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SCHOOL PLANT MANAGEMENT SERIES

School Building Maintenance Procedures

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HEALTH, EDUCATION, AND WELFARE
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Foreword

Adequate maintenance of school buildings representing a public investment of billions of dollars is a problem of grave concern to both taxpayers and school officials. Many large and a few small districts across the country have resources that permit them to give proper attention to this important phase of school administration. Many other districts are not so fortunate, but wish to utilize resources available to the best advantage.

This publication, one of a series dealing with school plant management problems, identifies, describes, shows the function of, and outlines maintenance procedures for many components of school buildings. It is hoped that it will be useful to all who are interested in school plant maintenance and that it will be of significant value to the thousands of school districts that do not have large maintenance departments.

Many school plant planning officials in State departments of education have contributed valuable suggestions for this publication. Manufacturers' associations have been helpful in supplying maintenance information about their products. Reference to these organizations is made in Appendix D. The author wishes to thank all who contributed in any way to this publication.

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Chapter I

IMPORTANCE OF MAINTENANCE

FEW EVENTS in the life of an American community generate greater pride and exuberance among its citizens than the dedication of a beautifully designed, well-planned public school plant. At some point during the dedication ceremony, the people are given an opportunity to tour the plant. They observe and comment on many of the plant's features, such as the site and its development, the architectural design of the building, the tastefulness of its furnishings, the decor of its accessories and equipment, and the smooth precision of its mechanical systems. The immaculate floors, the clean freshness of new paint, and the flawless performance of light fixtures and hardware often evoke the expression: "If we could only keep it like this!"

Desirable as it would be to keep the school building perennially new, the action of the elements plus the normal wear and tear of usage inevitably cause some deterioration. This starts the moment the building is completed and continues as long as it stands. To offset and reduce the rate of deterioration, it is necessary to make proper repairs and replacements as occasion demands. Good maintenance, the organized and orderly procedure by which proper repairs and replacements are made, can greatly reduce the rate of deterioration. The overall purpose of maintenance is to safeguard the public's investment, increase the functional life of the building, and provide the best possible environment for teaching and learning.

Overview

An estimated 125,000 public elementary and secondary school buildings in this country must be kept in good repair if they are to serve satisfactorily as centers of learning. Ranging in size from 1 classroom to more than 250 classrooms (with varying amounts of additional facilities for numerous school activities), these buildings constitute a heterogeneous group in building design, type of construction, condition and safety, age and life expectancy, obsolescence, usefulness, and occupancy. These are some of the factors which must be considered by management officials in planning maintenance programs.

Occpants of the country's public school buildings in the fall of 1963 numbered 40.2 million pupils, approximately 1,567,000 full- and part-time public school teachers,[1] approximately 200,000 building service employees (calculated by the U.S. Office of Education at the ratio of 1 worker for each 200 pupils), and an undetermined number of clerks, secretaries, lunchroom workers, and other nonclassified employees. The comfort, safety, efficiency, and well-being of all these people, plus countless others who use school facilities for one purpose or another, may well depend upon an effective program of maintenance and operation, a program which annually consumes about 10 percent of the school's current operating funds.

During the school year 1959–60, the most recent year for which national data are conclusive, current expenditures for all public elementary and secondary schools in 50 States and the District of Columbia amounted to $12,461,955,000, of which $422,586,000 (2.7 percent) was spent for maintenance, and $1,085,036,000 (6.9 percent) for plant operation.[2] (Budgetary practice customarily separates maintenance and operation costs in financial accounting, but these costs may not always be clearly distinguishable. For example, custodians, whose salaries are budgeted under operation, may make some minor repairs which should be, but are not usually, charged to maintenance. This procedure, often followed by school districts, whether there are separate operating and maintenance divisions or not, complicates the problem of determining exact amounts spent in each category.)

The per-pupil cost, based on an average daily attendance of 29,722,000[3] and a current expenditure of $10,251,843,000 in 1957–58, was $341.14,[4] of which $12.72 was for maintenance and $31.10 for operation. The combined per-pupil cost of maintenance and operation ($43.82) is 12.8 percent of the total cost per pupil in average daily attendance.

A recent study[5] of 116 city, suburban, and rural school districts,

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[1] *Regional Field Letter*, No. 563, January 20, 1964. U.S. Department of Health, Education, and Welfare, Office of Field Administration. Washington: U.S. Government Printing Office. p. 4.

[2] *Digest of Educational Statistics, 1963 Edition* (OE–10024–63, Bulletin 1963, No. 43). U.S. Department of Health, Education, and Welfare. Washington: U.S. Government Printing Office, 1963. p. 48–9.

[3] *Biennial Survey of Education in the United States, 1956–58* (OE–2–200–58). U.S. Department of Health, Education, and Welfare, Office of Education. Washington: U.S. Government Printing Office, 1961. p. 42, table 20.

[4] *Ibid.*, p. 72, table 42.

[5] "Maintenance Procedures and Costs in the Public Schools". *American School and University 1960–61.* (32d ed.) New York: Buttenheim Publishing Corp. 1960. p. 155–164.

selected at random throughout the country by the editors of *American School and University* in 1958–59, revealed that:

- **The average per-pupil cost of maintenance for all school districts studied ranged from a low of $4.87 in the New England States to a high of $24.11 in the Middle Atlantic States.**
- **The range in per-pupil maintenance costs was from $0.75 to $147.88.**
- **The average per-pupil maintenance cost for city districts was $14.24; for suburban districts $13.34; for rural districts $15.12.**

These data indicate that, while the average maintenance cost per pupil among city, suburban, and rural districts seems reasonable, the range is such that three conclusions may be drawn: (1) the few districts which report the lowest expenditures per pupil have new school buildings that require little maintenance or buildings that have very recently been thoroughly renovated, or else these districts are deferring necessary maintenance expenses; (2) districts which report the highest expenditures per pupil either have very old buildings requiring excessive maintenance, or else they have neglected maintenance problems in recent years, and are trying to eliminate them in one fell swoop; (3) most districts with expenditures that fall between the lower and upper limits probably operate long-range planned maintenance programs in which maintenance expenditures are spread about equally through the years.

The importance of school plant maintenance is recognized by most school officials, but frequently neither the money nor the staff available to them is sufficient to conduct an effective maintenance program. The result is that many school plants are deteriorating through neglect or inefficient maintenance practices. A casual examination of many public school buildings across the country shows this to be true. Districts lacking effective maintenance programs need help. This bulletin is intended to supply them with technical information that may help them improve their maintenance practices despite inadequate staff and funds.

Maintenance Programs

The importance of a well-developed long-range maintenance program is emphasized by many authorities in school plant management. Programs vary immensely in the quantity and quality of what they accomplish from region to region, from county to county, from district to district, and from school to school within the same district. In practice, most school districts follow one or more phases of the following types of maintenance programs: (a) all maintenance is done by the district's maintenance staff; (b) all maintenance is done by contract; (c) staff and contract maintenance are intermingled; (d) most maintenance is done by the staff but local journeymen are called in on special jobs; (e) the maintenance staff is augmented by regular custodians and other assistance during the summer months. It should be remembered, however, that there is no one best type of program for all school districts. Officials of each district should study carefully the district's maintenance needs, the finances obtainable, and the number of people available who have specialized skills for the jobs to be undertaken by the maintenance staff.

Application

A description of all conceivable maintenance procedures for the entire school plant—site, buildings, and equipment—seems neither feasible nor desirable for the purposes of this bulletin. Of the three school plant components—site, buildings, and equipment—buildings usually represent the greatest original cost, are more subject to deterioration caused by wear and tear of usage and action of the elements, require a wider range of maintenance activities, and consume more of the maintenance dollar than the other two components combined. For these reasons, only those procedures concerned with building maintenance are treated here. Information about them is derived from:

- Personal experience and observations of the author
- Consultations with superintendents, architects, contractors, and engineers
- Interviews with local school officials responsible for planning, conducting, and supervising school plant maintenance programs
- Correspondence with State Department of Education personnel responsible for school plant services
- Conferences with technicians concerned with the manufacture of materials for construction
- A review of pertinent literature, including numerous technical manuals, guides, and reports
- Visits to, and observation of techniques used by, the testing laboratories of two large school systems
- Analysis of manufacturers' specifications for maintaining various types of construction materials particularly those requiring special treatment and attention
- Published and unpublished notes and suggestions supplied by trade associations, organizations, and institutes representing the manufacturers of building materials, maintenance supplies, and equipment used in maintenance.

The vast amount of information available from the foregoing sources suggests that a valuable service can be rendered to many school districts by compiling selected portions of this information into a "how-to" manual. It seems obvious that districts with ample funds to staff their maintenance departments do not need such a manual, but for each such district there are literally dozens of others with austere budgets and limited maintenance staffs that will find the suggestions in this manual quite helpful. These suggestions, which cover many of the problems of building maintenance, are organized and presented in four major areas: Detecting Maintenance Needs; Exterior Maintenance; Interior Maintenance; and Mechanical Systems.

Chapter II

DETECTING MAINTENANCE NEEDS

TOP MANAGEMENT in our school systems must have complete information about facilities and their upkeep requirements if orderly, efficient, economical maintenance programs are to be planned and conducted. These programs depend on adequate budgets; hence pertinent data must be received early enough to allow thorough study and analysis of prospective programs in relation to money available. Some responsible person in each school district should collect and keep adequate records on each school building. On the basis of information thus assembled, officials can plan the program, assign priorities, and schedule the work. Three methods commonly used in keeping track of maintenance needs are (1) maintenance surveys, (2) routine inspections and periodic checks, and (3) reports submitted by building personnel.

The Maintenance Survey

The first step in planning sound, long-range maintenance programs is to collect data on all district-owned school buildings, grounds, and equipment. This can be accomplished by the maintenance survey, conducted by the district's director of buildings and grounds, the maintenance supervisor, or some other official responsible for the maintenance program.

The survey director and perhaps an assistant, both with wide practical knowledge of school construction, should visit and thoroughly inspect every school building in the district. Other members of the survey team may change from school to school, but for each school the team should include the principal, head custodian, one or more teachers, and one or more lay citizens representing the community in which the school is located. Lay citizens who have some knowledge of building construction can contribute more significantly to the team's efforts than those lacking such knowledge. Board members, at their discretion, may wish to join the team from time to time.

Survey techniques may vary from district to district, but experience has shown that satisfactory results can be achieved only if the team uses a carefully planned checklist. This document should list items to be checked and should provide space for writing in comments, observations, and estimated costs of each needed repair. School officials may wish to develop a checklist of their own. For convenience, the list may be divided into three parts—one for buildings, one for grounds, and one for equipment. The building checklist may start with the roof and end with the footing. Since this bulletin deals only with maintenance procedures for buildings, a sample survey checklist for them is presented in Appendix C, page 167. This sample is not intended to meet the requirements of all school districts, but merely to illustrate the kind of details that should be included.

Although the building maintenance survey can be conducted at any time, the summer months, when school is not in session, may be most practical, both from the standpoint of administration and of unhampered working conditions for the survey team.

When the survey document for a given building is completed, it should be transmitted to the offical responsible for keeping maintenance records. When all school buildings of the district have been checked, necessary data on maintenance needs can be tabulated, analyzed, and reported to the superintendent and through him to the board of education.

Routine Inspection and Periodic Checks

Once a complete maintenance survey has been made and the needs of the district's school buildings have been tabulated, analyzed, and evaluated, priorities can be assigned and the work programed over a period of time according to a reasonably well-defined schedule. This programing, however, does not assure that a record of maintenance needs will be kept current. For example, a roof judged sound and in good condition at the time of the survey may be damaged by extremes of summer heat and winter cold; extremes of temperature might also have caused stone and masonry walls to move and joints to open. If not detected and corrected at the proper time, these failures can result in heavy damage to building structure, interior walls, ceilings, floors, finish, furniture, and equipment.

Routine inspections should be made by the school principal and the building custodians, the principal being particularly alert to conditions affecting the health and safety of students, teachers, and other school employees; custodians, to conditions of roofs, gutters, downspouts, walls, doors, hardware, and mechanical systems—points where defects or failures can cause serious damages if not repaired. All needs of an emergency nature should have immediate attention by the maintenance department; those that can be deferred should be reported to the department where they can be given a place in the maintenance schedule.

Periodic checks, preferably twice annually, should be made by maintenance personnel who should inspect such items as electric motors, starter controls, heating and ventilating systems, water heaters, pumps, valves, fuel lines and connections, warning devices, safety equipment, and fire control apparatus. The services of other technically trained people may be required when special inspections are considered necessary—architects and structural engineers if structural safety is to be checked; boiler inspectors if boiler problems are involved; and safety engineers, often assisted by fire chiefs and insurance officials, if fire safety is to be determined.

Reports by Building Personnel

Close surveillance of the school plant by the principal may require the help of all school employees in a position to detect maintenance problems in their earliest stages. Custodians may discover and either correct or report malfunctioning safety controls for boilers, and thus prevent possible explosions causing property damage, plant shutdown, and injury to building occupants. Teachers may discover and report damaging moisture infiltration during seasons of heavy precipitation. Lunchroom workers, in daily contact with food preparation and service equipment, may report conditions which they consider hazardous. Similarly, other building personnel (and pupils) can and should inform the principal about maintenance problems that appear to need attention.

Every reported instance of maintenance need should be investigated by the principal, or should be referred by him to the head custodian for checking. Some complaints, reports, and observations by building personnel may be of little significance; others, of great importance. In school districts where board policy permits or directs custodians to perform maintenance functions, they should make simple repairs; more complicated jobs should be referred to the maintenance department, with emergency items assigned first priority. In districts where board policy prohibits custodians from performing maintenance functions, the principal should refer all established needs to the maintenance department, assigning a priority to each need. These procedures, if followed, will be helpful in preventing additional or prolonged property damage, will save money, will spread maintenance expenditures evenly over the years, and may prevent injury or death.

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Chapter III

EXTERIOR MAINTENANCE

EXTERIOR MAINTENANCE is concerned with preservation of the "skin," or exposed surfaces, and other exterior appurtenances of buildings. The function of these building elements—roofs, walls, windows, doors, and their auxiliary items—is to conserve heat during the cold weather; to prevent wind, rain, snow, cold, excessive heat, and harmful sunlight from entering when and where not wanted; to protect interior finishes, furniture, equipment, and accessories from the ravages of weather; and to insure comfortable living and working conditions for occupants.

Regardless of the kind and quality of materials used in constructing a building, or the skill and workmanship with which they are combined, weathering processes cause deterioration of exposed exterior surfaces. This deterioration, although often only partial, can be very rapid if not checked through exterior maintenance.

For purposes of this bulletin, exterior maintenance problems are classified under four major categories: (1) roofs; (2) walls; (3) stacks and towers; and (4) miscellaneous. Each of these categories encompasses several thousand individual items, all of which require attention at one time or another. Procedures for solving some of the more vexing problems relating to the maintenance of these details and items are described here.

Roofs

The components of a roof are the frame, deck, and mat. The framework, found under and at the edges, consists of joists or rafters for spanning; walls for support; flashings for joining mats to projections, walls, and other changes in elevation; gutters, scuppers, and downspouts for carrying water away from the mat surface; and sometimes of parapet walls and copings for protecting mat surfaces from wind and other destructive agents.

The structural design of a roof is determined by the arrangement of the frame, particularly the rafters or joists, and usually follows one of four patterns: flat, gable, hip, or decorative. More often used in school construction in recent years than any other design, the flat roof has little or no pitch. (In some instances, the flat roof is intended to hold water on the mat surface for insulating purposes.)

A gable roof is triangular in shape, as viewed from a cross section, and has its ridge along the apex and its eaves along the base vertices of the triangle. The pitch from ridge to eaves may be moderate or steep, and opposite roof surfaces can have either equal or unequal slopes.

The hip (or hipped) roof is usually shaped like a pyramid, the four faces of which cover the two sides and two ends of a building. The end faces are joined to the side faces by four rafters, each of which rests on top of a corner of the outside wall and extends to the ridge of the roof. These rafters are called hip rafters, and the line from corner to ridge, where roof surfaces change directions, is called a hip.

The decorative roof design, formerly used for school buildings more extensively than at present, consists of a gable or hip roof with one or more dormers to break the monotony of straight lines.

The underlayment to which a roof mat is attached is the deck. Deck material may be wood (boards or plywood); aluminum; steel; poured or precast concrete; poured or precast lightweight aggregate. A number of new types of material, such as zonolite, vermiculite, perlite, and tectum are now being used for roof decking. Whatever the material, it is fastened to rafters, joists, or beams by nails, cleats, or specially designed fasteners. Choice of deck material, however, usually depends upon the design of the roof and upon the type of mat that is to be applied.

The roof mat is the covering that is applied and fastened to the deck to keep a building watertight on top. Types of roofing material designed to meet all conceivable needs are available. If care is exercised in selecting the type of material for a particular roofing job, and if the manufacturer's specifications and instructions are followed in installing it, the material should give satisfactory service. Among the more common types of materials used for school roofs are asphalt roll; combination asphalt-felt, and asbestos-felt roll; metal, such as copper, aluminum, and ferrous-base metal (terne or galvanized); shingles, such as asphalt, slate, tile, asbestos-plastic, cement-asbestos; and wood; and bitumen or coal tar pitch, which are necessary in certain types of applications.

A roof mat that is built up on the job by using alternate layers of felt and coal tar pitch (or bitumen) so as to form a continuous membrane is called a built-up roof. If this type of roof is left with the top layer of coal tar pitch (or bitumen) exposed to the weather, it is *unsurfaced;* if slag or gravel is embedded in the top bituminous coating, it is *surfaced.* If the roof deck is practically level, that is, having a slope of less than 1 inch per foot, the mat may consist of coal tar pitch, surfaced with 300 pounds of slag or 400 pounds of gravel per 100 square feet to prevent damage to the bituminous or asphaltic compounds by extremes in temperature. Because of the low melting point of coal tar and bituminous materials, the built-up roof is satisfactory only on a relatively flat deck. If the slope of the deck is too steep, the melting tar flows to the lowest point, causing damage to gutters and downspouts or to fascia and exterior walls, and at the same time, leaving the roof membrane in a deteriorated condition.

Regardless of roof design or the type of materials used in the mat, some roof failures are inevitable. In general these failures may be attributed to:

- **Insufficient or improper specifications**
- **Inferior materials**
- **Faulty installation**
- **Inadequate inspection and lack of preventive maintenance**
- **Insufficient materials (particularly in built-up roofs)**
- **Use of unseasoned lumber for framing and substructure**
- **Application of improper materials**
- **Weather (wind, hail, snow, etc.)**
- **Structural failure**
- **Related failures affecting roof service**

When roof failures occur, they take one or more of several distinct forms, depending on the roof design, deck materials, and type of roofing materials. For convenience in relating these failures to a description of maintenance procedures required for them, school roofs are classified here according to roofing material and method of application: (1) built-up; (2) roll; (3) flexible shingles (asphalt and composition); (4) rigid shingles (slate, tile, and cement-asbestos); metal (copper, galvanized iron, tin, and aluminum); and (6) wood shingles.

Failures of Built-Up Roofs

In general, failures of built-up roofs take one or more of the following forms: (a) blisters, bulges, or wrinkles; (b) loose felts; (c) torn felts; (d) cracks; (e) damaged, weathered, or deteriorated bituminous coating or gravel surfaces; (f) flashing leaks; and (g) condensation problems. Although the last two are not really failures of the roof itself, they need to be considered in relation to the roof and its maintenance.

Blisters, Bulges, Wrinkles

Blisters, bulges, and wrinkles are caused by the presence of moisture and/or entrapped air in and between felts at the time of application; by moisture entering the roofing from above, after application, through punctures, ruptures, or openings in the felts caused by vibration of fans, pumps, or other machinery housed on the roof surface; or by moisture entering the roofing from below, after application, by the passage of vapor from within the building through the deck and insulation to the underside of the roofing material. The danger of entrapped moisture and air in built-up roofs lies in the expansion and contraction of these elements from heat and cold, which cause a loosening and separation of plies of roofing felt; this process results in pockets in which pressure from the expanded air and moisture often becomes so great that holes are blown through the roofing surface. These pockets may range from only a few inches in length or diameter, with only slight swelling, to several feet in length and diameter, with a swelling of a foot or more in height.

Where large portions of a roof become blistered, the problem is so serious that the only solution is to remove the existing roof completely and install a new roof from the deck or deck insulation up. If the damage is severe only in certain areas of the roof, damaged material may be removed and a complete new roof installed over the affected area.

Occasional, widely separated blisters, bulges, and wrinkles can be effectively and economically repaired. The procedure is to use a roofer's knife to cut or slit the blister from end to end in one direction and from side to side in the other, taking care to see that the slits are at right angles to each other and that they intersect at or near the center of the blister. The four points of felt created by the intersecting cuts should then be folded back as far as the cuts will permit, allowing the sun to warm the asphalt (or pitch) and evaporate the moisture. (This procedure produces good results only if done on a hot, dry day.) When the interior of the blister is thoroughly dry, it should be filled with a good-grade roofing cement, and the four points should be pressed back into place by standing on them. After they have been cemented in place, an airtight, moisture-proof seal can be secured by troweling some of the roofing cement over the cuts and about 2 inches beyond their edges. When completed, this portion of the roof should serve many years without further trouble.

Loose Felts

Loose felt in a built-up roof is essentially a problem originating in improper application. The difficulty may be caused by dampness at the time of application, which prevents proper adhesion of asphalt or pitch; by spotty, thin, or uneven mopping of asphalt or pitch, causing adhesive weakness; by improper heating of the adhesive compound (at either too high or too low temperatures) before applying; or by the use of felts with creases or wrinkles in them. A roof with this problem may withstand weathering and may prevent moisture penetration for a while, but will eventually break down, probably at an inopportune time.

Layers of felt with loose edges may catch winds, causing tears in fabric, separation of layers, and often complete loss of felt from affected areas. If there are adhesive weaknesses elsewhere, then blisters, bulges, and wrinkles may develop, creating points for possible moisture penetration.

Maintenance procedures for a roof with loose felt depend upon the extent and nature of the failure. If an entire roof surface is affected, the obvious remedy is to remove the mat down to the roof deck (or to the vapor barrier and the insulation over the deck if they are sound) and apply a new mat. Occasional bulges, blisters, or wrinkles caused by loose felts may be repaired as previously described. Where the problem is confined to poorly cemented edges, affected layers may be cut with a sharp knife; a slit should be made perpendicular to the edges of the layers, and it should extend as far across each layer as the area of poor adhesion seems to extend. The layers should then be turned back as far as the slit will permit. If moisture is present, the felt should be allowed to dry. A good grade of roofing asphalt or pitch should be brushed or mopped on each layer of dry felt, beginning with the top surface of the bottom undisturbed layer, each layer being pressed into place during the process.

If there is an apparent surplus of felt in any layer, this surplus should be cut away to insure a smooth, close joint along the edges of the slit. Measurement, experience, and judgment will be useful in determining the amount of material to be removed. If more than one layer needs to be trimmed in this manner, cuts should be made so that one will not lie directly over another when the layers are pressed back into position. When all layers have been pressed firmly into position, a roofing cement of good quality should be troweled over the exposed surface of the top layer, covering the slit and extending 6 to 8 inches beyond it.

In places where loose felt has disintegrated, it is necessary to remove the distintegrated layers and replace them with new felt mopped in place. When all layers that have been removed have been replaced, an additional layer extending at least 6 inches beyond all joints and forming an "overlap" for them should be mopped in place.

Cracks

Cracks and tears can develop in most types of built-up roofs, and may be due to one or more causes, common among which is failure to provide adequate expansion joints while the building is being constructed. This construction detail prevents strain and stress on the mat when temperature changes cause roof and deck materials to contract. If this is the cause, the most satisfactory solution is to install expansion joints at intervals to be determined by construction engineers. This is a complicated job that usually requires the attention of a building contractor working under the supervision of an architect.

In some instances, cracks and tears may be due to the evaporation and drying out of oils from the roofing felts, which then turn into a soft, porous, pulpy mass that readily cracks under intense solar heat or freezing temperatures. In this case, preventive maintenance is cheaper than neglect. A good asphalt and oil roof primer like the mixtures used by the manufacturer of the roofing felt should be mopped or brushed onto the roof surface once every 3 to 5 years, more often in regions where there are great variations in temperature. This procedure replaces oils taken from the felt by the heat of the sun's rays, puts new life into the paper, fills up the holes, and minimizes the possibility of cracking.

If roof cracks are too extensive and too deep to be corrected by applying two or more coats of roof primer, it is necessary to remove those roof sections that are extensively damaged and to replace them with new felt. Where this procedure is followed, it is usually desirable to use felt of the same type, weight, and quality, and asphalt compounds and pitches of the same quality and composition as were used in the original installation. Standard procedures for heating the asphalt or pitch, mopping the felt, and rolling it down should be followed, and if these sections, as parts of larger roof areas, necessitate the joining of old and new, care should be exercised to see that all joints are properly overlapped.

Damaged Surfaces

Surface finish for built-up roofs is either smooth or gravel. The smooth surface is produced by applying a coat of hot asphalt or coal tar pitch on top of the final ply of felt; the gravel surface, by embedding into this coating, while hot, a specified amount of roofing slag or roofing gravel. Either finish, applied according to manufacturers' specifications, will give satisfactory service under normal conditions, but some advantages, from the standpoint of maintenance, are claimed for each. The smooth surface is easier to inspect, allows defects to be detected more readily, and usually presents fewer complications when repairs are needed than the gravel surface. Some advantages claimed for the gravel-surface roof are that the gravel protects the asphalt and coal tar products from the damaging effects of weather; that the added weight holds the roof down and is particularly advantageous in areas of high wind velocity; and that the felt and its bituminous coating are protected when foot traffic over the roof is necessary.

Ordinarily, a smooth-surface roof requires resurfacing every 3 to 5 years, depending upon its original quality and on climatic conditions. When resurfacing is necessary, the first step is to clean the old surface thoroughly, removing any weathered bitumen. If the surface is wet, it should be permitted to dry. Then one of two general methods may be used: one is to apply a coating of hot asphalt or coal tar pitch; the other is to apply first a coating of asphalt roofing primer and then a coating of cold asphalt. There are differences of opinion as to the relative merits of the hot v. the cold application, but both have been used successfully, and satisfactory results may be obtained from either.

Properly installed, a gravel roof does not normally require resurfacing within its service expectancy, but it should be inspected regularly for any signs of deterioration. If resurfacing is indicated, all old gravel should be carefully scraped off. The surface should then be swept clean and allowed to dry before a coating of hot asphalt or coal tar pitch and a fresh supply of gravel or slag are applied. Standard practice is to heat coal tar pitch to not more than 375° F. and to apply it at the rate of 55 pounds per 100 square feet of roofing surface. While the pitch is hot, 300 pounds of roofing slag or 400 pounds of roofing gravel per 100 square feet of roofing surface should be embedded in it.

If a limited area of roofing, whether smooth- or gravel-surface, needs repairing, the defective roofing and the adjacent felt for several feet around it should be removed. The entire area should then be cleaned and dried before new plies of felt are mopped into place.

The final or top ply should extend at least 6 inches beyond the other plies. Finally, if the surface is to be finished smooth, one of the two suggested methods of refinishing should be employed to complete the job; or if the surface is to be gravel, the procedure described in the preceding paragraph should be followed.

Flashing Leaks

Flashing is the material (usually lead, tin, copper, aluminum, or sheet metal) used to seal roof joints at openings, edges, intersections of horizontal and vertical surfaces, and minor differences in elevation. Specific problems involving moisture penetration usually develop at four flashing locations: edge, base, through-wall, and cap.

EDGE

Edge flashings usually develop leaks because of a poor bond or a break in the bond (caused by differences in the rate of expansion and contraction of two different materials) between the roofing felt and the horizontal leg of flashing. Many types of mastic are available, but few are guaranteed to bond roofing felts to metal flashing securely and permanently. Asphalt or coal tar pitch of the same quality used on the rest of the roof is specified by some architects, but others prefer the extended leg of flashing to be bedded in plastic roofing cement, with the top layer of roofing felt lapped over and also bedded in the plastic cement. Another, and perhaps more common method, is to place the flashing leg on top of all roofing felts, bedding it in plastic cement and backstripping it with two layers of felt which are also bedded in the plastic cement. This method prevents water from getting under any of the basic roofing felts if there is a break in the bond. When sheet metal flashing is used, it is not advisable to solder joints, because the expansion and contraction of the metal with temperature changes will cause the joints to break, permitting entrance of water. A better method is to lap the sheet metal joints 4 to 8 inches, with or without mastic, and to allow the metal to slide when it expands or contracts. If heavier, extruded metal is used for flashing, the adjoining sections should be separated by about ½ inch, and the open joint should be covered with a 4- to 8-inch extruded joint cover.

BASE

Base flashing is used to seal construction joints at intersections of horizontal and vertical surfaces, such as the junction of the roof with parapet walls, vents, skylights, chimneys, towers, flagpoles, antenna masts, and other vertical projections.

A common but usually unsatisfactory practice is to install sheet metal as the base flashing, a practice which is being abandoned because of difficulties in securing a bond between the metal and the felts. Another method is to lap the horizontal leg on top of the felt and then back-strip on top of the leg, but this procedure often leaves open vertical joints where adjoining metal flashing strips meet, thus permitting water to enter behind the flashing. A more successful method is to turn the roofing felts up the vertical surfaces to a height of 8 to 10 inches to prevent wind-blown rain, standing water from clogged drains, or melting snow from going over the top of the felts and into the construction. This procedure requires capping the turned-up felts with sheet metal counterflashing from above, making no bond between the metal and the felt. When this procedure is employed, care must be taken to see that the turned-up felts are mopped the full 8- to 10-inch height, because dry felts under the counterflashing will not prevent water from coming under the flashing.

THROUGH-WALL

Through-wall flashing is used to seal out water from the sides of masonry walls that rise above roof decks. Practically all masonry walls (brick, concrete block, pumice block, cinder block, etc.) are vulnerable to penetration by water. Portions of such walls that extend above roof decks, such as parapets, fire walls, and chimneys, are often especially troublesome. Once water gets inside these walls, it filters down to reappear on the face of the wall, both inside and outside. Evidence of inside penetration is found in loose, broken, bulging, discolored, or disintegrated plaster; in peeling, blistered, or alligatored paint; in warped, unglued paneling; and in other types of damage. Outside damage usually takes the form of spalling, efflorescence, saponification, or other types of hydrolysis.

This type of water penetration and subsequent damage can be prevented by installing horizontal through-wall metal counterflashing above the turned-up base flashing felts, and by letting the metal counterflashing cover, and drop down over, these cemented base felts. This installation provides a continuous waterproof seal across the roof deck, up the wall above the roof, and through the wall to the outside.

CAP

Cap flashing is usually applied at the top of a masonry wall or chimney to provide protection against water penetration from that point. Material used for top flashing is usually metal, fiber glass (or other type of glass fabric), or some other type of synthetic cap flashing. The material is laid directly on the masonry, and wherever possible is cemented to it; or the material is laid on a sloped grout bed or a sloped wood block bolted to the masonry for drainage. The edges of the cap sheet are usually carried 4 to 6 inches down the face of the masonry wall. If exposed metal is used for cap flashing, a standing seam joint is recommended to accommodate expansion and contraction of the metal. If parapet walls are coped with concrete, cut stone, terracotta, or tile, the flashing material may need to be laid directly underneath the coping to prevent moisture penetration through broken joints or from underlip dripping.

Condensation

When interior humidity condenses on roof decks, within roof structures, and on walls, there is often a tendency to blame the condition on roof failure, but it is more accurate to ascribe it to faulty planning and design or to improper insulation and ventilation. Caused by moist, warm, inside air that comes into contact with the undersurface of roof decks, skylights, or inside surfaces of exterior walls (where there is insufficient insulation to prevent outside cold from being conducted inward), condensation leaves a deposit of water on these surfaces. This water often drips from the deck to the ceiling, leaving visible spots and sometimes causing extensive damage to ceilings, floors, and equipment. Wall finishes subjected to condensation are also severely damaged. If a vapor barrier was not applied to the roof deck before the installation of insulation and felt, the moisture may soak into the insulation, causing it to lose its insulating value, and if it is of organic material, to rot.

In instances of high humidity inside a building and low temperature outside, an excessive amount of above-deck insulation may be required to keep the vapor seal warm enough to prevent condensation. If this is true, a structural design that will permit the installation of the required amount of insulation between the deck and ceiling should be used. Also, adequate ventilation below the structural roof deck, either by means of exhaust ducts or louvers, is helpful in preventing unusual problems of condensation. The best time to solve the problem, however, is during the planning and construction of the building.

Roll Roofing

For purposes of this discussion, roll roofing is distinguished from roll fabric used in built-up roofs by the manner in which it is applied and the roof structure to which it is adapted. Manufactured with either smooth or mineral surfaces from asphaltic compounds and felt, it is usually fabricated in strips 3 feet in width by 36 feet in length. For ease in handling (both marketing and on-the-job), it is put up in compact rolls. The smooth-surface type is usually employed as an underlayment, but may be installed as a temporary covering. Mineral-surfaced roll roofing, manufactured with a straight selvage or with a patterned edge, is generally installed as a 1-ply roof on shops, sheds, temporary buildings, or other structures having a roof pitch of 4 inches to 12 inches. Fastened to the roof deck with nails and roofing cement (or with special fastening devices, if the deck is gypsum or other fibrous material), this type of roofing material should have overlapping seams, according to manufacturers' specifications, with horizontal edges parallel with, and vertical joints perpendicular to, the eaves.

Some common maintenance problems associated with mineral-surfaced roll roofing are those attributed to improper application of materials, to wind damage, or to loose nails and fasteners. More specifically, leaks are more apt to occur if seams do not have proper overlap, or if lap cement has not been applied in sufficient amounts properly spread over the lapped edges; if seams are face-nailed; and if nails are improperly spaced or are too close to the edge of the roofing material.

Exposed nails work out, leaving nail holes; roofing material pulls away from nails, leaving tears, breaks, and open seams; insufficient lap cement, or improperly applied cement permits separation of laps, often creating buckles or "fish mouths;" and inadequate overlap causes seams to pull apart, leaving exposed roof deck.

If defects are not serious but need attention, simple repairs may be made by renailing farther from the edges of seams, pulling out all loose nails, filling all nail holes and small breaks with asphalt plastic roofing cement and by applying adequate amounts of cement on laps where needed.

Large breaks and tears are more serious, and require somewhat more complicated treatment than minor defects do. Where breaks extend across the felt beyond the edges of seams, it is necessary to open the horizontal seams below the breaks and to insert strips of roofing of the same type of material as was originally used (with lap cement liberally applied before insertion) through these openings. The strips should be cut to extend at least 6 inches beyond the edges of breaks, with their lower edges flush with the lower horizontal edges of broken materials. When the repair strip has been inserted, the edges of the roofing around the break should be pressed down firmly, nailed securely with appropriate roofing nails at about 2-inch intervals and approximately ¾ inch from the edges of breaks. Lap cement should then be applied to the horizontal seam before it is pressed into place and renailed.

If leaks are due to open seams (either because they have pulled apart or because there has been an inadequate overlap), they can be stopped by applying 4-inch strips of woven cotton fabric that has been saturated with asphalt (Federal Specifications HH-C-581a) and asphalt roof coating (Federal Specifications SS-R-451) over the open seams. This procedure requires several steps: any accumulation of dirt or dust along damaged seams must be removed; any buckles (fishmouths) which terminate at damaged seams must be cut and repair strips inserted under them in the same manner as described in the preceding paragraph; all loose or missing nails must be replaced; roof coating must be applied along damaged seams and must be extended 3 to 4 inches beyond each side of such seams; a 4-inch strip of asphalt-saturated fabric (with its center directly over the exposed edge of the roofing) must be embedded in the roof coating; this fabric must be pressed down firmly so that it lies flat without wrinkling or buckling; finally, the saturated strip must be completely covered with roof coating so that it extends beyond the edges of strip to the same extent as the coating which was applied underneath the strip. If both vertical and horizontal seams are damaged and need repair, the vertical seams should be treated first, starting nearest the eaves and alternately repairing vertical and then horizontal seams on each roofing strip from eaves to ridge.

Where the seams of roll roofing are blind-nailed and are leaking, they can be repaired by face-nailing them with 1-inch nails at 2-inch intervals along a line approximately 1 inch from the edges of the sheets. When this operation is finished, the damaged seams should be treated in the same manner as was described in the preceding paragraph.

If large areas of roof have been damaged, the recommended procedure is to remove the covering from the damaged areas and replace it with roofing of the same type, using full-width sheets, lapped, cemented, and nailed according to manufacturers' recommendations for the particular material.

Flexible Shingles

Flexible roofing shingles are made from asphalt-saturated rag or asbestos felt and are called asphalt shingles. Talc of mica is applied to the underside to prevent sticking and to facilitate handling; natural mineral granules (from slate, marble, granite, or other natural stone) are embedded in the asphalt coating on the exposed side to improve durability and to increase resistance to fire. Two types of flexible shingles are manufactured—individual and strip. The individual consists of only one tab, while the strip has from two to four or more tabs. Usually, either type will provide a satisfactory roof if installed according to manufacturers' specifications. In general, the roof pitch should be from 4 to 8 inches per foot, but if the butt ends are cemented down, flexible shingles give satisfactory service when roof pitch is much less. In roofs with slopes of less than 4 inches to each 12 inches, the danger is that winds may be caught under the exposed edges or that blowing rains may penetrate the layers of shingles.

Other than normal exposure and wear, there are three principal causes of damage to flexible shingle installations: hail, wind, and faulty application. Hailstones of sufficient size, falling with great velocity, can damage most any type of roof, but asphalt shingles are especially vulnerable to punctures, pitting, or the loosening and separation of mineral granules from their exposed surface by severe hailstorms. Wind damage is usually associated with faulty installation, but it is sometimes difficult to prove this. If shingles have been nailed too high or are applied on decks having little slope (pitch), and are not securely cemented along butt edges, particularly in areas of considerable wind velocity, there is danger that wind may be caught between layers of shingles, bending, breaking, tearing, or displacing them. Where there is wind damage of this type, the three or four courses of shingles nearest the roof ridge, or the courses within 5 or 6 feet of the edge of the roof, suffer the greatest damage.

Wind and hail damage to individual shingles, to strips, or to small segments of a shingle roof can be repaired. In some instances it is necessary to replace damaged shingles; in others, where damage to shingles is only slight, repairs may be made by cementing them back into place. If there is evidence that shingles have been nailed too high, a small quantity of plastic cement can be placed under the center and about 1 inch above the lower edge of each tab, using a trowel, a putty knife, a calking gun, or other convenient tool. The quantity of cement for each tab should be no more than is required to make a spot approximately 1½ inches in diameter when pressed down. If too much cement is applied, the tabs will not lie flat when in position. Replacement of individual shingles or strips is accomplished by breaking any remaining seal (if cemented) between damaged and sound shingles, gently lifting the top course from the damaged members to permit removal of nails and of the damaged shingle, and inserting a new shingle or strip of the same kind in the exact position the old shingle occupied. The new shingle should then be nailed. Before the top course is pressed down, any old cement remaining on its underside should be scraped off and a small amount of new cement applied both to it and to the underside of the new tabs; both the old and the new should then be firmly pressed into place.

Rigid Shingles

Slate, tile, and asbestos-cement are the materials from which rigid shingles are made. Generally used on permanent buildings with pitched roofs, these shingles normally render satisfactory service for many years without substantial outlays for maintenance. Usually, repairs are necessary only when fasteners or nails work loose, rust out, or break, or when individual shingles have to be replaced because of breaks. When repairs are made, precautions should be taken to prevent damage to surrounding roof areas while the work is in progress. Being inflexible, this type of roofing material is easily broken if traffic is permitted over its unprotected surfaces. A practice that affords this protection is to attach wide boards to ladders, scaffolds, or work platforms at points where they rest on the roof to equalize the weight load of workmen and materials.

The most common type of maintenance required for a slate roof is the replacement of a broken shingle. Broken shingles are frequently caused by hailstones, carelessly thrown rocks or other falling objects or by repairmen who are unfamiliar with the characteristics of slate. The repair is made by removing the broken shingle, cutting the nail or nails which held it with a nipper or pincer, inserting a new slate of the same size and color as the broken one, and nailing it through the vertical joint of the next course above. The nail should be placed about 2 inches below the butt of the slate in the second course above. In order to prevent a leak around the nail a 3-by-6 inch strip of copper, galvanized iron, or painted tin (bent slightly concave to hold the metal in place) should be inserted under the course above for about 2 inches, should cover the nail head, and should extend about 2 inches below it. Another procedure for preventing leaks through exposed nail holes is to cover the heads of nails in these holes with roofing cement. Nail holes should be predrilled, and nails should never be driven tight enough to put a strain on the slate.

Where ridges or hips require replacement of slate, the treatment given to them under the original specifications for installation should be observed. This treatment usually follows one of three patterns—"Saddle," "Mitred," or "Boston." Regardless of the treatment, both nails and plastic roofing cement are usually required when ridge or hip slate is being replaced. Nails for the combing slate should pass through the vertical joints of the slates below. Replacement pieces should be pointed and embedded in plastic roofing cement and any exposed nails should be capped with it.

Broken clay or cement roofing tile can be replaced in the same manner as broken slate shingles (see p. 23). Spanish tiles are replaced by troweling portland cement mortar on the new tile surface that will be lapped by the course above and on the surface that will lap the course below before pressing the new tiles firmly into position, fastening them into place with copper wire. Interlocking tiles can be correctly laid in only one position, that is, interlocking with other tiles, and they require special fastenings.

