NATIONAL BUREAU OF STANDARDS REPORT

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Final Report
on
FIREPROOFING STRUCTURAL STEEL

by

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and

M. W. Sandholzer

NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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Report to
Office of the Chief of Engineers
Bureau of Yards and Docks
Headquarters, U. S. Air Force

NBS

U. S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

FIREPROOFING STRUCTURAL STEEL

ABSTRACT

The effectiveness of fire-protective materials which can be applied directly to structural steel members by spray techniques was investigated. Test specimens were prepared with protective coatings applied in 1/2-inch, 1-inch, and 2-inch thicknesses by a number of manufacturers, using normal field methods of application. Results of small-scale fire tests on the protected specimens and studies of the corrosion effects and surface characteristics of the coatings are reported. Results of a full-scale fire test of a steel column protected by a 1/2-inch coating of one of the products are also reported.

1. Introduction

In certain types of buildings such as aircraft hangars, it is common practice to leave the structural steelwork unprotected. In cases where automatic sprinkler protection cannot be furnished, the fire hazard may be high and losses great. There are on the market today various materials which can be applied by spray techniques directly to the steelwork, and which are claimed to be useful for protection against fire. The purpose of this investigation was to obtain performance data on some of these materials.

2. Method of Investigation

In determining the suitability of a sprayed type of fire protection material, a number of factors must be considered. In addition to its primary function of providing protection against fire exposure, the coating must be stable and well bonded and should not introduce a corrosion problem when applied to steelwork. Furthermore, its application must be practical under usually experienced construction conditions.

The general plan adopted for investigation of the coatings proposed a comprehensive study of small-scale specimens, to be followed by a limited study of full-scale specimens selected on the basis of data obtained from the small-scale tests. The program carried out with small-scale specimens included fire exposure tests on steel plate specimens to which the coatings had been applied in thicknesses of 1/2 inch, 1 inch, and 2 inches. Specimens with 1/2-inch thick coatings were used for determinations of a number of additional characteristics, which included bond strength, dusting tendency, reflectance, moisture retention, pH value, and corrosion effects. Thermal conductivity measurements were made on 1-inch thicknesses of the coatings, tested with no backing. On the basis of the data obtained, one full-scale specimen was prepared and subjected to a fire exposure test.

3. Materials

For the small-scale fire-test specimens, metal support structures were prepared which consisted of a 2-foot square, 16 gage, hot-rolled steel plate, spot-welded to a grid composed of 3/4-inch cold-rolled plasterers' furring channels. These specimen structures were sent to various manufacturers to be coated with fire-retardant materials in the three thicknesses of 1/2 inch, 1 inch, and 2 inches. Each manufacturer was supplied with four specimen structures for each thickness, two with the hot-rolled finish as received, and two shop-coated (one coat of "Rustoleum"). Metal grounds were welded around the periphery of the surface to be coated, to insure obtaining the proper thickness of the coating.

To provide specimens for the investigation of the other properties under consideration, each manufacturer was supplied with twelve 6-inch square specimen structures, of the same construction as the fire-test structures and provided with grounds for the application of 1/2-inch coatings. Six of the twelve were shop-coated and six were left with the hot-rolled finish as received. In addition, two wooden frames, 8 inches square by 1 inch deep and lined with polyethylene film, were sent to each manufacturer for the preparation of specimens for thermal conductivity measurements.

The coatings were supplied by eight different manufacturers and were said to have been applied with the same equipment and techniques normally used in the field. In some instances, the manufacturer indicated that his product required a bonding primer and that such a primer had been applied to the specimen structures before application of the fire-retardant coating. During inspection of the specimens for corrosion effects, evidence was observed that this primer had not in all cases been generally distributed over the 6-inch square plates but had been applied at one or two spots only. No similar inspection of the 2-foot square specimens was made.

The following list gives the names of the participating manufacturers, together with a brief note regarding the major components of each product.

Air-O-Therm Application Company
Jet-Sulation
A mixture of all glass fibers and binder.

Columbia Acoustics and Fire Proofing Company
Cafco Spray Standard Fiber
A mixture of all glass fibers and binder.

