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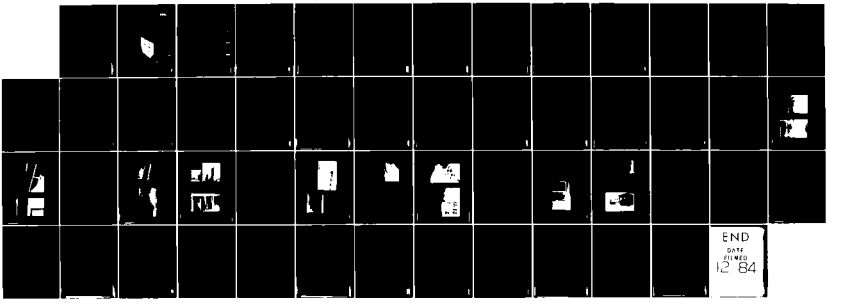

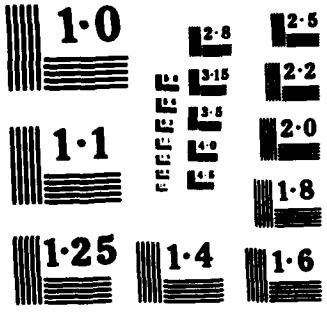
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US Army Corps
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Construction Engineering
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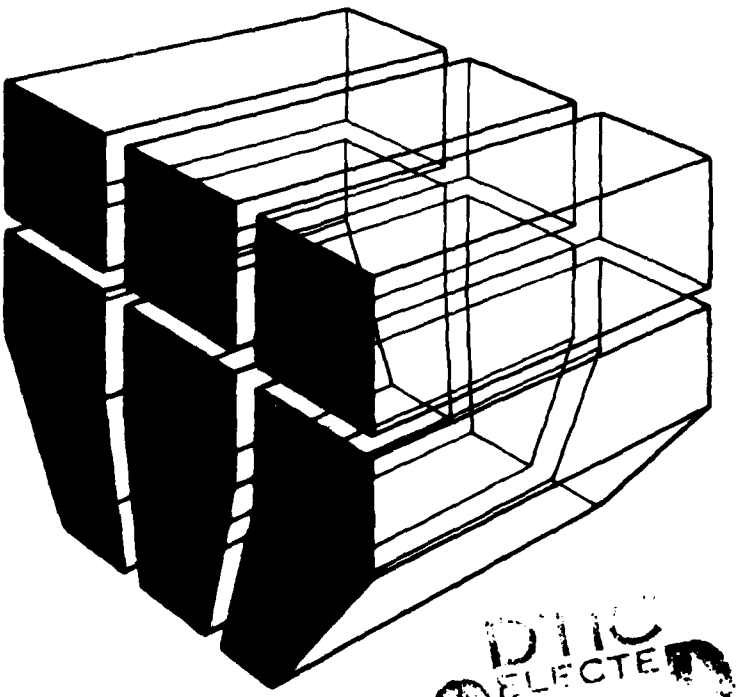
SPECIAL REPORT M-360
September 1984

REVIEW OF SIDING MATERIALS FOR TURNKEY PROCUREMENT OF ARMY FAMILY HOUSING

by
Richard Lampo



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Rapid changes in the siding materials industry have dated Army specifications for turnkey procurement of siding to be used on family housing. This investigation surveyed state-of-the-art sidings for information that would help update the specifications. Aluminum, steel, hardboard, and vinyl siding materials were evaluated based on (1) manufacturer's claims for performance and warranty and (2) field inspection of the different types in use.

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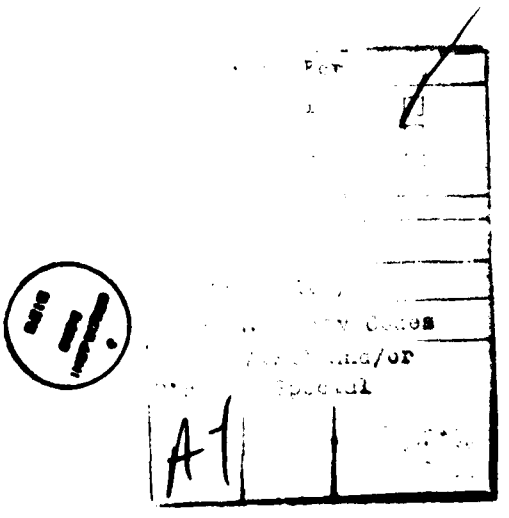
Despite the study's limited scope, some recommendations can be made to amend the current procurement procedures. For example, (1) a factory prefinished siding with a 15-year nonprorated warranty should be specified; (2) flexibility in material types should allow local selection for optimal performance in different geographic locations and to complement existing architecture; and (3) sidings should be installed in strict accordance with the manufacturer's instructions to preserve the warranty.

FOREWORD

This work was performed by the Engineering and Materials Division (EM), U.S. Army Construction Engineering Research Laboratory (USA-CERL), for the Directorate of Engineering and Construction, Office of the Chief of Engineers (OCE), under reimbursable Funding Authority Document (FAD) 2-270, dated October 1983.

Appreciation is expressed to John Bukowski, USA-CERL-EM, for contributions to this report.

Dr. Robert Quattrone is Chief, EM. COL Paul J. Theuer is Commander and Director of USA-CERL, and Dr. L. R. Shaffer is Technical Director.



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PROCUREMENT OF ARMY FAMILY HOUSING

1 INTRODUCTION

Background

The requirements used to specify residential siding materials for "turnkey" procurement of Army family housing[1] were written many years ago and do not reflect current technology in the sidings industry. For example, some acceptable materials are no longer marketed; others that would be suitable may have been developed recently and merit consideration for use on family housing. In addition to changes in technology, some manufacturers now offer different types of warranties.

To insure quality for family housing, the Army asked the U.S. Army Construction Engineering Research Laboratory (USA-CERL) to investigate available residential sidings and recommend how the turnkey specifications should be amended to reflect the current market. Moreover, the Army specifications need updating to facilitate procurement of sidings with the best available warranty.

Objective

The objective of this work is to investigate available residential siding materials and to recommend how to specify acceptable siding materials for turnkey housing contracts.

Approach

Before beginning this investigation, it was essential to define which materials would be "acceptable" for turnkey housing contracts. Based on the Corps of Engineers' experience with residential sidings, it was determined that acceptable siding materials must meet the following general requirements:

1. The finish normally will not require maintenance for a period of 15 years.

2. The finish will not fade more than a limited amount. (The limits of this requirement were to be determined from a survey of available materials.) Fading usually is expressed as a color difference of so many National Bureau of Standards (NBS) units over a given number of years.

3. The above criteria must be guaranteed in writing.

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[1] One-Step "Turnkey" Negotiated Contract for Army Family Housing (U.S. Army Corps of Engineers, Office of the Chief of Engineers, Internal Document).

A search was then conducted to locate manufacturers of siding materials meeting the necessary criteria. The different materials represented were compared for advantages and disadvantages, and manufacturers' claims were reviewed. Field observations were made of various siding materials at both military and nonmilitary sites. The investigation was discussed with representatives from various Government agencies to receive input from those considered experts in assessing siding performance. Specific recommendations were formed by considering all this information collectively.

Scope

Because of this study's limited duration, the siding materials were not subjected to a laboratory evaluation. In addition, recommendations related to turnkey procurement are limited to paragraphs 3.5.17, Exterior Finish Materials, and 3.5.19, Finishes.[2]

[2] One-Step "Turnkey" Negotiated Contract for Army Family Housing.

2 RESIDENTIAL SIDING MANUFACTURERS

Data Collection

Manufacturers listed in the 1983 edition of Thomas' Register[3] and MacRae's Blue Book[4] under "siding materials" were contacted to determine which ones make minimum 15-year guaranteed maintenance-free, factory-finished, residential siding. Other library references included the Building Products File[5] and Sweet's Catalog File.[6] The following professional associations were asked to supply information on, e.g., applicable specifications and installation procedures, and to identify any other potential suppliers of the required siding:

1. American Hardboard Association
   887-B Wilmette Road
   Palatine, IL 60067

2. Architectural Aluminum Manufacturer's Association
   35 East Wacker Drive
   Chicago, IL 60601

3. Vinyl Siding Institute
   The Society of the Plastics Industry, Inc.
   355 Lexington Avenue
   New York, NY 10017

George Butler Association, Inc. (an architectural-engineering firm working on designs for re-siding failed hardboard siding at Fort Riley), Kansas City, MO, also provided input and a list of sources for residential siding.

Product information and specimen warranties were requested from manufacturers of siding claimed to have a minimum warranty of 15 years. Table 1 lists these manufacturers alphabetically and shows the types of materials supplied. The materials represented are basically four types: aluminum, hardboard, steel and solid vinyl. Manufacturer representatives from Alside, Inc., Revere Aluminum Building Products, and H&W Building Products visited USA-CERL to discuss this study and provide input on their products.

Comparison of Results

Table 2 compares the products by manufacturer and tradename based on differences in warranty lifetimes, prorating or nonprorating, and warranties for hail damage and fading. Although some smaller manufacturers may have been inadvertently omitted, all major manufacturers are considered to be represented. It is emphasized that the materials and manufacturers listed may have

[3] Thomas' Register (Thomas Publishing Co., New York, 1983).
[4] MacRae's Blue Book (MacRae's, Chicago, 1983).
[5] Building Products File (Information Handling Services, 1983).
[6] Sweet's Catalog File (McGraw-Hill Information Systems Co., 1978).

Table 1

Siding Manufacturers and Product Type

Manufacturer	Main Office	Siding Types			
		Aluminum	Hardboard	Steel	Vinyl
Alcan Building Prod.	Warren, OH	x			x
Alcoa Building Prod.	Sidney, OH	x			x
Alsco	Akron, OH	x		x	x
Alside, Inc.	Akron, OH	x		x	x
Aluminum Industries, Inc.	Manchester, MO	x		x	
American Vinyl Bld. Prod.	Highland Park, IL				x
Bird, Inc.	Bardstown, KY				x
Celotex Corp.	Tampa, FL				x
CertainTeed Corp.	Valley Forge, PA				x
Edco Products, Inc.	Hopkins, MN	x		x	
Gold Bond Build. Prod.	Charlotte, NC				x
H&W Building Products	Booneville, MS				x
Hastings Aluminum Prod.	Hastings, MI	x			
Lynch Aluminum Mfg. Co.	Peoria, IL	x			
Masonite Corp.	Chicago, IL		x		
Master Shield	Weatherford, TX				x
Mastic Corp.	South Bend, IN				x
Modern Materials Corp.	Detroit, MI	x			
Nichols-Homeshield	St. Charles, IL				x
Republic Building Prods.	Oconomowoc, WI	x		x	x
Revere Al. Bld. Prod.	Cleveland, OH	x		x	x
Reynolds Aluminum	Richmond, VA	x			x
Variform	Kearney, MO				x
Vinyl Improv. Prod. Co.	Columbus, OH				x
Vynasteel Corp.	Milwaukee, WI			x	
Weyerhauser Co.	Tacoma, WA	x[1]			
Wolverine AL Co.	Lincoln Park, MI	x		x	x

[1] Aluminum-plywood laminate.

