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ISSUE SUMMARY

TITLE: VISUAL EXAMINATION RESULTS OF SEGMENT 2 FSV FUEL ELEMENTS 1-2415, 1-0172, 2-2693, 1-0108 AND 5-0801

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☐ DESIGN

APPROVAL LEVEL 5

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CONTINUE ISSUE SUMMARY ON GA FORM 1485-1.

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Notations in this column indicate where changes have been made

1. INTRODUCTION AND SUMMARY

Five Fort St. Vrain (FSV) fuel elements removed during Segment 2 refueling were shipped from Colorado to General Atomic's (GA) hot cell facility for detailed examination. One of the elements (1-2415) was discovered to have a cracked web during routine surveillance of 54 fuel and reflector elements at
/2 FSV in April 1982 (Ref. 1). Another (1-0172) was suspected, based upon later
/2 examination at GA of video tapes made during the surveillance program, of also
/2 having a cracked web. The presence of this crack was confirmed upon visual
/2 examination of the element in the GA hot cell. Of the other three blocks sent to GA, one (2-2693) was a typical control block, one (1-0108) was from a core position adjacent to element 1-2415, and the last (5-0801) was an element not previously examined but identified by design codes as one of the highest stressed blocks in Segment 2 of the FSV core.

This report presents the results of the detailed visual examination on the five elements carried out in July 1982 at GA. The cracked webs in elements 1-2415 and 1-0172 were carefully scrutinized and a stacking demonstration revealed no abnormal interference between the dowels and sockets of these two blocks when stacked in their in-core positions. The top, bottom, and side surfaces of all five blocks were visually inspected and photographed. No other cracks or damage attributed to the in-pile operation were seen on these blocks. The destructive examination is planned for fiscal year 1983.

/2 It should be noted that in Figures 1, 2a, 3d, 4, and 8 of this report the
/2 appearance of the cracks has been artificially enhanced. Without enhancement,
/2 the cracks would be difficult to see in the final figure reproductions. The
/2 resultant figures closely resemble the actual appearance of the cracks.

2. PROCEDURE

A detailed Test Specification (Ref. 2) describing all phases of the visual inspection was adhered to during this work. Other than minor devia-
/2 tions from the Test Specification (see Para. 2.2), all examinations were completed and documented as specified.

Notations in this column indicate where changes have been made

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2.1 Documentation

All observations, measurements and other notes made during the visual inspection were recorded in GA Lab Notebook No. 6637. All photographs taken are filed in the Core Materials Master Photo File in either print or negative form. In addition, prints of every photo are affixed in Notebook No. 6637 for viewing.

/2 ## 2.2 Exceptions to Test Specification

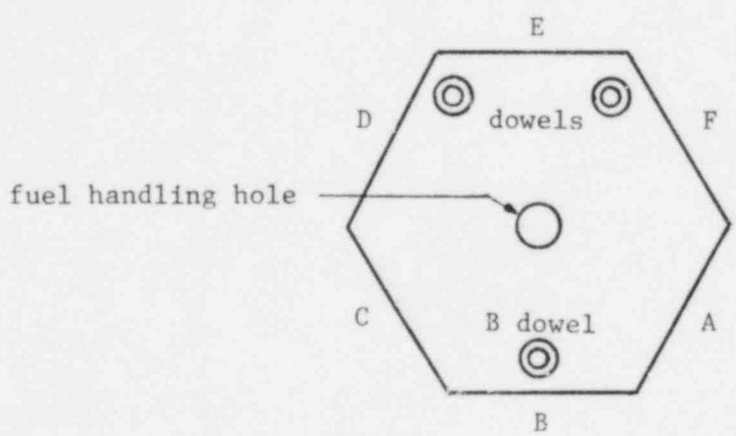
/2 Several minor deviations from the Test Specification occurred and are listed herein:

Exception	Spec. Section	Justification/Resolution
1. Visual exam. sequence different from that specified.	2.4	Blocks inspected in the order that they were stacked in the shipping cask because of time and hot cell window burnout constraints; order of inspection by block number was: 1-2415, 1-0172, 5-0801, 1-0108, 2-2693.
2. Operator did not keep daily notes.	2.5	Operator reviewed and signed off on logbook entries recorded by cognizant engineer.
3. Standard line card widths different from that specified.	2.7	Limitations in available pen sizesμ lines provided were judged adequate by Q.A. representative. Line widths in inches on cards used during the visual exam were: .008, .013, .014, .017, and .031 on card No. 4, .007, .013, .015, .018, and .032 on card No. 1.
4. Individual storage cans for each element not used.	3.4	Purge cans not available during time of visual exam.

3. VISUAL EXAMINATION RESULTS

Each element was inspected in detail for cracks, blemishes, stains and other markings, and any abnormal features using the in-cell Kollmorgen periscope. Selected areas were photographed through the Kollmorgen and Polaroid prints were made, especially when closeups of certain features were desired. All end and side surfaces of each block were photographed in composite form through the cell window using a tripod-mounted 35 mm single lens reflex camera. The visual observations on each block are given separately here followed by general observations, special procedures, and measurements. Throughout this report, references to the different fuel element surfaces are as follows: the top of the block is that end with alignment dowels, the bottom is the end with dowel sockets, and the side faces are identified thusly

TOP END VIEW OF FUEL BLOCK



3.1 FSV Fuel Element S/N 1-2415

The crack in this block, which extends down the entire length of the B face, was scrutinized closely in this visual exam. Figure 1 shows part of a composite photo of the crack with the coolant hole and B dowel visible at the

