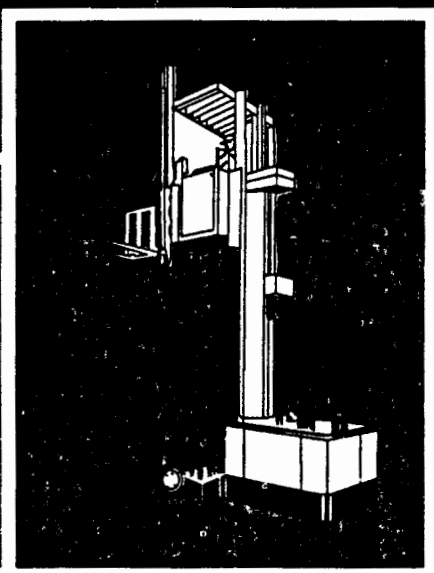
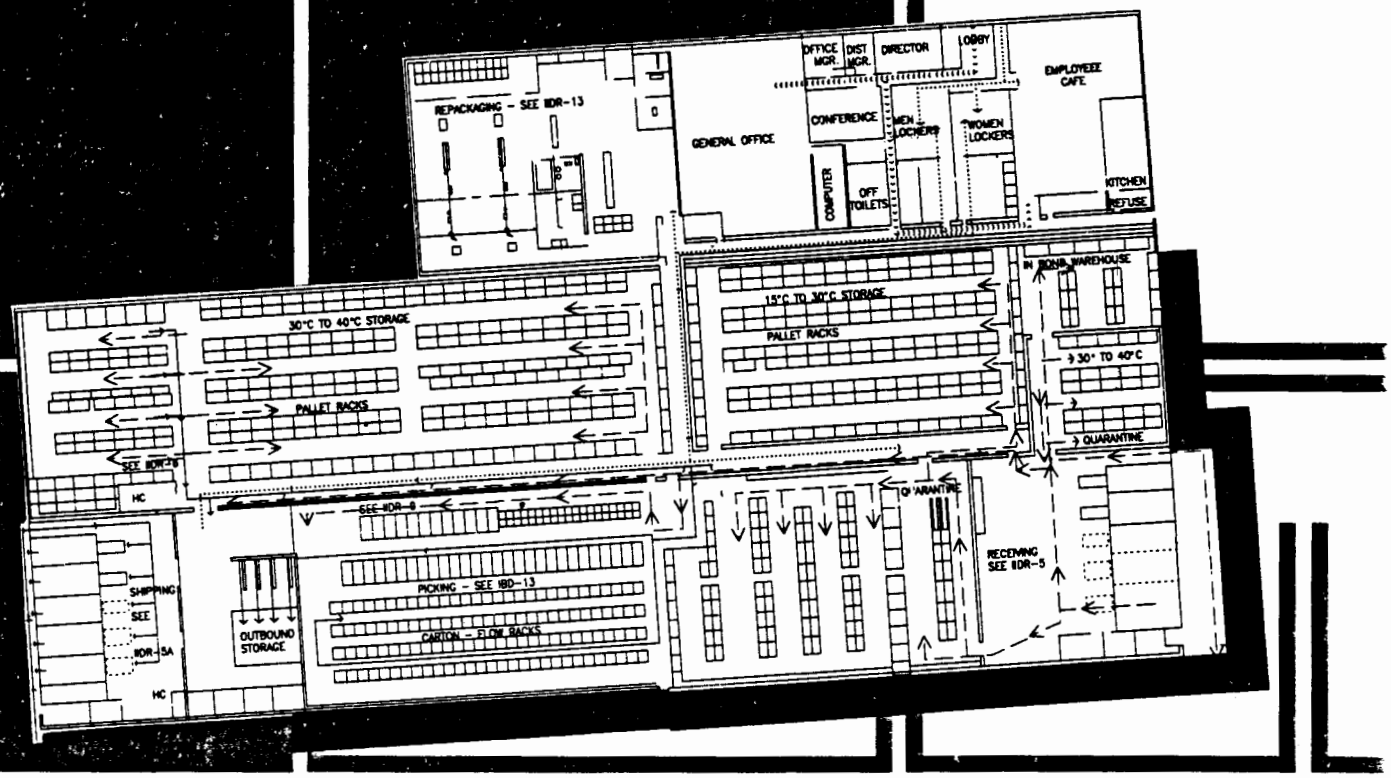
PNSP/89-3
Vol. 2

GUIDELINES FOR MEDICAL SUPPLIES DISTRIBUTION CENTERS

Volume No. 2

REGIONAL AND CENTRAL CENTERS —
STANDARDS FOR TECHNICAL SPECIFICATIONS





PAN AMERICAN HEALTH ORGANIZATION
Pan American Sanitary Bureau - Regional Office of the
WORLD HEALTH ORGANIZATION

GUIDELINES FOR MEDICAL SUPPLIES DISTRIBUTION CENTERS

Volume 2

Regional and Central Centers
—Standards for Technical Specifications—

PAN AMERICAN HEALTH ORGANIZATION
WORLD HEALTH ORGANIZATION
525 Twenty-third Street, NW
Washington, DC, 20037, EUA

1989

Published also in Spanish as:
Guías para Centros de Distribución de Suministros Médicos
Vol. 2 Centros Regionales y Centrales —Normas para Especificaciones Técnicas
ISBN: 92 75 32029 2

The publication of this manual, in English and Spanish, has been possible by financial support of the U.S. Agency for International Development under PAHO/AID Project 597-007 as part of the Plan for Priority Health Needs in Central America and Panama.

Publication prepared for the World Health Organization, WHO,
by Editorial Piedra Santa
5a. calle 7-55, Zona 1, Guatemala, Guatemala,
América Central. Teléfonos: 29053, 510231;
Telex: 9225 Santa-Gu; Fax: (5022) 510531.

ISBN: 92 75 12029 3

Foreword

The Plan for Priority Health Needs in Central America and Panama (PPS/CAP) in 1984 made drugs one of its seven priority areas.

Drugs constitute one of the inputs with a high impact on health care costs, representing on average an estimated 20 to 30% of total expenditures on health, and from 40 to 50% of the cost of all inputs utilized in the health services. This situation, in conjunction with other factors, such as the lack of access to drugs by the entire population, population growth, and the economic and financial difficulties facing the countries, evoke reflection about the effort to be made in order to optimize current investments in drugs through efficient supply systems.

Storage is one of the phases of the supply process that directly influence both the quality of the product and its cost. The former derives from adequate preservation of the initially established therapeutic and pharmacological quality of the drug, which requires the maintenance of suitable environmental conditions, in accordance with the particular requirements of each product during the time that it is in the warehouse.

The influence of storage on cost manifests itself both in relation to the maintenance of inventory levels, and to the losses that result from the damage, deterioration, theft, and expiration of products caused by inadequate storage.

The Pan American Health Organization, given the above factors and in light of the problems related to the situation in Central America, saw the need to develop this technical document providing guidelines for the planning, design, and construction of storerooms at the central and peripheral levels, as well as minimum storage requirements, with a view to improving the conditions of drug supply in the Region.

This book, published in Spanish and in English, consists of four volumes, the first three related to regional and central distribution centers, and the fourth aimed at local distribution centers.

Volume 1, Standards for Planning, Design, and Construction, covers in detail the three phases which any engineering project must pass through. Planning is discussed in the first fourteen chapters, from the concepts of organization of working equipment up through criteria to be used in surveys to select an appropriate site for a center to receive, store, distribute, and repackage medical supplies. Consideration is given to safety and the prevention of losses, as well as to appropriate

storage practices. There is an analysis of the critical factors that affect spatial planning, a list for identifying the different types of interior space that are required, and a description of methods and procedures for determining the amount of space needed. There are also two chapters devoted to an extensive discussion of appropriate equipment, including selection and installation costs, as well as evironmental standards for the various classes of interior spaces for a medical supply complex.

The topics of design and construction are covered in the chapters that follow in Volume 1. The purpose is to emphasize approaches to technical aspects, costs, and administration which will allow a project to be brought to completion, both in the anticipated amount of time and within the prepared budget. The technical information that is found in this part is perhaps unique because it refers specifically to the problems and solutions that present themselves at centers for the distribution of medical products as a result of the various types of supplies that are handled, the types of services provided for community health care, and the fact that they are considered to be essential buildings.

Volume 2, Standards for Technical Specifications provides general guidelines to specifications for materials, products, equipment, and installation techniques for some of the industrial equipmet, installations, or construction components in industrial-type buildings designated for the receiving, storage, distribution, and repackaging of medical supplies. It is not an exhaustive document to be used for the purpose of making construction bids, but rather a guide that provides engineers and architects in charge of a project of this type with useful information and criteria. For this reason, the standards have been broken down into three areas: architectural standards, mechanical standards, and fire safety standards. Each unit Includes general information, materials, products, and execution.

Volume 3, Reference Drawings, is a graphic supplement to Volumes 1 and 2. It presents 70 drawings, most of them draw to scale, which display general details applicable to the planning and design of regional and central buildings and installations. Each plan has a separate, brief explanation of its principal characteristics and mentions the chapter in which these are indicated. The intention of this set of drawings is to provide administrative, planning, and design teams with information which may be adapted to the specific conditions of their own projects and serve as a reference during the preparation of their respective construction drawings.

Volume 4 is devoted to local distribution centers. The planning, design, and construction of this type of center is covered in six chapters, and graphic information is provided in six reference drawings.

As a whole this work develops generic guidelines to planning the requirements, facilities, and equipment for the prototype of a center to be used in the storage and distribution of medical supplies. It presents guidelines and methods for the design and construction of such storage centers, in accordance with the planning criteria, and it proposes modes of administration.

Although originally conceived of for Central America, the technical excellence and stimulus associated with this effort makes it applicable the other developing countries.

The technical content of this document was prepared by the Pan American Health Organization, and, along with this publication, was financed by the United States Agency for International Development (U.S./AID), under the Plan for Health Priority Needs in Central America and Panama.

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Electrical specifications are not included because the information is provided in Chapter 26, Electrical Systems, Volume 1

Introduction

The Pan American Health Organization is publishing the present guidelines on the planning, design, and construction of distribution centers at the central, peripheral and local levels, and on minimun storage requirements, as a contribution to the efforts that the governments of the Region are making to improve drug availability for the entire population.

Drugs play an important role in disease prevention and the restoration of health, thus helping significantly to attain the goal fo HFA/2000, as a priority component of primary health care. The processes of drug storage and distribution currently differ greatly in the Region, and there are serious problems in the administration of that input which lead to significant losses, higher costs, and greater unevennsess of quality, availability, and use. The guidelines being published now are an attempt to help solve these problems.

Carlyle Guerra de Macedo
Director
Pan American Health Organization

Contributors:

Enrique Fefer, OPS/OMS, Washington, D.C.
Thomas D. Evans, TPM, Strategic Planners
Leonel Pinot Leiva, Editorial Piedra Santa, Guatemala
Renato Fernández Rivas, Guatemala
Augusto de León Fajardo, Arquisistemas, Guatemala
Humbert J. Tissot, TPM, Strategic Planners
Brian Berg & Associates, LTD.
Dickerson Engineering, Inc.
O'Donnell, Wicklund, Pigozzi & Petersen
Courtesy Graphics, Libertyville, Il.
Data Visuals, Deerfield, Il.
Ileana Santich, OPS/OMS, Washington, D.C.
Ronaldo Luna, OPS/OMS, Washington, D.C.

INTRODUCTION

Volume II is oriented to regional centers and main distribution depots. It includes general guidelines for the specifications of materials, goods, equipment and installation techniques for some of the industrial equipment, installations or manufactured elements for industrial buildings for the reception, storage, repacking and distribution areas.

Some of the specifications have been provided to assist the architect/engineer in the development of the design of certain elements of the building or selection of industrial type building equipment. Others focus on installation or construction practices that the architect/engineer may elect to add to his standard specifications. None of these guideline specifications is intended to be a complete specification suitable for a construction bid package; rather, each is intended only to convey concepts for selected industrial type equipment, components, and/or installations that are desirable for these types of facilities. The responsible architect/engineer shall establish all conditions and requirements for project specifications.

The format of these outline specifications generally provides for portions or all of the following information, as appropriate, for the topic being discussed:

GENERAL

Scope
Related Work Specified Elsewhere
Codes and Standards
Submittals
Product Delivery, Storage, and Handling
Acceptance Tests (i.e., factory, field)

MATERIALS/PRODUCTS

Technical Criteria
Sources
Owner's Stock

EXECUTION

Design Considerations
Scope of Work
Owner Furnished Equipment
Systems' Description
Job Conditions
Inspection
Fabrication
Installation
Curing

Protection of Installation, Material, or Product
Cleaning
Repair
Protection of Final Work
Testing Maintenance

The trademarks, brand names, equipment manufacturers, and technical agencies, companies, and associations mentioned in these guideline specifications and in the related chapters of text are mentioned to:

- establish a point of reference with respect to quality, design, safety, and/or performance criteria
- provide a source of technical information, should additional technical information be required
- identify one or more potential sources of supply for specialty items that are offered by few or only one manufacturer.

The mention of these items does not imply the preference or recommendation for said standards, technical data, products, or manufacturers by the Pan American Health Organization over other similar brands, products, companies, etc., not mentioned in the text.

CONCRETE PREFABRICATED/CAST-IN-PLACE

GENERAL

A. SCOPE

This specification covers materials and techniques to be used in the design and construction of all concrete work.

B. RELATED WORK SPECIFIED ELSEWHERE

A-02 Concrete Formwork
A-03 Concrete Reinforcement
A-04 Concrete Floors and Slabs on Grade
A-05 Joints in Concrete
A-06 Special Concrete Floor Finishes
A-07 Integral Floor Hardener
A-09 Pigmented Concrete Floors
A-12 Water Repellent Treatments

C. CODES AND STANDARDS

The work shall comply in all respects to all applicable codes, including the ACI 318 Building Code Requirements for Reinforced Concrete (American Concrete Institute, P.O. Box 19150, Redford Station, Detroit, MI 48219, USA). In the event of discrepancy, the more restrictive code shall govern.

All materials and procedures used shall comply with ASTM C 94 Specification for Ready-Mixed Concrete (American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19013, USA).

Where codes, standards, or other documents are referenced, the latest edition is intended.

D. CERTIFICATION

The concrete supplier shall furnish with each batch the certification specified for in Paragraph 14 of ASTM C 94.

MATERIALS/PRODUCTS

A. CEMENT

The cement shall conform to ASTM C 150 Standard Specification for Portland Cement. Where air entrainment is desired, the cement shall conform to ASTM C 175 Standard Specification for Air-Entraining Portland Cement

B. AGGREGATES

Aggregates shall conform to ASTM C 33 Standard Specifications for Concrete Aggregates. They shall be free from any substance that may react adversely with the alkalies in the cement, causing excessive expansion of the concrete.

The maximum size of coarse aggregate should be no more than 75 percent of the minimum clear spacing of

the reinforcing bars in structural floors, or 33 percent of the thickness of unreinforced slabs. When aggregate sizes larger than 25 mm. are used, the coarse aggregate should be handled and batched as at least two separate sizes to prevent segregation.

C. WATER

Water for mixing and curing, including free moisture and water in the aggregates, shall be of potable quality.

D. PIGMENTS

Where pigments are specified, they should be either natural or synthetic mineral oxides or colloidal carbon. Specific instructions shall be provided as to whether the pigment is to be incorporated into the entire batch or applied as a dry shake-on material.

E. CURING MATERIALS

Wet Burlap — If new burlap is used, it should be washed first to remove all sizing. Used burlap from sacks that have contained sugar must not be used.

Plastic Membranes or Waterproof Paper — Any plastic membrane used for curing should allow a moisture loss of not more than 0.055 grams per square centimeter of surface when tested according to ASTM C 156. Polyethylene of nominal 4 mil (0.1 mm.) thickness is generally suitable. Waterproof paper should meet the requirements of ASTM C 171.

