

**SECTION 700 MATERIALS DETAILS**



## Section 701 - Cement, Grout, & Mortar

### 701.01 Cement

Cement shall meet the requirements of the following specifications:

- (a) Portland cement . . . . . AASHTO M 85
- (b) Blended hydraulic cements  
excluding Types S and SA . . . . . AASHTO M 240
- (c) Masonry cement . . . . . AASHTO M 150

Fly ash or pozzolan may be substituted for Portland cement providing that the proportions of cement and fly ash or pozzolan conform to the requirements of Sections 552 or 602.

When blended cement (AASHTO M 240) is proposed for use, all requirements for fly ash modified concrete in the applicable sections shall apply.

Fly ash or pozzolan materials shall conform to the requirements of Subsection 712.04.

The product of only one manufacturing plant and only one brand of any one type of Portland cement shall be used on the project.

The cement shall be stored and protected against dampness. Cement that for any reason has become partially set or that contains lumps of caked cement will be rejected. Cement salvaged from discarded or used bags shall not be used.

### 701.02 Grout

Grout shall be packaged and ready for use with the addition of water at the construction site. Each bag shall be stamped to show the latest date at which it may be used. The product shall consist of a hydraulic cementitious system, graded and processed natural fine aggregate and additional technical components meeting the following:

- (a) Free of inorganic accelerators, including chlorides.
- (b) Free of oxydizing catalyts.
- (c) Free of gas-producing agents.

(d) The grout, when mixed to 130 percent flow on flow table (ASTM C 230 at 10 drops), shall not reduce in linear dimension when tested in accordance with ASTM C 157. Measurements shall be taken at 72 hours and 7 days.

(e) No bleeding shall be present for the first 2 hours after mixing when mixed to 130 percent flow on flow table (ASTM C 230 at 10 drops), as tested in accordance with ASTM C 232.

(f) Provide performance characteristics at 115 to 120 percent flow on flow table (ASTM C 230 at 10 drops), and minimum strength of grout shall be as follows when tested in accordance with ASTM C 109:

72 hours - 3,500 psi  
7 days - 5,500 psi  
28 days - 7,000 psi

(g) Manufacturer must state that the product is designed to be mixed, placed, and cured at atmospheric temperatures of 40 °F to 90 °F. Products proposed by the contractor for use shall be submitted for Engineer's approval and shall be accompanied by manufacturer's submittals substantiating all requirements of this

701.03  
Mortar

section, including (1) graphs or charts showing the time, temperature, and humidity curing requirements to achieve the specified grout strengths; and (2) recommendations for storage, mixing, application, and curing procedures.

Mortar shall be packaged and ready for use with the addition of water at the construction site. Each bag shall be stamped to show the latest date at which it may be used. The product shall consist of a cementitious system made up of:

- (a) Natural 3/8-inch maximum size aggregate, meeting ASTM C 33 except for grading, which shall be accomplished by blending of sieve sizes to get the optimum density.
- (b) Metallic aggregate free from nonferrous material, soluble alkaline compounds, and visible rust.
- (c) Water reducers, workability agents, air-entraining agents and catalysts.

The materials shall be blended to minimize bleeding, increase workability, resist exposure to freeze-thaw cycles and deicing salts, and shall prevent shrinkage within and at the perimeter of the patch, keyway, or other area to be filled.

The minimum compressive strength of the mortar, as tested by ASTM C 109 for a 3-inch slump, shall be:

24 hours - 5,000 psi  
7 day - 9,000 psi  
28 days - 10,000 psi

The durability of the products when tested at 300 cycles, ASTM C 666 procedure A, shall be:

<u>Submerged in:</u>	<u>DF (%)</u>
Water . . . . .	98
5% CaCl <sub>2</sub> . . . . .	95
5% NaCl . . . . .	85

The scaling resistance shall have a rating of 3-Moderate Scaling after 50 cycles when tested according to ASTM C 672.

The manufacturer must certify that the product is compatible for work that is 1 inch or more in depth and over 1 inch in width; and where the mixing, placing, and curing temperatures may range from 40 °F to 90 °F.

Products proposed by the contractor for use shall be submitted for Engineer's approval and shall be accompanied by manufacturer's submittals substantiating all requirements of this Section, including (1) graphs or charts showing the time, temperature, humidity, and curing requirements to achieve mortar strengths equal to the adjacent concrete; and (2) complete recommendations for storage, mixing, application, and curing procedures.

## Section 702 - Bituminous Materials

- 702.01 Asphalt Cements Asphalt cement shall meet the requirements of AASHTO M 20 for penetration-graded asphalt cement and AASHTO M 226 for viscosity-graded asphalt cement.
- 702.02 Liquid Asphalts Liquid Asphalts shall meet the requirements of the following specifications:
- (a) Rapid curing liquid asphalts . . . . . AASHTO M 81
  - (b) Medium curing liquid asphalts . . . . . AASHTO M 82
- 702.03 Emulsified Asphalts Emulsified asphalts shall meet the requirements of the following specifications:
- (a) Emulsified asphalt (anionic) . . . . . AASHTO M 140
  - (b) Emulsified asphalt (cationic) . . . . . AASHTO M 208
- CMS-2S: Shall comply with requirements of CMS-2, except that oil distillate by volume of emulsion shall be 12 to 20 percent, and the distillation residue shall have a minimum value of 60 percent.
- CMS-3: Shall comply with requirements of CMS-2, except that oil distillate by volume of emulsion shall have a maximum value of 4 percent and the distillation residue shall have a minimum value of 68 percent.
- 702.04 Bituminous Dust Palliatives Bituminous dust palliatives shall meet the requirements listed in table 702-1.

Table 702-1.--Bituminous dust palliatives.

General Requirements	ASTM Method	D0-1 Forest Service			D0-2 Dust Oil		D0-3 Dust Oil		D0-4 Clarified Dust Oil	D0-6	D0-6P	D0-8
		Light	Medium	Heavy	Medium	Heavy						
Flash Point:												
Tag Open-Cup, °F, Min.	D 1310	125	125	125	125	125	200	150	150	150	212	
Cleveland Open-Cup, °F, Min.	D 92	-	-	-	-	-	-	-	-	-	-	
Viscosity:												
Kinematic, @ 100°F, cSt	D 2170	40-70	90-125	135-200	90-125	135-200	20-100	75-150	75-150	25-50	50	
Saybolt Furol, @ 77°F, SFS, Max.	D 88	0.	0.5	0.5	0.5	0.5	0.	25	25	25	50	
Water, % Max.	D 95	-	-	-	-	-	-	5-15	5-15	5-15	5-10	
Asphaltenes, %	D 244	3-6	4-8	5-10	4-8	5-10	0-5	25	25	25	8	
Saturates, % Min.	D 2006-70	25	25	25	25	25	10	2.0	2.0	2.0	2.0	
24 Hour Settlement, %	D 244	-	-	-	-	-	-	-	-	-	0.1	
Sieve Test, % Max.	D 244	-	-	-	-	-	-	-	-	-	50	
Distillation Tests												
Total Distillate to 550°F, Max % by Volume	D 244	35	30	30	30	30	5	-	-	-	5	
Total Distillate to 680°F, Max. % by Volume	D 402	-	-	-	-	-	-	-	-	-	5	
Oil Distillate, % by Volume	D 244	-	-	-	-	-	-	-	-	10-20	5	
Total Residue, % by Weight	D 244	-	-	-	-	-	-	60	60	55	45	
Tests on Residue from Distill.												
Viscosity, Kinematic, @ 100°F, cSt	D 2170	75-250	200-600	500-1500	200-600	500-1500	20-150	200-600	200-600	150-450	250-1200	
Viscosity, Kinematic, @ 122°F, cSt	D 2170	98	98	98	98	98	98	96	96	96	98	
Solubility in Trichloroethylene, % Min.	D 2042	-	-	-	-	-	-	-	-	-	-	
Ductility, CM Min.	D 113	-	-	-	-	-	-	-	-	-	-	

702.05  
Application  
Temperatures

Bituminous materials shall be applied within the temperature ranges indicated in table 702-2.

