Bridge Expansion Joint Sealants

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Bridge joint seals placed in the field have been inspected and their effectiveness evaluated. Of the materials tested, seals of polyurethane and neoprene have shown the best results. The cast-in-place polyurethane seals, if properly installed, will effectively seal joints having up to ½ in. of movement. Poor construction practices account for a number of seal failures. Joints for preformed elastomeric seals should be engineered to fit the given conditions. A "movement-rating" system, which determines the movement capability, has been developed for preformed elastomeric joint seals.

•THE CALIFORNIA DIVISION OF HIGHWAYS has been studying joint sealants for the past 11 years. During that time many seals have been experimented with, including asphalt latexes, hot asphalts, silicone, polyvinyl chloride, nitrile rubber, butyl rubber, neoprene polymers, epoxies, coal tar extended polysulfides, modified polysulfides, straight polysulfides, polyurethanes (two-component and one-component), polyurethane foams (asphalt-impregnated, butyl-impregnated, neoprene-jacketed, plain), neoprene sheet, preformed elastomeric seals, neoprene header with steel reinforcement, and aluminum extrusions.

In the last few years, we have concentrated our research on three basic types of seals: two-component polyurethanes, polyurethane foams, and preformed elastomeric seals. The preformed elastomeric seals are now receiving the greatest emphasis.

CONSTRUCTION PRACTICES

During construction it is very difficult to get a properly formed joint to seal against. First of all, the concrete surface is usually porous or poor to bond to. Second, improper edging usually results in an irregular vertical surface. Third, if the joint groove is formed with wood, the stripping of this wood usually fractures the concrete edge (Fig. 1). Fourth, steel rollers damage the joint edges. Many of these fractures remain in an incipient failure stage until the sealer pulls them off or traffic breaks them off. A sizable number of what we call joint-seal failures are actually concrete spalls caused by construction practices. A good way to check for these hidden fractures is to drag a chain or tap a hammer along the joint. The incipient fractures will be readily apparent by a dull thud sound.

In patching joint spalls, another series of problems arises. The epoxy work has to be done carefully or the patches will fail. It is also more difficult to bond a seal to an epoxy surface. The two possible reasons for this are (a) the bond-breaking agent that is used on the forms, and (b) placement of the sealant before the epoxy has cured.

Armored joints would help alleviate many of the problems associated with formed joints, but there are also problems with armored joints. Some of these problems are loose or broken anchor straps, spalled concrete adjacent to the armor, and poor consolidation of concrete under the armor. Also, the riding characteristics of the roadway surface suffer from poor vertical alignment of the armor assembly.

California presently specifies a saw-cut joint groove (Fig. 2) in an attempt to minimize joint problems. This gives a uniform joint width. It also allows the selection of the joint groove width, with temperature taken into consideration, after the major

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Figure 1. Formed joint groove.

Figure 2. Saw-cut joint groove.

portion of the shrinkage, creep, and shortening of the structure have taken place (a very important feature for preformed elastomeric joint seals). It is important, however, to round or bevel the edges of the saw-cut groove. The saw-cutting will in some instances expose fractured or damaged concrete that would not otherwise show up until traffic was on the structure.

Another problem during construction is debris that sifts into the joints before they are sealed. Unless this debris is cleaned out prior to sealing the joint, future spalls may occur (Fig. 3). Normal practice in California is to clean out all debris, including the expansion joint filler, down to the waterstop, which is usually 6 in. below the deck surface, just prior to sealing the joint.

Incidentally, we do use a waterstop (Fig. 4) in conjunction with the joint seal in an effort to get a satisfactory seal. The material used is a polyvinyl chloride. Some of the difficulties with our present waterstop are as follows:

Figure 3. Joint spall.

1. The material stiffness varies with temperature.
2. The waterstop is difficult to place.
3. During concrete placement, it is difficult to keep the concrete from (a) flowing between top of bulb and expansion joint filler and (b) flowing between leg and expansion joint filler.

