CLANDESTINE DIVERSION OF SOURCE NUCLEAR MATERIALS IN A POWER REACTOR

William E. Hoehn

June 1967

P-3618

8

CLANDESTINE DIVERSION OF SOURCE NUCLEAR MATERIALS IN A POWER REACTOR

William E. Hoehn*

The RAND Corporation, Santa Monica, California

I am delighted to have the opportunity to participate in this Symposium, not only because of the impressive list of distinguished participants, but also because this Symposium is a manifestation of a spreading of the already great interest and concern at the policy-making level in the development of more effective systems of safeguards.

This spreading interest and concern has served to stimulate research on safeguards problems -- some results of which have been summarized by previous speakers -- but the principal thrust of this research has been essentially in the direction of increasing our data-gathering and interpretation capabilities. In the course of reviewing our present and prospective capabilities to detect diversion from reactors, I intend to raise questions concerning the incentives for diversion, the returns from limiting diversion opportunities, and the appropriate level of costs that we should be willing to incur for various systems.

Predictive methods and nondestructive measurement techniques in the past have been subject to sufficient inaccuracies that the detection of diversion by cross-checking reprocessing results would have been subject to considerable uncertainty. With the exception of

---

*Any views expressed in this paper are those of the author. They should not be interpreted as reflecting the views of The RAND Corporation or the official opinion or policy of any of its governmental or private research sponsors. Papers are reproduced by The RAND Corporation as a courtesy to members of its staff.

This paper was prepared for delivery at a Symposium on Safeguards Research and Development to be held at Argonne National Laboratory, Argonne, Illinois, June 26-27, 1967.

highly enriched uranium, all of the materials of interest are formed through neutron capture processes, so that a wide variety of materials and methods is potentially available to a would-be diverter. The possible materials include plutonium, uranium-233, and tritium. The methods would include variants of diversion of a part of the fuel normally used in the reactor; or diversion of material inserted into the reactor in addition to the normal fuel loading; or diversion of neutrons that would ordinarily be lost through leakage or through non-productive captures; or, of course, a combination of these methods. The basic reliance in any potential method is on the uncertainty in predicting reactor performance.

Against this variety of possible methods, the detection system consists of visual inspection of reactor intervals and fuel elements, theoretical calculations of burnup, and nondestructive testing measurements. The theoretical calculations of burnup and the scanning results can then be compared to reprocessing results when the latter become available. Unfortunately, the reactor calculations and the nondestructive testing calculations are still somewhat lacking in precision, and the reprocessing results are available only for a batch of fuel elements. The reactor operating data, the reprocessing data, and the data on initial fuel enrichment composition are all subject to errors or to deliberate misstatement, as the inputs are supplied by parties that must prudently be deemed adversaries. Moreover, there is as yet no indication that reprocessors are willing to be judged by what the computer says should be in the fuel rather than what is actually found in the initial assay.

Several potential methods of diversion have already been identified and safeguards countermeasures to each such scheme have been developed, but the basic problem is that no one knows for certain whether some other diversion methods may have been overlooked. I assume that bank examiners regard their methods as relatively foolproof and yet every now and again another embezzler is tripped up -- often more by accident than by the functioning of the examination system. Of course the embezzlement problem is somewhat less complex both because the material diverted -- money -- is readily measurable, and because the embezzlement conspiracy is usually one person or a few individuals, and does not involve officials of the bank. Even so, we have little idea how many embezzlers are currently operating undetected.

The moral to be drawn from this allusion is that no system of reactor safeguards can be considered truly foolproof unless measurement and prediction inaccuracies are eliminated -- and that is only a necessary, not a sufficient, condition.

However, I would like to suggest that a foolproof reactor safeguards system, although desirable, may not be necessary when the incentives for diversion are considered.

In his letter of invitation to this conference, Dr. Seaborg states that "... plutonium will be produced in nuclear power reactors throughout the world by 1980 -- if our projections are correct -- at the rate of more than 100 kg. a day." Although I am more than a little skeptical of the bases on which such forecasts have been developed, it is evident that a diversion of as little as 1 percent of even a smaller plutonium production rate accumulates a substantial stock of material. Nevertheless, the mechanical application of percentages to global production figures overstates the nature of the problem. Dr. Seaborg more nearly delineated the problem when he indicated our aim would be to develop methods "with a precision and accuracy sufficient to ascertain whether strategic quantities of nuclear materials could have been diverted to military uses." The operative word I would judge to be "strategic."

On this basis, the problem of safeguards in the nuclear nations -- the U.S., the U.K., and France -- may be viewed as of secondary interest, largely to be handled by disincentive systems such as those proposed in the Lumb Report. This is merely a recognition that, so far as reactors are concerned, more stringent provisions may be needed to guard against possible diversion by a well-organized group operating with tacit or implicit government or military support than are needed to guard against a lesser conspiracy of a few individuals motivated by personal gain and operating contrary to the desires of government and the military. This proposition is largely due to the inconvenient form of material diverted from power reactors, and would be much more dubious in regard to reprocessing plants.