Keasbey and Mattison Company
Sprayed "Limpet" Asbestos
A mixture of all asbestos fibers and Portland cement binder

Larson Products
"Plaster Weld"
A liquid bonding agent for plaster. A plaster of perlite, asbestos fiber, and gypsum was applied over the "Plaster Weld" by means of a plastering machine.

National Gypsum Company
Thermacoustic
A mixture of mostly glass with some asbestos fibers.

Smith and Kanzler Jetbestos Inc.
Spray Craft
A mixture of glass and asbestos fibers and binder.

United States Gypsum Company
Audicote
A mixture of perlite, bentonite clay, and asbestos fiber.

Zon-O-Lite Company
Zon-O-Lite Acoustical Plastic
A mixture of vermiculite, bentonite clay, and asbestos fiber.

In surface finish, the coatings ranged from a felted nap-like finish to a hard troweled surface. The average densities of seven of the coatings, as applied to the fire-test specimens, ranged from about 12-22 lbs/ft^3, with five of the group falling in the range of 15-20 lbs/ft^3. The eighth product was a plaster bonding agent not intended as a complete protective coating in itself, and the acoustical plaster applied over it was decidedly heavier than the other coatings, with an average density of about 50 lbs/ft^3. With most of the products the variation in density from specimen to specimen was large, and ranged as high as 50-55 per cent of the average in several cases.

4. Methods of Test

4.1 Small-Scale Fire Exposure

The tests were performed in a firebrick furnace that forms a cube-shaped combustion chamber, the specimen, with the fireproofed face down, providing the cover for the cube. The furnace is gas fired and vented by means of a baffled flue and chimney to the outside. The temperature in the combustion chamber is automatically regulated so that it follows the time temperature curve prescribed in ASTM Specification E119, "Standard Curve for Fire Tests." The times and temperatures specified are 1000°F at 5 min, 1700°F at 1 hour, 2000°F at 4 hours, and 2300°F at 8 hours.

The specimen is placed over the top of the combustion chamber, with 1/2 inch of the face of the specimen resting on the firebrick wall on all sides. An asbestos or mineral wool gasket is placed around the edges of the specimen to minimize heat flow from the specimen.

A transducer made of insulating firebrick, 2 feet long by 12 inches wide by 1 inch thick, is placed over the channel iron backing of the specimen plate. The underside of the transducer is blackened and thermocouples are placed on the under and upper surfaces. Two pieces of asbestos millboard, 24 inches long by 6 inches wide and 1/2 inch thick, with thermocouples placed on the upper and lower surfaces, are laid on either side of the transducer. Thus, a 3/4-inch sealed air space is formed by the millboard and transducer and the 16 gage steel sheet of the specimen. A thermocouple is placed on the geometric center of the steel sheet to indicate the temperature on the unexposed face of the fireproofed specimen. The transducer gives an indication of the heat flow from the combustion chamber through the fireproofing and steel sheet.

A reinforced sheet-metal pan, 43 inches by 43 inches with 2-inch high sides, is suspended from the ceiling of the test room. This pan is held 8 inches above the top of the transducer with the center of the pan above the center of the specimen. Water is piped to the pan and the outlets are arranged so that 1/2 inch of water covers the bottom of the pan at all times. Records of the water flow rate and the temperature of water entering and leaving the pan provide another method of measuring heat flow from the specimen.

The end point of the test was considered reached when the temperature on the unexposed surface of the steel plate reached 1000°F.

4.2 Thermal Conductivity

The thermal conductivity measurements were made in an 8-inch guarded hot-plate apparatus conforming to the requirements of Federal Specification LLL-F-321b and of ASTM Standard C177-45. The specimens were removed from the wooden frames and were air-dried to constant weight in an oven at 215°F immediately prior to test. The loss of weight on drying ranged from 0.8 to 2.5% for the various coatings, except the plaster coating which lost over 13% due to partial calcining of the gypsum at the drying temperature. Thickness of the specimens, measured after drying, ranged from 0.89 to 1.06 inches.