Cement-asbestos shingles that were originally laid by the American method can also be replaced in the same manner as broken slate shingles. If the original installation was by the Dutch-lap (or hexagonal) method, old metal fasteners, anchors, or nails must first be removed before the broken pieces of shingles are taken out. If the original nails cannot be withdrawn, the new shingle can be notched to avoid the nails before it is inserted in the same position as the old shingle.

Metal Roofing

Many metals are used for roofing, but those most commonly installed on school buildings are copper, aluminum, terne, and galvanized iron or steel. Metal roofing is usually manufactured in sheets from 2 to 4 feet in width and from 2 to 8 feet in length, or in rolls of about the same width but up to 90 feet in length. Of the four metals mentioned here, perhaps copper and aluminum are more maintenance-free than the other two, since terne and galvanized steel or iron have to be painted periodically. When properly applied, all of these metals give satisfactory service as roofs for many years. Improper installation seems to be the chief cause of metal roof failure; a common example of improper installation is failure to provide adequately for contraction and expansion of the roof due to temperature changes. This failure is indicated by breaks in seams or in the metal at points other than the seams. In batten-seam or standing-seam metal roofs, the horizontal seam, which is usually a locked, flat seam, should never be soldered. All fasteners for any type of metal roof should be checked for alloys that might cause galvanic action when in contact with the particular type of metal roof. Occasional damage by external forces makes some repairs necessary.

In copper roofing, small holes (often caused by falling objects, such as sharp-edged stones thrown on the roof) can be repaired with a drop of solder; larger holes, by soldering a piece of copper over them. A satisfactory soldering job can be done only if the surfaces to be joined are thoroughly clean and are buffed until the metal is bright. Zinc chloride or rosin should be used as a flux before the surfaces are tinned with a thin coating of solder containing equal parts of tin and lead. Where leaks occur in standing or in batten seams, these seams may be opened and re-formed; the copper should be bent only to rounded angles, never to sharp ones.

Aluminum roofing, like copper, requires expansion joints in all roof installations with flat seams. Batten- and standing-seam installations normally provide for the expansion and contraction of the metal. When soldering, brazing, or welding is necessary to repair holes, the methods employed and the materials used should be suitable for the aluminum alloy of the roof, since the alloy should not be allowed to come in direct contact with metals not compatible with it. Also, in the installation of a new aluminum roof or in the repair of an existing roof, the aluminum should always be protected from direct contact with wet or intermittently wet cement, concrete, or mortar. This can be accomplished by coating the metal with bituminous or other suitable compounds. If it becomes necessary to open seams and install new fastening devices, these should be of aluminum or a compatible metal such as nonmagnetic stainless steel, nickel, bronze, or a metal plated with zinc or cadmium, and when seams are re-formed, they should be bent to rounded angles.

Terne, a material consisting of sheet iron or steel (coated with an alloy of approximately 4 parts of lead and 1 part of tin) is usually called "short terne" when manufactured for roofing. It is produced in sheets and in rolls. Terne roofing is normally supplied with a shop coat of paint on both sides, but painting of exposed surfaces after installation and periodically thereafter is also necessary. If rust is present, the surface must be thoroughly cleaned with a wire brush, a steel wool pad, a scraper, or other convenient instrument, before any paint is applied. This cleaning process usually removes the original primer coat, making it necessary to apply another primer coat over affected areas as soon as practical after the surface is cleaned.

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This coat should be a corrosion-inhibitive primer that is applied generously and is brushed out to a uniform film thickness.. A good coating should be applied on all corners and edges because they are more apt to corrode than flat surfaces. Normal drying time for the primer coat is 48 hours. It is always good practice to allow ample drying time before applying finish coats.

Usually two finish coats (consisting of an oil-base paint, an enamel, or a special-purpose paint) should be brushed on well, and the first coat should be allowed to dry and harden before the second coat is applied. The entire operation should be undertaken only in fair, dry weather, and no paint should be applied during the early morning hours, when the metal is damp from dew.

Leaks in terne roofing, like those in other metals, are often caused by faulty seams. If the seams were originally soldered and have broken, they can be resoldered. They should first be thoroughly cleaned of any paint, grease, weather film, or other deposits, after which a rosin flux (no acid) should be applied, followed in turn by a solder of 50 percent lead and 50 percent tin. If the roofing was originally installed with formed seams (locked flat, standing, or batten), repairs can be made by opening and re-forming these seams, or if this procedure is not practical, the seams can be calked with a good-quality plastic calking material. This material can be applied with a calking gun, putty knife, or trowel, depending on the extent of repair necessary. If cracks or holes are present, they should be filled and coated over with the calking compound. Another method of making repairs of this nature is available through a recently developed material which, when used in combination with a glass fabric, is reported to be permanent. This material is said to be pliable at high or low temperatures; to have long life despite extreme weathering conditions; to waterproof any surface; to have a high tensile strength in a very thin application; and to be easily hidden with a coat of paint. Another great advantage claimed for this material is that it can be used on any type of metal, on any type of coping material, on concrete, or on any type of masonry.

Galvanized iron or galvanized steel roofing, like terne, is maintained principally by keeping it painted. Frequency of required painting varies with climatic conditions, but the job should never be deferred until rust appears on the roof surface. If rust is permitted to appear, it must be thoroughly cleaned from the metal with a wire brush. Turpentine or mineral spirits should then be used to clean the surface of grease, dirt, or any foreign material. After the surface is clean, a priming coat can be applied with a brush, spot-priming areas affected by rust and allowing ample time for the entire coat to dry before applying a finish coat of zinc, dust-zinc oxide paint. This finish paint is produced only in gray, but may be tinted to provide desired shades. If an existing coat of paint has deteriorated by blisters, peeling, or scaling, it must be removed, usually by wire brushing. Cloths soaked in turpentine or mineral spirits can then be used to remove dust and grease. When the surface is completely clean and dry, it can be refinished as new work. Layers of paint should not be built up on surfaces that are in good condition.

Locked, flat horizontal seams that leak can be repaired by soldering; standing and batten seams, by applying the same treatment as described for similar seams in other types of metal roofing (see p. 25). Other types of seams employed in galvanized iron or steel roofing installations, usually built-in for corrugated or V-crimp sheets, are the side- and end-overlap for the corrugated and the V-crimp overlap for the V-crimp sheets. These seams are not soldered. The pitch of the roof and the width of overlap are expected to keep out water. Such seams may leak as the result of improper application of the roofing, corrosion between the overlaps, or a failure of the exposed nailing. Repairs can be made by one of three procedures or by a combination of them: renailing, calking, or replacing all or part of the sheet or sheets in question.

Wood Shingles

Building codes of local, municipal, and State regulatory agencies, as well as standards promulgated by the Fire Underwriters Laboratory and the insurance rating factors used by insurance companies, often restrict the use of wood shingles for roofs on school buildings, but in localities where codes are less restrictive, roofing of this type is installed on some school structures. Generally, these are small, 1-story structures, usually with 2 or 3 classrooms. Sometimes they are cottages used for home economics instruction or other small auxiliary buildings.

Some factors that influence the length of service given by wood shingles are pitch and exposure of roof, character of the wood, kind of nails used, and the preservative treatment given the shingles, both before and after installation.

Wood shingles that have been treated with creosote oil by the full-cell process before installation have longer life than untreated shingles. A more common practice, however, is to stain them, after installation, with creosote and coal tar preservative, applying it by either the brush or the spray method. Pigmented stains containing creosote oil or its derivatives can be used if colored stains are desired. Heavy oil paints cause wood shingles to warp and curl, and are not normally recommended.

Cracked or broken shingles should be replaced, even if they do not leak, since they may allow water to reach nails in the next course below, contributing to their early failure. These shingles can be removed in the same manner as was described for slate shingles, except that at least four nails must be cut. When the broken shingle has been removed, it should be replaced with a new one of the same size. Both the new shingle and the one immediately above it should be nailed through the exposed butts, preferably with thin copper nails. Face nailing should never be done, however, except in the replacement of broken shingles. Furthermore, butts of warped or curled shingles should not be nailed down, since the nails invariably work loose, leaving nail holes as a source of potential leaks.

Roof Projections

Roof projections are those components of a building that extend above roof levels, and include such items as skylights, chimneys, vent pipes, ventilators, flagpoles, antenna masts, water towers, fire walls, parapet walls, and any mechanical equipment that may be mounted on roof surfaces. These projections originate at different points—some on, some under, and some at the edge of roofs, depending on their weight and the purpose they serve—but most necessitate structural holes or breaks in the roof deck and mat. A cardinal principle among roofing men is that the point where anything comes through a roof is a prospective fail point. Conversely, a roof with no such breaks usually has less failure. Special treatment is required at all breaks, or changes in elevation of roof surfaces. Flashings, one type of special treatment, have been discussed in relation to built-up roofs (see p. 17). Other problems requiring special treatment will be discussed here.

Coping for parapet and fire walls, for example, is often susceptible to moisture penetration because of material that is too porous, that is cracked or broken, that is poorly cemented to the wall, or that has joints in which mortar or calking material has deteriorated. If the coping is of stone, masonry, or concrete, and if porosity is the problem, correction can often be made by thoroughly cleaning the top surface and then applying a dampproofing compound, a masonry sealant or coating, or a silicone water repellent. Dirt and dust can be removed by air-blowing, brushing, hosing, or scrubbing, depending upon the character and amount of contamination. For extremely dirty surfaces, blast cleaning may be practical. If the surface is affected by efflorescence, this deposit can be removed by wetting and then washing the surface with a 20 to 30 percent solution of muriatic acid (or builder's acid), allowing the solution to remain on the surface for about 5 minutes before scouring it with a stiff-bristled brush. After being scrubbed, the surface should be flushed with water.

If concrete, stone, or masonry coping is cracked, broken, or spalled, repairs can be made by thoroughly cleaning the affected areas and by then filling cracks and openings with mortar. The mortar can be made by mixing 1 part of sand that passes a No. 3 sieve, ¾ part of portland cement, and ¼ part of limestone flour, powdered flint, or hydrated lime with enough water to make a mixture having a putty-like consistency. Wet the joints (or cracks to be filled) thoroughly, but permit them to absorb all surface water, before applying the mortar, or grout. After the mortar has set, it should be damp-cured, by wetting at intervals, for 48 hours. If cracks are large, a better job can be done if they are cut out in the shape of an inverted "V" and then cleaned before being grouted.

If mortar joints of masonry coping are soft, disintegrated, or cracked, tuck-pointing is usually necessary to prevent water infiltration. This is accomplished by cutting away defective mortar to a depth of at least ½ inch with hand or power tools and removing all loose material with a brush, or preferably, with a hose stream. Because high-cement mortars may shrink excessively while hardening, a process that lowers their effectiveness against water penetration by causing a reduction in the mortar bond, precautions should be taken against using mortar with higher portland cement content than the original.

If copings are loose or are not properly cemented to the tops of walls, they constitute a safety hazard and often permit leakage. They are dangerous because they might fall; and they may permit leakage when water flows from the top, down the edges, and to the underside, where it can enter tops of walls. All loose or improperly cemented sections that are in good condition should be removed, cleaned (as is the wall top), and replaced, using a full mortar bed or a heavy coating of plastic cement, depending on the nature of the coping material. The mortar joint should then be troweled so that there are no pinholes, hairline cracks, or voids through which moisture can enter. Broken and badly damaged sections of coping should be replaced with new material of like kind. Coping that is flush with the sides of a wall does not provide adequate drip, and in order to prevent moisture seepage into the wall, it is necessary to install through-wall flashing in the mortar bed, extending the flashing about 1 inch on both sides and turning it down to provide a drip. The same procedure should be followed when topping out masonry chimneys, piers, and pilasters.

In addition to the foregoing methods of repairing coping joints, some new procedures have been developed that rely on materials said to be highly satisfactory. A few manufacturers produce and market a type of glass fabric, recognized under various trade names, which can effectively seal joints against moisture penetration when used with a heavy-bodied paint-like product. A thin coat of the liquid is first applied over the joints and then spread to each side with a brush or special applicator. The glass fabric is then cut to size and applied over the joint or crack, extending over the surface to which the adhesive has been applied. This fabric is rolled or smoothed out to remove any wrinkles, following which another coat of the special liquid is applied and smoothed with an applicator. This material is said to be effective when applied to brick, metal, tile, stone, precast concrete, and other materials.

Scuppers, Gutters, and Downspouts

Another point of roof failure is at or around scuppers, a point often overlooked by those seeking to locate and correct roof leaks. Many buildings have flat roofs enclosed by parapet walls and inside drainage systems; other similarly constructed buildings have outside downspouts. In either case, scuppers must be installed to provide for the escape of water. For buildings with inside drainage systems, scuppers through the walls serve as a safety feature. If outlets become clogged, water can escape through them rather than collect on the roof and perhaps work its way over flashings and down into the building. Buildings with flat roofs, parapet walls, and outside downspouts must have scuppers to carry the water from the roof surface through the wall to the downspouts. Scuppers should be large enough to preclude clogging and should be unobstructed in any way by screens or other devices. But in some instances, precipitation in unusual amounts, slight settlement of roof structure, or the deposit of substantial quantities of wind-blown debris may prevent scuppers from performing their assigned function.

Where the volume of precipitation is greater than can be accommodated, it is necessary to install larger scuppers or to enlarge the throats of those in use. If settlement of roof structure (or some other condition) has caused the heads of downspouts to be higher than the roof surface, correction can usually be made by lowering the heads of the downspouts. All trash, debris, gravel, soil, or other deposit that may clog the throats of scuppers and cause a heavy collection of water on a roof should be removed periodically, frequency and removal depending on need. When copper flashings are used, the scuppers are usually completely lined with copper and this lining is soldered to the base flashing, with counterflashing being worked around the hole. A common though not frequent failure is the breakage of solder at these connecting joints by movement caused by temperature changes. This failure can be corrected by removing old solder around the break, cleaning the surfaces of metal to be joined (using rosin rather than acid as a flux), heating the seam thoroughly, and then applying plenty of half-and-half solder, which should be allowed to flow adequately over the joint.

Gutters are installed to conduct water running off a roof to outlets or downspouts. The kind of metal used for guttering largely determines the extent of maintenance required. Copper or aluminum, for example, require very little attention beyond being kept clean of sediment, leaves, or other trash. Galvanized iron gutters are more durable if they are kept painted both inside and outside with a good-quality outside paint. Adequate priming is required before paint is applied, however. In some instances, gutters may pull loose from fascia boards, and unless prompt measures are taken to refasten them, serious damage can be done to them during a heavy downpour of rain. In replacing supporting brackets, it is well to remember that gutters should have a slope of 1 inch to every 16 feet in length.

Downspouts are attached to gutter leaders to carry water down and away from building walls. They may empty into underground drainage tile or onto splash blocks. One of the chief maintenance problems of downspouts is their tendency to slip from the gutter leaders, to become loose at their joints, to develop loose supporting brackets, and to become filled with ice during cold weather or with leaves and trash at other times.

When downspouts have slipped from gutter leaders, they can be placed back in position by loosening all supporting brackets so that the downspouts can be moved without difficulty. When securely in place, all brackets should be remounted and securely fastened. If this difficulty is a recurring one, it may be necessary to solder the leader to the downspout. Loose joints of downspouts are usually repaired by soldering. Supporting brackets that are loose should be remounted with new nails or screws. Ice in downspouts can be dislodged by applying hot water copiously. If leaves and trash have been allowed to accumulate in downspouts, it may be necessary to remove the tubing so that a stiff wire or flexible rod can be inserted to dislodge the trash.

Walls

Walls of buildings are classified according to location and function, with some subclassifications based on materials used in their construction and on their elevation. From the standpoint of location, those serving as vertical enclosures are called "exterior walls;" those serving as partitions to divide and compartmentalize internal space are referred to as "interior walls." Either of these may be further classified as "below-grade" or "above-grade," depending on whether they are below or above the surface of the ground. From the standpoint of function, walls supporting vertical loads (their own weight and the weight of the structure above them) are classified as "bearing walls," whether exterior or interior; those that sustain no weight other than their own and that of doors, windows, and other attachments are called "nonbearing walls," and may be either exterior or interior. Nonbearing walls that are built and supported between columns or piers and on girders or other support are classified as "curtain walls," and are usually of light construction. Curtain walls are also sometimes called "thin walls."

Below-Grade Walls

Exposure and other factors cause distinct maintenance problems for below-grade walls. Some specific elements and details of below-grade walls that often require attention are footings, foundations, areaways, window wells, outside stairwells, and drainage design.

Footings

The lower portions of walls, piers, or columns which are spread to provide a safe base are called footing courses. Although many materials can be used for footings, concrete, sometimes reinforced with steel, is usually preferred unless unusual geological conditions are encountered. The concrete mixture is poured into a trench dug in the foundation bed or earth material on which a structure is to rest. Poured as a wide base, concrete footings serve to distribute, equalize, and transmit the weight of the superimposed structure to the foundation bed. Resting on top of footings is the foundation, which consists of below-grade walls, piers, and columns.

Footings may fail in several ways: by shearing, by direct crushing, by spreading, or by bending or rupture. Failure by shearing occurs most often when the weight of the superstructure is transmitted to the footing by piers or columns. If the foundation bed does not hold, or if the footing is not strong enough to withstand the pressure, it breaks around the base of the column, allowing settlement of the building at this point.

This type of failure can be repaired if corrective steps are taken during its early stages. Pressure on the footing can be relieved by lifting the building with heavy building jacks. The broken section or sections of footing can then be removed. A deeper, wider trench may be required for a new slab, which should be reinforced with steel for added strength. If there is evidence of soil movement, then the repair should include, before replacing the concrete footing, either digging to a firm foundation bed or driving a pile to solid earth or rock. When the new footing has been allowed to cure properly, the building jacks can be removed, allowing the pier or column to settle back to its original position.

Failure of footings by direct crushing is rare; ordinarily, it occurs only if the concentrated load of a pier or column is distributed by beams or girders whose webs are so thin that they fail by buckling. The solution to this problem is to remove the existing, damaged concrete footing and to replace it with new footing, using building jacks to hold the building's weight. At the same time, the webs of the beams or girders should be reinforced by vertical stiffeners or by additional web plates, and the spaces between the beams or girders should be filled with concrete or grout.

Failure of footings by spreading may occur under walls or piers, and usually occurs only when the foundation bed is of clay or some other yielding material, which tends to flow in a horizontal direction under the load of the footing. The problem is compounded if there are vertical joints in the footing, and if the footing is wide in relation to the superimposed wall or other construction. As in repairing other failures in footings, the weight of the superimposed structure must be carried by building jacks or other means while repair is in progress. The damaged footing should be removed and new material poured in place; the bottom layer should then be continuous and should be adequate in strength, width, and thickness to resist the tension.

Failure by bending or rupture is usually the result of a concentration of the load on the lower edges of the wall, particularly if the footing is much wider than the foundation wall it supports. A bend in the footing is a turning up of the edges, which permits all pressure to be concentrated on a smaller area of the footing immediately under the wall or pier it supports. Where a rupture occurs, the footing breaks rather than bends, and it permits concentrated pressure, just as bent footing does. Breaks, however, may occur either in the footing under the center line of the wall or at points close to the outer edge of the wall. Whether the footing is bent or ruptured, repairs can be made only by relieving it of the weight of the building, so that the damaged sections can be removed and replaced with fresh materials. Concrete for the new footing should have grillages of steel embedded in it for added strength against bending or rupture.

Foundations

Foundations are walls, columns, or piers that are below grade and that usually rest on footings. The purpose of a foundation is to provide a safe, permanent base for the superstructure so that structural movement will be minimized to prevent damage to the building. In general, foundation walls, columns, and piers are composed of poured concrete or of concrete blocks.

Some of the maintenance problems associated with foundations are cracks, water build-up and seepage, spalling, wall movement, and mortar joint damage if the foundation is made of concrete block.

Cracks in foundation walls, columns, and piers usually can be attributed to one of four causes: soil movement, weakness of the wall itself, footing failure, or earth tremors (in geographic areas subject to earthquakes). Hairline cracks may be of no serious consequence, and probably require no immediate remedial maintenance, unless there is evidence that the separation is growing. Larger cracks may be of such a serious nature as to require immediate attention. What kind of attention depends upon the underlying cause of the trouble.

If soil or earth movement is exerting pressure against the wall, as from a hillside, corrective steps include the following: (1) removal of offending soil by excavation to a distance of 4 to 6 feet from the damaged wall; (2) installation of a retaining wall, firmly set in rock or other substratum and securely braced with triangular pilasters, along the face of the excavation; (3) repairing the crack or cracks by grouting with cement if structure damage is not serious; (4) applying two or more coats of coal tar weatherproofing compound to the affected areas; (5) backfilling the dirt removed in step No. 1.

Water build-up against moistureproof foundation walls may eventually lead to their deterioration as moisture enters into tiny cracks and pores by hydrostatic pressure. If the water build-up is below frost level, the damage it causes may not be severe enough to be discernible in its early stages. If freezing is a factor, damage from the water can be serious, both by exerting pressure on the wall itself, thereby causing some displacement, and by enlarging cracks, pores, and opening mortar joints through molecular expansion. Failure to moistureproof foundation walls at the time of their construction can lead to serious water damage to them because of the porous nature of most materials used in their construction.

The problem of water build-up around and along the outside of foundation walls can be solved by performing the following operations: (1) removing the soil from the outside of the affected wall to a depth somewhat lower than the lowest layer of footing and a width from the wall of 3 or 4 feet; (2) installing regular drainage tile at the bottom of this excavation so that the tile line has a pitch (drop) of at least 1 inch to each 15 lineal feet, and then tying the lower end of the tile line into the surface drainage system, if any; or if there is no surface drainage system, running the tile line away from the building to a point where a dry well can be constructed so that the water draining into it can be absorbed by the surrounding soil; or if neither of the foregoing solutions is feasible, constructing an underground pit or catch basin, which should be lined with impervious material and covered with a standard grating (a sump pump of adequate capacity can be used to pump the water from the catch basin to the storm sewer); (3) covering the drainage tile in the bottom of the excavation to a depth of 12 inches and a width of 24 inches with crushed stone; (4) backfilling the entire trench with the soil originally taken from it; (5) replacing the sod and watering it down, or giving whatever treatment may be required to the leveled soil.

When foundation walls also serve as basement enclosures, moisture seepage through them into basement areas can damage material or equipment stored there, and may cause excess humidity throughout the building. The cause of seepage of this nature can be corrected in the same manner as described for water build-up (see above), but if there is only a slight leakage or dampness on the inside surface of concrete masonry or concrete walls, two or three heavy coats of portland cement paint applied to the inside surface are sometimes successful in stopping the leakage. The surface should be thoroughly cleaned and then wetted before applying the paint. Proper application of this paint to coarse-textured concrete requires a brush with relatively short, stiff fiber bristles such as an ordinary scrub brush. If the concrete is of a smooth or sandy finish, a whitewash or a Dutch-type calcimine brush is suitable. The paint should be vigorously scrubbed on in such a manner as to work the paint back into the voids and provide a continuous film of paint, free from pinholes or other openings through which water might penetrate.[1]

[1] *ACI Standard Recommended Practice for the Application of Portland Cement Paint to Concrete Surfaces* (ACI 616–49). Detroit, Mich.: American Concrete Institute, 1949. p. 3.

Concrete foundation walls (either poured concrete or blocks) that have not been dampproofed [2] and that are exposed to frost are often damaged by a process known as "spalling," a process by which particles and fragments of concrete or masonry are chipped away by the force of freezing moisture in the pores and voids of the concrete.

This problem can be solved by following these procedures: (1) dig a trench along the foundation walls to a depth of the footing and wide enough to accommodate workmen; (2) shore up the face of the trench if there is danger of a cave-in; (3) thoroughly clean the face of foundation walls of dirt, grease, oil, and loose mortar particles; (4) dampen the walls by spraying with water; (5) parget the walls from a point several inches above finished grade to the footing with a ⅜-inch coating of mortar, using a mixture of 1 part portland cement to 2½ parts of sand, proportioned by volume and mixed with water to a workable consistency; (6) if two parget coats are required, the first should be scratched with a coarse brush before it hardens so that the second coat can form a good bond to this roughened, scratched surface; the second coat should not be applied earlier than 24 hours after the first and then only after the first has been thoroughly dampened; (7) for proper curing, keep the second coat damp for at least 48 hours after hardening; [3] (8) when parget coats have been allowed to cure properly, remove shoring from trench wall and back-fill.

Another cause of foundation failure is wall movement resulting from contraction and expansion from temperature changes. This can be a serious problem in sections of the country where there are rapid and frequent changes in temperature, particularly if walls have not been designed with adequate expansion joints. The principal types of failure from this cause are cracks in solid walls, opened mortar joints in block or masonry walls, and in severe cases, wall displacement.

If the problem is serious enough to cause wall displacement (buckling, bulging, out-of-plumb alignment, or fragmentation at corners and on surfaces), the only satisfactory and lasting solution is to tear out and rebuild the entire wall from footing to eaves, making sure that adequate expansion joints are provided in the rebuilt wall. If the problem is less severe and there is no question about the structural safety of the walls, damage from wall movement may be confined to a few cracks or to opened mortar joints. Failures of this nature can usually be repaired satisfactorily, though not always per-

[2] "Dampproofing" and "waterproofing" are terms that are often misused. "Dampproofing" refers to treatments intended to reduce moisture penetration by capillary action; "waterproofing," to treatments intended to stop the flow of water through a wall.

[3] *Technical Notes on Brick and Tile Construction.* Washington: Structural Clay Products Institute. July 1961, No. 7.

manently, by using a special tool to cut out the cracks in the shape of an inverted "V" and by cutting away damaged mortar from broken joints to a depth of ¾ inch, and by then tuck-pointing both the cracks and the defective mortar joints with fresh mortar. In some instances, an application of two coats of asphalt or bituminous material over the repaired surfaces affords sufficient elasticity to prevent future cracks or damaged joints.

Areaways

Areaways are sunken spaces along outside walls of buildings that allow air and light to reach basement areas. Having little or no protection from the ravages of the elements, areaway walls, which are usually constructed of brick, stone, or concrete, are often subjected to heavy damage by the weather.

Areaways have some maintenance problems that are common to other below-grade walls, some that are common to above-grade walls, and others that are peculiar to themselves. Some maintenance problems peculiar to areaways are growth of thallophytic plants (molds, mildews, rusts, smuts, etc.), drainage, and often a rapid deterioration of mortar in masonry walls.

Plant growth on the surface of areaway walls and floors, particularly of mildew, mold, and moss, is primarily due to the continuous dampness and warmth and the absence of sunlight. Affected walls can be treated with a mildewcide to destroy the growth, but under conditions favorable to such growth, these treatments have to be repeated periodically. Longer-lasting results may be obtained by cleaning affected surfaces with an alkaline cleaner, such as a solution consisting of 1 pound of trisodium phosphate to a gallon of water. If this chemical is not readily available, one of the abrasive cleaners can be used. After the surface has been cleaned, it should be sterilized with a hypochlorite (chlorine) solution and then rinsed with clear water. When the surface is dry, a mildew-resistant paint can be applied. This paint can be purchased ready to apply, or can be made from any regular paint mix by adding a mildewcide or fungicide to it and stirring well before applying.

Since areaways are usually unprotected and are below finish grades, they often become "catch basins" for excessive surface water from rain or snowfall and for litter that may be thrown or blown into them. Well-designed areaways are provided with adequate underground drainage pipe, properly tied into the storm sewer or other drainage system, and with floor drains designed to prevent entry of any material too large or too heavy to be carried by the piping.

The principal maintenance problem under these conditions is to keep areaways free of litter and refuse and to remove and clean floor drains and sediment buckets periodically. Where the accumulation of dust or soil is such that underground pipes might become clogged, a good practice is to flush these pipes with water under pressure each time the drains and sediment buckets are removed for cleaning.

If areaways have been constructed without drainage pipe and if the collection of water in them is a problem, it might be more economical to construct a pit and install a sump pump at each troublesome location than to attempt to install underground drainage.

If, through neglect, underground drainage pipe has become clogged with soil sediment or other solids, and if no trap or clean-out plug has been provided, the pipe may usually be opened and the solids dislodged and flushed away by inserting a flexible cable with an auger or corkscrew attachment on the end, and by turning the cable when the auger attachment contacts the obstruction. At the same time a water hose must be inserted intermittently and water must be released, under pressure, against the obstruction within the pipe. If this procedure fails to open the pipe, the only alternatives are to dig out and replace the pipeline, or install a sump pump that will automatically pump excess water from the areaway.

The third type of maintenance problem for areaways—mortar deterioration in masonry walls— is usually caused by moisture penetration into the wall. This penetration may enter the wall through defective coping, through loose flashing under the coping, through the wall from the soil packed against it, or into the wall from rainfall blowing against its exposed surface. Procedures for correcting leaks through coping were discussed in connection with the repair of parapet walls and flashing (see p. 17) ; moisture penetration from the soil is similar to water build-up against foundation walls, and is corrected in the same way as was described for foundation walls (see p. 35) ; moisture penetration through exposed wall surfaces can be prevented by applying one or more coatings of waterproof material, such as silicone preparation, a stearate solution, or a paint manufactured specifically for application on masonry walls.

A number of products are available for waterproofing exterior surfaces of masonry walls; if applied early and often enough, they can prevent mortar deterioration by removing the cause. Water is carried into masonry as vapor when vapor pressure within the wall is less than that of the air surrounding it, or by capillarity when the water is in contact with the surface, irrespective of vapor pressure. Also, water can and does enter through large, visible holes, often present because of poor workmanship. Masonry water repellents made from the silicones are easily and effectively applied with a low-pressure spray apparatus or an ordinary paintbrush. They form an invisible film that works equally well over or under cement-based paints, or as a primer for oil-based masonry paints. These repellents prevent water penetration caused by either vapor pressure or capillarity. However, they not only prevent water from entering walls, they also prevent it from escaping from walls. Provision must be made, therefore, for the walls to "breathe" if these impermeable coatings are to be used.

If masonry joints are open because of unsatisfactory workmanship, or if they have been permitted to deteriorate from alternate freezing and thawing of water lodged in them, the recommended procedure is to tuck-point the entire affected surface. This is done by removing the soft, decayed, or cracked mortar to a depth of ½ to ¾ inch with hand or power tools. When all cutting is completed, all loose material should be removed with a brush or with a hose stream. The Structural Clay Products Institute recommends that for best results in replacement mortar, duplicate the original mortar proportions, but if in doubt, use prehydrated type N mortar (1 part portland cement, 1 part type S hydrated lime, and 6 parts sand, proportioned by volume).[4] A good bond can be assured by wetting all mortar joints thoroughly and allowing excess water to soak into the wall before applying fresh mortar. The fresh mortar should be packed tightly into joints in thin layers until the joints are filled. The outside surfaces of the joints should then be tooled until smooth and concave.

If openings and cracks in joints are small, a grout coating consisting of ¾ part portland cement, 1 part sand that passes a No. 3 sieve, and 1 part limestone flour, powdered flint, or fine hydrated lime will effectively seal them. These ingredients should be mixed with water to obtain a fluid consistency before brushing the grout into joints vigorously with a stiff fiber brush. It is recommended that all joints be wet thoroughly and excess water be allowed to soak in, before the grout is applied. A template may be used to keep masonry units clean while applying the grout. Two coatings are usually recommended for best results.[5]

Above-Grade Walls

Above-grade exterior walls may be constructed of a variety of materials, depending on applicable codes, functions to be served by

[4] *Technical Notes on Brick and Tile Construction.* Washington: Structural Clay Products Institute. No. 7, July, 1961.
[5] *Ibid.*

the walls, and other considerations. The materials most frequently used for wall construction in schools are brick, stone, precast block, concrete, metal, and wood. For purposes of this discussion, walls consisting of brick, stone, marble, block, structural tile, or a combination of these materials are called masonry walls; concrete, as a wall material, is usually reinforced with steel, is often poured monolithically with the spandrel beams reinforced to form upturned spandrels extending the full height of the wall, or it may be precast to form the wall which is then tilted into position (tilt-up walls); metal walls may have diverse treatments, but in recent years they are used as curtain or thin walls consisting of decorative panels, usually of laminated "sandwich construction," with a wide range of glass, metallic, ceramic, plastic, and other materials playing important parts in the overall treatment; wood walls for schools are usually restricted by building codes to buildings of 1-story design, where safety of occupants from fire can be improved by providing direct exits to the outside from each place of group occupancy.

Masonry Walls

Some common, troublesome maintenance problems encountered in above-grade masonry walls are mortar deterioration, open vertical and lateral joints, moisture penetration, spalling, efflorescence, failure of calking material at the perimeter of exterior door and window frames, and discoloration of surfaces due to atmospheric deposits of soot, dust, and other foreign matter.

Mortar deterioration may be due to poor workmanship, improper mixture of the elements contained in mortar, failure to protect it during the curing process against freezing or against too rapid dehydration, or to a combination of causes. The suggested maintenance procedure for deteriorated mortar joints is to cut out affected mortar to a depth of ½ to ¾ inch with specially designed masonry chisels or with power tools and then to repoint the joints, following instructions previously given for tuck-pointing (see p. 39).

Mortar breaks away from masonry most frequently along lateral and vertical joints, leaving a kind of stair-step pattern. This breakage is caused by excessive movement along a given length of wall, and this movement is caused in turn either by temperature changes or by failure of footing. The former results in expansion and contraction of materials in the wall itself and the latter, in uneven distribution of the load. Damage from movement caused by temperature changes can be prevented only by installing at proper locations in the wall, adequate expansion joints that will absorb the extremes of thermal shock. The services of an engineer are required to do this job properly. To repair joints opened by expansion and contraction without first installing expansion joints in the wall compounds the problem: the additional mortar placed in the joints leaves even less room for wall expansion.

If wall damage is due to failure of footings, the footings must first be repaired. The material used for this repair should be strong enough to carry the weight of the wall and also of the superstructure, if the footing supports a bearing wall. Once the underlying cause of damage is corrected, the open joints should be chiseled out and refilled with mortar in the usual manner for repointing joints.

If not promptly and effectively stopped, moisture penetration of masonry walls causes many problems. Poor workmanship in putting wall components together, materials of inferior quality, advanced age of the structure, damage of any type, or a combination of these factors are the usual causes of moisture penetration. Once a wall is in place, little can be done to erase the marks of poor workmanship or to substitute high-quality materials for inferior ones. Exterior film waterproofing of leaking walls can be effective, but in most cases it must be repeated periodically. A satisfactory waterproofing material must:

- penetrate easily into the masonry surfaces and remain there on drying
- harden on the surface sufficiently to resist erosion, but not concentrate to form a hard crust
- prevent entrance of water, and at the same time allow escape of vapor, i.e., create a negative capillary action
- expand and contract uniformly with the surrounding surfaces so as not to cause spalling
- be noncorrosive and harmless
- retain its preservative effects indefinitely.[8]

Several companies manufacture various types of weatherproofing materials for exterior masonry. Some are colorless or nearly so, such as the silicones, stearates, oils, varnishes, paraffins, and waxes; others are organic compounds that stain or color, such as asphalt, vegetable, and mineral oil. Rubber-base paints are also used for this purpose. Most of these materials, regardless of type, can be applied by either brush or spray apparatus. If the leakage is due to defective joints rather than capillarity, repair of the joints will probably correct the trouble without the application of weatherproofing coatings. Regardless of the cause of moisture penetration, joints that have a poor bond or that show mortar deterioration should be repointed *before* any weatherproofing substances are applied.

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[8] A. D. Brainard. "Methods of Pointing and Waterproofing Exterior Masonry." *1951 ASBO Proceedings.* Evanston, Ill.: Association of School Business Officials. p. 327–337.

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Spalling of masonry or concrete surfaces is the falling away of solid particles, and is usually caused by the alternate freezing and thawing of water trapped in the capillary pores of the wall material. This problem can be solved effectively by eliminating the cause of moisture penetration and by making provision for wall surfaces to breathe and dry out through the process of air circulation.

Efflorescence is the deposit by water-soluble salts of a powder or stain on the surface of masonry walls. It is a maintenance problem of concern, because it indicates the presence of excess moisture in the wall itself. The point or points at which this moisture enters the wall must be located and corrective steps taken. Experience shows that these points are usually located in or on parapet walls, copings, flashings, window ledges, lintels, perimeter openings (for windows, doors, or louvers), and other irregularities of wall surfaces.

Once inside a wall, water trickles downward to reappear on either the inside or outside surfaces, where salt deposits are left. These deposits and stains can be removed by scrubbing affected areas with a mild solution of muriatic acid and water (1 part acid, 9 parts water by volume), using a stiff fiber brush. The scrubbed area should then be thoroughly rinsed with clear water to prevent acid penetration into the pores of the wall surfaces.

(Those who handle muriatic acid should wear goggles and gloves to protect their eyes and hands against the accidental injury that can occur if the acid spills or splashes while being mixed with water or while the solution is being applied to the wall.)

Another maintenance problem common to all types of outside walls with windows, doors, louvers, or other openings is that of keeping joints around these openings airtight and watertight. Joints are formed wherever two types of materials meet (such as wood and stone, metal and brick, or metal and concrete). If not sealed, these joints permit moisture and air infiltration, allow heat loss, or impair the efficiency of air conditioning systems; in addition, they generally contribute to, or create, other maintenance problems.

The usual process by which joints are filled is known as calking, and regardless of the quality of materials used, calking is a recurring maintenance job. Normally, it is required at about 5-year intervals. Calking compounds of good quality adhere to both edges of a joint or crack, regardless of materials joined; form their own protective skin when allowed to cure for a few minutes; remain elastic to resist damage from normal expansion, contraction, or from moisture and temperature change; and effect a long-lasting, watertight and airtight seal. They are produced in a variety of colors, as well as white.

Calking compounds may be purchased ready-mixed in either bulk form or in cartridges, or the ingredients may be purchased separately and then combined before use. Whether purchased in bulk form or mixed on the premises, the compound must be loaded into a calking gun for easy application. There are two types of hand guns designed to speed the application of calking materials: the full-barrel accommodates either the bulk or the canned compound, which is loaded into the barrel with a putty knife or a loading machine designed for that purpose; the half-barrel accommodates factory-filled cartridges manufactured with or without applicator nozzles. Those with nozzles can be cut to provide any desired size of bead; metal nozzles with apertures of any desired size are available for use with cartridges without nozzles. In either case, the calking compound is forced out of the barrel by pressure created by a plunger that is activated by the alternate pulling and releasing of a "trigger" on the gun.

To seal a joint or a crack, the gun's nozzle is moved along the opening while constant pressure is simultaneously applied to the sealant in the cartridge. Only experience and practice can determine the speed with which to move the gun and the pressure to exert in order to discharge the right amount of sealant. Deep cracks or joints should first be packed with oakum or some other packing material, until only about 1/4 inch is left to be filled with calking compound. Small cracks can usually be filled satisfactorily with a putty knife as an applicator. Excess calking can be wiped off with a moist cloth. If old calking compound or sealant is present, it must be cleared from the joint's surface edges before new sealant is applied. If painting is required after calking, the compound should be allowed to form a tough outer skin before the priming for paint is applied.

In some localities, the atmospheric deposit of soot, dust, and other foreign matter on the outside surface of masonry walls creates a recurring maintenance problem. This deposit is usually heavier but less noticeable on rough-textured surfaces than on smooth-textured ones. Removal of this deposit is always difficult, expensive, and time-consuming, regardless of the type of wall material. The processes used in cleaning masonry surfaces depend upon the nature of the spots, stains, or deposits to be removed. The problem is complicated by the fact that the surfaces nearly always contain two types of materials: the clay units and the mortar, each of which has different characteristics. Many cleaning compounds that work satisfactorily on clay products have damaging effects on mortar.

The principal methods of cleaning masonry structures, as recommended by the Structural Clay Products Institute, are as follows:[7]

Sand blasting which consists of blowing hard sand through a nozzle by compressed air against the surface to be cleaned. This method removes the deposit from the wall surface, but may destroy the original texture of the unit, leaving a coarser texture which is particularly susceptible to the accumulation of soot or dirt. Due to the difference in hardness between clay units and mortar joints, sand blasting may seriously damage the joints. If so, it will be necessary to repoint the mortar joints after the surface has been cleaned. The application of a colorless waterproofing compound to the roughened surface will tend to make the wall self-cleansing, and will protect the surface against rapid soiling from smoke and dust particles in the air. Sand blasting should never be used on glazed surfaces or other units having smooth textures.

Steam or steam and water jet cleaning consists of washing the wall with a steam or steam and water jet under pressure. It is effective in removing soot and dirt, but will not remove stains which have penetrated the pores, nor will it remove such substances as mortar or paint. It may be used on both rough and glazed surfaces, but best results are obtained when used on glazed units.

In extremely stubborn cases, an alkaline such as sodium carbonate, sodium bicarbonate, or trisodium phosphate may be added to the water when cleaning by the jet method. These salt compounds will aid materially in the cleaning process, but some of the salt may be retained in the clay unit and will reappear later in the form of efflorescence. The amount of salt retained can be materially reduced if the surface is thoroughly soaked with clear water before the cleaning solution is applied. Also, the wall should be washed with an abundance of clear water after cleaning to remove salt from the surface.

Application of a cleaning compound is a method of cleaning that is particularly adaptable to small structures, and is probably used to a greater extent than any other method. It involves the development of a cleaning compound best suited to removing the particular material and stains found on the structure. The strength and chemical composition of the solution in each case can be adjusted by trial, but care should be exercised to prevent absorption of the solution into the pores of the masonry units in order to forestall efflorescence.

Efflorescence can frequently be removed by applying water with stiff scrubbing brushes. If this procedure is not effective, clear water should be applied to affected areas before they are scrubbed with water containing not more than 10 percent muriatic (commercial hydrochloric) acid. Immediately after scrubbing with this solution, the walls should be rinsed with clean water.