Table 702-2.--Application temperatures--degrees Fahrenheit (°F).

Type and Grade of Asphalt	Temperature ranges (min-max.)		
	Surface Treatments (Spray)	Central mixing plant (b)	Road Mixing
<b>Cutbacks:</b>			
MC 30	85 - (a)	60 - 105	60 - 105
RC-MC 70	120 - (a)	90 - 155	65 - (a)
RC-MC 250	165 - (a)	135 - 175(c)	105 - (a)
RC-MC 800	200 - (a)	165 - 210	135 - (a)
RC-MC 3000	230 - (a)	180 - 240	180 - 240
<b>Emulsions:</b>			
RS-1	70 - 140	50 - 160	50 - 160
RS-2	125 - 185	50 - 160	50 - 160
MS-1, MS-2, MS-2h	70 - 160	50 - 160	70 - 160
HFMS-1, 2, 2h, 2s	70 - 160	50 - 160	70 - 160
SS-1, SS-1h	50 - 160	50 - 160	50 - 160
CRS-1, CRS-2	125 - 185	50 - 160	50 - 160
CMS-2, CMS-2h	50 - 160	50 - 160	70 - 160
CSS- , CSS-1h	50 - 160	50 - 160	70 - 160
<b>Asphalt cements:</b>			
All grades 350 max.		As required to achieve a kinematic viscosity of 150 - 300 centistokes	

Notes:

- (a) Maximum temperature shall be below that at which fogging occurs.
- (b) Temperature of mix immediately after discharge.
- (c) Temperature may be above flash point. Precautions shall be taken to prevent fire or explosion.

702.06  
Material for  
Damp-proofing &  
Waterproofing  
Concrete & Masonry  
Surfaces

Material shall meet the requirements of the following specifications:

- (a) Primer for use with asphalt . . . . . AASHTO M 116
- (b) Asphalt for mop coat . . . . . AASHTO M 115  
Type II
- (c) Waterproofing fabric . . . . . AASHTO M 117

Fabric shall be waterproofed with asphalt, in agreement with the material specified for primer and mop coats.

(d) Mortar material shall meet the requirements of Subsection 705.05, except the mortar shall be uniformly mixed to spreading consistency in the proportion of one part Portland cement to three parts fine aggregate.

(e) Asphalt plank shall meet the requirements of AASHTO M 46 (ASTM D 517). Unless otherwise SHOWN ON THE DRAWINGS, planks shall be 1.25 inches thick and may be from 6 to 12 inches in width, but all pieces for one structure shall be of the same width, except such closers as may be necessary. The length shall permit the laying of the planks to the best advantage on the surface to be covered but shall not be less than 3 nor more than 8 feet.

(f) Asphalt roll roofing shall meet the requirements of ASTM D 224, 65-pound grade.

702.07  
 Membrane Material  
 for Waterproofing  
 Bridge Decks

Bridge deck waterproofing membrane shall be mesh-reinforced, self-sealing, rubberized-asphalt preformed membrane having the following properties:

Thickness . . . . .	65 mils . . . . .	_____
Permeance-perms (grains/ sq ft/hr/in Hg) . . . . .	0.10 . . . . .	ASTM E 96 Method B
Tensile strength . . . . .	50 lb/in . . . . .	ASTM D 882 modified for 1-inch opening
Puncture resistance (mesh) . . . . .	200 lb . . . . .	ASTM E 154
Pliability 1/4-inch mandrel, 180° Bend at -15 °F . . . . .	no cracks in mesh or rubberized asphalt	ASTM D 146

Primer and mastic shall be as recommended by the manufacturer and compatible with the membrane.

## Section 703 - Aggregates

703.01  
Fine Aggregate

(a) Structural Concrete. Fine aggregate shall meet the requirements of AASHTO M 6, except that:

(1) The soundness test is not required.

(2) There shall be no deleterious substances in excess of the following percentages:

Clay lumps and friable particles . . . . .	3.0
Coal and lignite, as defined in 7.1.6 of AASHTO M 80 . . . . .	1.0
Material passing the Number 200 sieve . . . . .	7.0

(3) Fine aggregate shall not contain any materials that are deleteriously reactive with the alkalis in the cement in an amount sufficient to cause excessive expansion of mortar or concrete, except that if such materials are present in injurious amounts, the fine aggregate may be used with a cement containing less than 0.6 percent alkalis calculated as sodium oxide or with the addition of a material that has been shown to prevent harmful expansion due to the alkali-aggregate reaction (see AASHTO M 80).

(4) The Minimum Sand Equivalent determined by AASHTO T 176 (Alternative method Number 2) shall be 75.

Lightweight aggregate, if required or permitted by the SPECIAL PROJECT SPECIFICATIONS, shall meet the requirements of AASHTO M 195.

(b) Granular Backfill Filter Material. Granular backfill filter material for underdrains and drainage blankets shall be permeable, shall meet the gradation SHOWN ON THE DRAWINGS, and shall meet the quality requirements for crushed aggregate base shown in table 703-3 unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

(c) Aggregate for minor concrete structures shall meet the requirements of AASHTO M 80 and M 6. Coarse aggregate size shall be as SHOWN ON THE DRAWINGS.

703.02  
Coarse Aggregate

Coarse aggregate for concrete shall meet the requirements of AASHTO M 80, aggregate Class A, with the following modifications and additions unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

(a) Gradation shall meet the requirements of table 703-1 for the specified classes of concrete.

(b) Subsection 6.3 of AASHTO M 80 is deleted.

(c) The following words are deleted from the first sentence of 6.2 of AASHTO M 80: ". . . that will be subject to wetting, extended exposure to humid atmosphere, or contact with moist ground. . . ."

Lightweight aggregate, if required or permitted by the SPECIAL PROJECT SPECIFICATIONS, shall meet the requirements of AASHTO M 195.

703.03  
Reserved

703.04  
Aggregate for Road  
Mix Bituminous  
Base

Aggregates for road mix bituminous base construction shall be crushed stone, crushed slag, or crushed or natural gravel meeting the quality requirements of table 703-3 unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

The gradation shall be as described in the SPECIAL PROJECT SPECIFICATIONS. When crushed gravel is used, not less than 50 percent by weight of the particles retained on the Number 4 sieve shall have at least one fractured face.

Table 703-1.--Coarse aggregate requirements for structural concrete.

AASHTO M 43 Size Number	Nominal Size Range	Percentage by Weight Passing Square Mesh Sieve Size (AASHTO T 27)										
		3 in	2-1/2 in	2 in	1-1/2 in	1 in	3/4 in	1/2 in	3/8 in	No. 4	No. 8	
7	1/2 in --No. 4	--	--	--	--	--	100	90--100	40--70	0--5		
67	3/4 in --No. 4	--	--	--	100	95--100	100	90--100	20--55	0--5		
57	1 in --No. 4	--	--	--	95--100	100	100	25--60	--	0--5		
467	1-1/2 in --No. 4	--	100	95--100	--	35--70	35--70	10--30	10--30	--		
357	2 in --No. 4	--	95-100	--	35--70	10--30	10--30	--	0--5	--		
4	2-1/2 in --No. 4	--	--	100	90--100	20--55	0--15	--	0--5	--		
3	1-1/2 in --3/4 in	--	100	95--100	35--70	0--15	--	0--5	--	--		
2	2 in --1 in	100	90--100	35--70	0--15	--	0--5	--	--	--		
	2-1/2 in --1-1/2 in	100	90--100	35--70	0--15	--	0--5	--	--	--		

703.05  
(Reserved)

703.06  
Aggregate for Base  
or Surface Courses

Aggregate materials shall conform to the requirements shown below unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

(a) Pit-Run Aggregate. Pit-run aggregates shall consist of native materials of a size and grading that can be taken directly from the source and placed on the road without crushing or screening. No gradation, other than a maximum size, will be required. The maximum size shall be as shown in the SCHEDULE OF ITEMS.

