R-93-09

ELASTOMERIC CANAL SEALANTS AIR-WATER-HEAT STUDY

May 1993

U.S. DEPARTMENT OF THE INTERIOR
Bureau of Reclamation
Denver Office
Research and Laboratory Services Division
Materials and Engineering Branch

7-2090 (4-81)
Bureau of Reclamation

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO. R-93-09	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
4. TITLE AND SUBTITLE Elastomeric Canal Sealants Air-Water-Heat Study		5. REPORT DATE May 1993 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Jay Swihart		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Bureau of Reclamation Denver Office Denver CO 80225		10. WORK UNIT NO. 11. CONTRACT OR GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Same		13. TYPE OF REPORT AND PERIOD COVERED DIBR 14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

Microfiche and hard copy available at the Denver Office, Denver, Colorado. Ed: TH

16. ABSTRACT

The Bureau of Reclamation tested various sealants for elastic modulus at 25- and 50-percent elongation over a 4-year period. The sealants were aged in three environments: **Air** – control at 70 °F and 50-percent relative humidity, **Water** – water immersion at 60 °F, and **Heat** – oven-aging at 158 °F. Sealant selection was based on Reclamation field and laboratory experience as well as manufacturer's recommendations. The use of primers did not improve sealant performance in this study. Several sealants are recommended for use as canal sealants. Other sealants tested should only be used under certain conditions, and a third group of sealants was found unacceptable for use as a canal sealant.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS-- canal sealants/ water seals/ bonding/ linings/

b. IDENTIFIERS-- American Society for Testing and Materials/

c. COSATI Field/Group 11/A ***COWRR:*** 1101 ***SRIM:***

18. DISTRIBUTION STATEMENT *Available from the National Technical Information Service, Operations Division, 5285 Port Royal Road, Springfield, Virginia 22161.*	19. SECURITY CLASS (THIS REPORT) *UNCLASSIFIED*	21. NO. OF PAGES 15
	20. SECURITY CLASS (THIS PAGE) *UNCLASSIFIED*	22. PRICE

R-93-09

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Denver, Colorado

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UNITED STATES DEPARTMENT OF THE INTERIOR ★ BUREAU OF RECLAMATION

ACKNOWLEDGEMENTS

Laboratory tests conducted by Konstantine Karpoff, Greg Myers, Cheryl Kramer, Linda Parkhill, Alice Comer, and Jay Swihart.

Frontispiece: Construction crew uses two-part canal sealant to cap-seal random cracks and seal contraction joints in concrete canal lining.

Art work by Cheryl Kramer.

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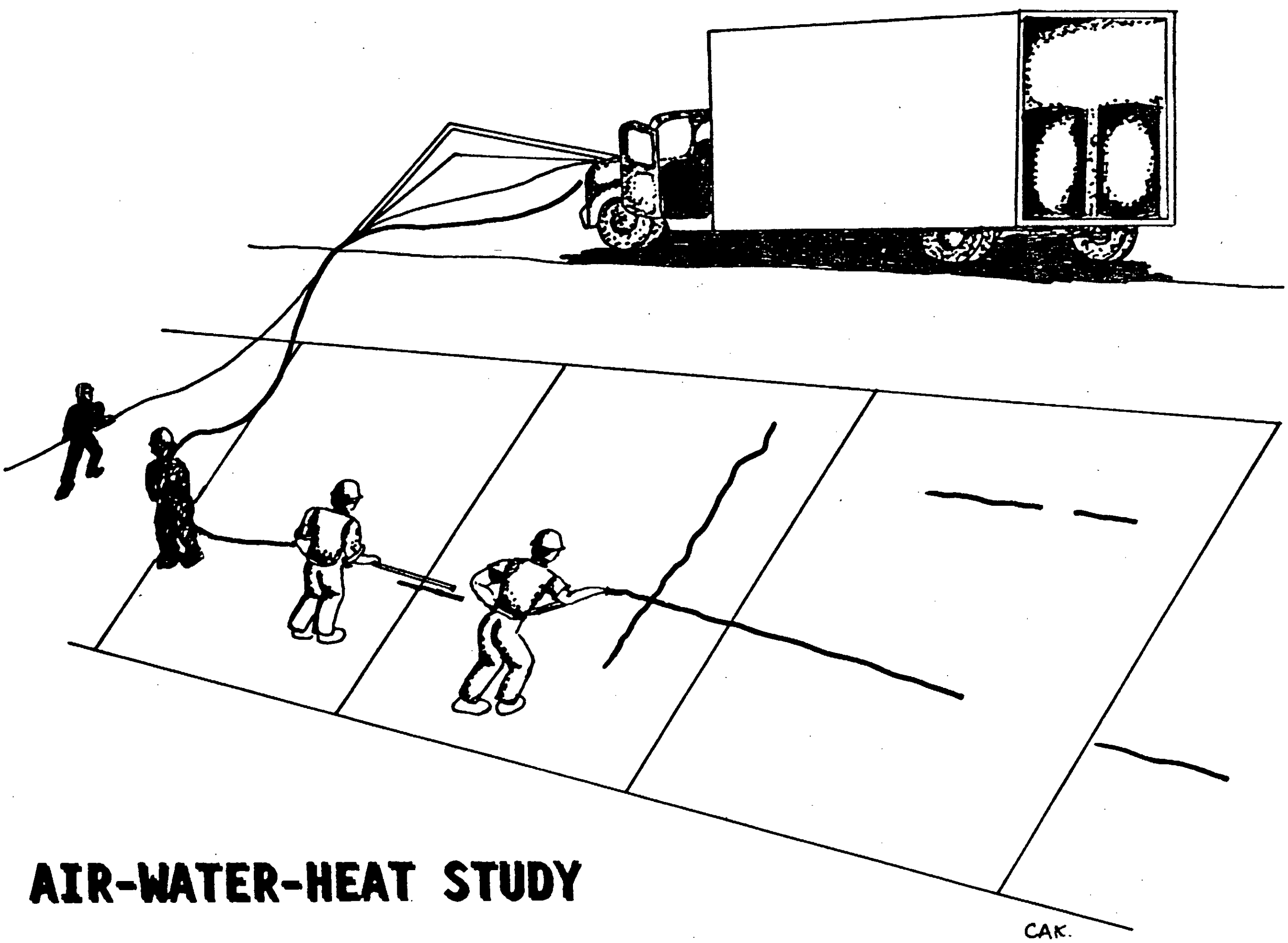
As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally-owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