4.3 Bond Strength

Specimens for testing the bond strength of the coatings were prepared by securely cementing a 4-inch square steel plate, with an eyebolt tapped into the center of the square, to the surface of the 6-inch square specimen of the coating. After conditioning at 75°F and 50% RH for two weeks, the specimen was suspended face downward and weights were added to a bucket hung from the eyebolt until the test section pulled away. Before test, a knife cut was made through the coating all around the 4-inch plate so that only the 4-inch square section was under test. The type of failure, whether in the cohesive forces in the coating itself or in the bond between the coating and the steel plate, was noted, as well as the weight required to produce failure. Four specimens of each coating were tested, two with the steel shop-coated before application of the fire retardant and two without shop-coating.

4.4 Dusting Tendency

The method devised for evaluation of the dusting tendency was based on the erosion effects of an air stream directed across the surface of the coating. The apparatus consisted of a sheet aluminum funnel provided with a sheet metal cover, to the underside of which was secured a holder to accomodate the 6-inch square specimens in horizontal position. The air inlet consisted of a 1/4 inch copper tube with a flattened, fishtail tip, introduced through the side of the funnel and so positioned that the air jet was directed against the horizontal surface of the specimen near one edge and at an angle of 45 degrees. The tip of the air inlet was 3/4 inch below the surface of the specimen. The air stream was directed over the specimen for 8 hours at a flow rate of 0.5 ft^3/min, and the dust was collected at the bottom of the funnel on a weighed filter paper. Two specimens of each coating were tested. It is not evident to what extent the method would simulate service performance.

4.5 Reflectance

Reflectance was measured with a Baumgartner reflectometer, which is described in the Illuminating Engineers Society Lighting Handbook. The reflectometer provides a measure of the fraction of incident light reflected by a surface.

4.6 Moisture Retention

Equilibrium moisture content was determined under conditions designed to indicate the effects of both increasing and decreasing ambient humidities. Constant humidity conditions at five different levels, namely, 17% RH, 30% RH, 54% RH, 80% RH, and 93% RH, were established by means of saturated solutions of appropriate salts or the use of controlled rooms. It was not feasible to maintain all of the humidity chambers at the same temperature, but they were all within the range of 73-78°F except that for 80% RH which was maintained at 90°F. The samples were kept at a selected humidity level until moisture equilibrium had been established, as indicated by constant weight, and were then moved to a different level and allowed to reach equilibrium, the moves being selected to provide various degrees of increase and decrease in humidity. Values obtained by oven-drying at 140°F were used as the dry weights of the samples.

The materials were prepared for these tests by removing the coatings from the steelwork and grinding them to a relatively fine condition. Each sample consisted of an amount of the powdered material which could be contained in a 3-inch watch glass without touching the flat plastic cover placed over the glass during the weighing operations, which were conducted under the prevailing laboratory humidities.

4.7 Determinations of pH Values

For these determinations, samples of the powdered coatings, as prepared for the moisture retention work, were used. A 5-gram sample of the coating was stirred vigorously for 5 mimutes with 75 ml of distilled water in a 150-ml beaker. After being allowed to settle for 30 minutes the pH value of the supernatant liquid was determined with a pH meter. The beaker was covered and the settling allowed to continue for 64 hours, after which the pH value of the supernatant liquid was again determined.

4.8 Corrosive Effects

In order to assess the corrosive effects of the coatings on the steel plates, specimens which had been stored for 20-21 months at 75°F and 50% RH were carefully examined. Each specimen was cut in half, and the coating removed from the plate. The plates were then inspected by personnel specializing in corrosion problems and familiar with common corrosion experience

4.9 Full-Scale Fire Test

After consideration of the data obtained in the small-scale fire tests and other studies, the Thermacoustic coating manufactured by the National Gypsum Company was selected for a full-scale fire test. A 1/2 inch Thermacoustic coating was applied over a special bonding primer to a 13-foot column consisting of a 6 inch by 6 inch, 20-lb stancion section. The application was made by a local contractor approved by the National Gypsum Company and was supervised by a representative of the National Gypsum Company. The column was conditioned at 75°F and 50% RH until moisture equilibrium had been reached, as indicated by constant weight of a sample of the coating, prepared by filling a metal pan 12 inches square and 1/2 inch deep.