(b) Grid-Rolled Aggregate. Grid-rolled aggregate shall consist of native materials of a quality that can be taken directly from the source, without crushing or screening, and broken down on the road by grid-rolling. No gradation other than a maximum size will be required. The maximum size shall be as shown in the SCHEDULE OF ITEMS.

(c) Screened Aggregate. Material shall consist of gravel, talus, rock, sand, shale, or other suitable material, and be reasonably hard and durable and reasonably free of organic material, mica, clay lumps, or other deleterious materials. The gradation requirements shall be as shown on the SCHEDULE OF ITEMS.

(d) Crushed Aggregate. Aggregate for crushed base or surface courses shall be crushed stone, slag, or gravel meeting the requirements shown in table 703-3 unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

Unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS, the crushed aggregate gradation shall meet the requirements of table 703-4 for the grading shown in the SCHEDULE OF ITEMS. Aggregate shall be well graded from coarse to fine within the gradation band.

Table 703-3.--Crushed aggregate quality requirements for base or surface courses.

Description	AASHTO Test Method	Requirement	
		Base	Surfacing
Percent Wear	T 96	40 max.	40 max.
Durability Index, Coarse and Fine	T 210	35 min.	35 min.
Liquid Limit	T 89	25 max.	35 max.
Plasticity Index	T 90	6 max.	2--9 max.
Dust Ratio: $\frac{\% \text{ Passing No. 200}}{\% \text{ Passing No. 30}}$	T 11 T 27	2/3 max.	2/3 max.
Sand Equivalent (Alternative Method Number 2)	T 176	35 min.	--

When crushed gravel is used, at least 50 percent by weight of the particles retained on the Number 4 sieve shall have at least one fractured face. Naturally fractured faces may be included in the 50 percent requirement, provided the roughness and angularity produce strength characteristics equivalent to mechanically fractured faces.

Table 703-4.--Crushed aggregate grading requirements for base or surface courses.

Sieve	Percent Passing (AASHTO T 11 and T 27)				
	Grading A	Grading B	Grading C	Grading D	Grading E
3-Inch	100				
2-Inch	65-95	100			
1-1/2-Inch			100		
1-Inch		60-90		100	
3/4-Inch	40-75		60-90	70-98	100
1/2-Inch		44-70			70-98
No. 4	22-45	28-50	30-55	36-60	44-70
No. 8	16-34	20-41	22-43	25-47	30-54
No. 30	8-22	9-26	11-27	12-31	15-34
No. 200	2-10 <sup>a</sup>	3-12 <sup>a</sup>	3-15 <sup>a</sup>	3-15 <sup>a</sup>	3-15 <sup>a</sup>
Sieve	Grading F	Grading G	Grading H	Grading J	Grading K
3-Inch	100				
2-Inch	65-95	100			
1-1/2-Inch			100		
1-Inch		50-85		100	
3/4-Inch	28-70		55-90	70-98	100
1/2-Inch		27-60			65-95
No. 4	10-35	15-40	20-48	25-55	33-60
No. 8				16-40	21-42
No. 30			5-20	6-22	8-24
No. 200	0-10 <sup>a</sup>	0-12 <sup>a</sup>	0-15 <sup>a</sup>	0-15 <sup>a</sup>	0-15 <sup>a</sup>
Sieve	Grading L	Grading M	Grading N	Grading O	
6-Inch	100				
4-Inch		100			
3-Inch			100		
2-Inch				100	
1-1/2-Inch					
1-Inch					
3/4-Inch					
1/2-Inch					
No. 4		15-45	15-45		
No. 8					
No. 30					
No. 200					

<sup>a</sup>For untreated base used under bituminous materials, Sections 403, 404, 405, 406, and 410, the maximum percent passing the Number 200 sieve shall be eight. For surfacing, the minimum percent passing the Number 200 sieve shall be six.

703.07  
Aggregate for Hot  
Bituminous Pavement

Aggregates for hot bituminous pavement shall be crushed stone, slag, or gravel meeting the quality requirements shown in table 703-5, unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

When crushed gravel is used, at least 50 percent by weight of the particles retained on the Number 4 sieve shall have at least one mechanically fractured face.

The pavement aggregate gradation shall meet the requirements of table 703-6 for the grading shown in the SCHEDULE OF ITEMS unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

Table 703-5.--Crushed aggregate quality requirements for hot bituminous pavement.

Description	AASHTO Test Method	Requirement
Percent Wear	T 96	40 max.
Durability Index, Coarse and Fine	T 210	35 min.
Sand Equivalent (Alternative Method Number 2)	T 176	45 min.
Stripping Test	T 182	Min. 95% coated <sup>a</sup>

<sup>a</sup>An approved chemical additive may be used to meet this requirement.

Table 703-6.--Crushed aggregate grading requirements for hot bituminous pavement.

Sieve	Percent Passing (AASHTO T 11 and T 27)			
	Grading A	Grading B	Grading C	Grading D
1-1/2-Inch	100			
1-Inch	95-100	100		
3/4-Inch	78-95	95-100	100	
1/2-Inch		68-86	95-100	100
3/8-Inch	54-75	56-78	74-92	95-100
No. 4	36-58	38-60	48-70	75-90
No. 8	25-45	27-47	33-53	62-82
No. 16		18-37	22-40	38-58
No. 30	11-28	13-28	15-30	22-42
No. 50		9-20	10-20	11-28
No. 200	0-8	4-8	4-9	2-10

703.08  
(Reserved)

703.09  
(Reserved)

703.10  
Aggregate for  
Cold Bituminous  
Pavement

Aggregates for cold bituminous pavement shall be crushed stone, slag, or gravel meeting the quality requirements shown in table 703-7 unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

When crushed gravel is used for dense- or intermediate-graded cold bituminous pavement, at least 50 percent by weight of the particles retained on the Number 4 sieve shall have at least one fractured face. At least 70 percent by weight of the particles retained on the Number 4 sieve shall have at least one fractured face for open-graded cold bituminous pavement. Naturally fractured faces may be included in the percentage requirement provided the roughness and angularity produce strength characteristics equivalent to mechanically fractured faces.

Aggregate gradation shall meet the requirements of Table 703-8 for the grading shown in the SCHEDULE OF ITEMS unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

Table 703-7.--Crushed aggregate quality requirements for cold bituminous pavement.

Description	AASHTO Test Method	Requirement
Percent Wear	T 96	40 max.
Durability Index, Coarse and Fine	T 210	35 min.
Sand Equivalent (Alternative Method Number 2)	T 176	35 min.
Stripping Test	T 182	min. 95% coated

Table 703-8.--Crushed aggregate grading requirements for cold bituminous pavement.

Sieve	Percent Passing (AASHTO T 11 and T 27)			
	Dense-Graded	Intermediate-Graded	Open-Graded	Top Dressing
1-Inch	100	100	100	
3/4-Inch	80-100	70-100	70-90	
1/2-Inch	60-85	50-70	40-70	
3/8-Inch				100
No. 4	35-60	15-35	0-10	
No. 8	23-44	11-23	0-7	
No. 16				30-60
No. 30	9-25	3-12	0-5	
No. 200	2-8	0-3	0-2	0-4

703.11  
Aggregate for  
Road Mix Bituminous  
Pavement

Aggregates for road mix bituminous pavement shall be crushed stone, slag, or gravel meeting the quality requirements shown in table 703-9 unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

Table 703-9.--Crushed aggregate quality requirements for road mix bituminous pavement.