Table 2

Comparison of Four Siding Material Types

Manufacturer	Trade Name	Finish	Life	Conditions	Hail Damage	Fading	Specifi-tions	Comments
Aluminum								
Alcan	Cedarwood	Polyvinylidene Fluoride	Lifetime	Nonprorated	None	Not Covered	A (1)	9
Alcan	Deluxe	Polyester Enamel	30 Yr.	Prorated	None	Not Covered	A (1)	
Alcan	Driftwood	Polyester Enamel	30 yr.	Prorated	None	Not Covered	A (1)	
Alcan	Vin-al-wood	Polyvinyl Chloride (PVC)	Lifetime	Nonprorated	None	Not Covered	A (1)	9
Alcoa	Cedar Shake	Water-borne Acrylic	Lifetime	Nonprorated	Lifetime	Not Covered	A (2)	
Alcoa	Country Oak	Polyvinyl Chloride (PVC)	Lifetime	Nonprorated	Lifetime (10)	Not Covered	A (3)	
Alcoa	Rustic	Water-borne Acrylic	Lifetime	Nonprorated	Lifetime (10)	Not Covered	A (3)	
Alcoa	(Smooth Texture)	Water-borne Acrylic	Lifetime	Nonprorated	Lifetime (10)	Not Covered	A (3)	
Alcoa	Western Oak	Water-borne Acrylic	Lifetime	Nonprorated	Lifetime (10)	Not Covered	A (3)	
Alsco	Dynalar	Polyester Enamel	30 yr.	Prorated	None	Not Covered	A (3)	11
Alsco	Premium 40	Polyvinyl Fluoride (Tedlar)	Lifetime	Nonprorated	None	5 E/10 yr.(12)	A (1)	11,13,14,15
Alsco	Ultimate	Polyvinylidene Fluoride	Lifetime	Nonprorated	None	5 E/20 yr.(12)	A (3)	11,13,14,16
Alside	Briar Cut	Acrylic Enamel	30 yr.	Prorated	None	Not Covered	A (3)	
Alside	Briar-Cut Supreme	Polyvinyl Chloride (PVC)	40 yr.	Prorated	None	Not Covered	A (1)	
Alside	Ultra-Deep Grain	Polyvinyl Chloride (PVC)	40 yr.	Prorated	None	Not Covered	A (2)	
Alside	Weather-grain	Acrylic Enamel	30 yr.	Prorated	None	Not Covered	A (2)	
Aluminum Inds.	Tuf-Side	Acrylic Enamel	30 yr.	Prorated	None	Not Covered	A (3)	
Aluminum Inds.	Vinylgrain	Polyvinyl Chloride (PVC)	40 yr.	Nonprorated	20 yr.(17,18)	Not Covered	A (3)	
Edco	Alume-Kore	Silicone Acrylic Enamel	40 yr.	Prorated	None	Not Covered	A (4)(5)	
Hastings	Deluxe	Silicone Polyester Enamel	40 yr.	Prorated	None	5 NBS/10 yr.	A (1)(6)	
Hastings	Insulated	Silicone Polyester Enamel	40 yr.	Prorated	None	5 NBS/10 yr.	A (4)	
Hastings	Woodgrain	Silicone Polyester Enamel	40 yr.	Prorated	None	5 NBS/10 yr.	A (2)	
Lynch	---	Polyester Enamel	20 Yr.	Prorated	None	Not Covered	A (2)(7)	
Modern Material	Craftmark 40	Water-borne Acrylic	40 yr.	Prorated	None	5 NBS/10 yr.	A (3)	
Republic	Dura Clad	Polyvinyl Chloride (PVC)	40 yr.	Nonprorated	None	Not Covered	A (4)	
Republic	Mirrogard	Acrylic Enamel	30 yr.	Prorated	None	Not Covered	A (3)	
Revere	Acry-Gard	Acrylic-Enamel	30 yr.	Prorated	None	Not Covered	A (3)	
Revere	Super-Gard	Polyvinyl Chloride (PVC)	40 yr.	Nonprorated	None	Not Covered	A (3)	
Reynolds Alum.	American Classic	Polyester Enamel	30 yr.	Prorated	None	Not Covered	A (3)	
Reynolds Alum.	Vinyl-Tuf	Polyvinyl Chloride (PVC)	50 yr.	Nonprorated	None	Not Covered	A (3)	
Weyerhauser	Panel 15	Water-borne Acrylic	15 yr.	Prorated	None	Not Covered	(8)	19,20
Wolverine	Super Tuff	Acrylic Enamel	30 yr.	Nonprorated	None	8 NBS/5 yr.	A (3)	21

Table 2 (Cont'd)

Manufacturer	Trade Name	Finish	Life	Conditions	Hail Damage	Fading	Specifications	Conditions
Hardboard								
Masonite	Colorlok	Water-borne Acrylic	15 yr.	Nonprorated	25 yr.	10 NBS/8 yr.	B (22)	23
Steel								
Alsco	Premium 40	Polyvinyl Fluoride (Tedlar)	Lifetime	Nonprorated	None	5 E/10 yr.(12)	C (8)	11,13,14,15
Alsco	Ultimate	Polyvinylidene Fluoride	Lifetime	Nonprorated	50 yr.(17,24)	5 E/20 yr.(12)	C (8)	11,13,14,16
Alside	Super Steel	Polyvinyl Chloride (PVC)	50 yr.	Nonprorated	50 yr.(17,24)	Not Covered	C (8)	11,13,27
Aluminum Inds.	Sure-Side	Polyvinyl Chloride (PVC)	Lifetime	Nonprorated	None	Not Covered	D (8)	13
Edco	Steel-kore	Silicone Acrylic Enamel	40 yr.	Prorated	40 yr.(17)	Not Covered	C (8)	
Republic	Steel Shield	Polyvinyl Chloride (PVC)	40 yr.	Prorated	20 yr.(17,18)	Not Covered	E (8)	
Revere	Super-Gard	Polyvinyl Chloride (PVC)	50 yr.	Nonprorated	50 yr.(18,25)	Not Covered	C (8)	
Vynasteel	Steeltek	Polyvinyl Chloride (PVC)	Lifetime(28)	Nonprorated	Lifetime(18)	5 NBS/10 yr.	C (8)	15
Wolverine	LifeSteel	Polyvinyl Chloride (PVC)	50 yr.	Nonprorated	50 yr.(25)	8 NBS/10 yr.	C (8)	21
Wolverine	Signature	Polyvinyl Chloride (PVC)	Lifetime(26)	Nonprorated	Lifetime(25)	8 NBS/5 yr.	C (8)	21
Vinyl								
Alcan	Driftwood	---	Lifetime	Nonprorated	None	Not Covered	F (29)	9
Alcoa	Super-V	---	Lifetime(31)	Nonprorated	Lifetime(25)	Not Covered	F (29)	
Alsco	Oceanside	Tedlar	Lifetime	Nonprorated	None	5 E/10 yr.(12)	F (29)	13,14,15,32
Alsco	Timbertone	---	Lifetime	Nonprorated	None	Not Covered	F (29)	13,14
Alside	Premium	---	Lifetime(26)	Nonprorated	50 yr.(17,24)	Not Covered	F (29)	
American Vinyl	---	---	60 yr.	Nonprorated	60 yr.(25)	Not Covered	F (29)	
Bird	---	---	50 yr.	Nonprorated	50 yr.(25)	Not Covered	F (29)	33
Celotex	---	---	40 yr.(31)	Prorated	40 yr.(17)	Not Covered	F (29)	
CertainTeed	---	---	50 yr.(31)	Nonprorated	50 yr.(25)	Not Covered	F (29)	
Gold Bond	---	---	50 yr.(31)	Nonprorated	50 yr.(25)	Not Covered	F (29)	
H&W Bld. Prod.	Heartland	---	50 yr.	Nonprorated	50 yr.(25)	Not Covered	F (29)	
Homeshield	Heritage	---	50 yr.	Nonprorated	50 yr.(25)	Not Covered	F (29)	
Master Shield	Premium	---	50 yr.	Nonprorated	50 yr.(25,28)	50 yr.(34)	F (29)	21
Master Shield	Tradesman	---	Lifetime(26)	Nonprorated	None	Not Covered	F (29)	13
Master Shield	Victorian	---	50 yr.	Nonprorated	50 yr.(25,28)	50 yr.(34)	F (29)	21
Mastic	T-Lok	---	50 yr.	Nonprorated	50 yr.(25)	Not Covered	F (29)	
Republic	Vina Clad	---	50 yr.	Nonprorated	None	8 NBS/10 yr.	F (29)	21
Revere	---	---	50 yr.	Nonprorated	50 yr.(25)	Not Covered	F (29)	
Reynolds Alum.	American Classic	---	50 yr.	Nonprorated	50 yr.(25)	50 yr.(34)	F (29)	21
Variform	Cedar Select	---	50 yr.	Nonprorated	50 yr.(25)	Not Covered	F (29)	
Variform	No Frills	---	50 yr.	Nonprorated	50 yr.(25)	Not Covered	F (30)	28
Variform	Varigrain	---	50 yr.	Nonprorated	50 yr.(25)	Not Covered	F (29)	
Vipco	Ambassador	---	50 yr.	Nonprorated	50 yr.(25)	50 yr.(34)	F (29)	21
Wolverine	Camelot	---	50 yr.	Nonprorated	50 yr.(25)	8 NBS/5 yr.	F (29)	21
Wolverine	Restoration	---	Lifetime(26)	Nonprorated	Lifetime(25)	8 NBS/5 yr.	F (29)	21
Wolverine	Vinal-side	---	50 yr.	Nonprorated	50 yr.(25)	8 NBS/5 yr.	F (29)	21

Table 2 (Cont'd)

A. Meets requirements of AAMA 1402.3-82.
B. Meets requirements of ANSI A135.6-1984.
C. Factory finish-coated or laminated 0.017-in.-thick, galvanized steel conforming to ASTM A-526, G-90 coating.
D. Factory finish-coated galvanized steel conforming to ASTM A-526,G-60 coating.
E. Product literature does not indicate galvanized steel. However, factory representative claims product is factory finish-coated galvanized steel conforming to ASTM A-526,G-60 coating.
F. Meets requirements of ASTM D-3679.
1. Available with aluminum substrate 0.024 in. thick.
2. Available with aluminum substrate 0.019 in. thick.
3. Available with aluminum substrate 0.019 or 0.024 in. thick.
4. Available with aluminum substrate 0.019 in. thick, fiberboard back.
5. Available with aluminum substrate 0.024 in. thick, fiberboard back.
6. Available only in white.
7. Other substrate thicknesses available on special order.
8. No standard industry or commercial specifications currently available.
9. Warranty is for 40 years if installed on Government property.
10. Will not perforate when subjected to hail.
11. Not to be used within 1 mile of saltwater.
12. E represents Hunter units rather than HBS units.
13. First 3 years will repair/replace defective side panels, thereafter will repair/replace defective panels after owner pays $100.
14. Warranty applies to installations in continental United States.
15. Chalking will not exceed a numerical rating of 8 in 10 years as measured by ASTM D-659.
16. Chalking will not exceed a numerical rating of 8 in 20 years as measured by ASTM D-659.
17. Hail damage prorated over life of warranty.
18. Service fee ($100) applies to warranty repair due to hail damage.
19. Panels only, no clapboard.
20. Aluminum laminated to plywood backing.
21. Fading due to manufacturing defects only.
22. Substitute is guaranteed for 25 years against defects in material checking, chipping, cracking, delamination, and splitting.
23. Liability limited to two times purchase price of affected siding.
24. Property owner pays first $200 for each incident of hail damage.
25. Hail damage, replacement of damaged siding panels only (no labor).
26. Warranty is for 50 years if installed on Government property.
27. Warranty as applied to Governmental entities.
28. Warranty covers materials only.
29. Wall thickness equal to or greater than 0.040 in.
30. Wall thickness is a nominal 0.037 in.
31. Painting of siding voids warranty.
32. Tedlar laminate.
33. Warranty covers deterioration from wind-blown sand.
34. Fading is warranted only when due to material or manufacturing defects. No criteria are given as to what constitutes fading or how to measure.

changed already, as some manufacturers not making siding materials that meet the required criteria stated they may be doing so in the near future. In addition, new products meeting the requirements may become available while current products (or manufacturers) may become defunct.