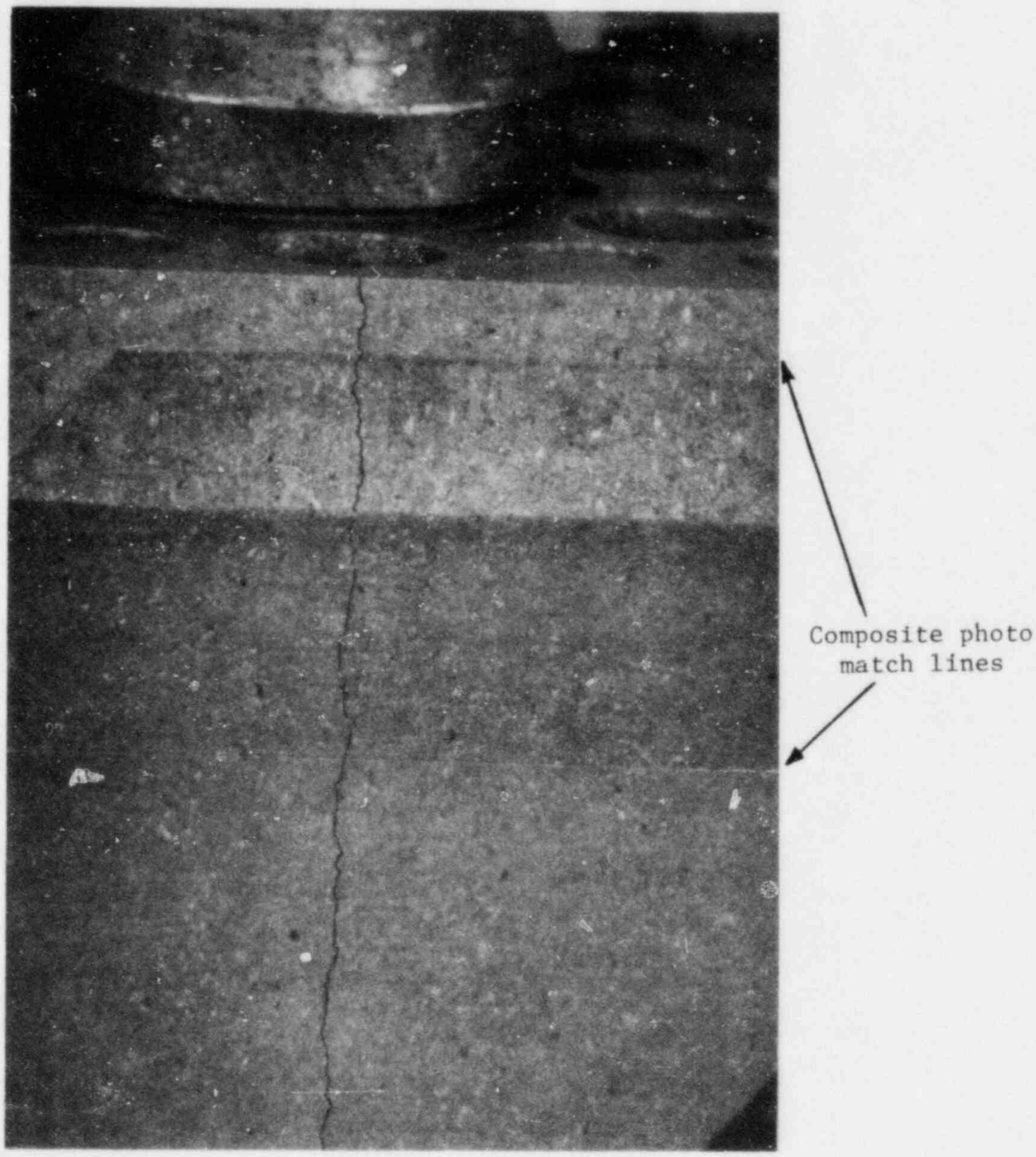
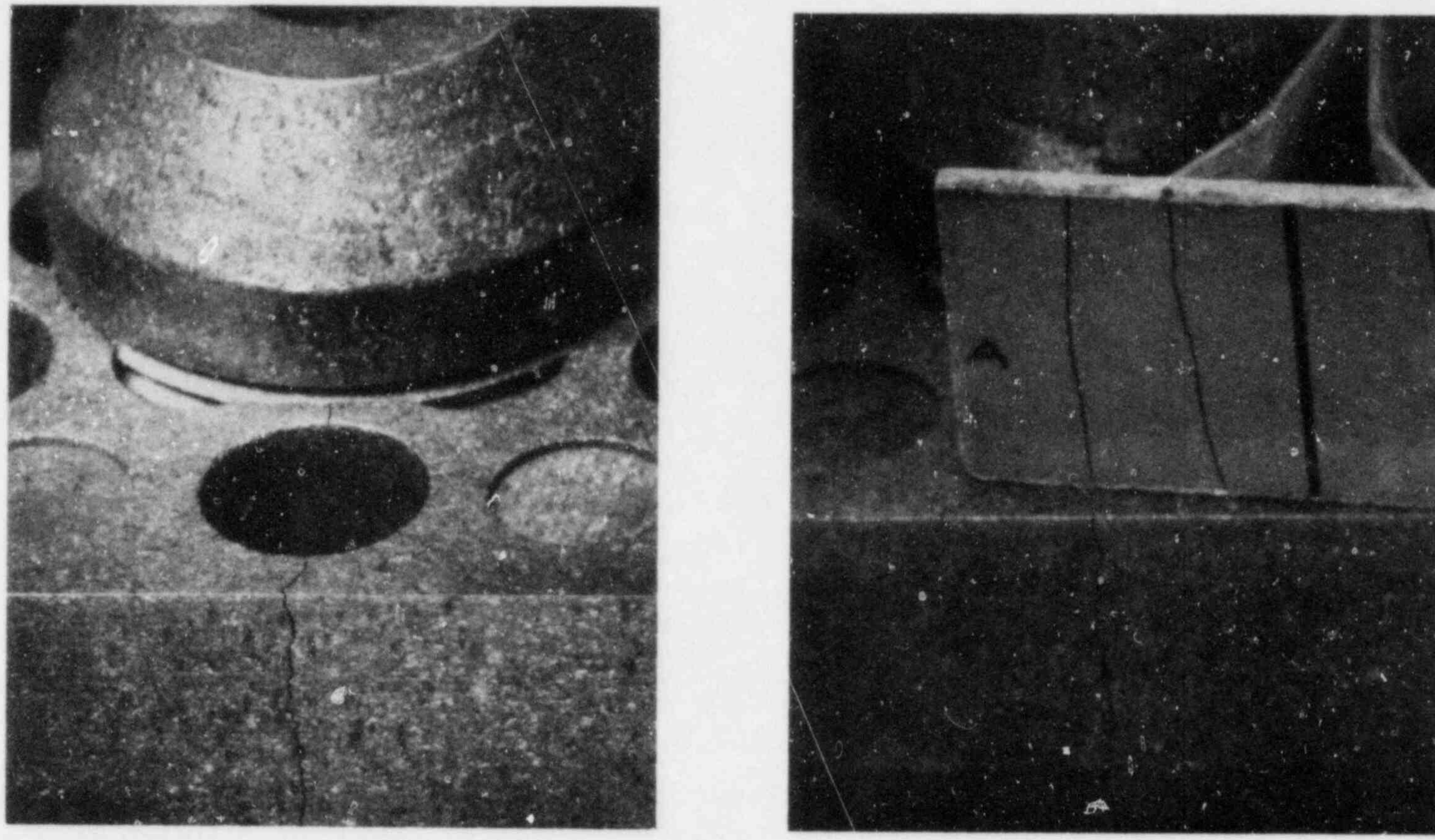


Fig. 1 Composite photo of crack at top of block 1-2415.
(Appearance of crack on photo enhanced with pen for clarity.)



(a) (b)

Fig. 2 Crack in element 1-2415. (a) Top view of block near "B" dowel showing crack extending across outermost coolant hole to dowel. (b) Example of use of standard line card for estimation of crack width. Line widths on cards were pre-measured. (Appearance of crack on photo (a) enhanced with pen for clarity.)