The column was tested in accordance with the ASTM Standard Methods of Fire Tests of Building Construction and Materials, E119-50. A load of 80,500 lbs was applied to the column during the test, and the time when the column had lost 75% of its maximum expansion was taken as the criterion of failure. The average temperature of the steel in the column at four different levels (approximately 2 feet, 4 feet, 6 1/2 feet, and 9 feet from the base of the column, respectively) was determined by means of six appropriately placed thermocouples at each level.

Before testing the column, measurements were made of the actual thickness of the coating at each of the four levels where the thermocouples were attached. At each level, measurements were made at 28 suitably spaced points. The individual readings showed thicknesses ranging from 1/8 inch to 1 1/8 inches, and the average for all of the measurements was 39/64 inch, or nearly 5/8 inch. The average thicknesses at the separate levels were 5/8 inch, 9/16 inch, 35/64 inch, and 47/64 inch at the 2-foot, 4-foot, 6 1/2-foot and 9-foot levels, respectively.

5. Results and Discussion

5.1 Fire Endurance

Results of the small-scale fire tests are given in Table 1, where the materials are listed in the order of performance in the 1/2-inch thickness with that showing the longest average endurance listed first. The specimens for which no results are given had cracked and were not suitable for testing.

There appeared to be no consistent correlation between the performance of the coatings and either their density or the particular fibers or minerals used. The fire endurance was evidently an individual characteristic of each coating, practically of each application. Although, in some instances, the results suggest a decided difference in the fire endurance of the specimens on shop-coated steel and those on steel with the hot-rolled finish as received, the variation between individual specimens of both types was so great that such differences must be considered largely fortuitous.

All except one of the coatings provided sufficient protection to keep the temperature on the back of the plate under 1000°F for at least 3 hours when applied in the 2-inch thickness, and for at least 1 hour applied in the 1-inch thickness. In the 1/2-inch thickness the period of similar protection ranged from about 1/2 to 1 hour for the different coatings. Performance in the 1/2-inch thickness is of particular interest inasmuch as coatings of that thickness can be applied in one operation, whereas the greater thicknesses require two or more separate applications. The Thermacoustic coating applied by the National Gypsum Company appeared to give somewhat the longest period of protection in the 1/2 inch thickness, with an average time of 70 minutes before the temperature at the back of the plate reached 1000°F.

In the full-scale fire test of the 13-foot column protected by a nominal 1/2-inch coating of Thermacoustic, load failure occurred at 41 minutes. The average temperature of the steel at the level about 4 feet from the base of the column reached 1000°F at 34 min 35 sec, and one point at that level reached a temperature of 1200°F at 34 min 12 sec. The coating adhered well to the steel throughout the test, and showed no tendency to loosen or spall.

5.2 Thermal Conductivity

Results of the thermal conductivity measurements are included in Table 2. The values given are the averages for two specimens of each coating, and the densities were determined after conditioning at 215°F for test. The thermal conductivity values showed no correlation either with density or with fire endurance as determined in the small-scale fire tests.

5.3 Surface Characteristics

The results obtained in the determinations of dusting tendency and reflectance are also shown in Table 2. The weights of dust dislodged from the coatings during the 8-hour application of the air stream ranged from .005 to .010 gram.

The reflectance values for the various coatings ranged from 32 to 59 per cent of the incident light reflected. The higher of these values would compare approximately to a concrete pavement or a light gray, painted wall, which generally reflect from 50 to 60 per cent of the incident light.

5.4 Bond Strength

Results of the bond strength measurements are shown in Table 3. In general, the coatings were effectively bonded to the metal so that either the cohesive forces within the coating itself failed before (or simultaneously with) the coating-metal bond, or a very strong force was required to pull the coating from the metal. With one product, the U. S. Gypsum Company Audicote applied to metal which had not been shop-coated, the coating-metal bond failed under relatively low force, probably due to rust formation. Shop-coating of the metal appeared highly advantageous in this case, although it did not significantly affect the results obtained with the other products.

5.5 Corrosion and Related Factors

In addition to an inspection of specimens stored for an extended period, it was of interest to obtain some information on the moisture adsorbing tendencies and the alkalinity or acidity of water extracts of the coatings, in connection with the possible corrosive effects of the coatings on steelwork. The program followed in determining the moisture content of the coatings was designed to indicate a possible hysteresis effect under conditions of adsorption and desorption, but sufficiently precise control to demonstrate this effect did not prove feasible with the facilities available. However, the data provide a comparative measure of the tendencies of the various coatings to adsorb and retain moisture, and the moisture content (per cent of moisture determined on the basis of the dry weight of the specimen) for the two humidity levels of 54% and 80% RH are shown in Table 4. It appeared that none of the coatings adsorbed an excessive amount of moisture.

