TESTIMONY OF
JAMES D. GILCREST
RELATED TO
FUEL CHANNEL BOWING

JANUARY 16, 1981

8102060356

My name is James D. Gilcrest and my qualifications have been submitted with my earlier statement.

The purpose of this testimony is to address the concerns related to the storage of bowed fuel channels in the proposed Dresden spent fuel racks.

The reason for the concern is that when the allowable fabrication tolerances are considered along with the results of recent Commonwealth Edison Company measurements of irradiated fuel channels, it appears that there is a potential for interference between the fuel channels and the racks in which the channels are stored. This potential interference is a concern because spent fuel assemblies are frequently stored with the fuel channel in place on the fuel assembly.

The channel fits over the outside of the fuel and is fastened to the fuel by a single bolt at the top of the fuel assembly. This bolt is part of the channel fastener assembly. The bolt passes through a corner gusset on the top of the channel and screws into a post on the fuel upper tie plate. The fuel assembly bail (which is used to lift the fuel) is an integral part of this same upper tie plate.

The fuel racks are composed of a checkerboard type array of fuel storage tubes. Within this array, fuel is stored both in the storage tubes and in the positions formed by the outside walls of the four surrounding storage tubes (the inter-tube positions). The fuel is supported in the racks on a fuel support plate located at the bottom of each storage position. The lower tie plate of the fuel assembly sits on a round beveled hole in this fuel support plate and is thereby both centered in the storage position and free to rotate. The fuel is supported in the horizontal direction by the storage tube walls. At the top of these walls lead-in clips, as shown in Figures 1 and 2, are attached to the walls. The purpose of these clips is to provide a smooth rounded surface to aid in the insertion of fuel into the storage position.

In evaluating the available clearances between the fuel channel and the storage positions, the dimensions shown on the General Electric fuel channel outline drawing were used for the channels. For the fuel racks the dimensions were taken from the Nuclear Services Corporation drawings. Engineering changes in the rack design which have occurred during the fabrication have been included in the evaluation.

Using the dimensions specified on the above mentioned drawings for the fuel channel and for the fuel rack, the minimum clearance between a straight fuel channel and the wall of the storage position is determined to be 0.346 inches total or 0.173 inches on each side of the stored channel. This is the clearance which exists below the storage tube lead-in clips in the inter-tube positions. The clearance inside a single storage tube is greater (0.496 inch total).

Recent measurements of irradiated fuel channels, as described in the testimony of Dr. O'Boyle, have shown that the axial bow of the channel can be greater than the minimum possible clearance in the rack. This combination of large fuel channel bow combined with the minimum size storage position, as specified on the drawings, would result in interference. This condition is shown in Figure 1.

There is also a potential for interference at the top of the inter-tube storage positions. This condition is shown in Figure 2. Again, the fuel channel outline drawing and fuel rack drawings were used to determine the maximum interference which could occur at this location. The calculations show that the potential exists for a 0.028 inch interference. This interference would occur between the channel spacer button located at the top of the channel and the lead-in clip as shown in Figure 2.

Measurements have been taken on completed fuel racks to determine the actual dimensions between the lead-in clips. These measurements have shown that the actual fabricated racks have dimensions between the lead-in clips which generally exceed the allowable minimum shown in the drawings (5.740").

However, a bowed fuel channel could incur two interferences, if it was stored in a storage position which had the minimum dimensions allowed by the drawings. One interference could occur between the middle of the channel (where bow is maximum) and the wall of the storage position. The other interference could be at the lead-in clips located at the top of each storage position.

The question which has arisen is whether this interference will cause damage to either the fuel or the storage racks. Based on a maximum fuel channel bow of 0.420 inch as measured by CECo and the minimum clearance of 0.173 inch, the maximum interference anticipated is approximately 0.25 inch. The 0.173 inch dimension is used rather than 0.346 inch because, as described above and shown in Figure 1, the fuel is centered in the storage position. An analysis has been performed to determine the load required to remove a fuel assembly from storage, if this 0.25 inch interference existed.