ELASTOMERIC

CANAL

SEALANTS



AIR-WATER-HEAT STUDY

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INTRODUCTION

Sealants are used to seal joints and cracks in a variety of concrete structures. Existing industry standards (i.e. American Society for Testing and Materials, Federal Specifications, etc.) provide minimum quality criteria for sealants used in structural, architectural, highway, and airport runway applications. Unfortunately, sealants conforming to these standards often prove unsuitable for applications involving prolonged water immersion (canals, reservoirs, dams, swimming pools, etc.). Therefore, this laboratory study was undertaken to identify promising materials for use as canal sealants.

Canal sealants must bond to concrete, withstand the environment, and accommodate joint movement both below and above the waterline. To meet these requirements, sealants must remain elastomeric (rubber-like). They should not harden to a point where joint movement causes them to either crack (cohesive failure) or disbond (adhesive failure), nor should they soften or deteriorate to a point where hydrostatic pressure or mechanical distress could force them out of the joint.

For this study, various sealants were tested for elastic modulus at 25- and 50-percent elongation over a 4-year period. The sealants were aged in three environments: **Air** – control at 70 °F and 50-percent relative humidity, **Water** – water immersion at 60 °F, and **Heat** – oven-aging at 158 °F. Sealant selection was based on Reclamation field and laboratory experience as well as manufacturer's recommendations. Twenty-six sealants (30 including those with primers) were included in this study:

Bostik 1000	Pecora Dynatrol 1
Burke U-Seal 3201	Polyguard JFR-3
Crafco Super-Seal 333	PRC 270
Dow 795	PRC 7000
Dow 888	PRC 7000 (primed)
Dow 888 (primed)	PRC RC-1
GE Silpruf	Ruscoe 965
Koch 9012 NS	Sikaflex 1A
Koch 9015	Sikaflex 2C
Koch 9028	Sikaflex 2C (primed)
Koch 9050 NS	Sonneborn NP-1
Mameco Vulkem 116	Sonneborn NP-2
Mameco Vulkem 202	Sonneborn NP-2 (primed)
Mameco Vulkem 203	Tremco Dymeric
Mameco Vulkem 922	Tremco Dymonic

CONCLUSIONS

1. Primers. – Use of primers did not improve sealant performance. In the field, primers are not only an extra step and expense, but have also caused premature sealant failure when improperly applied. Therefore as a general rule, primers should not be used. Exceptions to this rule should be evaluated on a case-by-case basis for each manufacturer's product.

2. The following sealants scored highly (7.0 to 9.5) in this study and are recommended for use as canal sealants. See Recommendations section for further information:

Bostik 1000	* Mameco Vulkem 202
Koch 9012 NS	Sikaflex 1A
Koch 9015	Sikaflex 2C
Koch 9028	Sonneborn NP-2

3. The following sealants received erratic or borderline scores (5 to 6.5). See Recommendations section for appropriate considerations for use as canal sealants:

Burke U-Seal 3201	Mameco Vulkem 116
# Crafco Super-Seal 333	Pecora Dynatrol 1
Dow 795	*# Polyguard JFR-3
Dow 888	PRC 7000

4. The following sealants scored poorly (0 to 1) and are unacceptable for use as canal sealants:

GE Silpruf	PRC 270
Koch 9050 NS	Ruscoe 965
Mameco Vulkem 203	Sonneborn NP-1
Mameco Vulkem 922	Tremco Dymeric
PRC RC-1	Tremco Dymonic

* Self-leveling – cannot be used on canal side slopes.
# No longer manufactured.

PROCEDURE

Modulus specimens were prepared per ASTM C719 (Modified), "Standard Test Method for Adhesion and Cohesion of Elastomeric Joint Sealants Under Cyclic Movement (Hockman Cycle)." Uncured sealant was troweled into place between freshly ground concrete blocks to form a 1/2- × 1/2- × 2-inch specimen as shown on figures 1 and 2. The specimens were allowed to cure fully before testing (21 days for the single component sealants and 7 days for the multi-component sealants). Six modulus specimens were prepared for each sealant: two for air, two for water, and two for heat.

A second set of six specimens was prepared with four sealants (Dow 888, Sonneborn NP-2, PRC 7000, and Sikaflex 2C) to evaluate the effect of priming the concrete before sealant application. The primers were recommended and supplied by the sealant manufacturer.

At various time intervals (every few weeks at the beginning to every few months later on) all of the specimens were tested for modulus on an Instron Series 1120 universal test machine at a crosshead speed of 0.2 inches/minute. The water and heat specimens were removed from their test environment the day before testing and allowed to come to equilibrium with the test environment. Load readings were taken at 25- and 50-percent elongation. Because the area of contact between the sealant and the concrete blocks is one square inch (1/2 inch × 2 inches) the recorded loads represent pounds per square inch. The test grips are shown on figure 3.

