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by

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Outdoor Exposure Sites of the National Research Council

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CANADA now has seven test sites for the study of the behavior of materials under outdoor conditions at different locations across the country. These sites were established by the Division of Building Research of the National Research Council. With arrangements completed for the reciprocal use of the nine sites of the American Society for Testing Materials, weathering studies can now be conducted at 16 different locations on the North American Continent. Climatic conditions at the sites vary from severe tropical conditions in the Panama Canal Zone to low arctic temperatures of the Northwest Territories. The N.R.C. Associate Committee on Corrosion Research and Prevention makes use of the sites in their studies of the atmospheric corrosion of metals and protective coatings for metals.

Location of Sites

During the exposure of materials to outdoor weathering, changes occur in their physical and chemical characteristics. These changes vary widely, depending in part upon the particular material, duration of exposure, and the atmospheric conditions to which it has been subjected. In selecting locations for exposure testing, it was accordingly decided that six different atmospheric conditions were essential. The conditions at the areas chosen were to be typical of a marine atmosphere, a marine-industrial, industrial, a far northern location in Canada, a rural location with high humidity and a rural, low humidity atmosphere. Seven widely separated exposure sites have been provided; five are land sites, and two are roof areas. The location of each site, and the atmospheric condition of which it is considered typical, are as follows:

Ottawa—rural, high humidity; located on the Montreal Road property of N.R.C., approximately four miles from the center of the city.

Saskatoon—rural, low humidity; until 1958 this site was situated on the campus of the University of Saskatchewan but because of new construction it was necessary to move to other university property on the Sutherland Road, approximately two miles northeast of the former location.

Norman Wells, N.W.T.—a far northern site; located in the Mackenzie River Valley, approximately 50 miles south of the Arctic Circle.

Montreal—industrial; located on the roof of a two-storey stores building of Canadian National Railways, in the Point St. Charles district and adjacent to the CNR Research and Development Laboratories at 1801 Leber St.

Halifax—marine-industrial; located on the roof of a Federal public building in the downtown area of the city, two blocks from the harbor.

York Redoubt, N.S.—marine; located on the east coast of Canada, approximately seven miles from the city of Halifax, this area is at an elevation of 100 ft., and is 300 ft. from the ocean.

Rocky Point, B.C.—marine; located on the west coast of Canada on the southeast extremity of Vancouver Island and approximately 15 miles from the city of Victoria, it is at an elevation of 50 ft. and approximately 1500 ft. from the ocean.

In addition to these seven sites, the site of The Consolidated Mining and Smelting Company of Canada Limited has been made available to the Research Council for outdoor corrosion studies. This semi-industrial site is located at Birchbank in the Columbia River Valley approximately six miles north of Trail, B.C.

The location of all the sites is shown in Figure 1.

A.S.T.M. Sites

Work of the American Society for Testing Materials on atmospheric testing dates back more than 50 years. During this time, many different sites have been used in exposing in excess of 25,000 test specimens. In recent years, the sites of the Society have been placed under the jurisdiction of the ASTM Advisory Committee on Corrosion. The work of this committtee has been essentially that of co-ordinating the activities of various ASTM committees interested in weathering studies and in providing the facilities and types of atmosphere required for their exposure testing programs. The location of these sites is as follows:

New York City—industrial atmosphere; located on the roof of the 16-storey Port of New York Authority Building at Eighth Ave. and Fifteenth St.

Columbus, Ohio—semi-industrial atmosphere; located on the roof of the five-storey Battelle Memorial Institute Building.

University Park, Pa.—rural atmosphere; located on land belonging to Pennsylvania State College.

Atlantic Coast: Kure Beach, N.C.—marine atmosphere; adjacent to the test facilities of the International Nickel Company at Kure Beach.

NOTE:—This paper was presented during the 42nd Annual Conference of The Chemical Institute of Canada, Halifax, N.S., May 25-27, 1959.