Conditional Warranties

The comparison in Table 2 shows warranty conditions to vary among products and manufacturers. Moreover, the different warranties sometimes have special qualifications, so that careful attention should be given to the table's footnotes. The warranties are also subject to constant change. The aluminum, steel, and vinyl manufacturers, in particular, represent a large residing market whose advertising is directed toward the homeowner consumer. As one manufacturer changes its warranty to be more appealing to the consumer, the competition soon follows. Some manufacturers now offer "lifetime" warranties, though most of these revert to a 50-year warranty for materials being purchased by Government agencies. Some manufacturers also give prorated warranties. That is, the warranty period may be for 30 years, but in most prorated warranties reviewed, the manufacturer's product liability decreases rapidly after the first 3 years. By 15 years, manufacturer liability may be less than 35 percent. The 30-year warranty life is therefore deceptive. When a given material is being considered for use, its warranty should be read in great detail to learn the limitations.

Finish Warranties

Almost all the materials reviewed have a finish guaranteed for a stated time period against cracking, chipping, crazing, blistering, flaking, peeling, erosion, and substrate failure due to manufacturer's defects. However, only a few siding manufacturers make any warranty claims for fading (usually by passing along any warranty the finish material's manufacturer has given to them). Even when a warranty on fading is given, the limits often are so great that repainting may be necessary or desired before the minimum 15 year period has expired. Furthermore, most of these manufacturers state that routine maintenance, such as repair of damaged finish and/or substrate and at least yearly cleaning of the siding by washing, must be performed for the warranty to remain valid.

All siding materials reviewed can fade when exposed to natural weathering. The severity of the exposure depends on the structure's geographic location as well as which direction a particular wall is facing. However, several manufacturers state their sidings are warranted for fading due to manufacturing defects only and not due to natural weathering.

Current turnkey procurement specifications require a finish guaranteed against fade not to exceed 10 NBS units in 10 years. It is beyond the scope of this study to present detailed color theory,[7] but in most cases, even a 5 NBS unit color change is seen as a major difference to the average viewer,

[7] F. W. Billmeyer and M. Saltzman, Principles of Color Technology (John Wiley and Sons, New York, 1981).

with visual differences often depending on the particular color. A source illustrating color differences due to fading for various colors is also available.[8]

Uniform color change over the entire structure is the most important aspect of fading. A uniform fading of 10 NBS units over a long time may go virtually undetected; however, if the finish under the roof overhang or the window air conditioner is only 5 NBS units different from the rest of the wall, the difference will be very obvious for most colors.

[8] Visual Examples of Measured Color Difference (National Coil Coaters Association, 1972). (It must be noted that the color changes given in this book are in Hunter units. The Hunter unit is an approximation of the NBS unit and, in many cases, closely approximates the NBS unit. In other cases, it can differ greatly. There is no constant conversion factor for converting from one unit to another.)

3 TYPES OF SIDING MATERIALS

Table 2 in Chapter 2 shows four basic types of residential siding materials that meet a low-maintenance requirement: factory-finished aluminum, hardboard, steel, and vinyl.

Aluminum

Residential siding made of aluminum has been marketed for many years and is available in a variety of finish materials. Manufacturers offer both clapboard and board-and-batten panel styles. An embossed woodgrain look has come into demand recently. Aluminum siding is available in various thicknesses, with 0.019 and 0.024-in. varieties being the most popular. These sidings are made with various aluminum alloys and heat treatments in attempts to increase dent resistance. Some manufacturers also offer a fiberboard-backed siding to increase denting resistance. A specification that applies to aluminum siding is Architectural Aluminum Manufacturers Association Specification AAMA 1402.3-82, Voluntary Specifications for Aluminum Siding.

Hardboard

Hardboard siding is manufactured essentially by shaping pulverized wood under heat and pressure into medium- to high-density boards or panels. Manufacturers offer hardboard siding with or without factory-applied prime and finish coats. Both smooth and imitation wood grain surface textures are available. American National Standards Institute (ANSI) Standard A135.6-1973, Hardboard Siding, is an applicable specification.

Steel

Steel siding materials have been gaining increased popularity. As with aluminum, steel siding is available in a variety of surface finishes and textures. Both clapboard and board-and-batten panel styles are available, with 0.017-in. (29-gage) galvanized steel commonly used as substrate. At present, no commercial or industry standards have been approved for residential steel sidings. The following general requirements can be used: the siding material shall be a minimum of 0.017 in. thick (29 gage), zinc-coated steel conforming to an ASTM A-526, G-90 coating. Siding panels shall be formed to provide full-length edge interlock so that, after installation, fasteners will be concealed from view. Siding shall be pretreated and either factory-primed and finish-painted or factory-laminated with a weather-resistant polymer film. When tested for 500 hr in accordance with ASTM B-117, the siding finish shall show no signs of cracking, blistering, peeling or significant color change and shall show no loss of adhesion from the metal more than 1/16 in. beyond a line scratched or scribed through the coating. Siding shall be erected in strict accordance with manufacturers' recommendations. Steel siding should not be installed within one mile of open saltwater or in other highly corrosive atmospheres. Steel siding materials shall be separated from aluminum surfaces with a coating of bituminous paint or asphalt varnish.

Vinyl

Through advances in quality, solid vinyl siding now represents a substantial part of the residential siding market, particularly for re-siding. The material can be formed to resemble various items such as brick, stone or wood. Clapboard and board-and-batten panel styles are available. Vinyl siding is available mainly in pastel colors, with only a few companies offering dark colors. Proper material compounding is important for optimal performance. A specification for vinyl siding is American Standards for Testing and Materials (ASTM) Standard D-3679, Rigid Poly (Vinyl Chloride) (PVC) Siding.

Comparison of Advantages and Disadvantages

Each material has advantages, disadvantages, and other items to consider before selection, as summarized in Table 3. One important consideration is cost. In general, the installed price of steel siding is slightly more than aluminum siding; aluminum is about the same as vinyl siding; and all are greater than hardboard siding. Specific comparisons may differ depending on the material's quality--usually a function of substrate thickness and finish type applied. Changes in raw material costs over time also could greatly change the relative cost of sidings.

Aluminum

Advantages. One major advantage with aluminum siding is that it requires little maintenance--just an occasional washing to clean the surface. Premium-finished aluminum sidings are long lasting and durable. In addition, aluminum corrosion products do not cause the orange-red staining possible with steel. Aluminum siding is immune to termites and other vermin, will not rot, and is fire-resistant.

Disadvantages. Probably the greatest disadvantage of aluminum is that it dents easily. Baseballs, golf balls, stones, sticks, hail, and other hard objects that strike the siding can produce permanent indentations. Even the end of a ladder resting against the siding can cause dents. The 0.024-in.-thick siding may better resist denting. Also, some manufacturers claim special treatments make their siding stronger than steel and thus more resistant to denting (to be discussed further in the next chapter).

Another drawback is that aluminum siding can conduct noise so that sound from rain, wind, or hail may seem louder to occupants than if a nonmetallic siding were used. Foam insulating backers dropped behind the siding during installation can help minimize this effect. Aluminum siding may interfere with television reception when indoor antennas are used. Also, metallic siding is conductive and must be grounded.

Hardboard

Advantages. Hardboard siding resists denting and does not conduct noise as can metallic sidings. Hardboard does not corrode and it undergoes little

Table 3

Comparison of Siding Advantages and Disadvantages

	Aluminum	Hardboard	Steel	Vinyl
Typical finish	Vinyl, acrylic, or polyester enamels	Water-borne acrylic	Vinyl	Except for a few, color is integral[1]
Relative installed costs[2]	Medium	Lowest	Highest	Medium
Usual warranty life[3]	30-lifetime	15-25	40-lifetime	40-lifetime
Relative weight	Very light	Heavy	Light	Very light
Typical material thickness	0.019-0.024 in.	.437 in.	0.0172 in. (29 gage)	0.040 in.
Relative expansion or contraction	High	Low	Medium	Very high
Moisture resistance	Excellent	Fair	Excellent	Excellent
Relative resistance to denting	Fair	Excellent	Good	Excellent
Possible corrosion	Yes	No	Yes	No
Noiseless	No	Yes	No	Yes
Immune to termites and other vermin	Yes	No	Yes	Yes
Fire-resistant	Yes	No	Yes	Self extinguishing, but can smolder and emit toxic fumes
Electrically conductive	Yes	No	Yes	No
Repaint if necessary or desired	Yes	Yes	Yes	Not recommended

[1] At least one manufacturer laminates the siding with a Tedlar film.
[2] Specific comparisons may differ depending on the qualities of the material--usually a function of the substrate and/or the type of finish applied.
[3] All warranties are limited and specific coverages can differ greatly from one another. Most lifetime warranties revert to 50 years when the siding is being purchased for use on a Government-owned structure.

thermal expansion. Since hardboard is electrically nonconductive, it requires no grounding.

Disadvantages. Hardboard can rot if exposed to extreme wetness. (No siding material should be used below grade. The first course must be at least 6 in. from the ground.) Improper nailing, e.g., when the nail is set below the siding surface, can cause the siding to deteriorate from moisture penetration which causes swelling and delamination. Hardboard can burn and is not immune to termites and other wood-damaging vermin. Once the factory finish has deteriorated, repainting will be necessary about as often as with regular wood siding.

Another disadvantage of the hardboard product in this study is that it is available as clapboard only and not as panel siding. (Factory-finished hardboard panel siding from the same and other manufacturers have only a maximum 5-year warranty on the finish.)