Description	AASHTO Test Method	Requirement
Percent Wear	T 96	40 max.
Durability Index, Coarse and Fine	T 210	35 min.
Stripping Test	T 182	min. 95% coated <sup>a</sup>
Sand Equivalent (Alternative Method Number 2)	T 176	35 min.

<sup>a</sup>An approved chemical additive may be used to meet this requirement.

When crushed gravel is used, at least 50 percent by weight of the particles retained on the Number 4 sieve shall have at least one fractured face. Naturally fractured faces may be included in the 50 percent requirement provided the roughness and angularity produce strength characteristics equivalent to mechanically fractured faces.

Aggregate gradation shall meet the requirement of table 703-10 unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

Table 703-10.--Crushed aggregate grading requirements for road mix bituminous pavement.

Sieve	Percent Passing (AASHTO T 11 and T 27)
1-Inch	100
3/4-Inch	80-100
1/2-Inch	60-85
No. 4	35-60
No. 8	23-44
No. 30	9-25
No. 200	2-8

703.12  
(Reserved)

703.13  
Aggregate for  
Surface Treatments

Crushed stone shall consist of clean, tough, durable fragments, free from an excess of flat, elongated, soft, or disintegrated pieces and free from stone coated with dirt or other objectionable matter. Aggregate shall meet the quality requirements shown in table 703-11 unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

Aggregate for bituminous surface treatments shall meet the requirements of table 703-12 for the grading shown in the SCHEDULE OF ITEMS unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

703.14  
Blotter

Unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS, aggregate for blotter material shall meet the gradation requirements shown in table 703-13 and shall be granular material free from organic matter and other deleterious materials with a minimum sand equivalent value of 45 measured by AASHTO T 176, Alternate Method Number 2.

Table 703-11.--Crushed aggregate quality requirements for surface treatments.

AASHTO Description	Test Method	Bituminous Surface Treatment Section 410
Percent wear	T 96	40 max.
Stripping Test <sup>a</sup>	T 182	min. 95% coated <sup>a</sup>
Durability Index	T 210	35 min.
One Mechanically Fractured Face, by Weight of Plus No. 8		50% min.

<sup>a</sup>An approved chemical additive may be used to meet this requirement.

703.15  
Bed Course Material  
& Mineral Filler

(a) Bed course material for sidewalks, paved waterways, and curbing shall consist of cinders, sand, slag, gravel, crushed stone, or other material specified in the SPECIAL PROJECT SPECIFICATIONS.

(b) Bed course material for slope protection shall be a free draining material consisting of sand, gravel, cinders, slag, crushed stone, or other material specified in the SPECIAL PROJECT SPECIFICATIONS.

(c) Mineral filler shall meet the requirements of AASHTO M 17.

Table 703-12.--Crushed aggregate grading requirements for surface treatments.

Sieve	Percent Passing (AASHTO T 11 and T 27)				
	Grading 6	Grading 6A	Grading 7	Grading 7A	Grading 7B
1-Inch	100	100			
3/4-Inch	90-100	95-100	100	100	100
1/2-Inch	20-55	0-20	90-100	95-100	70-98
3/8-Inch	0-15	0-5	40-70	0-30	
1/4-Inch				0-5	
No. 4	0-5		0-15		44-70
No. 8			0-5		30-54
No. 16		0-0.5		0-0.5	
No. 30					15-34
No. 200	0-2		0-2		0-2
Sieve	Grading 8	Grading 8A	Grading 9	Grading 9A	
1-Inch					
3/4-Inch					
1/2-Inch	100	100			
3/8-Inch	85-100	95-100	100		
1/4-Inch		0-40		100	
No. 4	10-30	0-5	85-100	95-100	
No. 8	0-10		10-40	0-40	
No. 16	0-5	0-0.5	0-10	0-0.5	
No. 30			0-5		
No. 200	0-2		0-2		

Table 703.13--Requirements for grading blotter material.

Sieve	Percent Passing (AASHTO T 11 and T 27)	
	Grading A	Grading B
3/8	100	100
No. 4	85-100	
No. 16	30-80	
No. 200	0-4	

**Section 704 - Masonry Units**

704.01  
Clay or Shale Brick

Brick shall meet the requirements of the following specifications:

- Sewer Brick . . . . . AASHTO M 91, Grade SM
- Building Brick . . . . . AASHTO M 114, Grade SW

The grade shall be as SHOWN ON THE DRAWINGS.

704.02  
Concrete Brick

Concrete brick shall meet the requirements of ASTM C 55, Grade A.

704.03  
Concrete Masonry

Solid blocks shall meet the requirements of ASTM C 139 or ASTM C 145, grades as specified. Hollow blocks shall meet the requirements of ASTM C 90, grades as specified.

Dimensions and tolerances shall be as SHOWN ON THE DRAWINGS.

## Section 705 - Joint Materials

- 705.01  
Joint Fillers
- Poured filler for joints shall meet the requirements of AASHTO M 173 or as SHOWN ON THE DRAWINGS.
- Preformed filler for joints shall meet the requirements of AASHTO M 33, AASHTO M 153, or AASHTO M 213 and shall be punched as SHOWN ON THE DRAWINGS to admit the dowels. The filler for each joint shall be furnished in a single piece according to the depth and width required for the joint. When the use of more than one piece is authorized for a joint, the abutting ends shall be fastened securely and held in position by stapling or other positive fastening approved by the Engineer.
- 705.02  
Joint Mortar
- Pipe joint mortar shall consist of one part Portland cement and two parts sand, with water added as necessary to obtain the required consistency. Portland cement and sand shall meet the requirements of Subsections 701.01 and 703.01(a), respectively. Mortar shall be used within 30 minutes after its preparation.
- 705.03  
Rubber Gaskets
- Ring gaskets for rigid pipe shall meet the requirements of AASHTO M 198. Continuous flat gaskets for flexible metal pipe shall meet the requirements of ASTM D 1056, with grade RE 41 used for bands with projections or flat bands and grade RE 43 used for corrugated bands. When used with metal pipe with annular reformed ends, the ring gasket shall be one-fourth greater in diameter than the depth of the corrugation. Gasket thickness for bands with projections or flat bands shall be 1/2 inch greater than the nominal depth of the corrugation and shall be 3/8 inch for corrugated bands. For pipe with flanged ends, a butyl rubber strip gasket shall be placed inside the channel band.
- 705.04  
Oakum
- Oakum, for joints in bell and spigot pipe, shall be made from either hemp (*Cannabis sativa*) line, Benares Sunn fiber, or from a combination of these fibers. The oakum shall be thoroughly corded and finished and free from lumps, dirt, and extraneous matter.
- 705.05  
Mortar for Masonry  
Beds & Joints
- (a) Composition. Masonry mortar shall be composed of one part Portland cement or air-entraining Portland cement and two parts fine aggregate by volume to which hydrated lime has been added in an amount equal to 10 percent of the cement by weight. Instead of air-entraining cement, Portland cement may be used with an air-entraining admixture in accordance with Section 602.
- For masonry walls not exceeding 6 feet in height, a mortar composed of one part masonry cement and two parts fine aggregate by volume may be substituted for the above mixture of Portland cement, lime, and fine aggregate.
- (b) Materials. Type I or Type IA air-entraining Portland cement, meeting the requirements of AASHTO M 85, may be used, except when the contract contains an item for concrete under Section 602, the contractor may use the same type as is used for that work.
- Masonry cement shall meet the requirements of AASHTO M 150.
- Fine aggregate shall meet the requirements of AASHTO M 45.
- Hydrated lime shall meet the requirements for residue, popping and pitting, and water retention shown for Type N in ASTM C 207.
- Water shall meet the requirements of Subsection 712.01.
- Air-entraining agents shall meet the requirements of Subsection 711.02.
- 705.06  
(Reserved)

705.07  
Rubber Waterstops

Rubber waterstops may be molded or extruded and shall have a uniform cross section, free from porosity or other defects, conforming to the nominal dimensions SHOWN ON THE DRAWINGS. An equivalent standard shape may be furnished, if approved by the Engineer.

