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RADIOGRAPHIC INSPECTIONS AT THE CALIPATRIA GEOTHERMAL TEST SITE

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RADIOGRAPHIC INSPECTIONS AT THE CALIPATRIA GEOTHERMAL TEST SITE

ABSTRACT

The Lawrence Livermore Laboratory (LLL) Nondestructive Evaluation (NDE) section of the Materials Engineering Division is making radiographic inspections to estimate the extent of corrosion and scale buildup at the Geothermal Test Site in Calipatria, California. This study, begun in early 1976, is continuing. The NDE section developed the radiation exposure techniques using ^{60}Co and ^{192}Ir isotopes; Hazards Control and NDE established radiography safety procedures. Five radiographic evaluations were made of the Geothermal Test Site from May 1976 to February 1977. Estimations of scale buildup from radiographs of operating plant pipes, valves, and tanks correlated closely with our actual scale measurements from used plant sections.

INTRODUCTION

In early 1976, the Lawrence Livermore Laboratory (LLL) Geothermal Program requested support from the Nondestructive Evaluation (NDE) Section of LLL's Materials Engineering Division to measure scale buildup and corrosion in the pipes, valves, and tanks at the Geothermal Test Site, Calipatria, California. Feasibility studies were started and equipment and material needs outlined. We chose radiography as a suitable method for measuring scale buildup. Because radiography is the only method yet found to monitor and evaluate scale buildup without dismantling the brine system, our efforts have been concentrated with this method.

In addition to transporting equipment to the Geothermal Site and developing exposure techniques, radiation safety procedures needed to be established. The NDE personnel worked with LLL's Hazards Control Department (HCD) personnel to satisfy these safety requirements. California state regulations also had to be followed because some exposures were made off federally regulated property.

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TECHNIQUE EVALUATION AND PREPARATION

Initially, scale buildup and corrosion was measured in used sectioned pipes and valves taken from the Calipatria Geothermal Test Site and sent to the NDE lab. We made radiographs with various x-ray films, energies, and filtering techniques. Because we used isotopes in the field, we developed final techniques using iridium-192 (^{192}Ir) and cobalt-60 (^{60}Co) sources. We made use of radiation-sensitive paper which makes development of radiographs fast and easy. This paper is lower in resolution and contrast than the films with slower speed; however, we found that paper was appropriate for exposure-alignment tests at the site.

We evaluated other methods to measure scale and corrosion. Penetrant inspection worked well for checking surface cracks, while ultrasonic testing proved useful for measuring corrosion wall thinning. However, scale measurements were unsuccessful using ultrasonics; we found that radiography was a good method for such measurements.

To process films on site, a darkroom was set up in a DOE trailer. The darkroom contains a film dryer, film viewer dry-paper processor and a master processing tank that holds smaller developer and fixer tanks. A locked transportainer was used to store the isotope and other supplies. Radiation measuring devices are on site and kept in calibration by HCD personnel.

SAFETY CONSIDERATIONS

A main consideration in radiography is radiation safety. The HCD helps to keep operations safe by sending a representative with the radiographers in the field. During radiographic operations, the Health and Safety Technician has the following items at the job site: (1) a record of lifetime accumulated radiation exposure for all LLL personnel involved; (2) survey meters in current calibration; (3) pocket dosimeters; and (4) appropriate copies of current safety regulations and procedures. The technician also helps monitor radiation during the radiographic exposures.

The LLL safety precautions must also conform to the State of California regulations. A reciprocal agreement with the State Radiation Licensing Board allows LLL radiographers to work in certain areas that are under state

jurisdiction. Whenever work is to be done in the field, the HCD informs the state, and a state representative can inspect the operation at any time.

April 1976 Inspection

The first on-site exposures were made in April 1976 to obtain baseline information. A 100-Ci ^{192}Ir source was used to make these exposures. Most radiography measurements were made from 4:00 p.m. to midnight to minimize personnel working in the area. A typical exposure lasted 30 min. The radiographers maintained strict surveillance during this time to prevent unauthorized persons from entering the radiation area. Measured at the nearest trailer, the most scattered radiation level was 15 mR/h. The maximum direct beam radiation at the compound fence was ~250 mR/h. A 2 mR/h perimeter was established and all personnel were kept well outside of it (Fig. 1).