Spray-applied Membranes (Liquid Membrane-forming Compounds) — When specified, they must meet the requirements of ASTM C 309 Standard Specifications for Liquid Membrane-forming Compounds for Curing Concrete.

EXECUTION

A. MEASURING, MIXING, AND TESTING

Prior to the start of the concrete work, an independent qualified testing laboratory, approved in writing by the architect/engineer and the owner, shall be engaged by the contractor to desing and test the concrete mix. No empirically designed mix shall be accepted.

A statement shall be furnished to the owner's resident engineer, before any concrete is delivered, providing information on the type and brand name of cement for each type and class of concrete.

All concrete shall be proportioned by weight (except that water may be batched by weight or volume).

Compression test cylinders shall be made by the contractor as follows:

- a minimum of one test per 50 cu. m. of concrete or fraction thereof for major pours,
- a minimum of one test for each day of pouring on which the pour exceeds 10 cu. m.,
- additional tests as may be directed by the architect/engineer.

In general, a minimum of six cylinders shall be taken for each test. They shall be standard size (15 cm. in diameter and 30 cm. long). They shall be prepared in accordance with ASTM C 31 Making and Curing Concrete Compression and Flexure Test Specimens in the Field and tested in accordance with ASTM C 39 Test for Compressive Strength of Molded Concrete Cylinders.

For normal concrete, three cylinders each shall be crushed at 7 days and 28 days. For high early concrete three cylinders each shall be crushed at 3 days and 7 days. Four copies of each test report shall be submitted to the architect/engineer. If the 28-day test shows a lower strength than specified, the owner shall have an independent laboratory of his choice make and test cores from the affected area. If these also show a strength below specification, the entire area affected shall be removed and replaced at no expense to the owner, including the cost of taking and testing cores.

A minimum of one standard slump test shall be taken for each two compression test cylinders. Slump tests shall be performed in accordance with ASTM C 143 Test for Slump of Portland Cement Concrete. Slump shall be within the limits established by the architect/engineer and less than a maximum of 15 cm.

If air content is specified, the testing shall be in accordance with ASTM Method C 138, C 173 or C 231.

All samples shall be obtained in accordance with ASTM C 172 Sampling Fresh Concrete.

Additional water may not be added at the job site without the express written permission of the architect/engineer. If permitted, the amount added shall be recorded on all copies of the delivery ticket, and the mixer drum shall be given an additional 30 revolutions before discharge.

B. PLACING AND FINISHING

Unless otherwise directed, concrete shall be placed only in the presence of the owner's resident engineer or his authorized representative.

Before concrete is placed, all equipment used for mixing and transporting shall be cleaned, and all water and debris shall be removed from spaces to be occupied. All forms or other surfaces that will be in contact with the concrete shall be thoroughly wet or oiled. See Guideline Specifications A-02 and A-03 for restrictions and precautions on the use of oil.

All concrete handling operations shall be done in such a way as to minimize segregation of ingredients. The rate of discharge from a truck's mixer shall be controlled by varying the speed and/or direction of rotation, rather than by use of a discharge gate. Concrete shall be conveyed from truck to the pour site as rapidly as practicable and without the use of an excessively long or deep chute. It shall be deposited as nearly as practicable in its final position; excessive free fall shall be avoided.

Temperature of the concrete at time of placement shall be between 10° C and 32° C unless otherwise directed. Concrete that has attained its initial set or has contained its mixing water for more than $1^1/_2$ hours shall not be used. Concrete must not be placed on top of, or in contact with, previously poured concrete that has hardened to the point that a seam or plane of weakness will result.

Placing must not be done when ambient atmospheric conditions prevent proper finishing or curing. Care shall be taken during hot and/or extremely dry conditions. Protective measures, such as retarders, may be used at the discretion of the architect/engineer. No concrete work shall be done when the temperature is 10° C or less without specific authorization by the engineer. Concrete shall not be placed during rain storms unless complete protection is provided.

Once pouring is started, it shall be continued until placing of an entire panel or section is completed. Construction joints shall be as detailed on the drawings and in accordance with Guideline Specification A-05. Concrete is to be thoroughly compacted by mechanical vibrators or other approved methods during the placing operations, especially around reinforcement and forms.

All finished concrete work is to be true to the elevations and lines shown on the drawings. Where pitch is specified, it must be uniform and in the direction indicated.

C. CURING AND PROTECTION

Concrete is to be protected from the harmful effects of the sun, rain, water flow, loading, vibration, drying wind, and mechanical injury. Immediately after placing or finishing, surfaces shall be protected against moisture loss for at least 7 days for normal concrete or 3 days for high-early-strength concrete. Curing shall begin as soon as the curing materials can be applied without damage to the finished surface.

Moist curing is the preferred method, but care must be taken to ensure that water is applied frequently enough and evenly enough so that no part of the surface ever dries out. Burlap or sand should be used to help retain the moisture.

Polyethylene film or waterproof paper may be used for moisture retention on surfaces where the visual results will not be objectionable. Where these membranes are used, adjacent sheets are to be lapped 10 cm. at all edges and ends, and sealed with mastic or pressure-sensitive tape. They shall also be weighted to prevent movement. Tears or holes are to be patched immediately.

Curing compounds may be used **only** where specified. It is imperative that none be applied to any surface that is to receive further surface treatment involving bonding — for example, toppings, coatings, tile, or another course of concrete.

D. SURFACE FINISHES (excluding Special Floor Finishes)

A standard finish shall be given to all exposed concrete unless otherwise required by the drawings or specifications.

All formed surfaces shall be repaired by patching with cement mortar, including all minor honeycombed or

otherwise defective areas and tie holes. Minor honeycombed or otherwise defective areas shall be removed to solid concrete and to a depth of at least 2 cm. Patching shall be done as soon as the forms are removed. All areas to be patched shall first be cleaned thoroughly.

CONCRETE FORMWORK

GENERAL

A. SCOPE

This specification covers materials and techniques to be used in the design and construction of formwork for cast-in-place concrete.

B. RELATED WORK SPECIFIED ELSEWHERE

A-01 Concrete Prefabricated/Cast-in-Place
A-03 Concrete Reinforcement
A-04 Concrete Floors and Slabs on Grade
A-05 Joints in Concrete
A-06 Special Concrete Floor Finishes
A-07 Integral Floor Hardener
A-09 Pigmented Concrete Floors

C. CODES AND STANDARDS

Formwork design and construction are the responsibility of the contractor and shall be in accordance with ACI 347 Recommended Practice for Concrete Formwork (American Concrete Institute, P.O. Box 19150, Redford Station, Detroit, MI 48219, USA). Design, including wind load provisions, is to be in compliance with the controlling local building code. In the event of discrepancy, the more restrictive code shall govern.

Where codes, standards, or other documents are referenced, the latest edition is intended.

MATERIALS/PRODUCTS

A. PLYWOOD FORMS

Plywood shall be DFPA exterior grade "Plyform," Class I or Class II, 20 mm. minimum, or approved equal. High density overlay shall be used for concrete surfaces to be exposed to view. Plywood or prefabricated forms are preferred where reuse is anticipated.

B. PREFABRICATED FORMS

Flat steel-faced form systems and steel-framed plywood-faced systems are acceptable for flat work. Fiber and metal tube forms are acceptable for exposed round columns where surface imprint is not objectionable. Special plastic and metal forms shall be employed where structural design profiles indicate their use.

C. BOARD FORMS

This type of form is acceptable only where other types of formwork are not suitable. Boards shall be construction grade quality or better.

D. FORM LINERS

Smooth surfaced form liners are acceptable as a means of achieving the quality of surface specified for exposed concrete. Where special textures and profiles are required, appropriate form liners shall be used.

E. CORNERS

Where shown on the drawings, concrete corners shall be chamfered; minimum chamfer is 20 mm. These are to be formed with adequately secured wood or vinyl inserts.

F. FORM TIES

Form ties shall be the tension adjustable, snap-off type to break off at a minimum of 20 mm. below the surface. Employ cones whose minimum diameter is 12 mm. or larger to facilitate patching. Wire ties and wood spreaders are not acceptable.

G. SURFACE TREATMENTS OF FORMS

Form oil, retarders, and chemical set inhibitors are acceptable types of bond-breakers. The use of form oil shall be restricted to surfaces that are not specified to receive additional surface treatment.

H. MISCELLANEOUS

Embedded anchors, inserts, sleeves, etc., are to be galvanized when exposed on exterior surfaces and on surfaces specified to receive surface finishes.

EXECUTION

A. REPAIR AND SURFACE TREATMENT

All previously used forms must be properly repaired to restore them to first class condition before reuse. Surface treatment of forms must be applied to form face surfaces before placing reinforcing, or in such a manner as to maintain the reinforcing free from all form treating materials.

B. INSTALLATION

Forms and formwork must be complete and of the strength and type of construction that will prevent spread, shifting, or settling when the concrete is placed. The formwork shall be tight enough to avoid leakage or washing out of the cement from the concrete. All forms shall be constructed so that they can be removed without damaging the concrete.

Special care must be taken to guarantee that forms are true to required lines, grades, and surfaces, so that the resultant concrete surfaces will have a neat and workmanlike finish.

For structural concrete, forms shall be aligned and braced adequately to result in finished concrete with the following maximum tolerances:

- vertical surfaces such as walls, beams, columns:
  - — to horizontal lines ± 6 mm. at any point
  - — to vertical lines ± 6 mm. in 3.0 m.
    ± 12 mm. in total height
- horizontal surfaces:
  - — to bottom elevation: ± 12 mm.
  - — to finished elevation: ± 6 mm.
  - — to plane or design slope: ± 3 mm. in 3 m.

The contractor is to build into his forms all sleeves, hangers, anchors, conduits, blocking, piping, bucks, nailing strips, anchor bolts, baseplates, etc., required to be placed in his concrete work. This includes items to be furnished by this contractor as well as similar items specified to be furnished by others. This contractor shall be responsible for correct placement of all such items that he furnishes and shall see to it that other contractors verify the locations and levels of all such work done for them, before proceeding with placement of the concrete.

All dirt, sawdust, debris, free-standing water, etc., must be removed completely from the forms and other contact surfaces before any concrete is placed.

C. REMOVAL OF FORMS

The contractor shall be responsible for the continuing integrity of the structure when removing forms. In no case shall forms be removed until authorized by the architect/engineer or his representative. No supporting forms or shoring shall be removed until the concrete members have acquired sufficient strength to support their weight as demonstrated by the 7-day test results. Vertical surface forms not exceeding 3 m. in height

may be removed after three days.

Upon removal of forms, the contractor shall place adequate reshores if required to prevent damage to the concrete by construction loads.

CONCRETE REINFORCEMENT

GENERAL

A. SCOPE

This specification covers techniques and materials including all reinforcing bars, wire fabric, and other reinforcing materials as indicated on the drawings or required by the specifications, together with all ties, spacers, supports, and other devices necessary to install and secure the reinforcement properly.

B. RELATED WORK SPECIFIED ELSEWHERE

A-01 Concrete Prefabricated/Cast-In-Place
A-02 Concrete Formwork
A-04 Concrete Floors and Slabs on Grade
A-05 Joints in Cast-In-Place Concrete
A-06 Special Concrete Floor Finishes
A-07 Integral Floor Hardener
A-09 Pigmented Concrete Floors

C. CODES AND STANDARDS

All work shall comply with the ACI 318 Building Code Requirements for Reinforced Concrete (American Concrete Institute, P.O. Box 19150, Redford Station, Detroit, MI 48219, USA), unless otherwise indicated. It shall also comply with the local building code. If there is any discrepancy between these, the more restrictive shall govern.

The details of construction including bending, splicing, and placing of reinforcing steel shall conform to ACI 315 Detailing Manual, unless otherwise indicated.

Where codes, standards, or other documents are referenced, the latest edition is intended.

D. SUBMITTALS

When steel frame structural elements are to be used for the building, the contractor shall submit three complete sets of shop drawings of anchor bolt locations, cross bracing details, etc. to the architect/engineer for approval. Upon final approval, submit six complete sets for distribution. If not otherwise specified by the architect/engineer, include in the shop drawings a complete schedule of all reinforcing steel with details of accessories, method of bending, cutting schedule, splicing details, and locations of splices and overlaps.

MATERIALS/PRODUCTS

A. BARS

Reinforcing steel bars shall conform to ASTM A615, Grade 60, (American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19013, USA), unless otherwise indicated.

B. WIRE FABRIC

Welded wire fabric shall conform to ASTM A185 Welded Steel Wire Fabric For Concrete Reinforcement. Flat sheets, not rolls, are to be used.

Test certification and proper identification of each manufacturer's lot shall be obtained prior to acceptance of the lot.

C. REINFORCEMENT DEVICES

All devices necessary for properly placing, spacing, supporting and fastening the reinforcement devices shall conform to ACI 315. Supporting devices for reinforcement steel must be designed for this purpose. Steel accessories shall be galvanized after fabrication or fitted with plastic tips if the underside of the concrete will be exposed.

EXECUTION

A. INSTALLATION

Bars are to be bent cold in accordance with the drawings and ACI 315 and 318. Reinforcing shall not be bent or straightened in a manner injurious to the steel. Bends for stirrups and ties shall be made around a pin having a diameter not less than two times the thickness of the bar. Bends for other bars shall be made around a pin with a diameter of at least six times the thickness of the bar for bars over 2.5 cm. thick. Hooks shall conform with Section 801, ACI 318. Reinforcing that is reduced in section or excessively corroded shall not be used.

Reinforcement must be accurately and uniformly placed in accordance with the drawings, properly secured in position, and supported by approved devices in such a way that its final location in the concrete will be according to the design. **Hooking of mesh to pull it into place is not an acceptable practice.**

Allowable tolerances:

Fabrication:

- Sheared length ± 25 mm.
- Stirrups, ties, and spirals ± 12 mm.
- All other bends ± 25 mm.

Placement:

- Concrete depth to form surfaces ± 6 mm.
- Minimum spacing between bars ± 6 mm.
- Top bars in slabs and beams
  (1) Members 20 cm. deep or less ± 6 mm.
  (2) Members more than 20 cm. deep but not over 60 cm. deep ± 12 mm.
- Crosswise of members-spaced evenly and within 5 cm. of stated separation
- Lengthwise of members ± 50 mm.

Maximum bar movement to avoid interference with other reinforcing steel, conduits or embedded items — 1 bar diameter.

With the exception of temperature reinforcement that shall be tied to main steel, reinforcement shall be securely tied with No. 18-gauge (1.3mm.) black annealed wire at one half of the intersections and at all splices. Ends of wire ties shall point away from the form.

All bars shall overlap a minimum of 24 bar diameters at splices, but in no case less than 30 cm. The clear distance between bars shall also apply to the clear distance between a contact splice and adjacent splices or bars. Splices are to be staggered. Splices in slabs at points of maximum stress are to be avoided wherever possible. Where they are necessary, such splices shall be welded or otherwise fully developed so as to transfer the entire stress from bar to bar without exceeding the allowable stresses of Table 1002 (a), ACI 318.

Edges of wire mesh shall be lapped not less than 20 cm. End laps shall not be made midway between supporting beams or directly over beams of continuous structures. End laps are to be offset in adjacent widths to prevent continuous laps. Panels shall be formed up to construction joints but with no wire passing through these joints. At control joint locations, cut alternate mesh wires crossing the joint.

Wherever conduit, piping, inserts, sleeves, etc., interfere with the placing of reinforcing steel as specified, the contractor shall consult the architect/engineer and follow an approved procedure. **The bending of bars around openings or sleeves is not permitted.**

At the time of concrete pouring, all reinforcement shall be free of oil, grease, dirt, concrete, loose rust or scale, any other bond-reducing material.