The load required to remove a fuel assembly, assuming the worst combination of dimensional tolerances, is composed of the drag due to fuel bowing, the drag at the lead-in clips and the dead weight of the fuel.

The drag due to fuel bowing was calculated by assuming that the fuel channel was a simply supported beam with a load imposed in the center. Since the maximum interference is 0.25 inch, the load to deflect the channel 0.25 inch was calculated using standard beam formulas. This load was determined to be 310 pounds. Therefore, in the worst case, the contact force between the channel and the storage tube wall is 310 pounds. However, for the forces on the channel to be balanced, it is necessary for this 310 pound force to be exerted in two opposite directions on the channel. Looking at the fuel channel as shown in Figure 1, a force of 310 pounds will be exerted toward the left at the middle of the channel. At both the top and bottom of the channel a 155 pound (310 pounds total) force will be exerted on the channel toward the right. Each of these contact forces will result in a drag force when the fuel channel is removed from the storage tube. So, when calculating the maximum drag force, a contact force of 620 pounds will be used.

This contact force multiplied by the coefficient of friction will give the drag force required to overcome this interference. To be conservative a coefficient of friction of 0.5 has been assumed. General Electric has performed tests which show that the coefficient of friction between zircaloy and stainless steel would be expected to be less than 0.5.

Multiplying the coefficient of 0.5 times the contact force of 620 pounds gives a drag force of 310 pounds. This is the maximum vertical force which would need to be applied to the fuel assembly to overcome the drag due to fuel bowing.

In order to determine the drag which would result from interference at the lead-in clips, it was decided to perform a test. A test was performed instead of calculations because it was a relatively simple test to perform, and because it was not apparent what assumptions should be made for a reasonable, yet conservative, analysis. The test was performed in the Leckenby Company shop on a completed 9x13 Dresden fuel rack.

The test consisted of lowering a short section of a fuel channel (with the spacer buttons and channel fastener) into a inter-tube storage position as shown in Figure 2. Stainless steel shims were then inserted between the spacer button and the lead-in clip to cause an interference. A dynamometer and crane were attached to the channel, and the channel was withdrawn from the storage position as the dynamometer measured the drag force.

The data obtained during this test is shown in Figure 3. The test was performed on four different storage positions. Drag values were obtained at three interferences. One space was checked at .021 inch interference, two at

.028 inch and two at .034 inch. The drag values for each of the readings taken are plotted on Figure 3. The one point at .028 inch interference and 263 pounds drag appears to be an invalid reading and will be ignored in this discussion. The data then shows that the drag will vary between 78 pounds and 173 pounds for the potential interference of .028 inch. For the purposes of determining the loads on the fuel assembly, an upper bound load of 200 pounds is assumed for the drag resulting from lead-in clip interference.

Therefore, the maximum load which may be applied to the fuel assembly bail to remove this fuel assembly from the rack is the fuel plus channel weight (680 pounds); plus the drag from the channel bow interference (310 pounds); plus the drag from the lead-in clip (200 pounds). This results in a total force applied to the bail of 1,190 pounds. Of this 1,190 pounds, only 510 pounds (1,190 minus the fuel assembly weight) will be transmitted to the fuel rack.

Of the 1,190 pounds which could be applied to the fuel assembly bail, only a portion of this will be transmitted to the fuel channel through the channel corner gusset shown in Figure 2. The load which will be transmitted through this gusset is the bowing drag (310 pounds); plus the lead-in clip drag (200 pounds); plus the channel weight (64 pounds). This is a total of 574 pounds. The remainder of the fuel assembly weight is supported directly by the upper tie plate and the bail.