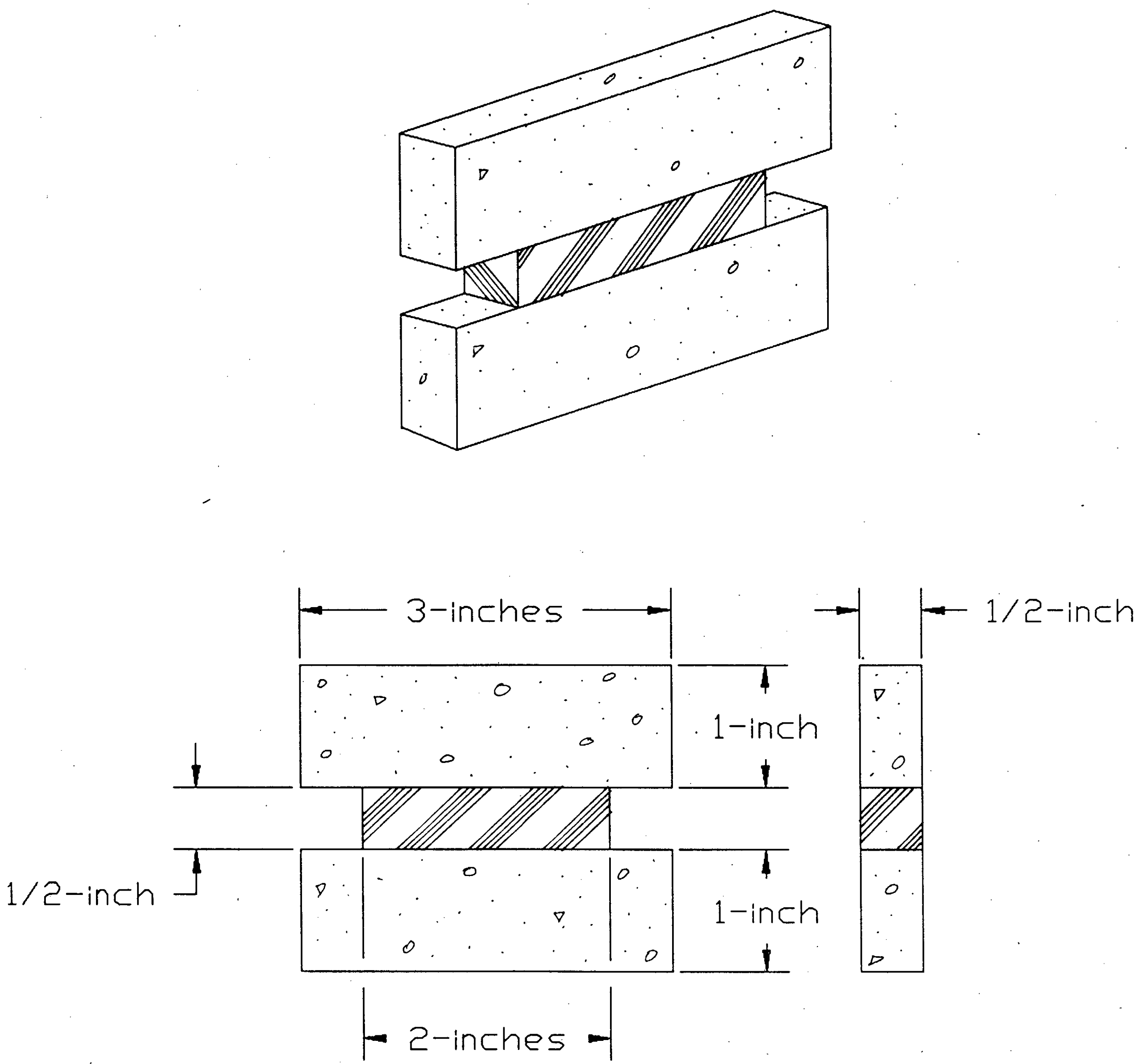

Figure 1. – Joint sealant–modulus test specimen.

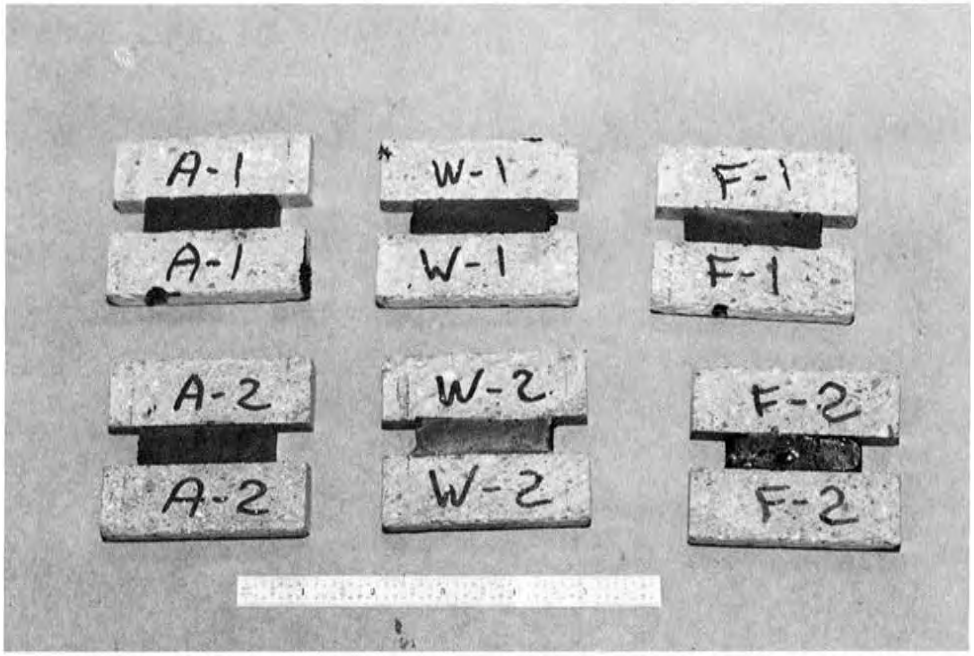

Figure 2. – Typical test specimens.

