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FINAL REPORT

OF THE

ARMY SCIENTIFIC ADVISORY PANEL

AD HOC GROUP

ON

PULSED REACTORS

NOVEMBER 1976

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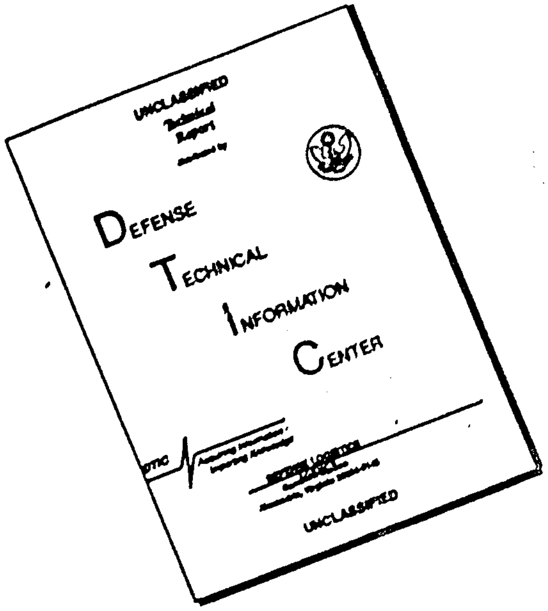

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Final Report

Army Scientific Advisory Panel
Ad Hoc Group on Pulsed Reactors

The Ad Hoc Group was asked to review the technical capabilities of the Army's two pulsed reactor facilities at White Sands Missile Range (the fast burst reactor (FBR)) and at Aberdeen Proving Ground (the Aberdeen Pulsed Reactor Facility)), and to review the technical considerations for a decision to close one, should that become necessary. We conclude that both facilities are operated safely, efficiently, and in a manner responsive to user needs; that the national workload is likely to be such that both should be retained for the foreseeable future; but that if only one can be retained, it should be the one most capable of supporting a high technology program; and that the APRF reactor is that one.

The Group visited both facilities for about one day each, and received good cooperation and informative, detailed briefings and tours at both. We also talked with the Test and Evaluation Command (TECOM) management at both sites, and visited the Harry Diamond Laboratories and its Diamond Ordnance Reactor Facility (DORF) reactor for added background. We carefully studied two basic review documents,* as well as scanning perhaps twenty back-up documents and publications. This amount of effort is not sufficient for a detailed study, but the basic features of the situation seem evident.

FAST BURST REACTOR CAPABILITY IS ESSENTIAL

The two fast burst reactors exist to provide a capability to help assess material, component, and system survivability/vulnerability in a nuclear environment. There are no nuclear weapons effects simulators that come close to duplicating threat level environments in all aspects. The fast burst reactors provide only neutron and gamma total dose, neutron pulse, and delayed gamma pulse environments. The reactors are used not only by the Army but by the Navy, Air Force, and others. The exposure levels provided by them are sufficient for threat level testing and vary depending on the system.

The classes of tests carried out at the fast burst reactors include:

(1) Advanced electronics components testing.

(2) Acceptance testing of finished hardware.

(3) Response mechanisms in propellants and optics.

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*A Study for Requirements for Nuclear Weapons Effects Research Reactors, prepared by Nuclear Weapons Effects Program Office, Harry Diamond Laboratories, dated November 12, 1975, and AMSTE-FA Letter, Subject: Harry Diamond Laboratories Reactor Study, dated November 28, 1975.

(4) Quality assurance for components or subsystems.

(5) Research on damage mechanisms, shielding factors, laser pumping.

(6) Neutron radiography.

(7) Some other miscellaneous work.

Most Army tactical systems in the past have required certification against integrated neutron dose only; however, new digital systems, because of synchronization problems and other complexities may be vulnerable to pulsed radiation with the time scale defined by application (i.e., speech, data transmission, secure voice), and by the nature of damage in the components. This will lead to increasing requirements for pulsed testing of Army equipment.

The pulsed reactors are only one of a suite of simulators required to assess vulnerability, such as electromagnetic pulse (EMP), flash x-ray, blast, and electron beam facilities. But without any pulsed reactor capability, vulnerability assessment would be virtually impossible.

BOTH REACTORS SHOULD BE RETAINED

The national capability for the kind of weapon effects simulation provided by these reactors has shrunk significantly during the last few years, with other facilities being closed or diverted/modified for other use. This now leaves only these two reactors with a direct, immediate commitment to fulfill the requirements. Energy Resources Development Agency (ERDA)-owned reactors could perhaps be reactivated or diverted from their current use, but this would be difficult to do. It is our judgment that the national workload will continue to require the use of both the Army reactors for vulnerability assessment, and it should be clearly recognized that use for non-Army programs is legitimate and necessary. Indeed, Navy and Air Force strategic system requirements are often more stressing and result in development of reactor capabilities which later benefit Army R&D and testing. Accounting and charging methods should be developed to provide for more nearly full cost recovery for non-Army projects. This would alleviate ambivalent feelings on the part of the reactor staffs about non-Army projects, and allow them to pursue their overall programs more aggressively and efficiently, thus benefiting all users.

