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324 AND 325 BUILDING HOT CELL CLEANOUT PROGRAM

AIR LOCK COVER BLOCK REFURBISHMENT

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SUMMARY

The high-density concrete cover blocks shielding the pipe trench in the hot-cell air lock of the 324 Building Radiochemical Engineering Cells had accumulated fixed radioactivity ranging from 1,100 to 22,000 mrad/hr. A corresponding increase in the radiation exposure to personnel entering the air lock, together with ALARA concerns, led to the removal of the contaminated concrete surface with a hydraulic spaller and the emplacement of a stainless steel covering over a layer of grout. The resultant saving in radiation exposure is estimated to be 7,200 mrad for personnel completing burial box runs for the 324 and 325 Building Hot Cell Cleanout Program. Radiation exposure to all staff members entering the air lock is now at least 50% lower.

ACKNOWLEDGMENTS

This work would have not been completed without the help of the following groups and individuals:

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- Battelle Hot Cell Technicians: Galen Buck and Jim Hutchens.
- BCS Photography Services, especially Jerry Everett.

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CONTENTS

FIGURES

TABLES

324 AND 325 BUILDING HOT CELL CLEANOUT PROGRAM
AIR LOCK COVER BLOCK REFURBISHMENT

INTRODUCTION

The air lock in the Radiochemical Engineering Facilities in the 324 Building at the Pacific Northwest Laboratory (PNL)[a] has been in service since the 1960s. During this period the air lock has been used to transfer equipment into the four working cells, to perform contact maintenance, and to remove burial boxes containing cell waste. Figure 1 is a cross-sectional plan view of the 324 Building Radiochemical Engineering Cells showing the location of the air lock. All of these activities had gradually worn the paint from the high-density concrete cover blocks shielding the pipe trench in the air lock and had deposited radioactivity which became unremovable by conventional cleaning methods.

This fixed radioactivity became a major source of radiation exposure to personnel entering the air lock. For each cell-waste burial box shipped to the disposal site, two manned entries into the air lock are required. The first entry is to prepare the waste box dolly tracks and position the waste box, and the second is to remove the protective plastic sheeting as the filled burial box is removed from the air lock. The 324 and 325 Building Hot Cell Cleanout Program, which requires many shipments of waste boxes, has a major goal to reduce radiation exposure to levels as low as reasonably achievable (ALARA) while completing the programmatic tasks. This report describes the cover block refurbishment in some detail in an effort to make this new technology more readily available to others.

METHODOLOGY

The removal of fixed contamination from the air lock cover block surfaces was a part of the ALARA goals of the 324 and 325 Building Hot Cell

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(a) Operated for the U.S. Department of Energy by Battelle Memorial Institute under Contract DE-AC06-76RLO 1830.

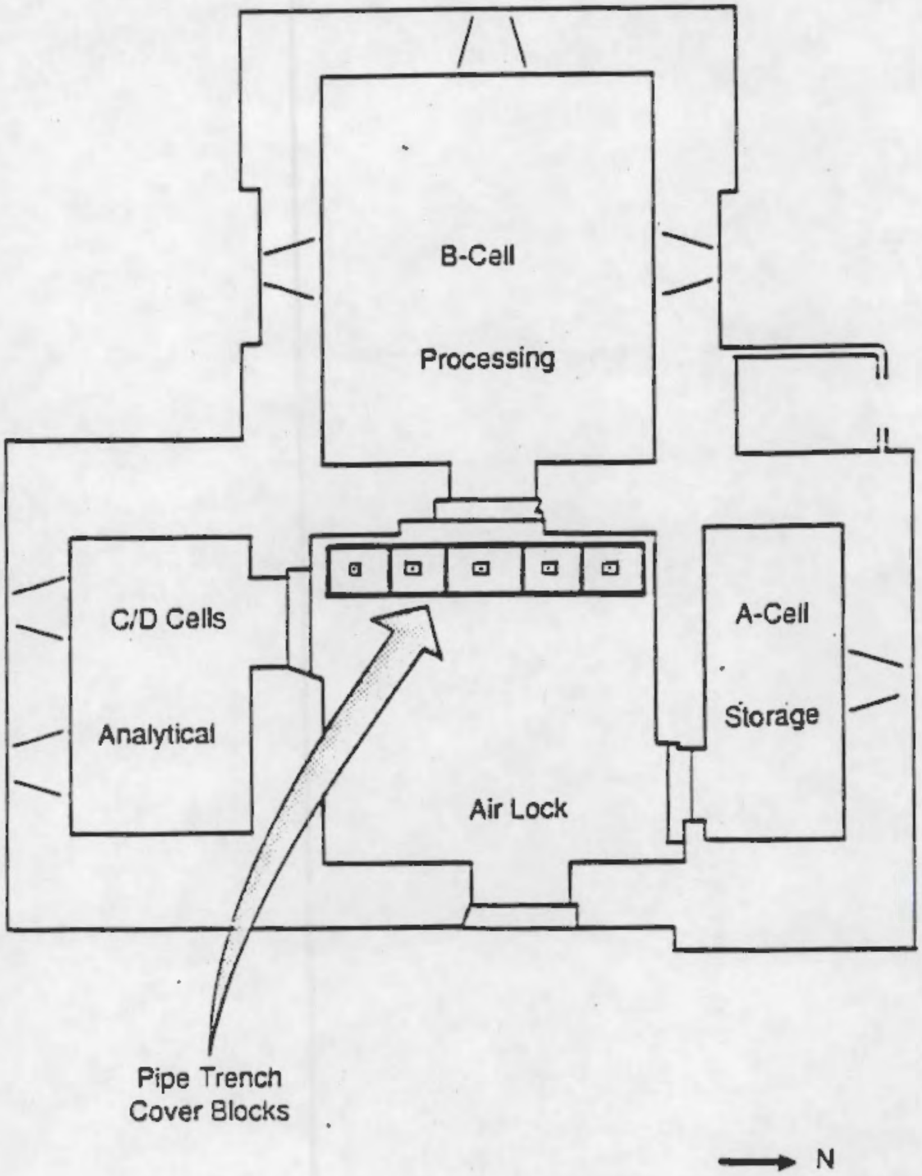

FIGURE 1. 324 Building Radiochemical Engineering Cells

Cleanout Program. Accordingly, the selection of the methodology was guided by the same goals.

ALARA CONSIDERATIONS

The concrete surfaces appeared free of macroscopic cracks but showed the wear of their 20-plus years of life (see Figure 2). To ensure both the removal of the fixed radioactivity and the strength of the newly grouted surface, it was decided that the concrete would be removed to a depth of at

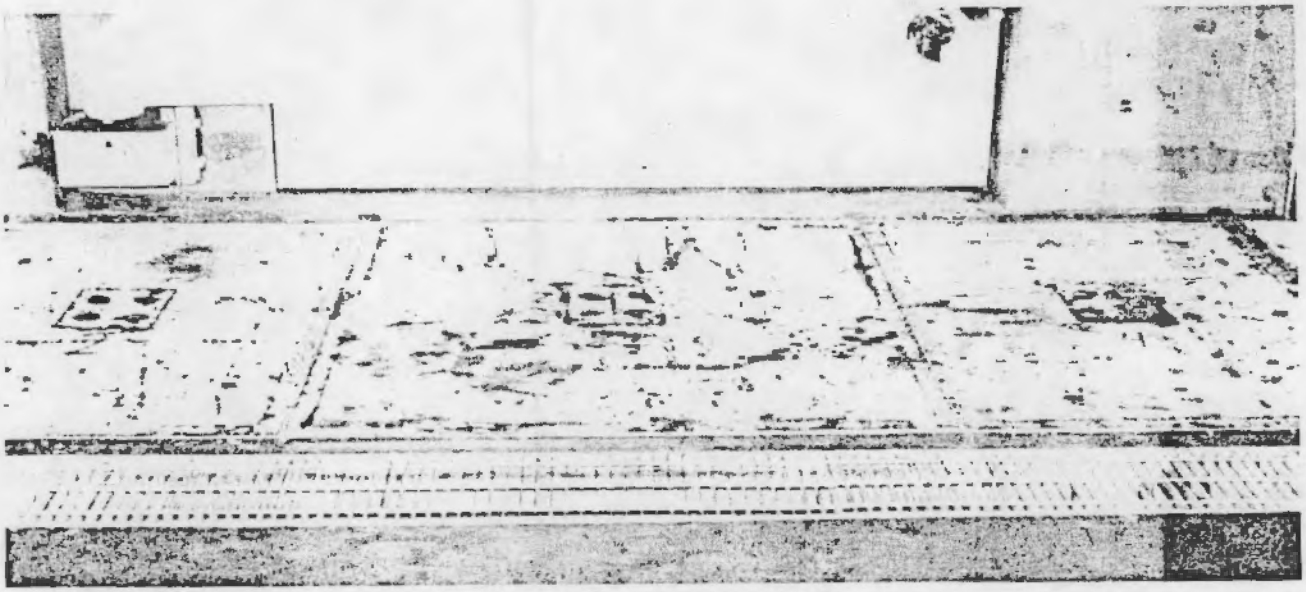

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FIGURE 2. Surface of Cover Blocks After 20-Plus Years of Service

least 1 in. Any remaining radioactivity at this depth would be shielded by overlaying 1 in. of grout.

To decrease any need for other refurbishment, a stainless steel surface for the refurbished cover blocks was planned. The final design specified a stainless steel surface plate 3/8 in. thick to be sealed to the cover block with quick-setting grout. The design included the welding of the surface plates to anchor bolts to prevent interference with the bottom of the cell door as it is opened and closed and to create the least depression and thus prevent water puddling.

Mechanical chipping, hydromilling, and hydraulic spalling are three methods which would quickly remove concrete to a 1-in. depth. Mechanical chipping is known to produce a lot of fine particulates as dust which may readily plug the air lock exhaust filters and which may be readily tracked towards the open air lock door. Hydromilling requires a jet of ultra high pressure water which may be readily misdirected towards the open air lock door, and the milling debris washed to the pipe trench sump underlying the cover blocks may clog the steam jet used to empty the sump. Hydraulic spalling, however, generates large aggregates, with a minimum of fine particles, and was believed to be least likely to spread contamination from the air lock. Thus the hydraulic spaller was chosen for the refurbishment, and the cleanup of spalled debris was expected to be the simplest and to yield the lowest overall radiation exposure to workers during refurbishment of the cover block consistent with the ALARA goals.

EQUIPMENT DESCRIPTION

The hydraulic concrete spaller developed at PNL removes concrete by exerting radial pressure against the sides of a shallow predrilled cylindrical hole (~2 in. deep x 1 in. dia) drilled into the surface (Halter et al. 1982). This concrete spaller, shown schematically in Figure 3, consists of four basic parts: a hydraulic cylinder, a 10,000-psi hydraulic pump, a push rod, and a bit with expanding wedges. The spaller, with push rod retracted, is inserted into a predrilled hole (~2 in. deep x 1 in. dia) and is then activated. This action hydraulically propels the push rod towards the bottom of the hole and forces the wedges of the bit into the wall and thereby spalls a piece of concrete aggregate about 8 in. in diameter. Figure 4 shows a bit and a push rod, and Figure 5 shows the expanded wedges of the bit when the push rod is inserted.

