UCRL-52367 Rev. 1

PHOTOGRAPHIC AND VIDEO TECHNIQUES USED IN THE 1/5-SCALE MARK I BOILING WATER REACTOR PRESSURE SUPPRESSION EXPERIMENT

D. Dixon and D. Lord
Compiled and Edited by W. Lai and R. Ingraham
E. McCauley and J. Pitts, Principal Investigators

March 16, 1978

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ABSTRACT

This report provides a description of the techniques and equipment used for the photographic and video recordings of the air test series conducted on the 1/5-scale Mark I boiling water reactor (BWR) pressure suppression experimental facility at Lawrence Livermore Laboratory (LLL) between March 4, 1977, and May 12, 1977. Lighting and water filtering are discussed in the photographic system section and are also applicable to the video system. The appendices contain information from the photographic and video camera logs. A separate report will be published covering the video system in detail. The procedures and preliminary results of the testing are given in a series of "quick-look" informal reports (UCID-17446-1 through -7).

INTRODUCTION

In the pressure suppression containment design of a lightwater reactor, the success of the system is based on the capability of the water heat sink to provide rapid and stable condensation of the released primary coolant during a hypothetical loss-of-coolant accident (LOCA). In the Mark I BWR design, the pressure suppression system encompasses a drywell that surrounds the reactor and channels the steam released during a LOCA into a torodial suppression pool.

Performance of the Mark I BWR pressure suppression system has been the subject of continuing investigation by many agencies. The LLL experimental program provides a large-scale (1/5) extension of these investigations into three dimensions.[1] The need for these tests exists not only for the assessment of existing system designs but also to provide insight into the basic hydrodynamic phenomena associated with wetwell behavior. This test series was conducted using gaseous N_2 to study early-time, air-clearing phenomena. The next test series will be conducted using steam to study late-time, pool condensation phenomena.

Two systems of visually recording these phenomena were used: photographic and video. The photographic system provided the higher speed recording system while the video system provided the investigators with the dual advantages of an immediately available presentation of a test and unique in-pool viewing.

PHOTOGRAPHIC RECORDING

General

We filmed a total of 25 tests that are documented in Appendix A. Figure 1 shows a typical setup, and Fig. 2 shows the port numbering system. Only those ports actually used for cameras are labeled. A Milliken camera was positioned at 5-90 and a Locam camera at 10-90; both were operated at 500 frames per second. All other positions used the higher speed cameras (Hycams) operated at 1000 frames per second; in Test 1.1 two of these cameras operated at 500 frames per second.

The original plan was to have only one test every other day, allowing time for filtering the water and checking the previous film for problems. However, a number of tests were conducted hourly each day; contractural constraints forced this procedural change. Also, calibration of the sensors required 8 h, and drift is significant only if the facility is down or unattended overnight. The shortened test procedure permitted use of a single calibration for a series of tests, but did not allow time for processing and checking film processed earlier in the day.

Equipment

Cameras

We used three types of cameras to film the tests: higher-speed cameras (Hycams) with a film speed of 1000 frames per second and lower-speed cameras (Milliken and Locam) with a film speed of 500 frames per second. Up to six Hycams, one Milliken, and one Locam were used. The number used in each test is listed in Appendix A.[2] The run times for cameras were ~16.8 s for the Hycams and ~32 s for the others (see Fig. 3).

After the cameras reached operating speed, a timing light exposed the zero time mark on one edge of the film up to 3 s before the event. This common index was simultaneously placed on all films to synchronize film frames for all cameras (Fig. 4). The event lasted approximately 10 s. A second timing light system was used for determining interframe rate.

All cameras were remotely started since their run was short, and for safety reasons, personnel were not permitted in the test area during testing. When the film was expended, the cameras stopped automatically. The lighting for the cameras could be manually or remotely controlled.

Lenses

All Hycams used 10-mm lenses. The Milliken at position 5-90 used a 5.7-mm lens, while the Locam