RESEARCH PROCEDURES

Experimental sealants are tested in our laboratory. If the results warrant, the seal is then placed in the field on an actual bridge to test its capabilities in use. The resident engineer submits a joint sealant report when the joint sealing is completed. Included in this report are contributory structure length to joint movement, type of structure, dimensions of formed joint, dimensions of joint when

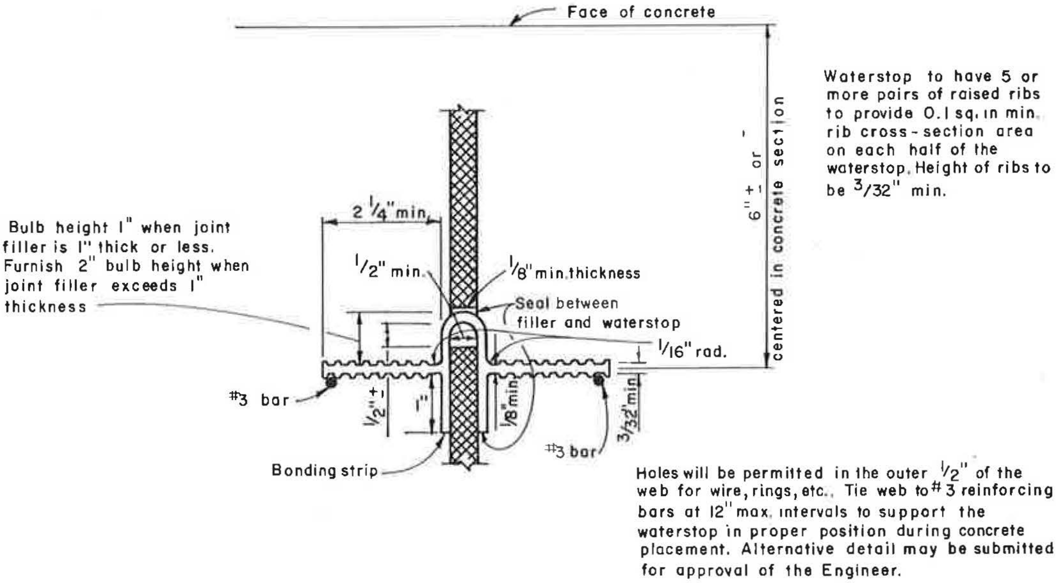


Figure 4. Waterstop detail.

sealed, joint sealant, type of primer or adhesive, date of installation, ambient temperature when sealed, weather conditions, total lineal feet, cost per lineal foot, and party installing the sealant.

On selected bridge deck joints, movement scribes (Fig. 5) are placed on the railing to measure the actual movement that the joint is subjected to over a period of time. The sealants are inspected periodically and a record is assembled and maintained.

RESEARCH RESULTS

Of all the material placed during this study, those from the polyurethane and neoprene families have shown the best results as effective bridge deck joint seals. Performance observations of seals placed in the field since 1966 are included in the Appendixes.

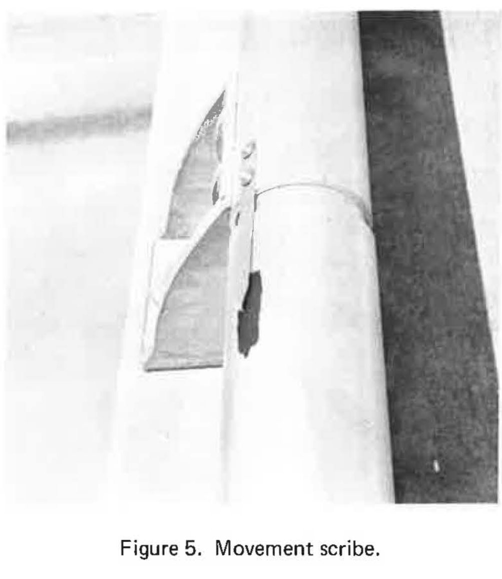


Figure 5. Movement scribe.

Polyurethane Cast-in-Place Seals

The polyurethane seal (Fig. 6) has its best chance for success if the joint movement is limited to ½ in. or less (Table 1). In joints having larger movement, the chances for a satisfactory seal diminish rapidly. The common type of failure is in adhesion to the concrete. Some of the more common installation difficulties experienced with this type of seal have been

1. Inadequate coverage of the joint face with primer,
2. Not allowing primer to dry sufficiently before sealing,
3. Inadequate mixing of the sealant,
4. Incorrect ratio of sealant components, and