CONCRETE FLOORS AND SLABS

GENERAL

A. SCOPE

This specification covers materials and techniques to be used in the design and construction of concrete slabs on grade, concrete floors, and other horizontal concrete surfaces including roads.

Successful slabs on grade require that very careful attention be given to all aspect of the design and the construction. The designer must know the end-use requirements of the concrete slab. The mix must be designed to give the proper slump, strength, etc. Site supervision must ensure that proper techniques are used in placement of reinforcing, provision of joints, placement and curing of the concrete, etc.

This and related specifications describe several of the many important design and construction factors. For additional information on these and other factors, the following references should be consulted:

— Publication of the American Concrete Institute (ACI), (P.O. Box 19150, Redford Station, Detroit, MI 48219 USA), particularly:
  - ACI 318 Building Code Requirements for Reinforced Concrete.
    Concrete Craftsman Series: Slabs on Grade.
    ACI 302 Guide for Concrete Floor and Slab Construction.
    ACI E2 Reinforcing Steel-Its Use and Benefits in Concrete.

— Publications of the Portland Cement Association (PCA), (5420 Old Orchard Road, Skokie, IL 60077, USA), particularly:
  - The Design and Construction of Concrete Floors.
    Why and How: Joints for Floors on Ground.

B. RELATED WORK SPECIFIED ELSEWHERE

A-01 Concrete Prefabricated/Cast-In-Place
A-02 Concrete Form Work
A-03 Concrete Reinforcement
A-05 Joints in Concrete
A-06 Special Concrete Floor Finishes
A-07 Integral Floor Hardener
A-08 Polyurethane Floor Sealer
A-09 Pigmented Concrete Floors

MATERIALS/PRODUCTS

See related guideline specifications.

EXECUTION

A. REINFORCING

In general, either steel mesh or bars may be used. The most important requirement is that the reinforcing

be placed in the proper location in the slab as shown and specified on the drawings. Since one of the principal functions of reinforcement usually is to control surface cracking, reinforcement is normally required to be in the middle or upper half of the concrete slab to be effective. (However, there are, at times, structural considerations that dictate additional reinforcing in the lower half of the slab.) Because placement of reinforcement is critical, the following points must be strictly observed:

- if mesh is used, it should be flat mats ("road mesh") rather than rolled mesh. The flat material is much easier to place at a uniform level, and the recommended wire size is stiffer, making it more resistant to displacement. The recommended minimum mesh size is 15 cm. x 15 cm. - D10/D10.
- reinforcing of any type must be positively supported at the proper elevation by devices manufactured specifically for this purpose - usually plastic or metal "chairs." The widely used technique of laying the mesh on the subgrade, placing the concrete, and then "hooking" the mesh to pull it up is definitely unacceptable. The reason "hooking" is unacceptable is that the next step in the operation involves walking on the mesh, which pushes it back down.

B. JOINTS

All normal concrete exhibits permanent shrinkage. If there are no definite provisions for controlling cracking, random shrinkage cracks will occur throughout a concrete slab. These should be prevented by providing control joints at appropriate intervals so that any cracking will occur along predetermined straight paths. As a rule of thumb, control joints are typically spaced about 6 m. apart. The location and design of control joints shall be performed by an engineer thoroughly familiar with the subject and structural design in seismically active regions.

Control joints are usually produced by saw-cutting a groove soon after the concrete is finished or installing a "zip-strip." Either of these should extend into approximately 20 to 25 percent of the thickness of the slab. Reinforcing that crosses these joints should normally be reduced by cutting alternate bars or wires.

Another type of joint is an isolation joint. These are predetermined full-depth interruption in the continuity of a concrete slab around built-in columns, piers, etc. Their purpose is to prevent the transmission of movement from one part of the building to another. Differential settlement that would cause cracking unless provisions were made for it is a typical example.

Yet another and critically important type of joint is an expansion joint. It, because of thermal, seismic, or other considerations, allows areas of the building to expand and contract or move, without damaging other portions of the building.

A fourth type of joint is a construction joint. These are provided whenever concreting is interrupted, such as at the end of a day's operation. They may be keyed and/or doweled as necessary to transmit loading. Wherever possible, they should be avoided by pouring large areas in a "checkerboard" sequence.

C. SLUMP

Slump is a measure of the fluidity of the concrete mix the higher the figure, the more fluid is the mix. Concrete with too low a slump is difficult to pour and consolidate. The more frequent problem, however, is that concrete with too high a slump tends to produce excessive cracking.

ACI recommends a maximum slump of 75mm. for most industrial floors. Slump should be stated as a maximum figure, because otherwise the permissible tolerance is quite large; e.g., the tolerance of a 75mm. slump (if not stated as 75mm. maximum) is ± 25mm. The statement of a maximum figure also provides the resident engineer with a clearer basis for acceptance or rejection of a load of concrete.

D. STRENGTH

Another important measure of concrete is its "strength," which actually refers to compressive strength. This property in concrete takes a long time to develop fully. The normal reference is to 28-day strength. ACI recommends a design value of 290 kg/cm^2 for most industrial concrete floors.

E. TOPPINGS AND COATINGS

Any concrete slab that is to receive further surface treatment must be moisture-cured, because application of any other form of curing agent could interfere with bonding of the topping or coating to the concrete. Also, it should be recognized that any significant cracking of the slab is likely to penetrate through a topping or coating.

F. TESTING

All concrete shall be certified prior to placement and test cylinders prepared during placement for testing by an independent laboratory.

JOINTS IN CONCRETE

GENERAL

A. SCOPE

This specification covers expansion joints, isolation joints, control joints, and construction joints in cast-in-place concrete.

B. RELATED WORK SPECIFIED ELSEWHERE

A-01 Concrete Prefabricated/Cast-in-Place
A-02 Concrete Formwork
A-03 Concrete Reinforcement
A-04 Concrete Floors and Slabs On Grade
A-06 Special Concrete Floor Finishes
A-07 Integral Floor Hardener
A-09 Pigmented Concrete Floors

MATERIALS

Joint Caps

All joints shall be capped flush with an approved material unless otherwise specified.

Forms

Forms for construction joints shall be folded edge, keyed galvanized metal unless otherwise indicated.

EXECUTION

A. REQUIREMENTS FOR JOINTS

Concrete shall be placed so that each unit of construction will be monolithic and terminate at one or more of the types of joints listed in (A) above.

B. EXPANSION AND ISOLATION JOINTS

Expansion and isolation joints must be provided to separate structurally (a) different areas of a large building and (b) a floor from other building elements such as columns, walls, machine foundations, and footings, respectively. Locations and details are to be established by the architect/engineer, shown on the drawings, and constructed as shown on drawings.

For roads exposed to temperatures of 38° C or higher, the location of expansion joints is especially critical. Expansion joints at least 25 mm. in width shall be provided at least every 12 m. maximum. This shall ensure the neutralization of concrete expandability that may reach 5 mm. per 10 m. when exposed to constant heat. Subsequent to cleaning of the joints, they shall be filled with asphalt.

Isolation joints around columns should normally be of a "diamond" pattern, formed with straight wood or premolded members oriented at 45° to column lines. Thirty-pound asphalt-saturated felt shall then be placed against the concrete around column bases with care being taken to produce a neat, flush surface with the

floor slab. A 3 mm. x 6 mm. deep square edge joint, as a continuation of the control or construction joint treatment, shall be formed into the floor's concrete. Concrete for floors around column bases shall then be placed against the asphalt-saturated felt. Forms shall remain in place for at least the initial 72 hours of slab curing.

C. CONTROL JOINTS

Control joints are to be provided where indicated by the architect/engineer. Construction joints are to be provided anytime the concrete is interrupted long enough for the placed concrete to harden.

At control joint locations, cut alternate mesh wires or reinforcing bars where they cross a joint. Within 20 hours after placing the concrete, saw-cut all required control joints along column lines and parallel to them to a depth of 5 cm., dividing structural bays, including outside wall corners, into areas not exceeding 40 sq. m., approximately. Saw-cuts must be straight and perpendicular to the concrete slab's surface. Do not overrun intersections. Flush or blow out all concrete dust and residues.

D. CONSTRUCTION JOINTS

Joints not shown on the drawings shall be so located and made as to cause the least possible reduction in slab strength and shall be subject to approval. These shall be only as required by concrete placement interruptions not planned. The size of a pour shall not exceed 12 m. in any horizontal direction, unless approved by the architect/engineer. If possible, construction joints should not be located less than 1.5 m. from any other joint to which they are parallel. Whenever possible, large areas should be poured by following a "checkerboard" sequence to minimize construction joints.

The hardened concrete surface at all construction joints shall be thoroughly cleaned, including removal of all laitance, and wetted before new concrete is placed in contact with it.

INTEGRAL FLOOR HARDENER (METALLIC)

GENERAL

A. SCOPE

This specification covers materials and techniques to be used in the design and construction of concrete floors that require special integral hardening surface treatments to minimize wear and dusting and/or to reflect light. The materials will increase the surface compression strength to up to 800 kg./cm.^{2} or more. These materials are widely used in receiving, shipping, warehousing, manufacturing, and other areas of industrial buildings. They are applied dry to freshly placed concrete and become a part of the finished concrete surface. The manufacturer of the material frequently also installs or supervises the installation of the material because application, though highly beneficial, must be performed by experienced trademen only.

Metallic hardeners are used to provide non-dusting, durable, abrasion and impact resistant, heavy-duty concrete floors with or without energy saving light reflectivity. They are also used when resistance to struck sparks is needed in areas where hazardous flammable materials are handled.

B. RELATED WORK SPECIFIED ELSEWHERE

A-01 Concrete Prefabricated/Cast-in-Place
A-02 Concrete Form Work
A-03 Concrete Reinforcement
A-04 Concrete Floors and Slabs on Grade
A-05 Joints in Concrete

C. CODES AND STANDARDS

Contractor compliance with the following codes, standards, and recommended practices is critical to the construction of a high quality industrial floor: Specifications for Structural Concrete Buildings, ACI 301-81; Recommended Practice for Concrete Floor and Slab Construction, ACI 302-80; Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete, ACI 304-73; Recommended Practice for Hot Weather Concreting, ACI 305-77 (American Concrete Institute, P.O. Box 19150, Redford Stations, Detroit, MI 48219, USA) and Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete, ASTM C-309-81 (American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19013, USA).

The contractor for the floor slab shall comply with the following specifications:

- maximum slump shall be 7.6 cm.,
- maximum total air content shall be less than 3 percent,
- calcium chloride or set-accelerating admixtures containing calcium chloride shall not be used, and
- admixtures that increase bleeding shall not be used.

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Owner's Sample

Samples of material and acceptance finish shall be made available for review by the contractor during bidding and before starting work. Coordinate procurement and selection of materials with the owner's

representative to obtain acceptable quality of materials, color, and finish in completed work.

D. SUBMITTALS

The manufacturer of the material shall provide written certification verifying that the metallic aggregate used in the light-reflective product contains ferrous metals only and that it is free of rust and oil. (This product purity produces installed floors without excessive rust and blisters caused by reactive nonferrous metals or other contaminates which prohibit long-term serviceability and reflectivity.)

Prior to starting work, construct a sample floor section approximately 2.5 m. x 3.0 m. in a location designated by the owner's representative in accordance with specifications to demonstrate the texture, color (if specified), and installation procedures that are of prime importance. The sample slab must be approved by the architect/engineer and the owner before work begins. The accepted sample shall remain in place until all work is completed. The contractor is to maintain the same controls and procedures throughout the job. The sample slab may not be incorporated into the final work.

E. ACCEPTANCE TESTS

All completed work including the texture of the surface finish shall match the approved sample slab.

MATERIAL/PRODUCT

The product contains specially processed metallic-aggregate (iron), cementitious binder, plasticizer, and water-reducing admixtures. The product shall be supplied as a premixed, ready-for-use surface hardener; proportioned, mixed, and packaged at the factory in moisture resistant bags not exceeding 25 kg. each; and delivered to the job site ready to apply. The material shall be Light Reflective Master Plate 200 or Masterplate 200 (Master Builders, Inc., 23700 Chagrin Boulevard, Cleveland, OH 44122 USA), or equal. The material shall be applied at a minimum rate of 8.8 kg./m^2.

Curing materials shall be as recommended by the manufacturer of the metallic-aggregate surface hardener specified.

EXECUTION

A. JOB CONDITIONS

Place the concrete base slab between screed points to minimize handling. Move the concrete into place with square-tipped shovels; do not use rakes. Vibrators, when used, shall be inserted and withdrawn vertically. Concrete shall be struck to the specified level with a wooden strike-off bar. Concrete shall be further leveled and consolidated with wood bullfloat or wood darby. This shall be completed before free moisture rises to the surface (bleeding). Begin floating adjacent to columns, forms, and walls so that these areas do not set before the rest of the slab.

B. INSTALLATION

Bleed water shall not be present during or following the application of this shake. Apply the first shake of the floor hardener to the floated concrete adjacent to forms, entryways, columns, and walls where moisture will be lost first. Apply two thirds of the specified total shake immediately following floating of the total area. **Distribute evenly. Do not throw the shake.**

Finishing machines with float shoes shall be used as soon as the shake has absorbed the moisture (indicated by darkening of the concrete's surface). Float just long enough to bring moisture from the base slab through the shake. Immediately following floating, apply the remaining one third of the total specified shake in the same manner, and machine float as specified. The surface shall be further compacted by a third mechanical floating if time and setting characteristics of the concrete will allow.

AT NO TIME SHALL WATER BE ADDED TO THE SURFACE!

As the surface stiffens further, indicated by loss of sheen, it shall be hand or mechanically troweled with the blades relatively flat. For best results and highest reflectivity, the final raised troweling should be conducted by hand with stainless steel trowels. Trowel blades should be run as slowly as possible to achieve the desired finish. Excessive trowel blade speed will "burn" or darken the floor surface, resulting in a possible loss of reflectivity. All marks and pinholes shall be removed in the final raised trowel operation. **Do not burnish trowel. The type of texture of the surface finish shall conform to the job sample.**

Field Service

During the initial installation period, the manufacturer of the surface hardener shall provide the services of a trained, full-time employee of the manufacturer to aid in securing proper use of the product.

C. CURING

Floors finished with metallic-aggregate surface hardener shall be cured as recommended by the surface hardener manufacturer. When a membrane curing compound is recommended, apply the membrane curing compound immediately after the floor surface has hardened sufficiently so that the surface will not be marred by the application. The compound shall be applied uniformly over the entire surface at a coverage that will provide moisture retention in excess of the requirements of ASTM C-309-81. When dry, the coating shall be protected from droppings of plaster, paint, dirt, and other debris by a covering of scuff-proof, nonstaining building paper.

Floors shall remain covered and be kept free of traffic and loads for at least 10 days after their completion. Adequate provision shall be made for maintaining the concrete temperature at 10° C or above during the curing period.

D. PROTECTION OF INSTALLATION

Protect the floor from construction damage.

E. SPECIAL CONSIDERATIONS FOR LIGHT-REFLECTIVE FLOORS

The preservation of optimum light-reflective properties in the described installation after curing requires special care and precautions. Adequate measures must be taken by the contractor to protect the light-reflective floor against mortar and plaster spills, paint splatters, cutting oils, acids, and other related construction debris.

After the light-reflective floor is put into service, an appropriate housekeeping procedure should be followed using high-alkaline solutions. The combination of: (1) proper application, (2) protection during the construction phase, and (3) diligent housekeeping after construction will ensure designed light reflectivity and long-term durability.

In the presence of frequent or continuously wet conditions, clorides, and acids and their salts, surface oxidation of the described light-reflective installation may be expected. The oxidation results from the interaction of oxygen and moisture on the metallic-aggregate (iron) particles found on the floor surface. In such cases, it would be preferable to use a nonmetallic mineral aggregate, dry-shake surface hardener or a nonoxidizing, light-reflective, dry-shake surface hardener.