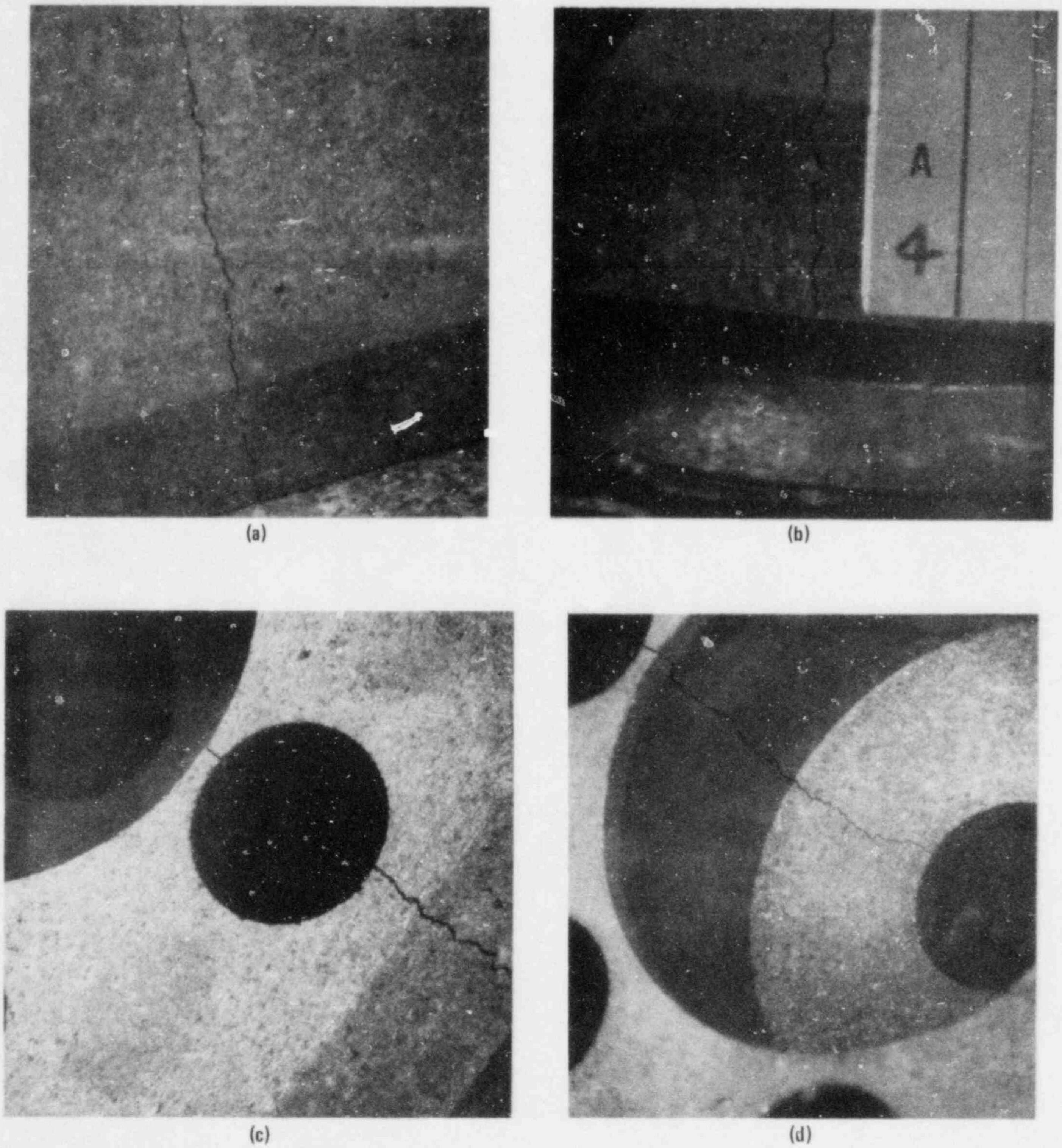


Fig. 3 Bottom views of crack in element 1-2415. (a) Bottom of ''B'' face (b) Standard line card used to gauge crack width (c) crack crossed outermost coolant hole into dowel socket (d) crack continued into dowel socket up to but not across coolant hole in the dowel socket. (Appearance of crack on photo (d) enhanced with pen for clarity.)

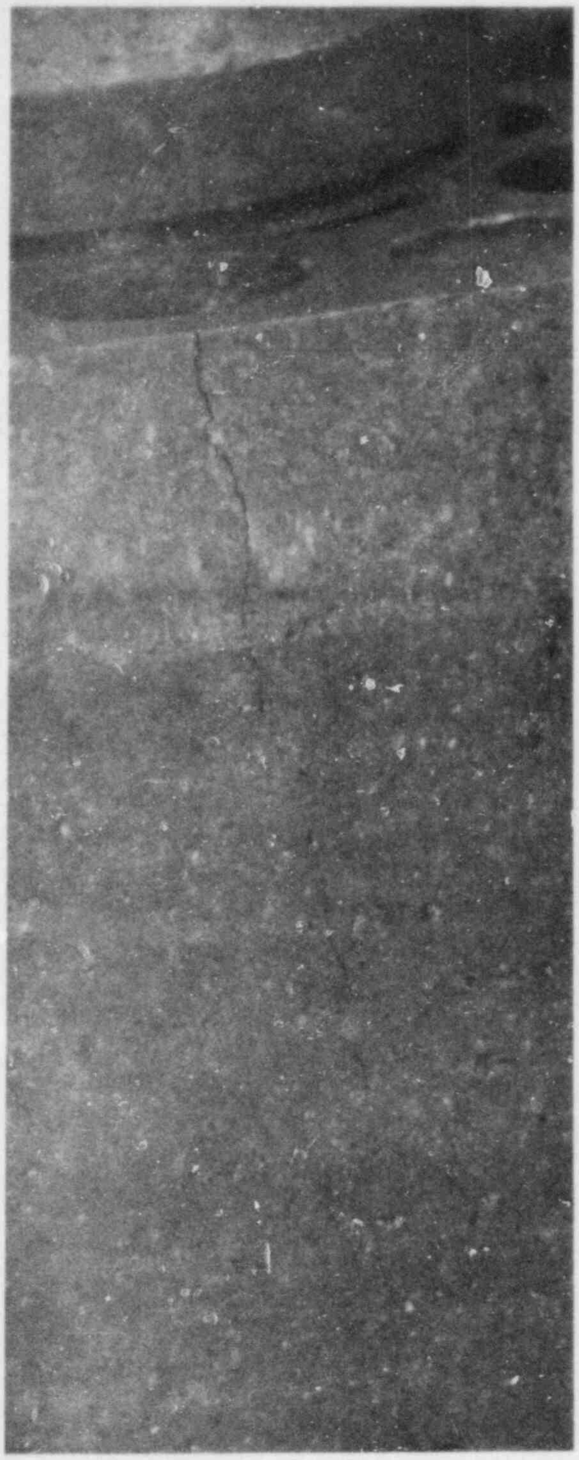
top of the block. The crack extends across the coolant hole and up to the B dowel as shown in Figure 2a. However, it was not possible to determine at the top of the element whether the crack extended further without removal of the dowel, which is not possible without block disassembly. The crack did not reappear on the far side of the dowel. Figure 2b shows the use of one of the standard line cards placed near the crack at the top of this blockμ the crack width at this point was estimated to be .008 to .010 in. (.20 to .25 mm).