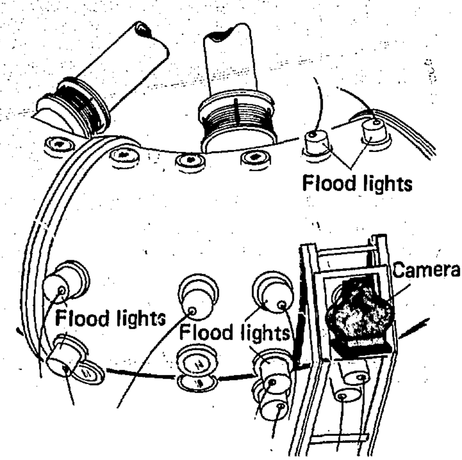


Figure 1. **Typical photographic setup.**

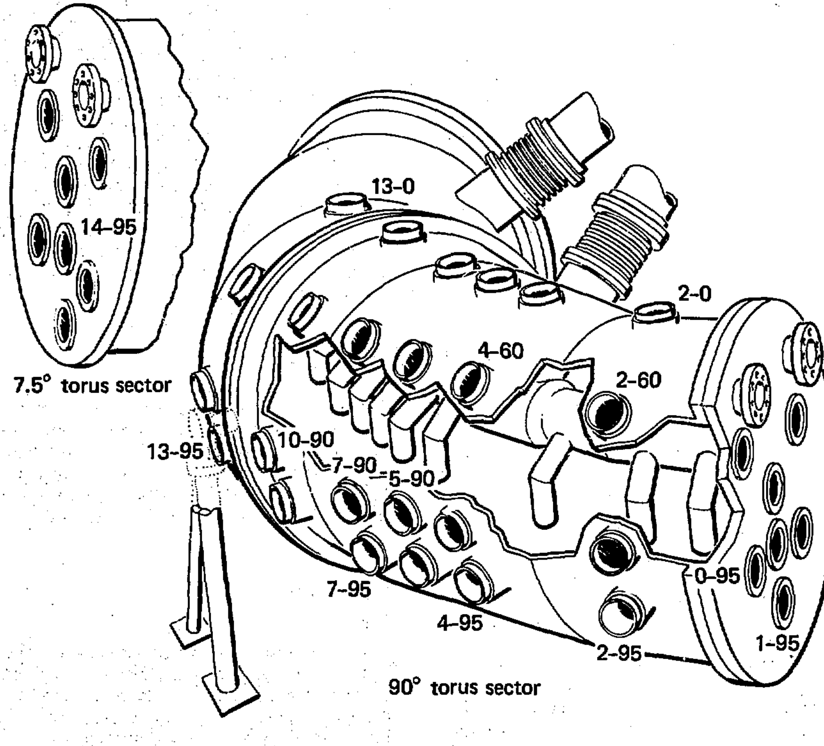


Figure 2. **Port numbering system.**

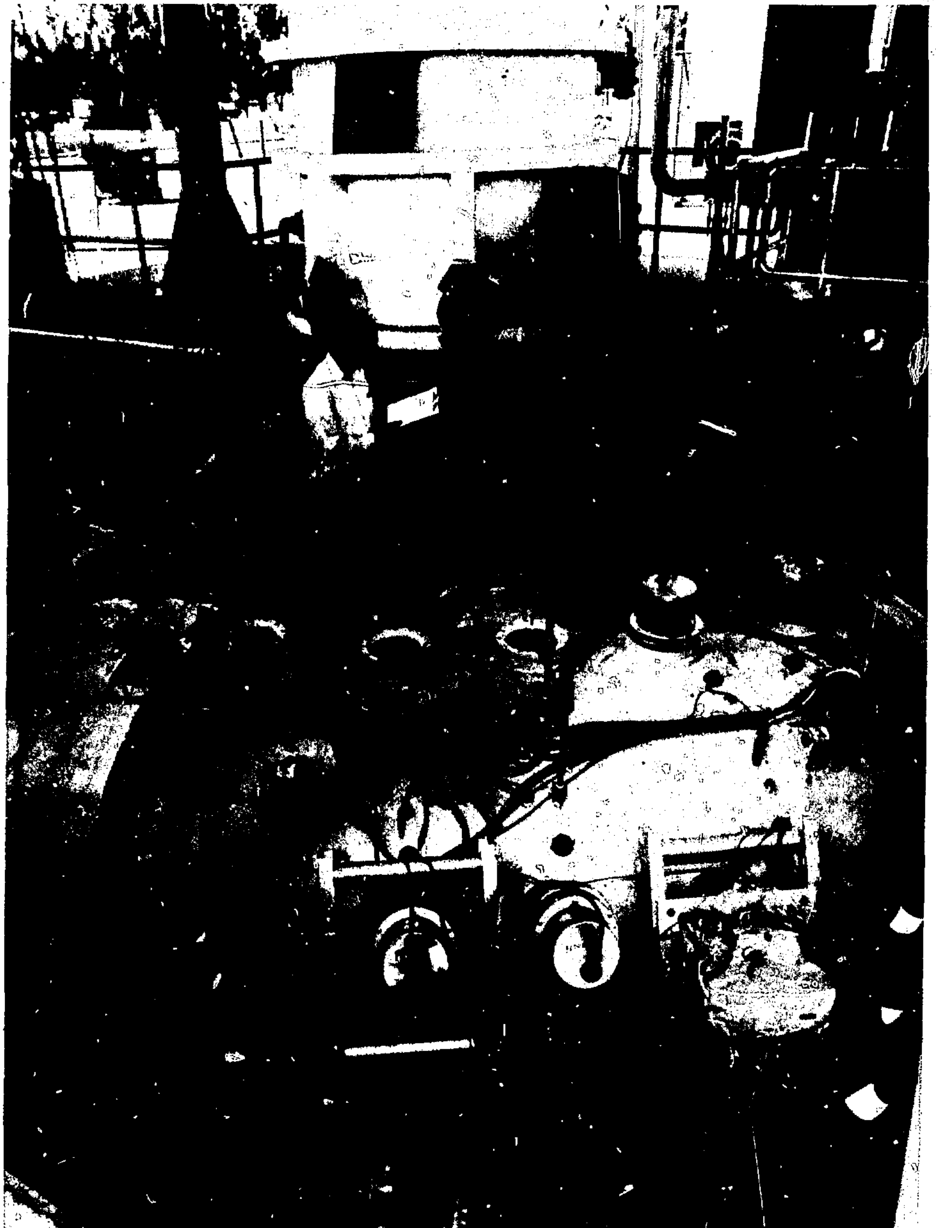


Figure 3. **Camera equipment.**

at position 10-90 used a 3.5-mm lens. While the wide angle lens caused noticeable distortion at the picture edges, the lens proved a valuable tool because of the greater coverage area.

Film

The film used was equally divided between two types: Ektachrome EFB and Ektachrome VNF. Both films have an ASA rating of 125, and both were forced-developed to an ASA rating of 375. Ektachrome VNF responds better to forced-processing, which is a method to enhance film sensitivity.

Camera Mounting System

Due to possible damage to camera equipment (particularly the high-speed cameras) from shocks generated by the tests, the cameras were isolated from the pressure vessel by using a separately designed camera mounting system bolted to the pit floor. The camera frame was manually adjustable in both altitude and attitude. Once the cameras were mounted, a sliding rubber sleeve between the lens and port was used to block out ambient light. The camera stands were designed to follow the curve of the pressure vessel wall.

During testing, we installed a Milliken camera at a point that did not permit the use of a free-standing mounting system. Therefore, we mounted the camera directly to a port. No damage or problems occurred. (The design of the camera allowed fo higher shock loads.)

Pressure Vessel Ports

The original concept was to install different sized ports for lighting and cameras. However, the ports installed were 20.3 cm in diameter. This provided greater flexibility in relocating cameras and lights. The large number of 20.3-cm ports (38) ensured adequate lighting and flexibility. There was a problem of keeping the above-water ports clear. Anti-fog and vacuum conditions helped clear some fog, but a spray wash might be a valuable addition in any future tests.

Water Clarity

Because the same water was used throughout the program, it was necessary to maintain water clarity. A swimming pool-type, diatomaceous-earth water filter was purchased and set up in the system. However, to cycle all the water (~2000 gal) through the filter required a minimum of 1 h, and usually there was only a 15- to 50-min period between tests. The quality of the movies indicates that filtering the water was helpful.