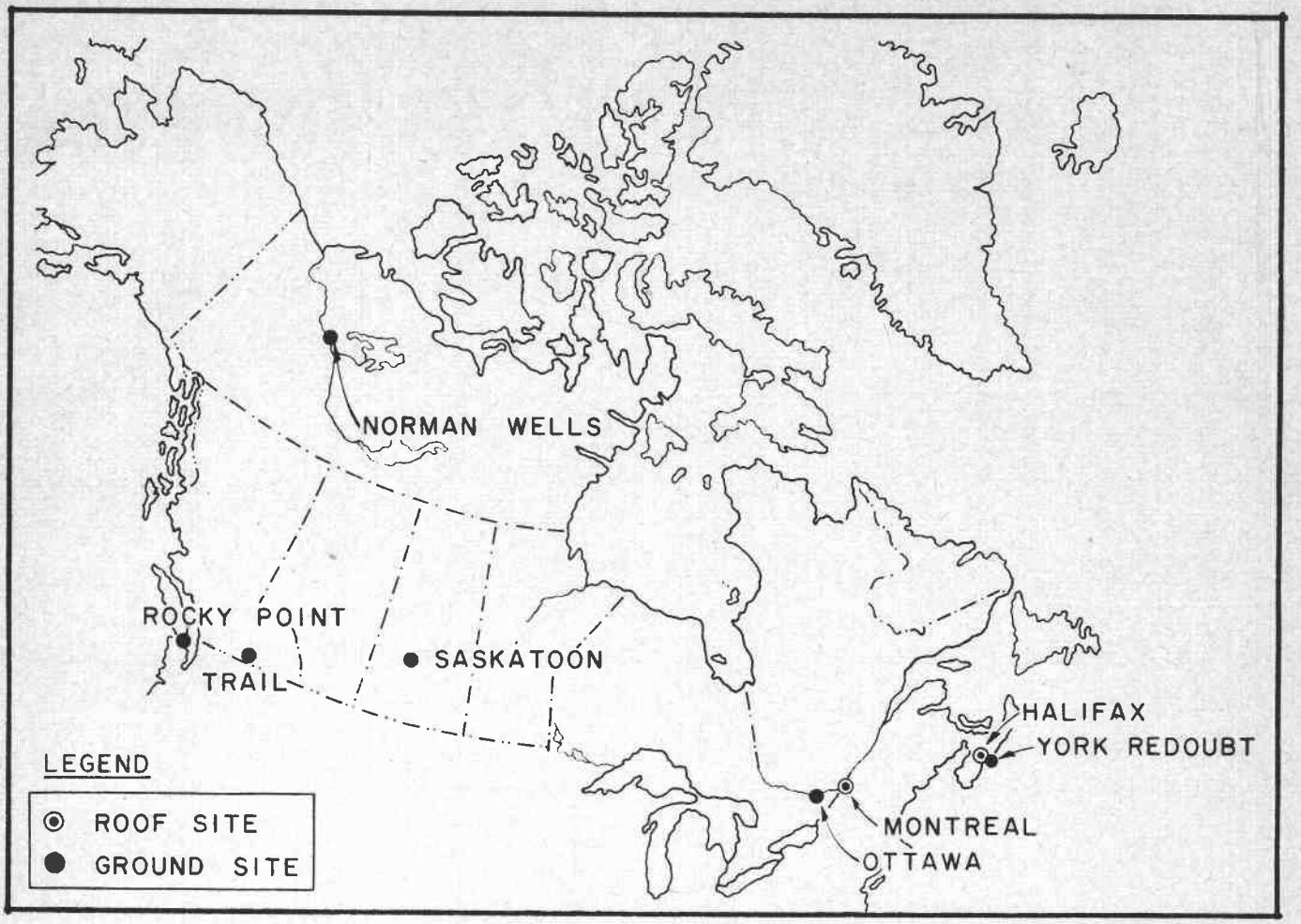


Figure 1—Map of Canada showing the locations of the exposure sites.

Gulf Coast: Port Aransas, Texas – marine atmosphere; on property of the University of Texas on the Gulf of Mexico.

Pacific Coast: Port Reyes, California–marine atmosphere; about 30 miles north of San Francisco.

Panama Canal Zone–tropical atmosphere; locations in the Canal Zone have been made available which are classified as mildly tropical at Gatun, Miraflores, and Cristobal. A severe tropical atmosphere exists at Barro Colorado Island in Gatun Lake. A more complete description of the ASTM sites [1] which have been used by the Society appears in the October, 1950, issue of the ASTM Bulletin.

