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CHANNEL CAULKING TESTS - C REACTOR

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Mechanical Development Unit

and

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March 19, 1965

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PT-IP-759 - CHANNEL CAULKING TESTS - C REACTOR

INTRODUCTION

The graphite movement which has occurred at the various reactors has been characterized by two problems: (1) Crooked channels and (2) cracks and miscellaneous voids where pieces of blocks are missing. Of these problems, the cracks and voids have been the most serious in the case of ball drops. Alleviation of the crooked channels can sometimes be accomplished by graphite removal methods such as broaching, but unless some method is found to prevent the balls from entering cracks, the total effect of a ball drop would still be intolerable. Of the two methods of closing the cracks, a paste caulking procedure is anticipated to be less expensive than sleeving, both in terms of cost of the operation and the number of process tube channels which might be lost. If the VSR channel does not require drastic straightening or entry of large tooling, satisfactory caulking can be done without removal of the step plug.

"Poison" chain may be considered as an alternative to caulking or sleeving for those outer VSR channels where the sole use of balls is for "total control" rather than "speed of control".

OBJECTIVES

The objectives of this test are (1) to authorize the experimental crack filling of one or two of the VSR channels at C Reactor with a wet mixture of graphite and sugar, (2) to demonstrate the durability of this mixture in subsequent normal reactor operation, and (3) to demonstrate by testing (actual or simulated ball drops) and borescoping, that the channels are or are not again acceptable for use with the normal charge of balls.

TEST SUMMARY

The experimental channels will be caulked in the manner demonstrated in the 195-D test tower (as described in the Detailed Procedure, routed with this document as an unclassified appendix). The mixture will contain approximately 6 percent sugar mixed with dry, crushed graphite and sufficient water to give the desired workability. It will be poured down the hole on top of a chain fill until the active zone depth of the mix is 6 to 8 feet, resting directly on top of the chain. Void filling will progress gradually downward through the VSR channel as the chain is slowly removed from the top. In the "active zone" the mixture will be forced into the cracks by means of an electrically driven vibrator (of a type commonly used with concrete), also suspended down the hole and operated in the graphite paste above the chain. The channel selected for the first test is intended to be one in which no problems except cracks exist. That is, unusually crooked channels and channels with small projecting broken block ends are not desirable for the initial phase of this program. Also, the channel chosen should have an

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open ball exit so that the normal ball exit system and ball washer can be used to assure easy and safe disposal to the contaminated sewer of excess material at the end of the operation. The present cask facility can be used for stray balls and other small items which may not be desirable to bring to the top of the reactor.

BASIS AND JUSTIFICATION

Many of the channels which have been borescoped in the K or C Reactors have shown some degree of voids in at least the upper half. The lower 10 to 15 feet of most channels appears to be reasonably tight and undisturbed. Where graphite movement has taken place, not only are the channels crooked, but cracks and gaps as wide as 2-inches have been observed. The mock-up tests have shown that it is possible to fill all such cracks with a graphite paste material which will harden and char with reactor heat. Though the final product is not as firm and dense as the original graphite, it is at least hard enough to withstand the prodding of a sharp pencil point and will stick to graphite blocks after heating, as demonstrated in the test samples irradiated in late 1964. Commercial granulated sugar contains such a low level of impurities that irradiated graphite coupon holders have shown higher radiation levels than the sugar mixtures they contained. Aside from sugar and moisteners, the mixture will contain only graphite, crushed to a maximum size of approximately 1/4-inch, together with such finer material as is generated during the crushing operation. After the channel has been caulked, the operating heat of the reactor will char the sugar binder, and the mixture will adhere to the graphite in the manner demonstrated by the test coupons which were irradiated. Though some shrinkage may occur in time, cracks which have been filled flush with the channel wall and laterally to a full depth of 1 to 4 inches will leave no cavities in which balls can be irretrievably lost.