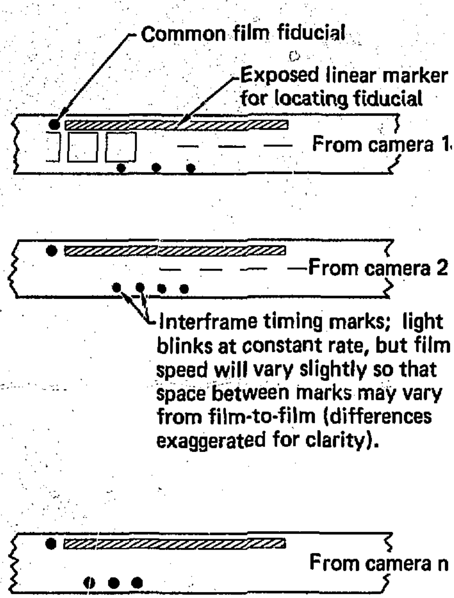


Figure 4. **Film fiducial and interframe timing. Sprocket holes omitted (not to scale).**

Lighting

The maximum standard lighting used was 16 lamps for a total of 16,000 W. The beams produced were oval. In addition, we used four smaller 2300-W "key" lamps (two sets) to highlight the areas being filmed. The advantage of the key lights, which are smaller in size, is that they could be installed closer to the ports and shifted to different positions within the port. We attached all lamps to the ports with a simple ring clamp that allowed the lamps to be tilted and easily aimed.

There was concern that the lamp heat might crack the port windows; thus, the time the lights were on was minimum, usually about 4 min per test. However, on one test the lights were inadvertently on for about 15 min without damage to the port windows.

One problem developed with the lighting system caused by the circuit breakers being very sensitive and occasionally causing the loss of a light during a test.

The critical areas of the interior of the two tori were painted white. This helped distribute the light and presented stronger silhouettes of the downcomers and phenomena.

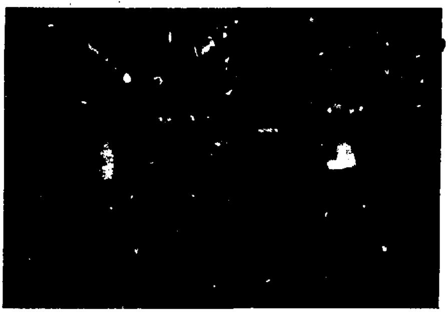
Two methods of enhancing visibility, backlighting and dyes, were considered and found unnecessary. Backlighting would have required substantial structural changes to the pressure vessel resulting in a less realistic test setting. It was felt that the loss of light transmission through the dyed water would negate any possible gain in contrast.

Results

The quality of the high-speed movies is illustrated by the selected frames shown in Figs. 5 through 7. The frames in Figs. 5 and 6 are indexed to the first frame in Fig. 5; the first frame in Fig. 6 occurred 12 ms after the first frame in Fig. 5.

0 ms

101 ms



128 ms

139 ms

152 ms

Figure 5. **Outboard downcomer viewed through port 1-95, air test 3.5. Relative time of successive frames in ms: 0, 101, 128, 139, and 152.**

Figure 5 shows asymmetric clearing of the outside of the downcomers. This radial asymmetry occurred on both the inner and outer rows of downcomers. This preferential clearing is characteristic of the downcomer configuration used in the Peachbottom Mark I BWR. The lateral clearing action is symmetric as shown in Fig. 6.

Considerable subpool and surface effects due to the variation in downcomer spacings are evident in the films. The right downcomer in Fig. 6 is next to the end plate. The last frame in Fig. 6 shows the bubble for the right downcomer pushing past the dividing line between downcomers. This could be interpreted as due to end effects. However, similar films taken at port 13-95 show identical subpool behavior. Port 13-95 is located near the middle of the torus (Fig. 2). Figure 7 shows the ease with which pool rise history may be obtained from the movies. Note the slope of the pool surface in the last frame of Fig. 7, which indicates flow in the longitudinal direction away from the region of closest downcomer spacing and toward the vent line region.