Proper finishing techniques, timely and proper application of the curing compound, and good housekeeping procedures will minimize surface oxidation. It should be noted that minor surface oxidation in the form of random speckling will not significantly reduce the overall reflective factor of the floor.

Although metallic light-reflective hardeners such as Masterplate are no more conducive to tire marking than any other type of industrial floor surface, material handling vehicles can be a source of tire marks that affect the aesthetic qualities of the light-reflective floor. Again, it should be noted that tire marks in isolated traffic areas will not hamper the overall light reflectivity of the floor. If aesthetic considerations determine tire marking to be undesirable, the tire industry should be consulted for their recommendations on tires designed to be "non-marking."

INTEGRAL FLOOR HARDENER (NONMETALLIC)

GENERAL

A. SCOPE

This specification covers materials and techniques to be used in the design and construction of concrete floors that require special coloring and integral hardening surface treatments to minimize wear and dusting, and/or to reflect light. The materials will increase the surface compression strength to up to 800 kg./cm.^{2} or more. These materials are widely used in receiving, shipping, warehousing, manufacturing, and other areas of industrial buildings. They are applied dry to freshly placed concrete and become a part of the finished concrete surface. The manufacturer of the material frequently also installs or supervises the installation of the material because application, though highly beneficial, must be performed by experienced trademen only.

Nonmetallic hardeners are used to provide a hardened, wear-resistant concrete surface for medium-duty service. Optionally they can also be used to color the concrete surface and/or to provide energy saving light reflectivity. The durability and surface dusting characteristics of nonmetallic hardeners are lower than those of metallic hardeners.

B. RELATED WORK SPECIFIED ELSEWHERE

A-01 Concrete Prefabricated/Cast-in-Place
A-02 Concrete Form Work
A-03 Concrete Reinforcement
A-04 Concrete Floors and Slabs on Grade
A-05 Joints in Concrete

C. CODES AND STANDARDS

Contractor compliance with the following codes, standards, and recommended practices is critical to the construction of a high quality industrial floor: Specifications for Structural Concrete Buildings, ACI 301-81; Recommended Practice for Concrete Floor and Slab Construction, ACI 302-80; Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete, ACI 304-73; Recommended Practice for Hot Weather Concreting, ACI 305-77 (American Concrete Institute, P.O. Box 19150, Redford Stations, Detroit, MI 48219, USA) and Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete, ASTM C-309-81 (American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19013, USA).

The contractor for the floor slab shall comply with the following specifications:

- maximum slump shall be 7.6 cm.,
- maximum total air content shall be less than 3 percent,
- calcium chloride or set-accelerating admixtures containing calcium chloride shall not be used, and
- admixtures that increase bleeding shall not be used.

Owner's Sample

Samples of material and acceptance finish shall be made available for review by the contractor during

bidding and before starting work. Coordinate procurement and selection of materials with the owner's representative to obtain acceptable quality of materials, color, and finish in completed work.

D. SUBMITTALS

Prior to starting work, construct a sample floor section approximately 2.5 m. x 3.0 m. in a location designated by the owner's representative in accordance with specifications to demonstrate the texture, color (if specified), and installation procedures that are of prime importance. The sample slab must be approved by the architect/engineer and the owner before work begins. The accepted sample shall remain in place until all work is completed. The contractor is to maintain the same controls and procedures throughout the job. The sample slab may not be incorporated into the final work.

E. ACCEPTANCE TESTS

All completed work including the texture of the surface finish shall match the approved sample slab.

MATERIAL/PRODUCT

The product contains specially processed natural nonmetallic aggregate (quartz) hardener. The product shall be supplied as a premixed, ready-for-use surface hardener; proportioned, mixed, and packaged at the factory in moisture resistant bags not exceeding 25 kg. each; and delivered to the job site ready to apply. The material shall be Colorcron or Maximent (Master Builders Inc., 23700 Chagrin Blvd., Cleveland, OH 44122, USA), or equal. Color and light reflectivity for Colorcron shall be specified, as required, by the architect.

The material shall be applied at a rate of approximately 5.0 kg/m^2 as recommended by the nonmetallic hardener manufacturer.

Color, if specified and used, will affect the cost of materials. The Finish Schedule should include the color required for bidding purposes.

Curing materials shall be as recommended by the manufacturer of the nonmetallic surface hardener specified.

EXECUTION

A. JOB CONDITIONS

Place the concrete base slab between screed points to minimize handling. Move the concrete into place with squaretipped shovels; do not use rakes. Vibrators, when used, shall be inserted and withdrawn vertically. Concrete shall be struck to the specified level with a wooden strike-off bar. Concrete shall be further leveled and consolidated with wood bullfloat or wood darby. This shall be completed before free moisture rises to the surface (bleeding). Begin floating adjacent to columns, forms, and walls so that these areas do not set before the rest of the slab.

B. INSTALLATION

Apply the first shake of the floor hardener to the floated concrete adjacent to forms, entryways, columns, and walls where moisture will be lost first. Apply two thirds of the specified total shake immediately following floating of the total area. **Distribute evenly. Do not throw the shake.**

Finishing machines with float shoes shall be used as soon as the shake has absorbed the moisture (indicated by darkening of the concrete's surface). Float just long enough to bring moisture from the base slab through the shake. Immediately following floating, apply the remaining one third of the total specified shake in the same manner, and machine float as specified. The surface shall be further compacted by a third mechanical floating if time and setting characteristics of the concrete will allow.

AT NO TIME SHALL WATER BE ADDED TO THE SURFACE!

As the surface stiffens further, indicated by loss of sheen, it shall be hand or mechanically troweled with the blades relatively flat. For best results and highest reflectivity, the final raised troweling should be conducted by hand with stainless steel trowels. Trowel blades should be run as slowly as possible to achieve the desired finish. Excessive trowel blade speed will "burn" or darken the floor surface, resulting in a possible loss of reflectivity. All marks and pinholes shall be removed in the final raised trowel operation. **Do not burnish trowel. The type of texture of the surface finish shall conform to the job sample.**

Field Service

During the initial installation period, the manufacturer of the surface hardener shall provide the services of a trained, full-time employee of the manufacturer to aid in securing proper use of the product.

C. CURING

Floors finished with nonmetallic aggregate surface hardener shall be cured as recommended by the surface hardener manufacturer. When a membrane curing compound is recommended, apply the membrane curing compound immediately after the floor surface has hardened sufficiently so that the surface will not be marred by the application. The compound shall be applied uniformly over the entire surface at a coverage that will provide moisture retention in excess of the requirements of ASTM C-309-81. When dry, the coating shall be protected from droppings of plaster, paint, dirt, and other debris by a covering of scuff-proof, nonstaining building paper.

Floors shall remain covered and be kept free of traffic and loads for at least 10 days after their completion. Adequate provision shall be made for maintaining the concrete temperature at 10° C or above during the curing period.

D. PROTECTION OF INSTALLATION

Protect the floor from construction damage.

E. SPECIAL CONSIDERATIONS FOR LIGHT-REFLECTIVE FLOORS

The preservation of optimum light-reflective properties in the described installation after curing requires special care and precautions. Adequate measures must be taken by the contractor to protect the light-reflective floor against mortar and plaster spills, paint splatters, cutting oils, acids, and other related construction debris.

After the light-reflective floor is put into service, an appropriate housekeeping procedure should be followed using high-alkaline solutions. The combination of: (1) proper application, (2) protection during the construction phase, and (3) diligent housekeeping after construction will ensure designed light reflectivity and long-term durability.

Proper finishing techniques, timely and proper application of the curing compound, and good housekeeping procedures will maximize the overall reflective factor of the floor.

Although nonmetallic light-reflective hardeners such as Colorcron or Maximent are no more conducive to tire marking than any other type of industrial floor surface, material handling vehicles can be a source of tire marks that affect the aesthetic qualities of the light-reflective floor. Again, it should be noted that tire marks in isolated traffic areas will not hamper the overall light reflectivity of the floor. If aesthetic considerations determine tire marking to be undesirable, the tire industry should be consulted for their recommendations on tires designed to be "non-marking."

POLYURETHANE FLOOR SEALER

GENERAL

A. SCOPE

This specification covers materials and techniques to be used in the treatment of a concrete floor so that it will not generate dust and can be easily cleaned. The treated surface **requires replacement in approximately one to two years at normal traffic levels.** The treated surface is **slippery when wet.** This sealer is **not suitable for slabs on grade without vapor barriers.**

B. RELATED WORK SPECIFIED ELSEWHERE

A-01 Concrete Prefabricated/Cast-in-Place
A-02 Concrete Formwork
A-03 Concrete Reinforcement
A-04 Concrete Floors and Slabs on Grade
A-05 Joints in Concrete

C. CODES AND STANDARDS

Minimum of one prime coat and two finish coats totalling not less than 4 mils (0.1 mm.) dry thickness of a proprietary "two coat" system for new work. Recoat using either a "two coat" or single coat system.

MATERIALS/PRODUCTS

The sealer is a milky liquid water based styrene/acrylate copolymer and urethane resin mixture that is supplied in 190 liter drums. The sealer provides a glossy, smooth, seamless, easily cleaned, water and wear resistant surface that withstands both lift truck, cart, and pedestrian traffic. Rubber tire and scuff marks are easily removed compared to many other surfaces. It is available clear and in a number of colors. The clear sealer is preferred if the concrete surface has a good appearance. Recommended manufacturers and brands are Tennant 420 Two Coat Urethane or Tennant 400 Concrete Seal (Tennant Company, P.O. Box 1452, Minneapolis, MN 55440, USA), or equal. Tennant 420 contains flammable solvents. Tennant 400 contains no flammable solvents.

EXECUTION

A. JOB CONDITIONS

Concrete must be at least 30 days old. The concrete surface must be thoroughly cleaned, properly prepared, and dry.

B. INSTALLATION

Surface preparation and be treatment must be performed by experienced personnel only. For first time users or in new facilities, the services of the manufacturer's representatives should be utilized for the initial application and for training local housekeeping personnel in application and maintenance. Surface preparation and treatment shall be strictly in accordance with the manufacturer's recommendations.

Good ventilation is required during surface preparation and sealer application because fumes (ammonia)

from the sealer are potentially toxic until it is cured. Smoking and open flames are prohibited when Tennant 420 is being applied or curing.

Local impact or wear damage to a treated surface is easily repaired by trained local personnel.

C. CURING

Curing requires a relative humidity greater than 40 percent.

The final coat of the "two coat" system must cure a minimum of 8 hours at 24° C at 50 percent relative humidity. The rate of cure depends on temperature and relative humidity. After 8 hours light pedestrian traffic is permissible. Maximum wear resistance is achieved after 7 days.

The final coat of the single coat system must cure 4-6 hours or longer depending on temperature and relative humidity.

PIGMENTED CONCRETE FLOORS

GENERAL

A. SCOPE

This specification covers materials and techniques to be used in the construction of mineral pigmented concrete floors prepared by integral mixing. These floors are appropriate for areas of heavy pedestrian traffic. Pigmentation **per se** does **not** harden the surface of the concrete.

B. RELATED WORK SPECIFIED ELSEWHERE

A-01 Concrete Prefabricated/Cast-in-Place
A-02 Concrete Form Work
A-03 Concrete Reinforcement
A-04 Concrete Floors and Slabs on Grade
A-05 Joints in Concrete

C. SUBMITTALS

Submit a sample of the specified pigmentation material for approval.

Prior to starting work, construct a sample floor section, approximately 2.5 m. x 3.0 m. in accordance with specifications to show the texture and color of the pigmented concrete. The sample slab must be approved by the architect/engineer and the owner before work begins. The accepted sample shall remain in place until all work is completed. The floor sealer specified, if any, shall be placed on one half of the slab after 28 days. The sample slab may not be incorporated into the final work.

Submit certified laboratory test reports showing the pigmented concrete's conformance of actual compressive strength, with pigment added, with the contract specifications.

D. PRODUCT DELIVERY, STORAGE, AND HANDLING

The pigmentation product shall be delivered by the contractor to the job site in sealed unit bags that are properly labeled to identify the product and its weight. It shall be properly stored to maintain it and its packaging in a dry condition.

E. ACCEPTANCE

The completed work shall match the approved sample slab.

MATERIALS/PRODUCTS

A. MINERAL PIGMENT

Color pigments shall be lightfast, wettable, weather resistant, alkali-resistant, and free of deleterious solid or soluble fillers or extenders and at least 95 percent finely milled pure mineral oxides. Carbon, if added for darker shades of color, shall be wettable and shall not exceed 3 percent of the cement's weight. Color pigments are available in many standard colors that can dramatically change the ordinary dull gray color of concrete to pleasing shades of color. The pigments are supplied in standard 4.1 kg. cartons or 22.7 kg. bags. Custom bagging is available in variable weights for premeasured batch designs. To avoid compressive strength loss, do

not use more pigment than 10 percent of the total weight of the cement used. The product shall be SGS Concentrated Cement Colors (Solomon Grind Chem Service, Inc., P.O. Box 1766, Springfield, IL 62705, USA), or equal.

EXECUTION

A. JOB CONDITIONS

Utilize the proper concrete mix design to achieve 150 kg/cm.^{2} compressive strength in accordance with ACI 301 standards (American Concrete Institute, P.O. Box 19150, Redford Station, Detroit, MI 48219, USA).

Mixing shall conform to ASTM C-94 (American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19013, USA) mixing standards and the cement to ASTM C-150 and aggregate to ASTM C-53.

B. INSTALLATION

A ready-mix agitator should be used to provide thorough mixing and dispersing of color into the concrete. To provide consistent and uniform color:

- load the ready-mix agitator with the selected mix design of cement, coarse and fine aggregate, and potable water leaving approximately 1 to 2 cu. m. of extra capacity in the ready-mix agitator;
- add the designated amount of color **by weight** and mix for a minimum of 5 minutes at full mixing speed (color is usually required at approximately 5 percent of the weight of the cement);
- **note that any change in proportioning the amount of water, aggregate, sand, and color to the cement and/or the type of cement and aggregate used for the same job can result in a variation of color tone in the finished job.**

C. CURING

The concrete shall be allowed to hydrate approximately 24 hours; then fog spraying with water shall be applied for proper curing.

D. PROTECTION OF INSTALLATION

In order to protect the floor from possible construction damage, cover during working hours with waterproof paper or polyethylene film **after** the concrete has cured for a period of 4 days.

E. MAINTENANCE

The pigmented concrete's surface may be sealed **after** at least 28 days of curing.

REINFORCED VINYL TILE

GENERAL

A. SCOPE

This specification covers materials and techniques to be used in the preparation of substrate surfaces, furnishing and installation of inert mineral fiber reinforced vinyl tile and base, and cleaning of all surfaces and work areas. The material will begin to soften at temperatures over 38° C making it susceptible to permanent indentation damage. The material itself is not slippery; however, slip resistance depends on how the surface is maintained.

B. SUBMITTALS

Before starting any work, submit samples for review by the architect/engineer and approval by the owner for each material, pattern, and color selected.

MATERIALS/PRODUCTS

Reinforced vinyl tile 30 cm. square and 3 mm. thick is excellent for pedestrain traffic and light carts. It should be used with 10 cm. vinyl or rubber cove base. Sanitation is generally easy but limited by the number of joints. Vinyl tile should not be used in areas subject to flooding. It is available in a wide variety of patterns and colors and should be coated with a good water emulsion finish.

A. FLOOR COVERING MATERIALS

Mineral fiber reinforced vinyl tile shall be 30 cm. square and 3 mm. thick. Colors and patterns will be selected by the architect/engineer and approved by the owner.