The pH values obtained for water extracts of the coatings, after settling for 1/2 hour and for 64 hours, are also given in Table 4. All of the values indicate a distinctly alkaline condition.

The actual corrosion observed upon inspection of specimens which had been stored 20 months, was mild and would not be expected to impair the service life of the steel. It is believed that such corrosion as was found developed immediately after application of the coatings, and that, after the coating had dried, the attack ceased or decreased to a minimum. The coatings are listed in Table 5 in the order of increasing corrosion, with notations as to the extent of corrosion observed. All of the specimens except the first two in the list showed some rust on the exposed upper edges of the angle iron grounds which had been welded to the plates as a gage for proper thickness of the coating. Although corrosion was not severe on any of the specimens, shop-coating of the steel evidently provided some protection against attack in every instance.

6. Conclusions

Dependable uniformity in application of the coatings by the usual spray techniques appears to be difficult and seldom achieved. Hence, the results obtained in tests of the specimens submitted should be interpreted with considerable allowance for probable variations.

The small-scale fire endurance tests, while directly applicable only to panel type protection, indicated that a 1-inch thickness of any of the coatings tested should, on the average, provide reasonable protection for about an hour or more. The best of the coatings appeared to offer such protection in a 1/2 inch thickness. In the full-scale column test, the 1/2-inch application of the coating selected as most promising in the small-scale tests, provided reasonable protection for about 40 minutes.

Most of the coatings showed satisfactory bonding to either the shop-coated or unpainted metal. However, the Audicote manufactured by the U. S. Gypsum Company tended to rust unpainted metal to an extent which decidedly weakened the bond, and shop-coating of the metal appeared necessary to provide a strong bond in that case. The Plaster Weld manufactured by Larson Products Company failed to bond the 1/2-in thickness of plaster during the small-scale fire tests, but performed satisfactorily with the thicker plaster coatings.

As tested, the coatings appeared to present no serious dusting problem. It is not known to what extent these tests could be considered applicable to field conditions. Light reflectance appeared to be quite similar to or somewhat less than that of a concrete pavement.

None of the coatings exhibited an equilibrium moisture content of excessive amount in the 50 to 80 per cent relative humidity range, and all showed alkaline reactions in water extracts. None caused serious corrosion which would impair the service life of the metal when applied to either shop-coated or unpainted steel, although in some cases, corrosion of the unpainted steel was sufficient to endanger the coating-to-metal bond. Shop-coating of the steel reduced corrosion in all instances.

Table 1. Results of small-scale fire tests

Manufacturer and Material	Finish on Plate	Density and time plate reached 1000°F: 1/2 in. thick, lbs/ft3	1/2 in. thick, min	1-in. thick, lbs/ft3	1-in. thick, min	2-in. thick, lbs/ft3	2-in. thick, min	Fiber or Mineral
Natl Gypsum Co. Thermacoustic	Unpainted	27.2	66	20.1	135	18.6	352	Glass and asbestos
	"	24.3	57	22.4	170	18.6	315	
	Shop-coated	28.4	88	18.4	77	17.5	310	
	" "	28.1	71	21.7	200	17.3	202	
	Average	27.0	70	20.6	146	18.0	295	
U. S. Gypsum Co. Audicote	Unpainted	20.3	63	19.6	164	-	-	Perlite and asbestos
	"	20.7	58	19.2	170	19.4	301	
	Shop-coated	17.5	40	17.7	75	18.3	248	
	" "	17.6	41	20.4	75	-	-	
	Average	19.0	50	19.2	121	18.8	274	
Air-O-Therm Application Co. Jet-Sulation	Unpainted	26.4	39	16.8	68	20.8	130	All glass
	"	25.1	43	16.0	68	-	-	
	Shop-coated	21.4	45	15.6	47	16.4	75	
	" "	15.9	35	23.3	47	-	-	
	Average	22.2	40	17.9	58	18.6	102	
Keasbey & Mattison Co. Limpet	Unpainted	12.9	44	9.8	78	10.1	340	All asbestos
	"	13.2	35	10.5	90	10.0	123	
	Shop-coated	12.4	-	12.3	110	10.9	330	
	" "	12.7	38	11.1	85	11.2	175	
	Average	12.8	39	10.9	91	11.5	242	
Smith & Kanzler Jetbestos Co. Spray Craft	Unpainted	21.1	63	13.6	91	13.3	316	Glass and asbestos
	"	16.3	32	14.3	74	15.0	398	
	Shop-coated	16.7	25	14.1	70	14.3	350	
	" "	15.2	22	14.8	50	19.0	380	
	Average	17.3	36	14.2	71	15.4	361	
Zon-O-Lite Co. Zon-O-Lite Acoustical Plastic	Unpainted	16.8	29	18.2	93	16.8	278	Vermiculite and asbestos
	"	16.9	33	18.2	75	16.0	290	
	Shop-coated	18.0	46	15.8	55	16.7	283	
	" "	16.8	35	16.0	60	13.3	290	
	Average	17.1	36	17.1	71	15.7	285	