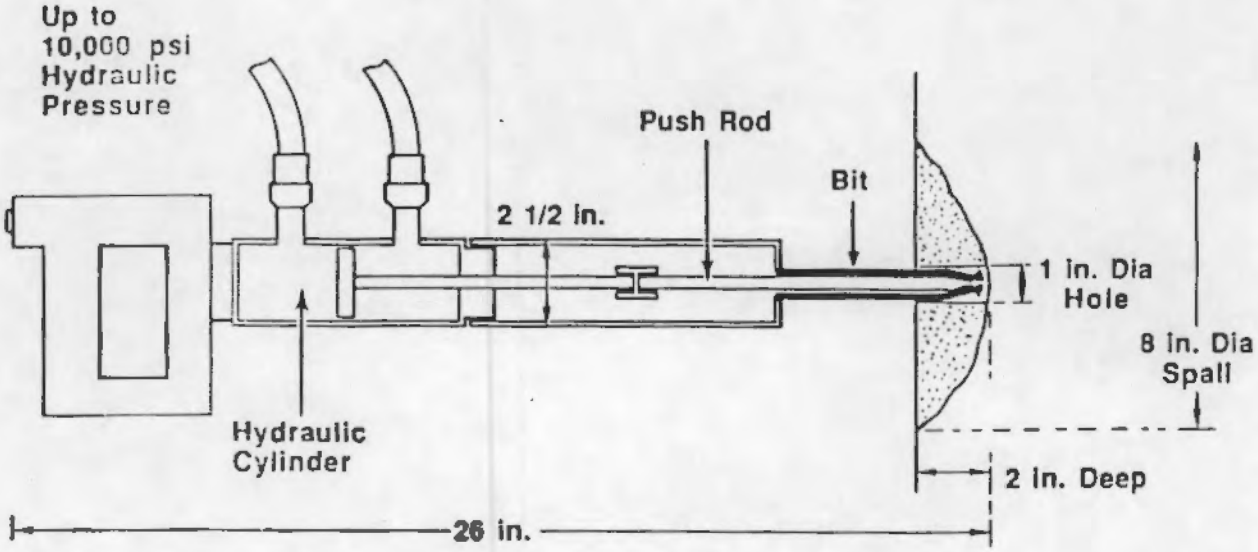

FIGURE 3. Schematic of Concrete Spaller

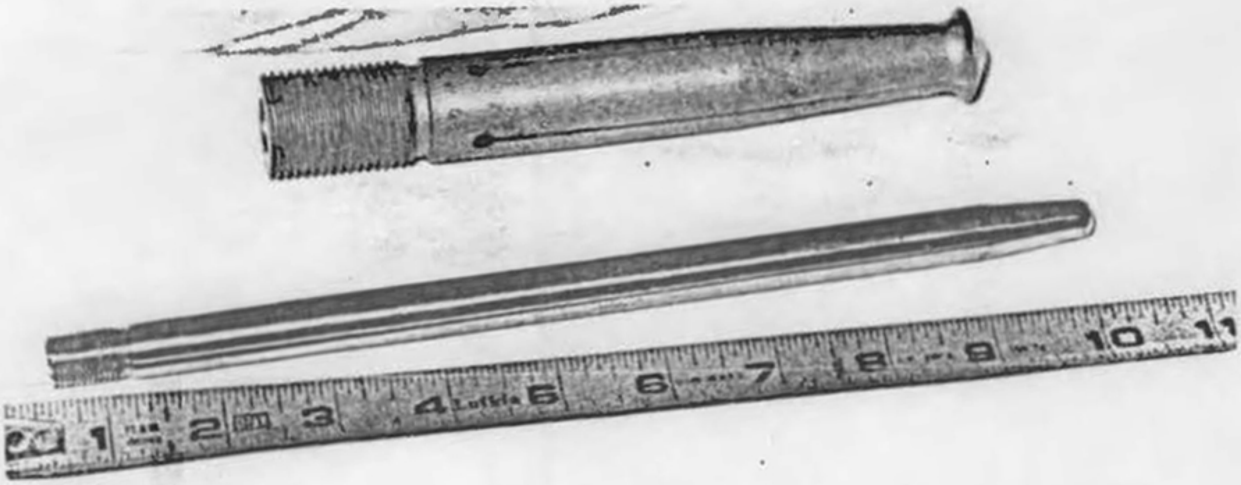

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FIGURE 4. Spaller Bit and Push Rod

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FIGURE 5. Push Rod Inserted into Bit To Expand Spalling Wedge

The concrete spaller was set up and tested nonradioactively to allow hands-on training of personnel of the construction contractor, Kaiser Engineers Hanford Company (KEH). During these equipment tests it was found that painting the concrete surface first with a latex paint kept the small spalled aggregates attached to the larger pieces (see Figure 6).

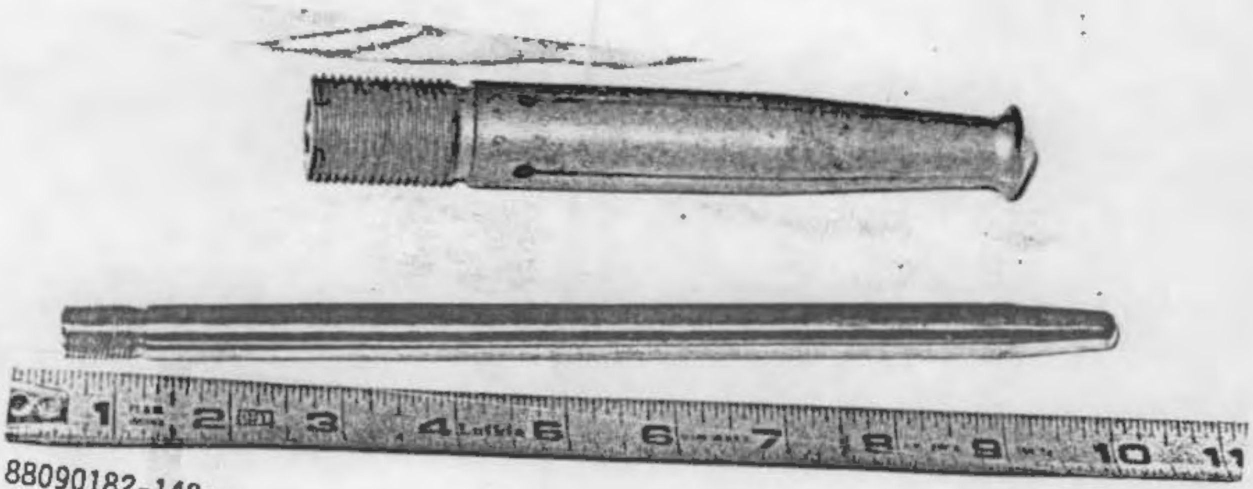

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FIGURE 4. Spaller Bit and Push Rod

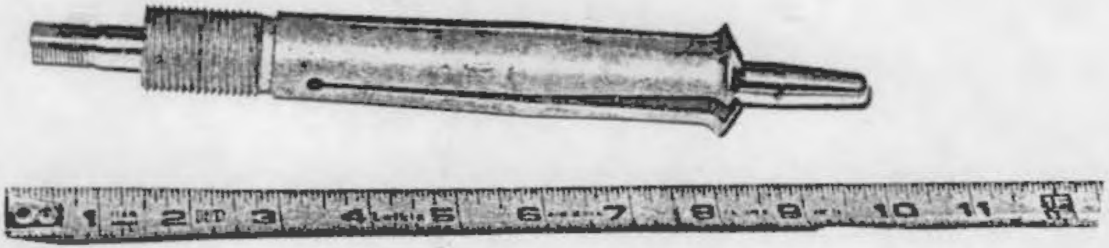

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FIGURE 5. Push Rod Inserted into Bit To Expand Spalling Wedge

The concrete spaller was set up and tested nonradioactively to allow hands-on training of personnel of the construction contractor, Kaiser Engineers Hanford Company (KEH). During these equipment tests it was found that painting the concrete surface first with a latex paint kept the small spalled aggregates attached to the larger pieces (see Figure 6).

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FIGURE 6. Spalled Aggregate Fragments Held Together by Paint Film in Cold Pretesting

COVER BLOCK REFURBISHMENT

The cover block refurbishment work was contracted to KEH, with PNL Radiation Protection Technicians (RPTs) providing radiation coverage. The workers wore fresh air-supplied masks.

PREPARATORY WORK

The cover blocks were washed to remove loose radioactivity. A pressurized (4,000 psi) water spray was used to wash the air lock as well as the cover block surfaces (see Figure 7). Radiation exposure rates were measured with a black widow CP at preselected areas on the cover blocks using a template. Figure 8 is a plan view sketch of the cover blocks showing initial exposure rates measured with the template and recorded as millirads per hour for window open/window closed measurements. The template was used periodically during refurbishment to measure exposure rates and verify that the background radiation level above the cover blocks was decreasing as expected. The periodic measurements of exposure rates are provided in the Appendix and are discussed in the Post-Refurbishment Analyses section of this report.

The heavily corroded mild-steel cover block lifting bolt holes, shown in Figure 9 for cover block #3, were cleaned with a tapping die and fitted with a threaded slotted-head plug. The cover blocks were then painted, and rubber matting was placed on the floor of the air lock and on the cover blocks to reduce the beta radiation exposure rate. The matting atop the cover blocks could easily be moved about, as needed, to work on the concrete surface.

DRILLING AND SPALLING

The optimum distance between the drilled spalling holes for aged high-density concrete was determined by measuring the initial spalled cavities. This spacing was particularly important at the edges of the cover blocks, where a deep spall could break out beneath the angle-iron framework and complicate the grouting process. The first spalled high-density concrete is shown in Figure 10. These atypical spalled aggregates were from a spalling hole located 4 in. from the edge and produced a spalled depth of about