TABLE 1

POLYURETHANE CAST-IN-PLACE SEALS

Material	Performance	Expected Movement (inches)												
		1/8	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2	Over 1 1/2
PRC 3105 (machine grade)	Satisfactory	4	8	4	2	1	1			1	1			
	Minor tears	1		4			1			1				
	Fail				1	5	1	1			4			2
PRC 3105 (pourable)	Satisfactory	1	2	3	3	2			1	1				
	Minor tears			1	1	2	1				1			
	Fail						1	2		1	3	1		
Terraseal 100 (one-component)	Satisfactory	2	1	2	2		1				1		1	
	Minor tears		1						1	1				1
	Fail	1						1				2		
Endoco U-Seal 3201 (machine grade)	Satisfactory	1	1		4		1			2				
	Minor tears					1								
	Fail													1
Uralane 8305	Satisfactory			1	1									
Ureseal 200	Minor tears	1	1	1										
Ceelrite	Fail	1								1				
Sikaflex T-68 (pourable)	Satisfactory										1			
	Minor tears													
	Fail		1											

Notes: 1. Condition of seals placed since 1966 as of inspection of June 1969.
2. Figures represent number of joint seal reports in each category.

5. Poor sealant shape factor (at present a width-to-depth ratio of 3 to 1 is used).

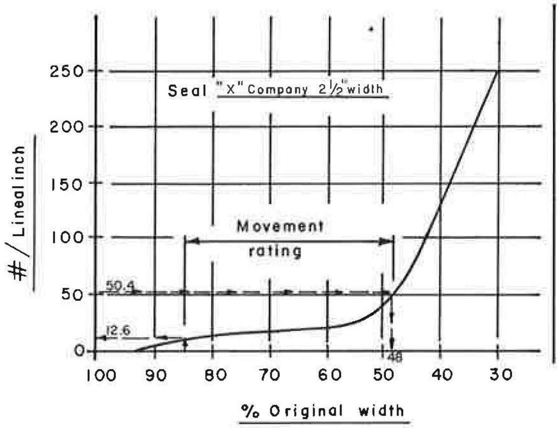
Preformed Elastomeric Seals

We have found that the size of preformed elastomeric seals (Fig. 7) must be chosen very carefully, and the joint geometry designed to fit the seal and the movement expected. We use compression seals in joints with up to 2 in. of movement.

A "movement-rating" system to determine the design movement capability of the seal has been developed for preformed elastomeric joint seals. The movement-rating

Figure 6. Polyurethane sealant.

Figure 7. Preformed elastomeric seal.



For example :

1. Pressure at 85 % nominal width = 12.6
2. 4 x pressure at 85 % nominal width = 4 x 12.6 = 50.4
3. % nominal width at 4 x pressure = 48 %
4. Movement Rating = nominal width (.85 — .48) = 2½" (.85 — .48) = 0.925"

Figure 8. Pressure-deflection curve for preformed elastomeric seal.

value is derived from the seal's pressure-deflection curve. The pressure at 85 percent of the uncompressed width is taken. This pressure is then multiplied by four. The movement rating of the seal is the deflection value between these two pressures. An example is shown in Figure 8.

This criterion, plus our rather arbitrary specification that the depth of seal shall be at least 75 percent of the nominal width, shall have stability of the top edges, and shall have 3 psi minimum pressure generation at 85 percent of nominal width, sums up our present method for selection of size and configuration.

Our success with preformed elastomeric seals dates back to our original installations of thick-wall seals in 1964. Even though these seals have been performing satisfactorily, they were very difficult to place, and were, in some cases, damaged during installation. In our larger moving joints (1½ to 2 in.), the size of the thick-wall seal required is excessive. With this in mind we are presently field-testing new thin-wall design seals. Some of the more common installation difficulties with the preformed elastomeric seal have been the following:

1. Top of material has been placed above deck level.
2. Leaks have occurred at changes in alignment.
3. Seals have been installed upside down or even sideways.
4. Adhesive has been wiped off the joint sides as the seal is slid in.
5. Sand intrusion has occurred because of poor or no adhesive.
6. Seal has been difficult to place in hot weather when the joint has closed up.
7. The maximum length available without splice has been 60 ft in some configurations, and satisfactory splices have been difficult to obtain.

Asphalt-Impregnated Polyurethane Foam

Asphalt-impregnated polyurethane foam (Fig. 9) is effective in sealing out solids in mild climates. It becomes very hard in cold climates and tends to lose its sealing capability.