Table 1. Results of small-scale fire tests (continued)

Manufacturer and Material	Finish on Plate	Density and time plate reached 1000°F: 1/2 in. thick		1-in. thick		2-in. thick		Fiber or Mineral
		lbs/ft3	min	lbs/ft3	min	lbs/ft3	min	
Columbia	Unpainted	18.3	35	19.1	126	17.0	345	All
Acoustics and	"	16.7	34	18.5	155	18.2	394	glass
Fireproofing Co.	Shop-coated	13.5	37	15.3	58	18.1	305	
Cafco Spray	" "	14.1	35	19.9	80	16.3	255	
	Average	15.6	35	18.2	105	17.4	325	
Larson Products								
Co.	Unpainted	54.7	25*	53.5	75	54.7	469	Perlite,
Plaster Weld	"	64.9	33*	53.8	163	47.4	398	asbestos,
	Shop-coated	52.0	21*	43.0	65	55.0	-	and
	" "	47.8	22*	39.6	56	43.6	204	gypsum
	Average	54.8	25	47.5	90	50.2	357	

* Plaster fell from steel plate at approximately 11 minutes

Table 2. Results of determinations of thermal conductivity and surface characteristics.

Manufacturer and Material	Thermal Conductivity Data		Dusting Results (dust collected)	Reflectance
	Density	Conductivity		
	lbs/ft^3	$BTU\ in/hr°Fft^2$	g	%
Nat'l Gypsum Co. Thermacoustic	20.8	0.34	.0103	32
U. S. Gypsum Co. Audicote	18.5	0.68	.0072	59
Columbia Acoustics and Fireproofing Co. Cafco Spray	19.8	0.43	.0061	59
Keasbey and Mattison Co. Limpet	12.5	0.35	.0051	49
Larson Products Co. Plaster Weld	46.1	0.79	-	51
Zon-O-Lite Co. Acoustical Plastic	15.8	0.65	.0054	48
Smith and Kanzler Jetbestos Inc. Spray Craft	20.8	0.48	.0050	46
Air-O-Therm Application Co. Jet-Sulation	20.0	0.33	.0047	52

Table 3. Results of bond strength determinations

Manufacturer and Material	Finish on Plate	Failure Load (lbs)	Region of Failure
National Gypsum Co. Thermacoustic	unpainted	60	Within coating
	shop-coated	42	" "
U. S. Gypsum Co. Audicote	unpainted	28	Plate surface-rust
	shop-coated	120	Plate surface
Columbia Acoustics & Fireproofing Co. Cafco Spray	unpainted	8	Within coating
	shop-coated	8	" "
Keasbey & Mattison Co. Limpet	unpainted	6	Within coating and on plate surface
	shop-coated	10	Within coating and on plate surface
Zon-O-Lite Co. Acoustical Plastic	unpainted	115	At scratch coat and on plate surface
	shop-coated	132	At scratch coat
Smith & Kanzler Jetbestos Inc. Spray Craft	unpainted	8	Within coating
	shop-coated	11	Within coating and on plate surface
Air-O-Therm Application Co. Jet-Sulation	unpainted	18	Within coating
	shop-coated	18	" "