Recommended brand and its manufacturers is Armstrong's Imperial Excelon (Armstrong World Industry, Inc., Gables One Tower Building, 1320 South Dixie Hwy., Coral Gables, FL 33146, USA), or equal.

B. BASE MATERIALS

The base shall be top set coved 10 cm. high and 3 mm. thick and include premolded end stops and external corners. Lengths shall be as long as possible.

C. ADHESIVES, ACCESSORIES, AND SEALERS

Subfloor Filler: White premix latex, to be mixed with water to produce a cementitious paste.

Primers and Adhesives: Waterproof and of the types recommended by the resilient flooring manufacturer for the material selected. Concrete curing or parting compounds may interfere with the bond. Special adhesives should be specified for on-grade installations or where accidental flooding may occur.

Sealer: Of the type recommended by the resilient flooring manufacturer for the material type and location.

D. EXTRA MATERIAL

An extra 5 square meters of tile of each of the colors and patterns of floor material for maintenance use. Clearly identify each box.

EXECUTION

A. SITE AND SUBSTRATE CONDITIONS

Inspect surfaces prior to installation. Call to the attention of the owner's representative any conditions that might prevent proper installation. Failure to do so will be construed as acceptance and approval of the substrate surfaces.

Ensure floor surfaces are smooth and flat with a maximum variation of 3 mm. in 3 m.

Ensure that concrete floors are dry (maximum 7 percent moisture content) and that they exhibit negative alkalinity, carbonization, and dusting.

Maintain a minimum 21° C air temperature in the flooring installation area for 3 days prior to, during, and for 3 days after installation.

Store flooring materials in the area of application. Allow 3 days for the material to reach the same temperature as the area.

B. LEVELING

Remove subfloor ridges and bumps. Fill low spots, cracks, joints, holes, and other defects with the subfloor filler.

Clean the floor. Apply, trowel, and float the filler to leave a smooth, flat, hard surface. Prohibit traffic until the filler is cured.

C. INSTALLATION

Floor Covering Material:

Open enough floor tile cartons to cover an entire area. Mix the tiles to prevent shade variations within any one area.

Clean the substrate. Spread the cement evenly in the quantity recommended by the manufacturer to ensure adhesion over the entire area of the installation. Spread only enough adhesive to permit installation of the flooring before initial set of the adhesive.

Set the flooring in place with joints as tight as possible. Press with a heavy roller to ensure full adhesion. Lay flooring with joints and seams parallel to the building lines to produce a symmetrical tile pattern. Install with minimum $^1/_2$ full size tile widths at the perimeter of the area to square the grid pattern with all joints aligned and with the pattern grain parallel for all units and parallel to the length or width of the room. Terminate resilient flooring at the centerline of all door opening(s) where the adjacent floor finish is dissimilar.

Install edge strips at unprotected or exposed edges where the flooring terminates. Scribe flooring to walls, columns, cabinets, floor outlets and other appurtenances to produce tight joints. Install flooring in pan type floor access covers. Maintain the floor pattern. Install feature strips and floor markings where indicated. Fit joints tightly. Continue the flooring through all office areas that will receive movable partitions without interrupting the floor pattern.

Where shown on drawings, form an integral cove at the walls and other transition points using the flooring material. Install backing for support.

Base:

Do not install the base until the plaster, concrete or other backing material has dried thoroughly. Fit joints tightly and vertically. Do not stretch the base during application. Maintain a minimum measurement of 457 mm. between base joints. Miter internal corners. Use premolded sections for external corners and exposed ends. Install the base on a solid backing. Adhere it tightly to the wall and floor surfaces. Scribe and fit the base tightly to the door frames and other obstructions. Install the base straight and level to a tolerance of plus or minus 3 mm. over 3 m.

D. PROTECTION

Prohibit traffic on the finished floor for 48 hours after installation.

E. CLEANING

Remove excess adhesive from the floor, base, and wall surfaces without damage to any element in

accordance with the manufacturer's recommendations.

Do not wash the floor for at least 3 days to enable the adhesive to develop a full bond. Clean and seal the floor and base surfaces in accordance with the manufacturer's recommendations.

BLOCK MASONRY

GENERAL

A. SCOPE

This specification covers materials and techniques to be used for design and construction of:

- block masonry units
- masonry reinforcing, anchors, and ties
- sheet flashings built into masonry
- filling hollow metal frames in masonry walls
- pointing and cleaning all masonry
- cavity wall insulation, where specified
- reinforcing for block masonry unit lintels
- access panels in masonry.

B. RELATED WORK SPECIFIED ELSEWHERE

A-12 Water Repellent Treatment
A-15 Hollow Metal Work
F-07 Fire Barriers
F-08 Fire Dampers

C. CODES AND STANDARDS

Install masonry work to meet the requirements of all local codes.

Allowable Tolerances:

Variation from plumb in the lines and surfaces of columns and walls shall not exceed 2 percent.

Variation from the level of the grades indicated on the drawings for exposed lintels, sills, parpets, horizontal grooves and other conspicuous lines shall not exceed 1 percent.

Fire wall ratings, estimated ratings, and equivalent thickness tables shall be as listed in the latest edition of the Fire Resistance Ratings published by the American Insurance Association (85 John Street, New York, NY 10038, USA) or in the Fire Resistance Directory published by Underwriters' Laboratories, Inc. (333 Pfingsten Rd., Northbrook, IL 60062, USA).

D. SUBMITTALS

Submit 2 samples of specified concrete masonry units for approval.

Prior to starting work, build a sample wall, approximately 1.2 m. x 1.5 m. face size, to show required facing material, the range of texture and color, the type and color of mortar joints, and the methods of laying and workmanship. Cleaning solutions and water repellent treatments shall be tested at this same time. The sample wall must be approved by the architect/engineer and the owner before work begins. It may be incorporated into the final work. Actual walls shall match the approved sample wall.

MATERIALS/PRODUCTS

A. BLOCK MASONRY UNITS

All block masonry units shall be the product of one manufacturer.

B. ANCHORS AND TIES

As specified and galvanized.

C. MORTAR MATERIALS

Cement; clear, sharp mason sand; and potable water.

D. MIXES

All masonry cement mortar for exterior walls and interior partitions shall consist of 1 part masonry cement to 3 parts sand by volume. The method of measuring materials for mortar shall be such that the specified proportions of the mortar materials can be controlled and accurately maintained during the entire progress of the work. Cementitious materials and aggregates shall be mixed for a minimum period of three minutes in a drum type batch mixer with the minimum amount of water consistent with satisfactory workability.

The mortar shall be retempered on the board as necessary to maintain consistency, but mortar standing for over one hour shall be discarded.

EXECUTION

A. SCAFFOLDS

Provide and maintain all scaffolds, staging, hoists, etc., required for the proper execution of all masonry work.

B. INSTALLATION

Components and Coatings

Openings: ascertain from the several trades, the sizes and locations of openings for pipes, ducts, etc.

Anchors and Ties: Build in all anchors, reinforcement, bolts, flashings, beams, frames, etc., as may be required.

Door Frames: Lay out the lines for all walls. All metal frames shall be set in advance of masonry work. Care shall be taken not to disturb the bucks and frames. If the frames are out of plumb in any direction, remove the masonry and reset the frames in a proper manner. Bed the anchors of the door and other frames in mortar. Completely fill the door frames with mortar or grout.

Bituminous Coating: Where indicated, apply a bituminous coating without breaks or pinholes to a thickness of 1.5 mm. to 3.0 mm.

Laying Concrete Blocks

Concrete block shall not be wetted before being placed in the wall. Partitions shall extend from the top of the structural floor to the bottom surface of the floor and/or roof construction above, except for interior walls shown otherwise on the drawings. The block units shall be laid to a line with full mortar coverage on vertical and horizontal face shells. Units shall be laid up in running bond with 9 mm. joints, struck concave where exposed. Joints in walls that are to be epoxy-coated shall be struck with a 1 inch (25 mm.) diameter pipe or similar object; other joints are to be struck in the conventional fashion. Special care shall be taken with striking of joints in exposed masonry block units so that the joints are completely filled. All cutting of units shall be done with a power driven saw with a carborundum disc blade.

Alternate courses of block walls shall be horizontally reinforced as specified, embedding reinforcing completely in the mortar. Use special reinforcing units at corners and intersections and for tying other types of masonry together.

For exposed work, particular care shall be taken to prevent smearing mortar on the surface of block masonry units. If a mortar smear occurs, it shall be allowed to dry. The large particles are removed by a trowel, and the remaining mortar is removed by a stiff fiber brush. All mortar smears, drippings, etc., on exposed faces of concrete masonry shall be removed, as specified in paragraph D-Cleaning.

C. PROTECTION

Cover the top of all work each night or at the termination of work. Extend coverings down the sides of walls 30 cm. to 50 cm. Keep all projections free of mortar droppings. Turn over and away from the walls each night all scaffold planks next to the walls.

The contractor is responsible for providing adequate bracing of walls during erection to prevent damage caused by high winds or other lateral loads until permanent bracing is installed and assumes responsibility for all damage because of failure to take such precautions.

Hot weather protection requirements for masonry being worked on and for 24 hours after completion shall be strictly observed. Protect all work from direct exposure to wind and sun when erected in an ambient air temperature of 35° C or higher at relative humidity levels of less than 50 percent.

D. CLEANING

Clean exposed concrete block with soap powder and clean water applied with stiff fiber brushes and again washed and rinsed with clean water. All mortar droppings shall be removed from projecting surfaces of whatever kind. If stiff brushes and soap and water do not suffice for cleaning, the surfaces shall be cleaned using a commercial cleaner such as "Sure-Klean 600" (Process Solvent Company, Inc., 755 Minnesota Ave., Kansas City, MO 66101, USA) or equal.

E. REPAIR AND POINTING

Remove and replace all masonry units that are loose, chipped, broken, stained, or otherwise damaged and any units that do not match adjoining units as intended. Provide new units to match adjoining units and install fresh mortar or grout, pointed to eliminate all evidence of replacement.

WATER REPELLENT TREATMENTS

GENERAL

A. SCOPE

This specification covers materials and techniques to be used in applying a liquid water repellent to all exposed surfaces of block masonry or exposed concrete elements.

Concrete and block masonry has a tendency to absorb moisture, especially in regions of high humidity and heavy rainfall. Water repellent treatment of these exposed elements reduces capillary water absorption, efflorescence, and dirt penetration and enhances the integrity of these elements including embedded reinforcing bars. **A water repellent treatment does not act as a barrier to water vapor.**

B. RELATED WORK SPECIFIED ELSEWHERE

A-11 Block Masonry

C. CODES AND STANDARDS

Provide liquid water repellent produced by a single manufacturer.

D. SUBMITTALS

Apply the water repellent to the sample wall (see the Guideline Specification for Block Masonry A-11), either partial or full coverage, as directed. Adjustment of the requirements, if any, based on the architect engineers examination and the owner's approval of the sample application will be by written change order. Proceed with work only after acceptance of test application or as otherwise directed.

Submit manufacturer's product specifications, instructions, and certification or other data substantiating that the materials comply with the requirements and are recommended for the indicated application.

Submit 2 copies of the manufacturer's warranty, signed by both applicator and contractor, agreeing to restore waterproof condition in the event of moisture penetration within 10 years after application.

MATERIALS/PRODUCT

Materials shall be translucent and non-yellowing. The substrate's surface shall appear unchanged after application.

The clear colorless non-photoreactive product is supplied in 3.8 l. pails and 190 l. drums. It is a single component blend of poly-siloxane resins. Product shelf life limitations and sensitivity to moisture before application, if any, shall be noted and precautions observed. Most products contain volatile solvents and may have a flash point below 37° C. All necessary precautions shall be observed.

Recommended brands and manufacturers are Sikaguard 70 (Sika Corporation, 875 Valley Brook Ave., Lyndhurst, NJ 07071, USA); Silikote 46-V-6 (The Valspar Corporation, Box 625, Raritan, NJ 08869, USA); or equal. Silikote 46-V-6 is also available through Delft in Mexico City, Mexico.

EXECUTION

A. JOB CONDITIONS

Do not proceed with application of water repellent:

- when ambient temperature is below 10° C, or
- when substrate surfaces have cured for less than 2 months, or
- when rain or temperatures below 5° C are predicted within 24 hours, or
- earlier than 3 days after the substrate became wet from rain or other moisture sources.

B. INSPECTION

Examine the substrate and the conditions under which the work is to be done. Do not proceed with the work until any conditions detrimental to proper and timely completion have been corrected.

C. PREPARATION

Where feasible, do not apply the water repellent until after installation of all sealants in or adjacent to the areas to be treated.

Clean the substrate of substances that may interfere with proper application. Remove all grease, curing compounds, surface treatments, coating, oils, etc., on old concrete by the proper means. A light sandblasting improves penetration on new and old concrete.

Test for moisture content to ensure that surface is sufficiently dry. Comply with the manufacturer's instructions.

Standing water must be removed. While residual moisture may not affect the treatment, **the drier the substrate the better the penetration.**

Protect adjoining work, including the sealant bond surfaces, from the water repellent. Cover all adjoining and nearby surfaces of metal and glass where there is a possibility of the repellent being deposited on them. Cover live plant materials with drop cloths.

D. INSTALLATION

Apply a heavy, saturating repellent treatment to all surfaces indicated to receive it. (Application rates of 2.5 sq. m. per liter are the heaviest rates generally recommended and provide the best protection.) Comply with the manufacturer's printed instructions and current recommendations using an airless spraying procedure unless otherwise indicated.

E. CLEANING

Clean any water repellent from other surfaces immediately, following the manufacturer's instructions.

STEEL WIRE MESH PARTITIONS

GENERAL

A. SCOPE

This specification covers techniques and materials used in the construction of security cages in warehouse areas. These types of cages are used to separate various types of areas within a warehouse and, with special additional installations, to provide a secure area for high value items or for controlled drugs. See Chapter 10, Controlled Drugs for additional information on applications for this purpose.

B. CODES AND STANDARDS

Comply with all applicable codes and regulations for the storage of controlled drugs.

MATERIALS/PRODUCTS

A. WAREHOUSE AREAS

Steel wire mesh partitions shall be the all wire type for normal industrial use and shall be constructed of not less than No. 10 gauge (3.3 mm.) steel wire fabric, with openings of not more than 5.0 cm. across the square. This mesh is to be securely attached to posts and other framing elements. Clearances at the bottom and sides of partitions shall be held to a maximum of 10.0 cm. Height shall be at least equal to the maximum storage height on either side of the partition. Steel reinforcing members shall be used at mullions and corners and horizontally as required to provide adequate stiffness to the assembly. Doors with an integral key lock shall be constructed of No. 10 gauge steel wire fabric on a steel door frame in a steel framed door opening.

B. HIGH VALUE/CONTROLLED DRUG AREAS

Enclosures for these purposes shall conform to the requirements of paragraph A above. In addition, they are to be equipped with self-closing, self-locking doors constructed of substantial material or, as an alternate, doors that are kept closed and locked at all times when not in use and that when in use are kept under direct observation of a responsible employee or agent. Doors shall preferably be hinged. Where hinges are mounted on the outside, they shall be sealed, welded or otherwise constructed to inhibit removal. Locking devices for such door shall be either of the multiple-position combination or key lock type.

Posts are to be:

- steel at least 2.5 cm. in diameter
- set in concrete or installed with bolts that are pinned or brazed, and
- placed no more than 3.0 m. apart with horizontal 3.7 cm. reinforcements every 1.50 m.

The cage shall have a ceiling constructed of the same material, or, as an alternative, the sides of the cage shall reach and be securely attached to the structural ceiling of the building. A lighter gauge steel wire mesh may be used for the ceiling of large enclosed caged areas if its walls are greater than 4.30 m. in height.

Clearances on all edges shall be held to a maximum of 30 mm. Where cutouts in partitions are necessary around pipes, ducts, etc., similar clearances shall be maintained. These openings shall be framed for added strength.