The above discussion addresses removal of a fuel assembly with the maximum interference. Insertion of a fuel assembly under thse circumstances would be resisted by the bow drag force of 310 pounds and the lead-in clip drag of 200 pounds. Since the fuel assembly weight exceeds this drag force of 510 pounds, the fuel will fully insert in the rack by its own weight. The only component of concern which would be loaded during this insertion is the channel fastener bolt. The load on this bolt is the drag force (510 pounds) minus the channel weight (64 pounds); a total of 446 pounds.

The effect of storage of a bowed fuel channel in a storage rack on the stresses in the rack has also been evaluated. The stresses in the rack were evaluated using a model in which a group of nine storage positions (3x3) were represented by equivalent beam members. The direction of the loads from the bowed channels in adjacent cells were selected such that the resulting stresses were maximized. Although the maximum stress due to the bowing would occur in a different region of the storage tubes than the maximum dead load and seismic stresses, these maximum stresses were conservatively combined. The resulting combined stresses due to dead load, seismic and bowing are below the allowable stress as defined by USNRC Standard Review Plan 3.8.4.

As described in the response to NRC Question 2 transmitted in Reference 1, the 510 pound vertical force applied to the rack will not result in any damage to the fuel rack.

The above discussion is based on the maximum measured fuel channel bow of 0.420 inch which results in a 0.25 inch interference. If the amount of interference were increased, the drag load due to fuel channel bow would increase proportionately. For instance, an increase to 0.500 inch fuel channel bow would increase interference to 0.33 inches. This would increase channel bow drag from 310 pounds to 409 pounds, and total bail load from 1,190 pounds to 1,289 pounds. This would not significantly affect the results described above.

It is therefore my conclusion that the possible interferences described above do not present any safety problem with respect to the fuel or the storage racks.

Reference 1: CECo response to NRC Question 2 contained in the letter from Janacek to Denton dated August 17, 1979.