Figure 9. Asphalt-impregnated polyurethane foam.

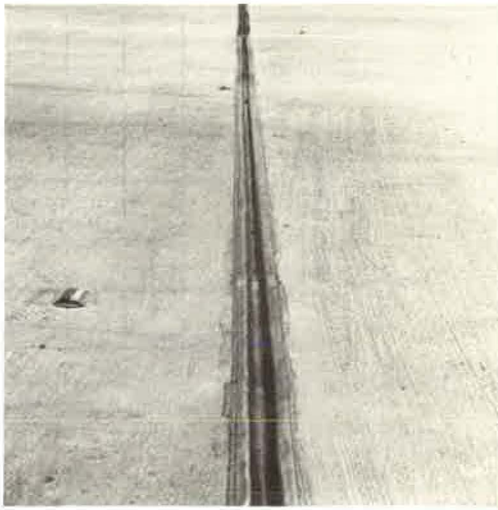


Figure 10. Neoprene strip.

Neoprene Sheet

Elastomeric sheets $\frac{1}{16}$-in. thick bonded to the deck concrete with a loop formed down into the joint were tried (Fig. 10). It was thought that this would be a fast and easy method for maintenance replacement of defective joint sealants. The neoprene did not maintain bond with the concrete, however, with traffic riding on the neoprene. This is an effective seal on elements not subjected to traffic.

Neoprene-Shielded Polyurethane Foam

Neoprene sheet bonded to polyurethane foam is a hybrid seal (Fig. 11). It combines the advantages of a thin-wall elastomeric seal with the inert qualities of plain polyurethane

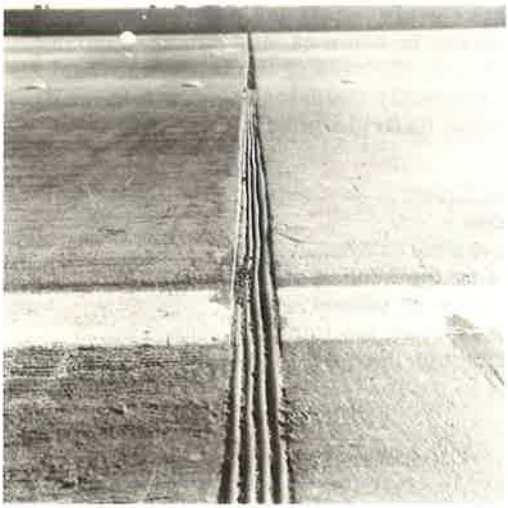


Figure 11. Neoprene-shielded polyurethane foam.

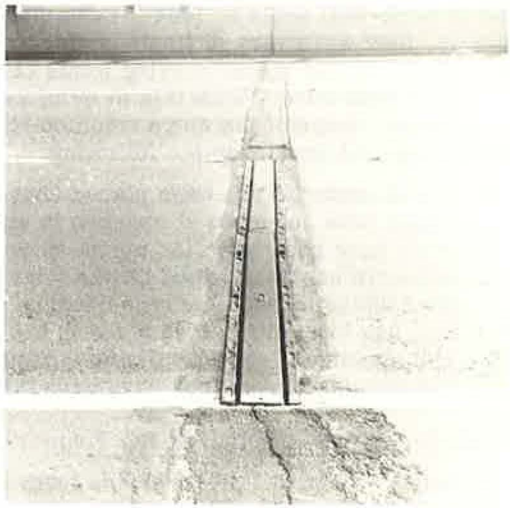


Figure 12. Transflex 150.

foam. The neoprene shields the foam from the detrimental effects of direct sunlight. The field installations, however, have had the following difficulties:

1. Cracking of the poor grade of neoprene used has occurred.
2. Inadequate bonding of the foam and neoprene has occurred.

We are presently field-testing extruded sections of this type of seal.

Transflex 200 (formerly Transflex 150)

This neoprene header with steel reinforcement functioned well for 2 years (Fig. 12). The plant-mix surfacing adjacent to the header, however, settled $\frac{1}{4}$ in. with the result that the neoprene edges of the header are now delaminating under the pounding of traffic. Additional installations of this type material are planned on concrete-surfaced decks.