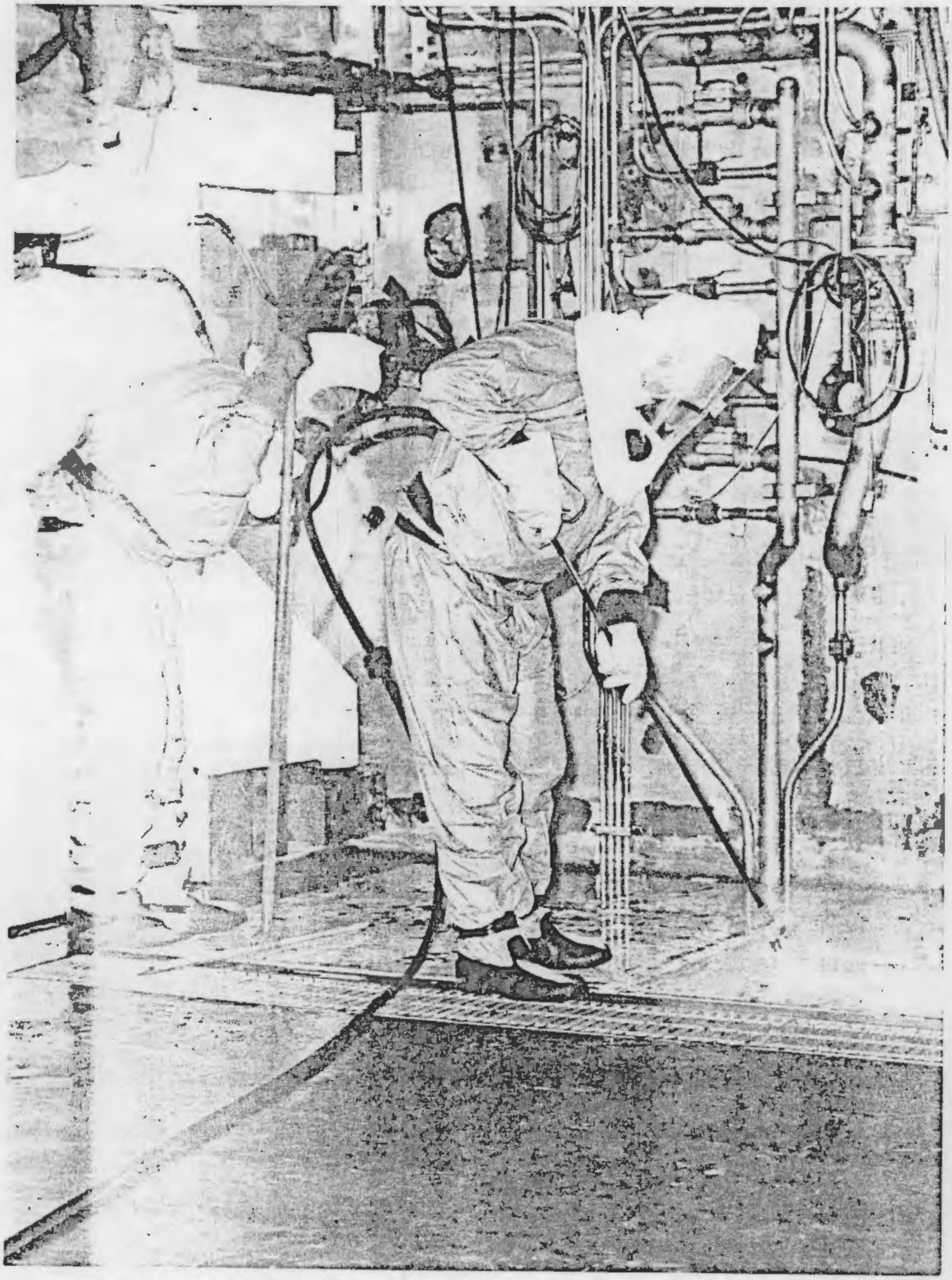

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FIGURE 7. Washing Cover Blocks Prior to Painting

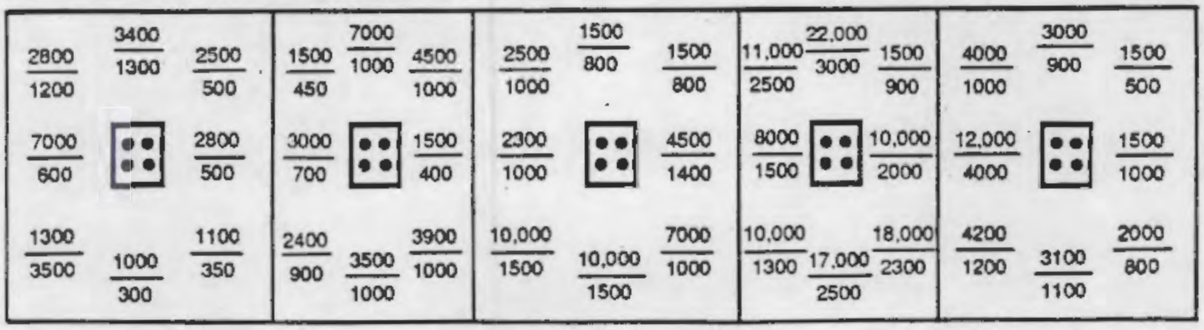
9-8-88 Start of Cover Block Refurbishing Work

FIGURE 8. Radiation Exposure at Selected Spots on the Cover Blocks as Measured with a Black Widow CP, with Window Open (mrad/hr)/Closed (mR/hr)

1/2 in. at the edge, along the angle-iron framework. Moving the spalling hole to 3 in. from the edge increased the spalled depth at the edge to 1 in., the desired depth. A nominal 8-in. spacing between drilled holes was found to be satisfactory.

Cover block #1 and one-half of cover block #2, totaling about 3,000 in.^{2} of concrete surface, required approximately 10 man-hours of air lock entry time to prepare, drill, and spall and to collect the spalled aggregate into a 30-gal barrel. The remaining concrete surfaces, totaling about 10,500 in.^{2}, required only about 12 man-hours in the air lock to complete the same tasks. This apparently increased spalling rate can be attributed only partially to acquired experience. It appears more attributable to the fact that construction forces were now shuttled to the air lock refurbishment job, for 1- to 2-hr air lock entry shifts, from other ongoing jobs. The productivity of these workers, however, was observed to vary markedly and may have been influenced by the physical requirements of their preshuttle task. The interface between the push rod and bit was lubricated with Molykote Aerosol between each spalling operation rather than every four operations as suggested by Halter et al. This lubrication sequence may have helped prevent wear or galling type failure. One spalling bit was replaced when the wedge portion broke away from one of the expanding prongs.

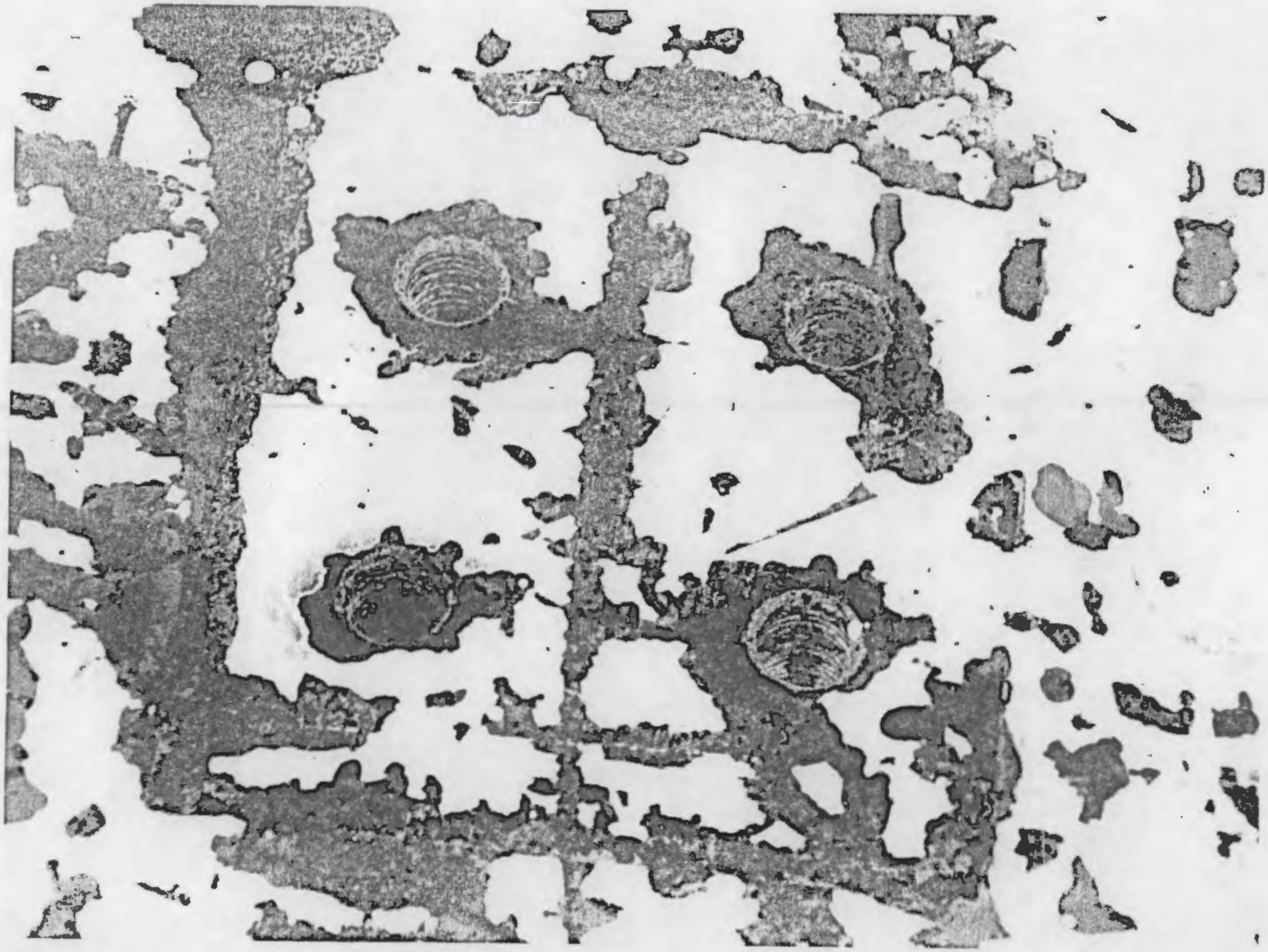

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FIGURE 9. Corrosion of Threads in Cover Block Lifting Bolt Holes