The waterstop may be compounded from natural rubber, synthetic rubber, or a blend of the two, together with other compatible materials which will produce a finished waterstop meeting the requirements tabulated in table 705-1. No reclaimed material shall be used. The contractor shall furnish a certificate from the manufacturer to show the general composition of the material and values for the designated properties in table 705-1. The contractor shall also furnish samples, in lengths adequate for making designated tests, as ordered by the Engineer.

Table 705-1.--Required properties and test methods, finished rubber waterstop.

Property	Federal Test Method Standard No. 601	Requirement
Hardness (by Shore Durometer)	3021	60 to 70
Compression Set	3311	30% max.
Tensile Strength	4111	2,500 psi min.
Elongation at Breaking	4121	450% min.
Tensile Stress at 300% Elongation	4131	900 psi min.
Tensile Strength After Aging	7111	80% original min.

705.08  
Plastic Waterstops

Plastic waterstops shall be fabricated with a uniform cross section, free from porosity or other defects, to the nominal dimensions SHOWN ON THE DRAWINGS. An equivalent standard shape may be furnished, if approved by the Engineer.

The material from which the waterstop is fabricated shall be homogeneous elastomeric, plastic compound of basic polyvinylchloride and other material that, after fabrication, will meet the requirements of table 705-2. No reclaimed material shall be used. The contractor shall furnish a certificate from the manufacturer showing values for the designated properties in table 705-2. The contractor shall furnish samples, in lengths adequate for making designated tests, as requested by the Engineer.

705.09  
Flexible Plastic Gaskets

Flexible plastic gaskets shall conform to AASHTO M 198, Type B, shall be produced from blends of refined hydrocarbon resins and plasticizing components reinforced with inert mineral filler, and shall contain no solvents. The gasket joint sealer shall be supplied in extruded rope form of suitable cross section and size as to fill the joint space when the pipes are joined.

705.10  
Bituminous Mastic

Bituminous mastic joint sealing material shall be a smooth, uniform mixture of bituminous cement, solvent, and mineral filler. The mineral filler shall consist essentially of short fiber asbestos. The mixture shall be readily applicable by means of a trowel or calking gun without pulling or drawing, and shall not sag or flow when applied to metal, concrete, or vitrified clay surfaces.

The compound shall be capable of withstanding freezing and shall not exhibit any tendency to separate or otherwise deteriorate while in storage.

Table 705-2.--Required properties and test methods, finished plastic waterstop.

Property	Federal Test Method Standard No. 406	ASTM Equivalent	Requirement
Tensile Strength	1011	D 638	Minimum 1,400 psi
Elongation at Breaking	1011	D 638	Minimum 250 percent
Hardness (Shore Durometer)	1082	D 1706	60 to 75
Specific Gravity	5011		Maximum $\pm 0.02$ from manufacturer's value
Resistance to Alkali (7 days using 10 percent NaOH)	7011	D 543	Maximum weight change: -0.10 percent to +0.25 percent. Maximum hardness change $\pm 5$ (Shore); maximum tensile strength decrease: 15 percent
Water Absorption (48 hours)	7031	D 570	Maximum 0.5 percent
Cold Bending	(a)	(a)	No cracking
Volatile Loss	6081	D 1203	Not more than manufacturer's value

(a) = The cold bend test will be made by subjecting a 1-inch by 6-inch by 1/8-inch strip of plastic waterstop to a temperature of  $-20^{\circ}\text{F}$  for 2 hours. The strip will immediately thereafter be bent 180 degrees around a rod of 1/4-inch diameter by applying sufficient force to hold the sample in intimate contact with the rod. The sample will then be examined for evidence of cracking. At least three individual samples from each lot will be tested and the result reported.

When applied to a tinned panel or glass plate, in a layer 1/16 to 1/8-inch thick, and cured at room temperature for 24 hours, the compound shall set to a tough, plastic coating and shall not shrink, crack, or loosen from the surface.

In addition, the material shall comply with the requirements of the following table:

	Min.	Max.
Grease Cone Penetration (ASTM D 217 Unworked, 150 gm., 25 °C., 5 sec.) 0.10 mm...	175	250
Weight per gal, lbs.....	9.75	---
Non-Volatile (10 gm, 105 °C - 110 °C., 24 hrs), pct.....	75	---
Ash (by ignition), pct.....	25	45

705.11  
Preformed Plastic Sealing Compound

Preformed plastic sealing compounds for concrete pipe joints shall meet the requirements of AASHTO M 198.

## Section 706 - Concrete, Clay, Plastic, & Fiber Pipe

- 706.01 Nonreinforced Concrete Pipe Nonreinforced concrete pipe shall meet the requirements of AASHTO M 86.
- 706.02 Reinforced Concrete Pipe Reinforced concrete pipe shall meet the requirements of AASHTO M 170 or AASHTO M 242. Elliptical pipe shall meet the requirements of AASHTO M 207. Pipe wall design and the use of elliptical reinforcement in circular pipe are optional. Reinforced concrete arch culvert pipe shall meet the requirements of AASHTO M 206.
- Precast reinforced concrete end sections shall meet the requirements of the cited specifications as applicable. Reinforced concrete D-load pipe shall meet the requirements of AASHTO M 242.
- 706.03 Perforated Concrete Pipe Perforated concrete pipe shall meet the requirements of AASHTO M 175.
- 706.04 Drain Tile Drain tile shall meet the requirements of AASHTO M 178 or AASHTO M 179.
- 706.05 Porous Concrete Pipe Porous concrete pipe shall meet the requirements of AASHTO M 176.
- 706.06 Vitrified Clay-Lined Reinforced Concrete Pipe Manufacturer's designs for fully lined or half lined pipes of the specified strength classes shall be submitted for approval. The applicable requirements of AASHTO M 170 and AASHTO M 65 shall govern. Liner or liner elements shall be clay of first quality, sound, thoroughly and perfectly burned, without warps, cracks, or other imperfections, and fully and smoothly salt glazed.
- 706.07 Clay Pipe Clay pipe shall meet the requirements of AASHTO M 65, for pipe with full circular cross section. When specified, the bell shall have integral spacer lugs to provide for an annular opening and self-centering feature.
- 706.08 Perforated Vitrified Clay Pipe Perforated vitrified clay pipe shall meet the requirements of AASHTO M 65 for circular, unperforated or perforated pipe.
- 706.09 Cradle Invert Clay Pipe Cradle invert clay pipe shall meet the applicable requirements of AASHTO M 65.
- 706.10 Asbestos Cement Pipe Asbestos cement pipe shall meet the requirements of AASHTO M 217.
- 706.11 Perforated Asbestos Cement Pipe Perforated asbestos cement pipe shall meet the requirements of AASHTO M 189.
- 706.12 Bituminized-Fiber Pipe Bituminized-fiber pipe shall meet the requirements of AASHTO M 177, ASTM D 1861, or ASTM D 1862.
- 706.13 Perforated Bituminized-Fiber Pipe Perforated bituminized-fiber pipe shall meet the requirements of AASHTO M 177. Type I or Type II couplings may be furnished.
- 706.14 Reinforced Concrete Arch Culvert, Storm Drain, & Sewer Pipe Reinforced concrete arch culvert, storm drain, and sewer pipe shall meet the requirements of AASHTO M 206.