CONCLUSIONS

1. Polyurethane poured-in-place seals should be restricted to movements of $\frac{1}{2}$ in. or less.
2. Preformed elastomeric joint seals, although far from the ideal, are the best seals we have at the present time.
3. The joint must be carefully engineered for compression joint seals.
4. Saw-cut joints are superior to formed joints.
5. Good inspection is a prerequisite for joint casting, preparation, and sealing.

FUTURE STUDIES AND RESEARCH

Much more knowledge is needed concerning

1. Adhesives for compression seals,
2. Pressure generation requirements for compression seals,
3. Sealing of skewed joints, and
4. Joint movement and temperature relationships.

Appendix A

CATALOG OF SEALANTS FIELD-TESTED TO DATE

I. Compression Seals
   A. Preformed elastomeric joint seals
      1. Acme S-497
      2. Acme B-496
      3. Acme B-462
      4. Acme S-500
      5. Brown B-2500
      6. Brown C-2500
      7. Brown D-3000
   B. Polyurethane foams
      1. Asphalt-impregnated
         a. Compriband
         b. Ureseal
      2. Neoprene-shielded
      3. Untreated
   C. Butyl rubber

II. Mechanical Seals
   A. Transflex 200
   B. Elastomeric sheets bonded to deck surface
      1. Neoprene
      2. Urethane

III. Poured-in-Place Seals
   A. Two-component polyurethane
      1. PRC 3105
      2. U-Seal 3201
      3. Ureseal 200
      4. PRC 3000
      5. PRC 220
      6. PRC 210
      7. Coast Pro Seal 962
      8. Allied
      9. Tabo
   B. One-component polyurethane
      1. Terraseal 100
      2. PRC RW-370-01
   C. Polysulfide
      1. Pressite 54, 55, 404, 1175.55
      2. Coast Pro Seal F-37
      3. Edoco 170281, 170282
      4. Fuller 400
      5. Churchhill 3C-51
      6. Chem-Seal
   D. Silicone
   E. Polyvinyl chloride
   F. Two-component neoprene
      1. Polymeric N-25-4-36
      2. Polymeric N-25-4-19
   G. Epoxy
      1. Epothak 2100
      2. Ceelrite
      3. Coast Pro Seal 805
      4. Epocast H 1356
   H. Asphalt latex

IV. Products to Be Evaluated in the Near Future
   A. Preformed elastomeric joint seals—new thin-wall cross sections
   B. Transflex 400
   C. Sikaflex T-68—two-component polyurethane
   D. Superseal 444—hot-poured polymer
   E. Uralane 8305—two-component polyurethane
   F. Extrusions of neoprene-covered polyurethane foam
   G. Aluminum extrusion