Initially, film was processed in our truck-mounted portable darkroom, because the on-site darkroom had not yet been established. Twenty-four locations were radiographed and all film cassettes were double loaded with films of different speeds to obtain more data for each exposure. Figure 2 shows a representative radiographic set-up. In some shots, especially those near the ground, scattered radiation produced poor radiographs. Scatter was reduced in later exposures by placing a lead sheet beneath the film. When the radiographs were evaluated, we estimated the scale thickness to be ± 2 mm. Table I contains typical exposures using ^{192}Ir . Because the

Table 1. Typical radiographic exposures, April 6-8, 1976 using 100-Ci ^{192}Ir source, 100-mm source-to-film distance, and 5M 3AA film load.^a

Identification	Time, min.	Remarks
V4-BO (horiz)	10	8-in. pipe
V7-BO	15	8-in. pipe
V14-BO	20	12-in. pipe
LV-714-DS	20	Single wall
MX-1	20	12-in. pipe

^aFilm load = 0.127-mm front lead screen, Kodak M film, 0.076-mm center screen, Kodak AA film. A 3.5-mm lead backing was placed behind the film cassette.

Fig. 1. Radiographic set-up using $17\text{-Ci } ^{60}\text{Co}$ source.

Fig. 2. Top view of radiographic set-up of Fig. 1 showing 2-mR perimeter and positions of monitors and operators.

^{192}Ir did not penetrate some of the heavier sections, ^{60}Co was recommended for use in future exposures; ^{60}Co is more penetrating than ^{192}Ir and it has a longer half life so that a ^{60}Co source is replaced less frequently. However, with ^{60}Co , there is more 4π radiation when the source is moved away from its containment pig to the exposure collimator. When the source is in the collimator, the radiation beam is directed toward the part and exposure rates are reduced in other directions. The increased radiation level from the ^{60}Co source requires a larger safety perimeter.

May 1976 Inspection

A 17-Ci ^{60}Co source was used on our second trip to the Geothermal Test Site. Paper radiographs provided an immediate check on alignment and exposure. Conventional x-ray film was used and returned to LLL for processing. We radiographed thirteen areas, completing our baseline survey. The ^{60}Co source proved more effective than the ^{192}Ir , especially on thicker parts. Table 2 contains a portion of the ^{60}Co exposure data.

Table 2. Typical radiographic exposures, January 10-14 1977, using 17-Ci ^{60}Co source and M AA film load.^a

Identification	Time, min	Source-to-film distance, mm	Remarks
V4-BO (horiz)	20	1220	8-in.-diam pipe
V-7-BO	20	878	8-in.-diam pipe
LV-711-DS	20	878	Adjacent to valve
MX-1	20	878	12-in. pipe

^aFilm load = 0.127-mm front lead screen, Kodak M film 0.076-mm center lead screen, Kodak AA film with 0.25-mm back lead screen. A 1-mm lead filter was placed in front of the film cassette and a 3.5-mm lead backing was placed behind the cassette.

June 1976 Inspection

After the plant had run approximately 300 h, another inspection was made. The plant was operating and the exposures were made at normal high-temperature and -vibration conditions. Thirteen sections of the plant were radiographed, two of which had not been previously examined. After we processed the film, we measured scale thickness.

January 1977 Inspection

A fourth trip was made in January 1977, and eight positions were rechecked for scale buildup. Film evaluation revealed a scale 5 to 65 mm thick, a significant increase from June 1976 (Table 3).

February 1977 Inspection

On this inspection, radiographs were taken at three spots along the reinjection pipe. The film showed scale thickness from 7.3 to 43.3 mm in one area (Table 3).

CONCLUSIONS

The NDE inspection program at the Calipatria Geothermal Test Site is supplying valuable information to project engineers and researchers. Radiographs together with ultrasonic wall thickness measurements and surface penetrant inspections help us to estimate the extent of scaling, corrosion, and surface pitting and cracking.

Table 3. Typical average scale thickness in sections of Geothermal Test Site facility.

Identification	Thickness, mm		
	June 14 1976	January 10 1977	February 15 1977
V4-B0 (horiz)	2	27	
V7-B0	<1	19	
V11-B0	15	5	
V14-B0		65	
RJ-SW-COR			7.3 to 44.3

Scale measurements from the radiographs are difficult to make because of scale layering. Careful evaluation by the film interpreter is necessary. Exposures can be made while the plant is in operation, although vibration can produce an unsharp image. Radiographic support will be continued while other techniques are investigated for measuring scale buildup.

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