Development of Canadian Sites

Exposure studies are usually undertaken on a long-term basis. It was therefore essential in selecting suitable locations for the Canadian sites that the different atmospheric conditions obtained be available for periods of at least 20 to 25 years. In addition to a long tenure of occupancy, it was essential that the sites be as free as possible of future encroachment, secure with respect to vandalism, accessible, and of adequate size. Well exposed areas away from trees and buildings were chosen apart from the two roof sites. Areas measuring approximately 200 by 250 ft. were decided upon for the land sites, with provision for future enlargement if warranted. Figure 2 is a photograph of the Ottawa site and Figure 3 shows a portion of the roof site in Montreal.

Site Exposure Facilities

The land sites are enclosed by a chain-link type of security fence. Grading and seeding has been done at a number of the sites where wind-blown abrasive materials might be a problem. The security of specimens at the roof sites has not presented any problem to date since access to them can only be obtained with the permission of the building authority.

The land sites have been provided with tubular racks 57 ft. in length on which the frames for holding the specimens are mounted. The racks are constructed of $1\frac{1}{4}$ in. galvanized piping with clamp-type fittings. Each rack holds nine specimen frames. The frames are made of stainless steel channels and measure 73 in. long and 39 in. wide. Each frame is fitted with grooved porcelain insulators to hold the specimens in place. The racks on the roof sites are 20 ft. long and hold three specimen frames each. The racks are constructed to hold the frames at an angle of 30° to the horizontal. A number of racks have been fitted with auxiliary brackets, however, to enable the frame to be raised to provide exposures when required of 45° to the horizontal. They are arranged in such a position that when the specimens are mounted they all face due south. Details of the construction of both the racks and the frames are shown in Figures 4 and 5.

Specimens Used

In the exposure program of the Associate Committee on Corrosion Research and Prevention metal specimens four by six inches in size are used. Seventy-five specimens are accommodated on each frame, mounted at 30° to the horizontal. Twelve specimens of each type of metal selected for exposure are prepared for each of the sites. This permits three specimens to be removed for examination after exposure periods of one, two, five and 10 years.

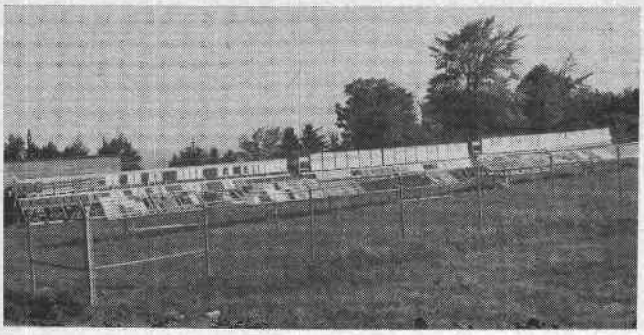


Figure 2—Specimens exposed at the Ottawa site.

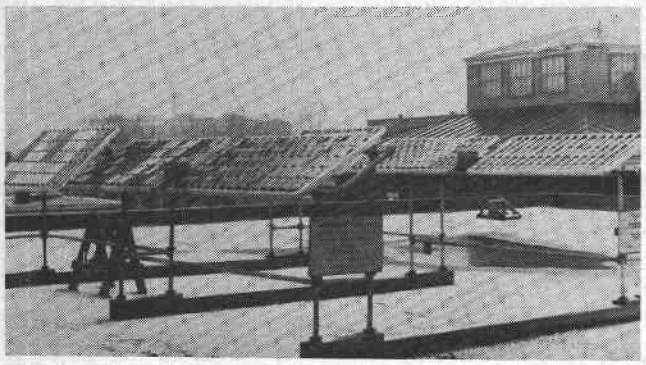


Figure 3—A view of the Montreal roof site (courtesy of CNR).

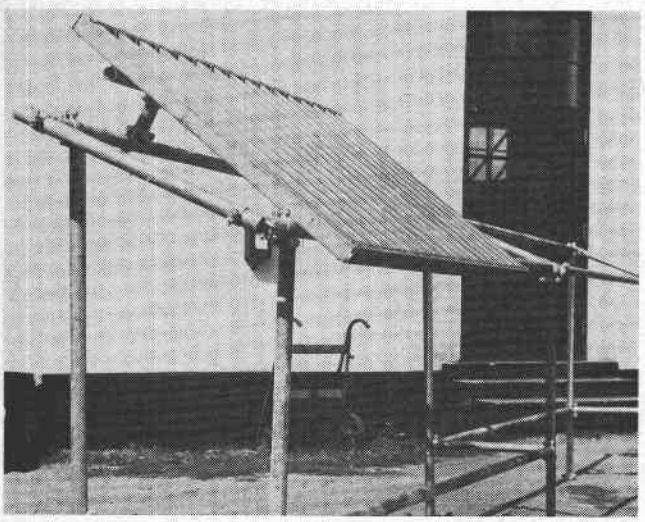


Figure 4—Roof rack with frame mounted at 45°.