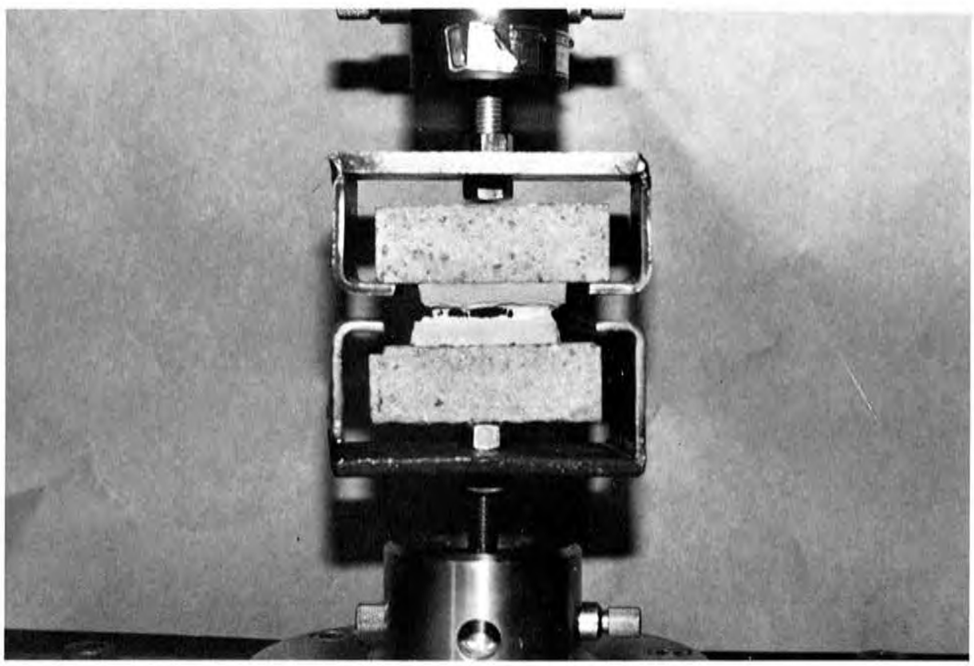

Figure 3. – Grips for sealant modulus testing.

Test end point – Failure for individual test specimens was defined either as a negative slope on the Stress-Strain curve or as more than 50-percent adhesive or cohesive failure. Typical adhesive and cohesive failures are shown on figures 4 and 5.

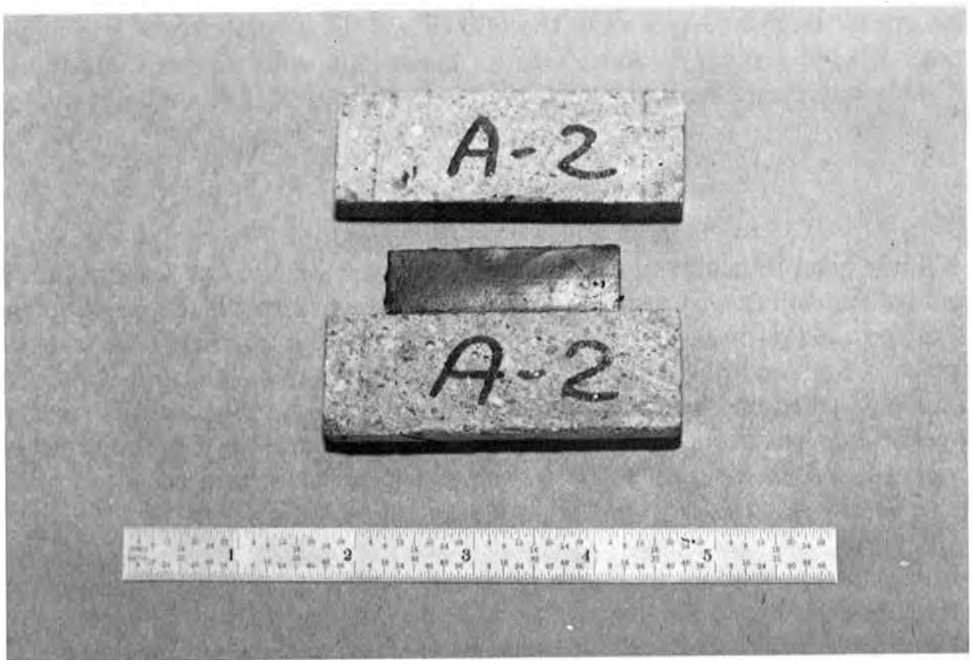

Figure 4. – Adhesive failure–loss of adhesion between sealant and concrete block.