The basic justification for the use of caulking in VSR channels can be summed as follows:

1. Caulking may well be the cheapest method for filling the cracks.

2. There are no irreversible decisions inherent in caulking which would interfere in any way with sleeving of the VSR channels at a later date. With respect to the prospect of further graphite movement over a period of years, re-caulking can be done when desired.

3. It will be necessary initially to remove as many as possible of the stray balls which have been observed in the channels. This itself will reduce reactivity enrichment requirements to some extent at the reactors, and may provide sufficient financial justification to pay the cost of the caulking.

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HAZARDS

Of the hazards connected with the caulking operation, that which is considered most serious is stray radioactive balls which can be missed in the magnet sweep prior to caulking, and which could be accidentally brought up during the caulking operation. To cope with such balls, and/or other moderate contamination which may be withdrawn from the channel, specific equipment will be used to limit contamination spread. Typical of these is that applied to the chain during withdrawal. The chain will immediately be funneled into a basket in the center of a barrel of water. The water will act as a radioactive shield, prevent surface drying of material which has been inside the reactor, and will minimize graphite dust contamination around the top of the unit. Just prior to the caulking operation, it is desirable to wash the channel with a water spray to minimize the graphite dust and broken chips which may be present on ledges and in cracks where stirring and agitation of the chain and vibrator might cause such material to come to the top.

Another hazard which has been anticipated is the possibility that a ball exit channel cannot be maintained completely open at the bottom. C and K Reactors were designed with bottom openings, and this path provides a convenient means of removal of excess caulking paste and ensures the appropriate disposition of the material washed from the channel prior to caulking. The hazard of a loose piece of a graphite block becoming dislodged during the operation will be minimized by pre-filling the channel with chain and by selecting a channel for the first attempt wherein no such loose blocks exist. Later attempts to fill channels which have loose protruding pieces of blocks can probably be facilitated by pushing such blocks back into position or breaking them and removing the pieces prior to the caulking operation.

Some water will be absorbed in the reactor graphite during the wash operation, and some will be evaporated from the caulking material during the early stages of reactor heating on startup. This water will be removed in the normal gas dryer during the period following startup with no particular difficulty.

Essentially complete removal of the excess caulking material remaining in the channel at the end of the wet part of the operation will be assured as follows:

1. When the operation is completed, the last step (chain withdrawal) will cut a hole through the soft cake in the bottom of the caulked portions of channel.

2. Multi-strands of heavier chain will enlarge this hole to 2-1/2 to 3-inch diameters.

3. Most of the remaining damp paste can be removed with the vacuum cleaner or flushed out of the lower 10 to 15 feet of uncaulked channel.

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4. A wire brush can be used for smoothing the upper portions of the caulked channel.

To avoid the hazard of breaking off a chain in the hole, proof-tested chain will be used with an air tugger hoist and air pressure regulated to apply forces within the safety factor of the chain. A dynamometer will be used to monitor these forces.

After cleanup, the channel may have a small amount of crumbly, friable graphite on its inside surface until the next outage, when borescoping will determine whether the cracks have been filled, and otherwise judge the success of caulking. After this initial inspection, the channel walls will be smoothed as necessary by a brush or by circulating balls for a suitable period during any subsequent outage after the caulking. Borescope records will be made before and after such ball movements for a fuller evaluation of the degree to which the channel voids are filled in any zones which were obscured from view in the first examination.

The ball washer system at C Reactor will easily remove all this loose graphite dust from circulating balls, whereas other provisions must be made at K because of the special "dry" type ball recovery system there.

TEST AREA

Tests are authorized at C Reactor. A ball magnet is now on hand which fits the C channel. The C ball-exit system is equipped for wet operation and can dispose of hot balls, unused graphite paste, and other debris quite readily without the necessity of secondary handling.