Green stain or efflorescence resulting from vanadium salts in the masonry should not be treated with an acid solution. If this is a problem, the recommendations of the manufacturer of the masonry used should be secured and followed.

Acid cleaning is not required for glazed masonry units. Mortar stains on glazed units can be removed by washing them with warm water and a soap powder, applied with a fiber scrubbing brush. After the units have been scrubbed, they should be rinsed with clean water.

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[7] *Reinforced Brick Masonry and Lateral Force Design.* Washington: Structural Clay Products Institute. 1953. p. 224–228.

Masonry walls of limestone should never be cleaned by the sand blast method, or with wire brushes, or by the application of acid. Soap powder, clean water, and fiber brushes, or approved machine cleaning processes may be used for cleaning limestone walls, but the walls should be rinsed with clean water immediately after the cleaning process.

The finish of exterior walls of marble is either polished or tooled (or sand-finished). Cleaning procedures are somewhat different for each, particularly if the marble has been neglected. If it has not been allowed to become soiled or stained, it can be kept clean with clean water and washing cloths, regardless of finish. The Marble Institute of America, Inc., suggests various methods and procedures for cleaning exterior marble, including the following:[8]

Exterior polished marble can be cleaned with a mildly alkaline soluble cleaner or soapless cleaner of the non-precipitating type that contains no grease, lye, or other corrosive fillers. The cleaner should be one that rinses freely, even in hard water; leaves no greasy or slippery film to catch and hold dirt; and does not scratch.

The marble area to be cleaned should first be wet thoroughly with clean, clear, hot water and then washed with a soluble cleaner made in accordance to manufacturer's directions. The marble should be washed from the bottom up in small overlapping sections. Each section should be rinsed with clean water, using soft cloths. Immediate drying of the surface with clean chamois or soft cloths will prevent streaking.

If the marble shows deep-seated stain and discoloration, a poultice should follow normal cleaning. This will draw out deep-seated stains and secure more uniform results than is usual by surface scrubbing. A poultice paste is made by mixing a powdered abrasive cleaner with hot water, stirring thoroughly with a stick or paddle until the mixture has the consistency of wet cement or plaster (use about 1 pound of abrasive cleaner for each 1½ square feet of surface to be covered).

The surface of the marble should be wet before applying the poultice with a plasterer's trowel or wooden spreader to form a uniform thickness of about one-half inch, completely shutting off the air from the face of the marble. Apply the poultice to the entire area to be cleaned and let it remain there for 48 hours, or until thoroughly dry. It should not be permitted to dry out too rapidly or be washed off by rain prematurely. To remove the poultice, dampen it slightly to avoid dust; use a wooden paddle to avoid scratches; rinse the stone thoroughly with clean water, being sure that no paste remains; then wipe dry.

Paste works best when freshly mixed and applied hot. In severe cases several applications may be necessary to secure best results.

Many highly colored marbles need special treatment to retain their polish and color. This treatment consists of the application of light colored waxes at

[8] *The Cleaning and Maintenance of Marble.* Mount Vernon, N.Y.: Marble Institute of America, Inc. (A. I. A. File No. 22–A). 1958. p. 8–11.

intervals of 1 to 3 months (only paste or water emulsion waxes that will not water spot should be used). A further treatment is to apply a colorless waterproof lacquer, especially designed for bonding to smooth marble surfaces with no tendency to yellow, at least annually. Waxing or lacquering of white marble is not recommended unless a creamy effect is desired.

Tool or sand finished exterior marble **can be steam cleaned satisfactorily if no harmful acid cleaners or injurious alkalies are used. Repointing to make joints waterproof should be undertaken along with cleaning.**

Sandblast cleaning is recommended only when properly supervised and then only on Group A marbles, and only if iron-free sand or abrasives no coarser than 120 grit size are used. Pressure should be kept at a maximum of 60 pounds and the nozzle should be kept at least 15 inches from the surface being cleaned.

On carvings, lettering and ornamentation, and on joint cement, pressure should be reduced and the nozzle kept at least 24 inches away. Windows, metal, wood, and exposed surfaces of other material should be protected against the sandblast, and the entire sandblast area should be hosed down upon completion.

Wire brushes, or sand and aggregate containing iron, should never be used to clean marble, because, despite rinsing, minute particles of steel will remain on the marble surface and cause rusting.

Concrete Walls

Exterior walls of concrete are generally classified as masonry walls, cast-in-place (monolithic) walls, or tilt-up walls. Concrete masonry walls have won a unique place in modern building construction. The blocks used to make up these walls can be precast in many different sizes and shapes, and can be made from a variety of aggregates, such as sand and gravel, crushed stone, cinders, expanded slag or clay, or volcanic materials. Masonry blocks of concrete are laid up and bonded together as a solid unit in the same way as brick. Cast-in-place concrete walls, used both below and above grade, require casting forms of sufficient strength to withstand the great pressure exerted on them by the raw concrete mixture. This strength is necessary to allow the concrete to cure true to line and level. No amount of surface treatment, after stripping, can overcome the ill effects of bulging walls, drooping beams, or irregular arrises resulting from weak or improperly braced forms.

Tilt-up walls also require casting forms, but these lie flat on the ground at positions where walls are to be placed. They consist of a frame to mold the shape and size of the slab and to provide openings for doors, windows, and other attachments. Attached to this frame is a bottom, onto which the concrete mixture is poured. The top side of the form is open to permit the use of floats, trowels, and other tools required in finishing the exposed surface of the poured concrete.

When the slab is cured, it is tilted into position and securely anchored so that touch-up work can be done to both the inside and outside face of the wall if such work is needed.

Maintenance procedures for concrete walls, regardless of type, are generally concerned with moisture control, spalling, structural cracks, efflorescence, broken or defective mortar joints, and calking failure.

Coarse-textured or highly porous concrete walls absorb moisture very rapidly, and hence may require special treatment to produce impermeability. For above-grade walls, this treatment usually consists of applying a water-repellent coating to the exterior surfaces. Many types of suitable materials are available, the most commonly used of which are cement-base, resin-emulsion, oil-base, and synthetic rubber-base paints. If coloring is not desired, a transparent, water-repellent coating of the silicone type can be used effectively.

No paint or coating, however, can be expected to adhere well to a concrete surface if interfering substances, such as dirt, dust, grease, oil, and efflorescent deposits, are on the surface. For any paint or coating to be effective, these interfering substances must first be removed. Recommendations of the concrete industry regarding the preparation of surfaces for painting should be followed. These recommendations include the removal of dirt and dust by air blowing, brushing, hosing, or scrubbing, depending upon the character and amount of contamination. Extremely dirty surfaces may have to be sand-blasted; grease and oil can be washed off with solvents or strongly alkaline solutions such as lye; efflorescent deposits, by washing with dilute muriatic acid (1 part acid to 4 parts water by volume), or by sand-blasting. Thorough rinsing of the surface with water should follow acid or lye treatment.[9]

A cement mixture that is not properly agitated when poured in place often cures with surface defects which are revealed when retaining forms are removed. These defects have the appearance of a "honeycomb" and consist of voids, pits, and cracks. Exterior surfaces of concrete walls that have these defects are unsightly, but need not remain so. The difficulty can be corrected by first cleaning the affected areas of all loose or defective concrete, dirt, grease, or other deposits. Then, if the pits and cracks are small, the surface should be thoroughly wetted down, and a grout of 1 part cement and 1 part sand should be scrubbed into the openings with a stiff brush. If the cracks and holes are large, the affected area should be dampened (not thoroughly wetted as for the application of grout), and a cement-sand mortar mixture of 1 part cement and 2 or 3 parts sand should be

[9] ACI Committee 616. *Guide for Painting Concrete* (Title No. 53–46). Detroit: American Concrete Institute. p. 824.

troweled into the voids. The mortar mixture should be no wetter than is necessary for packing it firmly into place. When the mortar has set, it should be cured for 2 or 3 days by frequent spraying with water, or by covering it with wet burlap.

Paint, including clear coatings, will give good results if applied to concrete that is seasoned and dry. New concrete is damp in the interior, even though its surface is dry, and if painted in this condition, the impounded moisture may later cause the paint film to blister and peel. Also, new concrete has a high degree of alkalinity, which is particularly harmful to any paint containing drying oils because of their susceptibility to saponification.[10] If concrete must be painted when new, the recommended treatment is to neutralize its alkalinity by brushing or spraying on a solution consisting of 3 percent phosphoric acid and 2 percent zinc chloride in water and allowing this to dry on the surface for 24 hours. All residues formed in the reaction should then be brushed off before painting.[11]

If there is no urgency about painting, seasoning is considered more reliable than surface treatment as a means of conditioning concrete for paint. Seasoning reduces the surface alkalinity of concrete by the process of carbonation, a process which reduces the free moisture content of concrete. A seasoning period of at least 6 months is recommended before applying paints containing drying oils; a period of at least 2 months, before applying alkali-resistant paints.[12]

Whatever the purpose in painting concrete walls—moisture control, decoration, or both—it is important to use paint of good quality. When paint of poor quality is used, its early failure can be expected, and since the cost of paint is only 15 to 20 percent of the total cost of material and labor for the job, a few dollars saved on inferior paint is false economy. A common practice in procuring quality paint is to seek bids from suppliers on the basis of a controlling specification. Purchasers must be sure, however, that the specification is adequate and that the paint delivered conforms to it. Federal specifications, often used for bid purposes, give the requirements for various types of paint. These documents may be secured at any of the regional offices of the General Services Administration (Atlanta, Boston, Chicago, Dallas, Denver, Kansas City, New York, San Francisco, and Seattle), or from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402. Another source of information on paints, the Building Materials and Structures Report, BMS 105, *Paint Manual*, compiled by the National Bureau of Standards, is

[10] *Ibid.*, p. 823.

[11] G. E. Burnett *and* A. L. Fowler. Painting Exterior Concrete Surfaces, with Special Reference to Pretreatment. *ACI Journal*, June 1947 (*Proceedings V. 43*) p. 1077–1086.

[12] *Guide for Painting Concrete.* op. cit. p. 823.

also available from the Superintendent of Documents. If bidding specifications are not utilized, the purchaser should find a product of a trade brand known to have performed satisfactorily under conditions similar to those in his locale.

The repair of spalled concrete walls is a waste of material and labor unless corrective steps have been taken to prevent the cause of spalling. These steps have been described in relation to moisture control in walls (see p. 36).

The customary method of repairing spalled surfaces of concrete walls is to remove all loose particles (including dirt, dust, or other atmospheric deposits) from affected areas by hosing with water, or if this is ineffective, by scrubbing with a stiff brush. Any unsound concrete should be chipped away with a pointed chisel or with pneumatically operated gads. The area should then be dressed down to a sound, newly exposed surface with a bush hammer or wire brush, and then scoured with water and compressed air jet to assure removal of all loose particles. When the surface has been properly prepared, a grout consisting of 1 part of portland cement conforming to the A. S. T. M. specifications for type II portland cement, Designation C 150–42, and 1 to 3 parts of fine sand meeting the specifications for good concrete can be used to fill the holes and fissures caused by spalling. The richer mixture (1:1) should be used for small holes and may be scrubbed in with a stiff brush. Mortar with a ratio of cement to sand of 1:2 or 1:3 will be more satisfactory for large than for small holes and should be firmly packed into place with a trowel. Affected surfaces should be thoroughly dampened not more than 1 hour before applying the grout, but care should be exercised to prevent surplus water on the surfaces. After the mortar has set, it should be cured for 2 or 3 days by covering with wet burlap, or by frequent spraying with water, using a nozzle adjusted for fine mist.

If a school district has enough buildings requiring surface placement of grout, a more economical procedure would be to apply the mortar by pneumatic pressure. This procedure utilizes an air jet to project the mortar directly onto the surface; the force of the air jet compacts the mortar into place. The American Concrete Institute refers to this procedure as "shotcrete," and has established specific standards for this type of application.[13] Special equipment is required for the processing and placement of shotcrete, and the work should be done by skilled operators only. The Institute can render valuable advisory services to school systems contemplating the use of shotcrete for either maintenance or construction purposes.

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[13] *ACI Standard Recommended Practice for the Application of Mortar by Pneumatic Pressure* (ACI 805–51). Detroit: American Concrete Institute. 1951.

Structural cracks of mortar joints in concrete masonry can be repaired in the same manner as was described for stone and brick walls (see p. 39). Load-bearing, concrete masonry walls may develop structural cracks other than those at mortar joints, particularly if they have been constructed without adequate tie mesh and tie bars, and without expansion and control joints. (Expansion joints for concrete block work are the same as those for brick and other types of masonry work. Control joints relieve stresses within block walls, allowing movement without cracking the masonry.) Structural cracks are also caused by building settlement, a condition usually brought on by weak or improperly designed footing under the wall.

It is usually not practical to repair structural cracks until the cause has been determined and removed. If such cracks are due to improper construction and design, the affected wall may have to be torn away and replaced with new material. Tie mesh, tie bars, expansion joints, and control joints may have to be added in the process. Concrete blocks salvaged from the original wall should not be reused in the new wall. If structural damage is due to failure of footings, the wall supported by them may have to be torn down, the footings replaced with new, stronger material, and a new wall constructed on these footings, using fresh material throughout. (Procedures for strengthening or replacing footings were described on p. 33.)

Minor settlement of a building can cause structural cracks in its walls if the walls are made of concrete blocks. These structural cracks can be repaired by cutting them out, at right angles to the face of the wall, to a depth of 1 inch and a width of ¾ inch. This cutting can be done only in solid blocks or in solid portions of hollow blocks. An electrically powered cutting tool or a stonecutter's chisel and hammer can be used for cutting. The surface and sides of any grooves made by this procedure should be thoroughly cleaned of dust and loose particles, and then wetted preparatory to filling them with bonding mortar. Then a bonding mortar composed of 1 part portland cement and 1 part sand, with just enough water to give the mixture a plastering consistency and prepared 1 to 3 hours before use, should be forcibly projected or dashed into the grooves to a depth of ¼ inch. After this layer of mortar has cured in place, the remaining ¾ inch can be filled with mortar composed of the same mixture of materials in the same proportions as used in the concrete blocks; white portland cement may be substituted for part of the gray portland cement, however, to lighten the color of the patch. This final layer of mortar should be kept moist for several days to insure proper curing and satisfactory bonding to the concrete masonry.[14]

[14] *Bonding Concrete and Plaster to Concrete* (ST-11). Chicago: Portland Cement Association. (n. d.)

Concrete masonry walls having extensive structural cracks but insufficiently damaged to require replacement can be repaired by applying portland cement plaster or stucco to their outside surfaces, particularly in cases where further wall movement seems unlikely. The application of portland cement stucco sometimes proves to be the most economical and satisfactory way of maintaining the exterior of masonry walls.[15] This procedure requires roughening the original surface with bush hammers or other special tools and then washing it to remove all dirt and loose particles. Old concrete blocks can be roughened satisfactorily by washing them with a solution containing 1 part muriatic acid and 4 to 6 parts water. The surface should be wetted with clean water, scrubbed with the acid solution, and then washed with clean water to remove all traces of the acid.

The bonding coat for the plaster or stucco should then be forcibly dashed on and cured. A brown coat should then be applied, and finally a finish coat. Each successive coat should be cured by light, frequent sprinkling with water; this prevents too rapid moisture evaporation.

Efflorescent deposits may not be as concentrated on concrete masonry as on brick or cast-in-place concrete, but extreme cases may develop occasionally. It is usually advisable to treat these cases by washing the affected areas with a muriatic acid solution (1 part acid to 4 to 6 parts water.) Following the washing, the wall should be dried thoroughly before applying a colorless, commercial dampproofing material, or boiled linseed oil, to prevent further efflorescence.[16]

Mortar joints may also break or become defective because of a poor bond between the mortar and masonry units, or for reasons other than structural stress. These joints can be repaired by first removing all broken, loose, or damaged mortar from affected joints with a hammer and chisel or other suitable tools, and by then cleaning the area thoroughly with clear water. If loose particles remain after the washing, these can be removed by a jet of compressed air directed into the open joints. New mortar should then be compacted into these joints in the manner previously described. It should meet current specifications for mortar, ASTM C-270, and should have a moisture content that will provide maximum workable consistency and minimum shrinkage. Vertical joints should be given special attention, as they are often improperly filled during construction.[17]

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[15] Ibid.

[16] *Notes on Efflorescence* (ST-6). Chicago: Portland Cement Association. (n. d.)

[17] *Building Watertight Masonry Walls* (CP-13). Chicago: Portland Cement Association. n. d.

Failure of calking material around frames for doors, windows, and louvers, or at other points where calking is used, is essentially the same, regardless of type of wall construction. Also, treatment and repair, or replacement of damaged calking is generally the same for all types of wall construction. This procedure has been described earlier (see p. 42).

Curtain Walls

The "curtain wall," in the sense the term is generally used, includes all elements comprising the "skin" enclosure of a building. Contemporary curtain wall systems are composed of panels that have a finished surface on one side and either a finished or unfinished surface on the other side, with one finished surface facing outside.

These panels, rigid and self-supporting to a greater or lesser extent, often have a superior finish that is maintenance-free for the life of a building; also incorporated in their construction are such valuable features as a vapor barrier, insulation, soundproofing, and condensation control—all of significant value to a school building. Coordinated for use with modular and nonmodular window units, curtain wall panels are fabricated from a variety of materials, such as aluminum, asbestos-cement, bronze, concrete, ceramic-faced tile, galvanized iron, plastics, porcelain-enameled metal, stainless steel, steel, stone, and structural clay tile.

From the standpoint of assembly and method of installation, there are two basic types of curtain walls: the stick system and the unit system. The former is designed for piece-by-piece field assembly and installation; the latter, for installation as preassembled wall sections consisting of at least one window and one or more spandrel panels. As a general rule, units 4 to 5 feet wide and 12 feet high are most practical for ease of erection, but some are as wide as 8 feet, consisting of two units, each 4 feet wide. The perimeter of most curtain wall panels is bounded by metal mullions to give stiffness and wind load resistance and to provide points for anchorage by welding or by fasteners to the rigid frame of the building.

Three types of mullions are commonly used in curtain wall systems, depending on the structural characteristics of the particular building and the manner in which movement must be accommodated. The "split mullion" allows the whole wall unit to expand and contract together; the "batten mullion" permits horizontal expansion of all components toward, or into, the vertical mullion; the "1-piece mullion" does not provide for expansion or contraction, except as these movements are absorbed by sleeved horizontals, by stress accumulation, or by structural gaskets.

Since most curtain wall panels have weather-resistive finishes, the major maintenance problem in this type of construction is leakage. If sealants have not been prepared and applied with care, premature failure at joints and around horizontal and vertical mullions is almost certain. An expensive process, resealing should be done with extreme care. There are three basic types of curtain wall sealants for use in eight types of installations. Classified according to composition and method of application, sealants are identified as (1) mastic compounds of the bulk type for gun application, (2) mastic compounds of the preformed type for hand application, and (3) preformed, extruded gaskets for hand application.

Whatever the nature of the resealing job, all surfaces to which sealants of any type are to be applied should be thoroughly clean before the resealing.

Joints between masonry walls, concrete slabs, and wood or metal framing of the curtain wall can be recalked with an oil-base compound applied with a gun. This compound, which hardens overnight, usually lasts for 5 to 10 years.

Glazing in metal frames or sash, where glass areas are not large or where glass breakage is expected to be frequent, can be accomplished economically with an oil-base glazing compound applied with either a gun or knife. This compound becomes firm in 1 to 6 weeks, and remains hard over a period of years.

Sealing and glazing of joints where good adhesion is required and repeated movement in the joint is expected, can be done with a 2-part rubber-base compound. This compound requires accurately controlled premixing and careful application with a gun. Although high in cost, this material serves long and well, curing to a rubbery consistency with excellent adhesion.

Sealing and glazing of joints where maximum adhesion on moving surfaces is required can be done with a mastic compound consisting of a 1-part rubber base, applied by gun. This mastic is self-sealing, has excellent adhesion, is nonhardening, and cures in about 60 days.

Metal-to-metal joints having maximum movement and mechanical fastening for continuous compression can be sealed with a preformed, nonresistant compound of low cohesive strength which is available in various extruded shapes and sizes. This material, easily shaped and deformed, will flow under pressure, can be applied by hand, and is suitable as a bedding for glass if spacers and a protective covering of some curing material are used. Since this material is permanently tacky, it collects dirt and dust and therefore should not be left exposed.

Many types of metal-to-metal and metal-to-glass joints that require hand application of sealants before assembly can be treated with a preformed resilient compound which is available in various extruded shapes and sizes. This compound is tough and rubbery, has great cohesive strength, and cures with less tackiness and dirt attraction than the nonresilient types. Used primarily in original installations, this procedure is suggested here only because, in some instances, units requiring this treatment have to be replaced.

Joints between metal framing and glass, or between panels, particularly where relative motion occurs, can be given a weather seal by inserting neoprene gaskets. This type of gasket is made of a solid, rubber-like material having high resistance to sunlight, weathering, oxidation, and deformation under load, and it can be extruded in any required shape. A positive pressure seal is provided because of the material's elasticity. In multistory buildings, neoprene gaskets are usually recommended rather than vinyl gaskets because of their superior performance.

Joints in curtain wall construction can also be treated with vinyl gaskets, which are composed of a solid plastic material and are used in the same way as neoprene. These gaskets can be extruded in any required shape, and have good resistance to sunlight, weathering, and oxidation. Because they have plastic rather than elastic characteristics however, they are rated as only fair with respect to deformation and the degree of pressure under load.

Wood Walls

Wood is a versatile material with many characteristics that commend its use in construction, but for outside walls in public schools its use is often restricted by building codes, some State and local fire safety regulations, insurance rates, or other factors. Nevertheless, there are many school buildings of wood construction. These buildings, when properly maintained, compare favorably in durability and comfort with those constructed of other materials.

Exterior walls of wood present three principal types of maintenance problems: painting, calking, and repair of loose and damaged boards.

Frequency of painting depends upon several factors, chief of which are weather and atmospheric conditions, quality of paint, and the skill with which it is applied, and the type of wood. As a general rule, exposed wood should be repainted every 3 to 5 years, but care should be exercised to prevent thick coatings from being built up by too frequent painting. It is good practice to repaint surfaces with the same kind of paint previously used unless experience shows it to be unsatisfactory. A new kind of paint should be used only if it is known to be compatible with the old. Incompatible paints may result in rapid deterioration or abnormal defects. Among such abnormal defects are "lifting," "crawling," "tackiness," and "alligatoring."

"Lifting" is a softening of the old paint, caused by strong solvents in the new. This may occur when synthetic rubber paint, which usually contains solvents commonly used in paint removers, are spread over oil paints.

"Crawling" occurs when a new paint coating fails to wet the surface of the old paint, and instead of spreading, collects in drops, as water does on a greasy surface.

"Tackiness" is failure of new paint to dry, a condition that may result when the residue left by paint removers has not been cleaned from the surface before the application of new paint.

"Alligatoring" occurs when newly applied paint slips over the old coating so that the old coating shows through the fissure, for example, when house paint is applied over bituminous paint. Paint or enamel applied over varnish, or white or light-colored house paint applied over dark-brown, green or other contrasting colors can have the same effect.

All exterior wood surfaces to be painted or repainted must be properly prepared. Any peeling, blistered, curling, or flaking paint on the surface must be removed by scraping, chipping, wire brushing, and/or sanding, and must be dry and free of dust. Sharp edges of firm paint should be sanded to a feather edge. Boards that have lost nearly all their paint should be replaced with wood that has good paint-retaining characteristics, particularly if the coating on surrounding boards has held reasonably well. When new wood is inserted, it should be fully primed. Individual boards that require extensive preparation should be spot-primed, and if it is necessary to remove deteriorated paint from an entire area, the affected area should be fully primed. When the priming coat, whether full or spot, becomes hard, one full coat of finish paint should be applied at the rate of 1 gallon to each 600 square feet of wall surface. Cracks and open joints in wood should be filled with 10 percent white-lead putty, worked well into cracks and holes after the prime coat has hardened. A finish coat should be applied over the putty. Loose boards should be renailed, the corners and edges being drawn together in the process.

Rosin that exudes from knots in pine wood and stain from asphalt, creosote, or other wood preservatives often "bleed through" any paint applied over them unless the knots and stained surfaces are given special treatment before they are painted. Many products that perform with varying degrees of success are available for this purpose. But it is difficult, and frequently impossible, to stop wood preservatives from bleeding through if the moisture content of the wood is, or becomes, sufficiently great to throw the preservative elements into solution.

Two types of stain sealers which have been used successfully are:

Specially prepared asphalt sealers, obtainable commercially, are usually effective for a wide variety of stains in addition to asphalt, and except under unusual conditions, require only one coat. These sealers are flexible, do not contain shellac or other brittle ingredients, require no thinners, and may be used on either interior or exterior surfaces. These sealers should be applied evenly by brush, without excessive brushing.

A mixture containing 1 gallon of 4-pound cut shellac, 2 pounds of aluminum powder, ¼ gallon of alcohol, and a handful of Spanish whiting, applied evenly by brush, is an efficient sealer against pine rosin and other stains, but this solution may have unsatisfactory adhesion caused by brittle film when the mixture dries.[18a]

Another cause of paint failure is mildew, a fungus growth prevalent in warm, humid climates and in warm, damp rooms anywhere. Mildew must be removed from the surface before repainting or it will eventually reappear on the surface of new paint, causing discoloration. Scrubbing infected areas with warm water and soap and then rinsing with clean water will remove mildew. A solution of 1 pound of trisodium phosphate in 1 gallon of water is also effective.[18b]

Mildew on outside surfaces may be prevented by use of a mildew-resistant paint or of a fungicide, such as bichloride of mercury or pentachlorphenol, added to ready-mixed paint. Among house paints in white or light colors, those containing zinc oxide, such as Federal Specifications TT-P-40, type I, are usually resistant to mildew, but their resistance is lessened if they are thinned excessively with linseed oil. Bichloride of mercury is toxic to humans, and if added to paint to prevent mildew, should be added in quantities of about 1 part to 500 parts of paint, or 1 to 900, depending on the severity of the mildew.[19] Pentachlorphenol is also effective, and is nontoxic to humans.

Paint of any quality can be rendered inferior and ineffective by improper handling. The manner in which paint is treated, from the time it reaches the user until it is applied, is referred to as "handling." The longer the time between delivery and application, the greater the handling required. Paints in storage undergo progressive separation of components, resulting in settlement of pigments and in the

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[18a] Adapted from: Sydney L. Risdon. *Specifications Covering Surface Preparation and Prime Coats.* Pittsburgh, Pa.: Pittsburgh Plate Glass Co. (mimeographed document, n. d.)

[18b] *Painting, Repairs, and Utilities* (TM 5-618), War Department Technical Manual. Washington: U.S. Government Printing Office, 1946. p. 19.

[19] Ibid.

formation of surface "skins." Some paints are adversely affected more rapidly in storage than others. Storage places should be dry and warm. It is wise to use all paint in storage within 6 months after receiving it, and to use first those materials that have been in storage the longest.

If paint has been in storage for 6 months or longer, it should be thoroughly agitated before being used or returned to stock. Inexpensive mechanical agitators are practical for this purpose, as well as for the agitation of all paint when it is issued for a job. Unless settled pigments are thoroughly redispersed, the paint will not have the qualities claimed for it, and may prove ineffective.

When paint is purchased in quantity and is delivered in drums with a capacity of 5 gallons or more, it must be poured into smaller containers, usually 1-gallon cans, for convenient on-job handling. Since the solids in paint have a tendency to settle, it is necessary to agitate and mix the contents of large containers thoroughly before pouring off smaller quantities of paint. Also, if the small pail already contains some paint of like kind, there should be a thorough mixing, when it is refilled, to blend the old and the new. When not in actual use, all buckets, drums, or cans should have airtight covers to reduce evaporation and prevent the formation of skin on top of the paint.

If skin is permitted to develop on top of any paint, it should be removed in one piece if possible; otherwise, the entire contents have to be strained in order to remove smaller pieces of skin that may be held in suspension.

Points on wood walls where calking is required should be checked for broken, deteriorated, or defective calking. All such material should be replaced with fresh compounds of appropriate types. These should be allowed to cure for several hours, or until a tough outer skin is formed, before paint is applied.

Another procedure that should precede the application of paint to exterior wood walls is the renailing of any loose siding or boards and the repairing of all serious surface defects such as nail holes, cracks, knotholes, and large dents. These repairs can usually be made by filling the holes and cracks with putty of a good grade.

Windows

Windows in exterior walls serve as a means of admitting natural ventilation and light into buildings, but with an increasing acceptance of air conditioning and the improvement of artificial lighting, they are slowly losing these basic functions; in fact there are some school buildings of contemporary design that are entirely windowless.

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Types of windows commonly used in exterior walls of schools are the double-hung, the casement, and the projected. These are stock windows that may be obtained in a variety of materials and finishes; for schools, those made of aluminum, steel, and wood are economical, safe, and practical.

All windows, regardless of type or materials, have some common maintenance problems. Among these are reglazing, replacement of putty, resealing outside joints around frames, and the repair or replacement of operating hardware. Painting is necessary for both wood and steel but is not essential for aluminum sash.

Reglazing should be done when window panes have been cracked or broken. The standard procedure for this operation is to remove all glazing materials (putty, glazier's points, or clips) from around the broken pane. A putty knife, chisel, or scraper can be used to remove putty; sharp-nosed pliers or a glazier's tool can be used to remove glazier's points and clips. All old putty under the broken glass should be scraped away so that the window backing and stops are perfectly clean. Any loose material should be wiped or brushed away.

Exact measurements of the width and height of the opening should be taken; the opening should be carefully checked for true edges. From these measurements ⅛ inch should be deducted from both the width and height. Replacement glass should be cut to these reduced dimensions from stock with a glass cutter.

Prior to inserting the new glass into the opening, a thin layer of glazing compound should be applied with a putty knife around the inside of the frame to be filled; the putty knife insures an even distribution of the compound. The piece of glass should then be pressed firmly into the frame, and any excess putty squeezed out, so that a layer about ⅛ inch thick remains between the glass and frame. Glazier's points should be inserted around the glass in wood windows and clips in metal windows to hold the glass.

Glazing compound should then be applied around all outside edges of the new glass, and pressed into position with the heel of the hand or a putty knife. When the putty is firmly in place, it should be shaped with a putty knife so that the angle from the frame to the glass matches the angle of existing work. After a thin skin has formed on the new putty the glazing should be painted for protection from the weather and the sun.

Old, dried-out putty around window glass probably leaks air, water, and heat, and should be replaced. The procedure for this operation is the same as for broken glass except that the old glass, if in good condition, can be reused.

Joints and cracks around frames must be resealed periodically to prevent heat loss and reduce moisture infiltration. Procedures for accomplishing this are described under the topic of "calking" (see p. 42).

The kind and amount of operating hardware for outside windows is largely determined by the type of window. For example, double-hung windows usually require some type of weight balances (spiral, steel tape, wedge, or in older buildings, cylindrical weights attached to window sash by cord and suspended over pulleys), a sash lock and keeper, pull-down handles (or grommet holes). Casement windows require such operating hardware as hinges, locking handles, and roto-gear operating devices. Projected windows require one or more of the following types of hardware: underscreen push bars, spring or cam latches, chain idlers, locking handle and strike plate, pole ring, friction hinges.

Except for accidental breakage or damage caused by vandalism, window hardware of good quality usually presents few maintenance problems. Hinges and other moving parts that do not function on the principle of friction may require a small amount of lubrication occasionally. The type of lubricant needed—oil, grease, or graphite—depends on the particular item to be lubricated. Locks with enclosed mechanisms, for example, should be lubricated sparingly with graphite. Latches, handles, locks, keepers, strike plates, push bars, chain idlers, and other items that are fastened metal to metal by welding require no special attention, but when attached to wood or to metal by screws, bolts, or other types of fasteners, periodic tightening or replacement of screws and nuts may be necessary. Occasionally, screw holes in wood become so enlarged that they will not hold the screws. When this is evident, the enlarged holes can be plugged with dowel pins or other wood of appropriate size, properly cemented in place. When window hardware items are broken or damaged, it is usually better and more economical to replace them with new items of the same kind than to repair them by welding, straightening, or soldering. Window hardware of steel may require occasional touching up with paint or enamel to prevent rust.

Weight balances are usually more troublesome than any other type of window hardware. The normal maintenance procedure for defective or inoperative balances, except for cylindrical weights, is to replace them with new ones. Most window construction of recent years is such that these items can be reached by removing a panel. Where cylindrical weights are employed, sash cord is the element that fails. Sash cords are replaced by removal of the window from its casing, and opening of the channel within which the sash weight operates.

Steps required for this operation are determined in part by the casing design, but usually it is necessary to remove a stop strip, and depending on which sash is affected, a division strip in order to remove a sash from its casing. (It is advisable to replace all four cords in a window at one time to prevent a probable repeat operation in the near future.) When a sash has been lifted from its housing, both cords should be detached from it; the cords should be knotted, so the weights will not drop. The sash should then be set aside to prevent glass breakage. The cylindrical weights to which the cords are attached operate in channels at each side of and between the casing and its frame. Access to these weights is secured by removing either the facing trim or a panel in the jamb, depending on design. Old cords can then be detached from the weights and removed from their pulleys. New cords should then be attached to the weights and inserted through and over the tops of their pulleys, being held or fastened securely until jamb panels are replaced. The sash should then be reinserted and the cords securely attached to them as they are placed between the jambs. The job is completed by remounting the stop and division strips and the facing, if it has been removed.

Doors

Exterior doors may be installed flush, or nearly so, with outside wall surfaces, or in recessed portions of them. Most outside doors for schools are of wood, metal, or glass. Wood doors, in addition to meeting appearance and exit requirements, should be able to withstand the damaging effects of weather, and hence should be made of the more durable species of wood, cemented with waterproof adhesives, and should be treated against rot, fungi, and termites. Wood doors encased in metal are usually preferred in locations that have direct exposure to the elements. Aluminum doors are perhaps most popular where metal is desired; they should not be used, however, in locations where they are likely to be exposed to fire hazards. They are lightweight, corrosion-resistant, rot-proof, and termite-proof. Glass doors usually are framed with metal, although tempered glass can be installed as a sheet without a supporting frame. Since tempered glass cannot be cut, drilled, or altered, all dimensions, holes, kickplates, hardware, and decorative treatment must be designed and detailed before the glass is manufactured. Wired glass is used in doors where there is particular exposure to fire hazards or a strong possibilty of impact or abuse. It is also desirable for use in locations where there is strong likelihood of flying glass.

Some maintenance jobs for exterior doors (such as painting, replacement of glass panels, weatherstripping, and calking) are performed in the same way as similar jobs for exterior windows. But the complexity of door hardware makes for certain maintenance problems peculiar to doors. Since most manufacturers of door hardware publish detailed descriptions and explanations of recommended maintenance procedures for their products, no attempt is made here to supply this information. Instead, attention is directed to some common failures that are both aggravating and damaging if neglected.

Door butts and *pivots* provide the mechanism by which doors are allowed to swing. In general, butts (hinges), particularly those commonly used in schools, are the types known as "mortise," "half-mortise," "half-surface," and "full-surface." Mortise butts are supplied with tight or loose pins. The tight-pin mortise type should be oiled between knuckles; the pin of the loose-pin mortise type should be removed before oil is dropped into the pinhole. Half-mortise, half-surface, and full-surface butts usually have loose pins, secured with set screws in their knuckles. In some, these set screws must be backed out and the pins removed to oil them; in others, where the top of the pinhole is covered with a screw cap, the screw-cap (but not the pin) must be removed to drop oil in the pinhole. Unless the manufacturer recommends another substance, graphite penetrating oil should always be used for this lubrication.

Doors that are improperly fitted or that have absorbed moisture may bind within their frames. The exact point of binding can be located by sliding a double thickness of paper between the door and its frame. Where swelling is the cause of binding, correction can be made by removing the door, planing it down on the butt edge, and refitting it. Binding, as well as sagging, may be caused by loose screws in one or more butts or by damaged butts. Tightening the loose screws (or if butts are damaged, replacing them) will overcome this difficulty. If screw holes are enlarged, they should be plugged with wood, or longer screws should be used. Sometimes, loose screws are caused by doors that are too heavy for the number and type of butts used. In this case, a third butt should be installed at the center of the door to give added strength and prevent sagging and binding.

Where pivots are used instead of butts, the pivots should have adjusting screws that will permit raising or lowering of doors to take up sag or compensate for settlement. An adjustment like this will provide an even distribution of weight on the bottom and center pivots, and hence give satisfactory service for a longer time.

Fire exit devices are designed to provide security against unlawful entry and to permit unhampered evacuation of building occupants.

Two types of anti-panic exit devices are in general use: rotary-action and rim-type. Major repairs to this hardware must be performed in a manner that will assure exit safety. For this reason, they should be made by trained workmen who have the right kind of tools and parts. There are, however, some minor types of adjustment that can be made by responsible building custodians.

If the crossbar of a rotary-action exit device cannot be locked in a depressed position, or if it binds in its active or supporting cases, the difficulty may be caused by faulty alignment of top, bottom, active, or supporting cases. If the trouble lies at either top or bottom (or both), all screws holding the incorrectly aligned case or cases should be removed. The crossbar should be locked in its depressed position by using the dogging devices. The top case should be pushed up to retract the latch fully. One should check to see that the top case is brought in line with the original screw holes. If the alignment is not made by this procedure, it will be necessary to turn the top rod out of its slide in order to bring the top case in line with the original screw holes. Then the top case should be fastened to the door and the top rod replaced. The bottom latch can be retracted and the bottom case realigned in the same manner as the top case. If the crossbar binds in either the active or supporting cases, it can usually be freed by tapping its ends lightly with a wooden mallet. If this procedure fails to release the crossbar, the supporting case (the one opposite the vertical rods) is probably out of alignment. If so, the case should be removed, the old screw holes plugged with wooden pegs, and the case set in a position which will permit the crossbar to work freely.

If the latch at either the top or bottom case does not enter freely into its strike-plate hole, the trouble might be caused by a sagging door, possibly a result of loose screws in the door butts. If this is the case, correction can be made by tightening the screws. If a sagging door is not responsible, position of the strike should be changed to one that will allow the latch to enter its opening. The same problem may be encountered with the bottom latch, but the cause may be different. Being located in the threshold or floor, the hole in the bottom strike may become clogged with dirt, sand, or other foreign matter that prevents free and easy action of the latch in the strike. This condition can be corrected by removing the accumulation with a knife blade, screwdriver, or other pointed tool.

Another minor problem, more often caused by abuse or accident than by wear and tear, is failure of the thumbpiece (on doors equipped with an outside handle) to permit sufficient retraction of the lock latch to release the door for opening. This failure usually is the result of a bent thumbpiece, and can be corrected, without removing any parts of the exit device, by bending the thumbpiece slightly upward from the pull handle.

The rim-type anti-panic exit fixture has neither the same complexity of design nor the same number of working parts as the rotary type, and hence is more easily maintained. Two common problems with the rim-type fixture are binding of the lock latch in the strike hole or failure to enter, and failure of the operating lever to release the lock latch. The first of these two problems is caused by dimensional change in doors, such as warping, swelling, or shrinking. When the divergence between the strike opening and the lock latch is not excessive, correction can be made by filing the lip of the strike hole. Realignment of the strike may be necessary in severe cases.

Some types of exit hardware have strike plates that can be adjusted to compensate for door shrinkage or swelling by loosening screws and sliding a top plate to right or left, as required, then retightening the screws.

The second problem—failure of the operating lever to release the lock latch—is a hazard to safety, but can be easily corrected. A frequent cause of this failure is lodgment or wedging of foreign objects between the bar stop and the operating lever, preventing the lever from releasing the lock latch when depressed. The difficulty can be eliminated by cleaning out the offending matter.

Another problem common to any type of exit fixture having an outside pull and thumbpiece is damage to the thumbpiece by excessive pressure on it. If the back bar of the thumbpiece is bent from this pressure, it obstructs the free operation of the key, preventing it from locking and unlocking the door. The procedure in correcting this difficulty is to remove all screws from the acting and supporting cases; to remove the bolt from the door so as to expose the back bar of the thumbpiece; then to straighten the back bar by tapping it lightly with a wooden mallet or by gripping it firmly in the jaws of wire pliers, gently exerting pressure as may be required; and finally, to replace the bolt, cases, and screws.

Door controls consist of push and pull bars, catches, bumpers, silencers, stops, openers, closers, and holders. Except for openers, closers, and holders, these controls are fixed items, attached to doors, jambs, floors, frames, or walls, and generally require attention only if bent, broken, or detached, or if screws or fasteners are loose. Openers, closers, and holders have moving parts, are complicated in design and function, and are subjected to continuous and varied usage, often with considerable abuse, such as forced and violent openings, wind, and draft conditions. If door controls are not kept in perfect working order, maintenance costs for glass, hinges, pivots, jambs and reveals, and latch repair and adjustment can be high.

Automatic openers, because of their original cost and subsequent maintenance requirements, are not often installed in school buildings, but closers, holders, and closer-holder combinations have universal acceptance and use. They are manufactured as separate items or in combination, with or without fusible links, by more than a dozen major companies in this country. Among a variety of closer models are decorative, surface applied, conventional, overhead concealed, concealed in door, and concealed in floor. Maintenance procedures are different for each brand and type. It is not feasible to describe them here, but manufacturers provide users with manuals that describe in detail procedures for adjustment and routine maintenance of their products. Maintenance personnel responsible for school building hardware are urged to secure copies of these manuals. If major or internal repairs to closers are required, these should be made by trained mechanics in the school system's repair shop, or the closers should be sent either to an authorized closer repair shop or to the manufacturer for necessary repairs. Otherwise, the lives of children housed in buildings with improperly repaired closers might be endangered.