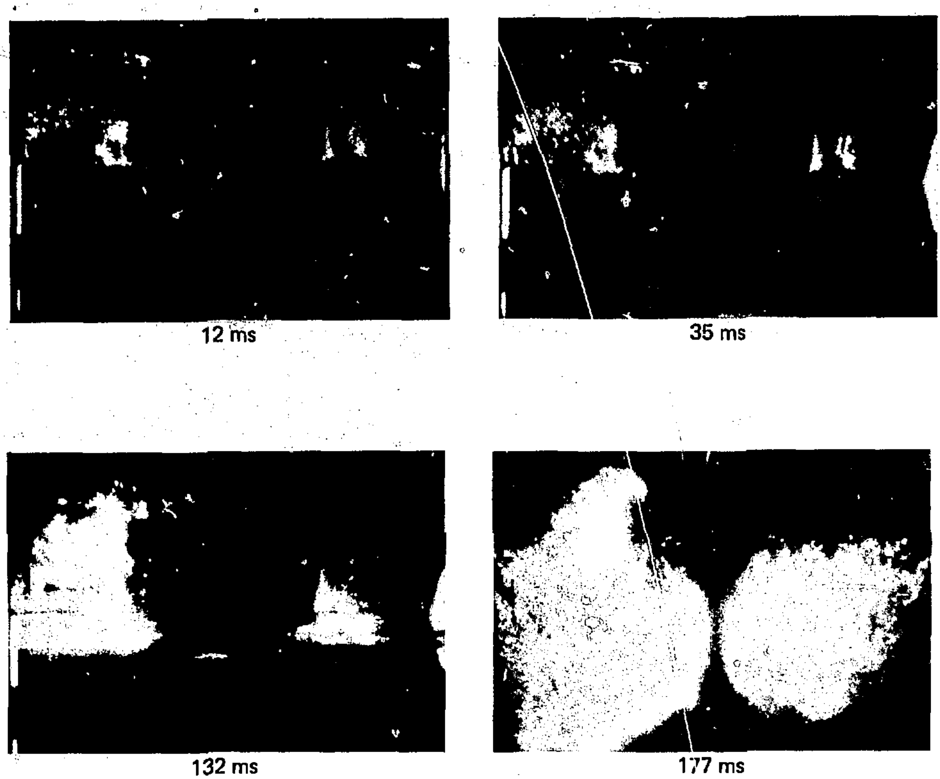
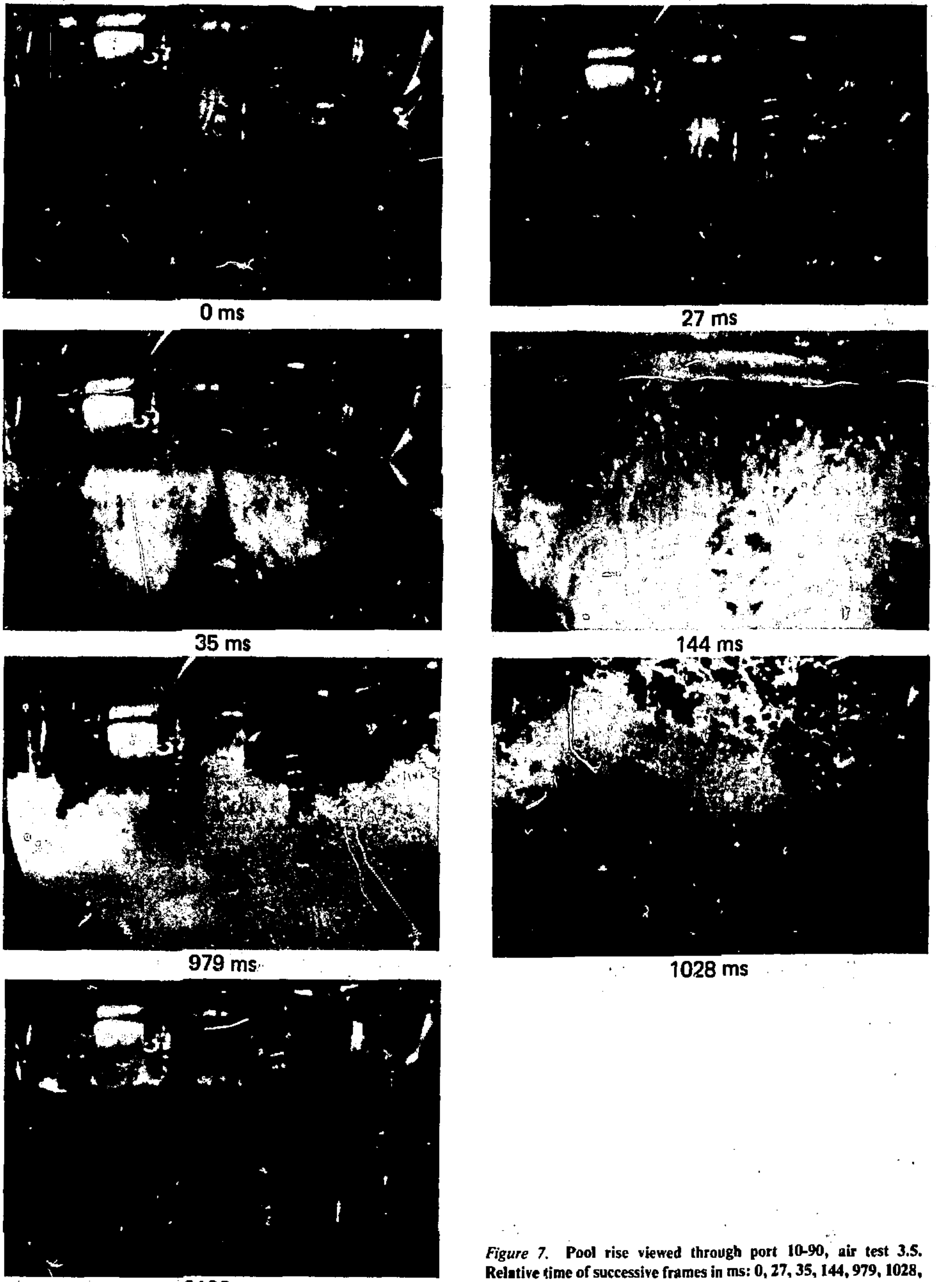


Figure 6. **Adjacent downcomers clearing action viewed through port 2-95, air test 3.5. Relative time of successive frames in ms, indexed to first frame of Fig. 5: 12, 35, 132, and 177.**



0 ms

27 ms

35 ms

144 ms

979 ms

1028 ms

3166 ms

Figure 7. **Pool rise viewed through port 10-90, air test 3.5. Relative time of successive frames in ms: 0, 27, 35, 144, 979, 1028, and 3166.**

VIDEO TECHNIQUES

General

The video system provided viewing of pool dynamics during the 1/5-scale air test series. The system is a combination of rod optics and high-gain electronic video [3] using a Storz lens. The video system had been demonstrated previously in a 100°C, air-blown vapor environment. The main advantages of the system are its ability to record under low-light-level conditions, and that it can be introduced through tube fittings into piping or chambers.

The rod-lens assembly has a set of illumination-carrying glass fibers in the annulus between the rod elements and the outside tubing. Illumination also can be supplied externally. In these tests the illumination was supplied by the high-speed camera lights, although normal daylight admitted through the unused camera ports would have been adequate for the extremely sensitive low-light video camera.

The rod-lens configuration (Fig. 8) consists of:

1. Lens tube.
2. Rod lenses and separators.
3. Objective lens assembly.
4. Outside tube (containing light fibers) and eyepiece.

The overall system (Fig. 9) consists of:

1. TV camera.
2. Support fixture.
3. 2X extender and focusing adapter.
4. Rod lens.
5. Tubing fitting.
6. Pipe thread, 2-1/2 in. diameter (fits into torus wall).

The instant replay ability of the video system allows on-the-spot assessment of system performance. During initial checkouts, direct observation of the interior volume showed numerous air leaks with the vessel filled to proper level in a pumped-down (~0.2 atm) pressure configuration. The effectiveness of the leak plugging operation was greatly aided by direct observation. The dynamic tests showed some additional leaks in the downcomer flange areas, which were subsequently corrected.

The video system also provided longer term visual analysis and aided in locating phenomena on the 400-ft lengths (approximately 10,000 frames) of high-speed film. Several phenomena, such as flow asymmetry in the downcomers and the pulsing gas flow characteristics, were originally noticed on the video tape and verified on the high-speed film. Figures 10 and 11 show examples of the video tape obtained for subpool and pool surface dynamics, respectively.

The entire video system is insensitive to vibrations either through the mounting fixture or directly from the water movement.

