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PRODUCTION TEST 234-5-2-MS

Evaluation of the A331 Crucible or Modification Thereof for Routine Use as a Reduction Crucible on the Remote Mechanical Line

Introduction:

In the production of plutonium in the 234-5 Building, plutonium tetrafluoride is reduced by calcium in a closed reactor at elevated temperatures. A magnesium oxide crucible inside the reactor contains the charge, and prevents impurities from entering the plutonium through contact with the metal walls of the reactor.

After reduction, the reactor is cooled to a safe handling temperature, and the charge and crucible are removed. Since the crucible is porous, it adsorbs some of the plutonium. The crucible fragments as well as the slag are stored for future processing which will involve dissolving the fragments and recovering the adsorbed plutonium.

The RG line uses a slip-cast crucible designated as A331. It has given satisfactory service in the RG equipment and presents no outstanding handling difficulties. The RMA line uses a moulded crucible designated by Sol which has twice the wall thickness and weighs about a kilogram more than the A331.

While this crucible has given satisfactory service under RM conditions, it is less desirable than the A331. Its smaller internal volume limits the size of the reduction charge which may result in lower yields and increased booster ratio requirements. Its larger weight and wall thickness make both removal of the charge after firing and breaking the crucible up into fragments more difficult and increases the space required for fragment storage.

Before RM start-up, the A331 crucible was tested in the RM equipment, in a dry run and in a uranium stand-in run, with unsatisfactory results. Since these tests were not performed under conditions that now exist in RM line operation, it is believed that they did not evaluate the crucible for RM line use. It is proposed that additional tests under RM line conditions be made on the present A331 crucible or on a modified version of the slip-cast crucible.

Objective:

The objective of this test is to evaluate the A331 crucible or modifications thereof with respect to its use as a reduction crucible on the RM line. Adoption of this crucible should result in improved reduction conditions, easier charge removal, and a reduction of waste materials for the recovery stream.

Basis:

Prior to the reduction step on the RM line, the reduction equipment is assembled by inserting the crucible into a thin-walled metal can. The annular space between the walls of the crucible and the can is packed with sand. This assembly, called a "can-pack", is placed on a furnace base and a charge, consisting of a mixture of plutonium tetrafluoride, 70-58, calcium, iodine and plutonium turnings from previous machining operations, is added to the crucible and tamped or vibrated to make it more compact. The assembly is then sealed into a furnace by hydraulic pressure on the furnace base, and the furnace is purged with argon and heated until the reduction reaction takes place. After the furnace has cooled, the can-pack is removed from the furnace to the cutting station. There the can-pack is gripped in the jaws of a vise and the can and crucible are cut off at a point just above the button. The button is then removed and the slag and crucible are broken into fragments and stored for future recovery of plutonium.

In one of the dry runs that were made prior to start-up, a can-pack containing an A331 crucible was put through this procedure except that a charge was not included. When the can-pack reached the cutting station, the vise jaws collapsed the can-pack before the cutter could operate.

Also prior to start-up, one of the uranium stand-in runs utilized a can-pack with an A331 crucible but with no sand between the metal can and the crucible. When this charge was fired, the crucible broke and molten uranium pierced the metal can and eroded away part of the furnace base. A low melting eutectic of iron and uranium was believed to be responsible for this erosive action.

The A331 crucible was temporarily dropped from usage on the RM line on the basis of these unsatisfactory results.

[redacted]

It is believed that the inclusion of a charge in the A331 assembly will strengthen the assembly enough to resist the crushing action of the vise jaws. Additional strength may also be obtained by increasing the wall thickness of the crucible. This can be done without sacrificing the advantage of a substantial reduction in weight from that of the S-1 crucible.

The inclusion of sand packed into the space between the crucible and the metal can will give added mechanical support to the crucible and may prevent molten metal from reaching the can if the crucible cracks during firing. It is believed that the thick-walled S-1 crucible has cracked during production runs without adverse results. The A331 crucible has been satisfactory under similar conditions on the RG line and is being used routinely for production by that line.

It is concluded that a re-evaluation of the A331 crucible on the RM line is justified.

One objection to the use of the A331 crucible in its present form is that the metal button that it produces must be pounded to reduce its diameter enough to permit it to go into the melting crucible used in the subsequent casting operation. Increasing the crucible wall thickness from the present 3/32 inch to 3/16 inch for added mechanical strength would also reduce the diameter of the button. If necessary, the shape of the bottom of the crucible could be modified to provide a suitable button diameter.

Advantages to be gained by use of the A331 crucible are as follows:

A. Process

1. Since the A331 crucible has a larger internal volume than the S-1, its use would be a step toward the still larger sizes required for reduction casting.

2. As a larger reduction charge is made possible by the use of a larger crucible, better reduction yields may be obtained, and the ratio of booster to charge may be reduced.

3. The weight of ceramic required for the crucible will be reduced by 700 grams if the crucible wall thickness is 3/16 inch, 1000 grams if the wall thickness is 3/32 inch, and 1200 grams if it is found that a 1/16 inch wall is feasible. This should mean less loss of metal to the crucible and less material to dissolve in the recovery operation.

B. Operation

1. Standardization with respect to reduction crucibles will be obtained between the RM and RG lines.

2. The thinner-walled crucible may be easier to unload from the can-pack after firings and easier to break up for storage for recovery. The crucible fragments will require less storage space.

C. Economic

Estimates of the cost savings which should be obtained by replacing the S-1 crucible with the A331 are as follows:

1. Direct cost of crucibles - none.

2. Decreased storage requirements and greater handling efficiency - $2.70 per charge.

3. Recovery of product from crucible fragments - $6.00 to $12.00 per run, depending on whether the feed to Recuplex is primarily Purex or Redox material, respectively. (The A331 will permit more batches of slag and crucible fragments to be charged per dissolver batch.)

In addition, some indirect savings, in the form of a reduced cost per unit of product, should be obtained when the capacity of the reduction step is increased by reason of the larger volume of the A331 crucible.

Procedure:

This Production Test will not require any changes in the procedures normally used in the RM line except that the A331 crucible will be substituted for the S-1 crucible when the can-pack is made up. All materials processed or produced under this test will be handled in a routine manner.

Data:

The following observations are needed to evaluate this test:

1. Observation of the can-pack and furnace base after each reduction, to determine the condition of the can-pack after firing.

2. Observation of the performance of the can-pack at the cutting station to determine whether the crucible withstands the pressure of the vise jaws.

3. Observation of the relative ease with which the button and slag can be removed from the can-pack and the crucible broken up into fragments after firing.

4. Observation of the relative volume required for storage of the crucible fragments.

5. Observation of the suitability of the buttons produced for introduction into the casting operation without non-routine processing.

Schedule:

Fifteen test runs using the A331 crucible or modifications thereof as required will be made. The test should be completed within one month after the test is approved.

[redacted]

Responsibilities:

The Process Unit will be responsible for making the observations and analyzing the results. The Operations Unit will be responsible for scheduling and performing the test runs. Test crucibles will be supplied by the 234-5 crucible shop. Conclusions will be drawn jointly by the Operations, Technical, and Process Units. A completion report will be issued by the Process Unit following the evaluation of results.

Issued by John M. Young
Process Unit

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