The door holder (hold-open device), whether it is in the closer or separate from it, offers many advantages for school buildings, particularly for exterior doors, at dismissals, fire drills, and other occasions when there is a mass exodus from the building. Besides offering a convenience, hold-open devices greatly reduce the wear and tear of constant opening and closing of doors.

A major maintenance problem with hold-open devices is caused by failure of installers to provide proper anchorage for them, a failure which often causes them to pull loose from and damage doors, frames, jambs and reveals, and other door elements. Template drawings and installation instructions supplied by the manufacturer should be used and carefully followed when hold-open devices are mounted. Oversize bolts that pass through the door should be used to anchor heavy-duty, ruggedly built devices, and in cases where wood doors are subjected to heavy usage, metal plates mortised in on both sides are recommended to prevent closers and hold-open hardware from pulling loose from them. Normal, routine maintenance of nonfriction hold-open hardware is the application of small amounts of graphite grease to all rubbing parts at least annually.

Locks and Latches

Locks and latches fall into two general categories—exposed and concealed. The former are face-mounted on, and the latter are mortised into, doors. These categories apply both to panic exit devices with built-in locks and individual locksets. From the standpoint of method of operation, locks designed for use on exterior doors are classified as lever tumbler, pin tumbler, or bit key. The lever tumbler has one or more flat tumblers, usually pivoted, which must be moved in certain positions by the key to permit operation of the bolt; the pin tumbler has a paracentric keyway with upper and lower round pins capable of vertical movement in corresponding holes in the key plug and shell of the cylinder, a movement activated by the proper key, which raises the lower pins to the surface of the plug and the upper pins into the cylinder shell, allowing the plug to rotate and operate the lock bolt; bit key locks have a combination of one or more wards and one or more tumblers operated by a bit or wing key.[20] Regardless of the type of lock, however, if any part becomes inoperative, replacement parts will be needed and may be secured through the local dealer who supplied the locks, or directly from the manufacturer. In ordering parts, it is necessary to refer to the manufacturer's catalog, locate the exact part needed, identify it by number, and provide any other pertinent information. This procedure prevents delays in delivery of parts for repairs. If the school maintenance department does not employ an individual who is familiar with lock repair, the broken lock should be sent to a local locksmith or returned to the manufacturer.

Some common minor troubles with door locks are aggravating, as well as damaging, and should be eliminated promptly. Among these troubles are the following:[21]

- Latch bolt binds in strike
- Key or knob turns with difficulty or will not turn at all
- Latch bolt will not enter strike
- Latch bolt hung on strike
- Auxiliary latch fails to deadlock latch bolt
- Lock loose on door
- Door cannot be opened with either knob or key
- Door knob off spindle
- Turn button on inside knob projects abnormally far out of knob

When a latch bolt binds in its strike, the trouble is usually caused by door warpage, which throws the bolt out of alignment with its

[20] Glossary of Key and Lock Terms (Bulletin No. 68). Glenn Riddle, Pa.: P. O. Moore, Inc. (n. d.) p. 2–3.

[21] Identification of these troubles, together with suggested solutions, are adapted by permission from *Care, Adjustment, and Maintenance Manual*. New Britain, Conn.: The American Hardware Corporation. (n. d.)

strike. If only slight adjustment is required, the strike can be filed slightly on the edge where binding is evident. If binding is severe and a major adjustment is necessary, the strike should be relocated on its jamb so that it is in alignment with the lock bolt. This may require additional mortise work. If so, the new location should be determined with care so that the door jamb will not be defaced.

When a door key or a knob is difficult to turn, the trouble is usually caused by a sagging door or one that is out of plumb. All screws in the door butts should be checked for tightness. If this is not the cause, correction might be made by filing the lower edge of the hole in the strike plate. If a major correction is required, the door will have to be removed from its jambs and remounted in a plumb position.

If a latch bolt will not enter its strike, it may be out of alignment with the door, or the hole in it may be filled with foreign matter. If only slight misalignment is the cause, correction can be made by filing the edge of the strike hole where entrance of the latch bolt is obstructed. If a more serious misalignment is evident, correction can be made by relocating the strike box. If the strike box is filled with foreign matter, the obvious remedy is to remove the offending material.

When a latch bolt hangs up on its strike, the trouble is usually caused by an insufficient curve in the lip of the strike. This can be corrected by making a slight bend away from the door in the lip. Also, a small amount of graphite applied to the bolt head will improve its operation.

Some locks are constructed with an auxiliary latch which, when depressed, deadlocks the latch bolt. If this auxiliary latch fails to function, it is probable that the strike is too far away from the door. Correction can be made by placing a shim of appropriate thickness under the strike plate, moving it closer to the door.

Sometimes wood doors of poor quality shrink excessively, causing the thimble of a mortise-type lock to stand out from the facing of the door and leaving the lock loose in the door. This difficulty can be corrected by completely disengaging the thimble from the threads of the shank, applying a small amount of automotive weather-stripping cement to the threads of the thimble and then turning the thimble on the threads of the shank until it is tight.

If a door cannot be opened with either the knob or the key, the latch bolt tail is not properly centered in the latch retractor. Correcting this difficulty requires loosening the inside thimble sufficiently so that the outside rose can be adjusted to the proper ring in the shank for door thickness, permitting the latch bolt tail to center in the latch retractor. Using the door key, check to see that the latch bolt is now functioning properly and if so, retighten the inside thimble.

If a key knob pulls off its spindle, its retainer or waldes ring on the spindle has been installed backward or is not properly seated. This problem can be solved by replacing the key knob on the spindle, engaging the ears of the spindle in the key knob. Then the large waldes ring should be replaced; the beveled edge of the ring should be away from the knob; the ring should be properly seated in its groove. Special pliers with pointed nose tips that fit into holes of the waldes ring are necessary for this job.

When the turn button on the inside knob of locks so equipped projects abnormally far out of its knob, the turn button spindle is not seated properly. Usually, this is easily corrected by inserting the key in the key knob, and while gently turning the key, rotating the turn button slightly in both directions until it snaps into place.

Stacks and Towers

A stack (or chimney, as used here) is defined as any structure or part thereof which contains a flue or flues for the discharge of gases. For satisfactory operation, stacks and chimneys must be designed and sized, by engineering formulas, to accommodate the volume of gas to be discharged and to meet draft requirements of furnaces, boilers, stoves, or water heaters served by them. When chimneys are designed with fans for forced draft, their height can be reduced considerably.

Towers are used primarily for elevator shafts or stairwells in multistory school buildings. These towers should be of fire-resistive construction, located outside the perimeter of buildings, as are stacks. Access to stairwells should be by standard fire doors, opening into a vestibule at each floor level.

Stacks and towers are usually constructed of brick, concrete, or protected steel, with some stack installations of exposed steel. Towers for elevator and stair shafts normally extend about 3 feet above the roof; they should be covered with glass skylights in metal frames protected underneath by wire netting. Stack and chimney height is determined by draft requirements.

Exterior maintenance of stacks and towers is essentially the same as that required for like materials in exterior walls, except that stacks of brick construction which extend several feet above roof levels seem to crack at mortar joints more frequently than brick-wall surfaces. This may be due to wind velocity, improper mortar mixture, inadequate coping, or a combination of these and other factors. If the structure is "in plumb," damaged joints can be repaired by repointing in exactly the same way as damaged joints in masonry walls. If the chimney or stack is "out of plumb," it should be torn down and rebuilt to insure maximum safety. Concrete stacks may require no more maintenance than weatherproof painting every 3 to 5 years to prevent spalling and to improve appearances. Metal stacks, although not normally used in school construction because of their factory-like appearance, may be found at large campus-type centers where the heating plant for the entire center is housed in a separate building. Essential maintenance for metal stacks is to keep them as free as possible of soot or other deposits resulting from combustion to prevent damaging chemical action on the metal by the combination of deposits with moisture, and to keep them painted to prevent the formation of rust by oxidation. Rust on metal stacks can be removed by manual methods—blast cleaning, flame cleaning, wire brushing, sanding, or scraping—or by chemical procedures. A number of chemical rust-removers are available that can be brushed onto affected metal and then flushed off with clear water. Rust should always be removed, never painted over.

Miscellaneous Exterior Maintenance

Although not technically a part of buildings, some exterior items whose maintenance is essential to building performance are included here. Among these are catch basins, storm sewers, debris removal, vegetation, and surface drainages.

Catch Basins

Catch basins usually require very little maintenance. They should be inspected regularly, however, because occasionally they become clogged with deposits of soil, leaves, grass, or gravel. Instead of performing their normal function, they then permit pools of surface water to form during periods of heavy rainfall or of melting snow. Where there is an accumulation of trash in catch basins, the grated covers should be removed, and a fork or small shovel inserted to dig out the litter. When the basins are clean and all openings leading from them free of blockage, cover grates should be carefully and correctly seated over the opening to prevent accidents to those who may walk across them.

Storm Sewers

Storm sewers, like catch basins, must be kept open if they are to perform properly. Sometimes these sewer lines become gradually clogged with root growth from trees and shrubs; occasionally, during periods of heavy run-off of surface water, they become quickly clogged with heavy deposits of silt. This condition can lead to flooded basements, damaged lawns, and other types of damage.

Where storm sewers are located on school premises and serve only school property, their maintenance is the responsibility of the school, but if they serve school property and are a part of the community storm sewer system, their maintenance is usually the responsibility of the local government. In either event, if there is an obstruction in a line, the obstructing material must be removed.

To do this it is necessary first to locate the point of trouble. The local water supply company probably will have instruments (and personnel who can use them) to locate the obstruction. If the blockage is not wedged into the sewer line too tightly, a fire hose attached to the city water main or one connected to the pump on a fire truck will provide a stream of water at extraordinary pressure, which can be directed at the obstacle. This pressure, together with erosive action of water, might flush the obstruction through the sewage line. Access to the storm sewer can be secured through the nearest manhole upgrade from the obstacle, but of course any water in the storm sewer must first be removed by pumping.

Another procedure which is often successful in opening storm sewer lines is to use a long, flexible cable with an augur-like attachment on its end. Cables such as this are manufactured with cranking devices which, in operation, give a rotary action to the cutting instrument on the cable's end. Tree roots, impacted soil, or other fairly soft material can be cut away with this device and then flushed out.

If these procedures fail and if the storm sewer is large enough to admit a person, it may be necessary for a workman to crawl into the line and to remove obstructions manually with tongs, chisels, hammers, and other hand tools.

Removal of Debris

Leaves, twigs, broken limbs from trees, and other types of debris are blown onto roofs and into gutters, scuppers, and downspouts. If not removed, this debris can cause water damage, particularly in buildings with parapet walls, where the water may accumulate sufficiently to get behind or under flashings. Usually, workmen must remove this offending matter manually by climbing to the roof. Access to the roof is usually gained through a manhole located somewhere in the attic, or, if the building has a flat roof without an attic, through a manhole in the ceiling of the top floor. In 1-story buildings it may be necessary to mount the roof by using a ladder from the outside.

Vegetation

Overenthusiastic, well-meaning people, untrained in the art of landscaping, are often placed on school improvement and beautification committees by Parent Teacher organizations or other interested groups. Frequently these people plant shrubs and other vegetation too close to walls and windows and sometimes use ivy to cover outside walls. Plantings such as these not only obstruct ventilation and the admission of natural light, but also damage walls, windows, doors, and other exterior elements of buildings by preventing the evaporation of moisture. Ivy grown on walls sends its root system into mortar joints, cracks, or other irregular points on wall surfaces, and in time may damage the walls. If it must be grown in this manner, it should be cut back as close as possible to the walls in February or March and in early July; at those times long shoots that protrude away from the wall should be removed, and all upper shoots should be cut back well below the roof or gutters.[22]

Surface Drainage

Backfills around buildings settle, leaving depressions at or near the base of walls. During heavy rainstorms, or when snow melts, these depressions hold water which gradually seeps into the soil to soften the base on which footings rest. This process often causes footings to break or give way, paving the way for wall settlement and inevitably for broken joints, cracks, and other damage. This condition should be corrected before damage is caused by filling the depressions with topsoil and bringing the elevation of the earth around the building to a point where water will drain away from it at all times.

[22] H. S. Conover. *Grounds Maintenance Handbook.* New York: F. W. Dodge Corporation (Second edition) 1958. p. 84.

Chapter IV

INTERIOR MAINTENANCE

INTERIOR MAINTENANCE consists of all those special services and activities (except those essential for daily operation) required to keep the inside of a building, with all its internal components, in safe, pleasing, usable condition. There is some overlapping between activities classified as part of maintenance and those classified as part of daily operation. Only those procedures most commonly classified under maintenance are described here. These are identified under five major headings: (1) surface and finishes, (2) doors and windows, (3) fixed (built-in) equipment, and (4) fire protection and safety. (Mechanical systems are recognized as internal components, but because of their complexity, are treated in a separate chapter.)

Surfaces and Finishes

School administrators, teachers, and pupils themselves agree that school surroundings have a pronounced effect on deportment, attitude, learning efficiency, and civic outlook of pupils. The surface and finish of ceilings, floors, and walls constitute one important element of the surroundings. Other important items whose surface and finish affect room appearance are chalkboards, tackboards, and trim.

Ceilings

This discussion on ceiling maintenance is limited to painting, repairs, and replacement. The amount and kind of maintenance, as well as recommended procedures for it, depend largely upon the type of ceiling material. Some of the popular types are plaster (conventional, with a choice of several finishes, or acoustical), concrete (which can serve as both roof deck and ceiling, with or without acoustical treatment), metal of various kinds (applied as a pan, panel, or in smaller sections, usually with acoustical treatment), laminates, and fiber (mineral, wood, or glass).

Plaster is durable, and it affords good insulation. It can also be installed as acoustical material. Plaster may be finished in several ways, such as smooth white, sand, or stipple. Many buildings (both old and new) having fresh plaster are occupied and used for an indefinite time before paint is applied to the plaster, particularly if the finish does not create excessive glare. This is done because it is believed that plaster has to cure for 6 months to 2 years before paint can be successfully applied to it. Improved plaster material and paints now make a shorter waiting period possible, but the presence of certain conditions can cause trouble if they are not recognized and if proper procedures are not followed. Some troublesome conditions to look for in new plaster are excessive moisture, "sweat-out" and "dry-out" spots, uneven density, and efflorescence.

Most of the large volume of water necessarily included in plaster mixture evaporates through the finished surface. If paint is applied too early, the escaping moisture will cause the paint to peel. It is therefore necessary to know the moisture content of new plaster before covering its surface with paint. This can be determined either by using a moisture meter or by loosely cementing a strip of clear plastic to the plaster's surface—there will be condensation on the back of the plastic strip if the moisture content is too high for painting.

Under normal conditions, when relative humidity is not high and the temperature is not below 50° F., plaster on a furred wall or ceiling will dry in 3 to 4 weeks; on an unfurred wall or ceiling, where it is applied directly to brick, tile, block, or similar structural material, only the surface of the plaster is open, causing the drying time to be lengthened. A meter should be used to determine the moisture content of new plaster on unfurred walls.

There may be areas in new plaster that are soft from "sweat-outs" and "dry-outs," the former being due to excessive moisture and slow drying and the latter to premature evaporation of water before the gypsum crystallizes. When sweat-out areas are indicated, it is usually necessary to remove material from the affected area and replaster. Dry-out spots can sometimes be corrected by spraying them with a solution of water and alum, using about 2 pounds of alum per gallon of water. This procedure provides necessary water for the gypsum to crystallize, and should be repeated as often as necessary to make the affected area harden. Both sweat-out and dry-out spots can sometimes be hardened by applying a coat of shellac or lacquer, particularly if the spots are small. Paint can then be applied satisfactorily.

When finish troweling has not been performed in a uniform manner, spots with nonuniform "suction" may appear. These spots are usually hard, have a "dead" appearance, and cause uneven gloss or color in the paint. Uneven mixing of lime and gauging plaster can also cause nonuniform suction. This condition can be corrected only by removing the material and replastering, but appearances can be made passable by touching up these spots with additional coats of paint, "feathering" each coat to its outer edges.

Occasionally deposits of chalk or tiny crystals of soluble salts appear on the surface of new plaster. As in masonry walls, these deposits are caused by efflorescence. The crystals should be brushed off at intervals of several hours until no more of them form. In no event should water be used to wash them away, since it may bring out more salts from beneath the plaster's surface. A wall or ceiling affected by efflorescence can usually be painted successfully before the efflorescing process stops, provided the plaster is on a furred wall or ceiling. In this case, two coats of latex paint or any other paint that is impervious to water vapor should be applied to seal the exposed surface, thereby transferring the crystal formation to the back of the plaster. This will permit paint to hold firmly without peeling.

In rare and isolated instances, very fine hairline cracks develop in new plaster, but these are not usually noticeable until after the surface has been painted. One procedure commonly used to detect such cracks *before* painting is to view the wall or ceiling at a low angle (with the eye close to it); cracks visible in this manner can be obscured with paint having a little texture, applied prior to the main coats.

The secret of long-term satisfaction with painted plaster lies in good material and careful workmanship in applying the primer coat. The bond between the plaster and first coat of paint determines the adhesion of all future coats. In order to insure a good bond, workmen should carefully prepare the surface of new plaster, and should make sure that atmospheric conditions are satisfactory before applying a suitable paint. It is well to remember that paints, primers, and seals produced by a manufacturer of good repute, sold by a dealer who merits confidence, and recommended for the particular kind of job are most likely to give satisfactory results.[1]

[1] *Painting New Plaster.* A manual prepared jointly by: The Finishing Lime Association of Ohio, 240 Huron Street, Toledo, Ohio. The Painting and Decorating Contractors of America, 2625 West Peterson Avenue, Chicago, Ill. The National Paint, Varnish, and Lacquer Association, Inc., 1500 Rhode Island Avenue, Washington 5, D.C.

(Procedures described here are recommended by these organizations, and are used here by permission.)

Hairline cracks in old plaster can usually be repaired satisfactorily by first cleaning them and then applying with the finger or a putty knife a ready-mixed spackling compound, a good sealer, or water putty. Ready-mixed vinyl paste is easy to apply, fast to dry, and takes paint almost immediately without priming. If the surface appears uneven after filling, it can be brought to a smooth finish by sanding lightly with fine sandpaper, either by hand or by using an oscillating sander.

Deep cracks must be widened and deepened (minimum width about ⅜ inch) in order to hold the filler and insure a satisfactory job. A special chisel should be used for this, although a putty knife is satisfactory for a small job. Preferably, the widened groove should be cut in the shape of an inverted "V." All loose dust should be removed by dry brushing, followed by cleaning with a damp cloth, before filling the groove with patching plaster, spackling compound, or water putty. The completed surface can be smoothed by sanding, as described above.

Larger cracks and extensive broken areas necessitate removal of all plaster from areas having excessive deterioration. All firm edges should be thoroughly cleaned and lath work slightly dampened before regular plaster is applied with a plasterer's trowel.

Sand-finish plaster is painted in the same manner as plaster with other finishes, but normally requires more paint the first time than for repaint jobs. Acoustical plaster can be painted, but its acoustical properties are impaired in the process. When acoustical tile, panels, or other similar installations are painted, care should be exercised to avoid filling or covering perforations or irregularities for sound absorption with paint.

Monolithic concrete designed to serve both as roof deck or floor base and ceiling for rooms below has many advantages, such as ease of maintenance, long life, structural safety, resistance to fire, and, possibly a protective capacity in case of enemy attack. Because sound reverberates so acutely from it, however, acoustical treatment is usually necessary in those areas of school buildings where quiet is important. This can be achieved by applying sound-absorbing materials to, or over, concrete surfaces in various ways. The most commonly used materials of this type are acoustical plaster, tile composed of metal, or fiber of mineral, wood, or glass. These can be attached to the concrete by direct application to it, or by indirect application, utilizing furring material, a grid system requiring specially designed fasteners, clips, Z-bars or T-bars, rods, wires, or other devices to support the particular type of system specified. Plaster can be applied directly to scarified concrete, or it can be applied to metal lathes which are fastened to the concrete. Tile of various kinds is generally fastened to the concrete by an adhesive.

Normally, there is little maintenance required for installations in which plaster has been applied directly to scarified concrete. If either plaster or tile comes loose from the concrete, as happens from time to time, the affected areas must be thoroughly cleaned of all old material before new material is applied. Plaster applied on furring, metal, wood, or gypsum lath can be repaired as previously described. Correction of any damage to suspended ceilings depends on the nature and extent of damage. If only a few tiles are damaged, these can be replaced in the grid without great difficulty. If large areas and the supporting system itself are affected, the entire system for the affected room may have to be taken down and replaced.

Walls

Interior walls, which are either bearing or nonbearing, can also be classified according to their prime function. A "division wall" is a bearing wall that runs between two exterior walls for the purpose of dividing a building into two or more parts or of separating one building from another. A "fire division wall," constructed of solid masonry or reinforced concrete, subdivides a building for the purpose of restricting the spread of fire. A "fire wall," constructed of solid masonry or reinforced concrete (starting with the foundation and continuing through all stories to and above the roof), with all openings usually protected by fire doors, serves to restrict the spread or fire, or to divide space into limited areas for fire protection. A "partition wall," which is wholly supported at each story, is a nonbearing wall that can run at any angle from the bearing walls for the purpose of dividing the interior of a building into compartments. There are code requirements for the materials used in interior walls that vary according to the purposes served by the walls. As a rule, interior walls need little maintenance.

Most maintenance problems posed by interior walls concern the surface and finish of division and partition walls. Where the finish or surface is concrete or plaster, maintenance procedures are essentially the same as those described for ceilings of the same material. If the wall is constructed of concrete block or cinder block without plaster, as is customary in many parts of the country, the standard procedure is to paint the wall with a flat wall paint, using either the oil-, latex-, vinyl-, or casein-base type with the desired color and reflectance factor. Application may be by brush, spray gun, or roller.

A brush fills cavities easier than a spray, whereas a roller has advantages on smoother surfaces, laying down a uniform coat in less time than other methods of application.

A tight-sealing, non-breathing type of paint should be avoided when repainting the interior of outside walls that are constructed of concrete, brick, stone, concrete block, or cinder block, unless these walls have been dampproofed. The reason for this is that the paint will be pushed away and its adhesion broken if moisture penetrates the walls.

Metal or wood, such as door and window facing, chalk and tackboard trim or rails, are a part of overall wall surfaces and must be refinished when rooms are repainted. Enamels, flat paints, stains, and varnishes can be applied to wood surfaces more economically by brush than by spray guns. Any wood surface to be refinished should first be thoroughly cleaned of all loose paint, blisters, oil, grease, or wax. This cleaning can be accomplished by one of several methods, but paint solvents and sanding are in common use. In addition, all holes, cracks, pores, or other irregularities should be filled and sanded to a smooth finish before paint is applied. Any wood that has been varnished will not take paint or enamel unless the varnish is removed or given special treatment to allow a bond between the paint and the wood.

Most untreated iron and steel (except stainless steel) will corrode if exposed to moisture and oxygen. Paint furnishes a protective coating to prevent corrosion, but for it to work successfully, the metal must be thoroughly cleaned of any rust or loose particles of paint from previous applications. This can be accomplished by flame cleaning, by applying rust remover with a spray gun or brush, by sand or grit blasting, by wire brushing (either by hand or mechanically), or by using solvents. When cleaned, the metal should be primed (usually with a red-lead alkyd varnish primer), followed by an intermediate coat or undercoat (which can be the same as the finish coat except that it should be tinted a different color), and finally the finish coat. The priming coat should always be of the rust-inhibiting type.

Before ceilings and walls of corridors, stairwells, and other exit routes of school buildings are repainted, consideration should be given to fire-safety paints, products developed fairly recently by the paint industry. Two types are available: one which does not support combustion and hence stops or retards flame spread, and another which both retards flame spread and prevents heat transfer to combustible materials that might be covered by it. Since the latter type does not feed combustion and becomes tumescent when subjected to heat, it helps insulate burnable surfaces, preventing them from igniting from the heat. Both types of safety paint can be obtained in popular colors.

Chalkboards

Manufacturers produce chalkboards with a wide range in quality under numerous trade names and labels, but basically boards are classified according to the method of fabrication and materials used in their manufacture. The most common types (each with great variation in quality) are *slate*, *metal*, *glass*, *wood*, and *composition*. With the exception of slate, which can be painted any desired color, these boards can be obtained in several colors, depending on the preference of the user.

Slate chalkboards are made from natural slate, surfaced to its natural plane, and honed to a smooth finish. Metal boards consist of a face sheet of galvanized steel, enameling steel, or other metal, surfaced with porcelain enamel, or other vitreous ceramic material, and coated with an abrasive paint (such as magnesium silicate, silicate, or silicon carbide) for a writing surface. Back-up sheets usually are of steel or aluminum, and the sandwich core is of fiberboard, plywood, or masonite. Glass boards of good quality are made from tempered, polished plate sprayed with a colored ceramic enamel containing an aluminum oxide abrasive. Wood chalkboards have a presdwood or other hardboard face with an abrasive coating for the writing surface; they may be backed with either metal or plywood, and they usually have a sandwich panel of shredded wood between the face and back. Composition boards are manufactured from a variety of products, such as gypsum, cement-asbestos, cardboard, fiberboard, hardboard, plywood, plastic, and metal, which are combined and fabricated in different ways. Perhaps the cheapest of the composition boards is pressed cardboard having a thin plastic sheet for the writing surface and paper for the back-up sheet. Cement-asbestos boards usually have a plastic face with fine, uniformly suspended silicon carbide evenly applied and baked on; some have base panels of shredded wood fiber, fabricated under hydraulic pressure; others have panels containing gypsum and wood fiber, formed under heat and pressure into a smooth, homogeneous hardboard. Some manufacturers give added strength and durability to their composition boards by using aluminum or steel back-up sheets.

Routine maintenance of chalkboards is primarily a matter of keeping writing surfaces clean, a chore which should be performed at frequent intervals, and according to the manufacturer's recommendations on cleaning. Major maintenance normally involves either replacing unsatisfactory boards or refinishing their surfaces; occasionally, trim or chalk trough material needs repairing or refastening.

Visual comfort is so important that chalkboards should be properly broken in before use and adequately maintained from day to day. Most manufacturers recommend the following for breaking in and maintaining a chalkboard:

(1) Using the side of a piece of pure chalk crayon of the nonglazed type, apply chalk to the entire writing surface of the board.
(2) Using a good-quality felt eraser, work the deposited chalk into the writing surface.
(3) Repeat these two steps. Then clean the board with a dry chamois of very high quality or with a soft, loosely knit cotton cloth. (The chamois or cotton cloth should be shaken out, not washed, to remove chalk dust.) It is important to remove break-in chalk dust from the board, because moisture in the air might condense on the writing surface and unite with the chalk's binder, making it difficult to clean the board.
(4) Erase and dry-clean the board at the end of each day of use. (To dry-clean a board, erase it with a clean felt eraser, and then wipe it with a soft cloth or chamois skin, or vacuum it with a special machine for that purpose.)

Most chalkboards can be washed without damage if proper precautions are taken. Water itself will not harm the board (except the cheaper composition boards), but when water is applied to chalkboard surfaces having particles of chalk and binder, it forms a gluey substance which can be removed only by continued washing with clean water. Repeated washings cause a gradual build-up of the gluey deposit until a white film covers the entire writing surface, resulting in glare, and making the chalkboard slick and ineffective. If a chalkboard *must* be washed, only clear, clean water should be used, and the board should then be rinsed with clean water. Immediately after rinsing, the board should be dried with a soft cotton cloth or a chamois, and then broken in just as if it were new.

There are a number of chalkboard cleaners, pressurized sprays, pretreated cloths, and other preparations on the market, but most of them contain caustic soda, oil, kerosene, or other substances harmful to chalkboard surfaces, and should not be used unless recommended by the chalkboard manufacturer. Oil should never be applied to any chalkboard, regardless of type, because it fills pores and leaves a slick surface, preventing chalk from making a visible mark.

A somewhat different problem is encountered when chalkboards develop "ghost" marks, a condition in which visible marks remain, no matter how carefully the board has been erased. This "ghosting" is essentially the result of incomplete erasing, and usually indicates that something is out of balance with respect to the chalkboard surface, the chalk, or the eraser. When this difficulty lies with the board's surface, the board itself is of poor quality and the remedy is to replace it. If the difficulty lies with the chalk, the remedy obviously is to change the type of chalk. Wax crayons and colored or white chalk of inferior quality are common offenders. The third factor in these three related items is the eraser, which may not completely remove chalk marks because of inferior quality. Most chalkboard manufacturers recommend a good-quality wool-felt eraser, because it is sufficiently firm, has separate erasing felts providing individual erasing edges, and has minute bristle-like fibers to provide the dual abrasive-brushing action necessary to the release of chalk particles.

Ghost marks sometimes appear on chalkboards even though none of the three related factors is responsible. Moisture from the atmosphere, cleaning agents, or an excessive amount of perspiration on the hands, coming in contact with chalk or board, can cause chalk to adhere stubbornly to board surfaces.

Regardless of cause, ghost marks can usually be removed from good boards by cleaning them thoroughly with a soft, moist cloth dipped in powdered pumice (obtainable at most drugstores), and then rinsing them with clean, clear water. Since air drying may leave the boards streaked, they should be dried with a clean soft cloth or chamois. The final step in this procedure is to break in, as previously described (see p. 78), all surfaces cleaned in this manner.

Manufacturers of slate chalkboards suggest that their boards be washed as often as necessary, usually once a week, and recommend the following techniques:[2]

(1) Erase and dry clean the board before washing.
(2) Use clean water.
(3) Wash one panel at a time, starting at the top and using a horizontal stroke.
(4) Remove the wash water with a window washer's squeegee. (This is the secret of avoiding the cementing of chalk binders and ingredients to the board.)
(5) Dry the board with a chamois or soft cloth.
(6) If ghost marks from chalk are still visible, rewash by using a small amount of ammonia in the water, or for extremely stubborn cases, use [one of the popular commercially-prepared mild abrasives].

Another procedure recommended for slate chalkboards is to scour them once a year, using powered pumice or other mild abrasive powder, or steel wool and soap pads of the finest texture obtainable to remove perspiration marks, crayon marks, residue from any adhesive tape or paste used on the boards, or any thin film of chalk binder remaining on them as a result of improper washing.[3]

[2] Pennsylvania State Producers Guild, Inc. *Slate Chalkboard Guide.* Pen Argyle, Pa.: The Guild. 1962.
[3] Ibid.

Chalkboards of all varieties sometimes become shiny, causing serious glare. This condition is usually evident when the pores or biting surface become clogged with foreign agents, deposits from inferior chalk, residue from improper cleaning agents, or from repeated washings performed improperly. If the board's surface is good, the glare created by these deposits can be eliminated and a good writing surface restored by the application of dry powdered druggists' pumice with a damp cloth, using light circular motions and covering an area of no more than 3 or 4 square feet at one time. While the surface is wet, it should be rinsed with a soft cloth dampened with clean water. Then the surface should be dried with a clean, soft cloth prior to using the break-in technique. Because of the abrasive action involved, this cleaning procedure is not recommended for cheap or inferior boards.

A more complicated maintenance procedure is involved when chalkboard surfaces become rough or pitted, conditions which may be caused by initial defects in the board, from the application of harmful chemical cleaners, from thoughtless misuse (such as applying adhesive tape, glue, or thumbtacks to board surfaces), or from years of neglect in cleaning them. Boards of good quality can be reclaimed if they are carefully sanded, cleaned, and resurfaced with an abrasive paint (of which there are several brands). If this procedure is not successful, the only solution is to replace the affected sections. If boards are not pitted, but need to be refinished, manufacturer's directions should be followed in renewing their surfaces. In recent years, there has been a growing tendency to install chalkboards in color, for visual reasons, and many school officials, in line with this trend, have resurfaced their "black" boards of good quality (both composition and slate) with an abrasive paint manufactured primarily for this purpose. Again, if this procedure is anticipated, the manufacturer's suggestions concerning a refinish job should be followed.

Slate chalkboards having a surface problem similar to those described above can be refinished by any of the following procedures:[4]

(1) Dry grind the surface under vacuum. (This can be done under contract by several reputable firms.)

(2) Wet grind, using abrasive scrub blocks. (This can be done by hand, by machine, by plans furnished by the manufacturer, or by contract.)

(3) Remove affected panels from the wall, place them on a flat bench or table top, and sand them, using water as a coolant and to control dust. (This can be done in the school system's maintenance shop, or by contract.)

Teachers sometimes cause discolorations and slick spots on chalkboards by inadvertently using colored chalk or wax crayons not in-

[4] Ibid.

tended for chalkboard use. These discolorations and spots can be removed from most boards by using powdered pumice on a moist cloth, scouring the surface gently in a circular motion, cleaning a small area at a time, rinsing, drying, and breaking in the board again.

Display Boards

Display boards consist of any material attached to walls, either recessed or face-mounted, for the purpose of hanging, fastening, tacking, pinning, or mounting illustrative and instructional materials that are adaptable to visual presentation on a flat surface. These boards, usually fabricated from cork, pulpwood, vinyl plastic, hardboard, or a combination of these products, are called corkboards, bulletin boards, tack boards, or pegboards. They may have auxiliary features, such as heavy hooks for mounting maps and other objects of considerable weight, spring clips for paper display, holes for pegs and hooks, and metal channels or tracks to accommodate sliding fasteners of various kinds. Frequently, display boards are enclosed in metal, wood, or glass cases with doors and locks.

Like chalkboards, display boards require little maintenance other than the care of surfaces, unless they are damaged by vandals or by careless use. Burlap-backed cork with vinyl coating is resistant to soil, perspiration, and water, and can be adequately maintained by occasional washing with water and any household soap or detergent. Boards of natural cork consist of a sheet of cork 1/8 to 1/4 inch in thickness, mounted on pulpwood or hardboard backing. These boards can be maintained by washing with soap and water, and if stubborn stains are encountered, by scrubbing with an abrasive soap and hot water. Surfaces of corkboards sometimes become rough with long, hard usage, but rubbing them with sandpaper of a very fine grade, a pumice stone, or carborundum hone restores the original smoothness of the surface.

Display boards improperly mounted on concrete block or on unfinished or unplastered walls sometimes become detached, primarily because the porosity of concrete block or the roughness of the wall prevents a good bond between the wall surface and the cement with which the board is attached. Recommended maintenance procedure for this problem is to clean old cement from the board's backing; mount masonite to the wall by using toggle bolts, screws with expansion nuts, or other mechanical fasteners; and then cement the display board to the masonite surface.

Floors

Adequate maintenance of an infinite variety of flooring materials for schools is possible only if their physical characteristics are known and if standard maintenance procedures for each type are followed. Materials most frequenty used for school floors are wood, concrete, terrazzo, magnesite, resilient covering, tile (clay and ceramic), slate, marble, and carpeting (recently promoted as a desirable floor covering material for most types of floors in many building areas). A brief description of, and the recommended maintenance procedures for, each of these materials follows.

Wood Floors

Woods in common use for school floors may be either hard or soft, with open grain (such as oak) or closed grain (such as maple), each obtainable in a variety of widths, thicknesses, and designs. Wood flooring is normally installed in one of two ways: strip installation, a method by which various lengths of tongue and groove strips are nailed to a subfloor or underlayment of wood, or, if installed over concrete, to wood screeds imbedded in or fastened to the concrete; and block installation, a method by which square wood blocks (end-grain or parquet types) are laid in mastic applied to an underlayment of wood or concrete.

Recommended upkeep for most oak floor installations—after a good foundation finish of penetrating floor seal—involves daily sweeping, plus a thorough "dry cleaning" and refinishing once a year.[5] Occasional buffing is optional. Soap and water are not recommended for scrubbing and mopping, especially if repeated often, because flooding the floors with water may cause the wood to swell excessively and buckle, and then shrink upon drying out, leaving cracks between the flooring pieces.

Because wax tends to leave oak floors slippery, it is not recommended for them in schools, particularly if a good-quality penetrating seal has been applied. Moreover, this seal resists wear exceptionally well, making a protective coating of wax unnecessary.

Daily sweeping, the backbone of good maintenance, eliminates loose dust and dirt that otherwise would dim the luster of the finish and eventually work into the grain of the wood. A cotton dust mop treated with mineral oil or a floor brush with good bristles is recommended for sweeping. In large unobstructed areas, such as gym-

[5] The National Oak Flooring Manufacturers' Association. *Hardwood Floors Reduce School Maintenance Costs.* Memphis, Tenn.: The Association (A mimeographed paper prepared for the Association by Maurice E. Collins.)

nasiums and corridors, a mop or brush 48 to 54 inches wide is recommended; in classrooms, mops or brushes 24 to 30 inches wide are most efficient, and especially serviceable is the swivel mop or brush whose head turns sideways at a twist of the handle, permitting the operator to reach places inaccessible to ordinary mops and brushes.

Some floor specialists favor spreading a wax-base sweeping compound before sweeping. The compound helps to settle the dust and aids in picking up dirt, particularly in areas of heavy traffic where a considerable amount of dirt may be tracked in. The compound also deposits tiny granules which, when swept, leave a slight gloss on the floor without slipperiness. Spots of hardened mud and other foreign matter undisturbed by sweeping can be removed by first buffing with a steel-wool pad attached to an electric polishing machine, next applying a wax-base sweeping compound, and then by sweeping.

Procedures for annually cleaning and refinishing oak floors differ slightly, mainly because of varying recommendations of manufacturers whose cleaners and seals are used. One successful method, among others, is to utilize a 3-man crew, with 2 scrubbing-buffing machines. The floor area should be swept thoroughly. Then, one workman, using a long-handled applicator with a lamb's wool pad 10 to 14 inches wide, applies a solvent type of cleaner made especially for hardwood floors to an area about 5 feet wide by 30 to 50 feet long. When this is finished, a second workman traverses the area with a polishing machine equipped with a No. 3 steel wool pad. This scrubbing operation aids the solvent in loosening all ordinary dirt and in removing spots. A third workman follows with a second machine equipped with a No. 2 steel wool pad, an operation that takes up the residue and leaves the floor clean and practically dry. By the time the entire floor has been treated in this manner, it is sufficiently dry for penetrating seal to be applied. The same 3-step procedure is repeated in applying the seal.

Penetrating seal (also called floor seal) is a relatively new type of finish which seeps into the pores of the wood, sealing them and providing a barrier against dirt and spots; in effect, the seal becomes a part of the wood itself instead of merely forming a surface coating. The wood becomes resistant to wear, chipping, scratching, and staining, but does not take on a glossy finish like that produced by varnish. A pleasing luster can be produced by polishing the floor, on the day after applying seal, with a brush attachment on a buffing machine.

A hardwood floor finished with a top-grade seal rarely requires resanding, but if years of neglect have detracted from its appearance, it can be restored to its original beauty by sanding and refinishing. Plenty of ventilation should be provided during refinishing, but care should be taken to prevent dirt and dust from blowing onto the floors. It should be emphasized that refinishing with seal is possible only when the existing finish is seal. Varnish, shellac, or lacquer must be removed and the floor sanded before being refinished with penetrating seal. The sanding should be done in such a way as to produce the smoothest surface possible; the smoother the surface, the better the refinishing job.

Northern hard maple, beech and birch flooring, like other hardwoods, require some kind of finish. The Maple Flooring Manufacturers' Association (MFMA) publishes a list of approved sealers for these hardwoods. (This list is available from the Association offices on request.) Proper finish, correctly applied, beautifies the floor, brings out the handsome grain pattern, makes scrubbing unnecessary, and adds greatly to the life of the wood. An MFMA-approved natural penetrating sealer, or color sealer combination finish, can be applied with minimum labor by merely pouring it directly onto the floor, then "squeegeeing" it with a rubber applicator and, after a few minutes, "burnishing" it with a motor-driven polisher faced with a fine steel-wool pad. This gives a finish of deep penetration, extremely great wear-resistance, and high polish, which is easy to clean and renew by reburnishing.[a]

Wood floors may be severely damaged in a number of ways, but the most common cause of damage is excess moisture, which may be the result of poor ventilation, unsealed walls, roof failure, open doors and windows during blowing rainstorms, or the use of too much water in cleaning. Excess moisture causes wood to buckle, cup, splinter, and decay.

"Buckling" is a bowing of individual boards or a rise of several boards from joists or subflooring. This condition is usually caused by dampness, but can be the result of improper installation, e.g., failure to provide for expansion. If moisture is the cause, the application of heat under or on the surface of affected areas will evaporate the excess moisture from the wood, sometimes allowing it to settle back to its original position. If this procedure doesn't work, affected boards can be ripped down the middle once or twice with a portable circular power saw, a procedure which removes enough wood substance to permit boards to settle to the subflooring. Face nailing along the sawed edges will secure the flooring.

"Cupping," the opposite of buckling, is a condition where board edges turn up, leaving the floor surface uneven. Where cupping is mild (very little difference between the surface of unaffected and the

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[a] Maple Flooring Manufacturers' Association. *How to Lay a Lifetime Floor of Northern Hard Maple.* 35 E. Wacker Drive, Chicago: The Association, p. 7.

edges of affected boards), a satisfactory remedy is to sand and refinish affected areas, being certain not to cut too deeply into the tongue and groove of adjacent boards. Sometimes damaged boards have to be replaced, a procedure described below.