Equipment

Cameras

Three cameras were available for the tests. Two cameras were standard video cameras (Hitachi), while the third (Cohu) was a high-gain, low-light-level camera. The cameras were mounted at instrumentation ports. As indicated in the video camera log of Appendix B, the low-light-level camera was first used for underwater observation (220°), then moved to observe pool swell (270°), and finally switched to observe the underwater effects of the longer downcomers (220°). Figure 12 shows the

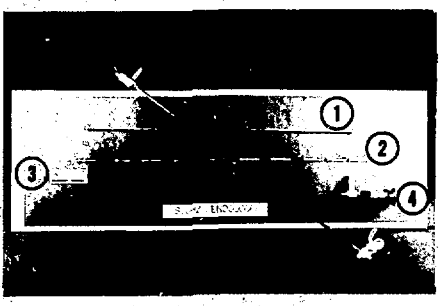


Figure 8. **Rod-lens system.**

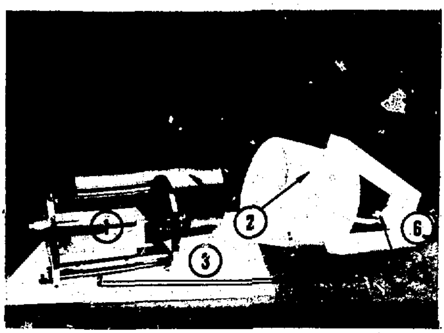


Figure 9. **Video system; a combination of rod optics and high-gain elecdtronic video using a Storz lens.**