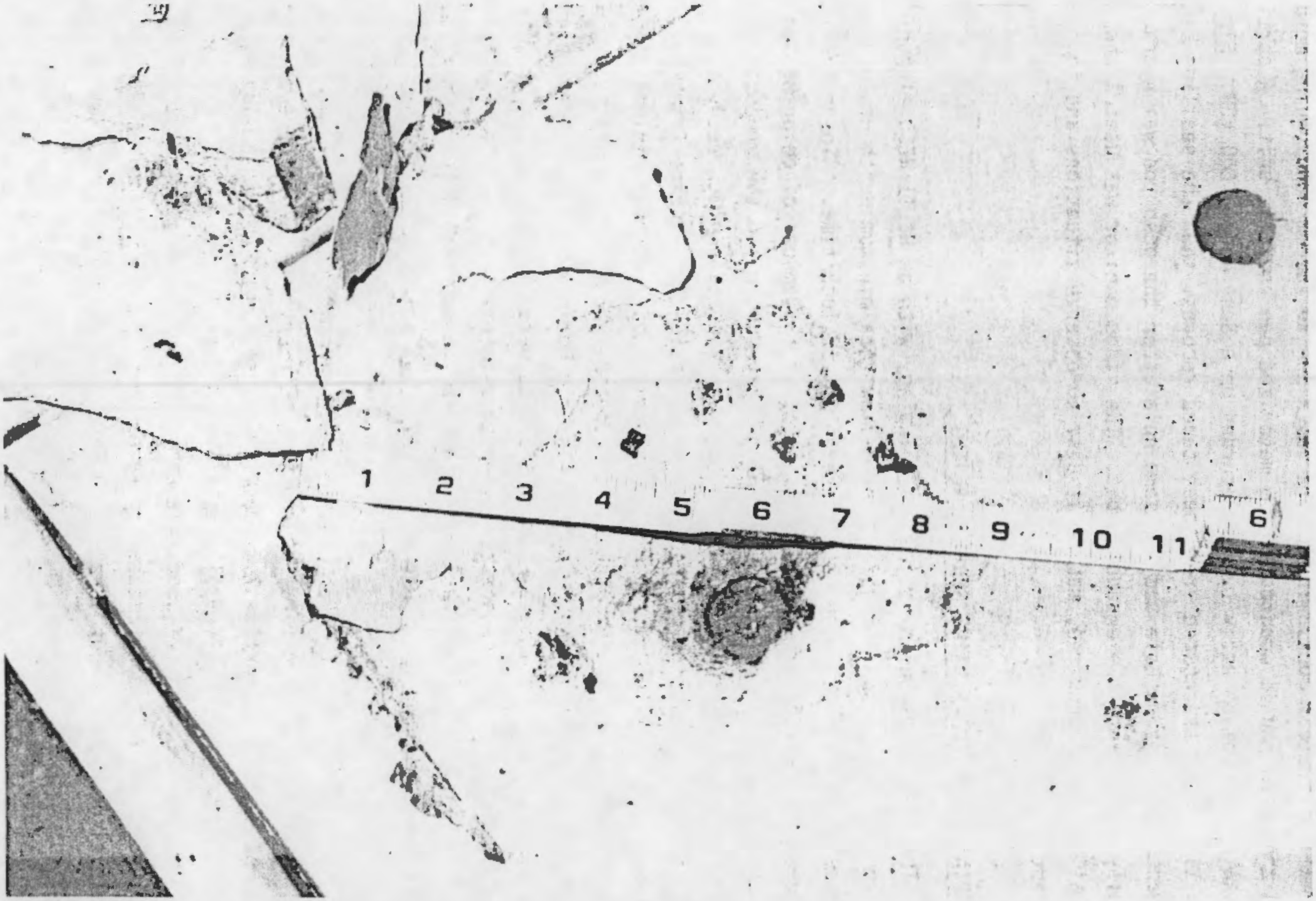

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FIGURE 10. First Spalled Hole on Cover Block #1

A remotely operated Rees Instruments CCTV Camera System was mounted on the wall of the air lock. The camera has a 30- to 150-mm nonbrowning motorized zoom lens and is mounted atop a motorized pan and tilt unit. A portion of the refurbishment activity was recorded on a Sony Model 7600 VCR. Figures 11 and 12, reproduced from these taped records, show the spalling bit as it was placed into a hole and the same hole after the push rod was hydraulically driven into the expanding bit. The video monitor was useful when in-cell problems occurred, making it easy to observe situations and to correct decisions.

CHIPPING AND FIELD-FITTING SURFACE PLATES

The most time-consuming job was chipping, with an HILTI HE60 electric rotary hammer, the spalled underlying cavity to a minimum depth of 1 in. This activity required about 21 man-hours of air lock time. Closer spacing between the drilled holes would have decreased the amount of chipping, and a functional problem with a chipper tool may have decreased the productivity during this task. Figure 13 is a photograph of a cover block ready to be grout-filled. The pairs of studs of unequal height protruding from the bottom of the spalled cavity were for the placement of the stainless steel surface plate. The taller stud was for bolting down the plate, and the shorter one was a leveling support. The bolt holes were field-located and drilled on the surface plates, and the plates were then used to adjust, by grinding, the leveling supports. These adjustments were made to keep the surface of the stainless steel plates within the design tolerance of +0.00 and -0.07 in. of the cover block surface.

GROUT

The nonshrinking natural aggregate grout, prepared in batches for each cover block, was Masterflow 713 Grout, manufactured by Master Builders. A two-part epoxy, Bond 1 Permagile Epoxies, was prepared and applied to spalled cover block surfaces as a bonding agent prior to pouring the grout. This ASTM C-881 epoxy is manufactured by Permagile Industries, Inc. The pouring and leveling of the grout is shown in Figure 14. When the grout was prepared

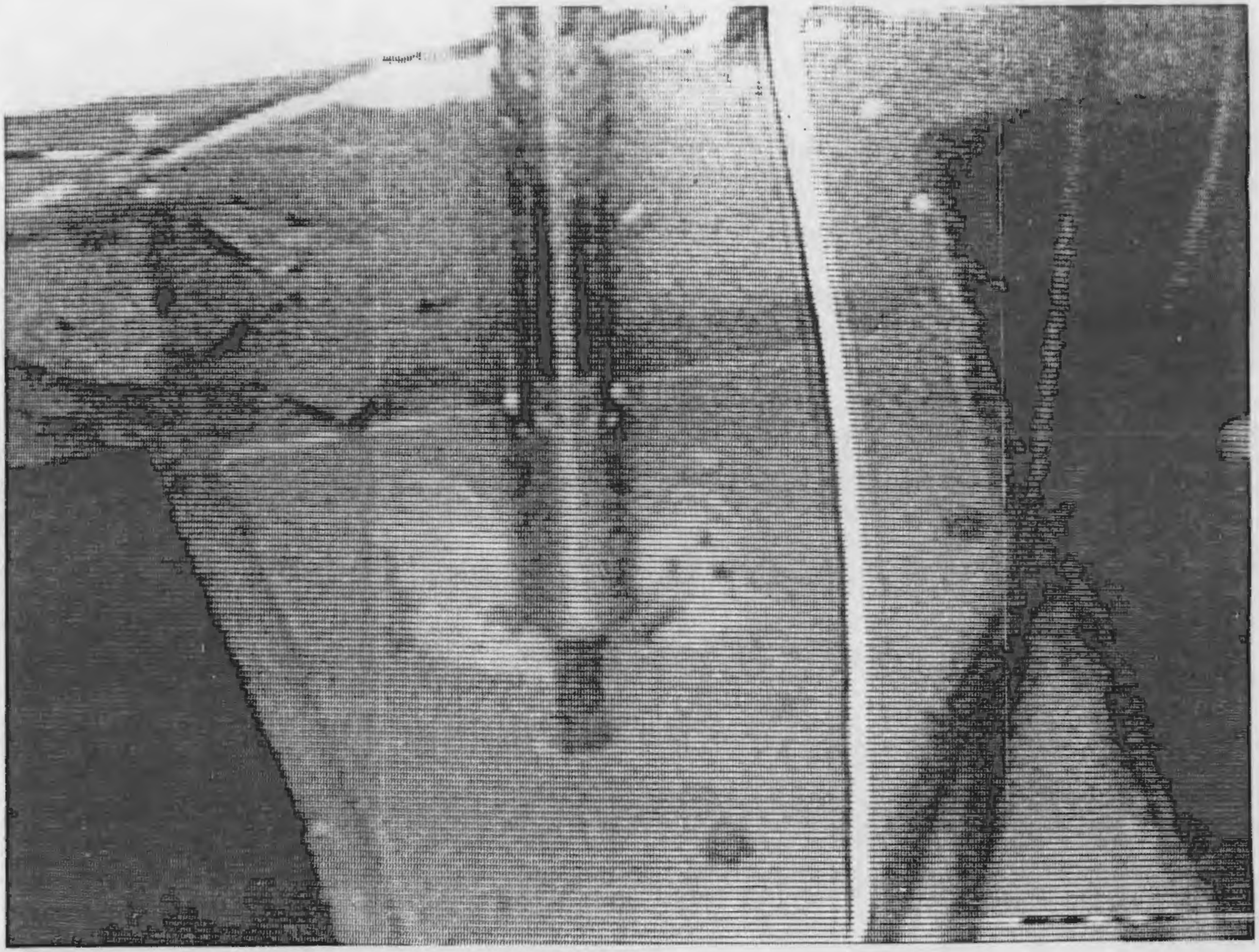

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FIGURE 11. VCR Photo of Spaller Bit Placed into Drilled Hole

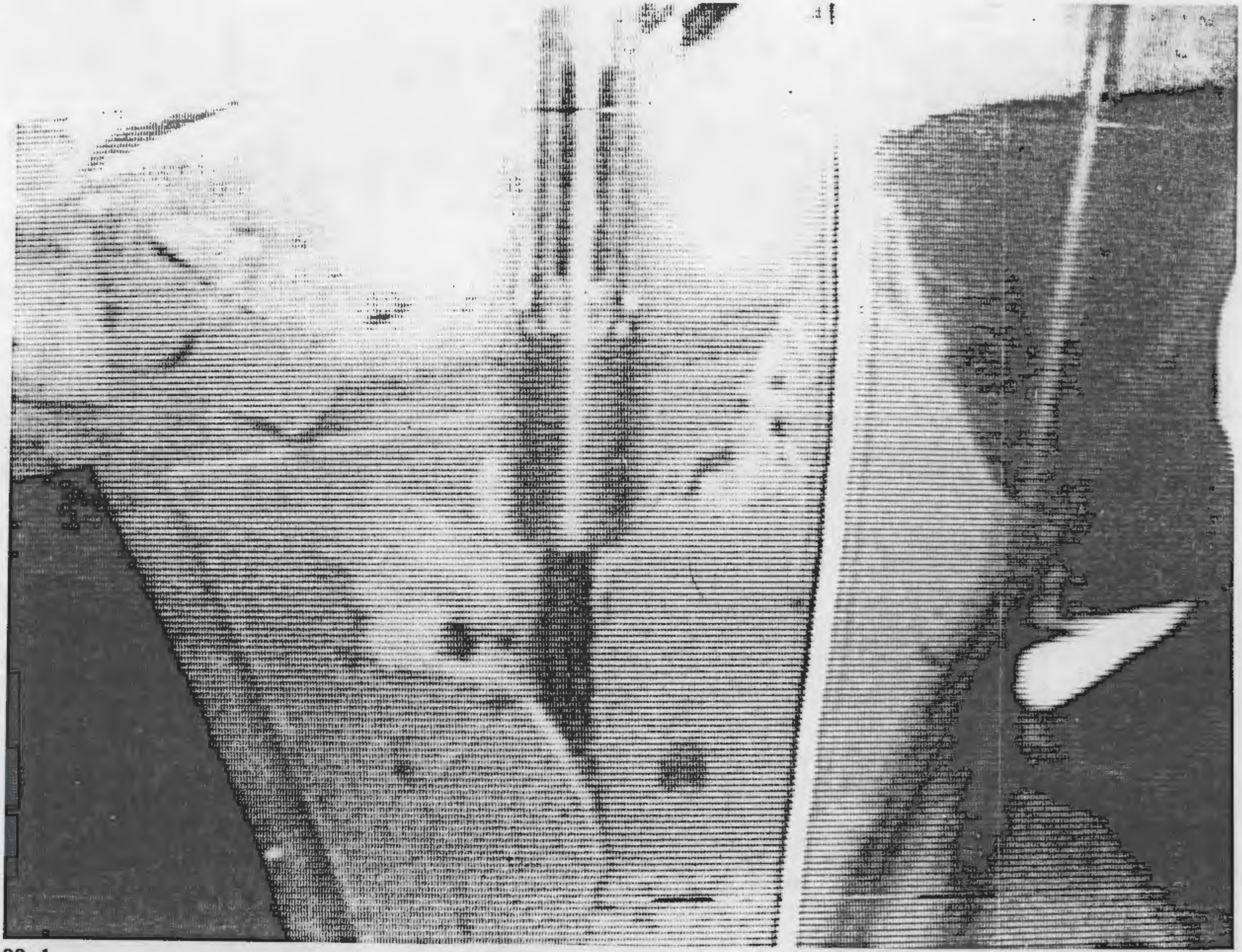

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FIGURE 12. VCR Photo of Hole in Figure 11 After Spalling