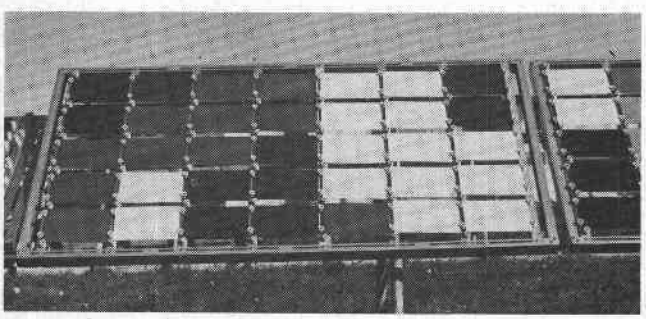


Figure 5—Painted metal specimens in place.

They are identified by drilled holes located according to a letter and number template. The drilled holes identify each specimen as to the type of metal, exposure site location, and the specimen number of a particular exposure period. For a limited number of specimens (metal coated types), an edge notching system has been used for identification. The specimens are also notched at the upper left-hand corner for correct orientation.

The painted metal specimens are 6 in. x 9 in. in size, and are exposed at an angle of 45° to the horizontal. A total of 35 painted metal specimens can be mounted on each frame. Six specimens of each paint system to be tested are prepared for each of the sites. The specimens are returned to the paint research laboratories for examination at the end of each year of exposure. After examination, unless failure has occurred, they are returned to their respective sites for further exposure. The coatings are identified by code letters with numbers stamped on the upper left-hand corner. For testing different paints on wooden substrates, the size of specimen is usually larger than 6 in. x 9 in. and in many tests is mounted vertically. Vertical test fences have been provided for the sites at Ottawa, York Redoubt, Saskatoon and Norman Wells for exposing different types of protective coatings applied to different substrates. These fences were first used in a co-operative study of the Forest Products Laboratories, the Department of National Defence, and the Division of Building Research in evaluating paint systems applied to plywood and hardboard substrates.