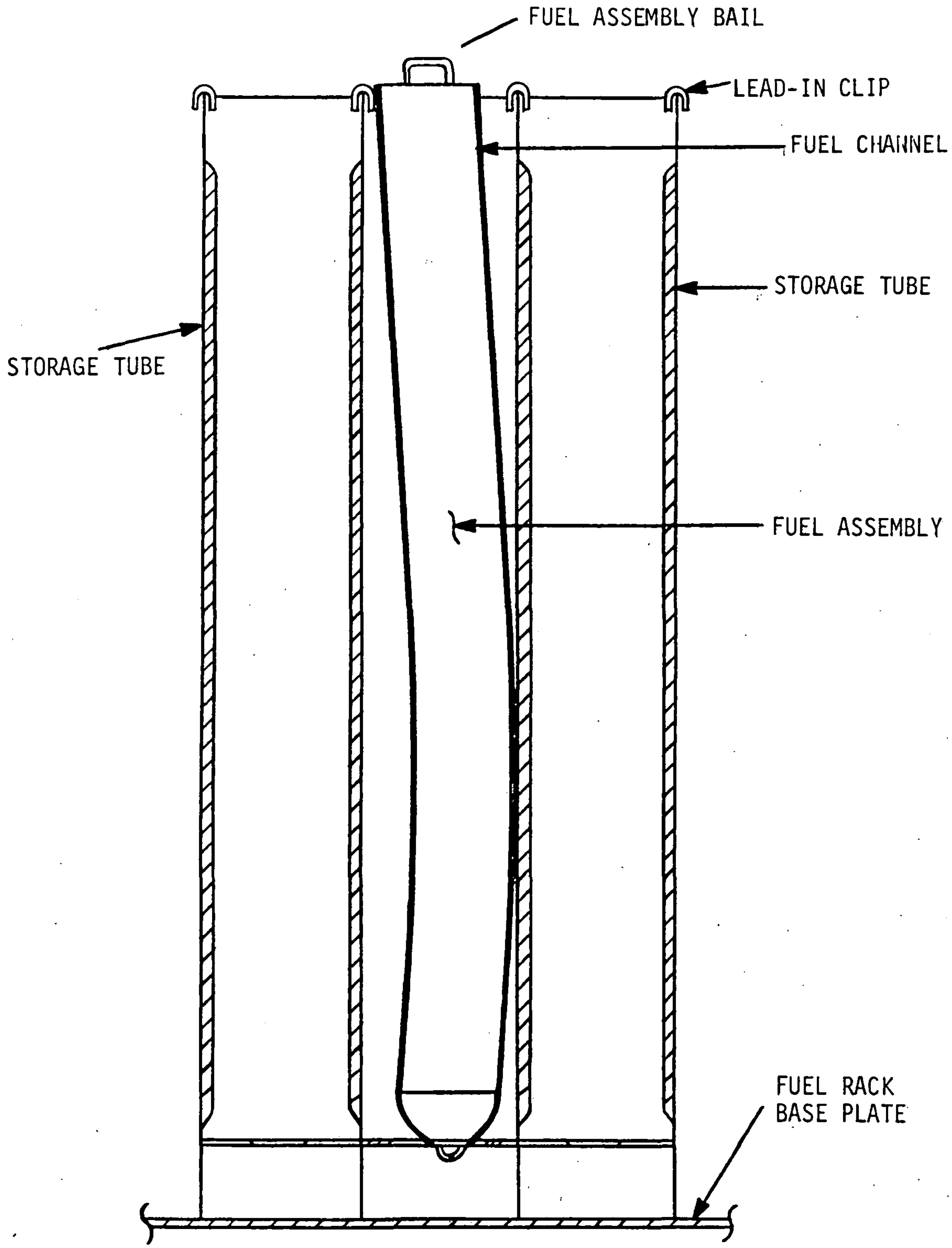

FIGURE 1 *

BOWED FUEL ASSEMBLY LOCATED IN AN
INTER-TUBE STORAGE CONDITION

*NOT TO SCALE

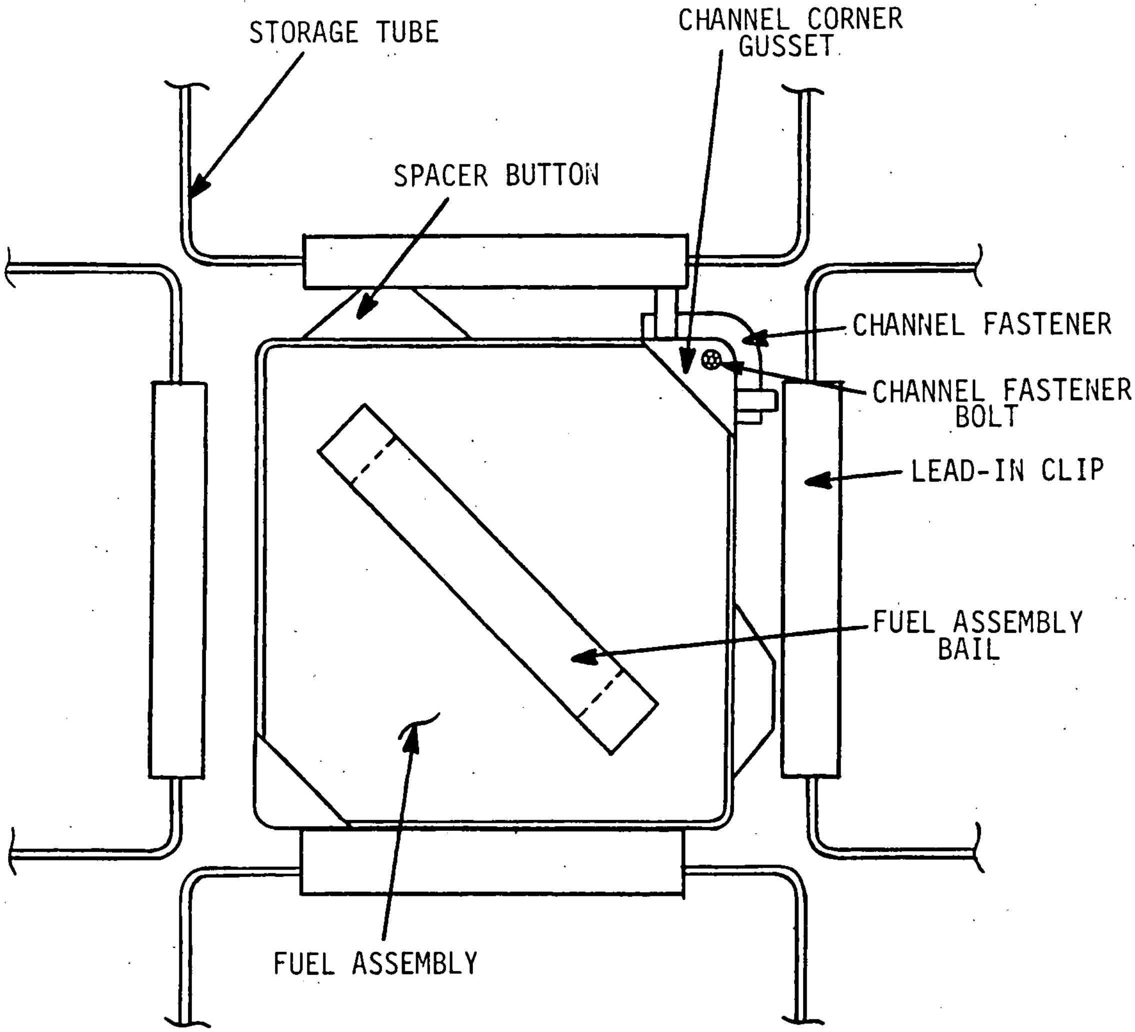

FIGURE 2 *

FUEL ASSEMBLY IN MINIMUM SIZE
INTER-TUBE STORAGE POSITION

*NOT TO SCALE

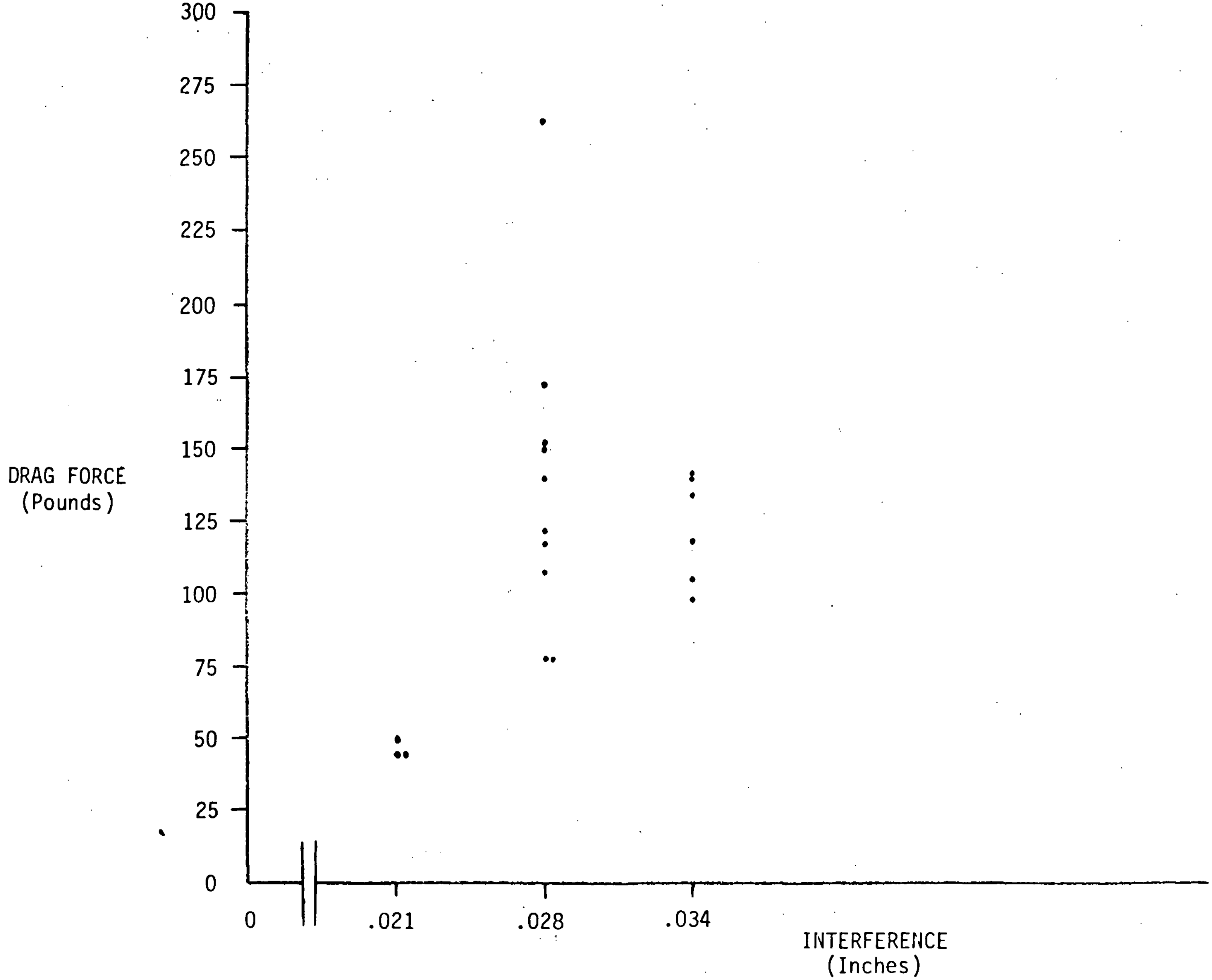

FIGURE 3
LEAD-IN CLIP INTERFERENCE TEST RESULTS

QUESTION NUMBER 2:

Regarding response #6: Indicate whether the loads imposed on a rack by a stuck fuel assembly have been considered.

RESPONSE:

Fuel handling and servicing in the fuel storage pool is carried out with one of several available half-ton hoists or the refueling grapple. The refueling platform is provided with the refueling