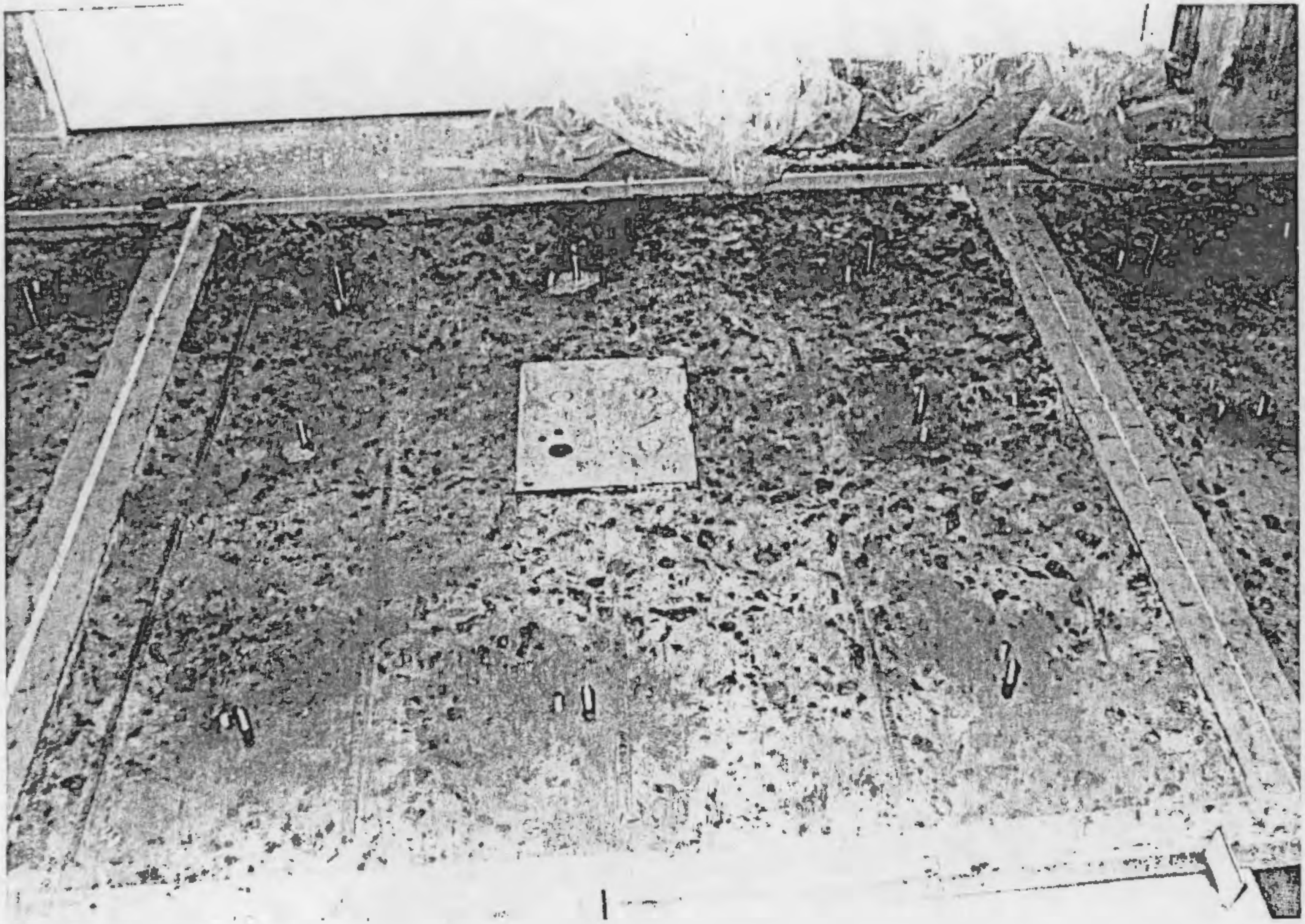

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FIGURE 13. Cover Block Ready for Grouting

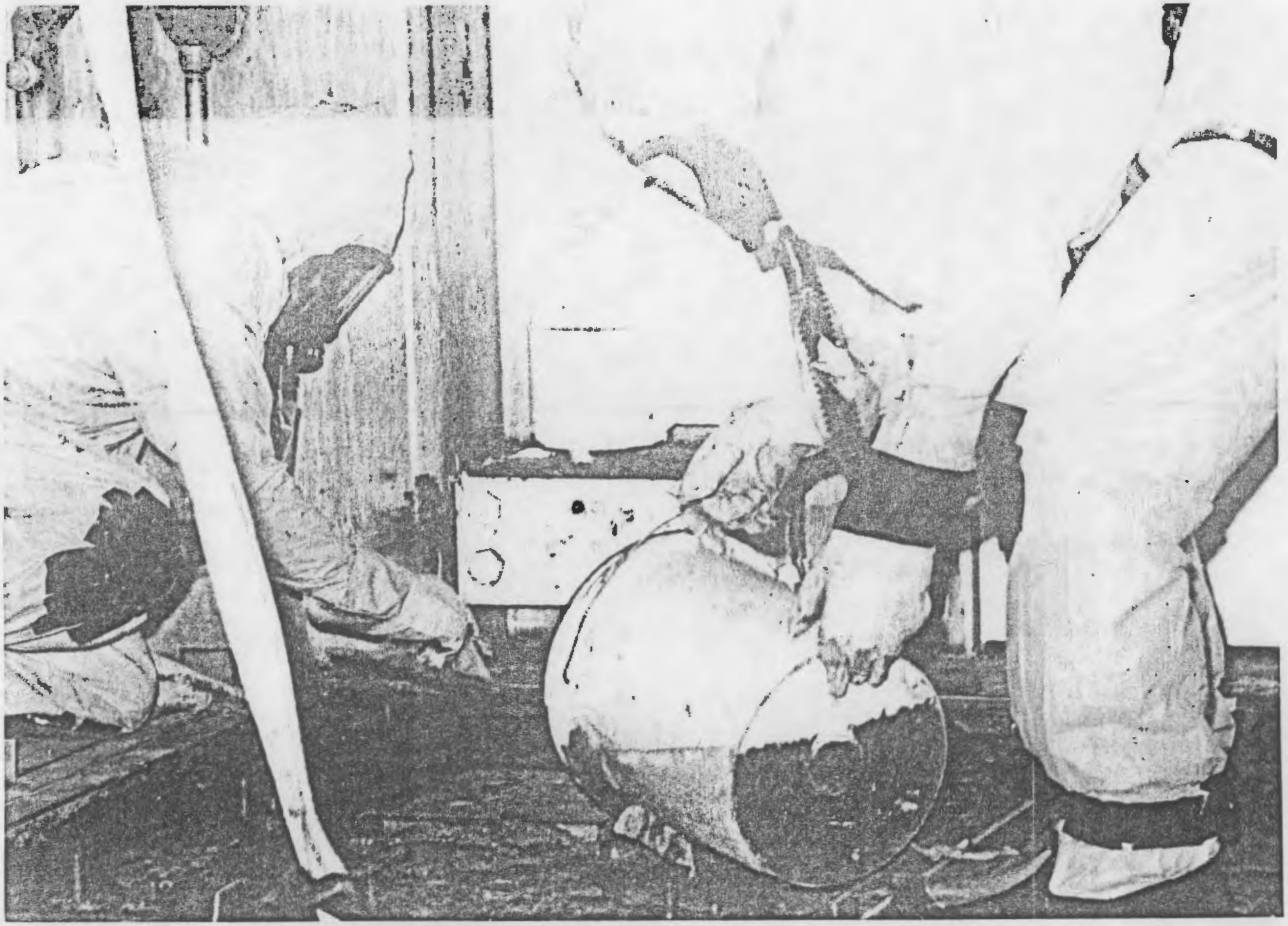

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FIGURE 14. Pouring and Leveling of Grout

with the standard frit/water ratio it was not easily workable in the small, oddly shaped areas interdispersed with anchoring studs. Therefore it was made more fluid after the first cover block was grouted and was then observed to flow out from under the stainless steel surface plates as they were being anchored into place. The stainless steel surface plate leveling supports were used to aid in determining the grout fill height during leveling.

INSTALLATION OF SURFACE PLATE

The stainless steel surface plate was placed over the grouted cover block (Figure 15) and the plate bolted down to contact the leveling supports with a "U" shaped spacer-washer under the nut. A tack weld was made in the "U" opening of the washer before the nut and washer were removed (Figure 16). The anchor studs were completely welded, as shown in Figure 17, and all protrusions above the surface plate were ground away.

DECONTAMINATION AND FINAL DETAILING

The next refurbishing step was to decontaminate the mild steel portions on the original surface of the cover blocks. These areas were the angle-iron framework and the cover block lifting plates anchored at the balanced point of the blocks. Dry sand was poured into the gap between the newly installed stainless steel surface plates and these paint-covered contaminated metal surfaces before grinding away the contaminated layer of metal as shown in Figure 18. The sand was then vacuumed out, and the gap was filled with GE RTV 102 silicone rubber sealant (Figure 19) rather than with a metal weldment. Although the stainless steel plates were tack-welded to the mild steel angle-iron framework, they were not seal-welded to it in order to preclude warpage and subsequent interference with the opening and closing of the cell doors. The freshly ground steel portions of the cover blocks were painted with Amercoat Red primer followed by a coat of Amercoat Grey paint, Figure 20.

