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MINUTES OF MEETING OF MTA TARGET COMMITTEE HELD JUNE 11, 1951

Russell H. Ball

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RESEARCH SERVICE BRANCH
Atomic Energy Commission
Berkeley Area
Berkeley, California

MINUTES OF MEETING OF MTA TARGET COMMITTEE
HELD JUNE 11, 1951

Present: UCRL: Alvarez, Brobeck, Brown, Dimmick, Hanson, Kane, Latimer, Lofgren, Martin, Newson, Reynolds, Street, Van Atta, Wallace

CR&D: Crandall, Frankel, Wyatt

AEC: Ball

N.A.A.: Taylor

Kane said that several months ago an interest developed in the possible use of NaK as a coolant for the primary target. Its advantages are its apparent lack of corrosion problems (the possibility of using primary target material unclad), good heat transfer properties combined with high boiling and low melting points, and radiation stability. Last March Brobeck, Gaylord, and Kane visited a number of installations having NaK systems. It appears that pumping, circulation, and container problems have been solved for NaK systems somewhat smaller in size than we will require.

Layouts have been made of a number of alternative target arrangements for the purpose of evaluating the applicability of NaK cooling to specific designs. For purposes of this study a graphite lattice and a 100-milliamp 350-Mev deuteron beam and a target 8 feet in diameter have been assumed.

The first scheme has both the primary and secondary targets contained within the vacuum envelope which is an extension of the beam tube from the accelerator. Both targets are NaK cooled and provision is made for the removal of both targets out the hole through the lattice. The operating procedure for target removal would be to continue NaK circulation for approximately one hour after shutdown to permit the decay of the shorter-lived activities. A crane would then remove a section of the beam tube, leaving a space into which the target assembly could be rolled. A handling truck containing helium cooling equipment of about 0.2 megawatt capacity would then approach from the side. Gravity drain would then be used to remove the NaK from the cooling system, following which helium would be circulated through the cooling tubes. The entire target assembly, together with the helium cooling system, would then be wheeled into a shielded room for processing. The slug removal process would be similar to the Chalk River arrangement, where the slugs are removed through a shielded breach to a coffin.

One disadvantage of the above target arrangement is that it requires NaK cooling of the secondary target, a location where such an efficient coolant is not required, whereas one of the main advantages is the relative ease with which the terminal section of the vacuum envelope could be replaced since the entire target assembly is removable.

A second target arrangement is one in which the target material is contained within a vertical array of tubes supplied by the NaK coolant through a header at the bottom and removed through a header at the top. To avoid having NaK in contact with the vacuum seal, the level of the NaK in the top header would be about 6 inches below the flat plate comprising the upper surface of the top header. The atmosphere above the NaK would be helium.

In answer to a question by Lofgren, Kane said that the gasket material could be soft iron, aluminum, or lead, but that some development work will be required to obtain a satisfactory gasket system for this target arrangement. Lofgren said that he has had experience using lead and gold gaskets and that lead requires spring loading to maintain a satisfactory seal. He said using a gold gasket, the bond between the metal and gasket approaches that of a weak solder joint because of the diffusion of gold into the adjacent metal surfaces.

A third target variation is to restrict the NaK cooling to the primary target. To accomplish this the primary target alone is placed within the vacuum envelope and the secondary target is water cooled with the cooling leads being supplied through the lattice. The assumption has been made that the secondary target thickness is 12 inches. It is also assumed that the uranium can be contained within aluminum rather than steel tubes.

This permits a reduction in the neutron loss to the containing material. The amount of NaK required is reduced somewhat by eliminating its use in the secondary target. In this arrangement the valves for control of the NaK and for the changeover to the helium system after shutdown are shielded by a movable wall which can move with the primary target during its removal from the lattice. This arrangement will permit manual rather than remote control of these valves. The change-over procedure from the NaK to helium cooling is similar in other respects to the system first described. The production in the lattice is not materially reduced below that of the first case described because production slugs can be inserted in the secondary tubes where they interrupt the lattice.

Since physical removal of the entire primary target involves considerable difficulty and expense, systems free of this limitation have also been studied. The first target arrangement of this character is one in which both the primary and secondary targets are within the vacuum envelope and the vacuum tank is in the form of a T, the long leg of which is an extension of the beam tube. The ends of the cross bar of the T are extended into an area relatively free of radiation where they are accessible for repairs. The processed slugs may then be removed vertically through the free surface of NaK at the end of the upper cross bar of the T. This system offers the advantage of never requiring the breaking of a NaK joint in normal operation. To facilitate slug removal the rate of NaK circulation may be greatly reduced over that required during normal operation since the heat load one hour after shutdown is less than 1% of the operating heat load. This system has the disadvantage of introducing a large amount of stainless steel into a high flux region of lattice.