Steel

Advantages. Steel siding manufacturers claim this material is more dent-resistant than aluminum siding (see the next chapter, as some aluminum manufacturers refute this) and therefore, is less prone to damage upon impact. As with aluminum siding, premium finished steel is very durable and relatively maintenance-free. Steel siding also is immune to termites and other vermin, will not rot, and is fire-resistant.

Disadvantages. Under certain conditions, steel siding can rust. Therefore, scratches or gouges made through the finish to the bare steel must be repaired quickly. Field cut edges are a point of possible corrosion. (Manufacturers claim this is minimized by cutting the siding properly--it must be sheared instead of sawed. Shearing supposedly makes the zinc galvanizing (and to some degree, the finish coating) flow around and protect the cut edge. Most manufacturers recommend that steel siding not be used within 1 mile of an open body of seawater or in other highly corrosive atmospheres.

As with aluminum, steel siding can conduct noise, but foam insulating backers may help minimize this effect. Steel siding also may interfere with television reception and because it is conductive, it must be grounded.

Vinyl

Advantages. Most vinyl sidings are solid-colored materials and, therefore tend not to show scratches and cuts. (Some vinyl sidings have laminated or coextruded finishes; however, the substrate vinyl usually is the same or a similar color.) The solid color also means no repainting is needed. However, with some colors, fading may be so severe that "recoloring" would be desirable.

Vinyl siding is immune to termites and other vermin and will not rot. It is electrically nonconductive and need not be grounded. Also, vinyl is a poor conductor of noise, making it quieter than most metallic sidings.

Disadvantages. Vinyl siding undergoes the greatest thermal expansion and contraction of the materials reviewed. This property presents several draw-

backs to vinyl siding use. Great care must be exercised during installation to allow for expansion and contraction, and further allowances must be made when installing in very hot or very cold weather to compensate for the extremes. The panel must be installed to move freely; otherwise, it may develop a series of periodically repeating waves called "oil canning." (Critical installation procedures will be discussed further in Chapter 5.) Because it is difficult to make these allowances with vinyl fascia covers, most manufacturers do not produce them. Instead, aluminum coil stock coated the same color as the vinyl generally is used for fascia and trim. Moreover, since dark colors can absorb more heat and cause oil canning or other permanent distortion, many manufacturers offer vinyl siding only in pastels. (Some manufacturers have been experimenting with coextrusion or laminates to help overcome this problem.) Painting of vinyl is also not recommended because of vinyl's great expansion and contraction. If a color change is desired or fading becomes unacceptable, it is best to replace the material.

Under certain conditions, such as a sharp blow during very cold weather, vinyl can crack. Storms causing sudden temperature drops and hail have been known to damage vinyl siding severely.* This problem can be controlled to some extent by formulating the vinyl properly. Also, although vinyl is not combustible, it can smolder and emit toxic gases in a fire. Vinyl siding can melt or become distorted if a heat source such as burning leaves or a hot charcoal grill is too near the structure.

Comparison of Manufacturers' Performance Claims

Most manufacturers of the various materials make claims emphasizing the advantages just discussed. Information in this section was taken from manufacturer's literature or personal conversations. Laboratory testing was not performed to substantiate any claim made.

Aluminum

Alcan Building Products. Alcan claims that last year more homes were remodeled with Alcan aluminum siding than any other brand of aluminum siding. The clapboard panels have a 5/8-in. base compared to a 1/2-in. base for other brands. This is supposed to provide greater strength and deeper, more attractive shadow lines. In contrast to some brands, vents in the clapboard panel base are lanced rather than punched, and are spaced 16 in. instead of 30 to 32 in. apart. This allegedly provides more thorough air circulation and reliable moisture drainage.

Alcoa Building Products. Alcoa's Alumalure 2000 finish supposedly resists chalking, fading, and erosion better than any other type of finish for residential siding that this company has tested. Alcoa's literature shows several comparison tests for corrosion exposure, color retention, mildew resistance, and chalking. The Alumalure 2000 finish was found superior in each case. The Super 40 treatment to the aluminum is claimed to give Alcoa siding extra strength and rigidity.

*The U.S. Air Force Strategic Air Command forbids the use of vinyl siding on its installations because of past problems with hail damage.

Alsco. This company claims to be the only manufacturer using Tedlar laminates over 20 years. Its success with Tedlar laminates is said to result from a patented process for laminating the material to various substrates, which was developed in cooperation with DuPont.

Alsco also claims the fluorocarbon finish on its "Ultimate" siding will outperform polyvinyl chloride (PVC) finishes in three important areas: (1) won't trap dirt or support mildew growth like PVC's porous surface can, (2) more resistant to chemical corrosion, chalking and fading than PVC, and (3) carries a Class A fire rating compared to PVC's Class B fire rating.

Aluminum Industries. This manufacturer states its 0.024-in.-thick SPEC II strain-hardened aluminum alloy material used for siding averages 46 percent stronger than the 0.0172-in. steel siding tested. Impact tests conducted by an independent laboratory are said to confirm this product's impact resistance.

Hastings Aluminum Products. Hastings claims to use silicone coatings for long color retention.

Modern Materials Corporation. This company claims to have pioneered the two-coat waterborne acrylic finish for aluminum siding. This coating is applied in a five-stage process. Modern Materials also states its coating system exceeds the performance of conventional solvent coatings for durability, weathering ability, toughness, and flexibility. The results given show better color retention, and chalk, corrosion, mildew, and mar resistance than conventional solvent coatings.

Republic Building Products. Republic claims that all its aluminum siding is made of special aluminum alloys tempered to a super-tough H-19 hardness for strength and durability.

Revere Aluminum Building Products. This company uses a roller coating process on its aluminum and steel siding. Revere alleges that roller coating is better than spray-applied coatings because the rolled coating is thicker, more flexible, and chip-resistant.

Reynolds Aluminum. Reynolds states in a comparison chart of properties that aluminum and steel siding will not interfere with television reception. In the same literature, this company claims that aluminum and steel siding need not be grounded.

Weyerhauser Company. Weyerhauser's Panel 15 is classified as aluminum siding because the finish substrate is aluminum. This product is different from all other aluminum siding materials reviewed, however, because the aluminum is laminated onto plywood backing. It is a combination exterior siding and structural sheathing available in panel form only--no clapboard. Weyerhauser claims Panel 15, with its stucco texture and matte finish, minimizes the effect of abrasions that would dent standard aluminum siding. Weyerhauser also states that a permanent thermoset bond between the aluminum skin and plywood core makes the siding exceptionally stable in both length and width. Changes in temperature and humidity should cause little dimensional change.

Steel

Alsco, Incorporated. See comments on Alsco aluminum sidings.

Alside, Incorporated. Alside does not warranty its Super Steel siding against fading. The manufacturer's representative for Government projects stated Alside could modify the warranty to include fading, if necessary.

Alside claims to provide full support to designer-architects, specifiers, purchasing officers, contractor-installers and inspectors. Alside steel siding is used on several military installations.

Alside also manufactures aluminum, fiberglass, and vinyl siding materials. However, the representative reported vinyl-coated steel to be the best value, and therefore submitted no detailed information about Alside's other products. Alside apparently will not bid on vinyl siding jobs for the Army.

Alside claims its Strata Wall System, consisting of the siding and complementary total wall insulation, provides high insulative qualities. Alside can design the entire outer wall. Furthermore, Alside alleges that because it does not polymer-coat the siding's panel interlock areas, no special grounding strap is needed to provide electrical continuity (this finish is applied using electrostatic spray techniques).

Revere Aluminum Building Products. Revere markets aluminum, steel, and vinyl sidings. This company says it will provide full support toward designing, specifying, and installing its materials.

Revere roller-coats metal coil stock, cures the coating, and then forms the panel. The roller-coated finish is said to be several times thicker than other finishes, making it more weather-resistant and durable than those finishes.

Republic Building Products. Republic's product literature for Steel Shield contains no indication that this company uses galvanized steel as the substrate. However, a Republic representative claims the substrate is a factory-finished coated galvanized steel conforming to an ASTM A-526, G-60 coating.

Vynasteel Corporation. Vynasteel stated it would meet any competitor's warranty and would not want its product to be rejected on the face of the warranty available to the general consumer. Vynasteel also says it will warranty to specifics of the job.

Vynasteel claims in one brochure that its steel siding is twice as strong as aluminum with a steel yield test of 40,000 psi and aluminum yield test of 18,000 psi. Another brochure states its steel siding is 2.5 times as strong as aluminum with steel yield tests of 50,000 psi. The information in these two brochures is inconsistent; however, no specifics were given about material thicknesses, type of alloys, or any heat treatments in either case.

Vinyl

Alcan Building Products. Alcan claims the formula for its solid vinyl siding provides an extremely flexible material and allows the siding to receive the necessary bends and deep embossing without cracking during manufacture.

Alcan's vinyl siding supposedly has a deeper butt edge than most sidings. In addition, its panel lock design is purported to help the installer align and lap each panel properly.

Alsco. ASTM D-3679 for vinyl siding specifies a minimum wall thickness of 0.035 in. Alsco claims, however, that siding performance depends on the wall thickness and that a 0.040-in. wall thickness should be considered minimum. (The vinyl siding products of all but one manufacturer surveyed have wall thicknesses equal to or greater than 0.040 in.)

Master Shield. Master Shield states than when and how compounding ingredients are mixed can affect vinyl siding performance. This company claims that, through an exclusive process, its vinyl raw materials are blended better and thereby produce a better quality siding with uniform properties.

Master Shield also claims its vinyl siding has better impact resistance than other vinyl sidings (typically a minimum of 0.04 in. thick). The resistance to fracturing supposedly is 48 percent greater than 0.017-in.-thick steel and 69 percent greater than 0.019-in.-thick aluminum. In addition, through even-heat postforming, Master Shield alleges its product receives a more even gloss, more uniform durability, and better weathering than other vinyl siding materials.

Reynolds Aluminum. Reynolds claims its vinyl siding is heavier and more durable than other types of solid vinyl siding. With eight colors available, Reynolds also claims to have a wider selection than other brands. (Four to six different colors is common.)

Variform. Because of its manufacturing process (a patent-pending wrinkle design), Variform claims its Cedar Select has more rigidity and greater strength than any other vinyl siding on the market.

Variform also claims that its "No Frills" vinyl siding with an average 0.037-in. wall thickness will perform as well as other vinyl sidings that have a 0.040-in. or greater wall thickness. This company alleges its quality control is better than most and, therefore, wall thickness requirements do not have to be set for 0.040 in. or greater to stay within the 0.035-in. minimum as required by ASTM D-3679.

4 FIELD EVALUATIONS OF SIDING MATERIAL

Nonmilitary Sites

The Springfield, IL, area was visited in December 1983 to view various residential siding materials as placed on nonmilitary homes and other buildings.* Aluminum, steel, and vinyl materials were observed. Some sidings were relatively new whereas others were at least 15 years old.