PREPARATION AND PROCEDURE

The graphite to be used will be collected from the 300 Area graphite shop from Grade AGOT graphite, left over from the machining of bars for the new high-temperature test reactor currently being built in the 300 Area. This material is being collected in barrels, carefully protected from the elements and possible contamination, and prepared for use as required. Purity checks of the batches of crushed material will be made to assure the grade of reactor graphite used.

Test details listed in the unclassified attachment include detailed stepwise procedures. The caulking compound will be mixed in a concrete mixer and added only as required to maintain the minimum quantity required above the chain for proper caulking.

OPERATING CONDITIONS AND LIMITS

At the end of the first full-power irradiation period after the caulking, the channel will again be borescoped for evaluation. If full power and graphite temperature has not been reached due to a premature shutdown, the examination

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will not be necessary until this requirement has been met. There are no other restrictions on the channel selected except that balls not be deliberately dropped until after the voids have been ascertained to be safely filled and the caulking mix thoroughly dried and hardened.

COSTS

The cost of reactor downtime, maintenance preparation, removing the VSR's and replacing them in the normal position, will be borne by C Reactor Processing and Maintenance. The cost of caulking equipment and the preparation and installation of the caulking will be borne by Equipment Development, Facilities Engineering. The cost of borescoping and evaluation will be borne by R&E. There should be no outage time lost as the work can be done concurrently with a normal or extended charge-discharge outage.

PROCESS STANDARDS

This document does not waive any requirements of C-100, "Inoperable Rods, Ball 3X Hoppers and Rod Testing During Outages," C-130, "Total Control,"and C-140, "Speed of Control." This means the vertical safety rod associated with the caulked channel shall be considered unserviceable for "Speed-of-Control" purposes until the rod has been drop tested and shown to meet the C Reactor VSR drop time requirements.

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RESPONSIBILITIES

Research & Engineering Section

Will arrange for the necessary borescoping and provide consultation and evaluation of results. The final report will be a joint responsibility of R&E and Facilities Engineering.

TWA for OHG

Facilities Engineering Section, Equipment Development Subsection

Will be responsible for providing the equipment, conducting preliminary mock-up tests, and engineering coverage for the on-reactor caulking operation. The final report will be a joint responsibility of Facilities Engineering and R&E.

DLH

Manufacturing Section, C Processing

Will be responsible for reactor safety, test management, and scheduling, as well as assistance in evaluating the results.

EJ

J.P. Cooke
Mechanical Development Unit
Equipment Development Subsection

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JPC/AR/dl

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PRODUCTION TEST PROCEDURE FOR C REACTOR

1. After a normal shutdown and cooling period, the channel will be opened and the rod tip and VSR seal assembly will be removed. It will not be necessary to remove the step plug. Equipment will be assembled at the top of the unit in readiness for the test, including a concrete mixer, the two ball-magnet hoists, a barrel of chain, several barrels of water, the chain-feed mechanism, and the shorter of the two channel magnets (procured for the DR ball drop two years ago).

2. A thorough borescope record (film) shall then be made of the channel (if not previously done), and from the borescope examination, a determination made as to whether the top half, top two-thirds, or all of the channel should be caulked. A record will also be made of retained balls visible in the channel.

3. Dry ice pellets shall be dropped to check that ball exit pipe is open, and a channel sweep with the magnet shall then be conducted to remove all possible balls lodged in crevices. Such balls will be dropped into the bottom of the channel, flushed through the trough into the washer to the disposal cask, and thus eliminated in the safest possible manner.

4. The channel shall then be examined with the borescope as a quick check to be sure the balls are gone and that no other immediate problems exist.

5. Insert the special liner of thin-wall tubing in the step plug to a depth just below the ball chute (the collar will prevent its going too deep).

6. Cover the zone around the VSR hole and ball hopper top with double thickness of heavy translucent plastic sheeting with an old air hose or cable about 4 inches under the outside edge and the sheeting taped to the deck. This will keep water and possible contamination from being spread. Rope off or designate this area as a separate radiation zone.

