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Performance of Multimirror Quartzline Lamps in a High-Pressure, Underwater Environment

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Performance of multimirror quartzline lamps in a high-pressure, underwater environment

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ABSTRACT

Multimirror Quartzline Lamps are extremely versatile and effective for nonconventional imaging requirements such as high-speed photo and video instrumentation and high-magnification imaging. The lamps' versatility though, is not limited to conventional environments. Many research experiments and projects require a high-pressure environment. Continuous photographic data acquisition in a high-pressure vessel requires wall penetrations and creates design problems as well as potential failure sites. Underwater photography adds the extra consideration of a liquid. This report expands upon the basic research presented in "Performance of Multimirror Quartzline Lamps in High-Pressure Environments" (NASA TM-83793, Ernie Walker and Howard Slater, 1984). The report provides information to professional industrial, scientific, and technical photographers as well as research personnel on the survivability of lighting a multimirror quartzline lamp in a nonconventional high-pressure underwater environment. Test results of lighted ELH 300 W multimirror quartzline lamps under high-pressure conditions are documented and general information on the lamp's intensity (footcandle output), cone of light coverage, approximate color temperature is provided. Continuous lighting considerations in liquids are also discussed.

1. INTRODUCTION

In 1984 basic research was conducted at NASA Lewis Research Center's Photographic and Printing Branch on the "effectiveness and failure rates of various multimirror quartzline lamps under high-pressure conditions..."[1] The report, "Performance of Multimirror Quartzline Lamps in High-Pressure Environments", described the survivability of various unlighted multimirror quartzline lamps in a high-pressure test environment. Pressures of up to 4400 psi were tested with no lamps imploding and only one-third showing signs of leakage. Lamps tested included General Electric's ELH, EJL, ELC, and ENG. All lamps are from the Multimirror Quartzline family and "consist of a small 2-Pin Quartzline lamp permanently cemented in a dichroic coated one-piece, all glass reflector, with a series of special faceted finishes to optically control the beam pattern."[2] Prior to this, testing had also been conducted on lighting in cryogenic and noncryogenic fluids in a 1 atm environment.

"Lighting in Cryogenic and Noncryogenic Fluids", NASA Lewis technical film C260, demonstrated that ordinary and high-wattage tungsten lamps could be submerged in various cryogenic and noncryogenic fluids without any "perceptual changes in performance." In noncryogenic fluids a variety of heat transport modes were evident and the bulbs quickly reached thermal equilibrium. Lighting bulbs in cryogenic fluids was also satisfactorily completed as initially a vapor film formed around the bulb surface and gradually the bulb achieved equilibrium with in its environment. Maximum operation time of the bulbs in tested liquids was not determined. The film is available on loan.

3. EQUIPMENT

NASA Lewis's High Pressure Test facility provided a convenient area to test the lamps up to 5000 psi. Figure 1 shows the layout of the test section utilized. In addition a current sensing transformer provided 20 mV to a chart recorder when a lamp was lighted. This enabled an exact tract whenever the bulb was on and quick visual indication if the lamp failed. The lamps tested were General Electric's ELH MR-16 Q bulbs (Fig. 2). Each lamp tested was held in the high-pressure chamber by a manufactured support device (Fig. 3). City water provided the liquid environment to test the bulbs in. A Calculight XP lightmeter was used to calculate the lamps' footcandle output while a Variac supplied the required voltage.

4. PROCEDURE

Footcandle and light cone measurements were made at a distance of 1 ft in order to test the ELH's intensity and area of illumination. As in previous testing of the lamps, area of illumination was determined from the center of the projected light to where incident light fell off by one f/stop as measured by the Calculight XP: 120 V, 300 W, 16 fc (approx.), light cone of 6 in. in diameter, color temperature 3350 K. Table 1 shows manufacturer's specifications for a variety of General Electric lamps.

Each of 11 individual lamps was placed one at a time in the support bracket and submerged in the pressure chamber. The first 6 lamps were tested as follows. Pressure was increased to 3500 psi and maintained for 30 sec at which point the lamp was turned on. The initial starting pressure was based on previous survivability tests of the lamps at that level. Pressure and current levels were recorded on chart paper. After 30 sec at 3500 psi the lamp was turned off and pressure increased to 4000 psi. Pressure was again maintained for 30 sec and then the lamp was turned on for 30 sec. After 30 sec, the lamp is turned off and the pressure increased to 4500 psi. At this pressure level, lighted lamp time was successively increased with each lamp. Lamp 1 remained lit for 30 sec, lamp 2 for 1 min, lamp 3 for 2 min, lamp 4 for 3 min, etc. up to lamp 6 for 5 min.