Among the remaining Nth countries outside the Sino-Soviet bloc, the most highly industrialized are distributed around the periphery of the Soviet Union itself. To satisfy the requirements for a strategic force to deter so powerful an adversary calls for a highly ambitious weapons program, as the British and French have belatedly discovered. That ambitious program would have to include an extensive materials acquisition effort. As an example, consider the case of West Germany, for which the Arthur D. Little "high" forecast assumes an installed capacity of 9,000 megawatts by 1975. At a plutonium production rate of 0.2 kg. per megawatt-year, reasonably typical of values given the present burnup projections, the annual production of this program would be about 1800 kg. of plutonium. Even if it were possible to divert as much as 5 percent per year, this would represent no more than 90 kg. diverted to weapons production. At the traditional estimate of 5-10 kilograms per weapon, this is sufficient for fewer than a score of nominal weapons per year. This rate would be so out of proportion to any reasonable estimate of West German strategic requirements, that a program based on clandestine diversion from reactors would be measured in decades. This of course abstracts from the further problems of covert reprocessing, weapons design and delivery, and the like. Since the forecast of German capacity is the largest of all the Nth countries, the above calculation represents an upper limit to the near-term potential for diversion.

Although the ultimate capability of the Chinese cannot yet be foreseen, the above assessment might well apply to a potential Japanese or Indian weapons program designed to serve as a deterrent to China.

This leaves for consideration a small group of countries involved in various regional disputes. These third-area conflict situations, by the very nature of the existing armed forces, are such that one or a very few nuclear weapons on either side would constitute a considerable strategic force. We have just staggered through an exceedingly trying period in the Middle East, and it is clear that possession of nuclear weapons by any of the parties to that conflict would have made that crisis far more dangerous.

Even for a country in a third-area confrontation, however, clandestine diversion of strategic amounts of material still requires an installed nuclear capacity large in relation to present generating capacities. Five hundred megawatts capacity would produce annually some 100 kg. of plutonium; again assuming that as much as 5 percent could be diverted without detection, this amounts to only 5 kg. per year, barely at the threshold of usefulness. The only third-area conflict country with plans at present for capacity of this magnitude is India, and my somewhat heretical view is that prospects for the spread of nuclear power plants in third-area countries are not good, given a thorough economic analysis. In fact, I have yet to review a proposed nuclear project for an underdeveloped country in which the nuclear alternative should have been preferred on competitive economic grounds. This then suggests that to the extent we are able to control the urge to assist a country's economic development by means of special subsidization of nuclear projects, third-area safeguards problems are unlikely to become markedly more complex or extensive than they are at present. Moreover, the technological backwardness of most of the third-area countries suggests that they could not develop a nuclear materials and weapons capability without substantial outside assistance.

This brings me to a final topic which, like an hereditary defect in the family line, is mentioned only in a whisper, if discussed at all. This topic is the open diversion of a complete fuel loading. We have noted that 500 megawatts of capacity produces roughly 100 kg. of plutonium per year, but the amount in the complete core would be still larger. Such an amount clearly would be of strategic importance to a third-area country; indeed, even smaller installed capacities would have sizeable inventories of plutonium. Moreover, in contrast to the degree of leverage that can be exerted against countries using enriched uranium, there would be little direct cost associated with total diversion from natural uranium systems. This, of course, makes the natural uranium system attractive as an option-preserving strategy, regardless of the small economic penalty thereby incurred.

My purpose in raising this unpleasant prospect is to point out that clandestine diversion is not the only alternative available to a country, and that a country which carefully evaluates its potential future need for nuclear materials might well regard the slow and anxious process of clandestine diversion and stockpiling as inferior to merely maintaining a ready source of materials.

I have repeatedly used a 5 percent diversion rate in my examples above to suggest that even with this large a leakage, the accumulation of materials in strategic quantities is painfully slow. I am inclined to believe that a relatively uncomplicated and inexpensive reactor safeguards system using little more than present material balance and inspection/verification techniques is at least this accurate, and probably better.

By way of summarizing the assertions and implications of viewing the reactor safeguards problem in this way, we may note the following points.

First, the current safeguards methods lack the necessary discrimination to determine, in the absence of direct evidence, that small diversions from power reactors occurred. Furthermore, there is no assurance that all of the potential methods of diversion have been identified and countered.

Second, in contrast to the slow and risky course of covert diversion, an alternative solution to the problem of materials acquisition might well be the open renunciation of safeguards and diversion of a complete core loading at a future date. These two points taken together suggest that the incremental benefits from marginal improvements in the safeguards system will not be large, so that the cost we should be prepared to incur to gain that improvement would be small.

There is not much point in paying for redundant locks on the front barn door if the door in the back of the barn is to be left wide open.

Third, the accumulation of strategic quantities of nuclear materials through clandestine means appears unattractive (and possibly infeasible) for any country which wishes a nuclear force to deter the Soviet Union or, probably, China. This means that the incentive for clandestine diversion from reactors is likely to be greatest for countries involved in third-area conflicts.

Fourth, the evaluation of the differential incentives and strategic requirements among countries suggests that the most cost effective application of scarce safeguards resources -- and anyone who has reviewed the IAEA's budget will recognize the aptness of that description -- is through a discriminatory system rather than one which concentrates equal effort on similar reactor facilities in all countries. This would free resources for safeguards functions at other facilities than power reactors and for research on some of the other pressing problems in efforts to limit the spread of nuclear weapons.

Finally, this analysis depends on each Nth country perceiving in an accurate and unambiguous manner that its strategic requirements would be poorly served by the mere possession of a few critical masses, however obtained. This will require a change in attitude in certain areas, wherein much of the dialogue has tended toward hand-wringing and other unhelpful reactions that can only reinforce an Nth country's belief that the possession of nuclear weapons in however small numbers is a desirable goal. We need much more forcefully and openly to set forth factual information about the enormous costs -- monetary and otherwise -- associated with attempts to secure nuclear weapons. We must endeavor to make plain to Nth countries that nuclear weapons, after all, are not some sort of treat that the big powers are trying to keep out of their grasp, but rather are a powerful drug that may produce dangerous and unpredictable side-effects in anyone who would take it.