Old and new aluminum sidings manufactured by Alsco were examined. All of these homes were in excellent condition. Although some had an acrylic finish, most of the siding observed was a Tedlar-laminated material that appears to weather very well, in agreement with the manufacturer's claims.**

Two houses with steel siding were inspected. Little information was available on these sidings--the manufacturers and the exact age of the materials were unknown. The one house was rusting very badly with appreciable loss of material in some places (Figure 1). It could not be determined if the steel was originally galvanized; the siding had been repainted. The other steel-sided house looked fine. It was learned that the owner had had some rust streaks on the walls but apparently had taken steps to remove the stains.

One vinyl-sided home observed was at least 15 years old. The siding was white and had little chalking. The vinyl's flexibility seemed to still be very good (at a temperature below 32°F). The structure's overall appearance was excellent. The manufacturer of the siding was thought to be either Mastic or Bird Incorporated. Some more recently vinyl-sided homes also were inspected, and most had an excellent appearance. However, a few showed oil canning, mainly the result of the siding having been nailed to the substrate too tightly (Figure 2). One new siding job was an example of very poor application, as oil canning was present everywhere. One place on the front of the house had a 1/2- to 1-in. gap showing where the siding had been overlapped improperly (Figure 3).

At one location, a contractor was blowing insulation into the walls of a home that had vinyl siding. To access the wall cavity, a single course of clapboard panels had been removed around the house. (This was done by unhooking a panel from the one below it and then unhooking the panel just above to expose the nails.) From an overall look at the house, color fading was not very obvious. However, if a removed panel was taken around the corner to another wall, the difference in color was very noticeable. This difference also was evident from lifting up the siding at lap joint areas and comparing it to the siding usually unexposed to weather and sunlight (Figure 4). The siding is yellow with approximately 5 years' exposure.

A commercial building with a yellow vinyl siding between 5 and 10 years old was also examined. Close examination showed it had faded greatly from its original color. Some chalking also was evident, but the color did not change much when the chalk was rubbed off.

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*The site visit was arranged by an Alsco Anaconda representative.
**"Tedlar" is a DuPont tradename for a polyvinyl fluoride film.

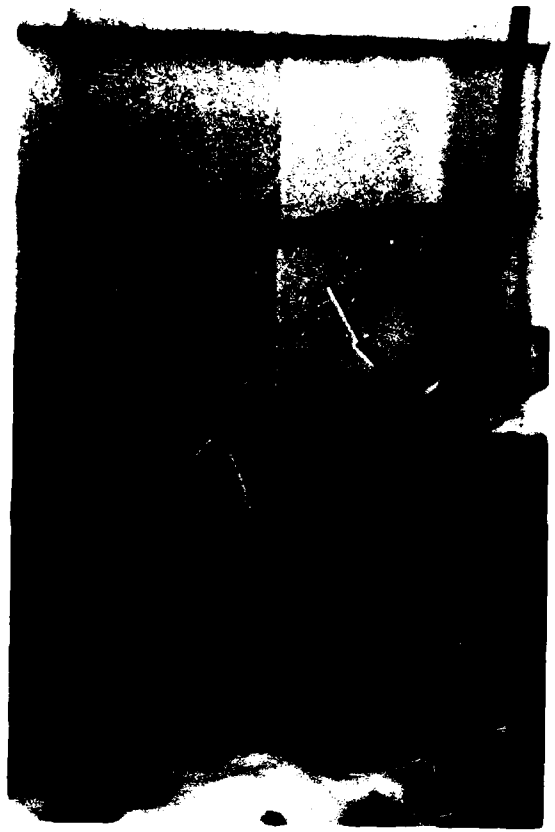

Figure 1. Corroded steel siding at entrance door stoop. Corrosion also is present on the rest of the house but may be exaggerated in this case through the use of de-icing salts. Age of the siding is unknown.

Figure 2. Oil canning on vinyl siding.

Figure 3. Improperly overlapped vinyl siding.

Figure 4. Fading of vinyl siding. The difference in color became obvious when the lap joint was lifted.

During the field visit, some installation problems were noted with aluminum, steel, and vinyl siding materials. (Critical application procedures will be discussed further in Chapter 5.) Of the three materials, vinyl siding requires the most careful installation because it can undergo the greatest expansion and contraction. The applied siding's dimensions must compensate for temperature extremes at that location. Vinyl siding probably is the most difficult to install and is best applied by experienced applicators; it does not lend itself to the average do-it-yourselfer. With all three types, it is best not to space nails farther apart than 24 in. on-center (most installation instructions specify 16 in. on-center). When possible, nails should be driven into the stud. The overlap should be directed away from most traffic flow and the entrance. Also, the overlap direction should not be mixed on a given wall.

Military Sites

Fort Hood, TX

Fort Hood, TX was visited to view some hardboard siding that was reportedly failing badly. This siding is a reverse board-and-batten style called "Insulite" and is manufactured by Boise Cascade. The manufacturer's warranty on the material is 5 years. The siding inspected was in very poor condition, with much swelling, warping, and delamination (Figures 5 through 8). It is literally popping off the wall.

The housing area where this material was used, Commanche III, consists of 900 units. Construction was finished around 1976 or 1977, so it took less than 4 years for the siding to fail.* Fort Hood is having some housing units re-sided with steel siding manufactured by Alside. Most of the steel siding being installed is white with colors used for small accent areas. White was chosen to minimize fading problems--particularly important if damaged panels should need replacing. The colored siding is being used mostly in areas higher off the ground where damage is less likely to occur.

Fort Hood's Commanche II housing area has 113 units with a combination of hardboard siding and brick. The hardboard is a variety of Masonite's X-90 sidings, which have a 5-year warranty on the finish. These units were constructed about 1975 and were repainted in 1982. Some of the siding was placed closer than 6 in. to grade and is soft and deteriorating because of dampness. The siding also was pulling away from the wall at some gable ends.

The siding on the Commanche I family housing units is Masonite's Color-Lok. Construction was completed on these units around 1974 and the siding has not been repainted or otherwise maintained since then. The overall appearance of the units is very good; however, closer examination of the siding showed some swelling along the bottom edge of the clapboard. The amount of swelling

*The purpose of this inspection was not to do a detailed failure analysis but to observe possible material problems. The failure analysis has been documented earlier by an NBS official reporting to the Corps.

Figure 5. Failed hardboard siding at the Commanche III Housing Area, Fort Hood, TX.

Figure 6. Closer detail of failed hardboard to show buckling and warping.

Figure 7. Another type of hardboard failure at Fort Hood. The hardboard finish has peeled off.

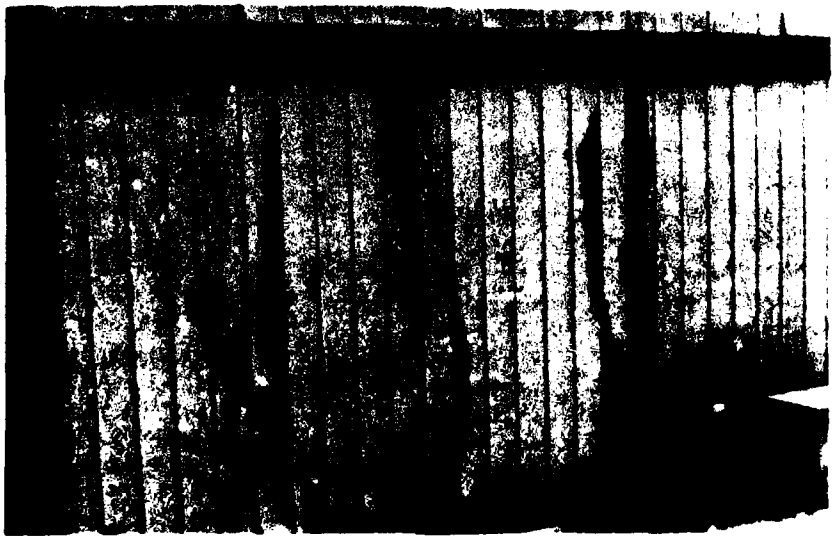

Figure 8. Advanced stages of finish peeling off hardboard siding. Buckling and warping are also evident.

seemed to differ depending on the degree of weather exposure on a particular wall or side. The finish also is somewhat cracked and split approximately 1-1/2 to 2 in. up from the bottom edge and extending horizontally along the siding. This is about the same distance from the bottom edge as the plastic panel-locking device on the panel's backside. Chalking on one gray panel gave a rate of approximately 4 by ASTM Test Method D-659[9] (the greater the chalking the lower the number on a scale of 0 to 10).

The housing units visited in Montaque Village were built in 1949 and renovated in 1976. The siding appears to be a medium density wood fiber composition board made to resemble shake siding. The dark brown finish on some of the housing units is almost entirely gone, exposing the fibrous substrate, and thick paint is peeling from the wood trim. The lighter colored siding of the same type is performing reasonably well. The manufacturer of this siding was not established.

The family housing units in Venable Village were constructed in 1969 and have a hardboard siding. The overall appearance of the housing area is excellent, with the siding performing very well considering there has been no maintenance since it was installed. Even where the finish has been punctured or gouged away, the exposed hardboard substrate is not swelling or otherwise noticeably deteriorating. However, the finish is heavily chalking with a reading of 2 or less by ASTM Method D-659, and the siding should be repainted soon. Again, the manufacturer was not determined.

The housing units in Walker Village had had siding rehabilitation between 1977 and 1982. Seven types of Masonite brand siding were used. The siding was preprimed and finish-coated after installation. Much of the siding is reverse board-and-batten design similar to the Insulite material used at Commanche III, except that the vertical grooves are not as deep. Although nothing like the problem at Commanche III, there is some swelling around the nails on certain units. On other units, no swelling is visible.

Fort Drum, NY

Fort Drum was visited to inspect 14-year-old hardboard siding in Fort Drum's family housing units. The Boise Cascade Color-Side was used in the 8000 Housing Area. The siding is clapboard style without concealed nailing--that is, nails are exposed along the lower face of the clapboard. Swelling is present along the bottom edge of the siding on all units inspected (Figure 9). The swelling is worse closer to the ground, especially in areas where water can splash onto the siding or snow can be piled up against the wall for lengthy periods (Figure 10). The Color-Side finish is also badly faded (Figure 11), although it must be remembered that the siding is 14 years old. It is most noticeable where pieces of new siding were used to repair damaged areas. The siding definitely needs repainting. Proper surface preparation, priming, and topcoating will help protect the siding from further rapid deterioration.

[9]ASTM D-659-80, Evaluating Degree of Chalking of Exterior Paints (American Society for Testing and Materials, 1983 Index).