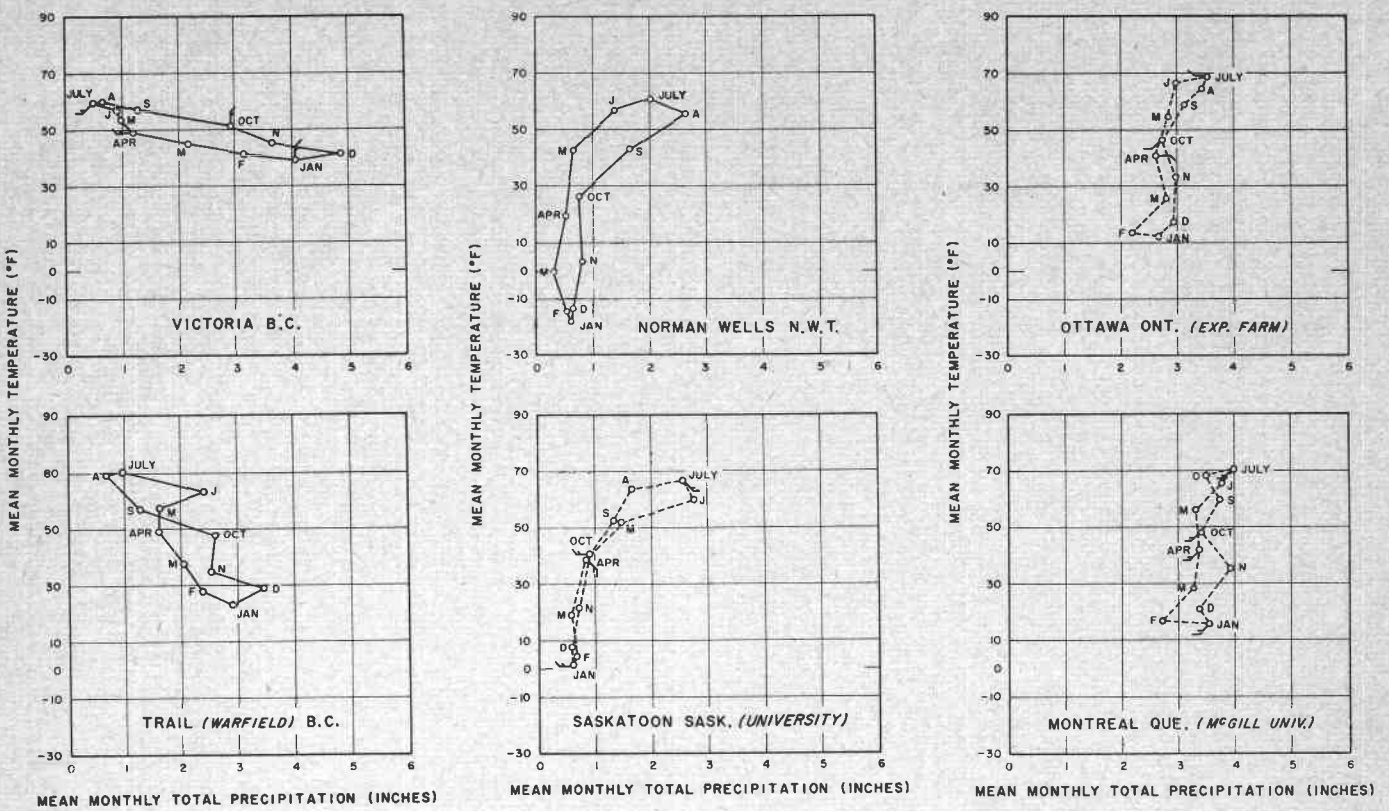
Site Calibration: Weather Records

Outdoor exposure studies on building materials must, of necessity, be on a long-term basis. Climate is one of the basic controlling factors in determining the performance of materials exposed to the atmosphere for comparatively long periods of time. A knowledge of such environmental conditions as heat and cold, moisture and sunshine, the properties of the particular material and its performance under these conditions is extremely important. From this information, materials may be selected which either will not deteriorate in service or can be altered to improve their resistance to the climates to which they will be exposed. The availability of complete weather records for each of the sites as an aid in assessing the particular behavior of different materials is, therefore, essential. Fortunately, in selecting sites which would be acceptable, weather stations of the Meteorological Division of the Department of Transport were either at or near to those finally chosen. Weather records are thus available for precipitation, wind velocity and direction, temperature and in most instances the number of hours and intensity of sunshine. A graphical representation of the average local climate based on records compiled over a number of years is shown on the hythergraphs prepared for each of the sites (Figure 6). The results of studies undertaken by the Division to develop instrumentation to record time-of-wetness on exposed metal panels has been reported [3].

Site Calibration: Atmospheric Pollution

In addition to knowing the climatic conditions to which materials have been subjected, it is essential to know the level of other physical and chemical agents that could have been factors in their degradation. The harmful effect of atmospheric pollution has received increased attention in recent years. The presence of such gaseous contaminants as oxides of nitrogen, ammonia, chlorine, hydrogen sulphide and sulphur dioxide in addition to chlorides, heavy metals, and suspended particulate matter may be factors in the behavior of the material. Sulphur dioxide, because of its known destructiveness to many materials and its prevalence in urban and industrial atmospheres is measured on a monthly basis at each of the sites. Chlorides are measured at a number of locations in the Halifax area. The methods used for determining the quantities of these two materials present in the atmosphere at the different locations have been described previously [2].

Standard zinc specimens and standard steel specimens have been set out for one- and two-year periods at each



BARBS	½	1	1½	2	2½
MEAN WIND SPEED (MPH)	1-3	4-7	8-12	13-18	19-24

DIRECTION: ARROW FLIES WITH THE PREVAILING WIND

Figure 6—Hythergraphs of each of the sites.

of the Canadian sites. These specimens are identical with those exposed for calibration purposes at the test sites of the American Society for Testing Materials. An indication has thus been obtained [4] of the relative corrosivity at the different sites in Canada and those of ASTM in the United States.