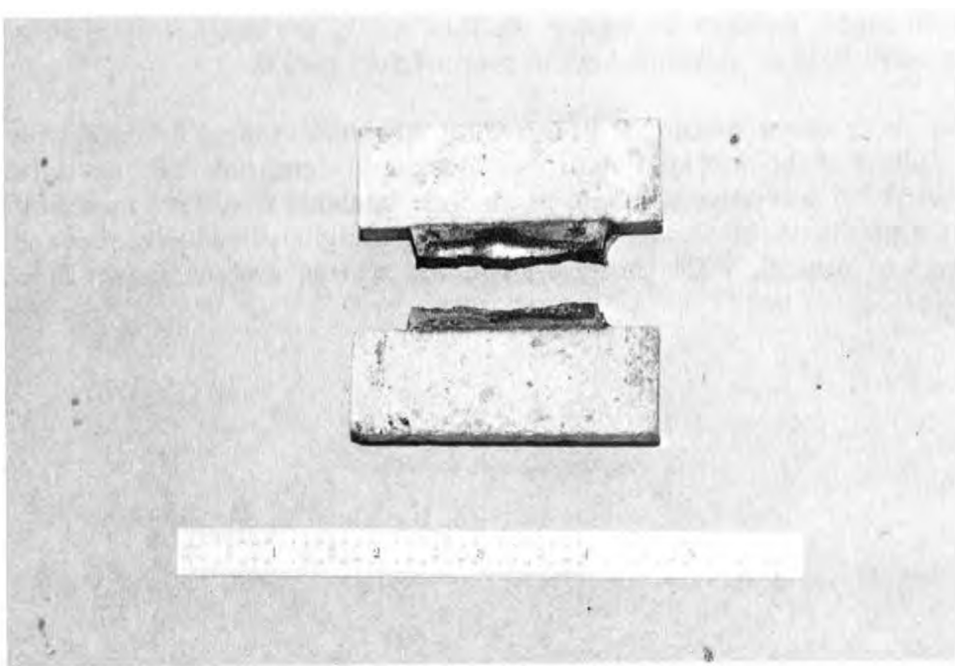

Figure 5. – Cohesive failure - failure within the sealant.

Sealant Groups – Early in the test program (when the majority of sealant specimens were in their first month of testing), the heat specimens were inadvertently exposed to 660 °F for about 15 minutes. Some heat specimens melted at this temperature; others appeared unaffected. As the long-term effects were not known, a complete new set of specimens was prepared for retesting. The group that was exposed to the 660 °F was labeled Group A and left in test. The new group was labeled Group B. Some Group A sealants were unavailable for inclusion in Group B and some additional sealants were included in Group B that were not in Group A.

DISCUSSION

Modulus is a fairly good indicator of sealant performance. Ideally, the sealant modulus should not be affected by atmospheric exposure, water immersion, or heat. If the modulus does change, it should stabilize in a reasonable period of time or change quite slowly so the sealant will not fail prematurely. A few sealants softened with aging; however, most sealants tended to harden with age because of continued polymer cross-linking. Hardening was usually most pronounced in the heat specimens, less pronounced in the air specimens, and least pronounced in the water specimens because absorbed water tends to act as a plasticizer and counteract the effects of crosslinking.

The 50-percent extension in the modulus test was chosen as the maximum joint extension expected in Reclamation hydraulic structures. Most joints would actually experience much less extension, except for those joints in which contraction of many slabs accumulates.

Joints in Reclamation canals experience frequent cyclical movement with changes in temperature – day to night, summer to winter. In this study, the sealant specimens were only subjected to a mere 10 to 30 movement cycles over a 4-year period.

Failure of the air or water specimens in less than 200 weeks (about 4 years) was considered undesirable. Failure of the heat specimens was considered significant, but less critical, because the heat test (158 °F) is relatively severe. In the field, sealants would not normally be exposed to such high temperatures, and areas exposed to heat (sunlight) are usually above the waterline and therefore less critical. With these criteria, the scoring system shown in table 1 was developed:

Table 1. – Sealant scoring criteria.

Score	Air	Water	Heat
10	No failure at 200 weeks; mod. stable	No failure at 200 weeks; mod. stable	No failure at 200 weeks; mod. stable
9	No failure at 200 weeks	No failure at 200 weeks	No failure at 200 weeks
8	—	—	No failure at 100 weeks
7	—	—	No requirement
6	No failure at 175 weeks	No failure at 175 weeks	—
5	No failure at 150 weeks	No failure at 150 weeks	—
4	No failure at 125 weeks	No failure at 125 weeks	—
3	No failure at 100 weeks	No failure at 100 weeks	—
2	No failure at 75 weeks	No failure at 75 weeks	—
1	No failure at 50 weeks	No failure at 50 weeks	—
0	No requirement	No requirement	—

TEST RESULTS – METHOD OF SCORING

Tables A and B in the appendix summarize the results for Sealant Groups A and B, respectively. The score for an individual sealant under a specific test environment is based on the average failure time for the two duplicate test specimens. For instance, if the two air specimens fail at 104 and 206 weeks respectively, then the average failure time is 155 weeks, which earns a score of 5 for the air environment.

The overall score for a sealant set is the lowest score earned in the three test environments. For instance, if the air specimens fail at 210 weeks with a 150-percent change in modulus (score = 9), the water specimens fail at 110 weeks (score = 3), and the heat specimens fail at 18 weeks (score = 7), then the overall score is 3 because of the poor performance of the water specimens.

The overall score was usually controlled by the performance of the water specimens for sealants scoring less than 7, and by the heat specimens for sealants scoring 7 or more.

Table 2 lists the scores for each sealant. The composite score combines the scores from Groups A and B for those sealants included in both. Note that there are 3 categories. Category I sealants earned the highest scores ranging from 7 to 9.5 and show the most promise as canal sealants. Category II sealants earned erratic or borderline scores ranging from 4 to 6.5. Category III sealants earned scores of less than 4 and are unacceptable for use as canal sealants.

Table 2. – Sealant performance scores.