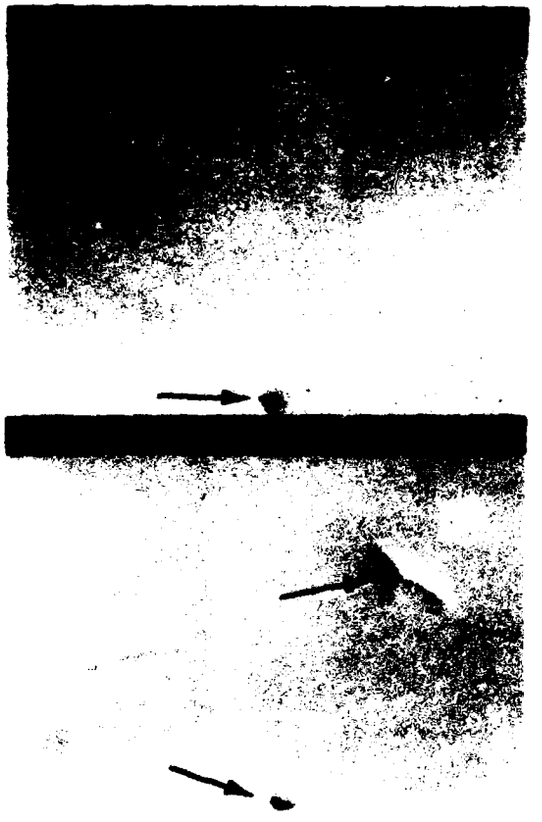

Figure 9. Swelling of lower edge of hardboard siding. The swelling is so extreme that nails appear to be countersunk. Also, a break in the finish has allowed the substrate underneath to swell.

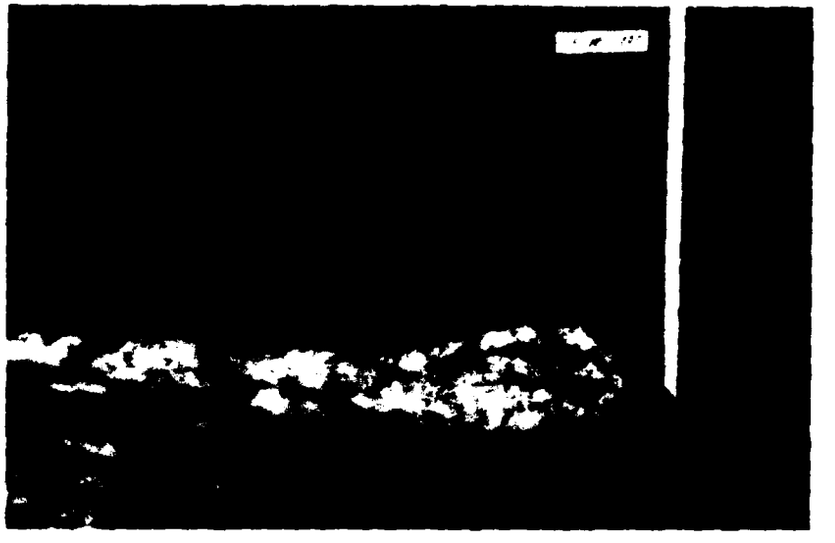

Figure 10. Snow piled against hardboard siding can cause deterioration.

Figure 11. Fading and chipping of hardboard siding. The degree of fading is obvious by comparing the surface previously covered by a cornerpiece with the rest of the panel.

In the 9000 Housing Area constructed during summer 1983, Masonite's Color-Lok siding was used. The units are mostly brick with the hardboard used in the gable ends and other accent areas (Figure 12). Some of the siding on the gable ends seems to have buckled away from the substrate wall. Most of it is not bad, with just a little waviness to the wall. However, one butt joint on a gable end exposed to the sun is pulled away at least an inch from the wall (Figure 13). Possible causes of this buckling are (1) not using enough nails (e.g., nailing farther apart than 16 in. on-center), (2) nailing into the wrong substrate material (e.g., foam insulating board instead of sound wood), (3) nailing too hard, thereby crushing any foam insulating sheathing material, and (4) leaving a joint gap too small for expansion (e.g., forcing a slightly longer than needed piece into place) (see Chapter 5, Critical Installation Procedures).

The Post Commander's house was also observed. This house had been re-sided with a white vinyl siding approximately 2 years ago and is in excellent condition. The manufacturer of the siding is unknown. The installation appeared to be very well done.

Fort Drum's location presents a very harsh environment for many siding materials, with great temperature extremes between winter and summer. The area typically receives a lot of moisture as weather fronts move across Lake Erie. In addition, snow can be piled up against the structures for many weeks at a time.

Fort Devens, MA

Fort Devens has installed much vinyl siding over the last 5 years. Vinyl siding was used to re-side barracks, office buildings, warehouses, and family

Figure 12. Successful brick and hardboard application at Fort Drum, NY.

Figure 13. Buckled hardboard siding on family housing at Fort Drum, NY.

housing units. Most of the siding is white, and the general appearance is excellent. The buildings look clean, bright, and pleasant. Overall, Fort Devens personnel seem very happy with this material.

Some walls of re-sided warehouses appear wavy; however, this is due to the substrate wall's unevenness. Due to the nature, age, and location of these warehouses, it was considered not worth the expense to level the walls. The real purpose of the siding was to eliminate the need for repainting.

A fading problem was noticed, particularly with a golden yellow siding material that was approximately 4 to 5 years old. One location using this color was Guest House T-3595, where the material has faded greatly in all areas normally exposed to the sun. The material protected by the roof overhang is much darker, and a color difference can also be seen by comparing one side of the structure to another. The most interesting point about this guest house is the fading around a large tree in the left side of the building front. When observed during winter when the leaves are gone, the outline (not a shadow) of the tree can be seen on the siding. The siding is not faded as much behind the tree since the leaves protect the siding from the sun during the summer when ultraviolet radiation is most intense. Vigorous rubbing of a faded area with a damp cloth produced no noticeable color rejuvenation. Light green- and beige-colored vinyl siding also had faded, although it was not as noticeable as with the golden yellow siding. To minimize fading effects, Fort Devens is now using white siding instead of colors.

Colored vinyl siding was also observed at Fort Devens' housing in the Boston area. The housing units are within a mile of the coastline. The siding is in excellent condition, but it is only 1 year old and would not be expected to have any problems.

Some vinyl siding is broken in places (Figure 14), although considering the amount used at Fort Devens, breakage is very minimal. Most breakage is around warehouse door openings and has occurred as vehicles or materials are run into the siding (Figure 15). Breakage could be lessened by framing the door with aluminum trim rather than removing the door framing and installing J trim right up to the opening. Fort Devens does not consider breakage to be much of a problem, however, because it happens so seldom and is easily repaired.

One building had had several courses of siding blown off during a wind storm (Figure 16), although this also was thought to be easy to repair. On some other buildings, the last piece of siding at the top of the wall had come loose from the finish trim; this may be due to improper crimping of the siding before it is slipped into the trim.

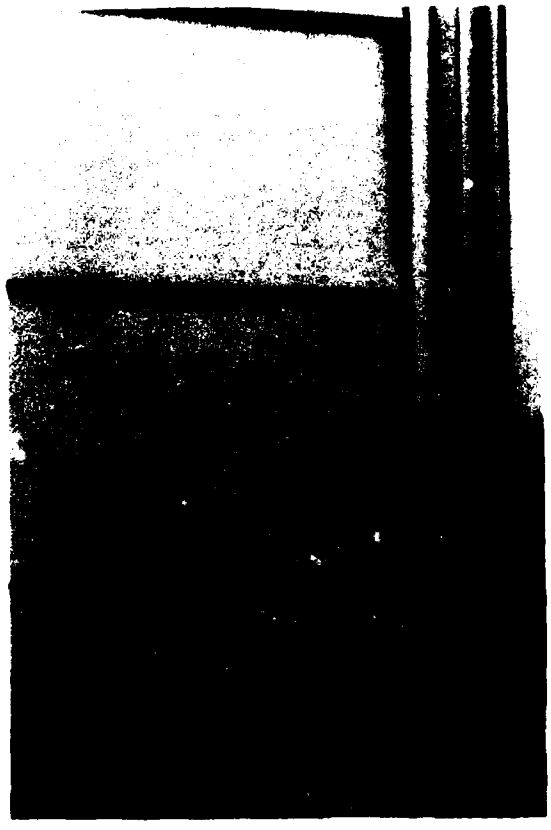

Figure 14. Damaged vinyl siding. A hole has been punctured and the door trim has been chipped at a much used entrance.

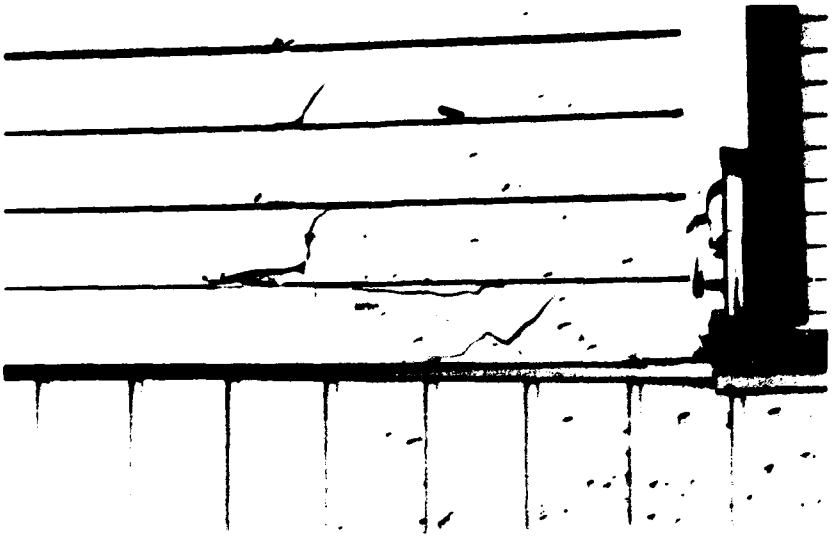

Figure 15. Damaged vinyl siding next to a warehouse cargo door at Fort Devens, MA. This example is not typical, but illustrates what can happen. (The small horizontal marks are mostly spattered paint.)

Figure 16. Wind-damaged vinyl siding at Fort Devens, MA.

5 CRITICAL INSTALLATION PROCEDURES

Proper installation is very important in meeting warranty conditions. Each manufacturer supplies a set of detailed installation instructions with its siding materials and, if they are not followed, the warranty usually can be voided. Although all the information in these instructions must be considered important, certain items were recognized in the course of this study as being critical. The construction inspectors should pay extra attention to these items to insure the contractor is following instructions. If any information in this chapter contradicts the manufacturer's written instructions for a siding, the manufacturer's method should prevail.

All Siding Materials

Combination foam insulation/sheathing panels are widely used. However, siding nailed into these materials only cannot be expected to hold. The nails must be placed into studs, underlying furring strips, or plywood sheathing. Also, the siding should not be nailed in a way that crushes the foam sheatning.

If at all possible, a lap joint (with aluminum, steel, or vinyl siding) or a butt joint (hardboard) should not be put directly above a window or door. This helps reduce the possibility of moisture damaging window or door operation.

The substrate wall or framing must be even. Uneven areas must be properly shimmed.

Aluminum

The application techniques for aluminum, steel and vinyl siding are essentially the same. As a general guide to installing aluminum siding, a booklet entitled Aluminum Siding Application Manual can be obtained from the Architectural Aluminum Manufacturers Association.* Important items to consider with aluminum are:

1. Panels must be "hung" on the wall--not nailed firmly to it. The nails must be placed through the center for the factory-slotted holes to allow the siding material to expand and contract.