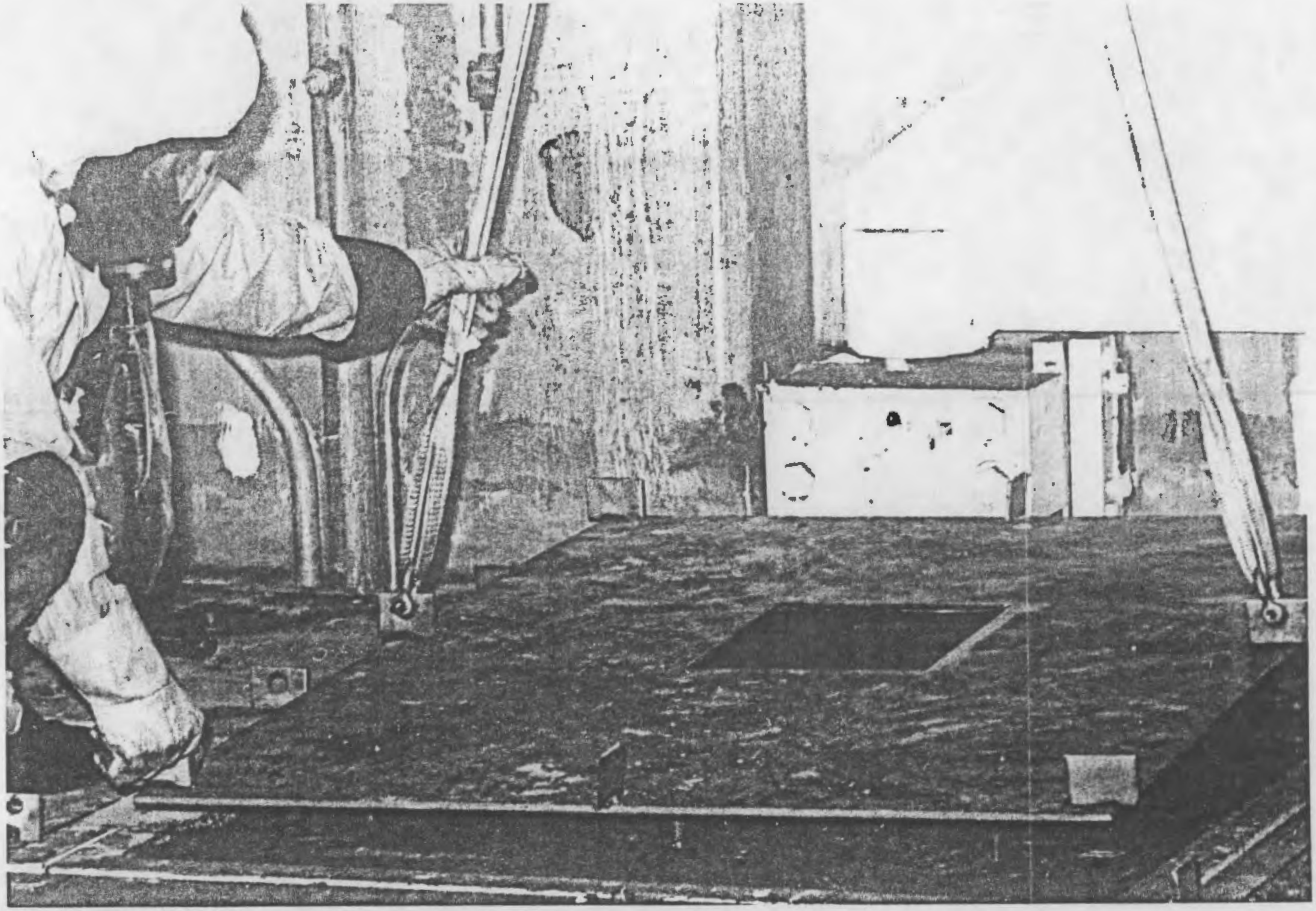

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FIGURE 15. Stainless Steel Surface Plate Being Lowered onto Fresh Grout

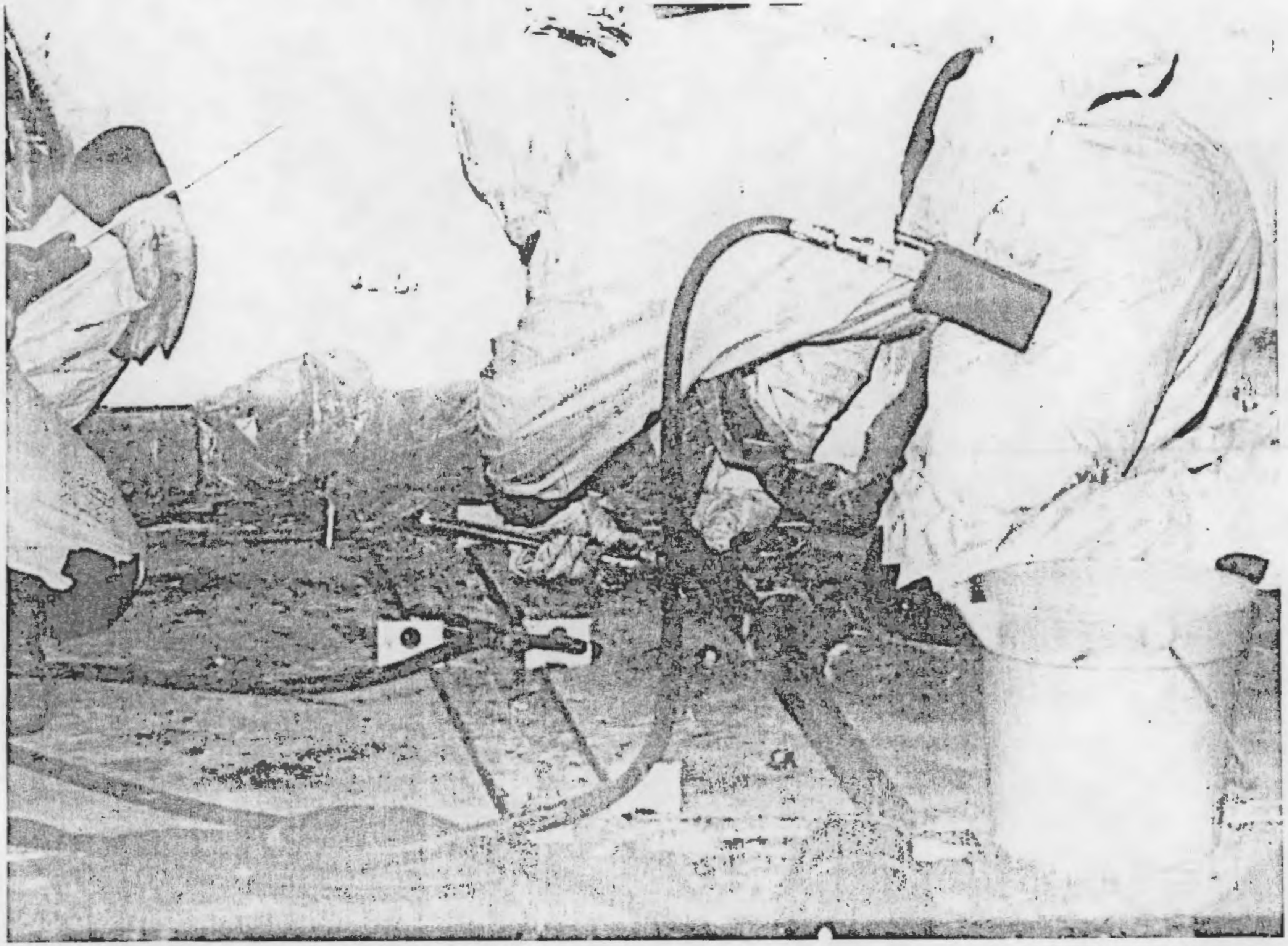

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FIGURE 16. Anchor Bolt Nut and Washer Being Removed After Tack-Welding

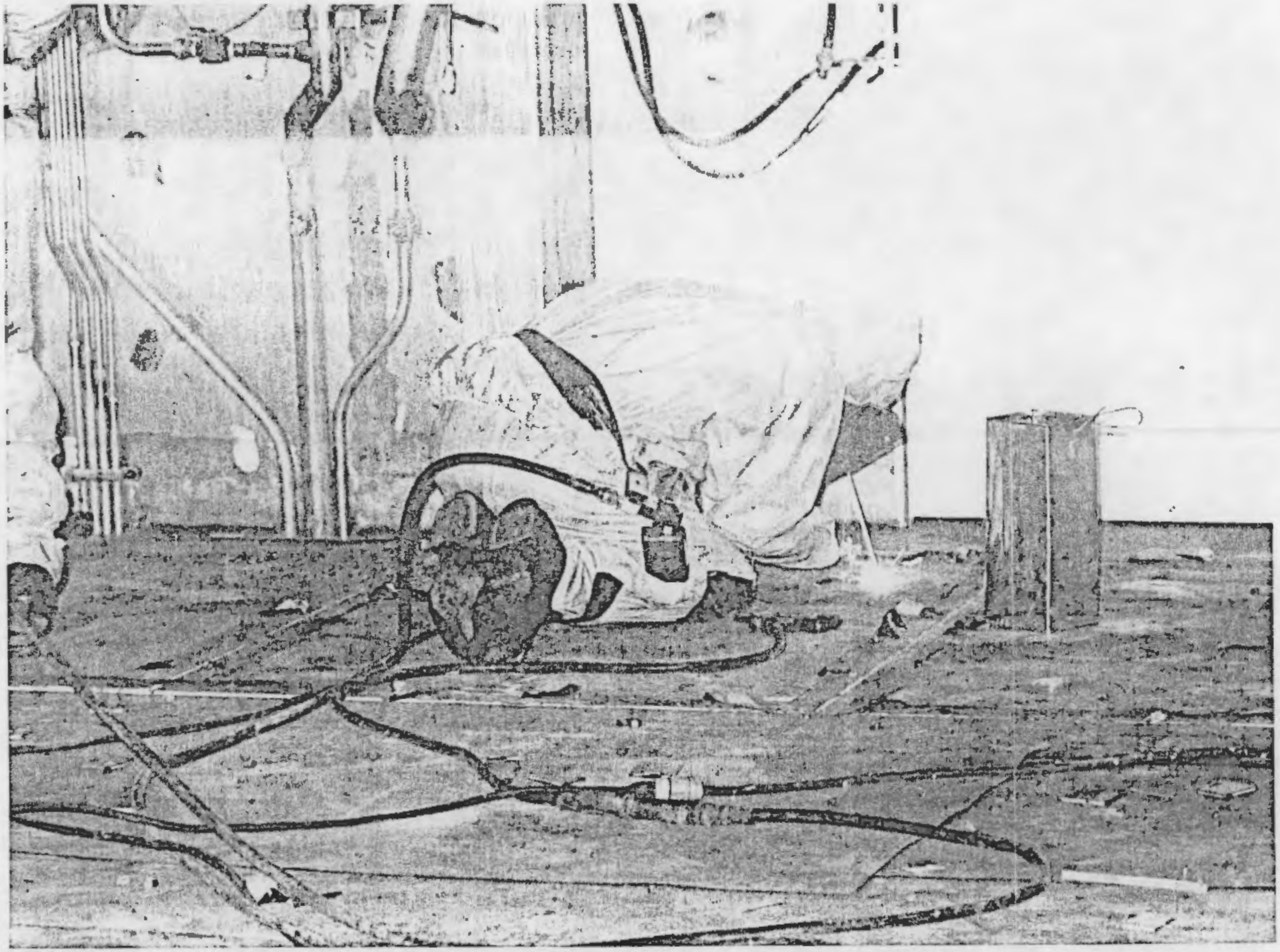

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FIGURE 17. Anchor Studs Being Seal-Welded to Surface Plate