7. Where the channel had loose pieces of graphite which have been broken out or pushed back, remove the top-works of the Saunders valve and replace same with a piece of 1/2-inch plexiglas. This will permit visual observation of falling dry ice pellets for confirmation that channel is open whenever this is desired. The channel shall then be spray-washed with a conical spray similar to a garden hose nozzle. The spray nozzle will be mounted on the bottom end of a 10-foot pipe and lowered slowly through the hole by means of its hose. The water is not to be turned on until the hose nozzle is approximately at the level of the ball entry chute or lower, and the trough water supply in the ball 3X tunnel, as well as the ball washer, shall be kept running during this operation. The spray is intended to

remove loose contamination (graphite dust) to aid in keeping the equipment in a reasonably clean condition upon subsequent removal from the hole, and will also ensure that any residual loose balls, flakes of rust, or other debris has been cleared from the lower parts of the channel and the ball exit system. The volume of water which gets into the graphite during this operation will not be great, and is normally removed from the gas system in the first few hours after startup. Observation of the stream of water passing through the plexiglas-covered exit valve will provide added confirmation that the lower channel is clean and clear.

8. A borescope inspection and movies are to be taken at this point as a final record prior to the caulking.

9. The lead end of the chain and the first 100 feet will be of heavier, 1500 pound proof test chain and provided with a cylindrical weight and multiple strands with a short cylindrical plug so arranged as to block the ball pipe at the bottom of the graphite channel and to clean the channel on removal. Insert this chain and determine the depth of fill in the channel from time to time with the aid of a steel tape and small weight. Record the data. From the top, progressively mark the chain with small pieces of 1/2-inch wide, thin aluminum strips (wrapped around links in such a manner so as to remain on the chain when passed over the sprocket wheel) at intervals which indicate 5-foot steps in the packing depth of the chain in the channel. The first 5-foot step shall be marked with a single strip, the second 5-foot depth with two markers, the third 5-foot mark with three, etc. The chain will be added until the channel is filled to the depth at which filling is to begin. Take RM readings with chain in place, establish new time limits over open channels as required, and set up system of radiation zones.

10. Insert the predetermined volume of caulking mixture through the funnel in the top of the liner tube inserted in Step 5. The volume needed will have been determined as a result of the borescope evaluation and will also depend on the depth of the channel which it is desired to fill. A slight excess over that required to fill the channel voids shall be constantly kept in the channel. The material will be supplied in premixed batches, but will be stirred in the small cement mixer immediately prior to insertion. Rinse the last of the mix down into the funnel and off the exposed chain with a small jet of water.

11. Insert vibrator into the funnel tube. Start the vibrator motor and slowly lower it through the mixture until it strikes the chain. Raise it up and down three or four times through this zone, noting the difference in motor sound when the vibrator head comes out of the mix. From the marks on the vibrator hose, it will be possible to determine the depth of caulking mixture progressively, adding more mixture as necessary to maintain at least 5 feet of mixture at all times above the interface between mixture and chain.

12. After the first section of channel has been vibrated enough to ensure void filling, withdraw enough chain to lower the interface approximately 2-1/2 feet, washing the moving chain with the small stream of water provided. The chain can also be tapped periodically to help shake off the adhering mixture. Vibrate the mix in the additional 2-1/2 feet of channel, sufficient to fill all local voids, then repeat the procedure progressively, sounding the top of the mixture with the vibrator tone and markings to be sure that the required depth of mix column is maintained. The vibrator flexible shaft will be marked at 2-1/2 foot intervals, and the chain markings at the 5-foot fill intervals will facilitate estimating the level of the working zone. The vibrator will be suspended from the Winch Level in order that the cable may be maintained as nearly vertical as possible, since this is the position which gives the best performance and the least load on the drive motor.

