Study Plan

The evaluation will include the following:

1. Scale up

- a. Evaluate experimental data from various test facilities (FITS, VEGES, NTS) with respect to the following questions:
 - (i) how typical are the combustion mechanisms in small enclosures as compared with full-size containments?
 - (ii) how well can they be scaled to full-size containments?
- b. Evaluate the ability to scale the instrument temperatures obtained from small-scale tests through analytic codes to the temperatures predicted for full-size reactor containments.

2. Completeness

Evaluate Sandia National Laboratory's program and the programs sponsored by industry with respect to the question of whether all important areas have been properly covered.

3. Detonation

- a. Comment on the need for extending experimental work to include effects of detonation on equipment, recognizing that most work to date has concentrated on deflagration, in view of the difficulty of detonation work and the low probability ascribed to such an event.
- b. Provide an independent assessment of the following research:

Recent research by the Sandia National Laboratory has established lower limiting concentrations of hydrogen (approximately 13-1/2%) in air which would support a detonation. Furthermore, additional testing with steam in the deated detonation tube facility has provided results indicating that steam addition to hydrogen-air mixtures had little effect on the detonability of mixtures.

4. Jet Flames

Develop inferences and comment on the quality of the inferences with respect to the following question:

What are the conditions under which autoignition of jet flames might occur, for release of a steam-hydrogen or hydrogen jet into an ambient mixture?

5. Suspended Water

Evaluate the influence of suspended water droplets on hydrogen combustion in a hydrogen-nitrogen-oxygen-steam mixture with respect to the following questions:

- a. What is the influence of suspended water as a function of droplet size and volumetric density on the limiting concentrations for hydrogen deflagrations and detonations?
- b. What is the nature of suspended water formed as a result of bulk condensation of steam in the subject mixtures? What are initial droplet sizes and what are the effects of coagulation?

4. Section C.3, Meetings and Travel, is deleted in its entirety and the following is substituted in lieu thereof:

"C.3, Meetings and Travel

Up to six (6) EEB meetings are to be held during the second year of the contract. Board meetings will normally be held in the Washington, DC area. The anticipated meetings are as follows:

6 members, 3 2-day meetings
6 members, 2 3-day meetings
2 EEB liaison, 3 2-day meetings
2 EEB liaison, 2 3-day meetings
2 staff, 3 2-day meetings
2 staff, 2 3-day meetings "

5. Section F.1, Period of Performance, is deleted in its entirety and the following is substituted in lieu thereof:

"F.1, Period of Performance

The technical effort to be performed under this contract shall be completed within a period of 16 months commencing on September 27, 1984 and expiring on February 27, 1986."

6. Section F.3, Report Requirements, is revised to add the following:

"Upon completion of the "Study on Hydrogen Combustion in Severe Light-Water Reactor Accidents," the final report shall be transmitted after normal Academy review. Reports resulting from these efforts shall be prepared in sufficient quantity to ensure distribution to the sponsors, committee members, and to other relevant parties in accordance with Academy policy. Reports may be made available to the public with restrictions."

7. Section G.10, Travel Reimbursement, paragraph no. 1 is revised to increase the domestic travel ceiling by \$24,550.00 from \$15,570.00 to \$40,120.00. Therefore,

Delete: \$15,570.00

Insert: \$40,120.00

8. Section G - Contract Administration Data is revised to include another paragraph, G.11 - Consideration. Therefore, add the following:

"G.11, Consideration

A. Estimated Cost and Obligation

1. The estimated cost of work for Year I (12 months) as delineated in the basic contract, paragraph B.1 - Brief Description of Work is \$77,737.00.

The estimated cost of Year II (8 months) as delineated in Modification No. 1, paragraph B.3 - Brief Description of Work is \$93,800.00.

2. As a result of this modification which increases the total contract amount by \$93,800 from \$77,737.00 to \$171,537.00, the amount obligated by the Government with respect to this contract is \$171,537.00."
9. Standard Form 26, Award/Contract, page 1 of the contract, Block No. 15.G, entitled Total Amount of Contract, is increased by \$93,800 for a revised total amount of the contract which is \$171,537.00.

All other terms and conditions set forth under this contract remain unchanged.