

DOCUMENT RESUME

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Report to Rep. Melvin Price, Chairman, House Committee on Armed Services; by Elmer B. Staats, Comptroller General.

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A 1976 contract between the Energy Research and Development Administration, now the Department of Energy (DOE), and KMS Fusion Inc. (KMS) covered the setting up and operation of a new laser, target experiments, target design and fabrication, and laser fusion theory. A 1977 contract provided for correcting problems with the laser system and further work in the areas of the 1976 contract. KMS has fully complied with the requirements of both the 1976 and 1977 contracts and has made several unique contributions in the area of target fabrication. Under the 1976 contract, it produced large-diameter thin-wall glass, plastic, and multilayer target shells and developed new techniques which are requirements for improving laser fusion efficiency and/or eventually commercially operating laser fusion reactors. DOE stated that the 1976 target work exceeded contract requirements and showed considerable innovation. DOE characterized work under the 1977 contract objectives as being satisfactory and demonstrating high competence in the art of target fabrication. The only major instance of inadequate performance was KMS' failure to achieve predicted laser power during the 1976 contract. KMS has had a significant role in developing laser fusion energy and may be capable of making significant contributions in the future. (HTW)

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COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

B-164105

May 4, 1978

The Honorable Melvin Price
Chairman, Committee on
Armed Services
House of Representatives

Dear Mr. Chairman:

Your October 3, 1977, letter requested that we review the participation of KMS Fusion, Incorporated, in the national laser fusion program. Specifically, you requested that we (1) review KMS Fusion's performance under its past and current contracts with the Energy Research and Development Administration--now the Department of Energy, (2) determine if KMS Fusion is contributing to the national laser fusion program, and (3) determine whether future Federal funding of KMS Fusion is justified. In conducting this work we reviewed the performance of KMS Fusion under the contracts with the Energy Research and Development Administration and the Department of Energy and also examined the current and anticipated role of KMS Fusion in the national laser fusion program.

KMS Fusion's performance was satisfactory and complied with the prescribed tasks with one major exception--its inability to achieve the laser power specified under the 1976 contract. This failure affected KMS Fusion's ability to adequately complete tasks in two of four major work areas, specifically the laser system, and experiments using the laser to irradiate the laser targets. The tasks in the remaining work areas of the 1976 contract--target fabrication and laser fusion theory--and 1977 contract were satisfactorily completed.

BACKGROUND

In laser fusion, microscopic round shells containing fuel --commonly called targets--are struck by an intense beam of light--a laser beam. The beam's energy heats the target's outer surface, causing its surface material to eject outward. This ejection also produces an inward force, which compresses the fuel to densities up to 100 times that of a normal solid. The compression heats the fuel to extremely high temperatures. At these temperatures and densities, the fuel atoms join or

fuse to form a new atom, at the same time releasing energy which can be converted to electricity.

KMS Fusion was formed in 1971 to conduct laser fusion research and development and related work in the design and fabrication of laser fusion targets. In July 1973 KMS Fusion demonstrated compression of laser fusion targets, and on May 1, 1974, KMS Fusion produced the first laser fusion thermonuclear neutrons in the United States. Shortly thereafter, KMS Fusion submitted to the Atomic Energy Commission--a predecessor agency to the Energy Research and Development Administration--the first of a series of proposals for Federal funding. Until that time, all work had been financed privately.

From October 1974 to January 1975, the Atomic Energy Commission and KMS Fusion held discussions leading to a letter contract in February 1975, under which KMS Fusion was to conduct a series of laser-target experiments to observe target behavior under various conditions. This \$350,000 contract was effective through June 1975 and, according to Department of Energy officials, was satisfactorily completed. In June 1975 KMS Fusion received its first major contract from the Energy Research and Development Administration to conduct laser fusion research mainly during fiscal year 1976. In October 1976 a second major laser research contract between KMS Fusion and the Energy Research and Development Administration was signed for work to be performed in fiscal year 1977. This second contract has been extended through August 1978 to provide for further work. As of February 10, 1978, KMS Fusion's Federal funding has totaled about \$22 million.