2. With aluminum siding, aluminum nails must be used.

3. Nails should be every 16 in. on-center and must be driven straight--not at an angle.

4. Nails must penetrate into sound lumber. A 3/4-in. penetration into the house frame should be made with plain shank nails. A 1/2-inch penetration with screw shank nails is acceptable when nailing into plywood.

*AAMA, 35 East Wacker Drive, Chicago, IL 60601.

5. When possible, job cut ends should be hidden by lapping under factory cut ends.

6. Panel laps should face away from the direction of approach to the structure or away from the direction of the most traffic (human or vehicular).

7. The laps should be staggered by at least two courses to provide a better appearance and give the siding better overall strength.

8. A snap-lock punch must be used to crimp the siding for a tight lock into the undersill or finish trim. This helps insure the panel will not come loose at this point during high winds.

9. The tops and bottoms of inside and outside cornerposts must be closed to keep out moisture, insects, and small rodents.

10. Aluminum siding must not be attached directly to concrete or other masonry surfaces. Furring strips must be used to eliminate all direct contact.

Hardboard

The hardboard product in this survey has a concealed nailing system that minimizes the potential for moisture infiltration into the substrate hardboard. Still, the nails should not be set or overdriven, and the nail head should remain slightly above the surface of the siding. The nails must not be set below the siding surface. (This is true for all hardboard sidings unless the manufacturer specifies to the contrary.)

Other fastening problems include using too few nails and/or not nailing far enough into sound wood. Nails should be no more than 16 in. on-center and should penetrate a minimum of 1-1/2 in. into the framing member stud. When the siding is installed over foam insulation/sheathing, extra fastener length must be provided.

If underlying foam insulating/sheathing panels are being used, special care must be taken not to nail the siding in a way that crushes the foam. This can cause waviness on the wall and possible buckling in the future.

Steel

The criteria for steel siding are the same as for the aluminum, except that galvanized nails must be used instead of aluminum ones and steel siding materials must be separated from aluminum surfaces with a coating of bituminous paint or asphalt varnish.

Vinyl

As a general guide for installing vinyl siding, a booklet entitled Rigid Vinyl Siding Application can be obtained from the Vinyl Siding Institute, The Society of the Plastics Industry, Incorporated.* Another booklet, How to Install Vinyl Siding, is available from B. F. Goodrich Chemical Group.** (B. F. Goodrich Chemical does not make siding--only vinyl raw materials.) Although this booklet is short and presented like a comic book, it contains good information. The criteria for installing vinyl siding are much the same as for aluminum and steel siding. However, some procedures with vinyl can be more difficult than with aluminum or steel and must be given extra consideration.

First, because vinyl can undergo tremendous expansion and contraction, it is even more important than with aluminum and steel siding that it be "hung" on the wall and that the nails be placed in the center of the factory nailing slot. The panels also should not be stretched when nailing. When finished, the siding panels should be free to move back and forth on the nails (or up and down for vertical siding).

Furthermore, the expansion and contraction necessitate a 1/4-in. clearance where the siding butts up to corner posts, J channel, or other accessory pieces. If the siding is installed in freezing temperatures, a 3/8 in. minimum clearance must be allowed. Likewise, for extremely hot weather when the panels have been sitting in the sun, a full 1/4-in. allowance may not be necessary.

Aluminum nails are a better choice than galvanized nails since they reduce the chance of rust staining, particularly in corrosive locations where the zinc galvanizing could be consumed.

*SPI, 355 Lexington Ave., New York, NY 10017.
**B. F. Goodrich Chemical Group, 6100 Oak Tree Blvd., Cleveland, OH 44131.

6 STRUCTURE DESIGN

Design Criteria

Some points must be mentioned about design criteria that can affect siding material performance. First, the absence of a roof overhang and/or gutters can allow excessive moisture to infiltrate a wall, which can be a major contributor to premature failure of the siding or the entire wall. This type design should not be accepted. Money spent in future maintenance will outweigh that saved initially.

In addition, these siding materials are not meant to be used below grade. They must be installed a minimum of 6 in. above grade.

One manufacturer representative stated that a foil-faced surface should not be used directly under vinyl siding since it can let heat build up behind the panel. If the heat becomes too intense, the siding could have permanent distortion. Another manufacturer recommended that foam drop-in insulation panels not be used with vinyl siding since it may restrict the necessary panel movements during expansion and contraction.

Exposure conditions can vary greatly from one location to another. Since different materials can perform differently under various exposures, the proper material must be chosen for a given location. Examples are:

1. Steel and aluminum sidings should not be used near marine coastlines --usually not within 1 mile of open seawater. Hardboard or vinyl siding should be used.

2. Hardboard may not be the best choice for extremely damp, humid locations.

3. Vinyl siding may not be the best choice for locations that have frequent storms with rapid drops in temperature and hail.

Further specifics on design criteria are beyond the scope of this work. The best criteria may be to determine which siding performs and which type does not from experience recorded at each location.

Wall System

The entire wall system must also be considered, as the wall design criteria may need to be different for each type of siding material. For example, hardboard siding can add to the wall's structural integrity whereas vinyl siding provides no support. The different siding materials can also dictate different insulation requirements. Aluminum and steel sidings have no inherent insulative properties as they conduct heat and cold well. In contrast, hardboard can add to the wall's insulative value. Because so much allowance is necessary at corners and other trim pieces due to vinyl's expansion and contraction properties, and the siding is not calked at these locations, air infiltration behind the siding readily occurs. Thus, the substrate wall must provide the necessary insulation since the siding does not.

7 OTHER MATERIALS

Other residential siding materials are available besides the four types covered in this survey--for example, asbestos-cement, asphalt, fiberglass, and stone.

Asbestos-cement siding is available as a factory finished product. Although there is no real hazard when the material is intact, improper cutting or sawing could create a hazardous dust. (However, any hazard created by improper cutting should not affect anyone except the installer.) A major disadvantage of this material is that it is brittle and can be broken or cracked easily upon impact. The other sidings also may break, as noted earlier. Still, because of the general negative consensus on materials containing asbestos, asbestos-cement products were dropped from consideration in this study.

No manufacturers of asphaltic siding were located that offer a 15 year or greater warranty.

Some manufacturers are making siding from cut stone which should have excellent weathering performance. However, the cost of the stone is reported to be greater than that of bricks. Also, because of shipping charges, the use of the material far from the manufacturer's location would make the cost even more unacceptable. No literature was received from these companies.

Alside, Incorporated makes a fiberglass-reinforced plastic residential siding material, which is reported to be much more expensive than its steel siding. (Supposedly the fiberglass cost compares with that of bricks.) Too little information was received on this siding material to include it in the study.

Redwood and cedar siding should be considered for use on military housing. These materials will give excellent performance for many years with virtually no maintenance as long as they are not painted. Once painted, they must be treated as regular wood with periodic repainting. If a color finish is desired, a transparent oil stain can be applied. Staining is easier than painting and will not blister or peel like paint. Other wood products depend on a quality paint coating for durability against the elements. If a needed repainting job is put off, the wood can deteriorate. Redwood and cedar are quite durable with no coating, special treatment, or stain.

8 RECOMMENDED CHANGES TO SPECIFICATIONS

Five important conclusions were considered in developing recommendations to the specifications. These can be summarized as follows:

1. Brick and stucco are the preferred siding materials in accordance with the turnkey specifications. Fifteen-year maintenance-free siding materials should be specified if funding does not permit brick or stucco.

2. Standard commercial or industry specifications should be used when possible. Specification criteria for steel siding (for which no standard industry or commercial specification is available) need to be established.

3. The current "turnkey" procurement specifications require lap siding to be a maximum of 8 in. wide. Many manufacturers make siding materials that are greater than 8 in. wide but are formed to simulate multiple courses of less than 8 in. Examples are siding materials commonly called "double-five" and "triple-four." Current requirements should be changed to allow this option.

4. It is not considered necessary to require a warranty against hail damage, since hail damage at Army installations has not been a major problem. Furthermore, there is no uniformity among the warranties (if any) that manufacturers provide for hail damage. However, aluminum, steel, and vinyl sidings are probably more susceptible to sudden drops in temperature (storm front) and impact from hail than hardboard siding. Therefore, for locations that have frequent hailstorms, aluminum, steel, and vinyl sidings should not be selected unless the manufacturer provides a useful warranty against hail damage.

5. Aluminum siding currently cannot be specified for use below the second floor line of two-story structures. Several aluminum siding manufacturers claim their aluminum siding has an impact resistance as great as or greater than steel, and vinyl siding manufacturers claim excellent impact resistance as well. However, since all three of these materials (aluminum, steel, and vinyl) are more susceptible to impact damage than hardboard siding, they should be limited for use on second-story levels (or at least 6 ft above the finished grade). A combination first story brick or stucco and second story aluminum, steel or vinyl siding would be acceptable.

Based on these findings, changes can be recommended to the specifications for turnkey procurement of residential siding materials used on Army family housing. The current requirements used are given below for comparison:

Paragraph 5 under Paragraph 3.5.17, Exterior Finish Materials:

Factory prefinished siding with a 15-year warranty on the finish (lap siding limited to maximum 8-in. width). Prefinished aluminum siding with or without backing is not acceptable below the second floor line of two story structures.

Unless brick or stucco is provided, the siding shall be factory prefinished siding with a 15-year warranty on the finish (lap siding limited to maximum 8-in. width).

Paragraph 3.5.19, Finishes:

Paragraph 3.5.19. Exterior siding materials shall have the manufacturer's written guarantee that the finish shall not require maintenance to repair because of cracking, chipping, crazing, blistering, flaking, peeling or erosion of the original finish and against manufacturing defects for fifteen (15) years. Exterior material shall also be guaranteed against fade not to exceed 10 NBS units for ten (10) years. The installation of the siding, appurtenances and accessories will be made under the direct supervision of the manufacturer's representative.

Paragraph 3.5.19.1.1. Siding, appurtenances, and accessories shall be installed in accordance with the manufacturer's printed instructions.

Paragraph 3.5.19.1.2. Upon completion of the installation, the manufacturer of the siding shall furnish to the Contractor and the Contracting Officer a certification that the siding system was installed in strict accordance with their printed instructions.

Paragraph 5 under Paragraph 3.5.17 should include the following provisions:

1. A factory prefinished siding with a minimum, nonprorated, 15-year warranty on the finish shall be specified. Aluminum, steel, or vinyl siding with or without backing is acceptable only for use on the second story (or at least 6 ft above the finish grade) of any structure. All siding materials shall be kept a minimum of 6 in. from finish grade.

2. Lap siding shall either be single pieces with a maximum 8-in. width or single pieces shaped to simulate maximum 8-in. width courses (that is, double-four, double-five, triple-four, etc., sidings are acceptable).