Where ceilings or roofs are sloped, it may be more practical to use rectangular partition panels and employ a 1.5 mm. thick sheet metal closure plate fastened to the ceiling or the roof with a downstanding leg sheared to a horizontal line and fastened to the partition frame in a burglar-proof manner.

Cage doors are to be constructed of No. 10 gauge (3.5 mm.) steel wire fabric on a metal door frame in a metal door flange. All sliding and hinged doors shall have integral locks. The lock is to be of the restricted keyway or maximum security type, which means that key blanks are not readily available on the market.

CLEANABLE SUSPENDED CEILINGS

GENERAL

A. SCOPE

This specification covers materials and techniques to be used in the design and construction of fire retardant suspended ceilings in Class I and Class II repackaging areas. It includes the furnishing and installation of cleanable suspended ceilings and related items required to complete this work including:

- suspension systems, complete with hanger wires and bracing appropriately sized for seismic areas as required to adequately support the ceiling panels and light fixtures, and uplift braces for pressurized rooms;
- cleanable lay-in ceiling units;
- perimeter closures and trim;
- sealants.

B. CODES AND STANDARDS

The ceiling shall be leveled. The installation shall be made in strict accordance with the manufacturers instructions.

C. RELATED WORK SPECIFIED ELSEWHERE

F-08 Fire Dampers

D. SUBMITTALS

The contractor shall submit manufacturer's product specifications and installation instructions for each required ceiling material, including load carrying data, the manufacturer's certified laboratory reports including Underwriters Laboratories, Inc. (333 Pfingsten Road, Northbrook, IL 60062, USA) flame spread rating, and other data required to demonstrate compliance with the specifications. The contractor shall also submit the manufacturer's recommendations for cleaning and refinishing, including precautions against materials and methods that may be detrimental to finishes.

The contractor shall submit 30 cm. square samples for each unit required and 30 cm. long samples of each component in the suspension system. In all samples show the full range of exposed color and texture to be expected in the completed work. Sample submittal and owner's review will be for color and texture only. Compliance with other requirements is the exclusive responsibility of the contractor.

Submit shop drawings and/or manufacturer's literature showing the relationship of the suspension system and ceiling panels to lighting fixtures, diffusers, partitions, and other items affecting the installation.

E. PRODUCT DELIVERY, STORAGE AND HANDLING

The product shall be delivered, handled, and stored at the job site in such a manner as to prevent damage as well as the intrusion of foreign matter or moisture. Packaged materials shall be in their original containers with the seals unbroken and the labels intact until the time of use. Wrapped or bundled material shall bear the name of the manufacturer and the product.

MATERIALS/PRODUCTS

A. CEILING UNITS

Washable fire-resistive, fiberglass reinforced plastic, white, embossed 3.2 mm. thick panels. Size as shown by the reflected ceiling plans. Panels shall be equal to Fire-X Glasbord (Crane Dyrotech, Box 2429, Joliet, IL 60434, USA). Alternately, fire-resistive, nonperforated 15.9 mm. thick panels, mylar white matte finished surface bonded to a mineral fiber substrate. The mylar shall have a dirt resistive washable polyester-film surface. Size as shown by the reflected ceiling plans. The panels shall be equal to Mylar* Fire Guard manufactured by the Armstrong World Industries, Inc., Architectural Building Products Division (Gables One Tower Building, 1320 South Dixie Highway, Coral Gables, FL 33146, USA).

The panels shall have a UL flame spread rating of 25 or less.

B. CEILING SUSPENSION MATERIALS

The suspension system shall meet the specification established and approved by the architect/engineer. Exposed cross runners shall be coped to lay flush with the main runners. Exposed components shall be either zinc coated steel or aluminum and have a white baked enamel finish to match the color of the ceiling panels. Deflection loading shall be limited to 3 percent of the space.

C. SEALANT

Clear, mildew-resistant sealant such as Dow Corning Silastic 73C, Dow Corning 786 (Dow Corning Corporation, Midland, MI 48686, USA), or General Electric's SCS Series 1200 (General Electric, Silicone Products Division, Waterford, NY 12188, USA), shall be used to seal the panels, suspension materials, and other ceiling components.

EXECUTION

A. JOB CONDITIONS

The ceiling panels should not be installed until all exterior openings have been closed, all wet work is completed, and the building humidity is acceptable to the contractor. Verify that a uniform minimum temperature of 15° C immediately before, during, and after installation will be maintained.

This work is to be coordinated with the work of all trades above the ceiling and either penetrating or supported by it. The work above the ceiling must be completed before the panels are laid. This applies to the edge configuration of light fixtures, diffusers, grilles, fire protection sprinkler heads and smoke detectors, etc., that must match the suspension system.

B. INSPECTION

Examine all areas that are to receive ceiling materials; notify the owner's representative of any that are not suitable, and see that these are corrected before starting any work. The application or installation of ceiling materials shall be an indication of the installer's acceptance of conditions.

C. INSTALLATION

Coordinate spacing of the hangers, carrying channels, runners, and moldings with the location of the electrical fixtures and other items occurring on or in the ceiling. Hangers shall not contact any insulation covering ducts or pipes. Splay hangers only where obstructions or conditions prevent plumb installation. Offset horizontal forces of splayed hangers by counter-splaying, bracing, or other suitable method as specified by the architect/engineer. Provide independent framing below all ductwork to support the ceiling. Do not attach framing to, or through, ductwork.

Installation of Grid

Arrange ceiling panels and orient directionally-patterned units.

Secure wire hangers by looping and wire tying, either directly to the structure or to inserts, eye-screws, or other devices that are secure and appropriate for the substrate and that will not deteriorate or fail with age or elevated temperatures. Wrap hanger wires tightly at least three full turns.

Install main runners 60 cm. or 1.20 m. on center and directly suspend by wire hangers spaced at a maximum of 60 cm. on center.

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* *Trademark of the I.E. Dupont Company.*

Provide hanger wires at all four corners of each light fixture and each ventilation or air conditioners supply or return air diffuser or register.

Install edge moldings at edges of each ceiling area and at locations where the edge of the units would otherwise be exposed after completion of the work. Secure the moldings to the building construction by fastening with screwanchors into the substrate through holes drilled in the vertical leg. Space holes not more than 7.5 cm. from each end and not more than 40 cm. on center along each molding. Level moldings with the ceiling suspension system. Miter corners of moldings accurately to provide hairline joints securely connected to prevent dislocation.

Installation of Ceiling Panels

Install the panels in coordination with the suspension system with edges concealed by the supports of the suspension members. Scribe or cut the panels to fit accurately at all penetrations. Install edge trim moldings as needed to conceal edges of panels that would otherwise be exposed to view after completion of the work. Install hold-down clips in all positive-pressure Class I, II, and XIII rooms.

Installation of Sealant

Apply sealant at every metal-to-metal joint and between the metal grid and all lay-in items. Apply a small continuous bead of sealant between the tee suspension members and layin items including panels, grilles, registers, light fixtures, etc. Wipe off any excess sealant on the face of the tee and item, leaving a small concave fillet.

On abutting metal members only the face of the members needs to be sealed; wipe flush. Seal all pop rivet holes with sealant. Seal the joint between the edge molding and the wall surface.

D. CLEANING AND PROTECTION

Clean exposed surfaces of the ceilings including trim, edge moldings, and suspension members. Comply with the manufacturer's instructions for cleaning. Remove and replace work that cannot be successfully cleaned or that is scratched, marred, cracked, or otherwise damaged.

E. OWNER'S STOCK

Furnish 10 percent extra panels of the quantity installed for the owner's stock for maintenance. The material shall be in the original sealed and properly labeled containers. The amount is approximate and shall be furnished to the nearest full carton.

HOLLOW METAL WORK

GENERAL

A. SCOPE

This specification covers materials and techniques to be used in the design, fabrication, and installation of hollow metal doors and door and window frames.

B. RELATED WORK SPECIFIED ELSEWHERE

A-11 Block Masonry
A-16 Finish Hardware
F-09 Fire Barriers

C. SUBMITTALS

Shop drawings shall be submitted for approval by the architect/engineer showing:

- details of each frame type
- elevations of each door type
- location in building of each item
- conditions at the openings with various wall thicknesses and materials
- typical and special details of construction including glazing
- the method of assembling sections
- location and installation requirements for hardware (assure that door and frame suppliers receive templates of finish hardware)
- size, shape, and thickness of materials, joints, and connections
- the type and performance data for door louvers, giving percentages of free area for louvers to be installed.

Samples shall be submitted for approval by the architect/engineer for a:

- typical flush door corner section
- typical door frame corner section

D. PRODUCT DELIVERY, STORAGE, AND HANDLING

Delivery of fabricated material to the project site shall be the responsibility of the manufacturer. Doors shall be individually packaged in cartons completely covering the entire door to prevent damage to the finish. The owner reserves the right to reject any material that has become damaged.

The contractor shall store the doors on the site under cover and in a dry area no less that 10 cm. above the floor or ground and in an upright position with 5 mm. separators between all doors. Do not stack doors flat. Do not let doors, paper, or cardboard covers become wet. If this should happen, remove the covers and dry the doors.

MATERIALS/PRODUCTS

A. HOT-ROLLED STEEL SHEETS AND STRIPS
Commercial quality carbon steel, pickled and oiled.

B. SUPPORTS AND ANCHORS
Fabricate of not less than 16 gauge sheet metal; galvanize after fabrication.

C. SHOP-APPLIED PAINT
For steel surfaces, use a rust-inhibitive, nonleadcontaining enamel primer or paint baked-on and suitable as a base for finish paints.

EXECUTION

A. FABRICATION
Fabrication shall be the best quality of hollow metal work produced. Exposed surfaces shall be smooth, straight, and true; arises sharp and clean; corners square; joints flush; and welds ground smooth and imperceptible.

Finish hardware shall be furnished by others, who shall also supply the necessary templates. Prepare all hollow metal work for hardware application at the factory.

Insofar as practicable, fabricate the work in the shop, ready for delivery and erection at the building. Trial-fit work that is impossible to completely fabricate in shop. Assemble in the shop to ensure proper assembly at the building. Provide holes, connections and fastenings for, from, and to work to other trades abutting, adjoining, or intersecting the specified work.

Provide concealed reinforcement of sheet or bar steel for hardware, including automatic devices, and other attached work where and as required by conditions. Hinge reinforcement shall not be less than 5 mm. thick by not less than 4 cm. wide by not less than 15 cm. longer than the hinge. Reinforcement for other hardware and attached work shall not be less than 12 gauge (2.5 mm.) and of sufficient size to receive fastenings. Secure the hinge, door closer, and door holder reinforcements with at least 6 spot welds. Secure other reinforcement with at least 2 spot welds. All material to be welded shall be free of all oil and dirt before welding.

Frames shall be shop-assembled combination type with integral buck, jamb, and trim and welded construction, unless otherwise indicated. At joints, miter and continuously weld for the full depth and width of the frame.

All frames shall be formed to profile and shall be No. 14 gauge (2 mm.) minimum thickness. Frames shall be reinforced at all points where hardware is to be applied and tapped to receive the hardware in accordance with the hardware schedule. Provide a galvanized metal guard welded to the frame at each mortise where required to maintain the reinforcement free of mortar and plaster. Punch all frames for rubber silencers, 3 each for a single door and 2 each for a pair of doors.

All frames shall have adjustable anchors on each jamb, spaced approximately 60 cm. on centers. For new masonry walls, provide anchors that are not less than 6.3 cm. x 40 cm. x No. 16 gauge (1.6 mm.) steel. For drywall and veneer plaster wall, provide anchors that are not less than No. 18 gauge (1.3 mm.) steel, "Z" shaped, stud width and 38 mm. deep.

Coat all frames for installation in gypsum drywall and veneer plaster partitions with bituminous sound-deadening material on the unexposed surfaces.

Hollow metal doors shall be of a full flush design without visible seams on the face, 44 mm. thick with lock edges beveled 13 mm. in 50 mm.

All flush doors shall be made of face plates of No. 16 gauge (1.6 mm.) metal, reinforced at 75 mm. centers, sounddeadened and fire-insulated with approved mineral wool or fiberglass insulation. All vertical joints shall be continuously welded and smooth so as to be imperceptible. Care shall be exercised in spot welding so that welds will not show when the door is painted. Doors shall have closed tops and bottoms. Joints are to be continuously welded and ground smooth.

Doors shall have following maximum clearances:

At heads and jambs	2.5 mm.
At the bottom when thresholds and undercuts are not required	9.0 mm.
At the bottom when thresholds and undercuts are required	3.0 mm.
Between pairs of doors	3.0 mm.

Provide a box reinforcement of not less than No. 16 gauge (1.6 mm.) steel within the lock stile of all hollow metal doors to receive and support the lock escutcheons.

Provide and securely fasten a continuous metal reinforcement within the hinge stile to receive the hinges. Make neat mortises for hinges, locks, and all other hardware required in connection with the doors. Provide and properly place all reinforcements required for flush bolts, kick plates, closers, stops, and other items of hardware required in connection with the doors.

Where indicated on the door and window schedule, doors and borrowed light frames shall be provided with hollow metal or square bar molding to secure glazing in accordance with the glass opening sizes shown on the schedule.

Fixed moldings shall be securely welded to the door and/or frame on the security side.

Louvers shall be of the sight-proof welded blade type. Louvers pierced into the face sheets will not be permitted. The types of louvers shall be as indicated on the drawings and with the following minimum free areas:

- inverted "V" inserted louver 55 percent free area
- inverted "Y" inserted louver 30 percent free area
- "Z" or slat type inserted louver 35 percent free area
- adjustable inserted louver 37 percent free area
- lightproof inserted louver 20 percent free area

B. CLEANING AND FINISHING

Remove oil, grease, sand, dirt, and other foreign substances. After cleaning, chemically treat the metal surfaces to assure maximum paint adherence.

Apply a prime coat to all ferrous metal surfaces. The prime coat shall be a dip or spray coat of a rustinhibitive metallic oxide, zinc-chromate or synthetic resin metal primer, baked-on or oven-dried. Verify the compatibility of the prime coat and the specified finish coat. Finished surfaces shall be smooth and free from irregularities and rough spots. The dry film thickness of the prime paint coat shall be .05 mm. minimum, including all corners and bends. The preferred color is medium gray.

In addition to primed finish, paint the back surfaces of the frames, the reinforcing struts, and the other ferrous parts concealed by building construction with one heavy coat of an approved bituminous sound-deadening material.

C. INSTALLATION

Install the doors and frames as shown on the drawings and as specified and in accordance with approved shop drawings.

Examine the work in place on which this work is dependent. Notify the owner in writing of any defects that may influence satisfactory completion and performance of this work. All such defects shall be corrected by the contractor in accordance with the requirements of the applicable specifications prior to commencement of this work. Commencement shall be construed as the work in place being acceptable for satisfying the requirements of this specification.

Install hollow metal work, including power operating equipment, in the correct locations and in alignment, plumb and to true planes. Make breaks, angles, and corners square with walls.

Install hollow metal frames prior to construction of the enclosing walls and ceilings. Brace the frames securely including all wedging and blocking until permanent anchors are set. Build the frame anchors into the walls or secure to adjoining construction, as specified. Fill the frames with mortar. Where separate floor topping is indicated, extend frames and mullions to the concrete subslab. In clean rooms, install the frames

flush with the walls.

Anchor the bottom of the frames with anchor bolts and lead expansion shields or with drop-in expansion bolts. Use carbon steel shims where required under floor anchors to level the frame. Installed frames that exceed the recommended tolerance shall be removed and reinstalled properly at no additional cost to the owner.

Apply trim moldings as indicated or as required to complete the installation.