Appendix B

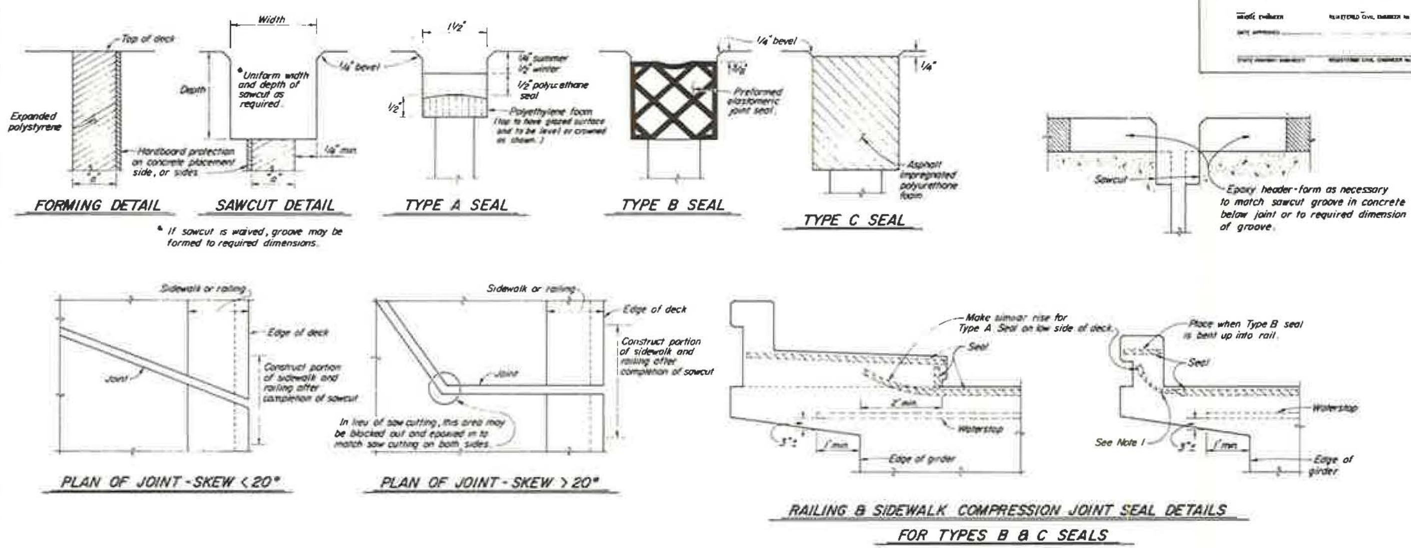
COMPRESSION SEAL INSTALLATIONS

Seal	Satisfactorily Sealed	Installation			Sand Intrusion		Cracking	Extruded From Joint
		Too High	Damaged	N.G.	Minor	Major		
S-497	4	1			3			
S-500				1	1			1
B-496	1	1						
B-610	2				1			
B-462		1						
B-2500		2			1	1		
C-2500	2		1					
D-3000	1							
Polyurethane foam:								
Asphalt-impregnated	6				5	7		
Neoprene-jacketed	1	3			1	2	6	
Open cell (not a water seal)	3				1	2		

Notes: 1. Inspection as of 6/69.
2. Figures represent number of joint seal reports in each category.

Appendix C

TENTATIVE JOINT SEAL STANDARD PLAN



DIMENSIONS "a" OF JOINT REQUIRED

Movement Rating (M.R.)	Bridge Type	"a" Dimension Deck Concrete Placed: Winter	Fall-Spring	Summer
2"	All except CIP/PS	2"	1½"	¾"
	CIP/PS	1½"	1"	½"
1½"	All except CIP/PS	1½"	1"	½"
	CIP/PS	1¼"	¾"	¼"
1"	All except CIP/PS	1"	¾"	½"
	CIP/PS	¾"	½"	¼"
½"	All except CIP/PS	¾"	¾"	½"
	CIP/PS	½"	¼"	¼"

NOTES:

1. Make cut in seal as shown, to bend seal on low side of deck if required. Do not bend seal on high side of deck.
2. Opening in rail and sidewalk to be constructed to the exact existing width of sawn deck joint.
3. Conduit in rail shall be placed to avoid interference with seal.
4. Sawcut groove widths shall be as ordered by the Engineer.
5. Waterstop shall have to be lowered for joints with a Movement Rating of 2" to provide ..... clearance.
6. Depth of sawcut as required by joint seal manufacturer.

Tentatively scheduled to replace standard plan dated 11/68.

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JOINT SEAL DETAILS

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Appendix D

APPROXIMATE MOVEMENT RATINGS AND GROOVE WIDTH SELECTION FOR PREFORMED ELASTOMERIC JOINT SEALS

Catalog Number	Size		Maximum Movement Rating (in.)	Nominal Groove Width (in.)
	W	D		
Acme S-502	1 3/4	2	1/2	1 1/8
Brown B-1500	1 1/2	1 1/2	1/2	1
Brown B-1750	1 3/4	1 3/4	3/4	1 1/8
Acme S-500	2	2	3/4	1 1/4
Brown B-2000	2	2	7/8	1 1/4
Acme S-497	2 1/2	2 3/4	7/8	1 5/8
Brown B-2500	2 1/2	2 1/2	1	1 1/2
Acme B-496	3	3 3/8	1 1/8	1 7/8
*Acme B-610	3 1/2	3 1/2	1 1/8	2 1/4
Acme B-462	4	4 3/4	1 3/8	2 5/8
*Brown K-3000	3	2 1/2	1 3/8	1 3/4
*Brown H-4000	4	4 1/2	1 5/8	2 1/2
Acme B-613	5	5 1/4	1 1/2	3 3/8
*Brown K-5000	5	3 3/4	2	3 1/8
Acme B-614	6	5 3/4	2	4

Notes: Movement rating and nominal groove width subject to verification.

Nominal groove width to be corrected for temperature (see accompanying chart).

Designer will place the required thermal movement rating for each joint on the contract plans.

*Pressure generation may be less than 3 psi at 85 percent nominal width.