3. If the following siding materials are used, they shall meet the accompanying specifications:

- Aluminum siding shall conform to the requirements of AAMA 1402.3-82, Voluntary Specification for Aluminum Siding, developed by representatives of the Architectural Aluminum Manufacturers Association, Chicago, IL, except that the aluminum substrate shall be a minimum of 0.024 in. thick if it is not fiberboard-backed. For fiberboard-backed aluminum siding, the aluminum substrate shall be a minimum of 0.019 in. thick.

- Hardboard siding shall conform to the requirements of American National Standard A135.6-1984, Hardboard Siding, approved by the American National Standards Institute (ANSI).

- Steel siding shall conform to the following requirements: the siding material shall be a minimum of 0.017-in.-thick (29-gage), zinc-coated steel conforming to an ASTM A-526, G-90 coating. Siding panels shall be formed to provide full length edge interlock, so that after installation, fasteners will be concealed from view. Siding shall be pretreated and either factory-primed and finish-painted or factory-laminated with a weather-resistant polymer

film. When tested for 500 hr in accordance with ASTM B-117, the siding finish shall show no signs of cracking, blistering, peeling or significant color change and shall show no loss of adhesion from the metal more than 1/16 in. beyond a line scratched or scribed through the coating. Siding shall be installed in strict accordance with manufacturers' recommendations. Steel siding should not be installed within 1 mile of open saltwater or in other highly corrosive atmospheres. Steel siding materials shall be separated from aluminum surfaces with a coating of bituminous paint or asphalt varnish.

• Vinyl siding shall conform to the requirements of ASTM Standard D-3679, Rigid Poly (Vinyl Chloride) (PVC) Siding.

4. Local choices should be allowed so that military post personnel can eliminate or specify certain materials based on particular geographic exposure conditions or to complement existing post architecture.

Paragraph 3.5.19.1 under paragraph 3.5.19, Finishes, should be changed to include the following provisions:

1. Exterior siding materials shall have the manufacturer's written guarantee that the finish shall not require maintenance to repair because of cracking, chipping, crazing, blistering, flaking, peeling, or erosion of the original finish. This warranty also will cover manufacturing defects for a minimum of 15 years.

2. To decrease the possibility of uneven fading due to different fading rates, only siding from a single batch or lot will be used on any single housing unit.

3. Extra pieces of siding equal to approximately 1 percent of the area covered from each batch or lot shall be included for storage in case of future repair needs.

4. A manufacturer's representative will instruct the installer of the siding, appurtenances, and accessories as to the manufacturer's required installation procedures. The Army's construction inspectors responsible for the job shall be included in this instruction.

Paragraph 3.5.9.1.1 should state that the siding, appurtenances, and accessories shall be installed in strict accordance with the manufacturer's printed instructions to avoid canceling the warranty. Variances from these printed instructions must have written approval from a manufacturer's representative authorized to do such.

No changes are needed to Paragraph 3.5.19.1.2.

Table 4 lists the siding materials from Table 2 that meet these recommended specifications. This table should be used only as a guide--it is not a qualified products list as no laboratory or field testing was performed to determine specification compliance.

Table 4

Siding Materials Meeting Proposed Specifications

Manufacturer	Substrate	Trade Name
Alcan Building Prod.	Aluminum	Cedarwood
Alcan Building Prod.	Aluminum	Vin-al-wood
Alcan Building Prod.	Vinyl	Driftwood
Alcoa Building Prod.	Aluminum	Country Oak
Alcoa Building Prod.	Aluminum	Rustic
Alcoa Building Prod.	Aluminum	(Smooth Texture)
Alcoa Building Prod.	Aluminum	Western Oak
Alcoa Building Prod.	Vinyl	Super-V
Alsco	Aluminum	Premium 40
Alsco	Aluminum	Ultimate
Alsco	Steel	Premium 40
Alsco	Steel	Ultimate
Alsco	Vinyl	Oceanside
Alsco	Vinyl	Timbertone
Alside	Steel	Super Steel
Alside	Vinyl	Premium
Aluminum Industries Inc.	Aluminum	Vinylgrain
American Vinyl Bld. Prod.	Vinyl	---
Bird, Inc.	Vinyl	---
CertainTeed Corp.	Vinyl	---
Gold Bond Building Prod.	Vinyl	---
H&W Building Products	Vinyl	Heartland
Masonite Corp.	Hardboard	Color-lok
Master Shield	Vinyl	Premium
Master Shield	Vinyl	Tradesman
Master Shield	Vinyl	Victorian
Mastic Corp.	Vinyl	T-lok
Nichols-Homeshield	Vinyl	Heritage
Republic Building Prod.	Aluminum	Dura Clad
Republic Building Prod.	Vinyl	Vina Clad
Revere Al. Building Prod.	Aluminum	Super-Gard
Revere Al. Building Prod.	Steel	Super-Card
Revere Al. Building Prod.	Vinyl	---
Reynolds Aluminum	Aluminum	Vinyl-Tuf
Reynolds Aluminum	Vinyl	American Classic
Variform	Vinyl	Cedar Select
Variform	Vinyl	No Frills
Variform	Vinyl	Varigrain
Vinyl Improv. Prod. Co.	Vinyl	Ambassador
Vynasteel	Steel	Steeltek
Wolverine	Aluminum	Super Tuff
Wolverine	Steel	Life Steel
Wolverine	Steel	Signature
Wolverine	Vinyl	Camelot
Wolverine	Vinyl	Restoration
Wolverine	Vinyl	Vinal-Side

9 CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Quality siding materials are available to meet the Army's construction needs for family housing. The four types studied in this work are aluminum, hardboard, steel, and vinyl materials. It was concluded that sidings with premium finishes probably are the best buy, requiring the least maintenance over the product lifetime. Overall, the finish quality is the most important aspect, with substrate quality or type being a close second. That is, a premium vinyl-finished aluminum siding will usually outperform a baked-acrylic-finished aluminum siding. Also, a premium vinyl-finished, tempered aluminum siding may perform as well as a premium vinyl-finished steel siding. Other findings were that:

1. Tedlar-laminated or polyvinylidene fluoride-coated siding materials (available over aluminum, steel, and vinyl substrates) probably are the best choice from the standpoint of maintenance needs over the material's life.

2. Premium vinyl-coated steel or tempered aluminum (for high impact strength) sidings are a close second to the Tedlar-laminated or polyvinylidene fluoride-coated siding materials for minimal maintenance over the product's lifetime.

3. Premium solid vinyl siding can be an excellent choice, especially for corrosive areas such as marine coastlines or near heavy industrial locations where aluminum or steel siding should not be used.

4. Hardboard can also be very acceptable. As with vinyl, hardboard can be used for marine coastal structures. Hardboard has the lowest initial cost but will need periodic repainting after the first 15 years' exposure.

5. Aluminum, steel, and vinyl siding materials are acceptable for second-story use. However, unless the manufacturer provides a useful warranty against hail damage, these materials should not be used in areas where hail is common.

6. All nonpremium-finished siding materials studied can be expected to require maintenance refinishing sooner and possibly more often than the premium-finished materials.

7. Siding materials finished in white or light colors are best because all finishes fade when exposed to sun and weather. Since colors normally lighten with weathering, the darker the color at the beginning, the more conspicuous and unacceptable it becomes later.

Recommendations

Paragraphs 3.5.17 and 3.5.19 of the current specifications for turnkey procurement of Army family housing should be amended to include provisions summarized as follows (Chapter 8 gives details):

1. Brick and stucco should be used as siding materials when the budget permits.

2. When funding does not allow brick or stucco, other siding materials can be substituted. As a minimum, these products should have a nonprorated, 15-year maintenance-free warranty. Prorated warranties under which the manufacturers' liability falls below 100 percent during the first 15 years are unacceptable.

3. Standard commercial or industry specifications, when available, will be used as criteria in Army turnkey procurement. Specifications for steel siding need to be developed.

4. Procurement options should include siding material types such as double-five and triple-four which are formed to simulate multiple courses of 8 in. or less.

5. The current requirement that sidings not fade more than 10 NBS units in 10 years should be eliminated until reasonable and meaningful standard criteria can be established. Such criteria should be developed to enable better quality control during procurement.

6. White or light pastel colors should be chosen for sidings to be placed on Army family housing.

7. Aluminum, steel, and vinyl siding materials should not be used on the first story (or at least the first 6 ft) of family housing.

8. Local choices should be permitted in order to procure the siding with optimal performance at a given geographic location and with features that complement surrounding architecture.

9. All sidings should be installed in strict accordance with the manufacturer's instructions. Any deviation from the recommended procedure must be approved in writing by the manufacturer's representative.

This study's limitations must be reemphasized and it should be pointed out that the siding materials industry is undergoing constant change. Moreover, since the need for inclusive specifications may grow as Army housing is upgraded and replaced, the following future research is recommended.

Laboratory Performance Testing

All materials surveyed in this study should be performance-tested in the laboratory to rank the different products. Tests should include (but should not be limited to): impact resistance, artificial weathering, impact resistance after artificial weathering, abrasion resistance of the finish, humidity effects, and salt fog effects. A qualified products list also could be developed from these tests.

Fading

Fading is a major unresolved issue, with siding manufacturers in little agreement about fading criteria. Appropriate criteria for specifying fading

resistance could be developed separately or as part of the previously mentioned laboratory performance tests.

Redwood and Cedar Siding Versus Prefinished Siding

The performance and cost of using redwood or cedar siding should be compared with the prefinished siding materials reviewed in this report. If the price and performance are found acceptable, these materials should be allowed as alternatives.

Inspection Handbook

An inspection handbook and critical item check-off list for siding installation should be developed. The handbook could cover siding materials such as aluminum, brick, hardboard, steel, stucco, and vinyl.

METRIC CONVERSIONS

1 in. = 2.54 cm

1 psi = 6.89 Pa

1 mi = 1.61 km

°F = (°C x 1.8) + 32

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Tempo, Richard G.
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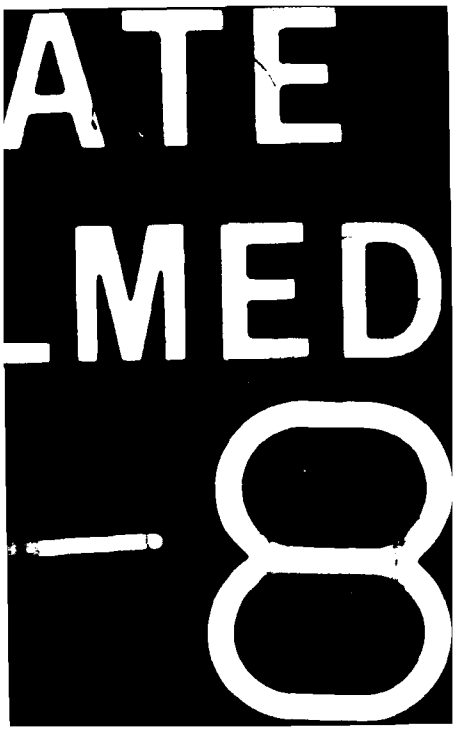
49 p. (Special report ; M-360)

1. Siding (building materials) - specifications. I. Title. II. Series : Special report (Construction Engineering Research Laboratory) ; M-360.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