Decayed or broken boards must be replaced. In the tongue and groove type flooring, this can be accomplished by sawing the damaged board down the middle with a portable circular power saw. The board can then be pried up from the middle; in doing this, one must be careful not to damage the tongue and groove of boards at each side. Replacement can be made by removing the lower lip of a new board, pressing its tongue into the groove of the adjoining board, and pressing the entire board into place. It will then be necessary to face-nail the new board with small-head finishing nails. These should be countersunk and the holes filled with plastic wood (which should be allowed to dry) before the surface is sanded to the desired finish.

"Splintering" is the partial separation of fragments, small slivers, or fibers from a piece of wood. In flooring, this usually occurs along, and in the direction of, the grain of the exposed surface. If splintering does not run too deeply into the wood, a satisfactory remedy is to apply two or three coats of floor sealer and to cement the splinters back to the wood. Difficult cases can usually be repaired by sanding and refinishing. If the splintering is very deep, then the affected board should be replaced.

Concrete Floors

Concrete floors are made from a mixture of portland cement, sand, gravel, and water that is cast in place and allowed to set as a solid mass. Although concrete usually serves as a base for other flooring material, it is often used for floors, without covering, in school building areas that are subject to heavy traffic or to rough treatment, such as corridors, storage rooms, stairs, furnace rooms, warehouses, and loading platforms.

Exposed concrete floors often develop two types of maintenance problems. One is inherent in the material, while the other may be due to abuse, accident, improper pouring, improper mixture, freezing before curing, or other physical causes.

"Dusting," a characteristic of concrete itself, can be a troublesome problem unless floors are sealed to prevent surface disintegration. Technicians of the Portland Cement Association recommend that concrete floors be allowed to cure and dry thoroughly before a sealer is applied. The length of time required for this depends on the time of year, conditions inside the building (moisture, heat, etc.), and other factors. A simple test to determine when a concrete floor is dry is to place a small piece (2 ft. square) of rubber mat or linoleum on the floor, leaving it weighted down for 24 hours. If there are damp spots on the linoleum at the end of the period, the concrete should be allowed to cure further until a retest shows no damp spots.

For either old or new floors, it is imperative to remove any oil, grease, dirt, dust, or other foreign matter before applying any sealer. This can be done by using an alkaline cleaner (for troublesome oil stains, use a solution of 6 ounces of trisodium phosphate to 1½ gallons of hot water), scrubbing with a steel wire brush attached to a floor machine or with a long-handle bassine deck scrub brush, and then rinsing thoroughly with clean water.

Concrete floors less than a year old (and some older ones) may require a neutralization of alkali in them. This can be done in several ways. One procedure is to apply a solution of 1 part 18 percent muriatic acid to 4 parts water, allowing the solution to remain on the floor for about 30 minutes before flushing it off with clean water. Another procedure is to mop the floor with a solution of 3 to 4 pounds of zinc sulfate to 1 gallon of water, allowing 48 hours for the solution to react to the concrete and to dry. The surface should then be rinsed with clear water to remove all of the chemical from the floor. The floor should be allowed to dry before going over it with a brush or push broom to remove any surface dust. (If damp spots remain on the floor after other portions of it are dry, this is an indication that it was not adequately rinsed.) When the floor has been cleaned, neutralized, rinsed, and is dry, a sealer should be applied as soon as possible. On below-grade floors it is imperative to apply the sealer within 24 hours after neutralizing and drying. Usually, one or two thin coats of approved resinous sealer, either pigmented or clear, are sufficient for sealing. The first coat should be allowed to dry thoroughly before the second coat is applied. If a high gloss is desired, one coat of clear sealer can be applied over two coats of pigmented sealer. After the sealer has dried, one or two coats of approved water-emulsion wax or else a deodorizing cleaner containing wax should be applied. Sealed floors that become dull should be rewaxed. Periodic inspection of concrete floors, as well as daily observations by custodians, should reveal signs of dusting, or powdering, of the surface of concrete floors. Areas having these signs should be resealed without delay.

Concrete floors sometimes develop holes in their surfaces, usually (but not always) caused by some physical action imparted to them by an outside force. The effective repair of such holes consists of chiseling them out to make their walls vertical or even slightly receding at the bottom; this makes the holes hold patching material better. Any loose sand, gravel, or dust must be removed from the walls and bottom of the hole by washing them or by directing a jet of compressed air into the cavity. All surfaces to which the patching mixture must bond should be moistened to the extent water is absorbed by them, with no water remaining on the surfaces, before filling the hole with either a mixture of portland cement and sand or a proprietary mixture, leveling it off about ½ inch above the surrounding floor surface to allow for shrinkage. To protect the patch from injury, it should be covered by boards placed on shims to prevent their weight from spreading the soft patch. Within an hour or so, the boards can be removed and the patch troweled down to floor level. Then it should be protected from injury until the patch has firmly set.

Terrazzo Floors

Terrazzo consists of a mixture of portland cement (to which color pigments may be added), marble or granite chips, and water. There are three principal methods of terrazzo installation: the sand cushion (floating) method, used where structural movement is anticipated; bonding the terrazzo to concrete, a method used for general areas (corridors, lobbies, rooms, etc.); and the monolithic method, used where terrazzo finish is desired at an economical price. The surface finish of each is the same, and procedures for its maintenance, as recommended by the National Terrazzo and Mosaic Association, Inc., are as follows:[7]

- New terrazzo and mosaic floors should be cleaned only with a neutral liquid cleaner, rinsed with clean, clear water, and after the surface is dry, treated with an approved penetrating seal to prevent efflorescence.
- For general cleaning, use one cup of neutral liquid cleaner (or see manufacturers' directions) to each three-gallon pail of water. Wet mop the solution onto the floor and allow several minutes for grime-dissolving action to take place. Squeegee, wet vacuum, mop, or wipe up dirt-laden solution. Keep floor wet at all times during cleaning operation to prevent dissolved soil from drying back on the floor. Thorough rinsing is required if soap or powder type cleaners are used.
- The liquid cleaner must be neutral, free from harmful alkali, acid, metallic salts, or other strong ingredients. Acid in any form is prohibited.
- If a mop dressing is used in daily sweeping, be sure it is non-oily; some sweeping compounds contain sand which abrades if left on the floor; also,

[7] National Terrazzo and Mosaic Association, Inc. Monolithic Terrazzo Specifications (Reprint from Producers' Council *Technical Bulletin #93*, September 1960). Washington: The Association.

cheap dye used in some sweeping compounds can cause stains that are difficult to remove; floor oils penetrate and permanently discolor terrazzo; and should never be used.

- Terrazzo floors containing abrasive aggregates should never be sealed and should be scrubbed regularly to keep the abrasive aggregate free of build-up of dirt or foreign matter.
- Scrubbing with an electric floor machine, using a solution of neutral liquid cleaner loosens dirt that is sometimes hard to get off in daily wet mop cleaning. Buffing with an electric machine after each cleaning restores the beauty of terrazzo and builds a natural sheen that becomes a permanent part of the floor.

Stains on terrazzo floors constitute another maintenance problem which, the Association suggests, should be treated as soon as possible, because they become more difficult to remove after they have dried. Stain removers fall into three general classes: those that dissolve the substance causing the stain; those that absorb it; and those that act as a bleaching agent. Before attempting to remove stains, one should know what caused them and why and how a certain type of remover should be used. For example, when a procedure specifies treatment with a solvent before cleaning, it may be that if the order is reversed, the alkali in the soap would set the stain, making its removal impossible. A mimeographed document entitled "Suggested Methods for Removing Stains from Terrazzo" is obtainable from the Association's headquarters in Washington. This document prescribes detailed procedures for removing stains caused by ink, iron, oil, tobacco, urine, coffee, and iodine.

A different type of maintenance problem is cracking of the terrazzo. There is no satisfactory remedy for this difficulty. The cracks can be calked with fresh portland cement, or other suitable material, but this, though necessary for sanitary reasons, may be more unsightly than the crack itself. Holes in terrazzo can be repaired more satisfactorily with the procedure previously described for holes in concrete floors (see p. 87). Patching should be done with a matrix containing 70 percent marble chips of matching colors. When the patch has cured sufficiently, it should be honed to a polished finish matching that of the original floor.

Magnesite Floors

Magnesite flooring is usually composed of magnesium oxychloride and various kinds of fillers or aggregates; the magnesium oxychloride, formed when magnesium oxide is combined with a strong solution of magnesium chloride, acts as a binder. The materials are mixed together, troweled onto almost any solid base, and allowed to set for a period of 48 to 72 hours, during which time a hard surface with high strength is formed. Variations in the amount and kind of fillers or aggregates can give the surfaces a plain or a terrazzo-like appearance.

Since magnesite floors are slightly porous, they should be sealed with one coat of floor sealer; excess sealer should be wiped off before the surface has dried. Sealing prevents possible impregnation of pores with grease or other harmful substances. After the sealer has dried, the floor should be waxed, using either a water emulsion wax or a solvent wax. Like other floors requiring wax, magnesite floors should be stripped with a neutral liquid cleaner, rinsed, and rewaxed periodically. Daily maintenance of these floors is normally limited to sweeping with a soft brush or yarn mop. If required, a wax-base (never oil-base) sweeping compound may be used when sweeping.

Cracks or holes in magnesite floors can be repaired in the same way as cracks or holes in concrete floors (see p. 85), except that the mixture for filling should be of the same materials (in approximately the same ratio) as were used when the floor was installed.

Resilient Floors

Certain kinds of floors or floor covering materials are referred to as "resilient" because they are said to possess some degree of elasticity. Seven basic types of material, each having its own physical-chemical characteristics, are in common use for school floors: asphalt tile, cork tile, linoleum and linoleum tile, mastic, rubber tile, vinyl tile (of which there are three kinds—vinyl asbestos, homogenous flexible, and calendered vinyl), and a new product of epoxy resins and silica. Each can be used to advantage in particular areas of school buildings. While all of them require sweeping, washing, waxing, polishing, and protection against indentation, each has some problems peculiar only to itself. Some characteristics of, and maintenance procedures for, each of these materials are presented here.

ASPHALT

Asphalt tile, a resilient floor covering low in initial cost, is made of a mixture of asbestos fibers, plasticisers, color pigments, and inert fillers bound together with an asphalt or resin binder.

The standard size of asphalt tile is 9″×9″×⅛″. There are four color groups—A, B, C, and D, with A group the darkest and D group the lightest. A and B groups usually contain asphalt binders, while the C and D groups have resin binders. This tile resists normal moisture; can be used on, above, or below grade; is nearly fireproof; and is easy to clean. Being hard and brittle, however, it chips easily,

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cracks under heavy loads or sharp impacts, and except for the grease-resistant variety, is adversely affected by oil or grease.

Cleaning solutions are not recommended for newly laid asphalt tile floors until the asphalt cement has set for 10 days. Once placed in service after being cleaned and waxed, asphalt tile needs to be washed and waxed only two or three times a year in most schools. When this is necessary, old wax should be removed entirely. Before washing, the floor should be swept thoroughly. Then it should be scrubbed with a floor machine that has a palmetto brush attached and with a neutral cleaner or mild soap. Stubborn spots can be cleaned with a #00 steel wool pad instead of the brush. (In no event should the floor be flooded.) The solution of dirt and water can be removed with a squeegee, or it can be picked up with a mop, pick-up pan, or wet vacuum. The washed area should be rinsed with clear water, using a clean mop, and the rinse water should be picked up as before.

When the floor is clean and dry, a thin coat of water-emulsion wax should be applied, either with a clean string mop or an applicator of lambs wool, using long, straight strokes without backtracking. When the wax has dried (drying time is usually ½ to 1 hour), a second, thin coat should be applied. When this coat dries, the floor should be buffed with a floor machine that has a # 00 steel wool pad attached.

The Asphalt and Vinyl Asbestos Tile Institute warns that waxes or cleaners containing gasoline, naphtha, turpentine, or mineral solvents should never be used on asphalt tile, since they soften the tile and cause the colors to bleed. The Institute also cautions against the use of varnish, lacquer, or shellac finishes for asphalt tile.[8]

If tiles are damaged and must be replaced, the old tile can be removed by one of two approved procedures: by applying heat to the top of a damaged tile (usually by means of a blowtorch, provided the operator protects the surrounding tile from the heat), a procedure which causes the cement under the tile to melt; or by freezing the tile with dry ice, a procedure which causes the cement to break and release the tile.

In addition to the blowtorch, there are two other acceptable methods of applying heat: placing a layer of paper over the damaged tile and moving a hot electric iron back and forth across it for a minute or two; or placing a flat-bottom pan containing boiling water on the tile for 3 or 4 minutes. Either of these procedures will usually melt the cement so that a rubber suction cup on a handle ("plumber's friend") will lift the tile from its position. (The cup will have more pull if its edges are wet.)

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[8] Asphalt and Vinyl Asbestos Tile Institute. *Maintenance of Vinyl Asbestos Tile and Asphalt Tile Floors.* New York: The Institute. 1960. p. 3.

A convenient freezing procedure is to construct a wooden frame the size of the tile or tiles to be removed (but not larger than 27 inches square). This frame should have a depth of 3 or 4 inches and should have no top or bottom. The frame should be placed over the damaged tile, a piece of dry ice cut, and, with tongs of some kind, the ice placed in the frame over the tile, covering the top with an insulating material to concentrate the coldness on the tile itself. Within 5 to 10 minutes the cement will have frozen sufficiently to break its bond, and the tile can then be chipped off with a chisel.

If it is evident that there is enough old cement to hold a new tile, carefully place the new tile in position and press down. If not, then scrape the old cement away, trowel down a small quantity of new cement (using a notched trowel), place the new tile in position, and press down on it.

CORK

Cork floor covering, available in either prefinished or unfinished tile or sheet form, is made of ground cork bark that has been molded and compressed under heat and hydraulic pressure; it is bound together by the cork's natural resins or by added resins. Cork is durable, and will not dust, crumble, splinter, or rot. Because of its softness, however, its use in school buildings is usually limited to auditoriums, libraries, music rooms, broadcasting studios, and other places where acoustical treatment for floors is desirable.

The initial setting period for new cork floor installations is 4 to 7 days, after which unfinished cork should be given two coats of approved penetrating varnish sealer; each coat should be buffed with a fine-grade steel wool pad.[9] Unless recommended by the flooring manufacturer, a sealer should never be applied to finished cork flooring. Both unfinished cork (after being sealed) and finished cork flooring should be given two thin coats of water-emulsion wax. When the second coat is nearly dry (tacky), the floor should be polished with a polishing machine, a weighted brush, or a clean, soft cloth.

When unfinished cork becomes worn or porous, a smooth surface can be restored by sanding with sandpaper of a very fine grade and by then polishing with a # 00 steel wool pad.

Grease, oil, solvents, gasoline, naphtha, turpentine, or strong alkaline cleaners should never be used to clean either finished or unfinished cork. Instead, a mild, neutral soap, with clean, soft water, should be applied and allowed to stand on the floor only long enough to

[9] Robert P. Darlington and Orville G. Lee. *School Floors* (Bulletin 240) Pullman, Washington: Washington State Institute of Technology, 1957. p. 20.

remove wax (if this is desired) or dirt. Flooding with water should be avoided.

Stains and spots too stubborn to respond to washing can sometimes be removed by rubbing them with a cloth dampened with acetone (flammable), or with carbon tetrachloride (fumes dangerous to health). If this procedure is unproductive, affected areas can be rubbed with a fine emery paper or with a #00 steel wool pad.

Cork tile severely damaged by indentations made by heavy objects or damaged by other causes can be removed by applying either heat or cold, as previously described.

LINOLEUM

Linoleum is composed of oxidized linseed oil or combinations of drying oils, fine ground cork, wood flour, mineral fillers, resinous binders, and color pigments in a wide range of colors; these materials are bonded, under heat and pressure, to burlap, felt, jute, or other backing. The usual title size is 9″ × 9″; rolls are 6 feet wide; linoleum thickness is $\frac{5}{64}$″, $\frac{3}{32}$″, and $\frac{1}{8}$″.

There are two types of linoleum—inlaid and printed. There are variations in quality within each type, although inlaid is usually superior. Printed linoleum has a color pattern that is merely printed on the surface and has a backing of asphalt-saturated paper felt that has been sealed and smoothed with several coats of pigmented paint-type sealer.

In most floor areas of schools, linoleum is durable and long-lasting if properly maintained, but it is not recommended for use on concrete subfloors or below-grade floors.

Linoleum can be maintained in the same way as asphalt tile. The protective coating required depends on its age and condition. If the floor is new, a phenolic resin dressing is the most satisfactory kind of protection. Conventional wax finish gives satisfactory results, except for the hazard of slipperiness and the soft finish. If linoleum, through neglect or misuse, has become porous, dried out, and brittle, the application of two coats of a penetrating type of seal with an applicator of lambs wool, allowing each coat to dry overnight, is recommended.

Another recommended procedure for treating and restoring lifeless linoleum is to give it a coat of warm, boiled linseed oil, rubbing the oil in well with an applicator of lambs wool. Excess oil should be wiped from the floor after 2 or 3 hours. Further use of the floor should be postponed until it is thoroughly dry. Although it leaves light-colored linoleum somewhat darker, this treatment should prevent further warping and cracking.

Dampness sometimes causes linoleum to curl up at its edges, a condition that can be corrected by drying the subfloor, applying linoleum cement along affected edges, and then pressing the edges down with weights. If curling extends for some distance, a straight, smooth board (with weights, if necessary) can be used to hold the linoleum down until the cement has set.

Small holes in linoleum can be repaired by filling them with plastic wood or sealing wax. If the pieces detached from the hole are available, large holes can be repaired by coating one side of a strong cloth or piece of canvas that is slightly larger than the hole with linoleum cement. A light coat of cement should then be applied to the bare floor underneath the linoleum; the cloth should be inserted (cement-covered side up) in the hole and under the edges of the linoleum. The cloth should be spread taut so that there are no wrinkles in it. Then the detached piece of linoleum should be placed on the cloth so as to match the contours of the hole, and a weight should be put on it. If the detached piece of linoleum is not available, the edges of the hole should be straightened by cutting it into a square or rectangle. A piece of linoleum that is as nearly like the damaged flooring as possible should be selected and a piece that is the exact size and shape of the hole should be cut from it. With the same procedure as with a detached section, the new material should be inserted and weighted down.

Faded linoleum can often be restored by scrubbing it with coarse steel wool, cutting off the faded pigments from its surface. Its sheen can be partially restored by waxing.

MASTIC

Mastic is similar in composition to asphalt tile, but is heated on the job and troweled in place, usually over old, worn, or cracked concrete in locations not exposed to extremes in temperature, to form a seamless, long-wearing, resilient surface. It has the appearance of an asphalt highway surface.

RUBBER

Available in tile or sheets, rubber flooring varies widely in form and properties. It is composed of a mixture of rubber (natural, synthetic, and/or reclaimed) and color pigments, heated and rolled out in strips under pressure. These strips are then cut to size. Rubber flooring has a dense, smooth surface; resists stains, abrasions, acids, and mild alkalies; is quiet, durable, and nonslip; and is highly resilient.

Correct maintenance of rubber flooring is a vital requirement if it is to give the type of service expected of quality material. The Rubber and Vinyl Flooring Council of the Rubber Manufacturers Association, Inc., gives detailed recommendations, based on years of study and experience by member firms, concerning installation and care of rubber and vinyl flooring. Many of these recommendations are presented here.[10]

The association emphasizes that paint, varnish, lacquer, or shellac should never be applied to rubber or solid vinyl floors, and warns against cleaning them with oils, grease, sweeping compounds containing oil, treated mops, and against removing spots from rubber floors with solvents, such as gasoline, kerosene, or naphtha.

While rubber flooring is highly resilient, it is nevertheless susceptible to indentation by constant pressure from furniture or other heavy objects. To prevent this damage, the following precautions are recommended:

- Provide glass, nonstaining rubber, or nonstaining plastic cups with flat undersurfaces not less than 2 inches in width, for legs of heavy furniture, such as desks, tables, chests, pianos, stoves, and refrigerators.
- Equip swivel type office chairs and other "rolling equipment" with broad-surfaced, nonstaining casters at least 2 inches in diameter.
- Remove all diameter buttons from legs of straight chairs and replace with nonstaining metal or plastic glides with flat bearing surfaces not less than one inch wide.
- Place nonstaining rubber or plastic cups on legs of chrome furniture.

After installing rubber or solid vinyl floors, a waiting period of several days (not less than 48 hours) should be allowed before cleaning them. During this time, the floors should be protected against construction traffic with overlays of heavy paper. Both the waiting period and the protection afforded by the paper provide favorable conditions for the flooring material to bond firmly. These floors should then be prepared for wax or polish as follows:

- Sweep or brush loose dirt from the floors.
- Dip and wring out mop in a pail of correctly-mixed cleaning solution* and mop floor.
- Rinse mop in second pail of clear, cool, or lukewarm water and wipe floor free of cleaning solution.

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[10] Rubber and Vinyl Flooring Council of the Rubber Manufacturers Association, Inc. *Approved Maintenance Methods for Rubber and Vinyl Floors.* New York: The Council (The Council's recommendations are used here by permission.)

*The Rubber and Vinyl Flooring Council of the Rubber Manufacturers Association, Inc., publishes a list of manufacturers whose products are approved as being free from substances harmful to rubber and solid vinyl flooring. This list is available at association headquarters, 444 Madison Avenue, New York, N.Y.

- After floor has dried, buff thoroughly, then inspect to make certain all marks have been removed.
- Floor is now ready for polish.

Polish can be applied efficiently and effectively by using the following procedures:

- Pour polish into shallow receptacle.
- Dip applicator (usually made of lambs wool, soft absorbent cloth, or felt and often furnished by the polish manufacturer) into polish and apply a thin coat (to avoid streaking) over a small area with a wiping motion. (Do not rub!)
- Continue until floor is covered.
- When floor has dried hard (about 30 minutes), buff by hand or by machine, but avoid any harsh buffing that might roughen the floor.
- For new floors, apply a second, thin coat immediately, then buff again.
- If polish wears off in certain sections of the floor, these areas can be cleaned and repolished without doing the entire floor.

Once rubber and vinyl floors have been cleaned and polished, as described in the foregoing paragraphs, maintenance consists chiefly of the following procedures:

- Frequent buffing to keep them in good condition and to reduce the number of washings and waxings that might be required. (Avoid harsh buffing.)
- Removal of loose dirt with a push broom, or clean, dry mop, then cleaning of floor with a mop dampened in clear, cold water. (This prevents damage to the polish.)
- If the floor is not clean at this point, use of a cleaner (with minimum concentration to prevent removal of wax), applied as previously described.

VINYL

Vinyl flooring is usually one of three types: "vinyl asbestos," a tile comparable to asphalt tile, except that it contains asbestos instead of asphalt, has vinyl resin binders, and is somewhat more flexible, resilient, and stain-resistant than asphalt tile; "homogeneous flexible" tile, which is comparable to rubber tile, but is usually laminated to a backing of cork or coarser vinyl; and "calendered," which is comparable to inlaid linoleum, except that a vinyl resin and plasticizer replaces the oxidized drying oils of linoleum. ("Conductive" vinyl is another type, but is used mostly in hospitals and other places where static electricity may be a hazard.)

In general, maintenance procedures for the three types of vinyl are the same as for rubber floors, except that in buffing, a stiffer brush, such as a tampico, can be used on vinyl floors without danger of roughening thin surfaces. The same precautions taken to protect rubber floors (see p. 94), such as choice of materials for casters, cups, glides, should be taken for vinyl. Checks should be made with their manufacturers to determine their nonstaining qualities when used on vinyl floors.

When repairs are required for sheet vinyl, these can be made in the same way as with linoleum (see p. 92), except that the oil treatment should not be used. Small holes and cracks in vinyl tile can be repaired by scraping a spare piece of tile with a scraper, knife, or piece of glass to obtain fine powder or shavings. These scrapings should be mixed thoroughly with a small amount of methyl ethyl ketone to form a putty. (If this solvent is not available, acetone can be used, although it is not as efficient as ketone. Special care must be taken with acetone, because it is flammable.) A small amount of clear lacquer or clear nail polish should be added to, and mixed well with, the putty. Before filling the hole or crack with this mixture, frame it with cellophane tape to prevent the mixture from spreading to surrounding portions of the tile. Apply the putty with a clean putty knife and allow it to set for a few minutes. Remove the tape and buff the repaired spot with steel wool or a fine-grade sandpaper.[11]

EPOXY RESIN

A resilient flooring material has recently been released for school use; it consists of an epoxy resin and a silica fill, reinforced with fiber glass. Claims made by its producer, based on experience with the material in a few schools in Ohio, indicate that it is permanently resilient; recovers from all indentations, even those from stiletto heels; will not pit, blister, or crack; is highly resistant to acids, ink, grease stains, detergents, animal stains, and alcohol; does not absorb moisture or dirt; is color-stable (nine natural slate colors); and is produced in five patterns simulating brick and slate arrangements. The manufacturer claims that the only maintenance required for this material is cleaning by sweeping and mopping.[12]

Tile Floors

Ceramic and quarry tile for floor installations are products of clay, water, and heat. Ceramic tile consists of a mixture of clay (basically aluminum silicate) and water, shaped and then fired in a kiln at high temperature. This tile is produced in a variety of types and colors, achieved through different coloring processes, methods of firing, and manufacturing techniques. Its surface may be either glazed (twice

[11] Floor Repair. *Building Maintenance and Modernization.* 10: 16–17, 50–51, February 1963. Milwaukee: Trade Press Publishing Co.
[12] Interview on February 20, 1963, with distributor.

burned) or unglazed. The glazed variety has a nonvitreous body, usually white, to the face of which a vitreous glaze of the desired color is fused. Unglazed tile has a dense, vitreous body with such characteristics as color and texture, distributed uniformly throughout the body. It is available as a porcelain type (with a fine-grain surface) or as a natural clay type (with a rugged surface comparable to quarry tile). Both glazed and unglazed tile can be used for floors, but the glazed variety has limitations in practical usage.

Quarry tile is composed of a mixture of graded shale clay and water; is produced by kiln firing in a variety of sizes; and is limited in color to red, brown, or fire-flashed. It is available in a nonslip abrasive surface tile commonly used in entranceways, corridors, lobbies, kitchens, dining areas, storage rooms, laboratories, toilet rooms, shower and locker rooms, and other building areas where washing and scrubbing must be done frequently.

Both ceramic and quarry tile are waterproof, fireproof, and stainproof; resist scratching, grease, dirt, and acids; will not indent; and are fadeproof. These characteristics make them practically maintenance-free. Simple cleaning is usually all that is necessary. Dusting is done with a mop or hairbrush. If a more thorough cleaning is required, washing can be done with warm, soft water and ordinary soap or detergents. Either a cotton mop or a scrubbing machine can be used to loosen particles of dirt adhering to the surface. Immediately following the scrubbing, the floor should be rinsed with clean water and either mopped or vacuumed until dry. Although tile surfaces resist the caustic effects of acid and ordinary cleaning compounds, the grouting between the tiles does not; for this reason, caustic or acid solutions should not be used in cleaning them.

Some people use sealers and waxes on tile floors, but the Tile Council of America considers this practice a waste of labor and materials, even though in some instances waxes may improve the general appearance of these floors.

If dust becomes a problem (and this would be due to deposit, not to the floor itself), sealing and waxing will not solve the difficulty, because the dust will simply settle on top of the wax. If the cause cannot be corrected at its source, daily dusting with an antiseptic dust-control compound will relieve, but not solve, the condition. In serious cases, daily scrubbing or wet mopping may be required.

Marble Floors

Marble flooring is made from quarried stone sawed to the desired thickness and polished to a smooth surface on one side. It is available in 15 to 20 colors and patterns, and is marketed in 3 standard sizes (8" square 8"×12", and 12" square). It is practically maintenance-free, but certain precautions and procedures should be followed in cleaning marble floors, stair treads, and platforms.[13]

- Any marble subjected to abrasive wear should be mopped or scrubbed regularly in a manner that will not leave a slippery film.
- First, wet the floor with clean, clear hot water.
- Then sprinkle an abrasive cleaner sparingly on the floor or put two handfuls of the cleaner directly into the pail of hot water before wetting the floor with it.
- Scrub or mop, by hand or machine, using a little water.
- Rinse thoroughly with clean water and dry with a clean mop or squeegee. (A wet vacuum will also do this job, perhaps better than by hand.)
- Prevent metal parts of mop or mechanical equipment from injuring base and risers and see that base is wiped dry when floors are scrubbed.
- Dampened white pine sawdust can be used satisfactorily as a sweeping compound.
- Sealers or preparations to bring up color may be especially desirable around urinals, water closets, and on standing marble, such as toilet partitions and entrances, but if sealers are applied, they should be of the type that will not yellow with age and must not increase the slip hazard. Soft waxes and resins that tend to pick up and hold dirt should never be used on marble.

Through neglect or accident, stains may develop on marble floors. MIA classifies all stains on marble under three categories: those of organic origin, those of metallic origin, and those caused by grease, oil, and similar substances. The Institute recommends a specific remedy for each type of stain.[14]

Organic Origin

Stains from lumber, wood, leaves, bark, tobacco, and bird droppings can be removed by applying hydrogen peroxide, either as a wash or as a poultice with whiting, or on white blotting paper. If hydrogen peroxide is used as a poultice, add household ammonia to start the action.

Urinal stains can be prevented by scattering an abrasive cleaner around urinals and water closets, leaving it there overnight. If this is not done and a stain appears, use the poultice method, possibly adding a bleaching agent.

Iodine stains will disappear of their own accord, but if their removal is urgent, apply a poultice of alcohol and whiting.

Metallic Origin

Stains from iron and steel have the appearance of rust, and may come from any point where iron and steel are present. The remedy is to either remove the source of the stain or protectively paint the metallic object to prevent

[13] Marble Institute of America (MIA), Inc. *The Cleaning and Maintenance of Marble.* Mt. Vernon, N.Y.: The Institute. 1958. p. 5. (Procedures and recommendations of the Institute are used here by permission.)
[14] Ibid., p. 10–11.

oxidation. Fresh metallic stains on a smooth surface can sometimes be removed by vigorous rubbing. If this fails, the rust can be converted to a soluble colorless compound by applying sodium hydrosulphite to the stain, dampening and leaving it in place not more than one-half hour. Immediately following, apply a solution of sodium citrate, and repeat if necessary. (Note: This procedure may cause a slight etching of the marble.)

Copper and bronze stains are usually greenish or muddy brown in color. They can be prevented at points where copper or bronze is in close proximity to marble by painting the back of plaques and plates—before installation—with non-staining, quick drying paint. Their exposed surfaces should be kept waxed, or coated with lacquer, to prevent discoloration of adjacent marble. If these precautions are not observed and stains develop, mix in dry form one part of ammonium chloride (sal ammoniac) and four parts of whiting or powdered chalk, add ammonia water and stir until a thick paste is obtained. Spread this mixture as a poultice over an area somewhat larger than the actual stain (to prevent spread of stain) and let dry. Remove the poultice with a wooden paddle, rinse thoroughly, and repeat if the stain persists.

Lead stains are bright yellow or orange in color, and will disapear if their source is removed (or protected against contact with marble).

Ink stains can be removed by first wiping off all surface ink, then covering the spot with a blotter soaked with alcohol, followed by another blotter soaked with ammonia. Any remaining stain can be removed with a bleaching power. (Some inks are metallic in nature and stains caused by them must be removed by reducing agents, as in the case of iron stains.)

Grease and Oil

Stains from oil and grease are usually light brown or yellow, with a dark center, and can usually be removed by the proper use of a solvent, such as a mixture of acetone and amyl acetate in equal parts, applied by means of a clean cloth, white blotting paper, or used as a poultice by adding whiting. Cover a larger area than the stain and leave to dry, then rinse thoroughly, and repeat if necessary.

Paint should be removed from marble as soon as possible, using a razor blade or a knife edge, protecting lower or adjacent marble surfaces from run-off. Any stain caused by paint can be removed by either of two methods: apply benzol as a one-half inch thick whiting poultice to an area larger than the stain itself. When dry, remove the poultice and bleach away any remaining stain. Rinse and repeat the procedure if necessary, or apply varnish or paint remover (liquid or paste) over the stained area, then remove and scrub with a fiber brush. Bleach any remaining color and use oil solvent to remove any remaining stain.

Perspiration stains should clear up with the use of an oil solvent, followed, if necessary, with a bleach.

Linseed oil stains, often the result of unwise use of oil paint or putty in conjunction with marble, are difficult to remove after they have become oxidized, but the use of an oil solvent, followed, if necessary, with a bleach, is sometimes effective.

Additional precautions and recommendations include the following:[15]

> Injury to marble may result from the injudicious use of harsh grits, or from such salts as sodium carbonate, sodium bicarbonate, and trisodium phosphate, which cause a physical damage by crystallizing in the pores. Experiments indicate that these salts can be used without damage if the marble surface is rinsed with clean water before applying them.
>
> The usual type of grit in trade cleaning preparations is not appreciably injurious to marble floors.
>
> As a rule, volcanic ash grit is less severe in its abrading action than crushed quartz, evidently because of the shape of the crystals.
>
> Available minerals that can be used as abrasives that are not injurious to marble are soapstone and talc. A mixture of 90 percent powdered soapstone and 10 percent soap powder seems to be as effective in cleaning marble floors as any trade preparation.
>
> Soap used with soft water will give satisfactory results in removing surface dirts from marble.
>
> Preparations containing a coloring ingredient different from the color of marble may gradually impart their color to the marble, but this discoloration can be prevented by pre-rinsing the marble.
>
> A limited number of tests indicate that ammonia water may cause yellow discolorations if used consistently.
>
> Acids dissolve marble; even those as weak as oxalic acid may prove injurious.

Carpeting

In recent years, carpets, once considered a luxury in school buildings, have been promoted as a basic floor covering for almost all school areas, including classrooms and corridors.[16] Carpeting not only insulates, but also gives acoustical treatment to, floors by catching sound where much of it occurs—on the floor. Tests have shown that carpeting is an effective acoustical material, capable of significant absorption of airborne sound; and it reduces impact noises considerably.[17]

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[15] R. E. Tilt. Floor Maintenance—Wood, Asphalt, Tile, Other Types. *1952 Proceedings*. Association of School Business Officials. Evanston, Ill.: The Association, 1952. p. 153–165.

[16] Carpeting in the Specs. *Progressive Architecture*, Oct. 1962. Split-Level Classrooms for Beginners. *Nation's Schools*. June, 1957.

[17] Cyril M. Harris. Acoustical Properties of Carpet. *The Journal of Acoustical Society of America*, Vol. XXVII, No. 6, Nov. 1955.

Two types of carpeting material—wool and a type of acrylic fiber—have been used in schools experimentally,* and seem to hold up well under experimental conditions. These materials in "contract" grades are recommended for school use by carpet manufacturers.

An evaluation of carpeted classrooms at the Peter Pan Primary School, Andrews, Tex., was made on the basis of actual expenses related to maintenance and upkeep for a period of 27 months. A significant conclusion drawn from this study is that floor-related costs are considerably less in carpeted than in noncarpeted rooms. This economy is attributed to the fewer man-hours, the decreased amounts of detergents, waxes, wax strippers, cleaners, abrasives, and steel wool pads, and the smaller capital investment in mechanical equipment that are required for carpeted floors.[18] Even though carpeting may have to be replaced every 10 years (the estimated life of good material in areas of normal traffic), its economically lower maintenance costs compensate for the higher initial cost before the end of the carpet's life.

In general, maintenance requirements for carpeted floors are daily vacuuming by machine, spot removal as needed, and a thorough cleaning once every 2 years.[19] One maintenance study showed that there is a saving of 47 percent in the average daily time required for cleaning 1,000 square feet of carpeted area in schools, as compared with an equal amount of space having a popular floor covering.[20] Spot removal, required only when stains and spots appear on carpets, is done by hand, using appropriate cleaners and solvents for the particular stain and for the fabric of the carpet. Biennial cleaning can be done with the rugs in place by using special cleaning solutions, a rotary scrubbing machine with appropriate attachments, and a wet pick-up vacuum. A more thorough job can be accomplished by removing the carpet material from the floors and contracting with a commercial rug cleaning establishment to dry-clean the material. This procedure costs more, but is superior, because the carpets are cleaned by machines especially designed to remove dirt embedded in their fibers, and unless wear is exceptionally severe, this procedure restores carpets to their original appearance.

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*Wool carpeting has been in use at the Peter Pan Primary School, Andrews Independent School District, Andrews, Tex., for about 5 years; acrylic fiber carpeting in the Shaker High School, Newtonville, N.Y., for more than 5 years.

[18] Frank Hyde (Director of School Properties, Andrews Independent School District, Andrews, Tex.). "An Evaluation of Experiences with Carpeted Classrooms" (Reproduced by the American Carpet Institute, Inc., New York 1, N.Y.).

[19] Carpeting in Schools: Case Study. *Contract.* Vol. 1, No. 3, Jan. 1961, p. 17–22.

[20] The American Carpet Institute, Inc. *News* (PE 6–2043). 350 Fifth Avenue, N.Y.: The Institute (Reporting on a maintenance study conducted under the supervision of Industrial Sanitation Counselors, a nationally-known maintenance firm.)

Interior Doors and Interior Window Elements

Maintenance procedures for exterior doors and windows were discussed in chapter III. This section deals with interior doors and interior elements of windows, such as hardware, shades and blinds, and glass replacement.

Doors

Interior doors develop many of the same maintenance problems as outside doors, and these require the same solutions. Additional emphasis is given in this section to the importance of door hardware, which, because of the safety factor, is one of the most important items in the maintenance schedule. Generally, maintenance procedures for interior door hardware are not difficult, and should not be deferred. In addition to the repair of specific difficulties described earlier, maintenance of interior door hardware should include:

- Checking and cleaning at regular intervals
- Tightening loose bolts, screws, or nuts
- Lubricating locks and latches with graphite (either stick or powder), using the lubricant sparingly
- Oiling hinges frequently, using caution to prevent oil from staining floors
- Replacing broken or lost screws, bolts, or nuts promptly
- Keeping hardware free from rust
- Inspecting door checks and closers frequently, oiling and adjusting when needed

Heat without proper humidification causes some doors to warp. This condition can often be corrected by demounting affected doors, placing straight 2″×4″ framing timbers on each side at right angles to the direction of the warp, then applying pressure for several hours with wood clamps.

Doors that stick or fit too snugly may have loose butts, or may have absorbed excess moisture. If loose butts are causing the difficulty, their screws should be tightened. (If the screw holes are too large to retain the screws, small wooden pegs should be inserted into the holes to give holding power or the screws should be replaced with larger ones.) If moisture has caused the problem and if the relative humidity of the locality is high, swollen doors can be demounted (after first locating binding points by sliding a piece of paper around the door's edge and its jamb when the door is in a closed position), and the points at which the door binds can be either sanded or planed down to fit the opening. Care should be exercised in planing or sanding veneer doors (whether hollow-core or solid) to prevent splintering of veneer edges.

Broken glass in vision strips or as inserts can be replaced by successively (1) removing the glazing bead (GB), which is normally used on interior doors instead of putty, (2) working the point of a wide wood chisel or the blade of a putty knife between the rabbet and the longest piece of beading, (3) springing the beading by twisting the chisel or putty knife, and (4) disengaging the beading at the corners. This procedure must be done with care to prevent damage to the bead strip. The remaining strips can be removed very easily. Any remaining glass fragments should be removed. The length and width of the rabbeted opening should be measured. Glass of appropriate type and thickness should be cut to fit the opening. The glass should be inserted. The beading should be replaced with screws or small brads, whichever were used originally. For safety reasons, standard practice allows the installation only of wired, laminated safety glass, or tempered glass in any part of the lower two-thirds of any door, or within 4½ feet of the floor of any corridor, partition wall, or landing.

Windows

Interior maintenance of windows, for purposes of this bulletin, is confined to three problems: preglazing preparations, warping and sticking, and repair or replacement of shades and blinds. Other types of window problems were discussed in connection with exterior maintenance.

Glass replacement for windows is, in many localities, an expensive, troublesome problem. In school systems where the size and type of windows are not standardized, the problem is compounded by variations in the size, kind, and thickness of window panes.

Efficiency and economy in glass replacement can be improved if certain preglazing procedures are followed. The maintenance department should have a flat-top table or workbench with calibrated guides along two edges, a metal straightedge of sufficient length to cross the largest piece of glass to be cut, and a glass cutting tool; these are the basic pieces of equipment needed for cutting glass.

Before the glass is cut, exact measurements must be known to prevent waste of time and glass. These measurements can be obtained by following standard procedures. Measuring will be simplified if the sash is removed from its frame and putty removed from the rabbet. (Measurement is more difficult if taken while the sash is hung, because dimensions should be taken from the puttied side of the sash, and for windows higher than the first floor, this procedure requires a window jack or a safety belt). Measurements can be taken from inside a hung window if it is of standard construction. This means that the flat, squared, inside edge of muntins matches the rabbeted outside edge. An exact measurement between the squared edges will be the same as that between the two rabbets on the outside. Any measuring tool of proper length can be used, but an extension rule which can be used to determine inside measurements is the most convenient and accurate.

After exact dimensions have been determined, the replacement pane can be cut from a sheet of glass placed on a clean flat surface. A straightedge must be held securely along the line where the glass is to be cut; at the same time, a glass cutter should be drawn once along the straightedge with sufficient pressure to score the glass. (Retracing the line will impair results.) The glass can then be broken along the scored line by placing the handle of the cutter under the line and gently pressing on the glass on each side of the line, or by gently tapping the glass on the underside along the line, then placing the scored line along the square edge of the table, pressing gently on the overhanging glass. (Only experience can help one judge the amount of pressure to apply when scoring or breaking glass.)