Adjust doors to fit accurately in their frames. Maintain maximum door clearances as specified in these specifications. Install astragals furnished for each pair of doors.

D. PROTECTION

Protect frames and doors from damage during subsequent construction.

E. CLEANING

Remove dirt and excess sealants or glazing compound from all exposed surfaces.

Touch up primer paint damaged during installation.

FINISH HARDWARE

GENERAL

A. SCOPE

This specification covers materials and techniques to be used in the selection, furnishing, and installation of finish hardware. The extent of finish hardware work shall be as shown on the drawings. Finish hardware associated with sliding doors, overhead doors, etc., where the provision of finish hardware with the door is the normal practice is excluded from this specification.

B. RELATED WORK SPECIFIED ELSEWHERE

A-11 Block Masonry
A-15 Hollow Metal Work
F-07 Fire Barriers

C. CODES AND STANDARDS

Comply with the codes, rules and regulations of the authorities having jurisdiction and with the standards of the NFPA (National Fire Protection Association, Battery March Park, Quincy, MA 02269, USA) and UL (Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL 60062, USA) as applicable to the work.

References to specific proprietary products, where present, are intended to establish minimum standards of quality and utility.

Each building shall be keyed with its own master. Locks for private offices shall also be operable by the master key of the building in which they are located. Locks in individual offices shall generally not be required. There shall not be a grand master key for use between buildings.

The following specific functions shall each have a submaster key common to all buildings:

- housekeeping closets
- equipment rooms to open mechanical equipment rooms, mechanical equipment shafts, penthouses and doors from penthouses to roofs
- electrical rooms to open electrical vaults, electrical closets, and electrical shafts

There shall be "a construction key" for all locks specified. This key shall become inoperable upon the initial use of a building master key.

D. SUBMITTALS

The contractor shall prepare and submit for the architect's review and approval a detailed finish hardware schedule for each door and opening indicating the complete designation of every item. The detailed schedule shall be based on the finish hardware schedule in the bid documents. The contractor shall also submit shop drawings and manufacturer's data that provide instructions for installation and maintenance of finishes and operating parts for each item for the architect's review and approval.

The contractor shall furnish finish hardware templates to each fabricator of doors, door frames, or other work and keys in sealed envelopes to the owner's representative.

E. PRODUCT DELIVERY, STORAGE, AND HANDLING

Each unit of finish hardware shall be individually packaged, complete with fasteners and accessories, and sealed. Each hardware package shall clearly indicate the contents. Finish hardware shall be delivered to the building in its original containers with seals unbroken and with the designated location of each item clearly identified and related to the finish hardware schedule as shown on the drawings.

Keys for all locks shall be furnished in envelopes sealed by the manufacturer and delivered to the owner's representative whose responsibility it will be to classify, label, and issue them.

Finish hardware shall be stored inside a building designated by the owner's representative that has hinged doors and safety locks. The contractor is responsible for the safekeeping of finish hardware until final acceptance of the building.

F. ACCEPTANCE TESTS

Acceptance of the work is subject to field testing and inspection as herein specified.

MATERIALS/PRODUCTS

A. LOCKSETS

The quality standard is equivalent to that of Sargent Lock Company, 100 Sargent Drive, New Haven, CT 06509, USA; Schlage Lock, 2401 Bay Shore Blvd., San Francisco, CA 94134, USA, or equal, as follows:

- exterior entrances main building: Sargent Series 70 Maximum Security
- exterior entrance to other buildings: Sargent Standard 6 pin cylinder
- interior heavy-duty use areas (viz., warehouse and repackaging): Sargent 7800 Series
- interior general purpose: Sargent Series 8
- controlled drug areas: Schlage Restricted Keyway Locks

B. DOOR CLOSERS

The quality standard is equivalent to that of the Sargent Lock Company as follows: Series 150 for exterior doors and either Series 50 or 60 for interior doors. Provide parallel-arm door closers at out-swing exterior doors and at interior doors where shown on the drawings. Door closers shall be sized in accordance with the manufacturer's recommendations and subject to the approval of the architect.

C. OTHER HARDWARE

Hinges, door pulls, push plates (satin-stainless), kick plates (satin-stainless), door holders, flush bolts and pulls, stops, bumpers, and thresholds shall be as specified by the architect and these specifications. Hinges on exterior out-swing doors shall be provided with nonremovable pins. Kick plates, door armor and push plates shall be No. 16 gauge (1.6 mm.), type 304 stainless steel. Plates shall be provided with countersunk screw holes. Edges of all plates shall be beveled with no sharp corners or edges. Armor plates shall be single piece or 2 piece door edge wrap type except where full height edge changes are scheduled. Hollow metal door frames and hollow metal doors shall be furnished shop fitted for mortised hardware.

D. FASTENERS:

All finish hardware shall be provided with screws, bolts, and other fasteners of a suitable size and type to securely anchor the hardware in place. The fasteners shall be compatible with both the unit fastened and the substrate and shall not cause deterioration of the finish hardware, substrate, or fastener. All exposed fasteners shall match the finish hardware, as to material and finish.

E. FINISH HARDWARE FOR FIRE-RATED OPENINGS

Finish hardware for fire-rated openings, where shown on the drawings, shall comply with NFPA 80 "Standard for Fire Doors and Windows" and other governing standards. Provide only finish hardware that is UL listed.

EXECUTION

A. INSPECTION

Examine work in place on which this work is dependent. Notify the owner's representative in writing of all defects that may influence satisfactory performance of this work or operation when completed. Commencement of work shall be construed as acceptance of the work in place as satisfying the requirements

of this specification.

B. INSTALLATION

Install finish hardware sets for all doors including door stops, thresholds, and seals as called for in the approved hardware schedule, listed on accompanying drawings, and specified herein.

Hardware Item	Dimension from finished floor (to center of hardware item except as otherwise noted)
Door knobs	96 cm.
Door pulls	114 cm.
Push plates	114 cm.
Single push bars	102 cm.
Exit device cross bars (panic hardware)	96 cm.
Cylinder dead locks	127 cm.
Flush bolts	182 cm. top, 30 cm. bottom
Upper edge top hinge	13 cm. below frame head
Lower edge bottom hinge	25 cm. from finish floor
Intermediate hinge(s)	Equally spaced between top and bottom hinges
Armor plates	As shown on the drawings

Install thresholds in a full bed of mastic and secure with flat head countersunk machine screws and lead expansion shields. Where door stops or bumpers are fastened to concrete or solid masonry, secure with medium- or heavy-duty anchors with $^1/_4$ inch diameter machine screws of lengths sufficient to make a secure anchorage.

Where installation of hardware involves cutting and fitting into surfaces that are to be painted, such hardware shall be installed, removed, and later reinstalled after painting is completed. Do not install surface mounted items until painting has been completed on the substrate.

Drill and tap hollow metal work for the application of surface-mounted hardware. Establish locations by template to assure accurate alignment. Comply with the hardware manufacturer's instructions in applying hardware. Apply, fit, and adjust accurately. After completion of finish painting, install door silencers for hollow metal door frames. Adjust strikes as required.

Exercise care not to mar or damage adjoining work when applying hardware. Cover knobs with heavy cloth, securely taped in place.

After final installation of all finish hardware, adjust and check each operating hardware item to assure proper operation. Replace all malfunctioning finish hardware items. Lubricate the moving parts of the hardware with the type of lubricant recommended by the manufacturer. Instruct the owner's authorized maintenance personnel in the proper procedures for adjustment and maintenance of hardware and hardware finishes.

C. TESTING

An acceptance test and inspection shall be held with the contractor, architect, resident engineer, and any other designated owner's representative to review the function and operation of all doors receiving finish hardware.

TRENCHING/COMPACTING/BACKFILLING

GENERAL

A. SCOPE

This specification covers techniques to be used in Trenching / Compacting / Backfilling: operations required for the installation of underground sewers and utility services including fire protection work. The terms "pipe" or "pipeline" used in this specification refers to any underground service being installed (viz., pipes, sewer, electrical conduits, etc.).

B. RELATED WORK SPECIFIED ELSEWHERE

A-18 Sewer Testing and Acceptance
M-12 Pipe and Pipe Fittings
M-14 Piping Supports and Hangers
M-15 Cleaning and Testing Piping Systems
F-03 Fire Main Pipe Systems
F-05 Automatic Sprinkler Systems
Electrical Systems —Chapter 26

C. CODES AND STANDARDS

Comply with all local codes.

D. ACCEPTANCE TESTS

Test as specified in the related specifications for acceptance by the owner's representative prior to backfilling.

EXECUTION

A. PROTECTION OF OTHER WORK AND PERSONNEL

The contractor shall protect and maintain all pavement, sidewalks, fences, sewers, drains, pipes, conduits, wires, hydrants, and other items that are to remain in place during construction. He shall also protect and maintain in good condition trees, shrubs, lawns, and landscape work that are not in the area assigned for the work or that need not be damaged during construction. All shrubs and small trees that are to be removed and replanted shall be handled and maintained in such a manner as to not damage them before replanting. No trees on the project site shall be removed without the written permission of the owner.

In expansion projects, the contractor shall provide adequate temporary bridges and protection devices for pedestrian and vehicular traffic including guardrails, barricades, lamps, and flags as required by all agencies having jurisdiction and/or as directed by the owner's representative. He shall remove same when the necessity for such protection ceases.

Where excavation work is required under existing footings, underpin them as required and as directed by the architect/engineer to adequately support existing construction in such a manner as to avoid raising, lowering, or otherwise damaging existing construction.

Excavated materials to be used for backfill may be temporarily stored along a trench in a manner that will

not cause damage to trees, shrubs, fences, or other property, and that will not endanger the bank of the trench by imposing too great a load. Remove any excess excavated material away from the premises as soon as possible and dispose of it in compliance with local codes or as directed by the architect/engineer.

B. DEWATERING FACILITIES

The contractor shall provide all portable pumping equipment and do all necessary pumping to maintain all excavations in a workable condition to the satisfaction of the owner's representative and the architect/ engineer.

Excavations shall be kept as dry as possible until backfill has been completed above the pipe. In ground containing an excessive amount of water, the contractor shall provide and maintain such pumps or well points and all associated pipes and connections to remove the water from the trench to assure safe and proper construction of the pipeline.

C. SHEETING, BRACING, AND SHORING

The contractor shall furnish, place, and maintain all sheeting, bracing, and shoring required to properly support the sides of the excavation to prevent all movement of the soil, pavement, or utilities in the banks or edges of the trench and to protect the construction work and workmen. Timbers shall be of adequate size and quality and, where required for the proper execution of the work, shall be tongued and grooved. Sheetings shall be driven in a manner to avoid cracking and splittings. Staging and ladders shall be provided where required.

The owner's representative may, at any time, request the contractor to provide sufficient or additional sheeting, bracing, and shoring to assure that the work will be constructed to proper line and grade or to assure the safety of the workmen.

D. TRENCHING

Excavation for all pipelines shall be as shown on the drawings. The minimum depth of cover shall be measured from the finished grade elevation. The trench shall be excavated so the pipe may be placed correctly on line and grade. Large rocks, stumps, masses of concrete, and other materials encountered in the trench shall be completely removed from the trench and shall not be used for backfill.

All excavations shall be made from the surface by the open cut method to a depth 10 cm. or $^1/_4$ the pipe diameter below the pipe laying grade, whichever is greater. The bottom of the trench shall be flat. The excavation shall be of sufficient width to provide adequate room for construction and installation of the work; however the width of a trench from the invert elevation to a point 30 cm. above the top of the pipe shall not exceed the dimension shown on the drawings, or the following:

- 6 inch to 12 inch pipe — 75 cm. trench width
- 15 inch to 30 inch pipe — outside pipe diameter plus 30 cm. trench width

If the maximum trench width as specified is exceeded, the contractor shall install, at his own expense, Class A concrete bedding to support the load of the backfill.

Where, because of the contractor's construction procedures, it is impossible to maintain proper line and grade, the contractor shall excavate below grade and replace the bedding with an approved slag or aggregate material to insure that the pipe will maintain correct line and grade.

When the bottom of the trench is soft and, in the opinion of the architect/engineers, cannot support the pipe, a further depth and/or width shall be excavated and be refilled to the pipe foundation's grade with Class B bedding. It shall be thoroughly compacted to assure a firm foundation for the pipe.

Where excavation is in rock or hard shale, the rock shall be removed to a depth of at least 20 cm. below the grade of the pipe, and the trench shall be refilled to grade with bedding, firmly compacted to provide a firm foundation for the pipe. No blasting of trenches will be done without the prior written approval of the architect/engineer.

Excavations shall at all times be finished to the required grade for an adequate distance in advance of the completed pipe, but not more than 30 m. of trench shall be open at one time ahead of the pipe laying operation without the approval of the architect/engineer.

E. PIPE INSTALLATION

As specified in the appropriate pipe, sewer, and electrical specifications.

F. BEDDING

Backfill for pipelines placed below the bottom line of any footings and within a 45 degree arc from the bottom of footings shall be Class A up to the bottom line of the footing. Backfill above the bottom line of the footing shall be as specified.

Bedding Classes:

Class A: The pipe shall be bedded on concrete with a strength of 220 kg/cm.^{2} or greater. After the initial set of the concrete, the initial backfill material shall be placed to 30 cm. over the pipe. The backfill above this point shall not be placed nor any sheeting removed until at least 48 hours after placement of the concrete bedding.

Class B: The pipe shall be bedded on angular bedding material conforming to ASTM D 448 Standard Specification for Coarse Aggregate, Size No. 67 (American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19013, USA). The bedding shall be placed on a flat trench bottom with a minimum depth beneath the pipe of one quarter of the pipe's outside diameter, but not less than 10 cm. and sliced under the haunches of the pipe with a shovel or other suitable tool to a height of one half the pipe's outside diameter or to the horizontal centerline. The initial backfill shall be hand placed to a level 30 cm. over the top of the pipe and shall consist of the same bedding material.

Class C: The pipe shall be bedded on granular material placed on a flat trench bottom or on a suitable undisturbed native material which has been hand shaped to fit the pipe barrel for a width of one half the outside diameter of the pipe. The bedding material shall have a minimum thickness beneath the pipe of 10 cm. or one eighth of the pipe's outside diameter, **whichever is greater**, and sliced under the haunches of the pipe with a shovel or other suitable tool to a height of one sixth of the pipe's outside diameter. Bedding materials may be crushed stone, rounded gravel, shells, pea gravel, sand or other commonly used noncohesive locally available, materials. The initial backfill shall be hand placed to a level of 30 cm. over the top of the pipe and shall consist of natural sand that passes through a 9 mm. seive and contains no silt, clay, or organic material.

Bedding class and material shall be as specified on the drawings and/or in pipe, sewer, and electrical specifications.

G. INITIAL BACKFILLING

Piping and other buried mechanical work shall be inspected and tested before backfilling.

Exercise particular care to backfill simultaneously on both sides of piping, sumps, etc. All temporary support blocking under piping shall be removed and the void filled with backfill material to secure a uniform bedding.

H. FINAL BACKFILL

The intent of this section is that the final backfill be placed and compacted so that subsequent settlement will not occur and that replacement of concrete, lawns, etc., may be done after completion of the backfill operation. Final backfilling as specified begins at the top of the initial backfill and continues vertically to the surface unless otherwise specified.

The final backfill under floor areas, under areas to be paved or blacktopped, or within 1 m. of such areas shall be natural sand that passes through a 9 mm. sieve and contains no silt, clay, or organic material. It shall be placed in 30 cm. deep lifts, each of which shall be mechanically compacted to 95 percent maximum dry density as determined by the modified Proctor method. Compaction shall be achieved by the use of a bulldozer, sheepsfoot roller, mechanical vibrator, or pneumatic means as approved by the architect/engineer. Flooding or water-jetting to compact backfill is not permitted.