Another variation of this theme is to use a T-shaped vacuum system but include only the primary target in the vacuum. The secondary target tubes would then be water-cooled and handled as in the previous case, while the slug removal from the primary target would again be accomplished by removal through the free surface of NaK. These arrangements in which the primary target is not removable as a unit offer the disadvantage of greatly complicating repair or removal of the end section of the vacuum envelope in case the need for such an operation should arise. The vacuum tube could be removed by draining out the NaK, cutting the process tubes out individually, then using remotely controlled cutting torches to free the vacuum chamber. The installation of a new vacuum tank section would be very difficult. One solution, however, may be to dissassemble a portion of the lattice and it may be desirable to design the lattice with the possibility of this dissassembly in mind. If it is not possible to dissassemble the lattice the new section of the vacuum tank could be put in place by the use of gasketed rather than welded joints.

Still another variation in design would have only the primary target within the vacuum system and provide for the removal of the primary target laterally through a hole in the lattice. A secondary target would essentially be a part of the lattice and would be water-cooled. This system has one big disadvantage--that one loses an appreciable fraction of the lattice volume to permit the lateral removal of the primary target unless one uses bayonet type tubes. This system was not considered worthy of further consideration.

The process of removing the target arrangement through the beam hole could be simplified were it possible to mount the entire NaK cooling system on wheels so that the entire target-cooling system could be moved as a unit. A sketch of such an arrangement was made, from which an estimate of the weight of the NaK cooling system of 220 tons was obtained. Such a system is therefore feasible.

Concern has been expressed recently regarding the loss of neutrons out the lattice hole. It would be possible to line the beam tube immediately outside the lattice with absorbent material and thereby reduce the neutron loss from this source. These losses can be reduced to any desired value providing one is willing to pay the cost of adding the absorbing blanket. In the case of tritium production this method would be particularly feasible because the resultant heat load would be very nominal.

Studies have been made of a lattice design which will permit disassembly. These studies have assumed the availability of a 30-ton crane and have resulted in a lattice 16 x 16 x 21 feet which involves between $\frac{1}{2}$ and 1 ton of stainless steel in the lattice support structure. In this target the graphite moderator and reflector are supported from the iron thermal shield at the top of the reactor. Brobeck pointed out that the weight of stainless steel required is essentially independent of the method of supporting the lattice. Wyatt said they have found it will be possible to utilize the structural strength of the graphite itself to support the graphite longitudinally and thereby avoid the use of any steel within the lattice in regions of high flux. Alvarez suggested that the roof of the lattice be built in the form of a self-supporting arch in order to remove its weight from the load which must be supported by the thermal shield.

Kane said that he is rather well convinced that a NaK system is feasible. The question remaining is whether the additional cost of a NaK system is worth the advantages obtainable. A possible exception to this viewpoint would be the consideration of the additional hazards presented by NaK in the event of a severe accident or sabotage.

Newson said that the design of a Mark II target is similar in many respects to the design of a pile--the main difference being that the target is subsidiary to an accelerator. One can classify target designs as being the model "T", "A", or "V", in analogy with the designation used for the Ford automobile. Thus, the model "T" target would be a temporary solution, and the model "A" a more conventional but still inefficient design, while the model "V" would be an essentially optimized design. A model "T" design would be quick, cheap, disposable, and inefficient, but would serve as a workable target for an interim period while the art develops to permit of a nearly optimum design. In considering the design of a target one has available 4 materials for the primary target and 3 or 4 coolants. In considering the design of model "T" target one is led to the selection of water as a moderator and coolant since it is inexpensive and a good neutron moderator, although it does have the disadvantage of an appreciable capture cross section. Using a lithium water system one would take at least a 3% neutron loss and even then one is required to use a high lithium concentration relative to water, which results in a high degree of product dilution. One possible model "T" design would be to place the target assembly in a deep canal of dimensions such as to provide for about 20 feet of water above the assembly and a minimum of about 5 feet on the other 3 sides. This arrangement would permit workers to observe the dismantling procedure through the water from the top of the canal without additional shielding and would prevent the steel walls of the canal from becoming highly radioactive. Newson estimated that the cost of portions of such a target arrangement which would be disposed of as about one megabuck. He said the cost of the uranium or thorium in the target is not considered in this figure since it is assumed that the operating life of the target would be at least one year, at which time one has made full use of the thorium or uranium contained. The target material would be placed within boiler tubes passing through the vacuum envelope and the secondary target could be placed either inside or outside the vacuum. Newson said that it might be desirable to load the lattice with lithium slugs out to low flux regions and to use the slugs from the low flux region to reload the high flux region after the discharge of the latter. A similar advantage might be obtained by placing lithium around the beam tube for exposure to a low flux followed by the use of such slugs for loading the high flux region.

Newson commented that the possibility presents itself of using liquid lithium as both primary target material and coolant in an optimum target design. Another possible system would be to deflect the beam downward upon the surface of a free pool of lithium. Van Atta pointed out in a model "A" target the cost could be considerably reduced in the case of tritium production by the substitution of air cooling for water cooling of the lithium slugs.