- 706.15 Reinforced concrete elliptical culvert, storm drain, and sewer pipe shall meet the requirements of AASHTO M 207.  
Reinforced Concrete Elliptical Culvert, Storm Drain, & Sewer Pipe
- 706.16 Reinforced concrete D-load culvert, storm drain, and sewer pipe shall meet the requirements of AASHTO M 242.  
Reinforced Concrete D-Load Culvert, Storm Drain, & D Sewer Pipe
- 706.17 Polyvinylchloride (PVC) sewer and drain pipe shall meet the requirements of ASTM D 3034.  
Polyvinylchloride (PVC) Sewer & Drain Pipe
- 706.18 Corrugated polyethylene (PE) drainage pipe shall meet the requirements of AASHTO M 252.  
Corrugated Polyethylene (PE) Drainage Pipe
- 706.19 Acrylonitrile-butadiene-styrene (ABS) sewer pipe and fittings shall meet the requirements of AASHTO M-264 and M-265.  
Acrylonitrile-Butadiene-Styrene (ABS) Sewer Pipe & Fittings
- 706.20 Corrugated polyethylene (PE) pipe for culverts 12 through 24 inch diameter shall meet the requirements of AASHTO M 294.  
Corrugated Polyethylene (PE) Pipe for Culverts

## Section 707 - Metal Pipe

707.01  
Corrugated  
Steel Pipe &  
Pipe Arches

- (a) Riveted Pipe and Pipe Arches. These pipes shall meet the requirements of AASHTO M 36.
- (b) Welded Pipe and Pipe Arches. Corrugated metal pipe and pipe arches fabricated by resistance spot welding shall meet the applicable requirements of AASHTO M 36.
- (c) Helical Pipe. Helically corrugated pipe with continuous lock or welded seams shall meet the applicable requirements of AASHTO M 36.
- (d) Coupling Bands. Coupling bands shall meet the requirements of AASHTO M 36.
- (e) Special Sections. Special sections such as elbows, tees, wyes, etc., shall be the same thickness as the conduit to which they are joined and meet the applicable requirements of AASHTO M 36.
- (f) Flared End Sections. Flared end sections for inlet and outlet ends of pipe and pipe arch culverts shall meet the applicable requirements of AASHTO M 36. End sections shall be fabricated in accordance with the details and dimensions SHOWN ON THE DRAWINGS, except minor variations may be accepted to permit the use of the manufacturer's standard methods of fabrication.

707.02  
Bituminous-Coated  
Corrugated  
Steel Pipe &  
Pipe Arches

These conduits and their coupling bands shall meet the requirements of AASHTO M 190. The coating shall be Type A, B, C, or D as shown in the SCHEDULE OF ITEMS. Coupling bands shall be fully coated with bituminous material. Pipe shall be made from material conforming to AASHTO M 218 zinc coated, AASHTO M 274 aluminum coated, or AASHTO M 289 aluminum-zinc coated.

Special sections, such as elbows and prefabricated flared end sections, shall meet the applicable requirements of AASHTO M 190. Coating and invert paving shall be of the type specified. Flared end sections shall meet the requirements of AASHTO M 243 or M 190 for the coating specified. The Engineer may waive the imperviousness test for coated pipe if no separation of coating from metal is observed.

When asbestos-bonded bituminous coating is specified, the above requirements shall apply; in addition, the special process of embedding asbestos fiber in the molten metallic bonding medium shall be used to bond the bituminous coating. Asbestos-bonded corrugated metal pipe shall be fabricated in accordance with AASHTO M 36 using asbestos-bonded sheets of base metal specified therein. Both sides of the metal sheets shall be coated with a layer of asbestos fibers pressed into the molten zinc bonding medium. Immediately after the metallic bond has solidified, the asbestos fibers shall be thoroughly impregnated with a bituminous saturant. The finished sheets shall be uniformly coated and free from blisters. After fabrication, the culvert sections shall be treated as specified for Type A, B, or C in accordance with AASHTO M 190. Coupling bands shall meet the requirements of AASHTO M 36.

707.03  
Polymeric-  
Precoated Steel  
Pipe, Pipe Arches,  
& Underdrains

- (a) Pipe shall meet the requirements of AASHTO M 245.
- (b) Coupling bands shall meet the requirements of AASHTO M 245 and M 246. Coating shall be Type A or B as shown in the SCHEDULE OF ITEMS.
- (c) Special sections such as elbows, tees, wyes, etc., shall be the same thickness as the conduit to which they are joined.

(d) Flared end sections for attachment to the inlet and outlet ends of pipe and pipe arch culverts shall meet the applicable requirements of AASHTO M 243 and M 246. End sections shall be fabricated in accordance with the details and dimensions SHOWN ON THE DRAWINGS, except that minor variations may be accepted to permit the use of the manufacturer's standard methods of fabrication.

707.04  
Corrugated  
Steel Pipe for  
Underdrains, Plain  
Galvanized or  
Precoated

Plain galvanized pipe shall meet the requirements of AASHTO M 36. Precoated underdrains shall meet the requirements of AASHTO M 245.

707.05  
Bituminous-Coated  
Steel Pipe  
for Underdrains

Pipe shall meet the requirements of AASHTO M 36 and shall be coated with bituminous material to meet the requirements of AASHTO 190, Type A coating, except that minimum coating thickness shall be 0.03 inch. Coupling bands shall be fully coated. The specified minimum diameter of perforations shall apply after coating. The Engineer may waive the imperviousness test if no separation of coating from metal is observed.

707.06  
Corrugated  
Aluminum Alloy  
Culvert Pipe &  
Pipe Arches

Pipe shall meet the requirements of AASHTO M 196.

707.07  
Corrugated Aluminum  
Alloy Pipe for  
Underdrains

Pipe shall meet the requirements of AASHTO M 196.

707.08  
Bituminous-Coated  
Corrugated Aluminum  
Alloy Culvert Pipe  
& Pipe Arches

Pipe shall meet the requirements of AASHTO M 196 and shall be coated with bituminous material meeting the requirements of AASHTO M 190.

707.09  
Bituminous-  
Coated Corrugated  
Aluminum Alloy  
Pipe Underdrains

Pipe shall meet the requirements of AASHTO M 196 and shall be coated with bituminous material meeting the requirements of AASHTO M 190.

707.10  
Structural Steel  
Plate for Pipe, Pipe  
Arches, & Arches

The plates and bolts and nuts for connecting plates shall meet the requirements of AASHTO M 167.

707.11  
Full Bituminous-  
Coated Structural-  
Plate Pipe, Pipe  
Arches, & Arches

Plates shall meet the requirements of AASHTO M 167 and shall be coated with bituminous material meeting the requirements of AASHTO M 243.

707.12  
Aluminum Alloy  
Structural Plate  
for Pipe, Pipe  
Arches, & Arches

Plates and the bolts and nuts for connecting plates shall meet the requirements of AASHTO M 219.

707.13  
Aluminum-Coated  
Type 2  
Corrugated Steel  
Pipe & Pipe Arches

(a) Pipe and coupling bands shall meet the requirements of AASHTO M 36 except that they shall be made from material meeting the requirements of AASHTO M 274.

(b) Special sections such as elbows, tees, and wyes shall be the same thickness as the conduit to which they are joined and shall meet the applicable requirements of AASHTO M 36 and M 274.