CONTRACT PERFORMANCE

The 1976 contract between the Energy Research and Development Administration and KMS Fusion covered: set up and operation of a new laser, target experiments, target design and fabrication, and laser fusion theory. The 1977 contract provided for correcting the problems with the laser system by modifying its design to increase its power and to improve the quality of its beam. The 1977 contract also provided for further work in the same areas as the 1976 contract--targets, target interaction experiments, and laser fusion theory--and a separate task in interpreting experimental results (this work had been included in the 1976 contract but was not separately indentified).

Targets

KMS Fusion has fully complied with the requirements of both the 1976 and 1977 contracts, and has made several unique contributions in the area of target fabrication.

Under the 1976 contract, KMS Fusion produced large-diameter thin-wall glass, plastic, and multilayer target shells and developed new techniques for (1) characterizing target shell parameters, (2) coating target shells with plastic to improve energy efficiency, (3) filling target shells with gaseous, solid, and liquid fuels, (4) improving the ability to store targets for extended periods of time, and (5) freezing fuels inside target shells. Development of these techniques is a requirement for (1) improving laser fusion efficiency and/or (2) eventually commercially operating laser fusion reactors.

Under the 1977 contract, double shelled glass targets were produced, target fabrication techniques were improved, and methods to extend target shelf life were developed. In addition, KMS Fusion developed a system to suspend targets for uniform irradiation by the laser. KMS Fusion also developed preliminary specifications for a system to inject targets into a commercial reactor.

The Department of Energy formally evaluated KMS Fusion's performance after the conclusion of the 1976 contract and during the 1977 contract period. The Department of Energy stated that the 1976 target work exceeded contract requirements and showed considerable innovation. Work under the 1977 contract was characterized by the Department of Energy as satisfactory, in accordance with contract objectives, and demonstrating high competence in the art of target fabrication.

Laser system and laser-target experiments

KMS Fusion's performance under the 1976 contract was deficient in this area because its laser system failed to deliver power levels specified in the contract. According to KMS and Department of Energy officials, this problem resulted from specifying laser power based on calculations which could not adequately predict laser performance and from using dirty laser optical equipment.

Sophisticated computer codes for predicting laser performance were under development by the Energy Research and Development Administration's Lawrence Livermore Laboratory and, therefore, were not available when the KMS Fusion proposal was prepared and evaluated. The use of the more simplified

calculations resulted in contract specifications of laser power levels that KMS Fusion could not achieve. Subsequent use of computer codes by KMS Fusion indicated that the laser would only be capable of achieving about 25 percent of the power originally predicted.

KMS Fusion's laser was initially limited to even less than 25 percent of predicted power because clean laser components and a clean laboratory environment were not maintained. Foreign particles on the laser's optical surfaces decreased its potential power output. When it became evident that the laser system would not deliver predicted power levels, a considerable portion of the 1976 experimental program plan was redirected. KMS Fusion achieved about one-half the expected results using its laser system in experiments with a simple glass-shelled target. Experiments yielding better results were prevented by the laser system's limitations.

Much of the 1977 contract effort was spent analyzing, modifying, and cleaning up the existing laser system to increase the output power. This was done with the aid of Lawrence Livermore Laboratory staff and the Laboratory's improved computer codes for predicting laser performance. Efforts to improve the physical environment included enclosing the laser beam, environmentally controlling the laser enclosure, and establishing a facility for cleaning laser optical and mechanical equipment.

Department of Energy officials stated that the experimental work specified in the 1976 and 1977 contracts has been achieved to the extent possible with the low power laser system. This system delivered 1,015 shots and contributed to understanding laser-target interaction physics, developing several optical elements, improving target design, and more reliable diagnostics. After cleanup, the average laser power nearly doubled.