Wood sashes, like wood doors, occasionally warp. If the warp is not severe enough to cause glass breakage when pressure is applied to straighten the sash, correction can sometimes be made in the same way as with doors, that is, by applying timber plates on each side and using wood clamps to draw them together sufficiently to straighten the sash. It may be necessary to leave the clamps on for several days.

A minor but aggravating problem is the wood sash that sticks or does not slide freely in its channels. If neither swelling nor warping is responsible, the condition can usually be corrected by rubbing a bar of hand soap in the channels or by applying liquid wax to them. Sometimes windows stick after paint has been applied. This condition can be corrected by running a narrow-blade putty knife around the edges of the sash, letting the blade extend into the channels as far as possible. It may be necessary to repeat this procedure two or three times, while exerting some vertical pressure on the sash to break the paint seal.

Shades and Blinds

Shades and blinds, the two most popular types of window covering for schools, serve two major purposes—to control light and to decorate. Natural light, whether admitted through windows or skylights (top lighting), must be controlled to prevent glare or to provide darkened areas for the operation of audiovisual equipment.

Both shades and blinds serve these purposes and can be obtained in colors that match and accentuate room decor.

Good shades are usually made of 8- to 10-ounce, unfilled, vat-dyed cotton duck cloth or another strong, durable material, and are manufactured in three designs: single-roller, double-roller, and folded. In the roller type (single and double), cloth is attached to metal or wood rollers 1⅛ to 1¼ inch in diameter by means of a sleeve, groove, or staples. The single roller is mounted either at the top of a window so that the shade is pulled down, or at the bottom so that the shade is pulled up by means of a cord running through a lock pulley at the top. Double-roller shades are usually mounted at the center, where the two rails of a double-hung window meet, with the top shade a "pull-up" and the bottom a "pull-down."

The principal components of roller shades are rollers (metal or wood), with an internal mechanism consisting of springs, bearings, pawls, ratchets, spindles, bung and cap, and gudgeon; slats (to give rigidity to the "pull" end of the cloth where the cord is fastened); mounting brackets and screws; cloth; and cord. Roller shades designed for darkening purposes usually have top, bottom, and side channels of metal to prevent infiltration of light.

Folding shades, the simplest of all window covers, are usually designed as portable "blackout" shades that can be moved from room to room, where they can be mounted or demounted (special brackets being permanently installed above the regular shades in these rooms) by using a special fork designed for that purpose.

Shade repair can be done satisfactorily, on a small scale, with a few simple tools, such as a cord clasper, a stapler and staples to fit (the stapler should have a curved foot to fit over the roller), and a combination wrench (spring winder-roller). Replacement materials normally required are rollers, cloth of the proper width and length, staples (if the slotted type roller is not used), brackets, and screws.

One maintenance job that will almost double the life of a good shade that is faded at the bottom from continuous exposure to strong sunlight is to remove the cloth from the roller and remount it, with the faded end attached. Duck cloth of better quality can be renewed if it is removed from the rollers and dry-cleaned, then remounted. Heavily damaged, rotten, and unsightly shade cloth should be replaced.

A top-mounted roller can be removed from its brackets by turning the notch in the spring assembly downward in the slot of the bracket to prevent the pawl from locking the spring tension. The combination roller-spring wrench should then be inserted between the roller and bracket to hold the spring tension while the roller is lifted from the slot. The roller should be turned a half-turn, and the pawl allowed

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to fall into the notch; the shade can then be pulled out of the pin bracket at the other end.

A bottom-mounted roller or the bottom roller of a double-mounted shade can be removed from its brackets by pulling the shade down one complete turn and easing it up again until the pawl slips into the notch, maintaining the tension of the spring. The roller can then be removed by lifting it out of the slotted bracket and pulling it out of the pin bracket. Care must be taken to see that pawls are engaged in the notches to prevent the spring from unwinding in a "runaway" fashion.

Venetian blinds afford greater flexibility in controlling light than shades do, and hence have had wide acceptance for school use, despite claims by some users that they soil easily and are difficult to maintain. Obtainable in a variety of colors and finishes, these blinds can complement almost any decorative scheme. When specifically designed both for controlling light intensity and glare and for providing dark rooms, venetian blinds serve both purposes well.

For practical reasons, most venetian blinds are designed for horizontal installation, but a few manufacturers produce one type for horizontal and another for vertical installation. In horizontal installations, the slats, or louvers, are aligned parallel with the head plate and stool of the window, and are operated by two sets of cords (or chains) located on each side of the window. In vertical installations, the slats (or louvers) are perpendicular to the window's head plate and stool, and may have either a top channel or both a top and a bottom channel, at the user's option. Vertical installations have a traversing mechanism that permits stacking of louvers at the right or left side, or half at each side, while the louvers are in either an open or semi-open position. Controls generally consist of two bead chains, both on one side or one on each side of the window, for traversing and rotating the louvers in unison. The drive mechanism and carriers are housed in a metal channel mounted on brackets at the top of the window. The lower ends of the louvers have metal stiffeners connected by continuous bead chains extending to magnetic fastenings at the sides or center of the opening.

The principal components of venetian blinds are slats (louvers), tape, lift and tilt cords, cross ladder, installation brackets and screws, bottom rail with end caps, and top rail (a metal channel or box that conceals the operating mechanism, which consists of a tilter, tilt rod and supports, cord lock, tape rolls, and pulleys).

In general, venetian blinds develop four recurring maintenance problems: worn or broken lift cords or tilt cords, damaged slats (louvers), and deteriorated tape and ladder strips. Procedures for replacing each of these items are outlined here.

Replacement of a lift cord is an operation requiring a pair of diagonal cutters and a cord string at least as long as the old cord. The blind does not have to be demounted. Instead, one can lift the side of the blind on which the damaged cord is located, facing it while cutting the knot from the old cord with the cutters. The cord should be pulled through the bottom rail to a distance of about 12 inches, and its end frayed out for 2 inches. The frayed end of the old cord should be held in one hand, and one end of the new cord inserted into the center of the frayed end to a solid part of the old cord. The new cord should be covered with the strings of the old cord smoothly and evenly, and the joint then wrapped securely and evenly. The knot on the right side of the bottom rail should be grasped, and the old cord pulled slowly and steadily through the bottom rail until the new cord has replaced the old. The loop length in the new cord should be the same as in the old. A single knot should be tied in the new cord on the right side of the blind, and the knot pulled into the recess of the bottom rail. The loop and slack in the new cord should be adjusted at about ⅔ the height of the blind. The cord on the other side of the blind should be cut off, a knot tied in it, and this knot pushed into the recess of the bottom rail.

Replacement of a tilt cord requires the same tools and materials as replacement of a lift cord, but if the blind is not to be demounted, a stepladder, a scaffold, or a sturdy table will be needed in order to reach the top of the window. With the stepladder or scaffold set firmly and securely, the panel should be removed from the top channel to expose the tilt rail. This is usually done by tilting the endpieces outward from the top channel. Once the tilt rail is exposed, the old cord should be removed from the guides, and a new cord threaded through them and over the friction wheel located on the tilting device. The end of the new cord should be pulled down to ⅔ the length of the blind and should be cut with the diagonal pliers. The cord and tilting device should be adjusted so that the ends of the cord are even and the slats parallel. Decorative knobs and the front panel should then be replaced.

No special tools are required to replace a venetian blind slat. The procedure for this operation is to loosen the fastening device for the lift cord on both sides of the bottom rail, and then to pull up lift cords on both sides to the first slat above the broken one. The broken or damaged slat should be pulled out from the tape and cross ladders at both ends, and replaced with a new one. The lift cords on both sides should be threaded down through the slats, between the two rows of cross tabs or ladders on the tapes, and through the holes in the bottom rail. New knots should be tied in the lift cords. The covering for the bottom rail should then be attached.

The replacement of tape in a venetian blind is a difficult operation, and normally requires demounting the blind and attaching it to a work frame while repairs are being made. The standard procedure for tape replacement is to disassemble the blind from bottom to headbox without interfering with its operating mechanism. (If the tilt and lift cords are worn, it is good practice to replace them at this time.)

The old tape should first be detached from both sides of the bottom rail. (Tapes are attached to the bottom rail with clamps, screws, or slide-in tape anchors.) Then the knot in the lift cord should be untied and the cord drawn though the bottom rail and slat notches, freeing the cord from the spindle. The slats should then be lifted out one by one, from bottom to top. If the slats have any special notching, as some do, they should be stacked so that all like notches are similarly placed in the stack. (This avoids confusion when the blind is reassembled.) The old tape should then be detached from its drum inside the headrail or headbox. New tape should be cut from desired material of proper width and to the exact length of the old tape (there are several types of suitable material); there should be one cross ladder for each slat. The new tape should then be attached to the teeth in the stapled loops or to the prongs in the tape roll (or drum), whichever device the tape roll is equipped with. The ladders in the new tape should be in horizontal alignment, and the slats inserted in the ladders, starting at the top. The lift cords should then be threaded through the slats, the tapes attached to the bottom rail, and the loops in the lift and tilt cords adjusted. The lift cords should be threaded through the holes in the bottom rail, their ends knotted, and the knots drawn back into the recessed holes. The covering and end plates for the bottom rail should then be attached, and the blind remounted.

Built-in Equipment

The great variety of built-in equipment in schools precludes any attempt to review in this bulletin maintenance procedures for all types. Furthermore, some of this equipment is of such a nature that it can be maintained only by personnel especially trained for that work or that it must be serviced by factory-authorized dealers and service personnel. For these and other reasons, only a limited number of problems relating to four types of equipment—lockers, stage equipment, bleachers, and auditorium seats—are presented here.

Lockers

Metal lockers are often subjected to abuse that causes excessive damage to doors, hinges, and other components. Two of the most troublesome, yet often neglected, problems are bent doors and damaged or broken hinges—items that, if neglected, can cause further damage or cause affected lockers to become useless.

Bent doors that are not too seriously damaged can be straightened, usually without difficulty, if the proper tools and materials are available: a wooden (or hard rubber) mallet, a ball pien hammer, a heavy plate of iron or steel, a wrench, screwdriver, clamps, a portable electric drill (or hand drill), stove bolts, and a wooden frame as large as the locker door.

First, all screws or bolts which hold the door to the locker must be removed. Then the door should be placed on a hardwood frame with clamps for squaring and leveling, and should be fastened on it. The iron or steel plate should be inserted under the bent portion of the door, the irregularity smoothed out by tapping it gently with a mallet, being careful not to crease the metal. The door should be replaced on the locker and refastened with the screws or bolts.

Bent or broken locker hinges prevent doors from working properly, cause an unsightly appearance, and sometimes create a safety hazard. Damaged hinges can be replaced, usually with nominal effort, when new hinges, rivets, locker bolts, and nuts, together with a socket wrench, pliers, cold chisel, ball pien and sledgehammers, and a punch, are available.

All bolts should be unscrewed from the locker door with a socket wrench, and the door removed from its hinges. The rivet heads should be cut off from the damaged hinges with a cold chisel and hammer. Segments of old rivets should be driven out with a hammer and punch. With bolts of proper size, new hinges should be fastened to the door frame, and rivets inserted through the hinge and frame, using the sledgehammer against the head of rivets and pien overhead with the light ball pien hammer until tight. Then the screws used for holding the hinge in place should be removed. Insert other rivets and pien over.

Stage Equipment

Stage equipment for the average school consists of the front-curtain valance and track system, the cyclorama setting, two side curtains, and necessary borders and headers. There is also a need for an exterior drop in back of the cyclorama curtain at about 3 feet from the wall.

Flameproof or fireproof curtains, draperies, and furnishings are essential in the school auditorium. One of the major maintenance operations for stage equipment of this type is the periodic demounting of draperies and curtains for dry-cleaning and the subsequent treatment of the material to make it flameproof. Demounting and remounting curtains and drapes is generally done by maintenance personnel, whereas, dry-cleaning and flameproofing are usually done by commercial firms. (Many concerns specialize in flameproofing theatre and school scenery, draperies, and other fabrics. It is advisable to deal only with concerns of known reliability, or if dealing with an unknown firm, to have fabrics tested for adequacy of treatment.) However, satisfactory treatment at less cost can be given by the school's maintenance personnel if proper procedures are followed.

Flameproofing chemicals may be applied to fabric by spraying, by brushing, or by immersing, but whatever the method, the object is to deposit in the fabric uniformly the desired amount of flameproofing chemicals, measured in terms of percentage increase in weight of the fabric after treatment and drying.[21] Effective treatment of fabric can be given, without professional assistance, by using nonproprietary solutions of flameproofing chemicals in clear water. (Stirring these chemicals in warm water will cause them to dissolve more quickly.) One of many formulas for a flameproofing mixture is:[22]

Diammonium phosphate $(NH_4)_2HPO_4$—7.5 parts, 7½ pounds
Ammonium chloride NH_4Cl—5 parts, 5 pounds
Ammonium sulphate $(NH_4)_2SO_4$—100 parts, 12 gallons

This treatment is effective in weightings of 10 to 18 percent, depending on the type of fabric to which it is applied. Wringing this solution from the fabric by hand leaves a weighting of about 16 to 18 percent.

If the immersion method is used, the container holding the solution should be large enough to permit all the fabric to be thoroughly wetted at room temperature, with no folds or strands being left unpenetrated. Care must be exercised in wringing the fabric. If a mechanical wringer is used, more of the solution is likely to be extracted, making it necessary to prepare a more concentrated solution to obtain the desired weighting. Best results will be obtained if the fabric can be dried, after wringing, in a horizontal position, since

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[21] National Fire Protection Association. *National Fire Codes* (vol. III). *Building Construction and Equipment*. Boston: The Association, 1962–63. p. 701–16.
[22] Ibid., p. 701–18.

placing it in a vertical position allows a certain amount of drainage of the solution, depending on the wetness of the wrung article.

Where solutions are applied by brushing or spraying, repeated application may be necessary to secure uniform impregnation and the desired weighting.

For a more detailed discussion of the techniques of treatment and testing of flameproofed fabrics, the reader is referred to:

National Fire Protection Association, *Handbook of Fire Protection* (10th ed., 1948), Ch. 31 Flameproofing and Preservative Treatments

National Bureau of Standards. *Flameproofing Textiles* (Circular C 455), 1946.

British Department of Scientific and Industrial Research. *Report of Fabric Coordinating Research Committee.* (Reviewed in *NFPA Quarterly*. Vol. 24, No. 2, p. 184.)

Robert W. Little. *Flameproofing Textile Fabrics.* New York: Reinhold Publishing Company, 1947.

There are other maintenance jobs associated with such stage equipment as automatic controls (timers, motors, relays, and other electronic devices), portable control consoles, and public address systems, but these jobs must usually be performed by technically trained people. Maintenance of stage hardware and other mechanical devices, such as headlocks, rope blocks, cams, pulleys, locking devices, cables, ropes, bearings, tracks, weights, and counterbalances is more a matter of periodic inspection than of specific repair and replacement.

Bleachers

Gymnasium seating is usually in the form of bleachers, either of the fixed and rigid type or the operable type. Fixed bleachers require little maintenance except periodic refinishing of exposed surfaces and occasional replacement of a broken board, brace, seat piece, or other element. Operable bleachers are usually designated as "folding," "telescopic," or "roll-out," depending on their mechanical design. Operable bleachers are operated either manually or by power; have a number of moving parts (paralleling devices, casters or wheels, glides, and automatic closure panels); utilize some hardware (locking devices, pulls, latches, and control bars); and, depending on the nature of installation, may have guardrails and end panels. Power-operated bleachers have control switches; are anchored either to the floor or to the wall; and require electric current for their operation. Manually operated bleachers may be either freestanding or anchored to the floor or wall.

While maintenance is not a major problem with operable bleacher installations, either school plant operating or maintenance personnel should annually inspect every element of them that contributes to the safety of spectators, evaluating the extent of wear or damage of any kind. Loose bolts, screws, nuts, and other fasteners should be tightened or new ones installed. All braces and locking devices designed to insure bleacher stability while loaded should be tested for performance. Most of these procedures can be performed by anyone familiar with bleacher operation, and if replacement parts are needed, these can be installed by removing broken or damaged parts while noting the exact manner in which they are attached so that new parts can be similarly attached. If defects are found in the control switches, motors, or wiring, repairs to these should be made only by a licensed electrician who has a knowledge of applicable local electrical codes.

Auditorium Seats

Manufacturers offer auditorium seats in a variety of styles, materials, and finishes, but those most frequently installed in school auditoriums are rugged in design and construction, having curved plywood about ½ inch thick for backboards and seat boards. (Some manufacturers place metal bands around these boards to prevent separation of plywood veneer from its core.) Backboards are mounted on open or closed steel or cast iron standards. Seats are mounted on metal arms fastened to the standards with compensating, ball and socket, roller stop, manually operated hinges. Both back and seat boards are attached to metal by means of small carriage bolts, usually with square nuts. Standards are attached to wood floors with wood screws, to concrete floors with lag bolts and expansion shields.

Properly installed auditorium seats give little trouble for many years if not accidentally or maliciously damaged, but carriage bolts, floor screws, lag bolts and their shields sometimes loosen, either through use of the seats or through floor vibration, contraction, or expansion. If serious permanent damage to the seats is to be avoided, they should be inspected three or four times each year, and all loose nuts, screws, and bolts should be tightened. Occasionally, lag bolts work loose in their shields, damaging the shields so that they no longer have holding power. Such shields should be replaced. This can be accomplished by taking out all lag bolts (usually four to each center standard) and lifting the standard from the floor sufficiently to permit removal of the damaged shield and insertion of the new one. (If the damaged shield cannot be lifted out of its socket, an electric drill with a bit slightly smaller than the hole can be used to fragment the shield for easy removal.) If the hole in the concrete floor is enlarged in the process of removing the damaged shield, it may be necessary to insert a somewhat larger shield than the old one.

Fire Protection Equipment

Three types of fire protection equipment may be used in schools: detecting, warning, and extinguishing. These may be installed separately, or under some conditions as a completely coordinated system to detect, warn, and extinguish simultaneously in case of fire. Most detective-warning devices are electronic, or at least transmit electric impulses which activate bells, horns, or other warning sounds. Their maintenance and care should be assigned only to people who have complete knowledge of their components, how they operate, and any special engineering features about them.

This section is confined to a discussion of maintenance procedures[23] relating to fire extinguishing systems located within school buildings. These systems are classified as *portable* or *fixed*, with some of both classifications often found in a single building.

Portable Fire Extinguishers

Portable extinguishers are classified according to which of the six extinguishing agents they employ: carbon dioxide, dry chemical, foam, soda acid, vaporizing liquid, and water. When maintenance work of a periodic nature is done on any of these types, the kind of work done, the person doing it, and the date should be recorded on a card, and the card attached to the extinguisher.

Carbon Dioxide

Carbon-dioxide extinguishers should be examined several times each year for tampering, mechanical damage, or weight loss. If the charge in the cylinder is 10 percent less than normal (by weight), it must be recharged to normal. If extinguishers are found empty and show no signs of being physically discharged, they should be inspected for a ruptured safety disc, leaks in the packing, or deterioration of the cylinder.

A safety disc may be ruptured by excessive pressure caused by high ambient temperature, but whatever the cause, it must be replaced with a disc of correct size and material, as specified by the manufacturer

[23] All procedures reviewed here are adapted from *Handbook of Safety Codes*, official publication of the Fire Equipment Manufacturers' Association, Inc., Pittsburgh 22, Pa. (1959).

of the particular extinguisher. If there is a defective seal in the discharge device, the extinguisher must be discharged and the seal repaired; the extinguisher should be recharged and then tested for further leaks. Any extinguisher that has been used should be recharged immediately.

If an extinguisher has been in use for 5 years and needs to be recharged, it must be subjected to a hydrostatic pressure test to determine its fitness to take a recharge. This test is made by removing the discharge device or valve and applying hydrostatic pressure to the cylinder in a water jacket to determine the expansion of the cylinder. The test should include a visual internal and external examination. The pressure applied should be 1⅔ (5/3) the service pressure, and should be held for 30 seconds or as long as necessary for observation. Cylinders with any of the following defects should be condemned:

- **Loss of metal thickness by localized pitting or corrosion in areas of more than .005 square inch for a cold-drawn cylinder, or one-third of a square inch for the hot-forged cylinder**
- **Loose scaly material on the outside of the cylinder, easily broken away by hammering or jolting**
- **Foreign deposits or inclusions on the outside cylinder wall or bottom**
- **Pressure expansion in excess of 10 percent of the total expansion**

If the cylinder passes the test, the date of the test should be recorded under the date of the original test on the dome of the cylinder.

To discharge a cylinder before recharging it, the outlet should be equipped with a suitable device to prevent recoil of the unit. In recharging, the cylinder must be dry internally and free of rust or foreign matter. In reassembling the cylinder valve, torque should be applied, with as much force as is specified by the manufacturer. The carbon dioxide for recharging may be contained either in a cylinder or a liquefier, but in either case it must be in a liquid state and its temperature should be between 0° F. and 88° F. The extinguisher should be placed on a scale during the recharging operation, and the weight of the carbon dioxide entering it should be recorded. The total weight should not exceed the weight of the carbon dioxide charge permanently marked on the extinguisher.

After the cylinder is fully charged, it should be placed under water for visual evidence of leakage. If there is no leakage, the cylinder should be dried thoroughly before being remounted or stored.

Carbon dioxide extinguishers should not be located in places where the temperature exceeds 130° F., because this amount of heat may cause rupture of the safety disc from excess pressure. If the ambient temperature is expected to exceed 130° F., the extinguisher should be undercharged in accordance with the manufacturer's recommendations.

Dry Chemical

There are three types of dry-chemical extinguishers: cartridge-operated, pressure-operated, and wheeled.

The cartridge-operated dry-chemical extinguisher should be inspected at regular intervals (not exceeding 6 months) to determine that:

- **Seal wires have not been tampered with or severed.**
- **The orifice of the discharge nozzle is free of foreign matter.**
- **The extinguisher shows no evidence of damage or distortion to its shell.**

This type of extinguisher should be examined annually to determine if:

- **The weight of the carbon dioxide pressure cartridge meets the weight limits established by the manufacturer. If not, the cartridge should be recharged or replaced.**
- **The carbon dioxide gas and dry chemical passages are clear. Follow the manufacturer's instructions on this point.**
- **The dry chemical has free-flowing qualities, and has a weight that is neither above nor below that prescribed by the manufacturer.**
- **The mechanism of the nozzle and cartridge operate freely.**
- **The hose and sealing gaskets have not been damaged. Extinguishers or parts which are not in good condition should be replaced.**

The manufacturer's instructions on the name plate of the cartridge-operated dry chemical extinguisher should be carefully followed when recharging the extinguisher. It is also desirable to release the pressure after use to clear the hose of dry chemical and relieve the pressure. Any dry chemical remaining in the shell after the pressure has been released should be inspected, after which the extinguisher should be refilled to the rated capacity specified by the manufacturer; only the dry chemical furnished by the manufacturer should be used for refilling. Fully charged cartridges should be replaced in accordance with instructions furnished by the manufacturer.

Hand extinguishers of the pressure-operated dry-chemical type should be examined at least once every 6 months to see that the seal wires are in good condition and have not been tampered with, that the pressure meets the prescribed limits, that the orifice of the discharge nozzle is clear, that there is no evidence of mechanical damage or distortion, and that the unit has proper charge (determined by weighing the unit).

In recharging, the manufacturer's instructions should be followed carefully. After use, the pressure should be released to clear the hose and relieve pressure. Only dry chemicals furnished by the manufacturer should be used, and pressurizing should be done only as specified.

The wheeled dry-chemical type of extinguisher should be examined regularly to see that the wire and lead seals are not broken, that the discharge nozzle is in closed position and not clogged, and that the extinguisher and hose are free of mechanical damage.

Annual examinations should be conducted to see that the nitrogen-pressurizing cylinder is properly charged, that the hose is clear of dry chemical, that the nozzle is not clogged or damaged, that the hose couplings and nozzle connectors are tight, and that the extinguisher and hose are free of mechanical damage or corrosion.

Recharging should be done if the pressure of the nitrogen cylinder is below the recommended minimum. Whatever remaining pressure there is should be discharged, the valves turned to the proper position, and only the dry chemical furnished by the manufacturer of the extinguisher should be used.

Chemical Foam

Chemical-foam extinguishers should be examined several times a year to make sure that they have not been tampered with or removed from their designated places, to detect injuries, to see that they are not empty, and to see that the orifice of the hose nozzle is not clogged. At the same time, they should be checked to see that there is no physical damage to the shell or seams. If an extinguisher shows evidence of mechanical damage, corrosion or distortion of the shell due to freezing temperatures or other causes, it may be unsafe for further use and should be subjected to a hydrostatic pressure test.

Chemical foam extinguishers should be recharged annually, as well as after use. They must be protected from freezing temperatures. Extinguishers that are in service should be subjected to the hydrostatic pressure test every 5 years to determine if they are capable of withstanding the pressure which may be generated during operation. This test should be applied at a rate-of-rise to reach 300 pounds per square inch in approximately 1 minute, holding the pressure at that point for 1 minute before releasing it. Any extinguisher which shows leakage, distortion, or other signs of weakness should be mutilated to the point where it cannot be placed back in service, and then scrapped.

When recharging the chemical foam extinguisher, its interior and all parts should be cleaned thoroughly with warm water, and water should be run through the hose and nozzle, making sure there are no obstructions in either. No rags, waste, or anything that might possibly clog the nozzle or screen should be used. The extinguisher head should be examined to be sure that it is held by four full threads in good condition. If more than one extinguisher is being recharged at a time, each head should be replaced on the extinguisher from which it was removed. The hose, head gasket, inner chamber, and loose stopple should be inspected, and any that are unserviceable, replaced. Only recharges furnished by the manufacturer should be used. The units of chemical foam charge in separate containers should be mixed in accordance with instructions on the package. Solutions for both the inner and the outer chamber should be thoroughly dissolved before being placed in the extinguisher. Neither chamber should be filled beyond the solution-level mark. When the chambers have been filled and the loose stopple replaced, the extinguisher head should be replaced and screwed down tightly.

Soda-Acid

Soda-acid extinguishers should be examined at about the same intervals and for the same reasons as the chemical foam extinguisher, discussed in the preceding paragraphs. Also, the soda-acid extinguisher must be recharged annually, as well as immediately after use, and must be protected from freezing temperatures. Those in service must be subjected to the hydrostatic pressure test every 5 years to determine that they are capable of withstanding pressures which may be generated during operation. The pressure test for soda-acid extinguishers is the same as for chemical foam extinguishers.

Recharging and cleaning procedures are also the same as for chemical foam extinguishers, except that the recharge consists of bicarbonate of soda and 66° of Baumé sulphuric acid of standard specifications properly compounded by the manufacturer. The bicarbonate of soda should be dissolved in water according to the instructions on the recharge package. It should be stirred until thoroughly dissolved; then the solution should be emptied into the extinguisher, up to, but not above, the water mark. If the bicarbonate of soda is dissolved in the extinguisher, care must be taken to avoid damage to the extinguisher's interior coating while stirring. The old bottle should be replaced with a new acid charge. The stopple in the bottle should be loose and the bottle should be replaced in the cage of the extinguisher. If the bottle in the recharge package is not the same size as the old bottle, the acid should be transferred to the old bottle, taking care not to spill the acid on bodily tissues or other surfaces. The extinguisher head should be replaced and screwed down by at least four full threads. Acid bottles and stopples should be replaced only with exact duplicates of those originally provided with the extinguishers; otherwise, the discharge may be impaired or the extinguisher rendered inoperative.

Vaporizing Liquid

Vaporizing-liquid extinguishers should be inspected several times a year to make sure that they are in place and ready for use. They should be checked more thoroughly at least once a year to ascertain their pressure, the condition of the pump, and whether they have been damaged. The direct-action type of pump should be tested by moving the pump handle several in-and-out strokes. Vaporizing liquid ejected in testing may be discharged into a clean, dry glass receptacle and later poured back into the extinguisher with a clean, dry funnel. Continuous-stream extinguishers can be tested by pumping up pressure and ejecting the vaporizing liquid in both up-and-down and around-the-clock positions. After completing the test, enough vaporizing liquid should be added to bring it up to the required level. Stored-pressure extinguishers can be tested by discharging a small amount of vaporizing liquid into the atmosphere. Before refilling a single-chamber pressure type of extinguisher, the remaining pressure must be released by inverting the extinguisher and opening the operating valve. The vaporizing liquid should be replaced and the extinguisher filled to its rated capacity. The nozzle should be pressed to the air hose, the extinguisher shaken, and more air added until the gauge remains at required pressure.

If an extinguisher of the stored-pressure type shows evidence of corrosion or mechanical injury, it may be unsafe for further use and should be returned to the factory for examination.

Recharging directions found on the extinguisher's name plate should be carefully followed. Only the vaporizing liquids furnished by the manufacturer should be used in recharging these extinguishers, as other liquids may make them inoperative and dangerous. After recharging, the extinguisher should be tested in the same manner as was outlined in the preceding paragraph, but water should never be used in the vaporizing-liquid extinguisher for testing or any other purpose.

Water

There are three main types of water extinguishers: cartridge-operated, cartridge-operated anti-freeze, and pump-tank.

The cartridge-operated water extinguisher must be kept from freezing, and should be inspected several times each year for signs of mechanical damage, corrosion, or distortion. If there is evidence of weakness, the extinguisher should be subjected to the hydrostatic pressure test; the pressure should be applied at a rate-of-rise to reach not less than 300 nor more than 350 pounds per square inch for hand types and 400 pounds per square inch for wheeled types in approximately 1 minute. This pressure should be held for 1 minute, while the extinguisher is being checked for leakage, distortion, or other failure.

Water-type extinguishers do not have to be recharged annually, but should be inspected to insure that the water level is up to the proper mark. Recharging is necessary after each use. Before recharging, the interior and all parts should be thoroughly cleaned with warm water. The water should be run through the hose and nozzle to make sure there are no obstructions in either. No rags, waste, or anything that might clog the nozzle or screen should be used. When being recharged, the extinguisher should be filled with water to, but not above, the water mark on the inside of the shell. If more than one extinguisher is being charged at a time, each head should be replaced on the extinguisher from which it was removed, and screwed down by at least four full threads.

If the cartridge-puncturing mechanism is unsatisfactory and is removable, it should be replaced; if it is not removable, the complete head should be replaced.

For water extinguishers of the cartridge-operated anti-freeze type, the same instructions and procedures as outlined for the cartridge-operated water type should be followed, but in recharging, an anti-freeze chemical supplied by the manufacturer should be used; the chemical should be thoroughly dissolved in water outside the extinguisher in accordance with instructions given on the recharge package. The solution should be put through a fine strainer while pouring it into the extinguisher.

The pump-tank water-type extinguisher should be examined several times a year to determine its general condition, and should be examined thoroughly at least once a year to check the condition of the pump and determine if there have been any injuries. The pump should be tested by operating it several strokes, discharging the solution back into the tank, then putting a drop of thin lubricating oil on the piston rod packing. Extinguishers must be kept full at all times, and recharged immediately after use.

When recharging the pump-tank water-type extinguisher with an anti-freeze solution, the chemical supplied by the manufacturer is best to use; it should be dissolved in water outside the extinguisher in accordance with instructions on the recharge package.

Fixed Systems

Of the four types of fixed fire-protection systems within buildings—high-pressure carbon dioxide extinguishing systems, fixed-foam systems, standpipe and inside hose systems, and sprinkler systems—the latter two are more frequently found in school buildings. Developed over a period of years, each of these two systems has its advantages over the other, and for this reason, they often complement each other in the same building.

Standpipe and Hose System

The standpipe system furnishes the only reliable means of obtaining effective fire streams within a short time, particularly at the upper stories of a building. Standpipe systems may be installed for first-aid protection, with a hose line for use by occupants of a building; for fire department service, with a valve outlet for use by the fire department only; or for both types of service. Local ordinances and insurance requirements may determine which type, if any, is to be installed in a particular building. The three types of service have one feature in common, namely closed valves available only for prompt firefighting; in standpipe systems with hose connections, there are also a length of fire hose properly installed on a rack or reel and a hose nozzle, both usually enclosed in a hose cabinet for protection and appearance.

Periodic inspection of this equipment is essential and should involve a "pull" test to determine the condition of the equipment at the valve and nozzle connections. The valve handle should be checked to be sure that it is in a fully closed position. The hose should be inspected carefully along its entire length and particularly at the valve end just below the coupling. If the hose appears discolored or damp, it should be removed to check the valve carefully for leakage and to cut away the damp section, or in the case of rubber-lined hose, to check it with water pressure if this is deemed necessary. The hose nozzle should be inspected, especially at the discharge end, to see that it is open; if the nozzle is of the adjustable type, it should be twisted to assure that it turns easily and is not in a "stuck" position.

Unlined hose should be visually inspected, fold by fold, to discover hidden objects or any excess dirt or dust in folds, or any cuts caused by vandalism. The condition of the hose can be determined by probing it with a sharp pencil point at several places. If the point will not enter without forcing, the hose is in a satisfactory condition. If in good condition, but dirty, the hose can be brushed with a soft brush and rehung on the rack; care must be taken to refold it properly. Any hose that is cut or has a hole of any kind must be replaced. Linen hose should always be stored to give air circulation, free from acid or other fumes and away from damp walls and moisture.

An unlined linen hose should never be water-tested unless it is 10 years old or unless it has been subjected to severe atmospheric conditions. Cleaning a linen hose with water is not recommended, but if done, the hose must be thoroughly dried before rehanging on the rack. The same rule applies for a hose that has been used against fire. The approved method of drying a linen hose is first to hang it up or place it on sloping racks where water will drain, and then to continue the drying for a period of time under conditions of warmth and air circulation. If the hose is 10 years old or older, it should be inspected for "dry rot." (The date of its installation will be stenciled on the hose.)

A lightweight, rubber-lined cotton hose may be removed from the rack and water-tested, but care should be taken not to drag or abuse the hose. After the test, the hose should be drained, dried, and rehung on the rack. This procedure is recommended as an annual inspection.

Hoses are usually stored on racks or reels located in cabinets. Racks should be inspected for missing or damaged parts, such as pins, buttons, nozzle clips; reels, for bent spokes or rims which might affect efficient operation.

Cotton, rubber-lined hose on racks should be taken off and reloaded every 60 to 90 days to change the folding and eliminate kinks which could damage the hose. Water should be run through a rubber-lined hose at least once every 3 months to keep the rubber "live." After the test, the hose should be drained, dried, and reloaded.

Unlined linen hose should be reracked at regular intervals and new gaskets installed in the female couplings and in the nozzle. If couplings require polishing, care should be taken to prevent polish from coming in contact with the hose.

Bent or dented nozzles or playpipes should be repaired or replaced. Damaged nozzles should not be used, as they can break or spray the stream. Valves should be maintained by replacement of faulty valve discs, packing, and bent stems. Missing rack parts, such as pins, rods, buttons, and nozzle clips, must be replaced, because a defective rack could encumber the hose line so as to make it useless.

Automatic Sprinkler

An automatic sprinkler system has an advantage over the standpipe and hose system in that it automatically provides for the prompt and continuous discharge of water directly on all burning material located under or near sprinkler heads. This is accomplished by means of a series of pipes attached to outlets known as sprinklers, which are so

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constructed that they open automatically whenever the surrounding temperature reaches a predetermined point.

There are two common types of sprinkler system: dry-pipe and wet-pipe. In wet-pipe systems, the pipes contain water under pressure, whereas in dry-pipe systems, the pipes contain air under pressure, which holds water back; a great enough rise in the surrounding temperature causes the air to escape from the sprinkler heads, thus allowing water to fill the pipes. The wet-pipe system is commonly installed in heated buildings, and the dry-pipe, in buildings or portions of buildings subjected to freezing temperatures. (A wet-pipe system with anti-freeze in the pipes may be installed in small, unheated spaces where it is impractical to install the dry system.)

To be effective, a sprinkler system must be properly maintained. The installing contractor should provide the school maintenance department with instructions, charts, and other essential information on proper techniques and procedures for sprinkler maintenance. Although automatic sprinkler systems employing standard devices and installed in accordance with the established rules are sturdy and durable, requiring a minimum expenditure for maintenance, these systems, like other equipment, may deteriorate through neglect or certain conditions of service.

The National Fire Protection Association recommends that sprinkler maintenance be assigned to competent automatic sprinkler contractors, and that their services include:[24]

- A minimum of four inspections a year at approximately regular intervals
- Sealing of valves where the seals are broken during the inspection
- Tripping of dry-pipe valves at least once every year
- Use of an inspection report form that conforms to the standard form of the automatic sprinkler industry, with copies furnished after each inspection to the property owner and to the insurance authority having jurisdiction.

In addition to the services performed by sprinkler contractors, there are some duties relating to sprinkler maintenance that can be performed by custodians or other school plant personnel. For example, every sprinkler valve should be inspected once a week. A report form which lists each valve by number and shows the portion of the sprinkler system controlled by each valve should be used when these inspections are made. On this report form should be recorded whether the valves are open or closed, properly secured or sealed, in good operative condition, turn easily, do not leak, and are readily accessible, and whether wrenches are in place. Other essential maintenance services for sprinkler valves include greasing valve stems at least once

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[24] National Fire Protection Association. *Care and Maintenance of Sprinkler Systems* (No. 13-A, May 1958). Boston: The Association, 1958. p. 5 ff.

a year; trying post-indicator valves with a wrench at each inspection, leaving them about one-quarter turn from the wide-open position (wrenches should be fastened to the valves or left nearby); keeping outside screw and yoke valves clean; and keeping pits clean and free of water (and protected against freezing).

At the weekly inspection of the control valves, the gauges that show water and air pressure on the system should be read to make sure that normal pressures are being maintained.

Regular testing of sprinkler systems by water flow may best be made in cooperation with the State or local inspection department having jurisdiction; it should include the test pipe at the top of the system and at the main drain valves. Such tests are designed to show whether a normal water supply is available on the system and to indicate the possible presence of closed valves or other obstructions in the supply line. (NOTE: If a sprinkler system has a direct connection to a central station or fire department, a water flow test should be made only after notifying the signal station.)

It is important to check sprinkler heads regularly to see that they are in good condition, clean, free from corrosion or loading, not painted or whitewashed, and not bent or damaged. Sprinklers that are protected to prevent or retard corrosion should be used if they are exposed to corrosive atmosphere. Broken sprinkler hangers should be replaced promptly, and loose ones, tightened.

In dry-pipe systems the air pressure should be checked at least once each week, pumping up the system when necessary. (Instructions pertaining to this and other maintenance procedures for dry-pipe systems should be posted at appropriate points.) In cold weather it is important to keep the valve closet properly heated with safe heating equipment, and to make sure that the low-point drains of the dry system are free of water. Each dry-pipe valve should be thoroughly cleaned and reset once a year, during warm weather. (No grease or other sealing material should be used to stop leaks on seats of dry-pipe valves, nor should force be used to make dry-pipe valves tight. Dry-pipe valves should carry a tag or card to show the date on which the valve was last tripped and the name of the organization making the test. These tags are usually available from the installing company or from insurance authorities.

Chapter V

MECHANICAL SYSTEMS

FOR CONVENIENCE in organizing the material in this bulletin, treatment of features of school buildings that provide special types of services is given under the general heading of mechanical systems. The multiplicity of maintenance requirements for the special service facilities precludes a comprehensive treatment, but some essential maintenance procedures are reviewed here for each of four systems: heating, ventilation, electrical, and sanitary.

Heating System

That schoolchildren do more and better work when they are comfortable is recognized by all who have had experience in the classroom. Controlled temperature within a desirable range for children, essential to their comfort and healthful living conditions, is made possible in cold weather by the heating system (and by ventilation); in hot weather, by air circulation and ventilation, or by air conditioning.

The heating system must be flexible enough to overcome the lowest outside temperature, yet operate satisfactorily when the outside temperature is only slightly below desired room temperature. Heat for this system is generated by the rapid oxidation of fuel or by electrical current. Except for most electrical and some gas installations, heat for school buildings is produced at one point, then transmitted to other points by means of steam, water, or air passing through pipes, or ducts. In steam heating systems, water is converted to steam, which is sent to all parts of the building; in the hot water system, the heated water rises or is forced by pump to all points where heat is needed; in hot air systems, the heated air rises by gravity, or is forced by fans, to all parts of the building. In all cases, room units (radiators, convectors, registers, etc.) are designed to retain the heated medium until it has given up a considerable part of its heat to room air.

With hot air systems, the warm air enters and is mixed with room air, tempering both the room air and air coming into the room from the outside. Heat from steam or hot water systems is delivered by one of three methods: conduction, convection, or radiation. The latter two methods are extensively used in school buildings, particularly where low-pressure steam or hot water boilers are used. Since boilers of this type are extensively used in schools throughout the country, attention here is devoted primarily to them.

Boiler Classification and Maintenance

Steam boilers may be of cast iron or steel construction. Those of cast iron are usually made in sections (U-shape), and are classified as low-pressure boilers. Steel heating boilers are classified according to the amount of pressure carried, the type of the setting, direction of flues, and the manner of firing. Those carrying 15 pounds of pressure or more are high-pressure boilers; under 15 pounds, low-pressure. Those on a brick foundation that are partially or wholly encased in brick are called brick-set boilers; those with the furnace encased in a part of the boiler, with a water leg extending down on each side of the furnace or firebox, are classified as firebox or water-leg boilers. Those with vertical flues are called upright or vertical boilers (but these are not extensively used in school heating); those with flues running from front to back, horizontal boilers. If a boiler passes gases from the furnace to a smokebox at the other end and then returns them to a smokebox or exhaust chamber over the firebox (from where they enter the smokestack), it is known as a horizontal return tube (H.R.T.) boiler, and is further designated as a 2-, 3-, or 4-pass boiler, depending on the number of times the hot gases pass through the tubes to heat the water. If flues extend only from one end of the boiler to the other, it is a straight-fired or 1-pass boiler. If there are two sets of grates, with the fire on the top set, the boiler is called a downdraft or smokeless boiler; if there is only one set of grates, with the draft coming from the ashpit up through the grates, it is an updraft boiler.