At the bottom of block 1-2415 (Fig. 3a) the crack appeared slightly wider and was estimated to be .011 to .012 in. (.28 to .30 mm) wide at this point (Fig. 3b). The crack also crossed the outermost coolant hole (Fig. 3c) and extended into the dowel socket and up to but not across the coolant hole in the dowel socket (Fig. 3d). The direction of the crack into the block at both the top and bottom is perpendicular to the B face on a line which, if extended, would intersect the fuel handling hole approximately through the middle. Assuming that this line of the crack holds true along the entire block length, it would appear that no fuel holes were intersected by the crack. This assumption should be confirmed in the destructive phase of block examination.

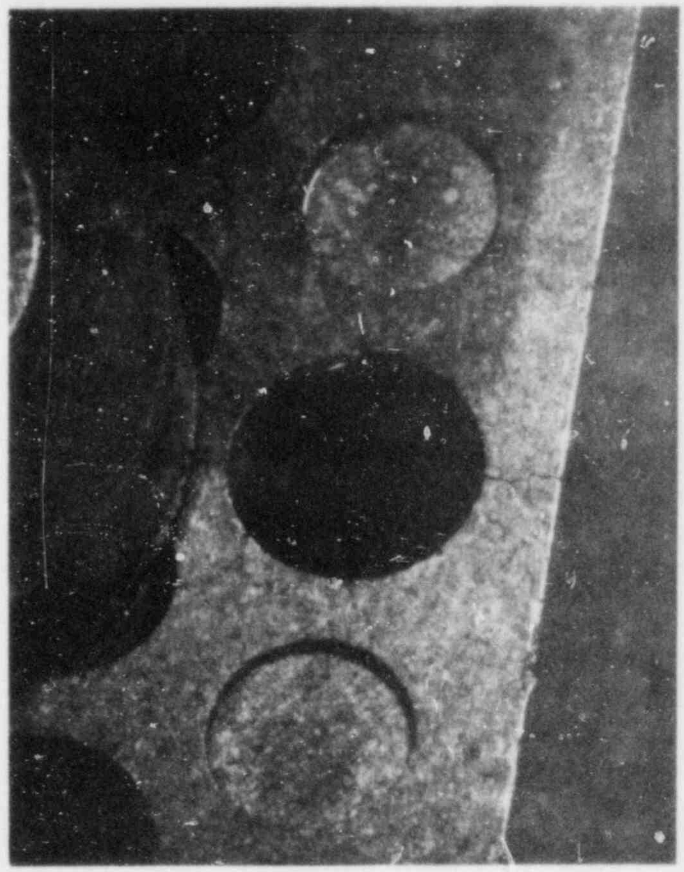
No other cracks were observed anywhere on block 1-2415. Numerous scratches and scrapes were seen that would be easy to mistake for cracks, but which are clearly not so when viewed through the Kollmorgen. Where there was any doubt, the alcohol evaporation test (see Ref. 2 section 4.2.1(c)) was employed. Face E showed some light rub marks approximately 2/3 of the way up from the bottom which appeared to be from an adjacent offset block. This face was indeed adjacent to the offset control block column in region 8. All dowels and sockets on this block were in excellent condition, with only some light wear marks apparent on the B dowel.

3.2 FSV Fuel Element S/N 1-0172

Element 1-0172 was cracked down the center of the B face similar to block 1-2415, but the crack was narrower and hard to see in some places, even



(a)



(b)

Fig. 4 Crack in element 1-0172. (a) View at top of "B" face (b) Top of block near "B" dowel showing crack crossing outermost coolant hole to dowel. (Appearance of cracks on photos enhanced with pen for clarity.)

through the Kollmorgen. Figure 4a shows the crack appearance at the top of the block and partway down the B face. Figure 4b shows that the crack goes across the outermost coolant hole at the top and up to the dowel. Crack width at the top of the block was estimated to be .005 to .006 in. (.13 to .15 mm). On the bottom of the block, the crack was so thin that it did not show up even in close-up pictures. It was apparent, however, that unlike block 1-2415, this crack did not cross the outermost coolant hole on the bottom end, and did not extend into the B dowel socket. Alcohol was used to verify this visual observation. The crack width at the bottom of this block between the side and the outermost coolant hole was estimated to be .002 to .003 in. (.05 to .08 mm).

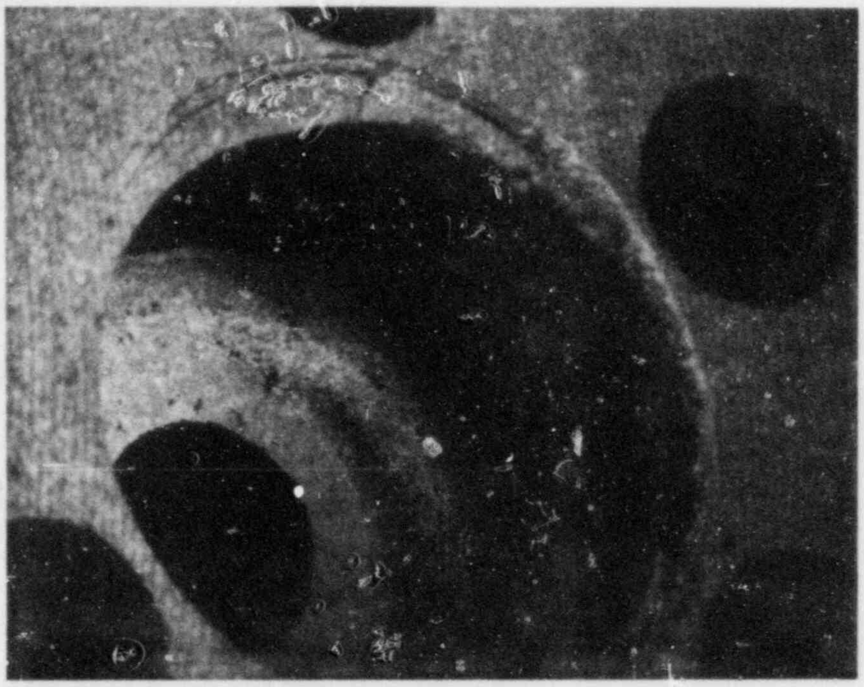
No other cracks were observed on any other surfaces of block 1-0172. Many scratches and other marks, all of a minor nature, were seen on all sides and on the top and bottom ends. Many of these marks can be attributed to handling, both at FSV and during the present examination at GA.