grapple and two additional hoists. Two additional hoists are provided on jib booms in the fuel servicing area.

The fuel storage racks for Dresden have not been specifically analyzed for possible damage resulting from a stuck fuel assembly. However, the maximum loadings from the available hoist equipment are about 1,000 pounds vertical which in itself will not affect the racks because the imposed stresses are low. Past analyses on other racks have shown that a combined loading of 2,000 pounds vertical and 1,000 pounds horizontal does not exceed elastic limits within the rack.

Reference 1: Commonwealth Edison Company Response to NRC Question No. 2 dated August 17, 1979.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
THE ATOMIC SAFETY AND LICENSING BOARD

In the matter of COMMONWEALTH EDISON COMPANY)	Docket Nos. 50-237-SP 50-249-SP
(Dresden Station, Units 2 & 3))	(Spent Fuel Pool Modification)

SS:

County of Santa Clara

AFFIDAVIT OF CARL R. MEFFORD

I, Carl R. Mefford, being first duly sworn, state that the attached testimony is true and correct to the best of my knowledge and belief.

Carl R Mefford

Subscribed and sworn to before me this 29th day of January, 1981.

Ruthe M. Kinnamon
Notary Public

OFFICIAL SEAL
RUTHE M. KINNAMON
NOTARY PUBLIC - CALIFORNIA
SANTA CLARA COUNTY
My comm. expires MAR 28, 1981
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