Maintenance of low-pressure heating boilers should not be neglected or passed over lightly. Insurance officials feel that there is a tendency to have a false sense of security about low-pressure boilers, which causes neglect of the routine testing of valves and controls.[1]

[1] Lumbermans Mutual Casualty Co. and American Motors Insurance Co. (Divisions of Kemper Insurance). *Heating Boilers: Maintenance and Operation.* Chicago 40, Ill.: The Companies. (n. d.) p. 1.

If these controls fail, the boiler may suddenly become a high-pressure unit, with a high potential for explosion and catastrophe. One out of seven heating boilers contains a dangerous defect that, unless corrected, may cause a serious accident. Of 725 explosions analyzed by insurance officials, 11 percent occurred in schools. Most of these were caused by conditions that could have been corrected with ease, such as lack of knowledge on the part of operators, defective safety devices and feedwater controls, the presence of burning trash in the boiler without sufficient water, excessive scale from improper feed water, and wearing away of the metal.

General recommendations for proper care and maintenance of boilers, prepared in accordance with recognized and proven practices established by the boiler industry, vary according to whether a boiler is in service or out of service.[3]

Boilers in Service

A steam heating boiler is equipped with safety valves to prevent excess pressure, a steam pressure gauge to indicate internal pressure, and a water gauge to show the level of water in the boiler. Safety valves should be of the spring-pop type, officially rated, and adjusted to open at a pressure not to exceed 15 pounds per square inch (psi). These should be tested once during the heating season, when the boiler is under pressure, by pulling the hand lever to be sure it works properly. If a safety valve must be replaced for any reason, a new one of the same size as the opening in the boiler should be installed and set to release at 15 psi. (This valve should be connected directly to the boiler, without intervening valves.)

The steam pressure gauge should be checked regularly to see that it is operating properly. The water line should be checked to see that it is at the recommended level.

In a hot-water closed-heating system, the boiler is equipped with a relief valve and an aircushion tank to prevent excess pressure, and has a combination altitude-pressure gauge and thermometer to indicate pressure and temperature in the boiler.

The relief valve (or valves) should be tested once during the heating season by pulling the hand lever to see that it works properly. The stationary and movable hands of the combination altitude-pressure gauge should be together when the system is full of cold water. On an open type of system, these hands should be together when the expansion tank is one-third full. The stationary hand on the

[3] W. W. Popyke. Care of the Heating Boiler is Important. *Oil Heating and Air Conditioning Age.* October 1959, p. 23–24; 48.

combination altitude-pressure gauge should always be set by the installing contractor or serviceman, and thereafter if the movable hand moves to a point below the stationary hand, water should be added to the system to bring the hands together. The expansion tank piping and overflow drainpipe of an open type of hot water system should be checked occasionally to be sure that all piping is free of obstructions.

If boilers are equipped with electrical control circuits, all elements of these circuits should be checked periodically to see that they are functioning properly. Many low-water accidents are due to defective electrical connections. If switches fail to make contact, the burner will not cut out, even though the water-level control is in good working order; or the return pump may not operate when the water-level control calls for water. Some of the causes for burned-out switches are:

- **Overloaded circuit resulting in low voltage and high amperage with excessive heat.**
- **Grounding of wires in control circuit.**
- **Short circuits in other control devices.**
- **Switch exposed to water or steam.**

All wiring for electric controls should be of good quality, heat-resistant, and enclosed in conduit; all junction boxes and switches should be covered for protection from dirt and moisture.

Some low-pressure steel boilers in service present a problem of internal pitting. A significant amount of this trouble can be prevented by keeping the system tight to prevent leaks and keep out oxygen and by treating the water before the heating season starts. This treatment should give the water proper alkalinity and remove excess oxygen and carbon dioxide. One of the common oxygen-removing agents is sodium sulfite.[3] Defective traps and vents at radiators are a common source of leakage and should be checked for proper operation. A portable pyrometer can be used to check steam traps, or a stethoscope with a ⅛ inch metal receiver can be used, placing the end of the rod on the trap and listening to it operate. A longer rod can be used to check ceiling and floor traps.

If scale forms inside a boiler, it can usually be removed by adding a chemical such as sodium silicate, soda ash, or trisodium phosphate. Either a boiler maintenance firm or a water treatment firm can supply the proper compound. If the system is tight, the treatment given at the beginning of the heating season should carry through the entire season, unless an excessive amount of make-up water is required at frequent intervals.

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[3] *Heating Boilers: Maintenance and Operation*, op. cit., p. 3.

Another procedure that will prevent the formation of scale and improve boiler efficiency is to wash and flush it internally, but the frequency of washing and flushing a steel unit depends on the water condition, amount of make-up, and condition of piping and equipment. Many steel boilers are cleaned annually to prepare them for internal inspection. If the gauge glass shows evidence of rust or other foreign matter in the water, the cleaning schedule should be adjusted to keep the water free of these elements. It is usually not advisable to drain hot water systems every year, as this only increases the rate of corrosion.

From the standpoint of safety during operation, water should be kept at the proper level in all heating boilers. It is not wise to depend entirely on water-level controls, emergency water feeders, or automatic alarms.[4] The gauge glass, gauge cocks, and connecting lines should be blown at regular intervals to make sure that all connections are clear and in proper operating order. The gauge glass must be kept clean because it is of extreme importance that the water level be accurately indicated at all times. If there is any question as to the water level indicated, and the true level cannot be determined immediately, the boiler should be removed from service and all water level indicating devices and attachments checked.

In case of low water, stop the supply of air and fuel immediately. For hand-fired boilers, cover the fuel bed with ashes, fine coal, or earth. Close the ashpit doors and leave the fire doors open. DO NOT ADD WATER TO THE BOILER. After the boiler is cool, determine the cause of the low water level, and correct it. Carefully check the boiler for effects of possible overheating, such as cracks, fused metal, or damaged joints, before placing it in service again.

FIRING DEVICES

The types of fuel and firing devices used with boilers play an important part in maintenance procedures. Three principal fuels are used in schools: oil, gas, and coal. Gas and oil must be fed into the furnace or firebox by means of automatic equipment. Coal may be fed by hand or by stoker, but stoker feeding is more economical, produces neither "highs" nor "lows" in building temperatures unless thermostats are damaged or changed, and helps prevent smoke and soot.

Oil. For oil-firing, an automatic draft regulator should be included in the breeching to maintain a constant draft of proper inten-

[4] The Hartford Steam Boiler Inspection and Insurance Co. *Heating Boilers.* Hartford, Conn.: The Company. (n. d.)

sity. Also, an effective oil filter should be included in the fuel supply line to the burner. Adjustments in the oil feed rate, atomization pressure, air supply, and draft should be made by a competent serviceman to provide an economical and clean flame of high efficiency.

The following parts of the oil burner should be cleaned periodically: nozzle, nozzle strainer, ignition electrodes, blower wheel, and all strainers and filters in the fuel pump and oil line. The stack safety switch should be removed and the portion extending inside the breeching cleaned. The position of the ignition electrode points should be checked and adjusted to burner manufacturers' recommendations. Bearings in the burner motor and automatic draft regulator should be oiled as required. Water and sediment should be drained or pumped from the fuel oil storage tank occasionally.

Gas. In gas-firing, a draft diverter or other acceptable equipment must be included in the breeching to maintain a low, constant draft and to protect against down drafts and pilot failures. The local gas company will usually inspect, clean, and make necessary adjustments in burner controls. Whether performed by the gas company or school employees, the following operations should be done periodically: cleaning the main burners and pilot burners when required; checking the gas input rate and burner air adjustment; checking the safety pilot and other controls for proper operation; and maintaining the draft properly.

CAUTION: If there is a pronounced odor of gas or if the boiler or burner appears to be operating in an erratic manner, close the manual shutoff valve immediately and call the gas company or local serviceman.

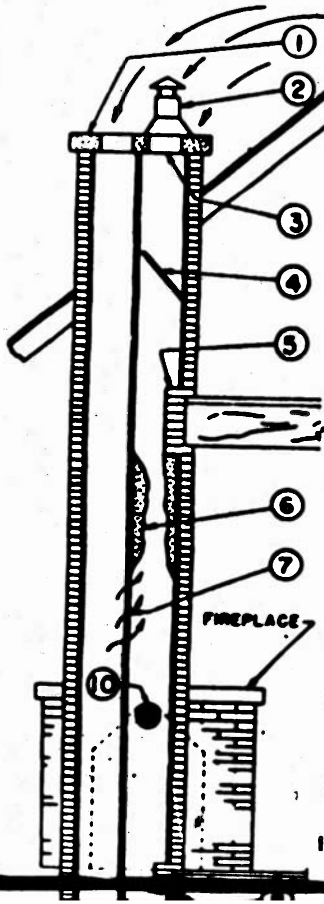
Coal. For stoker-fed coal firing, it is advisable to have a competent stoker mechanic check the stoker at the beginning of each heating season to set the coal-feed rate required for fuel input. At the same time he should adjust hold-fire control, air supply, and overfire draft for proper combustion.

At the end of the heating season, all coal remaining in the hopper should be removed and the stoker allowed to operate until all fuel in the coal screw-in tube has been discharged; all coal, ash, and clinkers should be removed from the firebox and retort; the tuyeres should be cleaned and inspected, and any segments that are damaged replaced; the refractory hearth should be repaired, and any leaks that may be present sealed; dust and ash should be removed from the wind box and air duct. The inside of the hopper should be thoroughly cleaned and swabbed with motor oil (used crankcase oil will do), or painted with red lead or other corrosion-resisting paint. A mixture of sawdust and motor oil should be prepared and placed in the hopper, and

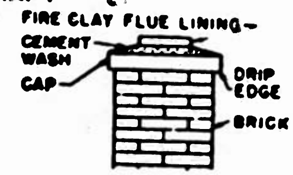
I·B·R CHIMNEY CHECK CHART

COMMONLY ENCOUNTERED DEFECTS WHICH CAUSE INSUFFICIENT CHIMNEY DRAFT

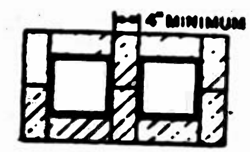
— HOW TO LOCATE AND CORRECT THEM —



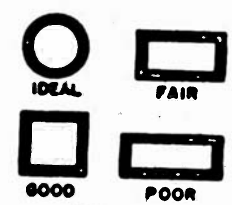
TROUBLE	DISCLOSED BY	REMEDY
1 TOP OF CHIMNEY LOWER THAN RIDGE OF ROOF, OR NEARBY TREES, BUILDINGS, ETC.	OBSERVATION.	EXTEND CHIMNEY WELL ABOVE RIDGE OF ROOF OR SURROUNDING OBJECTS
2 FLUE TOP, CAP OR EXTENSION RESTRICTS AREA.	OBSERVATION AND MEASUREMENT.	REMOVE, AND EXTEND CHIMNEY
3 CHIMNEY OPENING SMALLER THAN FLUE.	MEASUREMENT.	ENLARGE TO SAME SIZE AS FLUE.
4 OBSTRUCTION LODGED IN FLUE —BRICK, BROKEN TILE, MORTAR, BIRDS NEST, ETC.	LOWERING LIGHT OR WEIGHT DOWN CHIMNEY, OR MIRROR (SEE DETAIL D).	USE WEIGHT ON ROPE, OR ROD, TO BREAK AND DISLODGE OBSTRUCTION.
5 PROJECTION INTO CHIMNEY	LOWERING LIGHT OR WEIGHT DOWN CHIMNEY, OR MIRROR.	HAVE PROJECTION REMOVED BY MASONRY CONTRACTOR.
6 FLUE CHOKED WITH SOOT (FIRE HAZARD)	LOWERING LIGHT DOWN CHIMNEY, OR MIRROR.	CLEAN OUT BY LOWERING CHAIN OR BAG OF SAND ON ROPE.
7 LEAKS BETWEEN ADJACENT FLUES	SMOKE TEST (START SMOKY FIRE, THEN CLOSE TOP OF BOILER FLUE - SEE DETAIL E).	HAVE LEAKS CORRECTED BY MASONRY CONTRACTOR
8 LEAKS IN CHIMNEY WALL (FIRE HAZARD)	SMOKE TEST OR FLAME TEST (SEE DETAIL F).	RECEMENT JOINTS BETWEEN BRICKS AND BETWEEN LENGTHS OF FLUE LINING.
9 DEBRIS ACCUMULATED IN OFFSET.	LOWERING LIGHT OR WEIGHT DOWN CHIMNEY	DISLODGE WITH WEIGHT ON ROPE, OR ROD. REBUILD TO ELIMINATE OFFSET, IF NECESSARY.
10 HEATER, STOVE, OR FIREPLACE CONNECTED TO FLUE WHICH	OBSERVATION	REMOVE OTHER CONNECTIONS AND SEAL OPENINGS. USE FLUE FOR



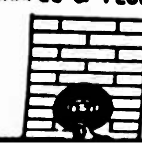
DETAIL A
RECOMMENDED TYPE OF CHIMNEY TOP

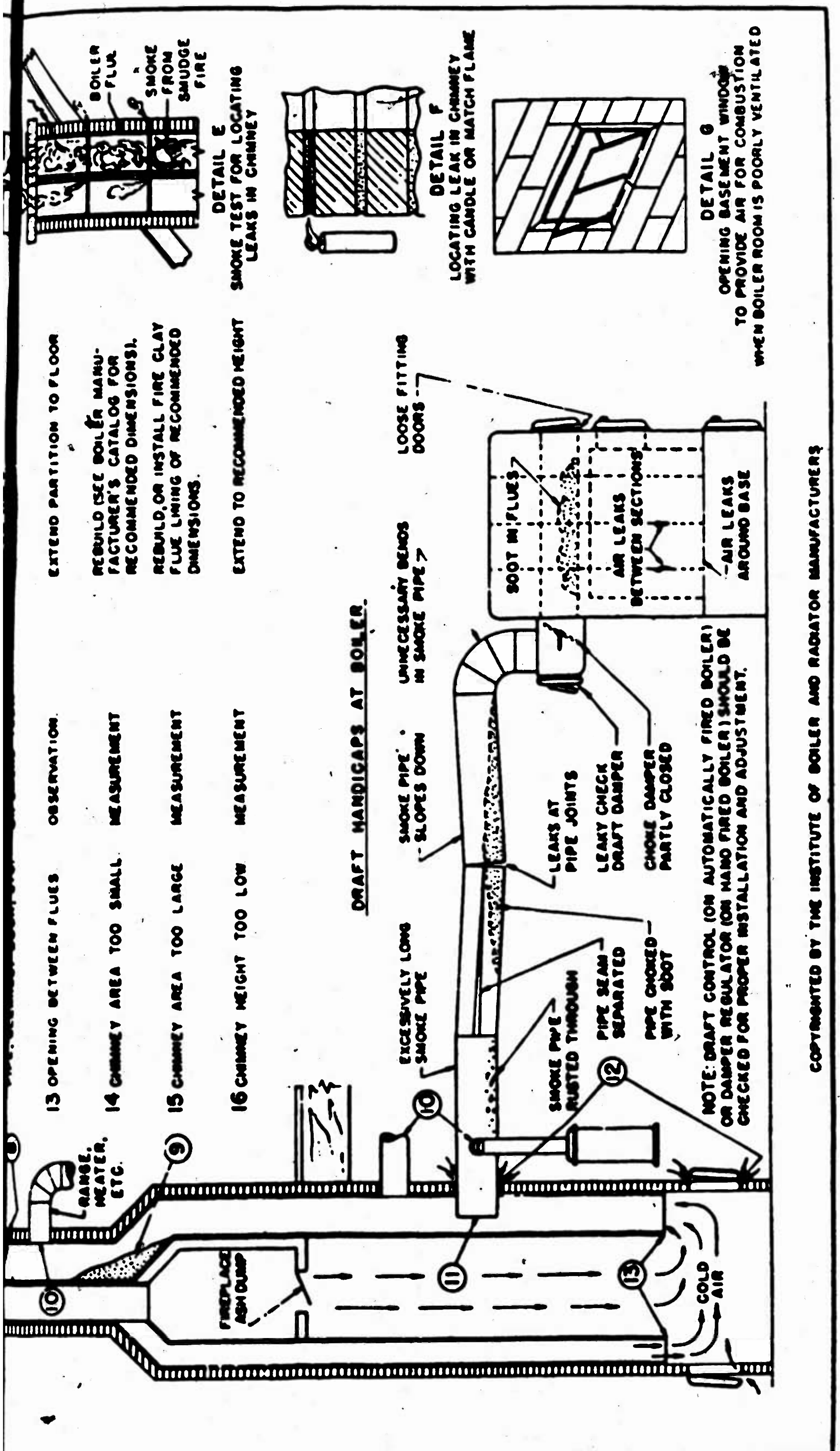


DETAIL B
RECOMMENDED DIVISION WALL BETWEEN ADJACENT FLUES



DETAIL C
COMPARISON OF COMMON SHAPES OF FLUES




13 OPENING BETWEEN FLUES
OBSERVATION.
EXTEND PARTITION TO FLOOR
14 CHIMNEY AREA TOO SMALL.
MEASUREMENT
REBUILD (SEE BOILER MANUFACTURER'S CATALOG FOR RECOMMENDED DIMENSIONS).
15 CHIMNEY AREA TOO LARGE
MEASUREMENT
REBUILD, OR INSTALL FIRE CLAY FLUE LINING OF RECOMMENDED DIMENSIONS.
16 CHIMNEY HEIGHT TOO LOW
MEASUREMENT
EXTEND TO RECOMMENDED HEIGHT
RANGE, HEATER, ETC.
FIREPLACE ASH DUMP
COLD AIR
DRAFT HANDICAPS AT BOILER
EXCESSIVELY LONG SMOKE PIPE
SMOKE PIPE SLOPES DOWN
UNNECESSARY BENDS IN SMOKE PIPE
LOOSE FITTING DOORS
SOOT IN FLUES
SMOKE PIPE RUSTED THROUGH
PIPE SEAM SEPARATED
PIPE CHOKED WITH SOOT
LEAKS AT PIPE JOINTS
LEAKY CHECK DRAFT DAMPER
CHOKE DAMPER PARTLY CLOSED
AIR LEAKS BETWEEN SECTIONS
AIR LEAKS AROUND BASE
NOTE: DRAFT CONTROL (ON AUTOMATICALLY FIRED BOILER) OR DAMPER REGULATOR (ON HAND FIRED BOILER) SHOULD BE CHECKED FOR PROPER INSTALLATION AND ADJUSTMENT.
BOILER FLUE
SMOKE FROM SMUDGE FIRE
DETAIL E
SMOKE TEST FOR LOCATING LEAKS IN CHIMNEY
DETAIL F
LOCATING LEAK IN CHIMNEY WITH CANDLE OR MATCH FLAME
DETAIL G
OPENING BASEMENT WINDOW TO PROVIDE AIR FOR COMBUSTION WHEN BOILER ROOM IS POORLY VENTILATED
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the stoker operated until the space between the coal screw-in and the tube is filled. (This will prevent corrosion and freezing together of these parts.) The transmission should be flushed and refilled with correct oil; the electric motor and automatic draft regulator oiled; the drive belt should be inspected and the fan wheel and housing cleaned.

CAUTION: Special instructions furnished on any automatic firing device and controls should always be followed exactly.

A schematic chart on chimneys and drafts showing the nature of 16 different problems, methods of locating them, and suggested remedies for each has been developed by the Institute of Boiler and Radiator Manufacturers.[5] This chart, which is inserted here, is self-explanatory.

Boilers Not in Service

Maintenance of most low-pressure boilers is started at the close of the heating season. At that time, the boiler and all its attachments, including piping, should be checked for necessary repairs. If major repairs seem to be needed, a boiler engineer could be consulted for verification of findings.

It is sometimes difficult to decide when to retube a boiler, particularly if no tube shows evidence of leaking; if tubes show heavy pitting, however, chances are that they will break down during the next heating season, causing inconvenience and if there is no stand-by boiler it is good economy to retube during the off-season. Before proceeding with this operation in old boilers, however, other parts should be carefully examined to determine if their general condition warrants an expenditure for retubing. In some cases a new boiler is more economical than a repair job on an old boiler.

All welded repairs should be made by a qualified operator. No repairs of any kind should be made either on boilers or piping while the part upon which the work is to be done is under pressure.

When necessary repairs have been made to boilers after the heating season, they should be laid up for the summer. Either of two procedures can be followed to protect idle boilers from corrosion—dry storage or wet storage. Regardless of method used, boilers should be drained (except cast iron units), cleaned, and inspected. The dry-storage method is recommended when the boiler is to be out of service for a month or more, particularly in areas of high humidity. Condensation of moisture on external surfaces, together with sulphur in the ash or soot, will corrode the plates. If the boiler is left dry, an

[5] The Institute of Boiler and Radiator Manufacturers *I-B-R Chimney Check Chart* (Used by permission).

added precaution can be taken to prevent internal corrosion: trays of quicklime or other moisture-absorbing chemicals can be inserted in the drums before the boiler is closed.

CAUTION: DO NOT BURN RUBBISH IN EMPTY BOILERS.

The wet method of storing boilers is preferred for those that must be available for emergency use and that are not subjected to freezing temperatures. This procedure requires draining, thoroughly cleaning, and filling them with water. Dissolved gases can be expelled by heating, with the unit vented to atmosphere. After the water has been boiled, it should be treated for removal of alkaline and oxygen to prevent pitting. About 3 pounds of caustic soda and 1½ pounds of sodium sulfite per 1,000 gallons of water, added through the manhole, are commonly used for this purpose.[6] When the boiler has cooled, it should be filled to the top to prevent further absorption of oxygen or other gases, and the manhole should then be closed.

All heating surfaces of tubes, flues, the sides of the firebox, the smoke hood, and breeching of boilers to be laid up should be cleaned of soot, scale, fly ash, rust, or other deposits. All joints should be checked and sealed with boiler putty; all door hinges should be oiled; a thin coat of grease should be applied to all ground surfaces, doors, and frames; platework should be painted with a high heat-resisting paint when appearance indicates this is necessary; and a caution sign placed on firedoors of dry boilers warning against starting fires in the fireboxes.

Ventilating System

Many theories, principles, ideas, and perhaps some prejudices on school ventilation have been advanced over the years, but practice in classrooms is usually a matter of individual preference. Some States have statutes prescribing standards for classroom ventilation. One such statute stipulates that a total of 30 cubic feet of fresh air must be provided per pupil per minute. This standard, perhaps the highest set by any such statute, is excessive, and is impossible to attain without a system of forced ventilation. For example, a room containing 35 pupils would require 1,050 cubic feet of fresh air per minute, and a room that is 21 feet wide, 31 feet long, and has a ceiling height of 12 feet, would require 8½ air changes per hour. This amount of air, brought through a duct having an opening of 6 square feet, would

[6] *Heating Boilers: Maintenance and Operation*, op. cit., p. 6.

enter the room at a velocity of 175 feet per minute and would create a draft.

While standards differ, there is universal agreement that some fresh air should be supplied inside school buildings, and that the amount in the various parts of the building should be related to the type of activity carried on.

Four or five changes per hour in full classrooms where the activity is sedentary would provide from 15 to 20 cubic feet per minute per child in a classroom of average size, and this seems adequate. Good ventilation is of vital importance for several reasons:

- It removes odors.
- It provides air circulation so necessary in diffusing heat to all parts of the room, preventing air and heat stratification, with hot air at the top and cold air at the bottom of the room.
- It is a factor in temperature control.
- It helps regulate relative humidity.
- It provides a supply of oxygen.
- It adds to the comfort of room occupants.

Two major types of ventilating systems fulfill these functions—gravity and mechanical.

Gravity Ventilation

Gravity ventilation is usually accomplished by an outside window, which operates in conjunction with one or more devices. Fresh air enters through an open window or windows, is spread over the room, and is extracted from it through an opening on the floor line of the corridor side of the room, or through individual ducts extending from an opening near the door in the corridor wall out through the roof (some extend only into the attic, but these are fire hazards, are not very satisfactory, and are not recommended). The air might also be exhausted by what is known as corridor ventilation, that is, by a system of openings in the corridor wall or in the bottom part of the corridor door; a series of ventilating ducts extending from the corridor out through the roof exhaust this air to the outside. In gravity systems, all ducts and vents should be ample in size to provide the air changes needed. (Air movement is accelerated if these vents are capped with approved ventilating heads.) Ducts may be equipped with dampers, which can be closed at night during the cold season to prevent an inflow of cold air. They should be open during the day, when rooms are occupied. Maintenance of gravity ventilating systems is not a major problem, and except for opening and closing of dampers, a duty generally of custodians, most maintenance procedures for this system are handled in conjunction with regular door and window maintenance. However, if approved vent heads are employed, it may be necessary for someone to mount the roof and oil their bearings occasionally. This can also be done by the custodian.

Mechanical Ventilation

Any system that forces air through a building (or parts of it) and exhausts some of it through ducts in the roof or by other means is a mechanical ventilating system. (A system that circulates room air without taking in fresh air or exhausting stale air through ducts or other means is a recirculation system, not a ventilating system.)

One of the most common types of mechanical ventilating systems admits fresh air through the windows and exhausts room air through ducts, as in the gravity system; instead of emptying to the outside through the roof, however, the ducts empty into a plenum chamber in the attic, where suction fans pull air from the rooms, exhausting it from the plenum chamber to the outside through louvers, which are sometimes of automatic design. Some motors used for this purpose have oil-impregnated bearings that require no lubrication; others may not be so equipped, and these require lubrication about once a month or at intervals recommended by the manufacturer. Other routine maintenance for these systems is to keep filters, plenum chamber, ducts, fans, and louvers clean. If motors operate fans by means of V-belts these must be replaced at infrequent intervals, probably once in 5 years.

Another type of mechanical ventilating system is the unit heater-ventilator or a combination unit heater-ventilator-air conditioning system. Most manufacturers make the system adaptable to either hot water or steam for heat, and some are adaptable to a changeover to chilled water in the summer for air conditioning. (More expensive installations require no changeover, having both hot and chilled water in different pipes so that the entire building or just one room, can be changed from heating to cooling by adjusting a dial.) In these systems, each unit has its own rubber-mounted motor and squirrel-cage fan for quiet operation. Individual room controls compensate for internal heat gains as well as external temperature changes. If properly operated, these unit systems take in some fresh air at all times, forcing it into the room to create sufficient air pressure within the room to exhaust stale air if the room vents are open. This system is really a combination of the gravity and mechanical methods of ventilation.

Most unit systems, regardless of manufacturer, have many features similarly designed; hence maintenance procedures for unit ventilators are applicablè, in general, to all types or brands. Each unit usually has hinged access doors for routine adjustments of valves and controls. There are enclosing panels, which can be removed by taking out a few screws, permitting access to the entire mechanism for other maintenance. The proper functioning of these units depends, among other things, on clean filters. Throwaway filters should be inspected and cleaned (or replaced) monthly. Permanent filters should be cleaned by immersing them in a hot (scalding) cleaning solution and moving them up and down to wash out dirt and oil. If cleaning tanks are used, grids should be placed in them to prevent the stirring up of sediment from the bottom. (A good cleaning solution for these filters can be made by dissolving 1½ pounds of washing soda in 10 gallons of water.) After cleaning, permanent filters should be allowed to drain and dry, and when dry, should be sprayed on both sides with a filter oil (or immersed in it) so that they are completely impregnated with oil.

Testing

One measure of the efficiency of any ventilating system is air circulation in the room. This can be measured by the smoke test. A smoke bomb or pot made up of tar, asphalt, or other substance having a smoke that is visible for some time can be lighted and placed near the entrance of the air stream. The motion and spread of smoke can then be observed to determine the rate and direction of air flow in the room.

Air Conditioning

Theoretically, anything that is done to air to make for more comfortable room conditions is air conditioning. More specifically, it is a process of cooling, filtering, circulating, and controlling the humidity of air. In some installations these functions are performed by a single unit which circulates the conditioned air to all parts of a building through a system of ductwork. Other installations combine these functions with the heating function, as is partially done by the unit heating-ventilating system, and more completely by the heat pump. At present, few school buildings in this country are air-conditioned, but current and proposed research may produce evidence that will show air-conditioned buildings to be more economical to build and operate, as well as more productive educationally, than conventional structures. Morever, present trends indicate that future school construction in many localities will include central air conditioning. Maintenance of air-conditioning equipment is a highly specialized field, requiring specially trained engineers and mechanics, and hence cannot be treated here.

Electrical Services

Electrical services include all wiring and controls (switches, thermostats, fuses, breakers, etc.) for lighting, power, heating (where electricity is used for this purpose), program systems, signaling or warning devices, and intercommunications systems. A number of related items necessary to safety in distributing electric current through a building are service entrances, transformers, main feeders, distribution panels, branch circuits, fuses, circuit breakers, outlets, grounds, and objects energized by electrical devices.

In most States, electrical installations in public buildings, including schools, must be done by a licensed electrician in accordance with the standards of the *National Electric Code*. Unless the school's maintenance department employes a licensed electrician, it is recommended that nearly all electrical maintenance be performed for the school, under contract, by local commercial firms engaged in this work. If proper precautions are taken, however, there are some jobs that can be handled by diligent workmen, even though they are not licensed electricians.

Some precautions which should be observed by any person who attempts any electrical maintenance are:

- Never tamper with or attempt to fix any electrical equipment unless authorized to do so. Electric current of 110 or more volts is deadly and should not be treated carelessly.
- Never take for granted that an electric circuit is "dead." Treat all circuits as if they were "alive" until it is established that they are not.
- Be sure that a circuit is open at the switch or fuse block before working on it.
- Before opening a power circuit carrying a heavy load, reduce the load; otherwise, an arc may cause a burn.
- Use fuse pullers when removing light or power fuses. Open the circuit at the switch and always wear goggles.
- Be cautious when working around contactors or circuit breakers. They sometimes trip unexpectedly.
- Handle tools with special care, and make certain that no part of the body is grounded when working on power and light circuits, motors, or panels. It is always safe practice to stand on rubber mats or insulated platforms. Rubber gloves and rubber-soled shoes are added safeguards. Never stand in water, wear wet shoes, or stand on moist concrete when working with electric current.

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School maintenance personnel who are not licensed electricians can perform some services relating to the main service entrance, distribution panels, outlets, switches, and lights. (The program system, electric clocks, intercommunication system, and other types of instrumentation probably should be maintained or repaired only by factory-trained mechanics and technicians.)

Main Service Entrance

The electric service entrance consists of a 2- or 3-phase lead-in cable, an insulator, a weather head (if the entrance is above grade), a transformer (in instances where the transformer is housed in a vault located inside or just outside a building), a switch box housing the main switch, fuses associated with it, and appropriate grounds. When lead-in wires enter a building above grade, they are usually fastened to the building by means of an insulator which is anchored to the wall or other element of the building. The insulator not only supports the weight of the cable between the building and the nearest utility pole to which the line is attached, but also makes it possible to provide a drip loop between the weather head and the lead-in. This drip loop is essential to prevent water from following the wire into the conduit of the weather head, where it can cause decay of the cable's insulating material. This part of the service entrance should be checked periodically to see if there has been damage by wind, ice, or vandalism. If damage is discovered beyond the insulator, the local power company will usually make repairs; damage from the insulator inward is the owner's responsibility, and should be attended to by an electrician.

The master switch box, located inside a building at a point not generally accessible to children, houses a switch, usually of the knife type, whose size is determined by the amount of current it is expected to carry. It has two sets of terminals—one for incoming wires and one for wires leading to the distribution panels. Between this switch and the distributing panels are fuses, sized and rated to take care of the normal load for the building, but these are sometimes blown by electric storms, by short circuits, or by the simultaneous use of all outlets (lights, motors, appliances, etc.), causing an overload. Fuses in the main panel are usually of the cartridge type, which may or may not have replaceable links. If links are not replaceable, new fuses will have to be inserted when old ones are blown; for those with replaceable links, the cost of the cartridge and its outer fittings, contact points, and insulation can be saved by unscrewing the cartridge at each end and inserting a new link of the same rating. Before removing any fuse, however, be sure that the main switch is open. Then use an insulated fuse puller to disengage cartridge fuses from their slots. (In some smaller panels, cartridge fuses are housed in pairs in bakelite boxes which have pulls mounted to them. These boxes can be removed from the panel by exerting pressure on the pulls; and after the boxes are removed, fuses can be safely taken out without using a fuse puller.) When any blown fuses have been replaced, close the main switch to restore service. (Note: If it is suspected that a fuse has been blown by a short circuit, the suspected circuit or circuits should be checked out to locate the short, which should be corrected, before replacing fuses and restoring service.)

Distribution Panels

Feeder lines are usually installed from the main service panel (or master switch box) to various zones within a building, the number of zones depending on the building's size, types of electrical service needed (110 volts or 220 volts), and the number of circuits required at each location. Feeder lines are wired into distribution panels, which are designed to accommodate the number of circuits needed at each panel. These panels may be of either the fused or breaker type, the breaker type being more commonly used in recent years. Whether the fused or circuit-breaker type, fuses and circuit breakers are designed to protect each circuit from overloading by allowing only a predetermined amount of electricity to pass through. Fuses contain a metal strip of low melting point called "the link," which is designed to carry a specific amount of current. Should more than this amount of current be drawn through the fuse, the link will melt and the circuit will be broken. The circuit breaker serves as a fuse, operating as an electromagnet. When an excessive amount of electricity (more than the breaker is designed to carry) passes through, the electromagnet opens, breaking the circuit, just as a melted metal link in a fuse breaks the circuit.

Maintenance of the distribution panels is usually a minor problem, requiring only an occasional replacement of fuses or a resetting of circuit breakers. If fuses are blown (and some distribution panels may have fuses of both the cartridge and the screw, or plug, type), the sources of trouble should be determined before replacing any fuse; likewise, if a circuit breaker trips, the source of trouble should be located and corrected before resetting the breaker switch. Fuses and fusestats of greater amperage than circuits are wired for should never be inserted as replacements. All fuses are plainly labeled on their face, and the 15-ampere fuse, which is used in more circuits than any other, has a special hexagonal design, such as the form of the cap or top, or the opening in the cap through which the mica or similar window shows. IN NO CASE SHOULD A BLOWN FUSE BE BY-PASSED BY INSERTION OF A COIN OR OTHER METAL IN THE FUSEHOLDER. This procedure, known to have been practiced in many schools, is extremely dangerous, and nullifies the entire principle of fuses as a safeguard against overloading circuits.

As a guide in tracing circuits, attention is directed, at this point, to the color scheme or code for multi-wire branch circuits, as established by the *National Electric Code*. Where installed in raceways, as aluminum-sheathed cable, as open work, or as concealed knob-and-tube work, the conductors of multi-wire branch circuits and two-wire branch circuits connected to the same system shall conform to the following color codes: [7]

- Three-wire circuits—1 black, 1 white, 1 red
- Four-wire circuits—1 black, 1 white, 1 red, 1 blue
- Five-wire circuits—1 black, 1 white, 1 red, 1 blue, 1 yellow

All circuit conductors of the same color shall be connected to the same underground feeder conductor throughout the installation. Any conductor intended solely for grounding purposes shall be identified by a green color unless it is bare.

Convenience Outlets

Indoor electrical outlets for convenience are installed in metal boxes, usually recessed in walls, with protective cover plates attached to them flush with wall surfaces. These convenience outlets are designed for 110 or 220 volts, with some 110-volt units and all 220-units polarized. (A recent practice in wiring is to install 3-wire cables, the third wire being used as a ground attached to each junction, switch, or outlet box.) Convenience outlets may contain more than one female plug, and may be wired to accommodate pilot lights.

Long or continuous use of convenience outlets wears out their connecting points, causing them to become pitted, and reduces their tension, making them inoperative and often dangerous from overheated contracts. While this problem does not occur often, it is important to take corrective steps when outlets are discovered to be defective. Before any corrective steps are taken, the particular circuit on which the

[7] National Fire Protection Association. *National Electrical Code* (NFPA No. 70). Boston: The Association, 1962. p. 36.

convenience outlet is located must be open at the distribution panel; this can be checked by removing its fuse, turning its breaker to an "off" position, or opening the switch that controls this circuit. When opening the circuit, for safety's sake, it should be tagged with a card warning others not to close it; or the panel door should be closed and locked to prevent anyone from opening the door while work is in progress.

Next, the cover plate should be removed from the outlet by taking out one or more screws (single outlets usually have one screw; duplex outlets, two.) The plug is held in place inside the metal receptacle by two screws. These screws should be removed and the plug lifted from the receptacle; then the screws at the terminal posts should be loosened to disengage the wires (the white-coated wire is attached to the neutral post and the colored wire to the hot post). If wire loops for terminal screws are bent or straightened somewhat during this procedure, new loops can be formed with a pair of electrician's pointed pliers. The open end of each loop should be worked clockwise around the appropriate terminal screws and the screws tightened. The plug should be mounted in the receptacle, the holding screws inserted and tightened, the protective plate replaced, and its screws tightened. Service should be restored to this circuit by closing it at the distribution box (the fuse should be reinserted or tightened, or the breaker switch closed).

Switches

Three main types of recessed, wall-mounted switches are the snap or toggle (available for single-pole, double-pole, 3-way, or 4-way installations), mercury flush tumbler (where the arc is completely enclosed in a glass-sealed, metal button), and the flush tumbler. (Rotary switches use the same principle as the toggle, but are not frequently used in schools, since they are surface-mounted.)

Faulty switches, which may cause electricity to jump or arc, are a hazard and should be replaced. The procedure for replacing them is essentially the same as the procedure for replacing convenience outlets—to open the circuit, protect it against unauthorized closing, remove cover plate and switch from the box, loosen terminal screws, and disengage both wires (more if it is a three- or four-way switch); then to attach wires to the new switch in proper order (hot wire to brass screw and neutral to white screw) and tighten screws; finally, to place the switch inside its box, insert and tighten its holding screws, and replace the cover plate. If a switch is being replaced with a mercury switch, it has to be mounted vertically with the end of the strip marked "TOP" at the top of the box. Service should be resorted by closing the circuit at the distribution panel.

Lighting

Artificial lighting for schools is the product of electricity and various devices designed to convert electric energy to light. These devices include incandescent, fluorescent, mercury vapor, and cold cathode lamps. For maximum efficiency, they are combined with sockets, luminaires, reflectors, shades, louvers, starters, shafts, ballasts, and controls in a variety of designs called light fixtures or lighting facilities.

Half of the investment in lighting design, equipment, and energy consumed may be wasted if these facilities are not properly maintained. This means that 50 percent of the illumination produced and 50 percent of the electricity consumed are of no value.[8] Lighting maintenance may be defined as the sum of services required to provide maximum returns from the lighting system. This includes the cleaning and washing of lamps, luminaires, and surrounding reflective surfaces at regular intervals, as well as repairs to, or replacement of, components of the system.

Repairing components, rather than replacing them with new, is all too often a wasteful procedure, because experience seems to indicate that, "Too much time and effort frequently are spent trying to patch, mend, or 'make do' an old part, when the economical way is to replace the worn fixtures, components, or materials before they break, burn out, or fail."[9]

The only way that lighting can be kept at a high level and costs at a low level is to plan a lighting maintenance program. This is illustrated by the fact that, with fluorescent lighting, the cost of an adequate system for lighting 700 square feet of space is $700; the cost of electricity to illuminate this space for 1 year is $60, making a combined total cost of $760. If the light output deteriorates by 30 percent during the year, a rate of annual deterioration that should be expected, according to some authorities, the dollar loss for the year is $228.[10] Under a planned lighting maintenance program, adequate stocks of the various components of the lighting system—tubes, globes, starters, sockets, ballast, luminaries, and other items used frequently—are kept on hand in order to make repairs with a minimum of delay.

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[8] Richard F. Tonigan. Lighting Maintenance. *The Nation's Schools*, 66: 97–98, Sept. 1960.

[9] Ibid.

[10] Waterfield Corp. *School Lighting Guide.* Vermilion, Ohio: The Corporation, 1962. p. 6.

The rate at which a lighting system is deteriorating can be determined by testing various areas of buildings periodically with a light meter. Incandescent lamps should have the proper rating for the voltage of current supplied. (The local electric power company can supply information on this point.) If the voltage supplied is substantially above the lamp rating, lamp life will be materially shortened; if substantially lower, lamps will not provide the light output of which they are capable.

The problem of voltage is not so critical with fluorescent lamps, because each ballast is designed to operate at the nominal voltage embossed on it. For example, ballasts embossed with a nominal voltage of 118 will operate satisfactorily on voltages between 110 and 125.

When fluorescent luminaires become inoperative, it is recommended that:

- All lamps be checked or changed.
- All sockets be examined, as lamps are removed, to determine whether there is proper and positive contact with lamp pins.
- All connections within the luminaires be examined to insure their conformity with the wiring instructions appearing on the ballast.
- Each ballast be examined and tested.

A planned lighting maintenance program should include the following practices:

- Periodic lamp replacement. (This will prove more advantageous than withholding replacement until failure occurs.)
- Periodic cleaning and washing of light fixtures.
- Use of cleaning and washing devices, techniques, and compounds of proven efficiency.
- Keeping of a supply of spare parts on hand. (A trip to the supplier for every replacement wastes time.)