	Sealant	Group A Score	Group B Score	Composite Score
I.	Sonneborn NP-2	9.5	9.5	9.5
	Sonneborn NP-2 (primed)	9.5	9.5	9.5
	Mameco Vulkem 202	9.5	–	9.5
	Sikaflex 2C	–	8	8
	Sikaflex 1A	7	8	7.5
	Koch 9015	7	7.5	7.3
	Koch 9028	7	7	7
	Koch 9012 NS	–	7	7
	Sikaflex 2C (primed)	–	7	7
	Bostik 1000	–	7	7
II.	Crafco Super-Seal 333	–	6.5	6.5
	Dow 888	–	6.5	6.5
	PRC-7000 (primed)	9	5	6
	PRC-7000	2	9	5
	Burke U-Seal 3201	4	7	5
	Polyguard JFR-3	–	5	5
	Dow 795	–	5	5
	Pecora Dynatrol 1	–	5	5
	Mameco Vulkem 116	–	5	5
	Dow 888 (primed)	–	4	4
III.	Mameco Vulkem 203	–	2	2
	Tremco Dymeric	–	2	2
	Tremco Dymonic	–	1	1
	Mameco Vulkem 922	0	1	1
	Sonneborn NP-1	0	1	1
	GE Silpruf	–	0	0
	Ruscoe 965	–	0	0
	Koch 9050 NS	–	0	0
	PRC RC-1	–	0	0
	PRC 270	–	0	0

RECOMMENDATIONS

Primers – Use of primers did not improve sealant performance. Of the four sealants that were tested with primer, the Sonneborn NP-2 performed equally well both with and without primer. The PRC 7000 performed equally erratically both with and without primer (perhaps slightly better performance with primer). Both Dow 888 and Sikaflex 2C performed better without primer. In the field, primers are not only an extra step and expense, but have also caused premature sealant failure when improperly applied. Therefore, until such benefits can be demonstrated, primers should not be used. If, in rare instances, some reason for consideration of an exception to this rule should arise, primers should be evaluated on a case-by-case basis for each product.

Sealants – The following sealants performed well in this study and earned scores ranging from 9.5 (almost perfect) down to 5 (borderline). The accompanying comments are provided to assist in sealant selection:

Sonneborn NP-2 (primed and unprimed) – This slow-set, two-component sealant received the highest score of any material evaluated. The heat specimens softened substantially but stabilized after only a few weeks. This product has been used on at least one Reclamation contract with good short-term results. (Score = 9.5)

Mameco Vulkem 202 – This self-leveling material also scored very highly; however, it has limited application for Reclamation as most of our work is on canal side-slopes and requires a non-sag sealant. This material could be used on canal inverts; however, contractors normally prefer to use a single sealant that works both in the invert and on side-slopes. (Score = 9.5)

Sikaflex 2C (primed and unprimed) – This two-part, low-modulus, slow-set, polyurethane sealant performed well both with and without primer - slightly better without primer. Cost is about $30 per gallon. (Unprimed Score = 8, Primed score = 7)

Sikaflex 1A – This is one of the few one-part products that received a high score. The convenience and versatility of one-part sealants often make them the sealant of choice even though they are relatively expensive ($25 to $30 per gallon). Reclamation has used this material extensively with good success. The only problems have been associated with use of a primer. (Score = 7.5)

Koch 9015 (Formerly Allied 9015) – This rapid-set material cures in 5 to 10 minutes and therefore requires special (expensive) application equipment. However, the equipment costs can quickly be recouped on large jobs because the sealant only costs about $15 per gallon. This sealant was used extensively on the Central Arizona Project with good results. (Score = 7.3)

Koch 9028 (Formerly Allied 9028) – This is a slow-set (hand-mix) version of the Koch 9015. It has been used with good results on Reclamation projects; however, it is slightly more expensive at $20 to $25 per gallon. (Score = 7)

Koch 9012 NS (Formerly Allied 9012 NS) – The sealant tested was a special non-sag version of a usually self-leveling product. This hot-applied sealant leaves the factory fully polymerized and therefore should prove more consistent than Super-Seal 333 - see below. Laboratory tests on this product look quite promising. Cost is $5 to $10 per gallon. (Score = 7)

Bostik 1000 – This is the other one-part, urethane sealant that received a high score. Shelf life is 12 months minimum, and the manufacturer does not require priming for wet conditions. Cost is $40 to $50 per gallon. (Score = 7)

Crafco Super-Seal 333 (Formerly Superior Super-Seal 333) – This one-part hot-applied sealant is quite inexpensive at $5 to $10 per gallon. It performed satisfactorily in this study, but has performed erratically in the field. Erratic field performance might be explained by the fact that this sealant arrives on the job site only partially polymerized. Further polymerization (cross-linking) is accomplished by pre-heating in the application kettle. Obviously, material applied from the kettle after 1 hour is quite different from material applied from the kettle at the end of the day. This erratic field performance prevents Super-Seal 333 from being more-highly recommended as a canal sealant. Crafco has recently discontinued the manufacture of this product in favor of their asphalt-based products. (Score = 6.5)

Dow 888 (primed and unprimed) – This one-part, low-modulus, silicone sealant is intended for use in highway joints. The manufacturer does not generally recommend its use for continuous water immersion; therefore, this product performed better than expected. The primer was intended to improve adhesion under wet conditions, but surprisingly this material performed better without the primer. Cost is about $60 per gallon. (Unprimed Score = 6.5, Primed Score = 4)