3.3 FSV Fuel Element S/N 5-0801

This block had not previously been examined and was the least marked and scratched of the five examined at GA. No cracks were observed anywhere on this block though it was predicted to have experienced high stresses during irradiation. The E face showed the imprint of an adjacent, offset block in the region 25 control column. The handling hole was slightly chipped. A handprint was observed on the E face.

3.4 FSV Fuel Element S/N 1-0108

This element was very clean similar to S/N 5-0801 with a minimum of scrapes and scratches. The dowel socket edges were particularly sharp and distinct compared to some of the other blocks. No cracks were seen anywhere on this block; several scratches were closely examined and checked with alco-



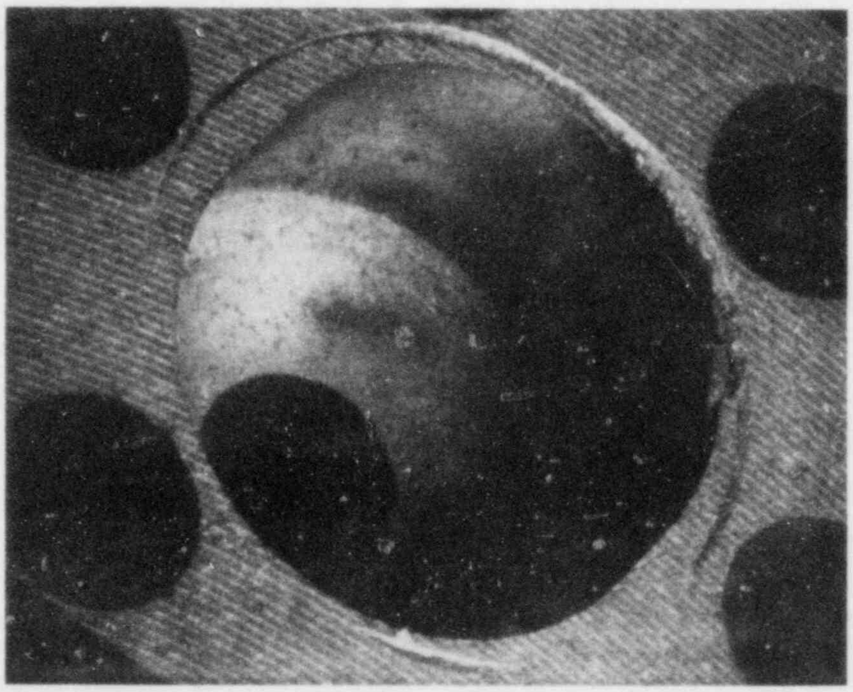
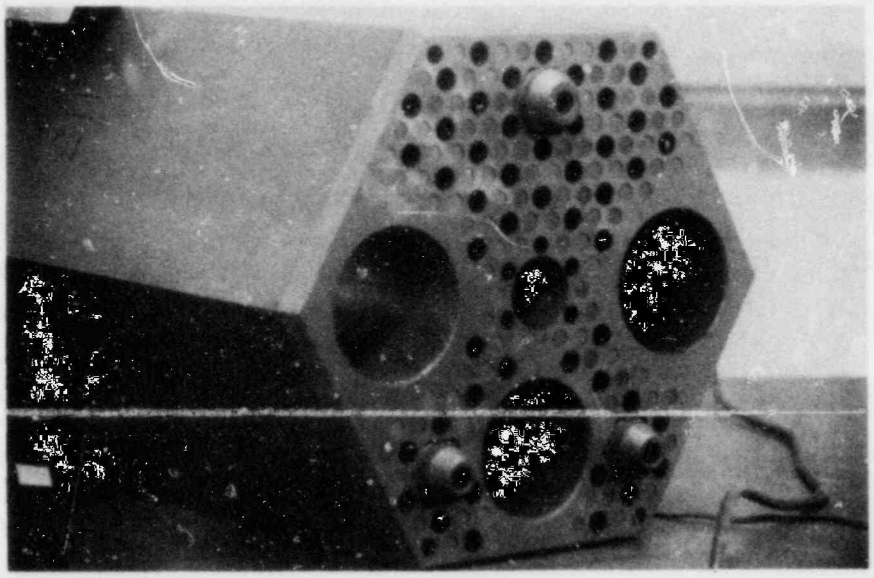
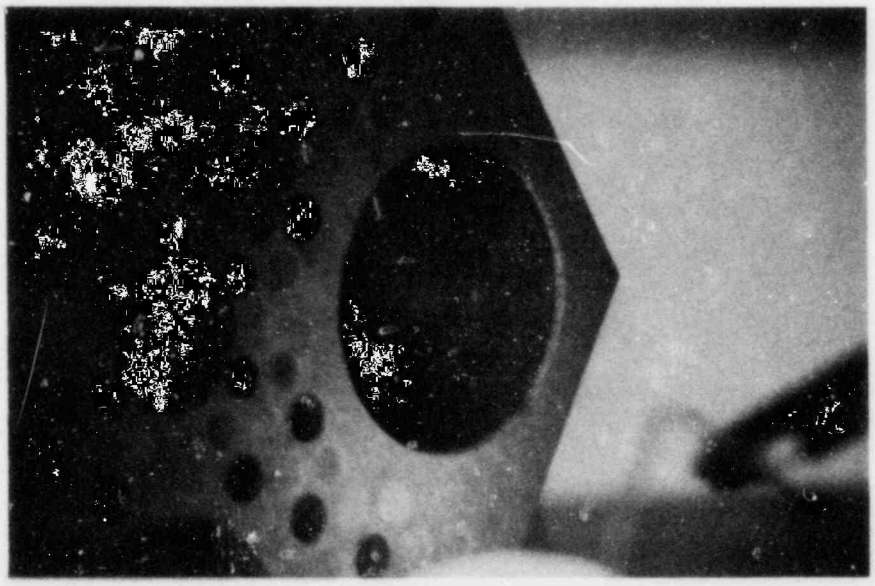


Fig. 5 Damage observed on two dowel sockets nearest "E" face on bottom of element 2-2693. See text Section 3.5.



(a)



(b)

Fig. 6 Control element 2-2693 (a) Overall top end view (b) Closeup of control rod penetration showing light, vertical scratches attributed to control rod movement.

hol to verify that they were not cracks. The E face showed the imprint of the adjacent offset control column in region 8.

3.5 FSV Fuel Element S/N 2-2693

This block was a control element, having two control rod channels and one poison channel in addition to fuel and coolant holes. The most notable feature observed on this block was slight damage to two of the dowel sockets on the bottom end, shown in Figure 5. This damage is tentatively being attributed to placement dowels on the bottom plate of the FSV shipping cask which prevent undue movement of the blocks during shipment.

Imprint marks of adjacent, offset blocks were seen on almost all faces since this control block was surrounded by standard fuel element columns in the reactor. All other marks on the block surfaces were minor scratches and scrapes typical of those seen on the other blocks examined.