Some suggestions and procedures that have proved helpful in washing light fixtures are:

- Render each luminaire shock-free before washing. (Turning off the lights may leave too little illumination to perform the work properly.) Sockets can be made shock-free by covering them with masking tape.
- Allow plastic parts to air dry; wiping them with a cloth or chamois creates an electrostatic charge which attracts and holds dirt.
- Fluorescent lamps are not as fragile as most people believe, but should be handled with care.
- The purchase of a small machine designed especially to grind old fluorescent lamps into small fragments for disposal is a good investment.
- Incandescent lamps in ceiling or other fixtures mounted beyond reach can be removed and replaced without a ladder or scaffold by using a rubber vacuum cup ("plumber's friend") with a handle of appropriate length.

Sanitary System

Sanitary facilities and plumbing are essential features of all school buildings (even though some small schools, mostly in rural areas, try to operate without them). These facilities require an abundance of water under pressure and a disposal system for wastes. Both requirements are met in communities where there are water supply and sewage disposal systems. Where these systems are not available to schools, individual water supply systems have to be developed, and either septic tanks or mechanically operated disposal plants have to be installed. Regardless of water source and means of waste disposal, building and plumbing codes, designed to protect the public by regulatory standards concerning cross-connections, back-siphonage, venting, installation, and other items affecting health and safety, are usually applicable either by local ordinances or by State law. However, variations between code restrictions and actual practice among school districts concerning number, type, and location within buildings of sanitary fixtures are often apparent.[11]

Maintenance problems relating to components of sanitary systems that are common to most schools involve water closets, urinals, showers, lavatories, and drinking fountains. Schools that have their own water supply and disposal system have additional problems with grease traps, septic tanks, disposal fields and tile lines, or with sewage disposal plants, if these are used instead of septic tanks.

Water Closets

Water closets operate in two ways: by releasing water from a tank, or by releasing it from the supply line by means of a flushometer valve.

The tank-type commode has a reservoir mounted on or above the back part of the fixture. Water is released from this reservoir to flush the commode by moving a handle, which lifts a rubber ball from its seat on the discharge pipe. As the water level in the reservoir recedes, a float falls, causing a supply valve to open. The tank has an overflow pipe to prevent flooding in case the supply valve sticks in an open position. A constant discharge of water through this overflow may require only bending the float rod to lower the water level; if the float itself is waterlogged, however, it should be replaced. If a

[11] School Planning Laboratory, *Plumbing Fixtures for Educational Facilities*. Stanford, Calif.: School of Education, Stanford University, 1959. p. ix.

leaking plunger valve is causing the discharge of water, then the thumbscrew should be removed from the valve, the rod lever taken out, and the plunger removed. The washer at the end of the plunger should be replaced, the valve seat checked and reground if it is cut or scored; then the assembly should be replaced.

Floats are usually made of either metal or plastic, are airtight hollow spheres, and are attached to the end of a rod which opens a water supply valve when the float is down and closes the valve when the float is elevated (by a full tank). Floats sometimes become waterlogged because of punctures, breaks, or leaks around their threads. This condition prevents their rising as the water level in the tank rises, and hence causes the intake valve to remain open, permitting a continuous flow of water into the tank.

Flush balls are usually made of rubber, are spherical, and have a lift rod screwed into one end. The purpose of the flush ball is to seal the discharge pipe after flushing so that the tank will be refilled.

Both the flush ball and the float can be replaced with new ones by simply unscrewing them from their respective rods and screwing on new parts. (Eyelets with screw threads are integral parts of these spheres.)

Flushometer valves depend upon water volume and pressure for their operation. They are used primarily on water closets, urinals, and service sinks to open supply lines to these fixtures, permitting a predetermined volume of water to pass through. These are metering valves which, when actuated, complete their cycle and shut off automatically. Unlike the tank, they can be operated continuously, that is, without any intervals between flushings. There are two basic designs of flush valves—the diaphragm type and the piston type. The theory of operation of each is fundamentally the same. Each has an upper chamber and a lower chamber connected by a by-pass, which is a small hole or orifice no larger than a pinhole (measuring between .020 and .030 inches in diameter). In the diaphragm type, the separation between the two chambers is by a flexible diaphragm; in the piston type, a piston with its molded cup separates the two chambers.

With either type, when the handle of the valve is moved, pressure is released from one chamber, thereby opening the water line and allowing water to be discharged into the fixture with sufficient force to flush and cleanse it. While water is being discharged from the supply line, a small amount passes through the tiny hole to reestablish pressure in the other chamber, causing the valve to close and shut off the flow of water. The complete cycle requires only a few seconds.

Generally, the only maintenance required for the flushometer valve is to keep it clean, especially the small opening or orifice between the two chambers. (It sometimes becomes clogged with a grain of sand or other particles in the water supply.) Gaskets, washers, and other rubber or plastic parts wear out and have to be replaced occasionally; also, in the diaphragm type, the diaphragm has to be replaced about once each 3 or 4 years. When it is necessary to dismantle one of these valves, it is always advisable to have the manufacturers' drawings, specifications, and instructions at hand.

When water pressure or volume is inadequate to operate the flushometer valve, it will "hang up" when flushed and not return to a closed position, permitting water to flow through and preventing pressure from building up sufficiently to close it. In this event, it is necessary to close the supply valves to all fixture branches, allowing the pressure in the system to build up before turning on the branches, one at a time. This procedure usually builds up enough pressure to seat the flushometer valve and stop the flow of water. When normal pressure in the system is restored, the valve will operate in its usual fashion without sticking.

Urinals

Urinals are operated by means of the flushometer valve, which has been described, or by an automatic flush tank, which is not used as widely now as formerly. It consists of a tank mounted on the wall (or concealed between walls) above the urinal, a siphon, or upside-down U-shaped tube, leading from the tank to the urinal. The siphon discharges water from the tank to flush the urinal as frequently as water fills the tank to a predetermined level. The water supply line to the tank has a throttling valve to control the frequency of flushings by controlling the speed with which water fills the tank. There should also be a stop valve on the high pressure (or water main) side of the control valve. The stop valve should always be used to start or stop the flush tank operation, or to isolate the throttling valve, tank, and siphon for repairs. Once the throttling, or control, valve has been set to flush at a desired frequency, it should not be tampered with unless it needs repairs.

Siphons sometimes develop leaks causing loss of air. These must be stopped, since air lost from the siphon tube will cause it to stop functioning. If the tank constantly discharges small quantities of water as a stream, it probably has a faulty siphon. If it cannot be repaired, a new one will have to be installed.

Showers

Showers, lavatories, and drinking fountains have similar maintenance problems, most of which relate to spray or shower head controls, and faucets.

Shower heads require very little maintenance except an occasional cleaning to remove mineral deposits (customarily found in water) from forming inside the discharge opening. Some manufacturers produce shower heads that can be made self-cleaning if one adjusts the head to a full open position. Those requiring cleaning can be taken apart (usually by loosening an Allen screw, then backing the head off the supply pipe), and affected parts can be scrubbed with a light abrasive.

Master controls regulating water temperature for showers should be located in a cabinet or other enclosure and made secure against tampering or adjustment by unauthorized persons. (This is a safety precaution against possible injury by scalding water.)

Faucets and other water supply outlets have valves which shut off and regulate the flow of water. Most of these valves have hard rubber or composition gaskets, which wear out, as evidenced by water dripping from the faucet. Where gasket replacement is indicated, the branch supply valve (usually located beneath the lavatory or drinking fountain) should be closed; then the handle assembly should be removed by unscrewing the union nut with a wrench of appropriate size (a monkey wrench may scar the fitting). The handle should be removed by turning it in a counterclockwise direction until it is freed from its channel. The old gasket should be removed from the bushing by taking out its holding screw with a screwdriver. A new gasket should be placed on the shaft, and the screw inserted and tightened. The bushing and valve seat should be checked for scars or erosion which could cause a leak. A scarred bushing should be replaced; a valve seat can be reground with a special valve-grinding tool available at most hardware and plumbing stores. Instructions for its use are furnished with the kit.

Grease Traps

While grease traps and disposal systems are not internal components of buildings, they are a part of the sanitary system for those schools which must have their own waste disposal systems. For this reason, they are discussed here.

The purpose of a grease trap or interceptor is to catch wastes from the kitchen that interfere with the efficient operation of the septic tank. These traps should be cleaned by scraping or scouring and then flushed with a hose at regular intervals during the school year. Solid particles or deposits should be removed monthly; grease from the top of the trap, as required. If odors occur around the interceptor, it is probable that its top is not well-seated, that cleaning may be required, or that the discharge line is blocked. With the use of new detergents, grease traps should have the capacity to hold the discharge from the kitchen for a 24-hour period. Liquids from them should discharge directly into the septic tank, not into the subsurface disposal system.[12]

Septic Tanks

Septic tanks should be inspected at least once each year. Frequency of cleaning depends on their capacity and the amount of daily flow of sewage into them. When the total depth of scum and solids exceeds one-third the depth of a tank, it should be cleaned by pumping. (There are no chemicals or digesting yeasts capable of reducing solids in the septic tank to a point where cleaning is unnecesary.) In cleaning these tanks, scouring or the use of any caustic should be avoided, because these procedures kill bacteria. (Wherever possible, tank cleaning should be done in the spring, when warm weather hastens the formation of bacteria essential to septic tank operation.)

In most communities where septic tanks are used, there are commercial firms that clean them. In these communities school officials may prefer to use this service, by contract, rather than provide necessary equipment for maintenance personnel to do the work. (The local health department can make suggestions on how or where to obtain septic tank cleaning services.)

When large septic tanks are being cleaned, care should be taken not to enter them until they have been thoroughly ventilated and gases have been removed to prevent explosion hazards or asphyxiation of workers. Anyone entering a septic tank should have one end of a stout rope tied around his waist; the other end should be held above ground by another person strong enough to pull him out if he should be overcome by any gas remaining in the tank.[13]

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[12] Kentucky State Department of Education. *School Plant Operations for Kentucky Schools*. Frankfort, Ky.: The Department, 1958. Part II, Topic 9.

[13] U.S. Department of Health, Education, and Welfare, Public Health Service. *Manual of Septic Tank Practice*. Washington: U.S. Government Printing Office, 1959. p. 31.

Disposal Field

The disposal field for a septic tank system is the soil through which lateral lines run. The area of a satisfactory field depends upon soil percolation (absorption of liquids by the soil and their subsequent evaporation) and the volume of fluid to be absorbed. (In some smaller installations a sand filter is employed for this purpose.) The field requires little maintenance except keeping it free of weed or tree growth, or of cuttings or other litter, so that natural evaporation of moisture from the soil will not be impeded. Precautions should be taken to prevent trucks or other heavy vehicles from crossing the field, as these vehicles compact the soil and may damage the tile system underneath.

Tile Lines

Tile lines carry effluent from the septic tank to be dispersed in the disposal field. Also known as the lateral system, these lines consist of farm tile in a 2-foot trench with 6 inches of crushed stone over and under to allow water to seep into the soil. The linear feet of subsurface disposal tile required will depend upon soil percolation and the daily amount of water discharged into it.

Lateral tile lines may fail if septic tanks are not cleaned at proper intervals, causing tile pores to become clogged; or heavy machinery driven across the soil's surface may crush them. In either event, the maintenance procedure is to dig up the tile, and replace it with new. If the crushed stone becomes intermixed with soil while uncovering tile lines, it is advisable to discard this stone and replace it with new. If the entire field and its lines are clogged with sludge, it may be necessary to relocate the septic tank and to develop an entirely new field downgrade from the old, connecting the sewage lines at the new location.

Sewage Disposal Plants

In addition to the septic tank method of sewage disposal, there are special treatment plants which may be used at any location where the effluent can be either absorbed in the soil or piped away. In practice, these are utilized only where the nature of the soil prevents it from absorbing water in large quantities or where public health authorities having jurisdiction require special treatment plants.

Aside from the regular maintenance of electric motors to operate treatment plants, certain maintenance procedures must be followed in caring for agitators, aerators, pumps, and tanks. Information on these procedures should be obtained from the installing contractor.

APPENDIX A

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APPENDIX B

Glossary of Maintenance Terms

Anchor—Irons of special form used to fasten together timbers or masonry.

Anchor bolt—Bolt which fastens columns, girders, or other members to concrete or masonry.

Areaway—A sunken space, usually walled with brick, stone, or concrete, to afford entry or permit access of air and light to a basement.

Backing—The bevel on the top edge of a hip rafter that allows the roofing board to fit the top of the rafter without leaving a triangular space between it and the lower side of the roof covering.

Ballon frame—The lightest and most economical form of construction, in which the studding and corner posts are set up in continuous lengths from first-floor line or sill to the roof plate.

Baluster—A small pillar or column used to support a rail.

Balustrade—A series of balusters connected by a rail, generally used for porches, balconies, and the like.

Base—The bottom of a column; the finish of a room at the junction of the walls and floor.

Batten (cleat)—A narrow strip of board used to fasten several pieces together.

Beam—An inclusive term for joists, girders, rafters, and purlins.

Bedding—A filling of mortar, putty, or other substance in order to secure firm bearing.

Blooming—A term used to designate a condition of concrete floors, in which they give off a powdery dust. This means that the flooring is actually disintegrating, though very slowly.

Braces—Pieces fitted and firmly fastened to two others at any angle in order to strengthen the angle thus treated.

Bracket—A projecting support for a shelf or other structure.

Break joints—To arrange joints so that they do not come directly under or over the joints of adjoining pieces, as in shingling, siding, etc.

Bridging—Pieces fitted in pairs from the bottom of one floor joist to the top of adjacent joists, and crossed to distribute the floor load; sometimes, pieces of width equal to the joists and fitted neatly between them.

Building paper—Cheap, thick paper, used to insulate a building before the siding or roofing is put on; sometimes placed between double floors.

Built-up-timber—A timber made of several pieces fastened togther, and forming one of larger dimension.

Carriages—The supports or the steps and risers of a flight of stairs.

Casement—A window in which the sash opens upon hinges.

Casing—The trimming around a door or window opening, either outside or inside, or the finished number around a post or beam, etc.

Ceiling—Narrow, matched boards; sheathing of the surfaces that inclose the upper side of a room.

Center-hung sash—A sash hung on its centers so that it swings on a horizontal axis.

Chamfer—A beveled surface cut upon the corner of a piece of wood.

Checks—Splits or cracks in a board, ordinarily caused by seasoning.

Clamp—A mechanical device used to hold two or more pieces together.

Columns—A support, square, rectangular, or cylindrical in section, for roofs, ceilings, etc., composed of base, shaft, and capital.

Concrete—An artificial building material made by mixing cement and sand with gravel, broken stone, or other aggregate, and sufficient water to cause the cement to set and bind the entire mass.

Conductors—Pipes for conducting water from a roof to the ground or to a receptacle or drain; downspout.

Coping—The top layer, or covering course, of a wall, usually consisting of a concrete slab, cut stone, or half tile, cemented into place and waterproofed, at joints.

Cornice—The molded projection which finishes the top of the wall of a building.

Counterflashings—Strips of metal used to prevent water from entering the top edge of the verticle side of a roof flashing; they also allow expansion and contraction without danger of breaking the flashing.

Darby—A float for finishing cement.

Deadening—Construction intended to prevent the passage of sound.

Drip—The projection of a window sill or water table to allow the water to drain clear of the side of the house below it.

Dry wall—A wall constructed of plaster board, cement board, or some other type of material, nailed or stapled to framing members, with joints filled, taped, and sanded to give the appearance of a plastered wall. Also, an outside wall usually constructed of field stone without the use of mortar or cement.

Dry Well—A pit, basin, or hole in the ground, usually lined with brick, stone, tile or lightweight aggregate block. This pit serves as a catch basin for surface water until it is absorbed.

Dusting—A term used to designate a condition of concrete flooring, similar to blooming. Dusting is attributed to the natural chemical action which takes place as the lime content of the concrete unites with the moisture ever present in the air.

Efflorescence—A change on the surface, or throughout, to a powder from a loss of water. An example of this is frequently seen on the outer surface of brick walls which have the appearance of being streaked with white powder.

Fascia—A flat member of a cornice or other finish, generally the board of the cornice to which the gutter is fastened.

Ferrules—Rings or caps, usually of metal, put around a tool handle, post, pile, etc., to strengthen them or prevent them from splitting.

Flashing—The material used and the process of making watertight the roof intersections and other exposed places on the outside of the house.

Flue—The opening in a chimney through which smoke passes.

Flush—Adjacent surfaces even, or in some plane (with reference to two structural pieces).

Footing—An enlargement at the lower end of a wall, pier, or column, to distribute the load.

Foundation—That part of a building or wall which supports the superstructure.

Framing—The rough timber structure of a building, including interior and exterior walls, floor, roof, and ceilings.

Furring—Narrow strips of board nailed upon the walls and ceilings to form a straight surface upon which to lay the laths or other finish.

Gable—The vertical triangular end of a building from the eaves to the apex of the roof.

Gambrel—A symmetrical roof with two different pitches or slopes on each side.

Girder—A timber used to support wall beams or joists.

Groove—A long hollow channel cut by a tool, into which a piece fits or in which it works. Two special types of grooves are the *dado*, a rectangular groove cut across the full width of a piece, and the *housing*, a groove cut at any angle with the grain and part way across a piece. Dados are used in sliding doors, window frames, etc.; housings are used for framing stair risers and treads in a string.

Ground—A strip of wood assisting the plasterer in making a straight wall and in giving a place to which the finish of the room may be nailed.

Header—A short joist supporting tail beams and framed between trimmer joists; the piece of stud or finish over an opening; a lintel.

Heel of a rafter—The end of foot that rests on the wall plate.

Hip roof—A roof which slopes up toward the center from all sides, necessitating a hip rafter at each corner.

Hydrostatic pressure—The force exerted by underground water.

Hydrolysis—The chemical process of decomposition involving addition of the elements of water.

Jamb—The side piece or post of an opening; sometimes applied to the door frame.

Joists—Timbers supporting the floor boards.

Laths—Narrow strips to support plastering.

Lattice—Crossed wood, iron plate, or bars.

Lintel (header)—The piece of construction or finish, stone, wood, or metal, which is over an opening; a header.

Louver—A kind of window, generally in peaks of gables and the tops of towers, provided with horizontal slots which exclude rain and snow and allow ventilation.

Mullion—The construction between the openings of a window frame to accommodate two or more windows.

Muntin—The vertical member between two panels of the same piece of panel work. The vertical sash-bars separating the different panels of glass.

Newel—The principal post of the foot of a staircase; also the central support of a winding flight of stairs.

Nosing—The part of a stair tread which projects over the riser, or any similar projection; a term applied to the rounded edge of a board.

Parapet—A low wall extending above the lower edges of a roof. Also, a low wall or protective railing at the edge of a platform, bridge, etc.

Piers—Masonry supports, set independently of the main foundation.

Pilaster—A portion of a square column, usually set within or against a wall.

Pitch—Inclination or slope, as for roofs or stairs, or the rise divided by the span.

Pitch board—A board sawed to the exact shape formed by the stair tread, riser, and slope of the stairs and used to lay out the carriage and stringers.

Plaster—A mixture of lime, hair, and sand, or of lime, cement and sand, used to cover outside and inside wall surfaces.

Plate—The top horizontal piece of the wall of a frame building upon which the roof rests.

Plate cut—The cut in a rafter which rests upon the plate; sometimes called the seat cut.

Plumb cut—Any cut made in a vertical plane; the vertical cut at the top end of a rafter.

Ply—A term used to denote a layer or thichness of building or roofing paper, as in "two-ply," "three-ply," etc.

Pointing—The process of scratching out old mortar from the joints of a masonry wall and replacing with new mortar or other material.

Pulley stile—The member of a window frame which contains the pulleys and between which the edges of the sash slide.

Purlin—A timber supporting several rafters at one or more points, or the roof sheeting directly.

Ridge—The top edge or corner formed by the intersection of two roof surfaces.

Rise—The verticle distance through which anything rises, as the rise of a roof or stair.

Riser—The vertical board between two treads of a flight of stairs.

Roofing—The material put on a roof to make it windproof and waterproof.

Saponification—The hydrolysis of any ester into the corresponding alcohol and acid; hence, any hydrolysis.

Sash—The framework which holds the glass in a window.

Scab—A short piece of lumber used to splice, or to prevent movement of two other pieces.

Scaffold or staging—A temporary structure or platform enabling workmen to reach high places.

Scale—A short measurement used as a proportionate part of a larger dimension. The scale of a drawing is expressed as ¼ inch=1 foot.

Scupper—An opening cut through a parapet wall to permit water falling on a building roof to escape to a downspout or directly to the ground.

Sheathing—Wall boards, roofing boards; generally applied to narrow boards laid with a space between them, according to the length of a shingle exposed to weather.

Sheathing paper—The paper used under siding or shingles to insulate in the house; building papers.

Siding—The outside finish between the casings.

Sleeper—A timber laid on the ground to support a floor joist.

Spalling—The chipping or crumbling of a masonry wall.

Span—The distance between the bearings of a timber or arch.

Specifications—The written or printed directions regarding the details of a building or other construction.

Stucco—A fine plaster used for interior decoration and fine work; also for rough outside wall coverings.

Stud—An upright beam in the framework of a building.

Subfloor—A wood floor which is laid over the floor joists and on which the finished floor is laid.

Threshold—The beveled piece over which the door swings; sometimes called a carpet strip.

Truss—Structural framework of triangular units for supporting loads over long spans.

Valleys—The internal angle formed by the two slopes of a roof.

Water table—The finish at the bottom of a house which carries the water away from the foundation.

Wooden brick—Piece of seasoned wood, made the size of a brick, and laid where necessary to provide a nailing space in masonry walls.

APPENDIX C

Building Maintenance Survey
(Checklist)

Name of School ________________; Bldg. Identification ______; Age of Bldg. ____; Survey Date______

Survey Team: ________; ________; ________; ________; ________; ________, Chairman

Fill in all blanks that apply to this building.

I. EXTERIOR MAINTENANCE

	No. squares	*Year installed*	*Observations*	*Cost estimate if repairs are needed*
A. Roof				
1. Design				
a. Flat	______	______	______	______
b. Gable	______	______	______	______
c. Decorative	______	______	______	______
2. Mat				
a. Type				
(1) Built-up	______	______	______	______
(2) Composition	______	______	______	______
(3) Concrete	______	______	______	______
(4) Corrugated	______	______	______	______
(5) Gravel	______	______	______	______
(6) Metal	______	______	______	______
(7) Paper-felt	______	______	______	______
(8) Shingle	______	______	______	______
(9) Other	______	______	______	______

b. Condition (indicate condition by checking appropriate terms)

(1) Cracks	______	(7) Powdery	______	Nails, caps, cleats:	
(2) Bulges	______	(8) Alligatored	______	Loose	______
(3) Wrinkles	______	(9) Open seams	______	Rusted	______
(4) Blisters	______	(10) Rust	______		
(5) Tears	______	(11) Fish mouths	______		
(6) Brittle	______	(12) Debris	______		

I. EXTERIOR MAINTENANCE—Continued

A. Roof—Continued

3. Ridges, edges, valleys: Damaged coping ____; Rust ____; Bleeding ____; Poor bond ____
4. Gravel stops: Decayed ____; Deteriorating ____
5. Fascia: Decayed ____; Loose nails ____; Open joints ____; Needs paint ____
6. Expansion joints: Broken ____; Insufficient ____
7. Flashing and counterflashing: Loose Joints ____; Rust damage ____; Bent or broken metal ____; Cement deteriorated ____
8. Projections:
   a. Skylights: Glazing ____; Calking ____; Flashing ____; Condensation ____
   b. Chimneys: Loose brick ____; Decayed mortar joints ____; Broken cap ____; Loose cap ____; Bulging ____; Leaning ____; Dangerous cracks ____
   c. Vent pipes
   d. Ventilators
   e. Antenna
   f. Flagpole
   g. Monitors
   h. Firewalls
   i. Towers

   (c.–i.) Evidence of moisture penetration at base ____; Rust ____; Missing, broken, or deteriorated caps ____; Other defects ____
9. Parapets: Out of plumb ____; Spalling ____; Cracked ____; Decayed mortar joints ____
10. Coping: Porous ____; Cracked ____; Open joints ____; Underside drip ____; Loose sections ____
11. Scuppers: Cluttered with debris ____; Deteriorated ____; Throat too small ____
12. Gutters: Sagging ____; Rusting ____; Broken joints ____; Loose or missing anchors ____; Missing sections ____; Heavily pitted ____; Replace entirely ____
13. Downspouts: Disconnected at scuppers or gutters ____; Leaking joints ____; Missing sections ____; Rusting ____; Too high from ground ____; Mashed and bent ____; No splash blocks ____; Discharged water drains toward foundation ____; Discharged water on walks ____; Underground drainage tile clogged ____; Obstructions in downspouts ____
14. Roof deck: Rotted ____; Warped ____; Stains evident ____; Rust spots ____; Cracks ____
15. Rafters and purlines: Sagging ____; Over-spanned ____; Split or broken ____; Decayed ____; Twisted ____; Improperly tied ____

Total Estimated Cost of Roof Repair $________

B. Walls

1. Below grade
   a. Footings: Cracked ____; Evidence of settling ____; Evidence of soil and/or rock movement ____; Moisture penetration ____; Frost damage ____; Mildew ____; Damp walls ____
   b. Foundations: Cracked or broken ____; Spalling ____; Mortar shrinkage ____; Soft or deteriorating mortar joints ____; Wall movement indicated by open joints ____; Water build-up ____
   c. Areaways, window wells, outside stairwells: Inadequate drainage ____; Clogged drainage ____; Frost damage ____; Mildew ____; Damp walls ____;

I. EXTERIOR MAINTENANCE—Continued

B. Walls—Continued

1. Below grade—Continued

   d. Underground drainage system: Evidence of water build-up ____; Tile lines clogged ____; Tile lines broken or damaged ____; Obstruction at entrance to storm sewer ____

2. Above grade

   a. Cornices: Cracked ____; Loose ____; Decayed ____; Dangerous ____

   b. Masonry walls: Cracks ____; Open joints ____; Efflorescence ____; Bulging ____; Out-of-plumb ____; Leaning ____; Loose brick ____; Mortar shrinkage ____; Spalling ____; Broken arches ____

   c. Curtain walls: Cracked panels ____; Crazed panels ____; Faded panels ____; Flaked panels ____; Weathered surfaces ____; Corrosion evidence ____; Rusted fasteners ____; Deteriorated calking ____; Broken or cracked glass ____

   d. Wood siding: Decayed boards ____; Paint failure ____; Cracking ____; Crumbling ____; Flaking ____; Mildew ____; Alligatoring ____; Blisters ____; Loose nails ____; Warped boards ____; Loose boards ____

   e. Windows: Broken, cracked, or missing glass ____; Deteriorated putty ____; Decayed sash ____; Damaged muntins ____; Balance damage ____; Sash cord broken ____; Weatherstripping needed ____; Decayed frames ____; Calking around frames ____; Cracked or broken lintels ____; Cracked or broken sills ____; Paint failure ____; Rust prevalence ____; Warped, bent, or sprung projections ____

   f. Doors: Improperly hung ____; Cracked or broken lintels ____; Rusted lintels ____; Poorly anchored frames ____; Deteriorated frames ____; Worn thresholds ____; Broken glass ____; Damaged mullions ____; Loose or broken hinges ____; Worn closers ____; Worn or inoperable panic exit devices ____; Stops or safety chains missing ____; Damaged locks ____; Calking needed ____; Paint needed ____; Replace entire door ____

   g. Vents and louvers: Damaged or broken ____; Rusted ____; Screens missing ____; Loose ____; Replace ____

   h. Porticoes and entrances: Decayed columns or pilasters ____; Worn step tread ____; Broken or loose handrails ____; Damaged floors or floor covering ____; Frost damage ____

Total Estimated Cost of Wall Repair $______________

C. Stacks

1. Brick or masonry: Loose brick ____; Open joints ____; Loose or broken caps ____; Leaning ____; Cracks ____; Broken flue tile ____; Lightning Damage ____

2. Metal or other: Loose guys ____; Rust ____; Loose anchors ____; Broken seams or joints ____; Replace completely ____

Total Estimated Cost of Stack Repair $______________

D. Miscellaneous exterior maintenance

1. Catch basins: Filled with dirt or litter ____; Broken or missing gratings ____; Deteriorated basin walls ____; Broken connections at junction points ____

2. Storm sewers: Clogged with debris, roots, or dirt ____; Broken gratings ____; Broken or damaged tile ____; Broken connections at junction points ____

3. Vegetation damage: Root growth under walkways ____; Trees or shrubs too close to building ____; Roots in sewage or drain lines ____; Excessive vegetation growth on sewage disposal field ____

I. EXTERIOR MAINTENANCE—Continued

D. Miscellaneous exterior maintenance—Continued

4. Drainage problems: Soil sloped toward building ____; Soil depressions near building ____; Walks inundated during rains ____; Dangerous holes in soil or surfaces around playground equipment ____
5. Sewage disposal system:
   a. Septic tank and disposal field: Clogged septic tank outlets ____; Septic tank needs cleaning ____; Damaged tile in drainage field ____; Relocate tank and field ____
   b. Treatment plant: Worn or damaged pumps ____; Worn or damaged motors ____; Receiving tanks need cleaning ____; Aerators need cleaning or replacing ____; Enclosure needs attention ____

Total Estimated Cost of Miscellaneous Exterior Maintenance $____________

ESTIMATED COST OF EXTERIOR MAINTENANCE NEEDS

1. Roof (Items A–1 through 15) $____________
2. Walls (Items B–1 through 2–h) ____________
3. Stacks ____________
4. Miscellaneous exterior maintenance ____________

____

TOTAL EXTERIOR MAINTENANCE $____________

II. INTERIOR MAINTENANCE

A. Structural System (Wood)

1. Joists (Ceiling and floor: wood): Sagging ____; Over-spanned ____; Buckled ____; Split or broken ____; Improperly bridged ____; Dry rot ____; Termites ____; Improperly tied ____; Dampness ____
2. Girders and sills: Moisture ____; Cracked ____; Split ____; Decayed ____; Termites ____
3. Sole plates
4. Templates
5. Top plates
6. Studding
7. Ledger strips
8. Lintels

(Items 3–8:) Cracked ____; Split ____; Broken ____; Decayed ____; Sagging ____; Moisture ____; Dry rot ____; Termites ____

9. Stairs and stairwells: Broken or loose balustrades ____; Loose handrails ____; Worn treads ____; Broken or splintered nosing ____; Slippery tread ____; Loose newel posts ____; Decayed, damaged, or broken stringers ____; Damaged risers ____

B. Structural System (Steel)

1. I-Beams
2. Open truss or open web steel joists
3. Channels
4. Studs
5. Base plates
6. Tubular steel columns: Damaged inserts ____; Damaged or broken brackets ____; Rust and oxidation ____

II. INTERIOR MAINTENANCE—Continued

C. Structural System (Concrete)

1. Beams
2. Joists
3. Lintels
4. Trusses
5. Columns
6. Posts

} Chalking ____; Rusted fittings, anchors, etc. ____; Efflorescence ____; Cracks ____; Expansion or contraction displacement ____

ESTIMATED COST FOR STRUCTURAL MAINTENANCE $______________

D. Interior surfaces and related elements

1. Ceilings: Cracks ____; Sagging ____; Broken laths ____; Loose plaster ____; Needs paint ____; Needs cleaning ____
2. Walls: Cracks ____; Bulging ____; Broken plaster ____; Broken laths ____; Other damage ____; Paint ____
3. Floors
   a. Wood: Badly worn ____; Splintered ____; Remove old finish ____; Raised grain ____; Refinish ____; Oiled ____; Moisture penetration—swelling ____; Split tongue and groove ____; Warped ____; Exceptionally noisy ____
   b. Resilient tile or covering (rubber, asphalt, vinyl, vinyl-asbestos, cork, linoleum, etc.): Broken, cracked, or curled tile ____; Burns ____; Missing sections ____; Loose sections ____; Stains ____; Odors ____; Mold or mildew ____; Defective underlayment ____; Badly worn ____; Discolored ____; Bleeding ____; Pitted or serious indentations ____; Replace completely ____
   c. Hard-surface tile (marble, slate, quarry, ceramic, etc.): Broken ____; Loose ____; Uneven surface ____; Bad joints ____; Discolored ____; Stains ____; Dust problems ____
   d. Concrete or magnesite: Dusting ____; Pitted ____; Discolored ____; Cracks ____; Rough or irregular surfaces ____
   e. Terrazzo: Cracked ____; Discolored or stained ____; "Bloomed" ____; Slippery____
4. Chalk and tack boards: Loose trim ____; Slick ____; Faded ____; Pitted surfaces ____; Loose chalk trough ____; Refinish ____; Replace ____
5. Doors: Improperly hung ____; Broken panels ____; Broken glass ____; Loose or missing screws ____; Loose or broken jams ____; Door sag ____; Loose brackets ____; Broken brackets ____; Worn or defective closers____; Worn, damaged, or missing hardware: Locks ____, strike plates ____, turn knobs ____, pulls ____, hinges ____, kick plates ____, stops, bumpers ____
6. Transoms and breeze windows: Broken glass ____; Broken or damaged hardware ____; Damaged sash ____ Deteriorated putty ____
7. Windows: Decayed casing or trim ____; Broken or damaged security devices ____; Defective weatherstripping ____; Decayed stools ____; Broken or missing pulls ____ Broken or cracked glass ____; Loose putty ____
8. Shades and blinds: Torn, worn, or damaged fabric ____; Damaged rollers ____; Broken brackets ____; Loose brackets ____; Worn or damaged cords ____; defective cord and tape locks ____; Bent, kinked, or warped slats ____; Defective tilters ____; Worn tapes ____; Worn lock ladders____

II. INTERIOR MAINTENANCE—Continued

ESTIMATED COST OF REPAIR OF INTERIOR SURFACES $____________

E. Built-in equipment

1. Lockers: Broken hinges ____; Warped, bent, or sprung doors ____; Missing handles and pulls ____; Broken locks ____; Locks with lost keys ____; Hooks missing ____; Bent or damaged shelving ____; Rust damage ____
   COST $____________

2. Stage equipment
   a. Curtains: Soiled ____; Faded ____; Torn ____; Replace with new ____
   b. Curtain and drapery tracks, traverse rods, etc.: Broken cords or cables ____; Loose floor blocks ____; Damaged rope locks ____; Damaged or worn rigging ____; Counterweight system damaged or broken ____; Loose anchors ____
   c. Curtain or drapery motors and controls: (Should be checked thoroughly by an electrician.)
   d. Lights and light controls: Dead bulbs ____; Dead switches ____; Exposed wiring ____; Overloaded circuits ____; Defective rheostats ____; Overfused panels ____; Replace extension cords with permanent wiring ____; Evidence of shorting in any circuits ____
   COST $____________

3. Auditorium seats: Missing parts: back ____, arm rests ____, Standards ____, seat ____, hinges ____, hinge arms ____, connectors ____, screws ____, bolts ____, nuts ____; Seats not secured to floor ____

4. Auditorium exits: Broken exit signs ____; Exit lights not working ____; Doors do not operate freely ____; Defective hardware ____
   COST $____________

5. Gymnasium equipment
   a. Bleachers: Loose, warped, or broken boards ____; Loose, broken or missing side or back rails ____; Broken hinges ____; Broken casters ____; Loose or broken anchors ____
   b. Backstops: Loose anchors ____; Inoperable winches ____; Worn hoist cables ____; Open gear box (winch) ____; Broken or damaged pulleys ____; Broken, damaged, or loose guys or turnbuckles ____; Broken or damaged liftwires or chains ____; Loose braces ____; Loose sheaves ____; Loose or broken goals ____; Stabilizer cables need adjustment ____
   COST $____________

6. Shower and dressing room equipment
   a. Lockers: Broken hinges ____; Warped, bent, or sprung doors ____; Missing handles and pulls ____; Broken locks ____; Locks with lost keys ____; Hooks missing ____; Bent or damaged shelving ____; Rust damage ____
   b. Showers: Shower heads clogged ____; Floor slippery ____; Clogged strainers and drains ____; Broken or missing soap holders ____; Leaking valves ____; Water mixers not operating safely ____; Shower stall walls need cleaning ____; Shower heads missing ____
   c. Sanitary fixtures: Broken commodes ____; Broken flush valves ____; Damaged, broken, or missing commode seats ____; Leakage at base of commodes ____; Clogged urinals ____; Loose anchors ____; Rusty toilet partitions ____; Broken toilet stall doors ____; Broken toilet tissue dispensers ____; Broken or inoperative soap dispensers ____; Damaged lavatories ____; Leaking lavatory faucets ____; Broken or inoperative paper towel dispensers ____; Broken or damaged mirrors ____
   COST $____________

II. INTERIOR MAINTENANCE—Continued

E. Built-in equipment—Continued

7. Display cases: Broken or cracked glass ____; Broken locks ____; Damaged doors ____; Loose anchors ____

COST $______________

8. Instructional equipment
   a. Science laboratory tables: Loose, damaged, or exposed electrical connections and outlets ____; Leaking water faucets ____; Unsatisfactory gas connections, outlets, or jets ____; Broken or missing drawer and door pulls ____; Damaged locks ____; Damaged locker doors or drawers ____; Sink damage ____
   b. Home economics equipment: (Have an electrician check all electric stoves, washers, dryers, and other built-in electrical equipment both for repairs needed and for safety); Broken cabinet doors and door hardware ____; Broken mirrors ____; Faucet leaks ____; Improper or damaged gas connections and outlets ____; Replace extension cords with permanent wiring ____; Install pilot lights where needed ____
   c. Shop equipment: (Every piece of built-in, permanent, and floor-anchored equipment should be thoroughly checked by the instructor using the equipment and by a knowledgeable mechanic to determine what repairs are needed and to evaluate their safety features.)

ESTIMATED COST OF REPAIRING BUILT-IN EQUIPMENT $______________

9. Fire protective equipment
   a. Sprinkler systems: (Check all valves in water feed lines to see that they are open, free of corrosion; check air pressure in dry lines; determine that the entire system is fully operable.)
   b. Standpipe and hose: (Check hose to see that it is properly stored, is not decayed, is attached to standpipes, and that its nozzle is open and ready for use.)
   c. Fire extinguishers: (Inspect hose, nozzle, and gaskets; examine as to condition of pump or pressure and for deterioration or injuries due to misuse; test the direct acting pump type by moving the pump handle several in and out strokes; test continuous-stream type extinguishers by pumping up pressure and ejecting vaporizing liquid in both up-and-down and around-the-clock positions; test the stored-pressure type extinguisher by discharging a small amount of vaporizing liquid to the atmosphere. Before recharging, read the manufacturer's directions on the instruction name plate.

   Soda-acid type extinguishers should be examined several times each year to see that they have not been tampered with, are not empty, have not been removed from their designated places, and to see that the orifice of the nozzle is not clogged. Subject this type extinguisher to a hydrostatic pressure test every 5 years to see that it is capable of safely withstanding the pressures which may be generated when in operation. Follow manufacturer's instructions when recharging the soda-acid extinguisher.

   Chemical foam type extinguishers—Follow same inspection procedures as for soda acid extinguishers.

   Cartridge-operated type extinguishers should be inspected to see that the water level is up to the proper mark. Cartridges should be removed, examined, and weighed. If there is a weight loss of ½ ounce or more for

II. INTERIOR MAINTENANCE—Continued

E. Built-in equipment—Continued

cartridges, they should be discarded. Other inspection procedures should be the same as for soda-acid extinguishers.

COST OF FIRE PROTECTIVE EQUIPMENT $______

F. Electrical and mechanical systems

1. Electrical system: Obsolete wiring ____; Insufficient service outlets ____; Obsolete light fixtures ____; Overloaded circuits ____; Overloaded service panels ____; Exposed wiring ____; Replace extension cords with permanent installation ____; Replace service panel ____; Rusty or leaking weather-head ____; Insufficient grounds ____. COST $______
2. Heating: Different types of heat-generating units require different maintenance procedures. Each manufacturer provides instructions and recommendations for operating and maintaining his particular product. These instructions should be followed if satisfactory results are to be achieved. COST $______
3. Ventilating system: Distributing ducts need cleaning ____; Filters need replacing ____; Automatic controls are not functioning properly ____; Fans and motors need cleaning ____; Fans and motors need oiling ____; Vent dampers need adjusting ____; Roof dampers need adjusting or repairing ____; Thermostats need adjustment ____; Shaft bearings need oiling ____. COST $______

TOTAL COST OF ELECTRICAL AND MECHANICAL SYSTEMS $______

APPENDIX D

Manufacturers' Organizations Furnishing Helpful Information

The author and the Office of Education are indebted to many manufacturers, associations, and institutes for literature, specifications, and recommended maintenance procedures relating to products their members supply for school constructions. Associations whose printed materials are quoted directly or are adapted in any way for use in this publication are the following:

Acoustical Materials Association
American Carpet Institute
American Ceramic Society
American Concrete Institute
Asphalt & Vinyl Tile Institute
Building Stone Institute
Building Waterproofers Association
The Finishing Lime Association
Fire Equipment Manufacturers Association
Institute of Boiler & Radiator Manufacturers
Maple Flooring Manufacturers
Marble Institute of America
National Fuel Oil Council
National Oak Flooring Manufacturers Association
National Paint, Varnish, and Lacquer Association
National Roofing Contractors Association
National Sanitary Supply Association
National Terrazzo & Mosaic Association
Oil Heat Institute
The Painting and Decorating Contractors of America
Pennsylvania Slate Products Guild, Inc.
Portland Cement Association
Rubber and Vinyl Flooring Council of The Rubber Manufacturers Association
Steel Boiler Institute
Structural Clay Products Institute
Structural Tile Institute
Tile Council of America

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