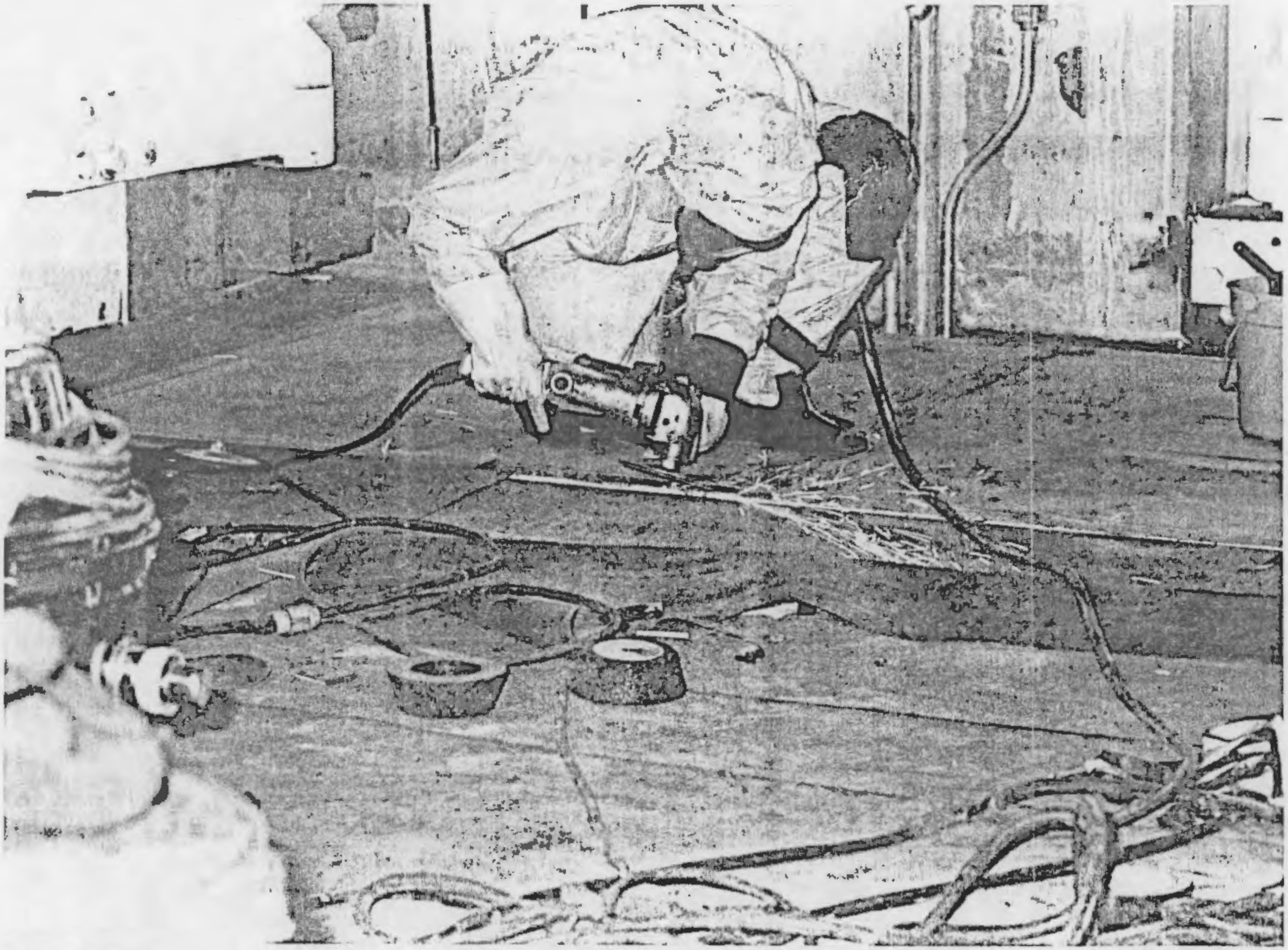

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FIGURE 18. Grinding Contamination from Steel Angle-Iron Framework

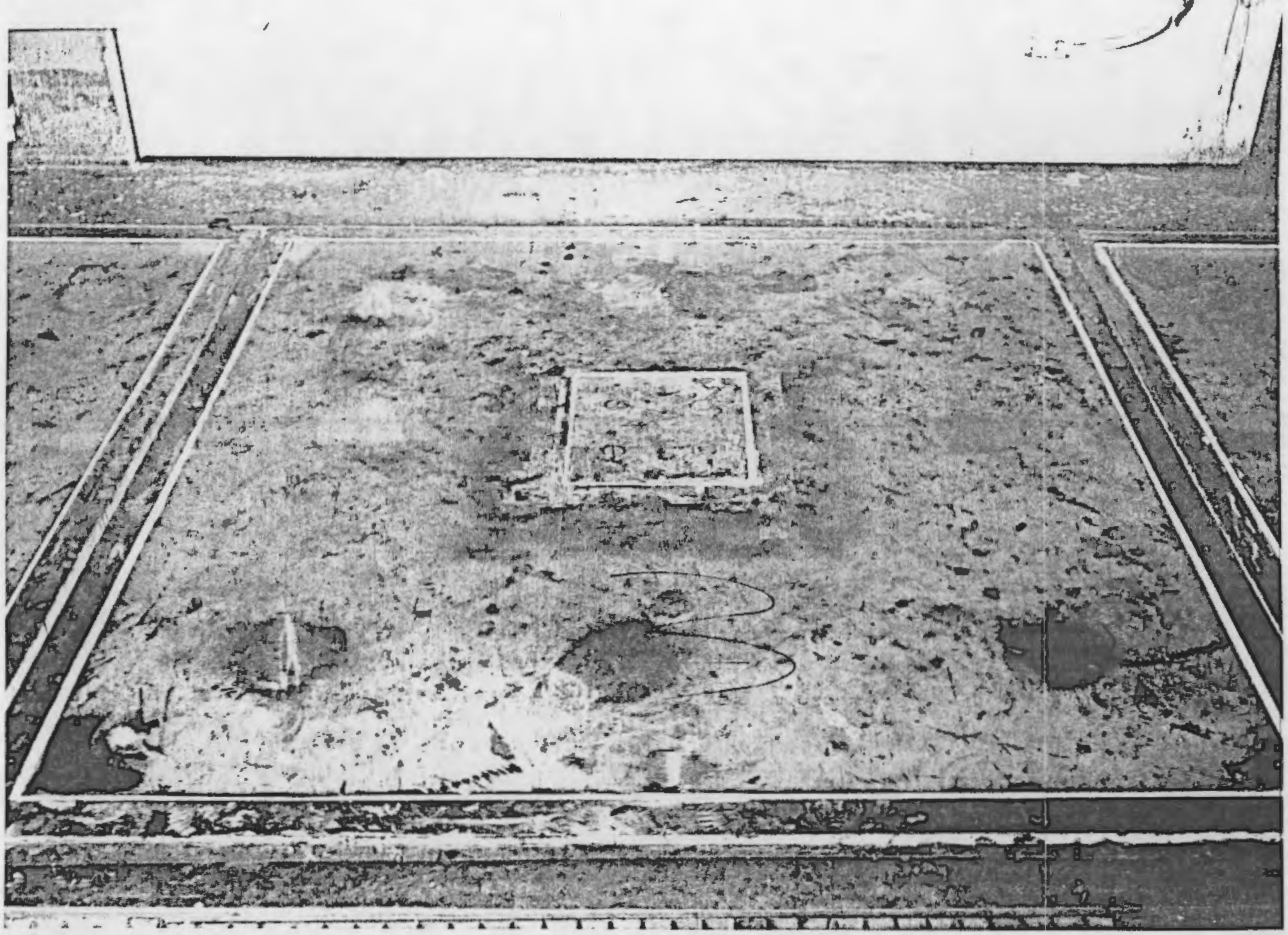

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FIGURE 19. Silicone Rubber Sealant Placed Between Metal Joints

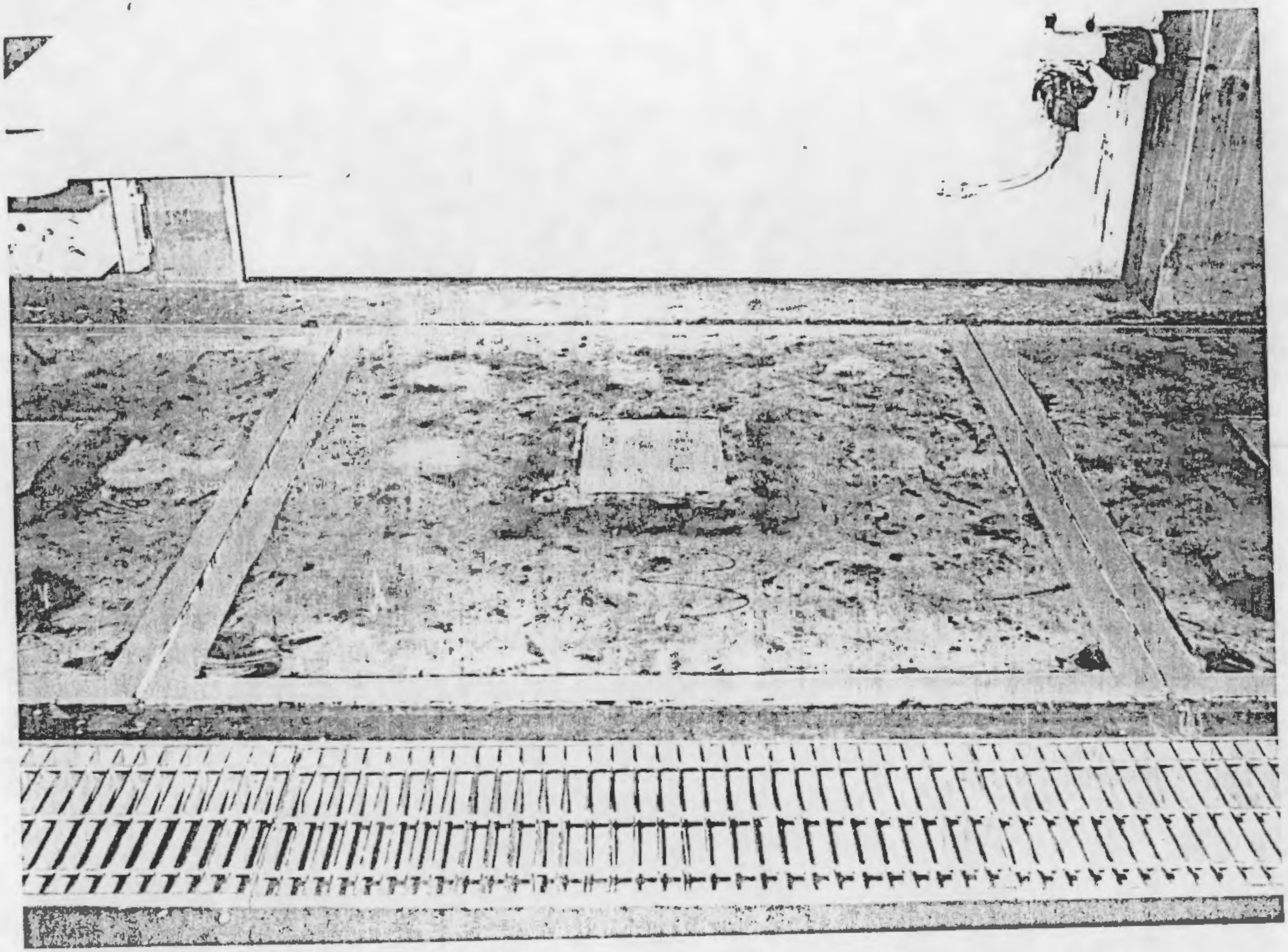

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FIGURE 20. Refurbished Cover Blocks with Steel Surfaces Painted

WASTE

Seven 30-gal barrels were filled mainly with spalled aggregates and concrete chipping debris. These barrels were slipped into 55-gal drums at the threshold of the air lock door, and lids were bolted on. All the 55-gal drums were released by the RPT for disposal without requiring any additional surface cleaning.

Additional refurbishment wastes included nonrecoverable protective clothing from 84 air lock entries, contaminated equipment, and surplus supplies. The rubber matting placed on the floor of the air lock was a major waste disposal item.