The next 5 lamps were tested to the maximum pressure of the system - 5000 psi. Testing up to 4000 psi was the same for these lamps as the others. At 4500 psi, the lamps were lit for only 30 sec. At 5000 psi a total light time of 5 min was attempted. After each of the bulbs was tested, they were inspected visually for any damage or discoloration. Postpressure testing consisted of relighting the lamps in a normal environment to see if they were still functional. A Plexiglass chamber was used in case of explosion.

5. RESULTS

The compact design and high light output of the ELH lamp is ideal for many photographic and video assignments. Although a large enough sample was not taken to make statistical conclusions, the following results were observed. All of the lamps survived up to 4500 psi (Table 2). As the pressure was increased to 5000 psi two lamps failed while lighted. Both lamps 7 and 8 appeared to have had microscopic leaks and burned out. Upon visual inspection both lamps had small amounts of water in their inner lamp body with some black stains on the glass envelope. It appears that the leaks occurred through the conductor penetrations of the glass envelopes.

After all lamps had been tested in the high-pressure environment, they were relit in a regular fashion to see if any damage had occurred under testing. All lamps that survived the high-pressure test functioned normally during regular postpressure lighting.

A measure of conductivity showed 7000 Ω of resistance in the city water. This compared with 70 000 Ω as measured with ionized water.

6. CONCLUSIONS

The General Electric line of Quartzline lamps are extremely versatile for use in a variety of photographic and video assignments. As the results of this report indicate, all the ELH Quartzline lamps functioned well up to 4500 psi with no protective housing and initially appear to be able to handle 5000 psi with some degree of success. Lighting in liquids becomes relatively easy when a few simple precautions are followed.

As mentioned in "Lighting in Cryogenic and Noncryogenic Fluids", the lamps should be totally submerged in a noncryogenic liquid prior to powering up in order to prevent "localized cooling and high thermal stresses" which may cause certain lamps to crack. When the lamp is totally submerged prior to lighting, thermal equilibrium is easily achieved by the lamp and its environment. Additionally, lamps can be used in any liquid environment "provided thermal equilibrium can be achieved." This proves true not only for the rugged and compact ELH lamps tested but for regular household lamps as well.

The Multimirror Quartzline lamps continue to provide imaging specialists with an extremely versatile lighting tool under a variety of conditions. By knowing light output and area of coverage prior to installation, lighting of hostile environments can be easily facilitated.

7. ACKNOWLEDGMENTS

Special thanks to John Burke, John Dorner, George Pindroh, and Bill Richardson for making this report possible.

8. REFERENCES

1. E.D. Walker and H.A. Slater, "Performance of Multimirror Quartzline Lamps in High-Pressure Environments," NASA TM-83793, 1984.
2. E.D. Walker and H.A. Slater, "Method of Reducing Temperature in High-Speed Photography," NASA TM-83620, 1984.

3. R.C. Hendricks and K.J. Baumeister, "Lighting in Cryogenic and Noncryogenic Fluids," NASA TM X-1654, 1977.

4. "General Electric Photographic Lamp and Equipment Guide," 1988.

Table 1. Multimirror Quartzline Lamps For Large Format Applications

Lamp code	Watts	Rated, V	Average rated life, hr	Filament	Approximate color temperature, K	Base	Approximate beam spread	Average footcandle at 100 cm
EPZ	50	13.8	1000	CC-6	3150	2-pin	Narrow beam	[a]800
DJT	50	13.8	1000		3150			800
DDM	80	19	50		3300			2 800
DDS	80	21	1000		3125			1 500
DED	85	13.8	1000		3125			2 000
EPT	42	10.8	8000	CC-6	2900	2-pin	Medium beam 20° to 30°	[b]100
ENL	50	12	1500		3050			150
DDK	80	19	40		3300			600
EPX	90	14.5	500		3150			640
ESD	150	120	12	CC-8	----	Oval 2-pin		------
ELD/EJN	150	21	40	CC-6	3350	2-pin		700
EJL	200	24	50		3400			550
EKX	200	24	50		3400			800
ELC	250	24	50		3400			750
ENH	250	120	175	CC-8	3250	Oval 2-pin		1 000
ELH	300	120	35	CC-8	3350	Oval 2-pin		8 000
ENG	300	120	15	CC-8	3450	Oval 2-pin		11 000
ERV	340	36	75	CC-8	3300	Oval 2-pin	Broad beam ~45°	[c]900
ENX	360	82	75	CC-8	3300	Oval 2-pin		850

[a]Center beam.
[b]Measured over a 1 ft^2 area.
[c]Measured over a 2 ft^2 area.