Laser fusion theory and the interpretation of experimental results

According to Department of Energy officials, the majority of specific tasks in the laser fusion theory work area were satisfactorily completed. In some tasks, delays were encountered because it was difficult to reconcile results KMS Fusion predicted with actual experimental results. A program to interpret the results of laser-target experiments was established and maintained under both contracts supporting the KMS Fusion experimental plan. In the 1976 contract, related tasks were integrated into the four major work areas. Under the 1977 contract, the interpretation of experimental results was established as a separate work area and it was defined and expanded.

The Department of Energy officials said that all tasks were satisfactorily completed and significant advancements were made in measuring products of laser-target interaction.

ROLE OF KMS FUSION

Department of Energy and KMS Fusion officials generally agree on the company's role in the national laser fusion program. Both believe that KMS Fusion should principally have a supportive role involving laser-target interaction experiments and target design and fabrication.

The Department of Energy's current plan assigns scientific feasibility achievement for laser fusion to the national laboratories. Using large, expensive laser systems, the experiments at the national laboratories are designed to achieve rapid progress. This may not fully answer significant physics questions which must be answered prior to commercialization. In many cases, the unknown physics of laser-target interaction can be investigated with smaller, less expensive laser systems, such as the one at KMS Fusion.

KMS Fusion is experimenting with different laser wave lengths and laser optics to achieve better and more understandable coupling of laser energy to the target. According to Department of Energy officials, most of KMS Fusion's work is supportive of the national laboratories instead of redundant. KMS Fusion is pioneering work in targets made of materials other than glass, such as plastic, in layering various materials on glass targets, and in freezing fuel to the inside of targets to obtain better performance. In the future, Department of Energy officials expect KMS Fusion to play a key role in commercial mass production of laser fusion targets.

KMS Fusion has submitted a proposal to the Department of Energy to increase the power of KMS Fusion's laser system (at a cost of about \$1.7 million) to--according to KMS Fusion officials--permit higher power experiments allowing better observation of laser-target interaction and more accurate extrapolation of results to theoretical higher power experiments. The Department of Energy has not yet acted on KMS Fusion's proposal for the upgrade and, KMS Fusion is currently working under an extension of its 1977 contract.

CONCLUSIONS

In a research program such as laser fusion, which is still at an early stage, many experimental approaches must be covered so that one or more will contribute significantly to rapid research progress and commercialization. KMS Fusion has

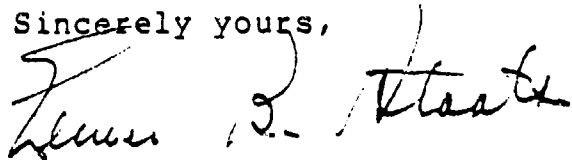
had a significant role in developing laser fusion energy and, according to Department of Energy officials and our consultant 1/ may be capable of making significant and unique contributions in the future. Our consultant reviewed KMS Fusion contracts and progress reports, compared the stated results with the Energy Research and Development Administration's formal evaluations, and discussed the findings with Department of Energy and KMS Fusion officials. He generally agreed with Department of Energy officials' conclusion that the failure to achieve predicted laser power during the 1976 contract is the only major instance of inadequate performance under KMS Fusion's contracts with the Energy Research and Development Administration and the Department of Energy. Our consultant agrees with the Department of Energy in that he believes that this should not affect KMS Fusion's ability to contribute to the laser fusion program in the future.

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We discussed these matters in detail with your staff in February 1976 and provided them with answers to specific questions previously furnished to us. We discussed a draft of this report with Department of Energy and KMS Fusion officials who agreed with its contents.

As agreed with your office, copies of this report are being sent to the Chairman, Subcommittee on Public Works, House Committee on Appropriations, Congressman Carl Pursell, and other interested committees and Members of Congress.

Sincerely yours,



Comptroller General
of the United States

1/ Our consultant has an engineering and physics background and has been involved in the laser fusion area since 1969.