PRC 7000 (primed and unprimed) – This one-part sealant performed erratically in the water test environment both with and without primer. The primed specimens performed slightly better but still erratically. Scores ranged from 2 to 9. Small quantities of this product have been used without primer on Reclamation contracts with good success. Cost is $25-30 per gallon. (Composite Scores: Unprimed = 5, Primed = 6)

Burke U-Seal 3201 (Formerly Edoco U-Seal 3201) – This two-component slow-set sealant was included in both Groups A and B and earned borderline scores ranging from 4 to 7. This sealant was used extensively on the Central Arizona Project with mixed results. Cost is $20-25 per gallon. (Composite Score = 5)

Polyguard JFR-3 – This self-leveling hot-applied sealant earned a borderline score and costs only $5 to $10 per gallon. However, the manufacturer recently decided to discontinue manufacture of this product after a fire at their production facility. (Score = 5)

Dow 795 – This one-part silicone product earned a borderline score. It is intended for use as an architectural sealant, and the manufacturer does not recommend its use for continuous water immersion. It has high movement capability (rated for 50-percent joint movement) and excellent weatherability. Cost is $40 to $60 per gallon. (Score = 5)

Pecora Dynatrol 1 – This one-part, non-sag, polyurethane architectural sealant also earned a borderline score. The manufacturer recommends use of a primer for continuous water immersion. However even with primer, the manufacturer expects decreased longevity in water immersion applications. This study did not evaluate the effectiveness of primer with this product. (Score = 5)

Mameco Vulkem 116 – This single-component sealant received a borderline score. In the field, it has had an erratic problem with outgassing. However, material that did not outgas was well-bonded and elastomeric, although somewhat stiff (hard). (Score = 5)

APPENDIX

Results for Sealant Groups A and B

Table A - Test Results for Sealant Group A

Sealant	Description	USBR M-41 Class	Weeks in test	Initial Modulus 25%	Initial Modulus 50%	Observations: Air	Observations: Water	Observations: Oven	Score
Burke U-Seal 3201	2-part polyurethane Rapid-set	A	227	11	20	No Failures Modulus Stable	Adh fail @ 122 wks Modulus down 75%	Melted at 660 F	4
Koch 9015	2-part polysulfide Rapid-set	R	228	10	13	No Failures Modulus up 200%	No Failures Modulus up 50%	Cohes fail @ 31 wks Modulus up 200%	7
Koch 9028	2-part polysulfide Slow-set	S	228	7	11	No Failures Modulus up 200%	No Failures Modulus Stable	Cohes fail @ 31 wks Modulus up 500%	7
Mameco Vulkem 202	2-part polyurethane SELF-LEVELING	A	227	12	20	No Failures Modulus Stable	No Failures Modulus Stable	No Failures Modulus up 50%	9.5
Mameco Vulkem 922	2-part polyurethane Slow-set	A	29	34	59	Adh fail @ 29 wks Modulus stable	Adh fail @ 7 wks Modulus stable	Adh fail @ 7 wks Modulus up 150%	0
PRC 7000	1-part polysulfide	B	227	14	22	No Failure Modulus up 100%	Adh fail @ 31 wks Modulus down 50%	Adh/Coh fail @ 227 wks Modulus erratic	1
PRC 7000 (primed)	1-part polysulfide	B	227	14	21	No Failures Modulus up 50%	Adh fail @ 227 wks Modulus Stable	Cohes fail @ 227 wks Modulus erratic	9
Sikaflex 1A	1-part polyurethane	B	227	24	33	No Failures Modulus up 100%	No Failures Modulus Stable	Adh fail @ 16 & 20 wks Modulus up 300%	7
Sonneborn NP-1	1-part polyurethane	B	227	24	38	No Failures Modulus Stable	Adh fail @ 2 & 6 wks Modulus up 25%	No Failures Modulus up 25%	0
Sonneborn NP-2	2-part polyurethane Slow-set	A	235	26	40	No Failures Modulus Stable	No Failures Modulus Stable	No Failures Modulus down 90%	9.5
Sonneborn NP-2 (primed)	2-part polyurethane Slow-set	A	235	23	35	No Failures Modulus Stable	No Failures Modulus Stable	No Failures Modulus down 75%	9.5

Table B-1 - Test Results for Sealant Group B (Continued)

Sealant	Description	USBR M-41 Class	Weeks in test	Initial Modulus 25%	Initial Modulus 50%	Observations: Air	Observations: Water	Observations: Oven	Score
Bostik 1000	1-part polyurethane	B	180	38	49	No Failures Modulus up 50%	No Failures Modulus Stable	Adh Fail @ 19 & 37 wks Modulus Stable	6-7
Burke U-Seal 3201	2-part polyurethane Rapid-set	A	210	4	7	No Failures Modulus Stable	No Failures Modulus Stable	Melted @ 10 wks Modulus down 90%	7
Crafco Super-Seal 333	Hot-applied PVC, Coal-Tar, Rubber	C	261	4	6	Peeling & split Modulus up 800%	Peeling & split Modulus up 300%	Adh/Coh Fail 1 @ 2 wks Modulus up 300%	6.5
Dow 795	1-part silicone	B	245	25	37	No Failures Modulus down 50%	Adh Fail 138 & 172 wks Modulus Stable	Adh Fail 138 & 156 wks Modulus up 200%	5
Dow 888	1-part silicone	B	200	14	16	No Failures Modulus Stable	W-1 Adh Fail @ 200 wks Modulus down 50%	No Failures Modulus Stable	6
Dow 888 (primed)	1-part silicone	B	200	15	17	No Failures Modulus up 50%	W-2 Adh Fail @ 51 wks Modulus down 50%	F-2 Adh Fail @ 188 wks Modulus up 50%	4
GE Silpruf	1-part silicone	B	118	7	8	Adh Fail @ 3 & 118 wks Modulus Stable	Adh Fail @ 3 wks Modulus up 100%	Adh Fail @ 3 & 118 wks Modulus up 350%	0
Koch 9012 NS	Hot-applied PVC, Coal-tar, rubber	C	239	2	4	No Failures Modulus up 150%	No Failures Modulus up 200%	Adh Fail @ 6 wks Modulus up 1000%	7
Koch 9015	2-part polysulfide Rapid-set	R	211	13	19	No Failures Modulus up 50%	No Failures Modulus Stable	Coh fail @ 73 wks Modulus up 200%	7.5
Koch 9028	2-part polysulfide Slow-set	S	211	7	12	No Failures Modulus up 200%	No Failures Modulus Stable	Adh fail @ 14 & 20 wks Modulus up 800%	7