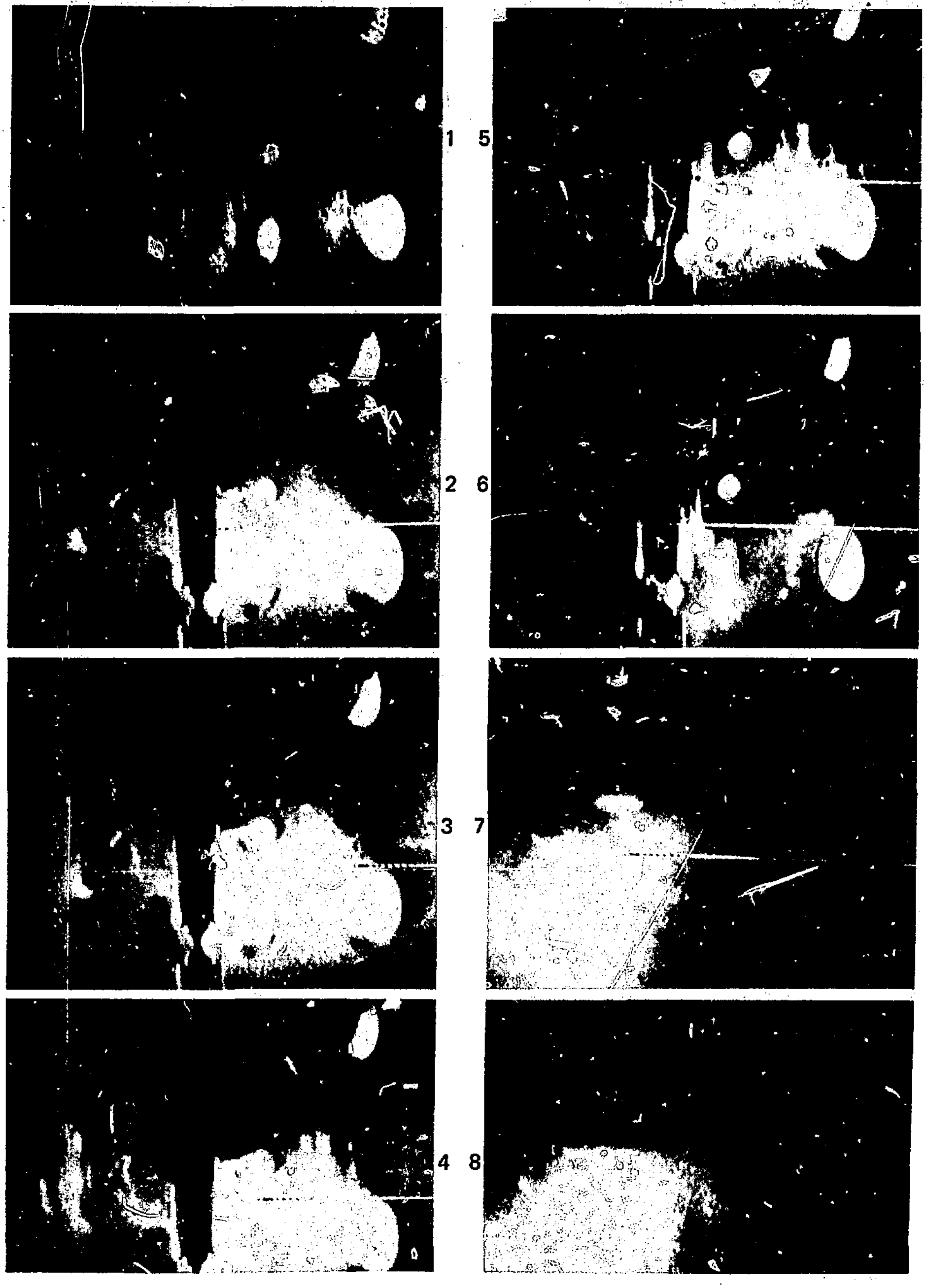


Figure 10. **Video tape example of subpool surface dynamic air test.**

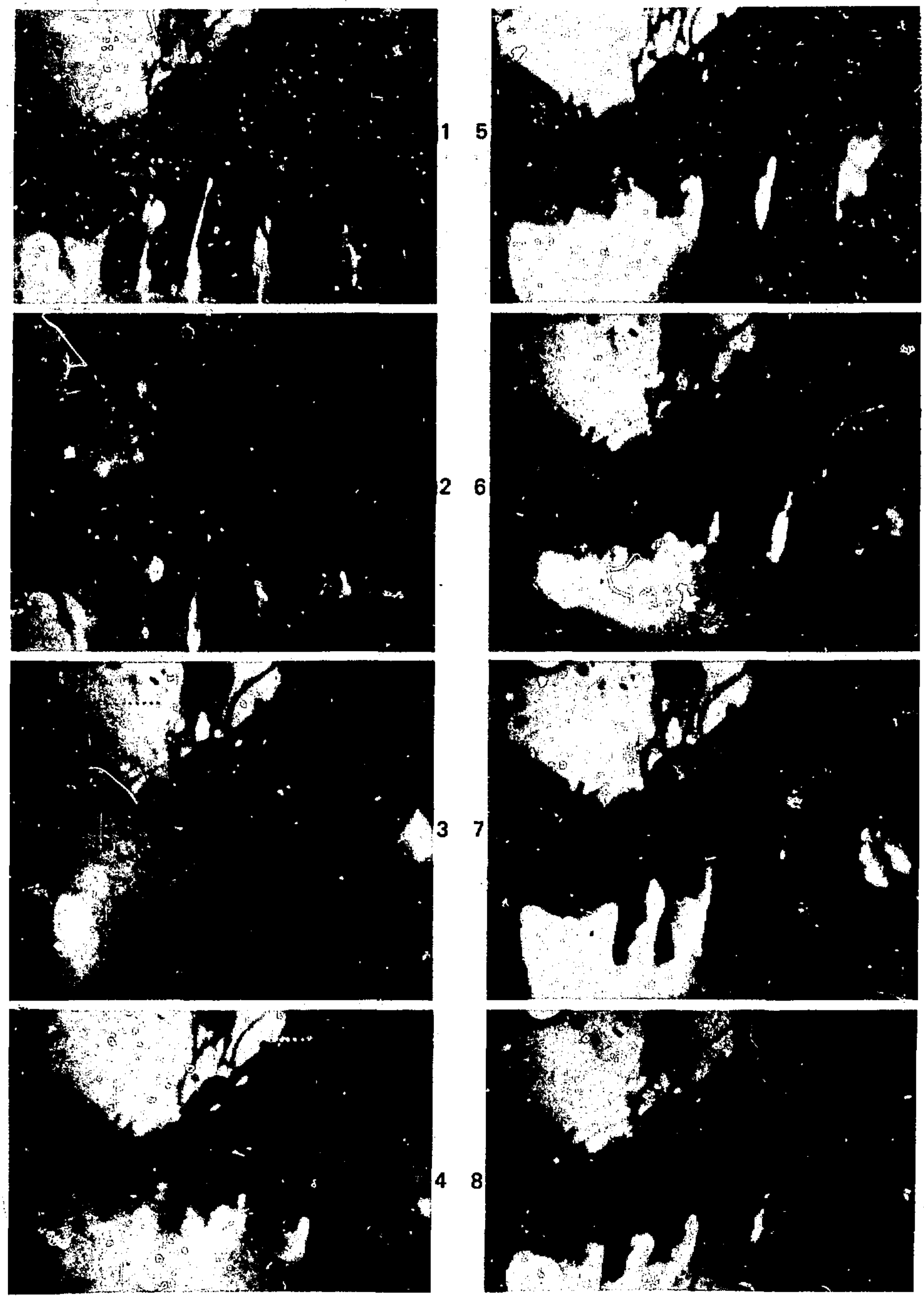


Figure 11. **Video tape example of pool surface dynamic air test.**

location of the ports where the cameras were mounted.

The original plan was to field three low-light-level cameras. However, two were still at the factory during these tests having their framing speeds changed from 60 fields per second to a selectable 60, 120, 180, and 240 fields per second. Their use is expected for the future steam tests series.

The three cameras were connected by 75-ft long coaxial cable to three video recorders and monitors in a separate trailer. The equipment consisted of:

1. Two Sony 2850 video cassette recorders.
2. One Sony EV320F 1-in., reel-to-reel video cassette.
3. Two black and white Sony CVM-112 video monitors.
4. One Sony Unimedia UMT-1203 monitor.

A 10-kHz timing signal, triggered by a fiducial signal, was recorded on one audio channel of the video tape. The three recorders were manually started 1 min before each test and allowed to run for 2 min after each test.

2X Extender and Focusing Adapter

The 2X extender and focusing adapter in the optical system allowed the TV screen to be filled and permitted focus control over the depth of field. For all tests the optics were focused to show the overall interior volume and large scale events.

Rod Lenses

The rod lenses were 90° types that could rotate to provide complete control over the view volume. However, rotating the lenses also required rotating the cameras to keep the TV monitor in proper orientation to the internal view. Because of the positions of the rod lenses, the fields of view were not obscured as quickly as those of the high-speed cameras, and their quick recovery allowed late-time observations.

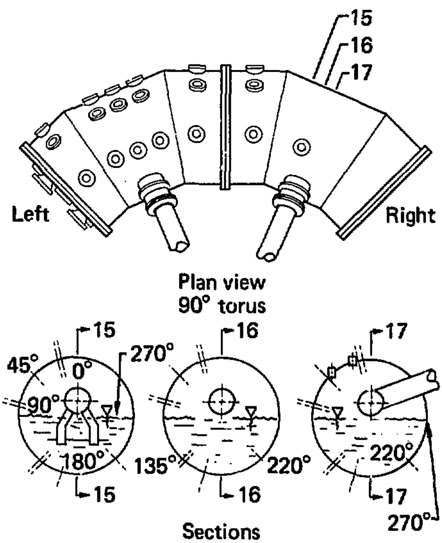


Figure 12. **Video camera port locations. Refer to Appendix B for exact camera locations in each test run.**

Framing Speed

Since phenomenon observation is a function of framing speed, a range of speeds as represented by the high-speed cameras and the video system provides the optimum system. Some flow velocities can be calculated from the video pictures with respect to event timing. These are approximate and limited by the framing speed. More accurate flow velocities could have been obtained from sophisticated, post-test film analysis using the available electronically-enhanced scanning microdensitometer. Program budgetary constraints did not permit this activity.

ACKNOWLEDGMENTS

We extend appreciation to those who provided the expertise to document this program. In the photographic section, Daniel Crawford designed the camera and lighting fixtures and accessories and implemented the camera systems, Phillip Kerrigan did the film processing and camera operation, and John Blunden did the optical printing and film editing and copying. In the video section, Gary Carter performed the video operations, Richard Petrini did the 10-kHz timing and optics, and William Biehl and Frank Tickel worked on mechanical fixturing.

NOTES AND REFERENCES

1. W. Lai and K. Collins, Editors, *Mark I 1/5-Scale Boiling Water Reactor Pressure Suppression Experiment-Quick Look Reports*, Lawrence Livermore Laboratory, Repts. UCID-17446-I through -7 (1977).
2. The films have been edited to display the initial 500 ms of each air-water test. Each camera sequence is preceded by a port-identification illustration similar to that shown in Fig. 2. Column 6 of Appendix A, headed "Approximate Start Time," lists the approximate experiment time at the start of each edited sequence.
3. D. Lord, G. Carter, R. Petrini, *Flow Observation by Rod Lens and Low-Light Video*, Lawrence Livermore Laboratory, Rept. UCRL-52324 (1977).