The insides of the control and poison channels were inspected with the aid of a small in-cell spotlight. No cracks were observed in any of these holes. Shallow vertical scrape marks as shown in Fig. 6b, probably due to control rod movement, were seen in the two control rod channels.

3.6 Stacking Demonstration on Blocks 1-2415 and 1-0172

As called for in section 4.2.3 of the Test Specification (Ref. 2), block 1-2415 was stacked on block 1-0172 in their irradiation positions to investigate the fit of the dowels and sockets. This procedure is shown in sequence in Figure 7. The blocks stacked together easily with no apparent mismatch or interference. In fact, with the blocks stacked together but the weight of the top block supported by the overhead crane, there was noticeable lateral clearance, particularly at the B face dowel and socket location. This is shown in Figure 8. Figure 8a shows the view of the B faces just before finally lowering block 1-2415 onto 1-0172 ; the larger crack size in block 1-2415 is apparent. Figure 8b is a double exposure made by moving the top block to the two

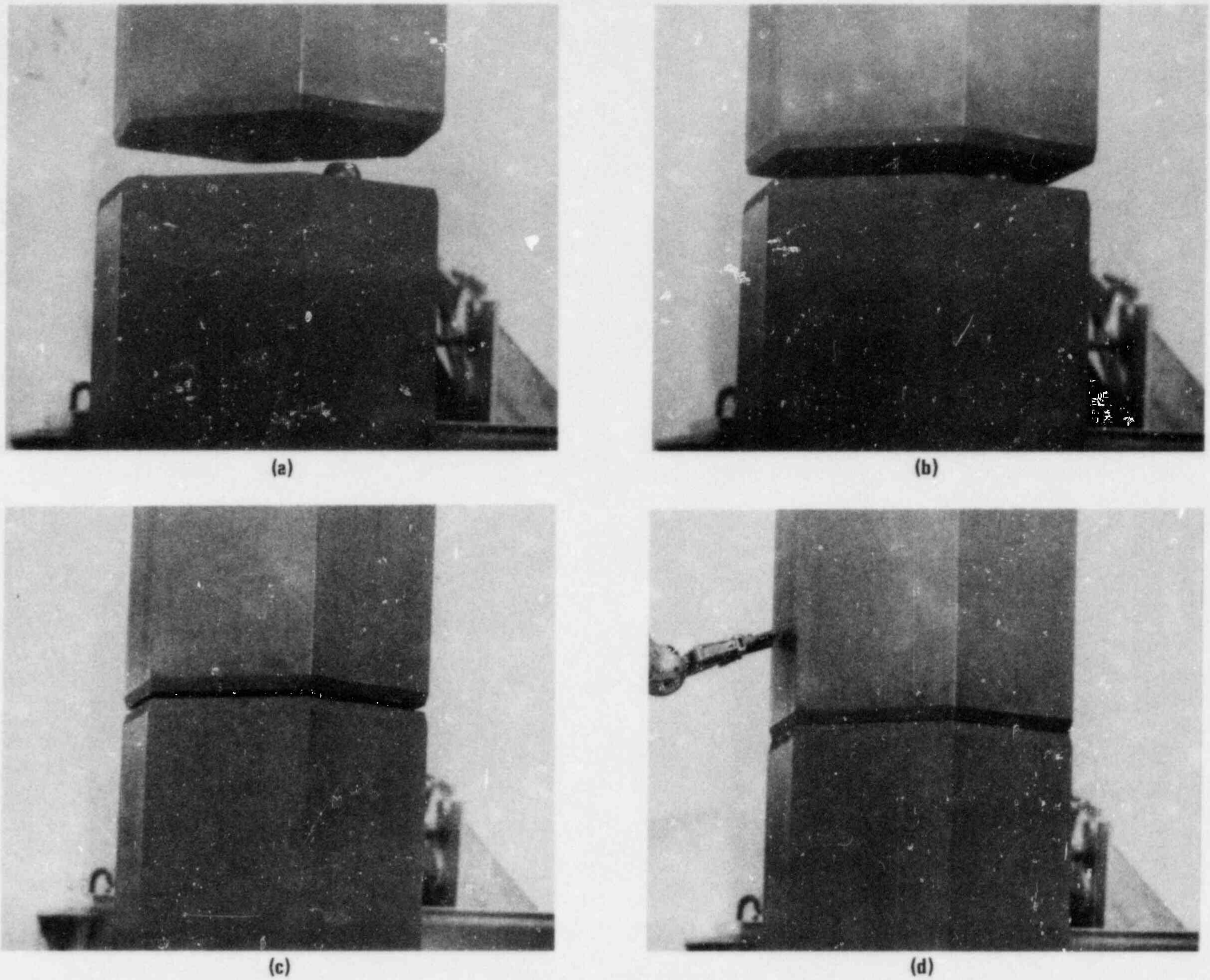


Fig. 7 Stacking demonstration with block 1-2415 (top) and 1-0172 (bottom) in each photo. (a) Blocks approximately 6 inches apart (b) dowels about to engage sockets (c) dowels engaged (d) fully seated.