Table 2. Test Results for Individual ELH Lamps

Lamp	Pressure, psi	Time, sec	Condition
1	3500	30	NF[a]
	4000		
	4500		
2	3500		
	4000		
	4500	60	
3	3500	30	
	4000	30	
	4500	120	
4	3500	30	
	4000	30	
	4500	180	
5	3500	30	
	4000	30	
	4500	240	
6	3500	30	
	4000	30	
	4500	300	
7	3500	30	
	4000	30	
	4500	30	
	5000	300	F[b]
8	3500	30	NF
	4000	30	NF
	4500	30	NF
	5000	300	F
9	3500	30	NF
	4000	30	
	4500	30	
	5000	300	
10	3500	30	
	4000	30	
	4500	30	
	5000	300	
11	3500	30	
	4000	30	
	4500	30	
	5000	300	

[a]No failure.
[b]Failure.

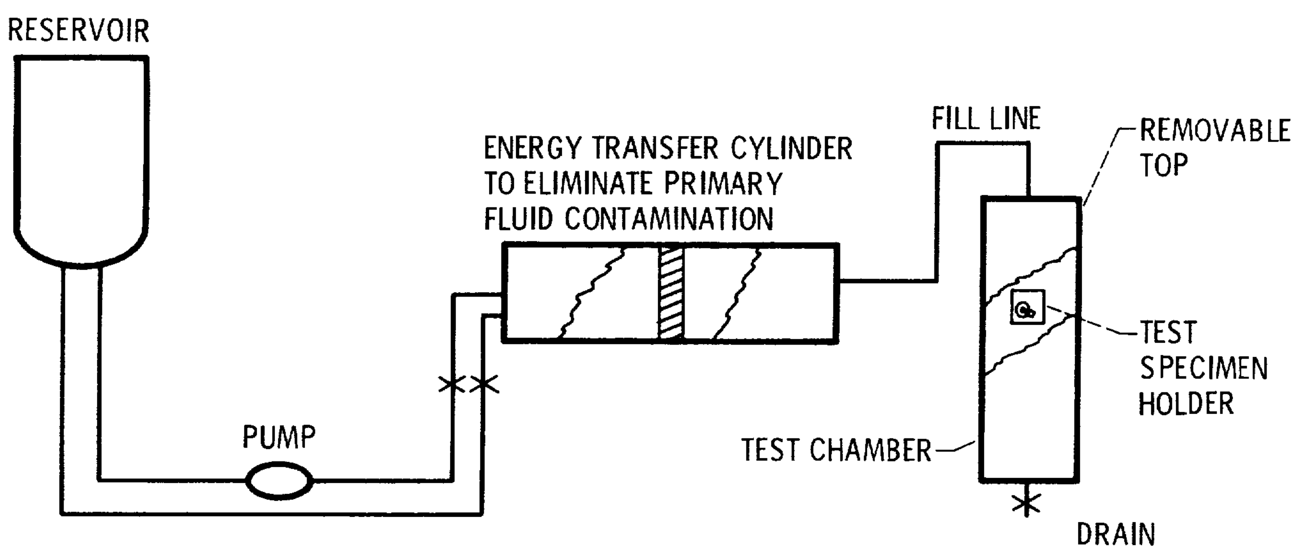

Figure 1. - High-pressure test facility.