Table 4. Results of moisture content and pH determinations

Manufacturer and Material	Moisture Content		pH Values	
	54% RH	80% RH	1/2 hr	64 hr
	%	%		
National Gypsum Co. Thermacoustic	.85	6.72	9.3	8.3
U. S. Gypsum Co. Audicote	1.71	5.69	9.7	8.7
Columbia Acoustics & Fireproofing Co. Cafco Spray	.63	2.32	9.3	9.5
Keasbey & Mattison Co. Limpet	.67	3.66	11.1	10.7
Larson Products Co. Plaster Weld	.31	.95	8.6	7.7
Zon-O-Lite Co. Acoustical Plastic	2.27	10.22	9.9	9.1
Smith & Kanzler Jetbestos, Inc. Spray Craft	.65	2.32	9.1	9.7
Air-O-Therm Application Co. Jet-Sulation	1.75	4.55	9.9	9.7

Table 5. Observations on corrosion effects

Manufacturer and Material	Finish on Plate	Corrosion Observed
1. Keasbey & Mattison Co. Limpet	shop-coated	No failure
2. Air-O-Therm Application Co. Jetsulation	shop-coated	No failure
3. Columbia Acoustics & Fireproofing Co. Cafco Spray	shop-coated	No rust on plate
4. National Gypsum Co. Thermacoustic	shop-coated	No rust on plate
5. Keasby & Mattison Co. Limpet	unpainted	Scattered pin-point rust on plate
6. Air-O-Therm Application Co. Jet-Sulation	unpainted	Scattered light, superficial rust on plate
7. Smith & Kanzler Jetbestos, Inc. Spray Craft	shop-coated	Paint blistered in one area on plate
8. Zon-O-Lite Co. Acoustical Plastic	shop-coated	Scattered pin-point rust on plate
9. Columbia Acoustics & Fireproofing Co. Cafco Spray	unpainted	Scattered light, superficial rust on plate
10. National Gypsum Co. Thermacoustic	unpainted	Scattered superficial rust areas on plate
11. Larson Products Co. Plaster Weld	shop-coated	Scattered rust on faying surfaces of plate and angle grounds

Table 5. Observations on corrosion effects (continued)

Manufacturer and Material	Finish on Plate	Corrosion Observed
12. U. S. Gypsum Co. Audicote	shop-coated	Scattered rust on faying surfaces of plate and angle grounds
13. Smith & Kanzler Jetbestos, Inc. Spray Craft	unpainted	Medium superficial rust on plate
14. Zon-O-Lite Co. Acoustical Plastic	unpainted	Few large areas medium superficial rust on plate and faying surfaces
15. Larson Products Co. Plaster Weld	unpainted	Medium superficial rust over entire surface of plate
16. U. S. Gypsum Co. Audicote	unpainted	General heavy superficial rust over entire surface of plate

U.S. DEPARTMENT OF COMMERCE
Frederick H. Mueller, Secretary

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

THE NATIONAL BUREAU OF STANDARDS

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Optics and Metrology. Photometry and Colorimetry. Optical Instruments. Photographic Technology. Length. Engineering Metrology.

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Organic and Fibrous Materials. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Plastics. Dental Research.

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Mineral Products. Engineering Ceramics. Glass. Refractories. Enameled Metals. Concreting Materials. Constitution and Microstructure.

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Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.

Data Processing Systems. SEAC Engineering Group. Components and Techniques. Digital Circuitry. Digital Systems. Analog Systems. Application Engineering.

• Office of Basic Instrumentation. • Office of Weights and Measures.

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Radio Standards. High Frequency Electrical Standards. Radio Broadcast Service. High Frequency Impedance Standards. Electronic Calibration Center. Microwave Physics. Microwave Circuit Standards.

Radio Communication and Systems. Low Frequency and Very Low Frequency Research. High Frequency and Very High Frequency Research. Ultra High Frequency and Super High Frequency Research. Modulation Research. Antenna Research. Navigation Systems. Systems Analysis. Field Operations.

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