The Army use of the pulsed reactor facilities could well increase. Our impression is that the Army will be placing greater emphasis on assessing the vulnerability of its already fielded systems. For current and future developments, the trend toward increased complexity of battlefield systems will probably continue, and this will mean increased need to carefully harden and assess vulnerability of these systems. A long list of systems under development which will require vulnerability assessments is included in the reference documents.

We observe that the expenditure involved in retaining both instead of one of these facilities is small on an absolute scale (a small staff with operating budget on the order of $500K per year), small compared to some other weapons effects simulation facilities, and small compared to the benefits gained in confidence in system operation in a nuclear environment.

Finally, shutting down a pulsed reactor may be an irreversible action. Such facilities are "different" from power reactors, and seem to have an unwarranted but widespread reputation for being only marginally safe. This will make it difficult to obtain a new operating certificate in the future, even if a reactor were only "mothballed". In view of this and of the uncertainties in predicting workload, we suggest that a decision to close such a facility be based not on workload projections, but on actual observed underutilization over a significant period. Shutdown and decommissioning costs are such as to delay realization of savings for several years, in any case.

An alternative to TECOM's operation of both reactors would be to assign operating responsibility for the APRF to the Harry Diamond Laboratories, either as part of Harry Diamond Laboratories' lead role in nuclear effects testing for the Army, or to operate the reactor as a DoD facility with major support provided by the Defense Nuclear Agency (DNA). This alternative would preserve the FBR for Army test requirements and allow better integration of the APRF into the suite of major nuclear effects tests facilities in the Washington area. The ad hoc group has not, of course, explored the willingness of DNA or Harry Diamond Laboratories to assume this responsibility.

RETAIN APRF, IF ONLY ONE CAN BE FUNDED

Our recommendation here is based heavily on our experience and views of the nature of the problem of vulnerability to nuclear effects. These effects are complex and hard to calculate. They cannot be well simulated, even in underground weapons tests, and especially not in combination. Consequently, confidence in vulnerability assessments and in hardening is not based directly on particular tests in simulation facilities, but on synthesis and detailed analysis of results, on interpolation, extrapolation, calculation, informed guess, and especially on the understanding by the designers of the damage and hardening mechanisms involved. Individual tests to specification levels are a necessary but very much insufficient part of this process. Stated differently, the real essence of nuclear vulnerability assessment is a continuing search for "Achilles heels," for new effects which may seem small in the simulator test, but may be very important in the combination of real environments.

This process depends on individual scientists and engineers developing even better understanding of the phenomena involved, and this certainly extends to those operating the simulation facilities. If only one reactor can be retained, it should be the one with the best and most versatile reactor staff, and with the facility best suited to a wide range of future reactor applications. In our judgment, APRF has the edge on both counts.

The APRF staff gave more evidence of detailed understanding of their reactor, its capabilities and functioning, and how to adapt it creatively to varied needs of users and customers. In fairness to the FBR staff, it should be pointed out that they chose to concentrate their discussions during our visit on cost matters, and on complementarity of the FBR and other WSMR test facilities. However, this choice of emphasis indicates in itself, a difference in attitude which bears out our judgments about the relative levels of technical competence.

It may be unfair to penalize the FBR staff for concentrating their efforts on cost and efficiency. These things are important -- their staff has been cut, and the FBR appears to operate with fewer people and, thus, possibly more efficiently.* Efficiency optimizations require special skills, too, but the criteria for choosing the single facility to be retained should be different from the criteria for judging performance of each if there are more than one. The one facility is the only facility, and technical capability must become more important than narrowly construed cost/effectiveness, especially since the nature of future requirements cannot be anticipated with confidence.

Our judgment as to the relative competence of the two staffs is formed of many indicators, some large, some small, and not all pointing in the same direction. Perhaps the most concrete indicator is the diversity of the projects undertaken by the APRF. They include:

(1) Modification of the core to accept the large glory hole -- a non-trivial change.

(2) Reactivity control by use of external neutron reflectors.

(3) Adaptation of the reactor for laser pumping experiments and corollary development of flux traps both inside and outside the core.

(3) Development of techniques to burn rocket fuel in the glory hole. This seems a real tour-de-force to us because the fuel burn influences the reactivity of the core, and that burn, being itself the object of the experiment, is not predictable. It also illustrates the diversity and changing nature of possible future requirements.

(5) Use of fission foils, in collaboration with National Bureau of Standards and the DORF staff, in accurate dosimetry.

Such things not only demonstrate versatility and expertise, but add to the rigor with which even routine measurements can be made.

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* We were unable to scrutinize the cost basis for the two facilities in sufficient detail to determine the validity of cost comparisons. The projects at the two facilities are sufficiently different that such measures as "pulses per person" may be misleading.