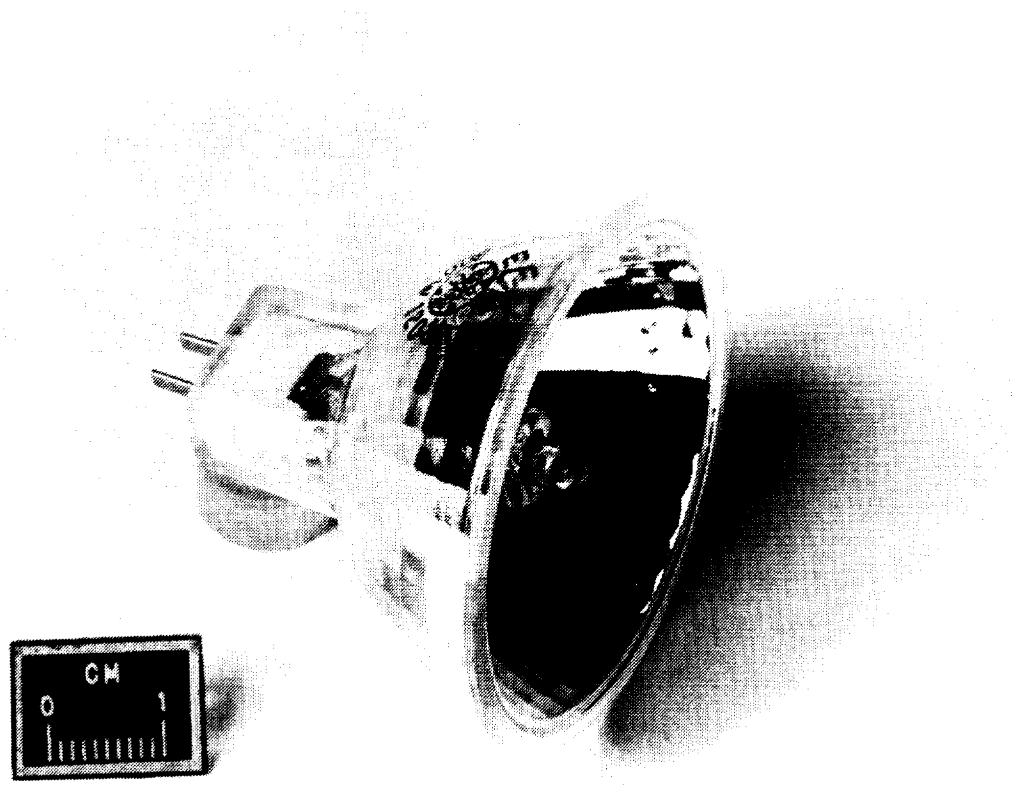

Figure 2. - ELH · MR-16 Q lamp.

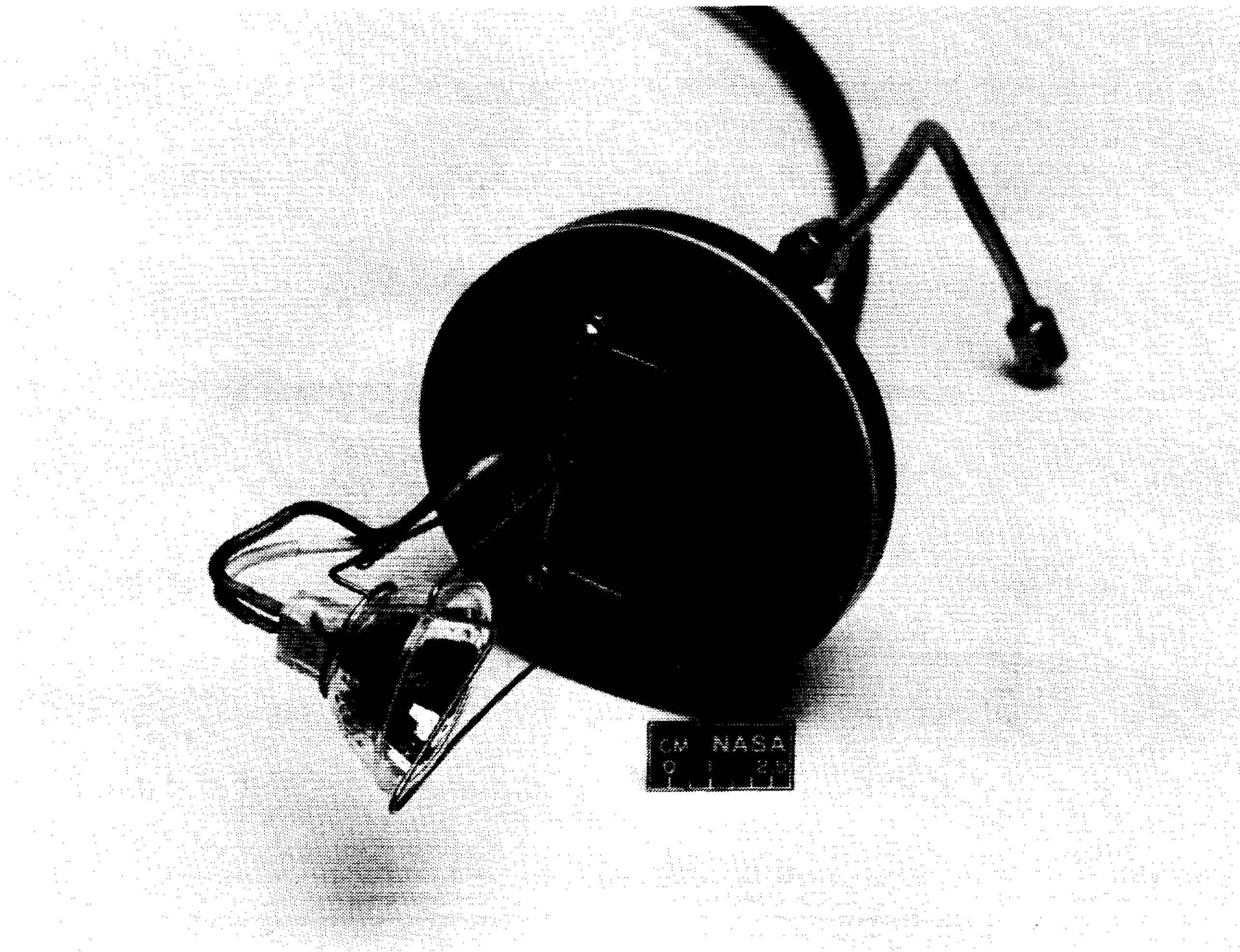

Figure 3. - Manufacture lamp support device.

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15. Supplementary Notes

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