MLD

APPENDIX A:
PHOTOGRAPHIC CAMERA LOG

Test No.	Date	Camera locations	Zero mark	Timing marks	Approximate start time (s)	Comments
1.1	3-18-77	1-95[a]	Yes	Yes	2.00	Thirteen 1-kW lights.
		2-95[b]	Yes	Yes	2.04	EFB film.
		4-60	Yes	Yes	1.96	
		4-95	Yes	No	2.00	
		7-95[a]	No	Yes	–	
1.2	3-25-77	1-95	Yes	Yes	0.60	Fourteen 1-kW lights.
		2-95	Yes	Yes	0.60	Filter on for 1-1/2 h, 6 h/6 h before test.
		4-60	Yes	Yes	0.52	
		4-95	Yes	Yes	0.60	EFB film.
1.3	3-30-77	1-95	Yes	Yes	2.72	Fifteen 1-kW lights.
		2-95	Yes	Yes	2.72	EFB film.
		4-95	Yes	Yes	2.68	
		14-95	Yes	Yes	2.64	
1.3.1	4-26-77	0-95	No	Yes	–	Sixteen 1-kW lights.
		1-95	No	Yes	–	VNF film.
		2-95	No	No	–	
		4-60	No	Yes	–	
		4-95	No	Yes	–	
		14-95	No	Yes	–	
1.4	4-26-77	0-95	No	Yes	–	Sixteen 1-kW lights.
		1-95	No	Yes	–	VNF film.
		2-95	No	No	–	
		4-60	No	Yes	–	
		4-95	No	Yes	–	
		14-95	No	Yes	–	
1.5	4-26-77	0-95	No	Yes	–	Sixteen 1-kW lights.
		1-95	No	Yes	–	VNF film.
		2-95	No	No	–	
		4-60	No	Yes	–	
		4-95	No	Yes	–	
		14-95	No	Yes	–	
1.6	4-26-77	0-95	No	Yes	–	Sixteen 1-kW lights.
		1-95	No	Yes	–	EFB film.
		2-95	No	No	–	
		4-60	No	Yes	–	
		4-95	No	Yes	–	
		5-90[a]	No	No	–	Milliken (500 f/s).
		14-95	No	Yes	–	
2.1	4-26-77	0-95	No	Yes	–	Sixteen 1-kW lights.
		1-95	No	Yes	–	VNF film.
		2-95	No	No	–	
		4-60	No	Yes	–	
		4-95	No	Yes	–	
		14-95	No	Yes	–	
2.2	4-26-77	0-95	No	Yes	–	Sixteen 1-kW lights.
		1-95	No	Yes	–	VNF film.
		2-95	No	No	–	

Test No./Date		Camera locations	Zero mark	Timing marks	Approximate start time (s)	Comments
2.2 (continued)	4-26-77	4-60	No	Yes	–	
		4-95	No	Yes	–	
		5-90[a]	No	No	–	Milliken (500 f/s) at 5-90.
		14-95	No	Yes	–	
2.3	4-26-77	0-95	No	Yes	–	Sixteen 1-kW lights.
		1-95	No	Yes	–	EFB film.
		2-95	No	No	–	
		4-60	No	Yes	–	
		4-95	No	Yes	–	
		5-90[a]	No	No	–	Milliken (500 f/s) at 5-90.
		14-95	No	Yes	–	
2.4	5-3-77	0-95	Yes	No	2.80	Sixteen 1-kW lights.
		1-95	Yes	Yes	2.84	EFB film.
		2-95	Yes	Yes	2.80	
		4-60	Yes	Yes	2.92	Poor image from 4-60.
		4-95	Yes	Yes	2.80	
		5-90[a]	No	No	–	Milliken (500 f/s) at 5-90.
		14-95	Yes	Yes	2.84	
2.5	5-3-77	0-95	Yes	No	2.72	Sixteen 1-kW lights.
		1-95	Yes	Yes	2.72	EFB film.
		2-95	Yes	Yes	2.72	
		4-60	Yes	Yes	2.80	
		4-95	Yes	Yes	2.72	
		5-90[a]	No	No	–	Milliken (500 f/s) at 5-90.
		14-95	Yes	Yes	2.72	
2.6	5-3-77	0-95	Yes	No	3.20	Sixteen 1-kW lights.
		1-95	Yes	Yes	3.20	EFB film.
		2-95	Yes	Yes	3.20	
		4-60	Yes	Yes	3.28	
		4-95	Yes	Yes	3.24	
		5-90[a]	No	No	–	Milliken (500 f/s) at 5-90.
2.7	5-12-77	0-95	Yes	Yes	3.24	Sixteen 1-kW lights and four key lights.
		1-95	Yes	Yes	3.24	
		2-95	Yes	Yes	3.24	Image fuzzy at 2-95.
		4-60	Yes	Yes	3.24	
		4-95	Yes	Yes	3.24	VNF film.
		5-90[a]	No	No	–	Milliken (500 f/s) at 5-90.
		14-95	Yes	Yes	3.28	
2.8	5-12-77	0-95	Yes	Yes	3.20	Sixteen 1-kW lights and four key lights.
		1-95	Yes	Yes	3.16	VNF film.
		2-95	Yes	Yes	3.16	
		4-60	Yes	Yes	3.20	
		4-95	Yes	Yes	3.20	
		5-90[a]	No	No	–	Milliken (500 f/s) at 5-90.
		14-95	Yes	Yes	3.16	
2.9	5-12-77	0-95	Yes	Yes	1.28	Sixteen 1-kW lights and four key lights.
		1-95	Yes	Yes	1.28	
		2-95	Yes	Yes	1.28	
		4-60	Yes	Yes	1.32	