This is not to imply that the FBR staff are static and unimaginative. Creative adaptations of the FBR have also been performed. The difference between the FBR and the APRF staffs are not, by any means, overwhelming -- the FBR people are good, too. The differences are, to some extent, ones of interest and emphasis, and some result from management direction. But the differences seem real and significant for the issue at hand, and they favor APRF.

The differences in the facilities reflect the diversity and interests of the staffs. We will discuss the major ones here. On the whole, the differences which can be distinguished tend to favor the APRF. This may be because the APRF was built as a follow-on to the FBR, and some improvements were made in its design.

(1) Reactor operating limits, peak fluence, etc. The APRF design was tested to core structural failure at Oak Ridge during its development. These tests provide well defined limits for its operation and verify the calculations of its mechanical response. The design itself provides greater ability to withstand the stresses of high peak power pulses. APRF can pulse repeatedly at 1.7×10^{17} fissions, with a safe upper limit for occasional pulses above 2×10^{17} fissions. FBR can probably pulse repeatedly at about 1.5×10^{17} fissions.*

(2) Safety is adequate and comparable. Both reactors have had one incident during early phases of operation, and both deficiencies have been rectified.

(3) The larger glory hole in APRF provides both higher fluence for larger experiments and, perhaps more important, better uniformity across the larger experiments. It is not used in a large fraction of the exposures, but does provide added flexibility for special needs, some of which can be important. We would suggest that such capability be added to the FBR, but doubt that it can be done as easily as claimed by FBR staff. Doing the necessary careful design and checkouts extended over about two years for the APRF, and even building on their experience, it would occupy a substantial part of the energies of the limited FBR staff over quite some time.

(4) Background and scattered radiation in experiment area. There seems to be disagreement here, both facilities claiming a lower level, which is desirable. It appears likely that APRF has a lower thermal neutron background, which is important for reducing undesired activation, etc. The walls of its experiment area are much less massive and are farther away, and the floor is of borated concrete. Scattering from the reactor framework may be greater for APRF, but seems a less serious problem than that of thermals.

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* This comparison is preliminary. A carefully defined comparison requires some work to prepare. The differences are not great in any case.

(5) Personnel exposures at both sites are within acceptable guidelines. At APRF, one contractor technician received over 500 MR during the course of an experimental sequence. The exposure was within acceptable limits and warranted no intervention on the part of APRF staff.

(6) Proximity to other simulation facilities may favor the FBR for low level, more routine work, but the APRF is closer to a larger variety of large machines. Thus, APRF is somewhat more convenient for doing really difficult and challenging vulnerability testing. The FBR staff is more intimately connected with the other facilities close to it, many individuals being cross-trained for operation of EMP, FXR facilities, etc. This advantage may not be as great as it may appear since, in general, the entire complex of simulators associated with FBR seems understaffed to us. To fully realize even the potential advantages of its situation would require substantial augmentation of the FBR and Nuclear Effects Branch staff. Proximity of APRF to Harry Diamond Laboratories, which is the Army's lead laboratory for nuclear effects R&D, should be an important factor in integrating its work into the Army's effort.

(7) Security plans seem to be progressing adequately at both places. The FBR seems to have complied more quickly with stated requirements, while the APRF staff are implementing a plan developed by them and specially tailored to their site. The relative isolation of the FBR has an uncertain effect on security. In general, if both sites comply with their requirements, having two reactors rather than one does not appreciably add to the risk. We doubt that closing one site would result in funding or other actions which would increase the security of the other appreciably.

(8) The mobility of the APRF seems to us to be an advantage. It allows quick access to an experiment after the burst. It allows a cleaner experiment geometry for simulating free field exposures. The advantage of APRF's multiple experiment stations are real, but more subtle. It seems true that only very occasionally do more than one outside experimenter use the facility simultaneously, but the APRF staff itself do appear to use the several areas simultaneously to develop reactor modifications or techniques which can later be used by experimenters. This seems to us an important function of the reactor staffs, and it appears to receive more attention at APRF than at FBR, partly because of the mobility of the reactor.

On the whole, these comparisons favor the APRF, especially if the criterion for selecting one facility is that it be as flexible as possible and best able to contribute to long term advancement of the national capability in vulnerability assessment.

ADDITIONAL COMMENTS

While we were not asked to address the DORF facility, it appears to us that if any of the three reactors should be closed, DORF is the logical candidate. Its staff and capabilities appear quite good, but much of the work could be done at the pulsed reactors, and there are many triga-type reactors available nationally -- the Armed Forces Radiobiology Research Institute reactor being one. To close one of the two remaining useful pulsed reactors while retaining a triga-type would be inappropriate.

We are concerned that TECOM, with its emphasis on validation testing rather than research, will not support the leavening of "researchy" projects at either reactor necessary to retain long term competence. We suggest that TECOM give assurance of support for such work to the reactor staffs, and take steps to strengthen this aspect of their work, especially at the FBR.

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A review of the technical capabilities of the Army's two pulsed-reactor facilities at White Sands Missile Range and Aberdeen Proving Ground was performed and recommendations made on technical considerations in the event closure of one or more facilities is directed.

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