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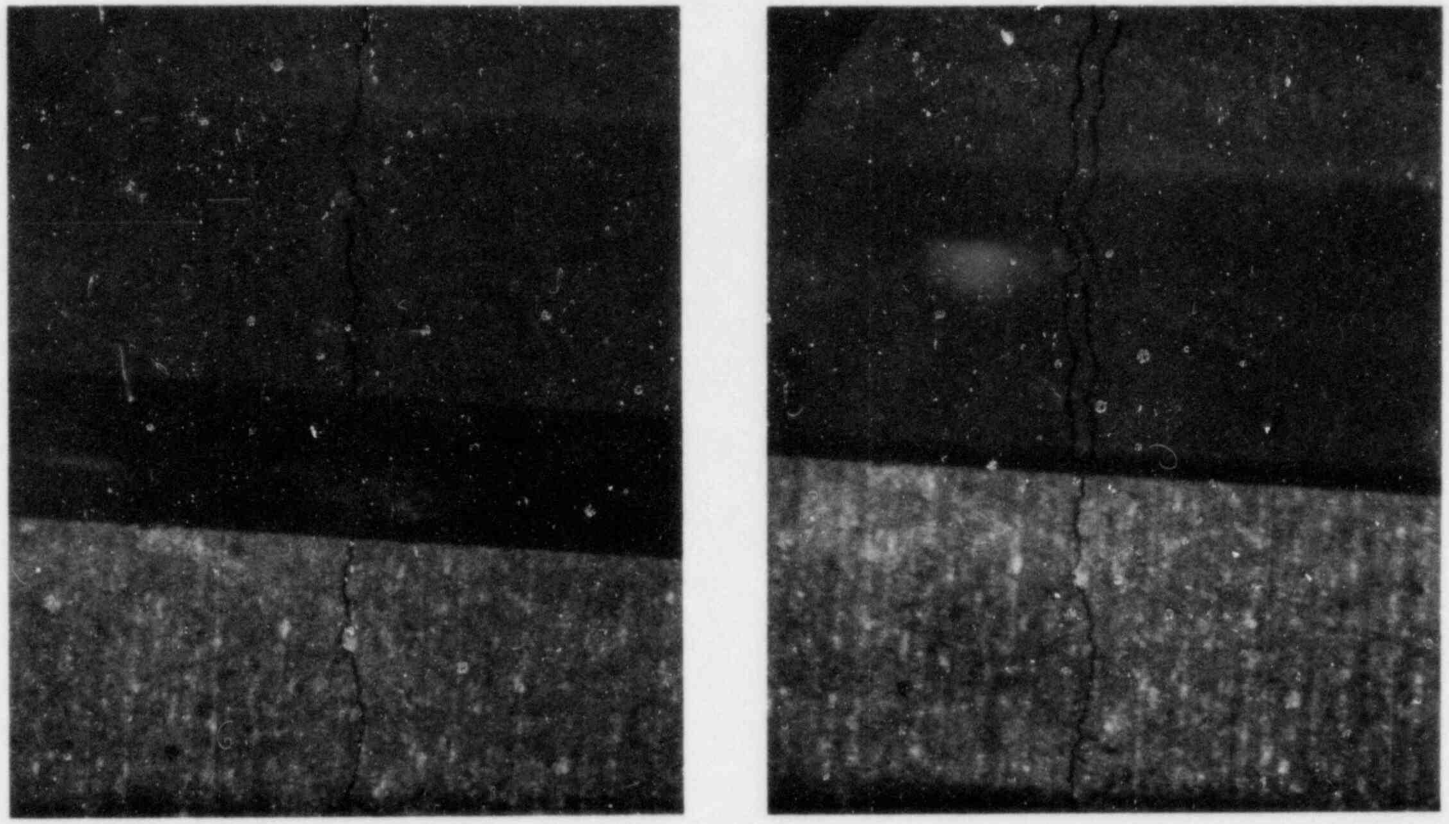
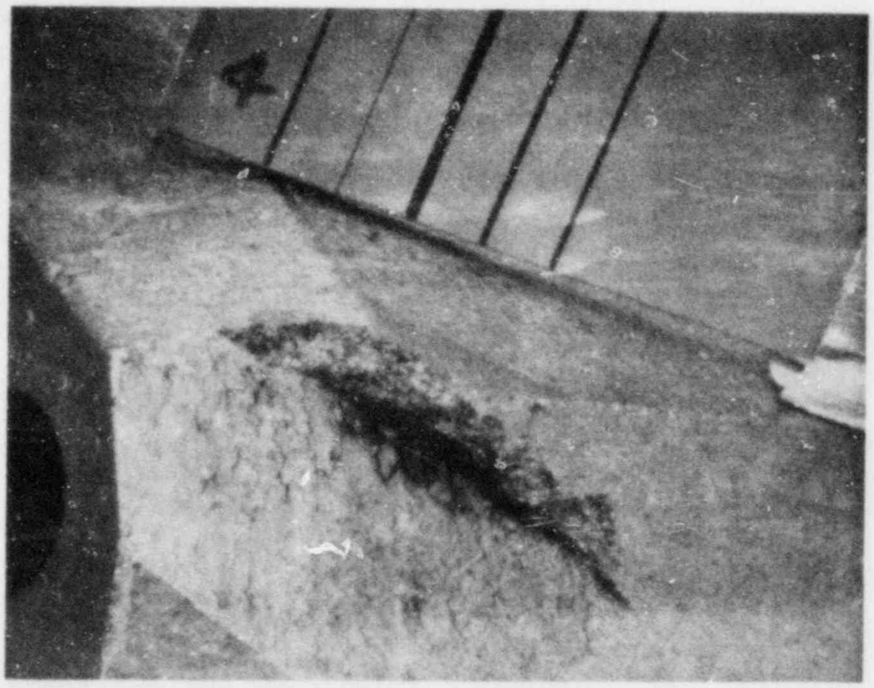
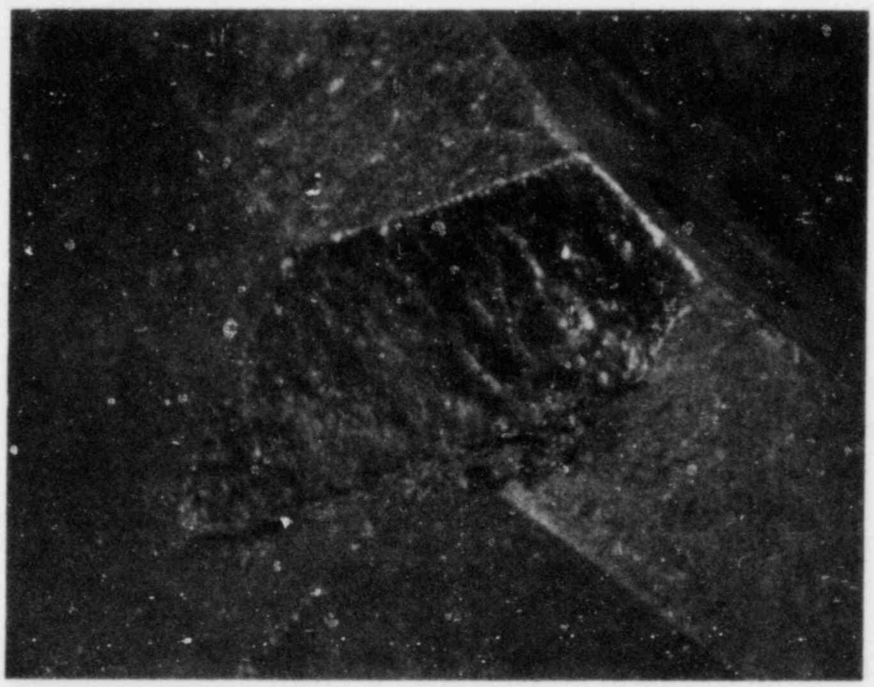


(a) (b)

Fig. 8 Stacking demonstration of blocks 1-2415 (top) and 1-0172 (bottom) at the "B" faces showing cracks in both blocks. (a) Just before fully engaged (b) fully engaged; double exposure showing lateral movement possible at "B" dowel and socket. (Appearance of cracks on photos enhanced with pen for clarity.)



(a)



(b)

Fig. 9 Damage at the top corners of two of the five blocks examined which occurred when the blocks were removed from the FSV shipping cask; (a) block 1-2415, (b) block 1-0172.

extreme positions allowed by the lateral clearance. From this exercise the relative movement and thus the diametral clearance at this point was estimated to be .040 to .050 in. (1.02 to 1.27 mm). The nominal design clearance is .040 in.