POST-REFURBISHMENT ANALYSES

The cover block refurbishment was completed in 10 working days within a period of 12 calendar days. Because the KEH workers always worked in pairs within the air lock, the actual work time for the pair was normally the time when one worker reached his radiation dose limit. Since each individual received radiation doses at different rates, the maximum usage of available radiation dose was not achieved. This was evident during the first four working days, when a total of 15.9 hours were spent in the air lock by 14 workers. After the fourth working day, the air lock work force was shuttled from other nearby job assignments to spend about 1 to 2 hr in the air lock before being shuttled back to the other assignment. Continuity of operations within the air lock was maintained by having a worker suited and ready to enter as another worker, who had either reached his radiation dose limit or had become physically tired, departed the air lock. In this manner, the actual work hours increased to 95.7 hours for the last six days. A total of 111.6 man-hours of air lock work, spread over 84 separate air lock entries, were needed to complete the refurbishment.

The periodic measurements of the radiation exposure rate at the surface of the cover blocks are shown in the Appendix. The use of the template, described previously, allows the measurements to be compared. The exposure rate definitely decreases, and the apparent decontamination factor ranges from 3 to 225. The radiation exposure measurements at the refurbished cover blocks do not go to zero as the background radiation level near their surface is controlled by the contaminated bridge crane, the penetrating radiation from the adjoining cells, and the general surface contamination of the remainder of the air lock.

A sample of spalled cover block concrete was taken and was submitted for radiochemical analysis to determine the penetration depth of ^{137}Cs and ^{90}Sr into the high-density concrete. Two analytical samples were cut from the spalled piece with a diamond-coated saw blade and were cast in resin and analyzed. The analysis consisted of counting in a gamma ray spectrometer, scrape-removing a layer of paint and recounting the sample, and then recounting the sample between each removal of four thin layers of concrete. The separate residues of paint and layers of concrete were then counted by a gamma spectrometric method and also in the beta counter where beta absorption curve studies were made. These latter counts allowed the ^{90}Sr concentration to be estimated as a function of depth into the concrete.

Figures 21 and 22 show the percent of the radionuclide species ^{137}Cs and ^{90}Sr remaining in the concrete as a function of the depth of high-density concrete removed. Differences in penetration depths may reflect error in accurately removing each layer of concrete rather than show different porosities between the two samples. At zero depth, the percentage decrease from 100% reflects the radioactivity that was removed with the surface paint. About 50% of the ^{137}Cs inventory and 30% of the ^{90}Sr inventory in the samples were found in the painted layer. Strontium appears to migrate more readily than cesium into the concrete.

Although the radioactivity could have been removed from the cover blocks by a much shallower concrete removal method than by the hydraulic spaller, the depth was needed on the cover blocks to ensure grout strength to support and seal to a stainless steel flooring plate. Painted concrete walls can be decontaminated by removing the paint and about a millimeter of the underlying concrete. This penetration depth found in the high-density concrete cover blocks is similar to penetration depths reported for other nuclear facilities (McIsaac et al. 1985).

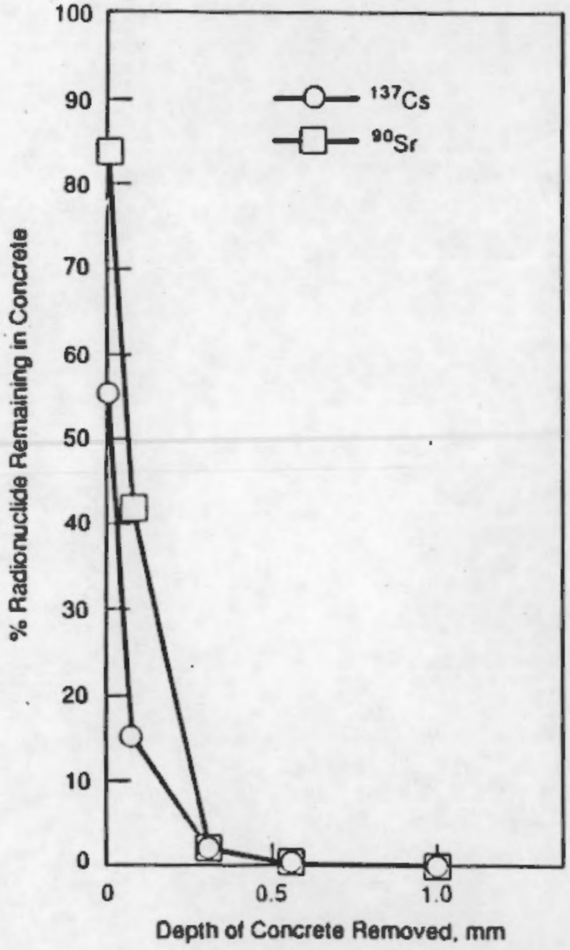

FIGURE 21. Radionuclide Penetration into Concrete Sample 52186-48-1

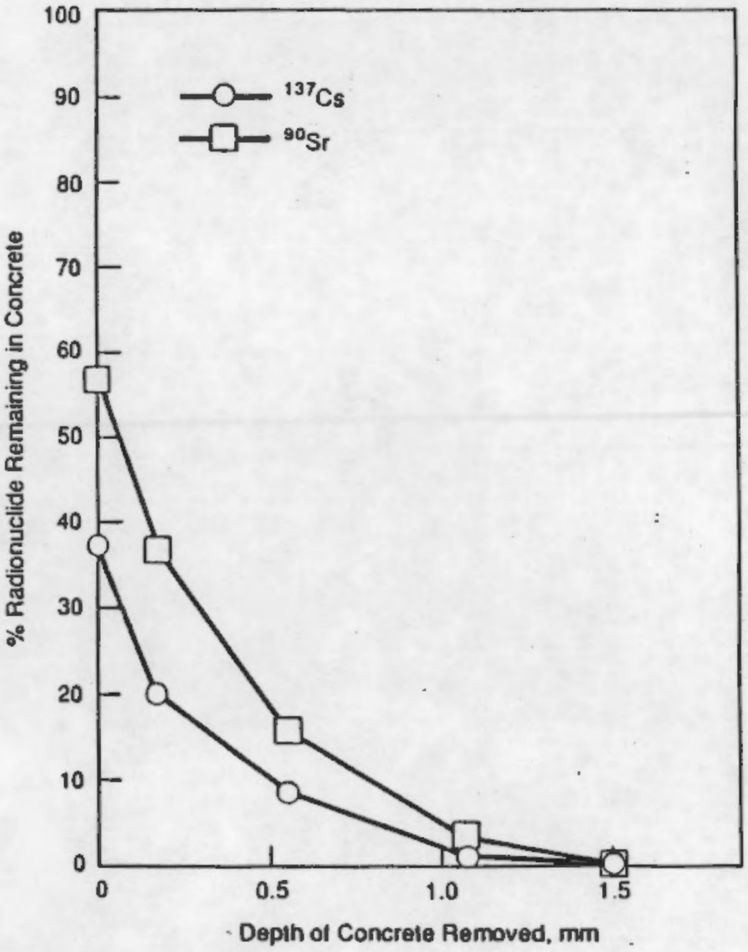

FIGURE 22. Radionuclide Penetration into Concrete Sample 52186-48-2

The radiation exposure readings from self-reading pencil dosimeters were recorded by the KEH timekeeper for each worker making an air lock entry. These radiation readings, in millirems per hour, are shown in Table 1. A total of 8,921 mrem of radiation dose was recorded for 84 air lock entries totaling 111.6 hr spent in the air lock, for an average exposure rate of 80 mrem/hr. Except for September 14, there was a decreasing radiation exposure rate from the start of the refurbishment work to the finish. On September 14 the dose rate ranged from 364 to 80 mrem/hr for 16 entries into the air lock.

TABLE 1. Radiation Exposure Data, Kaiser Engineers Hanford Company Workers, Based on Self-Reading Pencil Dosimeters

Date (1988)	Air Lock Entries	Total Dose, mrem	Total Hr	Average Dose Rate, mrem/hr
September 8	2	420	1.28	328
September 9	6	648	4.38	148
September 10	0	--	--	--
September 11	0	--	--	--
September 12	2	268	3.0	89
September 13	4	470	7.22	65
September 14	16	2,410	18.32	132
September 15	11	1,090	13.65	80
September 16	10	1,120	19.95	56
September 17	14	1,200	20.90	57
September 18	17	1,195	21.28	56
September 19	2	100	1.62	62
Total	84	8,921	111.6	80

CONCLUSIONS

The cover block refurbishment has decreased the radiation dose per burial box removal by 40%. Air lock entry activities have experienced a 50% reduction in radiation dose since the completion of refurbishment.

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APPENDIX

RADIATION EXPOSURE RATES ON COVER BLOCKS THROUGHOUT REFURBISHMENT

TABLE A.1. Beta and Gamma Radiation Exposure Rates on Cover Blocks Throughout Refurbishment. With window open, mrad/hr; window closed, mR/hr.

9-8-88 Start of Cover Block Refurbishing Work

2800/1200	3400/1300	2500/500	1500/450	7000/1000	4500/1000	2500/1000	1500/800	1500/800	11,000/2500	22,000/3000	1500/900	4000/1000	3000/900	1500/500
7000/600	⁘	2800/500	3000/700	⁘	1500/400	2300/1000	⁘	4500/1400	8000/1500	⁘	10,000/2000	12,000/4000	⁘	1500/1000
1300/3500	1000/300	1100/350	2400/900	3500/1000	3900/1000	10,000/1500	10,000/1500	7000/1000	10,000/1300	17,000/2500	18,000/2300	4200/1200	3100/1100	2000/800

9-9-88 After Pressurized Water Decontamination

800/250	1800/350	2000/400	1500/450	4000/1000	2000/800	2000/1000	1000/500	1000/1000	1500/1000	15,000/2000	3500/1500	2500/1000	2000/1000	1000/400
5000/450	⁘	3000/450	1000/500	⁘	4000/1000	1500/1000	⁘	4000/1000	4500/1500	⁘	5000/2000	7000/1800	⁘	1500/800
800/300	450/250	400/300	1500/800	3500/1000	4000/1000	6000/1500	4500/1500	3000/1000	4000/1500	8000/2800	10,000/2200	3500/1500	1500/1000	1500/800

9-15-88 After Spalling of 1 to 2 in. Concrete

450/120	100/80	70/70	300/200	200/200	220/200	150/150	150/150	200/200	250/250	190/190	200/180	150/150	150/150	170/150
100/100	⁘	100/100	150/120	⁘	200/150	170/150	⁘	170/150	500/200	⁘	200/200	150/150	⁘	120/100
120/100	100/90	100/80	200/130	170/130	150/150	130/130	120/110	130/130	200/170	130/130	150/150	150/120	100/100	100/100

9-19-88 After Grout and 3/8-in. SS Plate Installation

70/70	60/50	100/70	200/150	150/150	200/200	130/130	150/150	200/200	280/280	180/180	120/120	90/90	100/100	100/100
70/70	⁘	70/70	100/100	⁘	100/100	100/100	⁘	150/150	130/130	⁘	80/80	70/70	⁘	80/80
100/100	80/80	60/60	90/90	80/80	100/100	80/80	100/100	100/100	110/110	80/80	80/80	70/70	80/80	60/60

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