707.14  
Aluminum-Zinc-Alloy-  
Coated Corrugated  
Pipe and Pipe Arches

(a) Pipe and coupling bands shall meet the requirements of AASHTO M 36 except that they shall be made from material meeting the requirements of AASHTO M 289.

(b) Special sections such as elbows, tees, and wyes shall be the same thickness as the conduit to which they are joined and shall meet the applicable requirements of AASHTO M 36 and M 289.

707.15  
Bituminous-Coated  
Polymeric-Precoated  
Steel Pipe, Pipe  
Arches, & Underdrains

These conduits and their coupling bands shall meet the requirements of AASHTO M 190. The coating shall be Type A, C, or D, or invert paved only, or 100 percent paved only. Pipe shall be made from material conforming to AASHTO M 245 Polymeric Precoated Steel Pipe.

## Section 708 - Paints

708.01  
(Reserved)

708.02  
Paint for Timber  
Structures

Paint for timber structures shall be white or as SHOWN ON THE DRAWINGS and shall meet the requirements of AASHTO M 70, Type I, Class B. The paint as specified is intended for use in covering previously painted surfaces. When applied to unpainted timber, turpentine and linseed oil shall be added as required by the character of the surface in an amount not to exceed 1 pint each per gallon of the paint.

708.03  
Paint for Steel  
Structures

(a) General. All paint furnished shall be shipped in strong, substantial containers, plainly marked with the name, weight, and volume of paint content, together with the color, formula, and the name and address of the manufacturer. Paint systems shall be of the type SHOWN ON THE DRAWINGS. Except as otherwise required in the cited specifications, all paint shall meet the following requirements:

(1) The paint shall not show excessive settling in a freshly opened full can and shall easily be redispersed with a paddle to a smooth, homogeneous state. The paint shall show no curdling, livering, caking, or color separation and shall be free from lumps and skins.

(2) The paint as received shall brush easily, possess good leveling properties, and show no running or sagging tendencies when applied to smooth steel vertical surfaces.

(3) The paint shall not form a skin within 48 hours in a three-quarters filled closed container.

(4) The paint shall dry to a smooth uniform finish, free from roughness, grit, unevenness, and other surface imperfections. It shall show no streaking or separation when flowed on clean glass.

(5) The paint shall show no thickening, curdling, gelling, or hard caking after 6 months storage in a full, tightly covered container at a temperature of 70 °F.

(b) System 1--Vinyl Paint System.

(1) Vinyl wash primer shall meet the requirements of MIL-P-15328.

(2) Vinyl intermediate coat shall meet the requirements of MIL-P-15929, MIL-P-15930, or SSPC-Paint-8 or -9.

(3) Third and fourth coats shall be the same as the intermediate coat.

(4) Final coat shall be the same as the intermediate coat or SSPC-Paint-8 or -9 or Fed. Spec.-TT-P-615 to obtain the specified finish color.

(c) System 2--Epoxy-Polyamide Paint System

(1) Primer coat shall meet the requirements of MIL P-24441, Formula 150 and the color as specified.

(2) Intermediate coat and third coat shall meet the requirements of MIL-P-24441, using contrasting color sequences.

(3) Final coat shall meet the requirements of SSPC-Paint-8 or -9 or Fed. Spec.-TT-P-615 to obtain the specified final coat, and shall be applied in accordance with the recommendations of the manufacturer of the undercoat. The entire paint system shall be supplied by the same manufacturer.

(d) System 3--Inorganic Zinc Silicate System.

(1) Primer coat shall be an inorganic zinc silicate paint of the two-component self-curing type that, when mixed, cures without the use of a separate curing solution, and shall have the properties described herein.

a. Pigment. The zinc pigment component shall meet the requirements of ASTM D 520 for Type II. The average particle size of the zinc powder shall not exceed 10 microns as determined by the Fisher sub-sieve sizer.

b. Vehicle. The vehicle component shall consist primarily of an alkyd silicate in an appropriate alcohol solvent. Total solids, by content, shall be determined by drying the sample to a constant weight at 100 °C.

c. Mixed Paint. Mixed paint shall meet the following requirements:

1. The zinc portion shall be at least 75 percent by weight of the total solids of the dried coating.

2. The total solids, when heated at 100 °C for 3 hours, shall be not less than 72 percent by weight.

3. The paint shall tolerate up to 1 percent water contamination without gelation.

4. The usable pot life of the mixed paint shall be not less than 12 hours at 77 °F. There shall be no hard settling that cannot be easily redispersed during this period.

5. The inorganic zinc coating shall be formulated to produce a distinct contrast in color with blast-cleaned metal surfaces and with the topcoat.

d. Resistance Tests. Test panels of steel meeting the requirements of ASTM D 609, having dimensions of 2 by 5 by 0.125 inches, shall be prepared by blast cleaning leaving all surfaces with a dense and uniform anchor pattern of not less than 1.5 mils, measured with an approved surface profile comparator or Testx-pressé tape. A 3- to 4-mil coating (dry thickness) shall then be applied to the test panels in accordance with the manufacturer's current printed instruction. The coating shall be cured as recommended by the manufacturer. Each of the following tests shall be performed on a minimum of three panels. The material will not be accepted if any individual test panel fails any of the following tests:

1. Fresh Water Resistance. Panels shall be scribed down to base metal with an X of at least 2-inch legs and shall be immersed in fresh tap water at 75 °F, plus or minus five degrees. The panels shall show no rusting, blistering, or softening when examined after 30 days.

2. Salt Water Resistance. Panels shall be scribed down to base metal with an X of at least 2-inch legs and immersed in five percent sodium chloride at 75 °F, plus or minus five degrees and examined at 7, 14, and 30 days. The sodium chloride solution shall be replaced with fresh solution after each examination.

3. Weathering Resistance. Panels shall be tested in accordance with ASTM G 23, Type D. The panels shall be placed on test at the beginning of the wet cycle. After 1,000 hours of continuous exposure, the coating shall show no rusting, loss of adhesion to the steel test panel, or blistering.

4. Weather and Salt Fog Resistance. Panels shall be tested in the weatherometer as specified in Part 3 above for 300 hours. After this period the panels shall be removed and scribed with an X of at least 2-inch legs down to base metal. The test panels shall then be tested in accordance with ASTM B 117. After 1,000 hours of continuous exposure, the coating shall show no loss of bond, nor shall it show rusting or blistering beyond 1/16 inch from the center of the scribe mark.

5. Resistance to Elevated Temperatures and Thermal Shock. Panels shall be exposed to a temperature of 500 °F for 1 hour, then quenched immediately in water 65 °F plus or minus five degrees. Panels subjected to this test shall show no blistering or flaking of the coating.

6. Adhesion Panels. Adhesion panels shall be tested in accordance with ASTM D 3359 and shall attain a rating of three or greater.

7. Mud Cracking Resistance. The coating, when applied to test panels as provided above, to a 5- or 6-mil dry film thickness shall not show mud cracking when viewed under 10 power magnification.

e. Manufacturer and Brand Name Approved for Inorganic Zinc Primer. Prior to approval and use of inorganic zinc, the contractor shall submit in triplicate to the Engineer a certified test report from an approved independent testing laboratory showing specific test results meeting all quantitative and resistance test requirements of these specifications. The certified test report shall also contain the exact ratio, by weight, of the pigment component to the vehicle component of the paint used for the tests, the lot tested, the manufacturer's name, brand name of paint, and date of manufacture. Upon approval by the Engineer of this certified test report, further resistance tests will not be required, except as hereinafter noted, of that manufacturer for that brand name of paint for a period of 2 years from the date of test completion. New certified test results shall be submitted any time the manufacturing process or the paint formulation is changed, and may be required by the Engineer when sampling and testing of material offered for use indicates nonconformance to any of the requirements specified.