Use of Sites

Increasing use is being made of the Canadian sites by the Associate Committee on Corrosion Research and Prevention in their atmospheric exposure studies with metals and protective coatings for metals. Metal specimens mounted at the sites include three types of steel: copper bearing, copper-nickel alloy, low alloy residual; three stainless steels: type 302, 316, and 430; three aluminums, types 3S, 57S and 65S; two magnesium alloys, types AZ80X and ZK61X; commercial zinc, hot dipped galvanized steel, electroplated zinc on steel and sprayed zinc on mild steel; sprayed aluminum on mild steel, and electroplated cadmium on steel. Specimens of riveted couples of 3S aluminum and steel, 3S aluminum and copper and 3S aluminum and zinc have also been exposed. More recently specimens of sheet copper, Muntz metal, Monel and two types of lead sheet have been prepared for exposure. Many of the different metals have now completed five years of exposure. A progress report describing the performance of these metals after one and two years of exposure at the different sites is available [5].

The paint systems for steels under test by the Associate Committee on Corrosion Research and Prevention include five types of priming paint and one enamel. These systems which were applied by dipping to 20-gauge stock of cold rolled steel and include red lead and linseed oil, red lead and vinyl (over a wash primer), red iron-oxide and alkyd, two variations of red iron-oxide and zinc chromate with alkyd and a grey alkyd enamel. A progress report describing the paint systems in detail and their field performance is also available [6]. Six additional primers have been applied to structural steel and exposed; these include Canadian Government Specifications Board paints 1-GP-14, 1-GP-40, 1-GP-65, and 1-GP-81, a zinc-rich paint and U.S. Federal Primer TT-P-636.

Extensive use is made of the Ottawa site by the Division in carrying out weathering tests on a number of

different building materials. In particular the site is used by those engaged in development work on protective paint coatings. Outdoor weathering forms an important part of the test program in deciding upon the suitability of certain coatings designed to meet specific needs. Work is at present in progress in an attempt to obtain a correlation of the behavior of paints, when tested under the natural weathering of the exposure site and the closely controlled accelerated conditions of weatherometers.

Other building materials recently exposed include different types of plastic tubings and sheeting. Five asphaltic coating materials have been set out at Ottawa and Halifax as part of a study in determining the effect of various environments in the degradation of these materials. Masonry test piers of different combinations of clay bricks and mortars have been under observation for a number of years as part of the Division's study of efflorescence. After initial testing, the masonry wallettes that are used in water penetration studies, are weathered at the Ottawa site to enable measurements to be made of any change in their resistance to wind-driven rain.

Administration

The sites are administered by the Division of Building Research. The staff of the regional laboratories of the Division at Saskatoon, Norman Wells, and Halifax give the necessary assistance for the operation of four sites in these areas. The sites at Montreal, Rocky Point, and Trail are supervised, respectively, through the co-operation of the staff of the Research and Development Laboratories of Canadian National Railways, the Pacific Naval Laboratories at Esquimalt of the Defence Research Board and of the Research Department of the Consolidated Mining and Smelting Company Limited at Trail.

In carrying out the metals exposure program of the Associate Committee, the usual procedure is to have all specimens prepared by the different suppliers and then shipped to the Division in Ottawa for checking and recording information concerning composition, weight, and identification. They are then shipped to the sites for prescribed periods of exposure; after exposure all specimens are returned to the Division to be checked and photographed prior to their return to the suppliers for detailed examination of appearance, pitting and weight loss. Great care is taken in preparing the painted metal specimens for test. The paint that is applied to the specimens is made to the desired specification in the Division's paint laboratory and all coatings are applied in the paint laboratory under close control. Exposed painted metal specimens are returned to the Division annually where they are examined for general appearance, film integrity, color, and gloss. The specimens are returned to the sites for further exposure except those that have failed. For other materials the exposure program is more flexible depending upon the particular study and the nature of the materials. Masonry test piers and wallettes, for example must be examined in the field while sheet plastic materials and bitumens coatings are examined quarterly.

Conclusions

The Canadian test sites have now been in operation approximately seven years. The different atmospheric conditions provided have enabled a wide range of materials to be subjected to many different atmospheres. The results obtained to date are most encouraging and indicate that this is a useful testing method. It is only through a better understanding of how a material weathers that improved resistance to the elements can be incorporated into its make-up.

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This paper is a contribution from the Division of Building Research, National Research Council of Canada, and is presented with the approval of the Director of the Division.

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