Table B-2 - Test Results for Sealant Group B (Continued)

Sealant	Description	USBR M-41 Class	Weeks in test	Initial Modulus 25%	Initial Modulus 50%	Observations: Air	Observations: Water	Observations: Oven	Score
Koch 9050 NS	1-part polysulfide	B	73	18	20	No Failures @ 73 wks Modulus up 100%	Adh Fail @ 8 & 47 wks Modulus down 100%	F-1 Adh fail @ 73 wks Modulus up 100%	0
Mameco Vulkem 116	1-part polyurethane	B	210	45	72	A-2 Adh fail @ 210 wks Modulus up 100%	W-2 Adh fail @ 105 wks Modulus up 100%	Adh fail @ 10 & 32 wks Modulus up 200%	5
Mameco Vulkem 203	1-part coal-tar, Polyurethane	B	211	3	6	No Failures Modulus up 600%	Adh fail @ 33 wks Modulus up 100%	Adh fail @ 74 wks Modulus up 1000%	1
Mameco Vulkem 922	2-part polyurethane Slow-set	A	211	20	38	No Failures Modulus up 200%	Adh Fail @ 4 & 106 wks Modulus up 100%	Adh fail @ 74 wks. Modulus up 300%	1
Pecora Dynatrol 1	1-part polyurethane	A	243	15	24	No Failures Modulus up 150%	Adh Fail 136 & 243 wks Modulus up 100%	Adh Fail @ 3 wks Modulus up 400%	6
Polyguard JFR-3	Hot-applied PVC, Coal-tar, rubber	C	239	2	3	Adh Fail @ 187 wks Modulus up 300%	No Failure Modulus up 250%	Adh Fail @ 8 wks Modulus up 2000%	6
PRC RC-1	1-part polyurethane	B	73	29	38	No Failures @ 73 wks Modulus up 100%	Adh Fail @ 8 wks Modulus up 20%	No Failures @ 73 wks Modulus up 100%	0
PRC 270	2-part polyurethane Slow-set	A	91	32	52	No Failures @ 91 wks Modulus up 50%	Adh Fail @ 54 & 78 wks Modulus down 30%	F-1 Adh fail @ 143 wks Modulus up 100%	1
PRC 7000	1-part polysulfide	B	210	9	13	No Failures Modulus up 50%	W-1 Adh Fail @ 210 wks Modulus stable	Cohes Fail @ 210 wks Modulus down 50%	9
PRC 7000 (primed)	1-part polysulfide	B	210	8	13	No Failures Modulus up 50%	Adh Fail @ 73 & 210 wks Modulus stable	Cohes Fail @ 210 wks Modulus down 75%	5

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Table B-3 - Test Results for Sealant Group B (Continued)

Sealant	Description	USBR M-41 Class	Weeks in test	Initial Modulus 25%	Initial Modulus 50%	Observations: Air	Observations: Water	Observations: Oven	Score
Ruscoe 965	1-part nitrile rubber	B	22	1	1	Cohes Fail @ 22 wks Modulus up 600%	Adh Fail @ 22 wks Modulus down 30%	Adh Fail @ 10 wks Modulus up 13000%	0
Sikaflex 1A	1-part polyurethane	B	210	34	53	No Failure Modulus up 50%	No Failure Modulus Stable	Adh Fail @ 105 wks Modulus up 100%	8
Sikaflex 2C	2-part polyurethane Slow-set	A	200	14	21	No Failures Modulus Stable	No Failures Modulus down 50%	Cohes Fail @ 132 wks Modulus down 100%	8
Sikaflex 2C (primed)	2-part polyurethane Slow-set	A	200	14	22	No Failures Modulus Stable	No Failures Modulus down 50%	Adh Fail @ 13 & 51 wks Modulus Stable	7
Sonneborn NP-1	1-part polyurethane	B	210	31	45	No Failure Modulus Stable	Adh Fail @ 2 & 3 wks Modulus Stable	No Failure Modulus Stable	0
Sonneborn NP-2	2-part polyurethane Slow-set	A	211	12	18	No Failure Modulus Stable	No Failure Modulus Stable	No Failure Modulus down 75%	9.5
Sonneborn NP-2 (primed)	2-part polyurethane Slow-set	A	210	15	23	No Failure Modulus Stable	No Failure Modulus Stable	No Failure Modulus down 80%	9.5
Tremco Dymeric	2-part polyurethane Slow-set	A	210	36	55	No Failure Modulus Stable	Adh Fail @ 46 & 73 wks Modulus down 75%	No Failure Modulus Stable	1
Tremco Dynonic	1-part polyurethane	B	210	22	38	No Failure Modulus Stable	Adh fail @ 10 & 20 wks Modulus down 20%	No Failure Modulus up 100%	0

Mission

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American Public.