13. When the vibrator has reached the level predetermined in Step 2, where it is desired to consider the operation complete, the vibrator will be withdrawn slowly while being rinsed with the water stream to remove the surface layer of carbon and keep the surface wet enough to prevent contamination from being scattered.

14. The vibrator head and hose will then be lowered into a special tank of water and left with the motor and cord hanging from the rack above it until such time as it can be decontaminated and released. (Note that motor and cord are to be kept as clean as possible from contamination.)

15. The remaining small size chain will then be removed slowly to prevent the adherence of caulking compound. When the end of the large chain appears, a special grab hook with a latch will be attached, and the small chain and chain feeder removed from the zone. The small chain will be fed directly into the special basket in the center of a barrel of water as it comes from the chain feeding mechanism and stored underwater until such time as it is determined whether the attached contamination is at a level high enough to make burial necessary or whether it can reasonably be cleaned for reuse. (It is anticipated that it will not be difficult to decontaminate the chain by simple water washing plus a rinse with hot water so that it will dry quickly without forming a coating of rust. If this proves practicable, the same length of chain can be reused indefinitely.)

16. It is desired that as much of the heel at the bottom as possible be removed with the large chain as it is withdrawn. A pair of grab hooks with a special safety latch has been provided, and this chain will be withdrawn slowly with a tugger hoist. Tugger hoist air pressure will be adjusted so that no greater force can be applied than proof test of chain. A tubular plastic sleeve will be placed around the chain and extended with it to contain any loose paste, but as much as possible of this material will be removed with the vacuum

cleaner just below where the chain enters the plastic sleeve. Chain and sleeve will then be placed in a closed cardboard box for convenience in transport to the decontamination facility.

17. The water hose used previously to flush the channel should then be lowered clear to the bottom and the water turned on to flush the remaining caulking material out of the channel through the ball washer to the sewer. If the weight of the hose assembly is insufficient to penetrate the heel of the caulking compound immediately, water may be turned on to provide a water lance action. The plexiglas window in the ball exit valve shall be observed during or at the completion of this operation and the water not turned off until a clean stream of water has passed this point. The water spray should then be turned off during withdrawal at a point at least one foot below the caulked zone. The hose should then be carefully drained and withdrawn.

18. The wire brush assembly shall then be inserted clear to the bottom of the caulked zone, raised once to the bottom of the funnel tube with the hoist, and lowered a second time and withdrawn into the funnel tube where it is to be fastened, disconnected from its long rod, and withdrawn with the funnel tube from the hole (put plastic or paper over end of the funnel tube while carrying it over the unprotected part of the deck). The lower end of the funnel tube shall then be lowered into a barrel of water and the brush assembly ejected under the water.

19. The spray shall then be lowered to the bottom and the last of the loose material washed from the ball exit section. Check the plexiglas window again to be sure the pipe is clean, after which the hose shall be turned off below the caulked zone and removed.

20. A quick check shall then be made with the borescope.

21. The equipment at the top of the unit can now be removed and the VSR hardware restored to service.

The following is an alternative or supplemental procedure since the removal of the mixture with the vacuum system is easily possible.

1-8. Procedure the same except that no plexiglas window is required on the ball exit valve.

9. The ball exit valve will be closed to the "crack" position and the exit pipe and the bottom 3 or 4 feet of channel filled with clean balls. The heavy multi-chain, minus the cylindrical weight, will then be inserted as in Step 9 of the other procedure.

10-16. Same as previous procedure.

17. Vacuum cleaner shall then be used to remove as much loose mix as possible.

18. Wire brush step same as 18.

19. The vacuum probe shall then be lowered to the bottom to pick up the remaining loose mix. When a few balls begin to come up the hose, it may be assumed that the loose mix is gone.

20. A quick check with the borescope shall then be made with the balls to be drained from the pipe while the borescope is at the bottom so that it will be possible to make sure that no plug of balls was left behind.

21. Same as previous procedure.

JP Cooke:dl

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