3.7 Dowel and Socket Dimensions

Although it was not called for in the visual exam procedure, several cursory dimensions of the dowels and sockets on blocks 1-2415 and 1-0172 were taken. A dial caliper was used to obtain these measurements, and no standards were employed. Table 1 gives the data. The O.D. measurements on the dowels seem satisfactory in that the percent shrinkage calculated by comparison with the nominal preirradiation dimensions agrees well with values determined previously in the surveillance characterization at FSV (Ref. 1). The socket measurements are probably in error, however, because the shrinkage determined from them is roughly 4 to 5 times the block average determined previously and because of the dowel to socket clearance determined indirectly during the stacking procedure (see Section 3.6). The dimensions shown in Table 1 indicate only .010 in. (.25 mm) diametral clearance between the B socket of block 1-2415 and the B dowel of block 1-0172, while the clearance apparent in Figure 8b was estimated to be .040 to .050 in. (1.02 to 1.27 mm). Since the stacking experiment was considered conclusive, no further measurements were made.

3.8 General Features

Figure 9 shows deep gashes at the tops of the first two blocks examined (S/N's 1-2415 and 1-0172). The source of these has been traced to a protruding index bracket on the shipping cask that gouged the blocks as they were removed for this examination. This damage was avoided on the other three blocks after the problem had been identified.

A feature seen on all the blocks examined is shown in Figure 10. A long, vertical scrape or scratch down the center of the C face, and sometimes near

Notations in this column indicate where changes have been made

the right hand edge of the D face was observed. The source of these marks is
/2 not known but it has been speculated that fuel handling in the fuel storage
/2 wells at the reactor site may be the cause.

4. REFERENCES

1. SAURWEIN, J. J., ''Nondestructive Examination of FSV Fuel Element 1-2415'', General Atomic Company, Document No. 906505, Issue A, May 17, 1982.

2. DONCK, H. A., ''Test Specification for Nondestructive Examination of FSV Fuel elements S/N 1-2415; 1-0172; 2-2693; 1-0108; 5-0801'', General Atomic Company, Document No. 906553, Issue A, July 1, 1982.

Table 1

POSTIRRADIATION MEASUREMENTS ON TWO FSV FUEL ELEMENTS

Block Number	Item	Measurement	Mean Dimension[a] in.(mm)	Nominal Preirradiation Dimension in.(mm)
1-2415	B dowel	outside diameter	1.7458(44.3433)	1.750(44.450)
1-0172	B dowel[c]	outside diameter	1.7484(44.4094)	1.750(44.450)
1-2415	B socket[b],[c]	inside diameter	1.7588(44.6735)	1.790(45.466)
1-0172	B socket[b]	inside diameter	1.7469(44.3713)	1.790(45.466)
1-2415	E face dowel	outside diameter	1.4981(38.0517)	1.500(38.100)
1-2415	E face dowel	outside diameter	1.4979(38.0467)	1.500(38.100)

[a] Average of three measurements taken at 0°, 45° and 90° orientations.
[b] See text, Section 3.7, concerning these measurements.
[c] The dowel and socket engaged during the stacking demonstration, See text, Section 3.6.

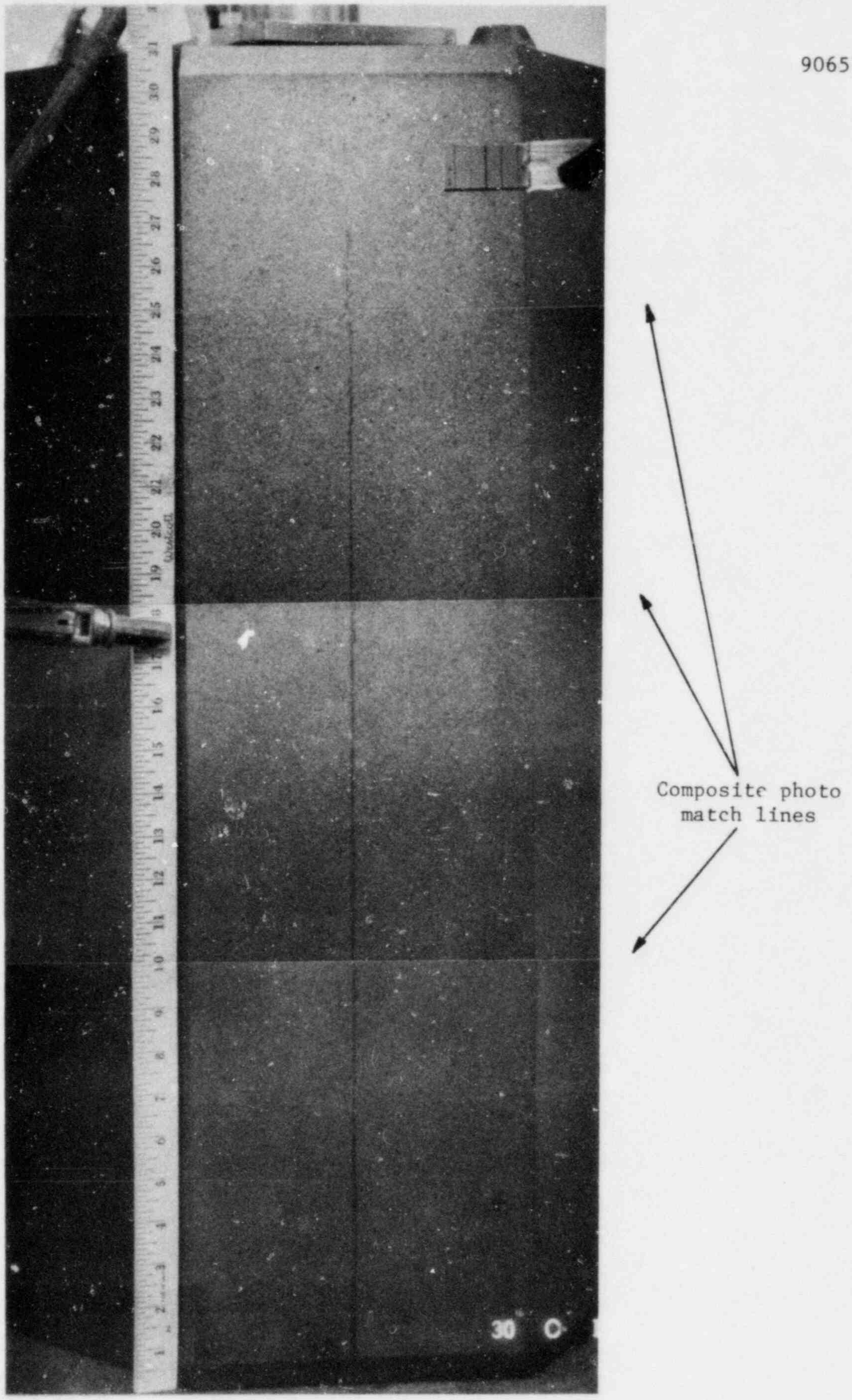


Fig. 10 Composite photo of ''C'' face of element 1-0108 showing vertical scratch seen in same location on all elements examined. See text, Section 3.8, (scale in inches).