(2) Intermediate coat shall be applied as recommended by the manufacturer in a single application employing multiple spray passes. The color of the intermediate coat shall contrast with both the primer and final coat. The tie coat shall meet the requirements of MIL-P-15328, or MIL-P-24441, Formula 150.

(3) Final coat shall be applied as recommended by the manufacturer in a single application employing multiple spray passes. The final coat shall meet the requirements of SSPC-PC-8 or -9. For MIL-P-24441 intermediate coat see System 2, Final Coat.

The contractor shall submit final coat color chips for approval of color by the Engineer.

(e) System 4--Alkyd-Oil Basic Lead Silico-Chromate System.

(1) Primer coat shall meet the requirements of Fed. Spec.-TT-P-615 or AASHTO M 229.

(2) Intermediate coat shall be the same as the prime coat but tinted to contrast with both the prime coat and the final coat.

(3) The contractor shall submit final coat color chips for approval of the color by the Engineer.

(f) System 5--Organic Zinc-Rich Paint System.

(1) Prime coat shall meet the following requirements:

a. Description. This specification covers a one-package, thermoplastic, organic zinc-rich primer whose mechanism of drying is that of solvent release. It is intended for use only on blast-cleaned open steel structures exposed to the air.

b. Composition. The composition of the organic zinc-rich paint is specified in the following tables.

The average particle size of the pigment shall not exceed nine microns as determined by the Fisher Sub-Sieve Sizer. The red iron oxide must first be ground into a portion of the vehicle to provide a Hegman grind sufficient to produce the specified color of the finished paint.

The necessary additives to prevent gas formation in the containers during storage shall be incorporated into the formulated paint.

c. Infrared Characteristic Curve of Primer Vehicle. When dried upon a potassium bromide disc, a film of the primer shall have infrared absorption maximums at the same wavelengths and to the same relative degree as that shown by the curve on file.

The composition of the extracted zinc dust pigment shall match the X-ray diffraction curve on file.

Table 708-1.--Pigment ingredients (62.3 percent of composition weight, minimum).

Ingredient	Specification	Parts by Weight of Pigment	
		Type I Red Tint	Type II Gray Tint
Zinc Dust	ASTM D 520	95.0 min.	95.0 min.
Red Iron Oxide <sup>a</sup>	_____	1.5 max.	_____
Zinc Oxide	ASTM D 3280	_____	1.5 max.
Thixotropes and Additives	_____	3.5 max.	3.5 max.

<sup>a</sup> Fe<sub>2</sub>O<sub>3</sub> 98.5 percent minimum; oil absorption, 21; fineness through 325 mesh screen, 99 percent minimum; and specific gravity, 5.15.

Table 708-2.--Vehicle ingredients (37.7 percent of composition weight, maximum).

Ingredients	Specification	Parts by Weight of Vehicle
Polyary1 Ether <sup>a</sup>	_____	19.0
Ethylene Glycol Monoethyl Ether Acetate	MIL-E-7125	66.8
Toluene	Fed. Spec.-TT-T-548	14.2

<sup>a</sup>A polyhydroxy polyalkaryl polyether of the following properties:  
 Specific gravity . . . . . 1.18  
 Viscosity of 49 percent solids in methyl ethyl ketone,  
 Brookfield RVF, 20 rpm No. 5 spindle . . . . . 5,500 to 7,700 cps  
 Reduced viscosity (0.2 g/100 ml.  
 dimethylformamide) . . . . . 0.4 to 0.6  
 Ultimate tensile strength . . . . . 9,000 to 9,500 psi  
 Ultimate tensile elongation . . . . . 50 to 100 percent  
 Softening temperature . . . . . 212 °F  
 Bulking value . . . . . 9.83 lbs. per gal.

d. Characteristics of Paint:

The paint shall, in addition to the preceding composition, meet the following requirements:

Volatiles at 105 °C, percent by weight . . . . . 28-32  
 Weight per gallon, pounds . . . . . 17.2-18.0  
 Viscosity, KU at 77 °F . . . . . 100-120  
 Metallic zinc, percent by weight of extracted  
 pigment by Federal Test Method Standard  
 No. 141, Method 7221 . . . . . 90.2 min.  
 Dry time at 77°F, 50 percent relative  
 humidity, 6-mil wet thickness:  
 Set to touch, hours . . . . . 3/4 max.  
 Dry hard, hours . . . . . 5 max.  
 Storage life, years . . . . . 1 min.

e. Properties of Cured Coating. When applied to a plate glass panel with a 6-mil gap clearance doctor blade and cured for 15 days at 77 °F plus or minus five degrees, and 50 percent relative humidity, plus or minus 5 percent, the coating shall have the following properties:

Pencil hardness . . . . . B min.  
 Color (for Type I only) . . . . . Not lighter than  
 Federal Standard  
 Color 31575

When applied by air or airless spray to a minimum dry film thickness of 1.5 mils on blast-cleaned steel having an anchor profile pattern of 1.0 to 1.5 mils, the mixed paint shall completely wet the surface of the steel with no evidence of dry spray particles or sagging.

When applied to a wet film thickness of 6 mils on a metal panel corresponding to Fed. Spec.-QQ-S-698, the panel being previously cleaned by blast cleaning to produce a 1.0- to 1.5-mil anchor pattern, and cured for 15 days at a relative humidity of 50, plus or minus 5 percent, and tested in accordance with the Conical Mandril Test, Federal Test Method Standard No. 141, Method 6222, there shall be no loosening of the film above the point of the longest continuous crack.

When a steel panel is blast cleaned to white metal and coated with 3- to 4-mils dry film thickness of this coating and cured for 15 days at 75 °F plus or minus two degrees and 50 percent relative humidity plus or minus 5 percent and diagonally scribed to expose base steel, there shall be no underfilm corrosion on the surface of the panel extending beyond the scribed lines after 1,000 hours when tested in accordance with ASTM B 117.

Prior to use, the paint shall be thinned with not more than one part of thinner to four parts of paint using a power-agitated stirrer. The thinner shall consist of a mixture of 82 percent by volume of ethylene glycol monoethyl ether acetate and 18 percent by volume of toluene.

(2) Intermediate coat shall be the same as the prime coat tinted to contrast with both the prime coat and the vinyl wash coat.

(3) Vinyl wash tie coat shall meet the requirements of MIL-P-15328.

(4) Final coat shall meet the requirements of SSPC-Paint-8 or -9, or Fed. Spec.-TT-P-615 with the color as specified.

(g) Sampling and Testing. Unless otherwise specified, sampling will be performed in accordance with Federal Test Method Standard No. 141, Method 1022.

The paint will be tested in accordance with methods of Federal Test Method Standard No. 141, as follows:

Test	Method # 141	ASTM Method
Percentage of Pigment	4021	--
Isolation of Vehicle	4032	D 2698
Nonvolatile in Vehicle	4053 <sup>a</sup>	--
Phthalic Anhydride		D 563
Uncombined Water	4081	D 1364
Consistency: Krebs-Stormer		D 562
Coarse Particles and Skins		D 185
Weight per Gallon		D 1465
Set to Touch Time	4061	--
Condition in Container	3011	--
Brushing Properties	2141, 4321	--
Skimming	4141	--
Rosin and Resin Derivatives	--	D 1542
Storage Stability	4142	--
Dry Through Time	4061	--
Fineness of Grind		D 1210

<sup>a</sup>A gravity convection oven may be used to determine the non-volatile content of the supercentrifuged vehicle if the procedure outlined in ASTM D 2369 is modified as follows: Weigh accurately from 0.8 to 1.2 gram of sample (by difference), heat for one hour, cool and weigh. Use the lower value to calculate the percentage of nonvolatile matter.