Test No./Date		Camera locations	Zero mark	Timing marks	Approximate start time (s)	Comments
2.9 (continued)	5-12-77	4-95	Yes	Yes	1.32	
		5-90[a]	No	No	–	Milliken (500 f/s) at 5-90.
		14-95	Yes	Yes	1.28	
2.10	5-12-77	0-95	Yes	Yes	2.72	Sixteen 1-kW lights.
		1-95	Yes	Yes	2.68	VNF film.
		2-95	Yes	Yes	2.72	
		4-60	Yes	Yes	2.80	
		4-95	Yes	Yes	2.72	
		5-90[a]	No	No	–	Milliken (500 f/s) at 5-90.
		14-95	Yes	Yes	2.72	
2.11	5-12-77	0-95	Yes	Yes	1.44	Sixteen 1-kW lights and four key lights.
		1-95	Yes	Yes	1.40	VNF film.
		2-95	Yes	Yes	1.44	
		4-60	Yes	Yes	1.44	Hard to determine 4-60 zero timing,
		4-95	Yes	Yes	1.44	edge fog.
		5-90[a]	No	No	–	Milliken (500 f/s) at 5-90.
		14-95	Yes	Yes	1.44	
3.1	5-3-77	0-95	Yes	No	3.08	Sixteen 1-kW lights.
		1-95	Yes	Yes	3.12	EFB film.
		2-95	Yes	Yes	3.12	
		4-60	Yes	Yes	3.16	
		4-95	Yes	Yes	3.16	
		5-90[a]	No	No	–	Milliken (500 f/s) at 5-90.
		10-90[a]	No	No	–	Locam (500 f/s).
		14-95	Yes	Yes	3.16	Slight edge fog on 14-95.
3.2	5-3-77	0-95	Yes	No	2.88	Sixteen 1-kW lights.
		1-95	Yes	Yes	2.92	EFB film.
		4-60	Yes	Yes	3.04	
		4-95	Yes	Yes	2.88	
		10-90[a]	No	No	–	Locam (500 f/s) at 10-90.
		14-95	Yes	Yes	2.92	
3.3(a)	5-3-77	0-95	Yes	No	2.76	Sixteen 1-kW lights.
		1-95	Yes	Yes	2.76	EFB film.
		2-95	Yes	Yes	2.76	
		4-60	Yes	Yes	2.84	
		4-95	Yes	Yes	2.76	
		5-90[a]	No	No	–	Milliken (500 f/s) at 5-90.
		10-90[a]	No	No	–	Locam (500 f/s).
		14-95	Yes	Yes	2.76	
3.3(b)	5-3-77	0-95	Yes	No	2.88	Sixteen 1-kW lights.
		1-95	Yes	Yes	2.92	EFB film.
		2-95	Yes	Yes	2.88	
		4-60	Yes	Yes	3.04	
		4-95	Yes	Yes	2.92	
		5-90[a]	No	No	–	Milliken (500 f/s) at 5-90.
		10-90[a]	No	No	–	Locam (500 f/s).
		14-95	Yes	Yes	2.92	
3.4(a)	5-3-77	0-95	Yes	No	2.76	Sixteen 1-kW lights.
		1-95	Yes	Yes	2.80	EFB film.
		2-95	Yes	Yes	2.76	

Test No./Date		Camera locations	Zero mark	Timing marks	Approximate start time (s)	Comments
3.4(a)	5-3-77	4-60	Yes	Yes	2.84	
(continued)		4-95	Yes	Yes	2.76	Sixteen 1-kW lights.
		5-90[a]	No	No	–	Fog on port 5-90 until splashed,
		10-90[a]	No	No	–	Milliken (500 f/s) at 5-90.
						Locam (500 f/s) at 10-90.
		14-95	Yes	Yes	2.84	
3.4(b)	5-3-77	0-95	Yes	No	2.20	Sixteen 1-kW lights.
		1-95	Yes	Yes	2.24	EFB film.
		4-60	Yes	Yes	2.28	
		4-95	Yes	Yes	2.20	
		5-90[a]	No	No	–	Milliken (500 f/s) at 5-90.
		10-90[a]	No	No	–	Locam (500 f/s).
		14-95	Yes	Yes	2.24	
3.5	5-3-77	0-95	Yes	No	2.48	Sixteen 1-kW lights.
		1-95	Yes	Yes	2.52	EFB film.
		2-95	Yes	Yes	2.52	
		4-60	Yes	Yes	2.64	Port 4-60 dirty.
		4-95	Yes	Yes	2.48	
		5-90[a]	No	No	–	Fog on port 5-90. Milliken (500 f/s).
		10-90[a]	No	Yes	–	Locam (500 f/s) at 10-90.
		14-95	Yes	Yes	2.52	

[a]500 frames per second (f/s).
[b]All camera speeds are 1000 f/s unless otherwise noted.

APPENDIX B: VIDEO CAMERA LOG

Test No.	Date	Standard camera #1[a] Section	Standard camera #1[a] Angle (degrees)	Standard camera #2[a] Section	Standard camera #2[a] Angle (degrees)	High-gain camera[b] Section	High-gain camera[b] Angle (degrees)
1.1	3-18-77	15	45	16	135	16	220
1.2	3-25-77	15	45	16	135	16	220
1.3	3-30-77	15	45	16	135	16	220
1.3.1	4-26-77	15	45	17	270	16	220
1.4	4-26-77	15	45	17	270	16	220
1.5	4-26-77	15	45	17	270	16	220
1.6	4-26-77	15	45	17	270	16	220
2.1	5-3-77	15	45	17	270	16	220
2.2	5-3-77	15	45	17	270	16	220
2.3	5-3-77	15	45	17	270	16	220
2.4	5-3-77	15	45	16	220	17	220
2.5	5-3-77	15	45	16	220	17	220
2.6	5-12-77	15	45	16	220	17	270
2.7	5-12-77	15	45	17	270	16	220
2.8	5-12-77	15	45	17	270	16	220
2.9	5-12-77	15	45	17	270	16	220
2.10	5-3-77	15	45	17	270	16	220
2.11	5-3-77	15	45	17	270	16	220
3.1	5-3-77	15	45	16	220	17	270
3.2	5-3-77	15	45	16	220	17	270
3.3(a)	5-3-77	15	45	16	220	17	270
3.3(b)	5-3-77	15	45	16	220	17	270
3.4(a)	5-3-77	15	45	16	220	17	270
3.4(b)	5-3-77	15	45	16	220	17	270
3.5	5-3-77	15	45	16	220	17	270

[a] Hitachi, Model HV-62U.
[b] Cohu, Model 4300 SIT.