Final backfill in open areas (e.g., lawns, fields, unpaved areas) shall be selected excavated material that shall be free of rocks, clay, and other materials that could interfere with proper compaction or settlement or that could damage or displace the sewer pipe. The final backfill need not be compacted to 95 percent maximum dry density unless this is specifically required by the architect/engineer. The backfill shall be placed and compacted in layers not to exceed 30 cm. in a manner that does not disturb the bedded pipe and shall be mounded over the trench. The contractor shall fill and regrade the trench until settlement is completed and

the final top dressing or seeding can be done.

All supports shall be removed as the trench is backfilled in such a manner as to prevent the caving-in of the sides of the trench or any damage to the pipe or structures. If it is necessary, some supports may be left in place to protect the work or adjacent structures and property. These supports shall be cut off or left not less than 60 cm. below the final surface grade. Sheeting and shoring below the crown of the pipe shall remain in place.

I. TESTING

Field test installations and submit results for acceptance prior to backfilling.

SEWER TESTING AND ACCEPTANCE

GENERAL

A. SCOPE
This specification covers techniques to be used in the testing and acceptance of sewer installations.

B. RELATED WORK SPECIFIED ELSEWHERE
A-17 Trenching, Compacting, and Backfilling

C. SUBMITTALS
The contractor shall submit test results to the owner's representative for acceptance.

D. ACCEPTANCE TESTS
All work shall be subject to field testing and acceptance tests as specified herein.

EXECUTION

A. JOB CONDITIONS
All new or changed sewer piping shall be left uncovered or unconcealed until it has been tested and approved by the owner's representative. Where such work has been covered or concealed without testing and approval, it shall be exposed for testing at the contractor's expense. Prior to final acceptance, the contractor shall make all necessary corrections and adjustments and finish all cleanup operations.

B. TESTING
All sewer lines shall be tested by the contractor, who shall supply all pumps, gauges, valves, piping, and other equipment required to properly conduct the test. The cost of all tests shall be borne by the contractor.

The owner's representative shall be present during all tests. The contractor shall notify the owner's representative at least 24 hours prior to starting any test and shall not start the test until he is present. Sewers shall be tested in the sequence detailed on the drawings or as designated by the owner's representative. Tests shall be in accordance with one of the following methods unless local codes are more restrictive, in which case they shall take precedence.

Hydrostatic Testing
This is the preferred testing method and shall be followed unless directed otherwise by the owner's representative.

A system can be hydrostatically tested in its entirety or in sections:

- if tested in its entirety, all openings shall be closed, a 3.0 m. standpipe attached at the highest point of the sewer, and the system filled with water.
- if tested in sections, each section shall be filled with a 3.0 m. head of water as described above.

Water in piping under test shall stand for at least 15 minutes before starting inspection of the entire sewer system. The system must be tight and without leaks at all points.

Air Testing

This test method is intended only for special cases where water damage could result from a hydrostatic test. It is to be used only at the direction of the owner's representative.

The air test shall be made by attaching a compressed air testing apparatus to any suitable opening. After closing all other inlets and outlets to the system, air shall be fed into the system until there is a uniform gauge pressure of 0.4 kg/cm.^{2} This pressure shall be held, as indicated on the presure gauge and without introduction of additional air, for a period of at least 15 minutes.

Test Results

The contractor shall submit all test results to the owner's representative for acceptance.

C. REPAIR

All defects appearing during tests shall be remedied immediately, at the contractor's expense, and the defective sewer lines retested to the complete satisfaction of all authorities and the owner's representative.

PLUMBING FIXTURES AND TRIM

GENERAL

A. SCOPE

This specification covers materials for water saving plumbing fixtures, their trim, and toilet and bath accessories.

B. RELATED WORK SPECIFIED ELSEWHERE

M-15 Cleaning and Testing Water Piping Systems

MATERIAL/PRODUCT

A. FLOOR SINKS

Floor sinks for housekeeping closets shall be of the following type as shown on the drawings. Elevated wall mounted service sinks are not to be installed. The sink shall be stainless steel, floor mounted, at least 75 cm. long and not more than 25 cm. high. Trim shall be rough chromeplated faucet with a $^3/_4$ inch diameter hose connection, pail hook, vacuum breaker, and wall brace equivalent to American Standard Model 8343-111 (American Standard, P.O. Box 6820, Piscataway, NJ 08855, USA) or equal.

Two water flow control valves suitable for installation in the supply lines shall be provided for each faucet equivalent to American Standard Aquamizer Model 2592-012.

B. LAVATORIES

Lavatories shall be 50 cm. x 38 cm. vitreous china with a 10 cm. to 12.5 cm. high back, concealed reinforced wall hangers, and drilled for a centerset fixture with 10 cm. centers equivalent to American Standard New Lucerne Model 0355-012.

Lavatory P-trap shall be $1^1/_4$ inch diameter No. 20 gauge (1 mm.) chromeplated with $1^1/_2$ x $1^1/_4$ inch diameter with male and female connections. Lavatory supply tubing shall be $^3/_8$ inch outside diameter x 30 cm. long, chromeplated. Lavatory trim shall be dual or single faucet centerset type with water inlets on 10 cm. centers, bright chromeplated finish, $1^1/_4$ inch diameter pop-up waste, and low-flow aerators (less than 11.2 lpm) equivalent to American Standard accessories.

C. WATER CLOSETS

The bowl shall be white vitreous china elongated shape with siphon jet action, wall-hung with 4 bolts and with a $1^1/_2$ inch diameter top spud for the exposed flush valve equivalent to American Standard Afwall Model 2477-016.

The toilet seat shall be white solid, plastic, open front type. Stainless steel hardware is preferred.

The flush valve shall be chromeplated with a vacuum breaker and screw driver angle stop and designed for 11.3 l. per flush, equivalent to Sloan Valve Company "Royal" Model No. 110-3 (Sloan Valve Company, 10500 Seymour Ave., Franklin Park, IL 60131, USA).

D. URINALS

Urinals shall be white vitreous china, wall hung, washout type, wall hangers, 2 inch diameter outlet connection, and $^{3}/_{4}$ inch diameter top spud for an exposed flush valve equivalent to American Standard Washbrook Model 6501-010.

The flush valve shall be chromeplated with a vacuum breaker and screw driver angle stop and designed for 3.7 l. per flush, equivalent to Sloan Valve Company "Royal" Model No. 186.

E. ACCESSORIES

Toilet Areas

Tissue dispenser Waste disposal container, wall mounted behind the toilet Wall mounted ashtrays

Lavatory Areas

Wall mounted soap dispenser above the lavatory Recessed combination paper towel dispenser and waste receptacle Mirror with integral stainless steel shelf Electric hand dryers, where required, shall be the brushless type to minimize particulate generation

Shower Stalls

Towel Hook
Soap Tray

EXECUTION

A. INSPECTION

The contractor shall inspect related installations and notify the owner's representative in writing of any situations that may be detrimental to installation or operation of the units.

B. INSTALLATION

The contractor shall verify exact locations of all accessories with the architect/engineer and install them in accordance with the manufacturer's printed instructions. Installations shall be true, plumb, level, and the accessories shall be rigidly anchored to the substrate.

C. TESTING

In accordance with specifications.

AIR HANDLING UNITS

GENERAL

A. SCOPE

This specification covers air handling units' equipment specifications, procurement, and installation criteria.

B. RELATED WORK SPECIFIED ELSEWHERE

F-08 Fire Dampers
M-02 Central System Coils
M-03 Fans and Fan Drives
M-04 Vibration Isolation
M-05 Air Filters
M-06 Air Filter Gauges
M-07 Duct Work
M-09 Controls and Instrumentation
M-12 Pipe and Pipe Fittings
M-16 Balancing Air, Chilled, and Hot Water Systems

C. CODES AND STANDARDS

Air handling units shall be designed, fabricated, and installed in conformance with the applicable standards of AMCA (Air Movement and Control Association, 30 W. University Dr., Arlington Heights, IL 60004, USA), ASHRAE (American Society of Heating, Refrigeration, and Air Conditioning Engineers, 1791 Tullie Circle, N.E., Atlanta, GA 30329, USA), ACRI (Air Conditioning and Refrigeration Institute, 1815 N. Fort Myers Drive, Arlington, VA 22209, USA), and SMACNA (Sheet Metal & Air Conditioning Contractors National Association, Inc., 1611 N. Kent Street, Arlington, VA 22209, USA).

D. SUBMITTALS

Shop drawings and submittal data shall be provided to the owner by the successful supplier within 10 working days of notice of contract award. The drawings shall be complete in all respects with all information pertaining to the materials of construction and component equipment and shall be presented in a single binder appropriately indexed. Shop drawings shall be reviewed and returned by the owner within 15 working days of receipt.

The successful supplier shall deliver to the owner the required copies of operating and maintenance data on all equipment furnished. This shall include the model and serial number of all equipment; performance data; the manufacturer's written instructions for the operation and maintenance of the component equipment; and a lubrication schedule indicating all equipment to be lubricated, recommended lubrication interval, and the type and quality of lubricant to be used.

The air handling unit's manufacturer shall provide a warranty for the equipment manufactured by him and all purchased components. Said warranty shall be for a period of one year from the date of final acceptance of the building by the owner.

E. PRODUCT DELIVERY, STORAGE, AND HANDLING

Where multiple units are required, a schedule of priority will be furnished by the owner that shall determine the manufacturing and delivery sequence.

In general, units shall be delivered in one piece. Where size and shipping limitations require that the units be handled in more than one piece, the manufacturer shall indicate this on the shop drawings.

All equipment shall be suitably packaged and protected for overland trucking, overseas shipping, and for storing the equipment exposed to the weather at the job site.

MATERIALS/PRODUCTS

A. HOUSING

Floor and Base Structure

The floor shall be constructed of No. 10 gauge (3.5 mm.) carbon steel. The floor shall be continuously welded to an all welded structural channel, continuous base, supplied under each air handling unit. The floor shall be insulated externally by the manufacturer with 6 pound density rigid board fiberglass and covered with a No. 18 gauge (1.2 mm.) carbon steel jacket, painted or hot dip galvanized. The design shall transfer the equipment load to the supporting base and shall minimize potential heat transfer by the connections through the insulated panels. Provide lifting lugs to facilitate hoisting the air handling unit into place.

Unit Casing

Units shall be double wall sandwich type construction consisting of a minimum No. 14 gauge (2.04 mm.) galvanized steel inner sheet; 1 inch (25 mm.) thick, 3 pound (1.4 kg.) density fiberglass insulation; and a minimum No. 18 gauge (1.3 mm.) galvanized steel outer sheet.

Panels shall be reinforced and joined together according to the manufacturer's standard practice so that the deflection of any panel section shall not exceed L/240 of the span under 8 inches positive pressure and/or 6 inches negative pressure. All joints shall be suitably gasketed or sealed.

Filter Mounting Frames

The prefilter mounting frames shall be for nominal 61 cm. x 61 cm. x 5.10 cm. deep, disposable filters that have a rated average efficiency of 25 percent (ASHRAE Standard 52-76) and that are UL (Underwriters Laboratories, 333 Pfingsten Road, Northbrook, IL 60062, USA) Class 1 approved.

Final filter mounting frames shall be for nominal 61 cm. x 61 cm. x 30.5 cm. deep, rigid cell, disposable filters that have a rated average efficiency of 25 or 50 percent (ASHRAE Standard 52-76) and that are UL Class 1 approved. All mounting frames shall be galvanized metal.

Filters shall be provided with all mounting hardware.

Doors

Doors shall be factory mounted and of a double wall insulated construction. A minimum 25 mm. x 10 mm. thick sponge neoprene gasket shall be provided to seal the door. The gasket shall be provided with framing to assure its placement. Doors shall open against the air pressure and shall be as large as practical for easy access. A minimum of three 10 cm. long heavy-duty hinges and two door handles shall be provided for each door.

Each door shall have a 30 cm. x 30 cm. double glazed viewing window consisting of two 6 mm. thick wire reinforced panes mounted in neoprene rubber gaskets flush with the door surfaces.

Drain Pan

Full length drain pans shall be provided for each bank of cooling coils. The pans shall be pitched toward the condensate outlet. All pans shall be installed to be completely self-draining. The pans and condensate outlets shall be constructed of No. 10 gauge (3.6 mm.) galvanized steel sheet. The condensate outlet shall be at a sufficient height, considering the internal pressure, positive or negative, to permit the installation and seal of a fabricated pipe trap to the pan drain.

B. FINISHES

Structural members shall be cleaned and painted. Equipment surfaces shall be free of scale, rust, weld

splatter, and other foreign substances or blemishes. Galvanized steel sheet material or aluminum need not be painted unless the surface has been altered or damaged during fabrication.

C. ELECTRICAL

Lights

Air handling units shall have factory installed vapor tight fixtures in each section having access doors or viewing windows. These shall be strategically placed to permit optimum viewing and to avoid obstructing filter removal. If necessary, provide more than one light per section. These shall be prewired to switches on the outside of the unit. The conduit path shall be sealed to prevent air flow through the conduit.

Motors

Units shall be equipped with open drip proof motors. Motor wiring shall be brought to a junction box on the outside of the unit.

Air handling units shall be Buffalo Forge Co., 490 Broadway, Buffalo, NY 14240, USA, or equivalent.

EXECUTION

A. INSTALLATION

Coils

The air handling unit's manufacturer shall install all coils prior to shipment.

All air handling units shall be installed in accordance with the approved construction drawings, shop drawings, and the manufacturer's recommendations.

Do not connect trap drain lines directly into a closed drainage system. Provide an air break that is at least two pipe diameters in height between the drain pipe and the drain. Prime all traps prior to start-up.

CENTRAL SYSTEM COILS

GENERAL

A. SCOPE

This specification covers the cooling and heating coils to be installed into air handling units and provides criteria for their selection, design, fabrication, and installation.

B. RELATED WORK SPECIFIED ELSEWHERE

M-01 Air Handling Units
M-03 Fans and Fan Drives
M-04 Vibration Isolation
M-09 Controls and Instrumentation
M-12 Pipe and Pipe Fittings
M-15 Cleaning and Testing Piping Systems
M-16 Balancing Air, Chilled, and Hot Water Systems

C. CODES AND STANDARDS

Central system coils shall be designed, fabricated, and installed in conformance with the applicable standards of AMCA (Air Movement and Control Association, 30 W. University Dr., Arlington Heights, IL 60004, USA), ASHRAE (American Society of Heating, Refrigeration, and Air Conditioning Engineers, 1791 Tullie Circle, N.E., Atlanta, GA 30329, USA), ACRI (Air Conditioning and Refrigeration Institute, 1815 N. Fort Myers Drive, Arlington, VA 22209, USA).

Coils shall be suitable for operation at 14.5 kg./cm.^{2} and 104°C and shall have been leak tested at an air pressure of 18.1 kg./cm.^{2} minimum with the coil under water.

D. SUBMITTALS

Shop drawings and related data shall be provided to the architect/engineer for review and approval. All shop drawings shall be identified with part numbers as shown on the Equipment Schedule in the drawings. The shop drawings shall indicate the manufacturer; tube material, size, and wall thickness; fin type, material, fin thickness, fin spacing; number of rows; circuit arrangment; and performance information from a computer printout.

All coils shall be certified by the manufacturer as to their testing and rating in accordance with the ASHRAE Standard 33-64 Method of Testing and Rating Forced Circulation Air Cooling and Air Heating Coils or ACRI Standard 410-64 Forced Circulation Air Cooling and Air Heating Coils.

E. PRODUCT DELIVERY, STORAGE, AND HANDLING

Coils shall be delivered to the air handling unit manufacturer for installation prior to shipment.

MATERIALS/PRODUCTS

A. COILS AND COIL COMPONENTS

Coils shall be constructed with $^5/_8$ inch outside diameter seamless phosphorized copper tube. Coils that can

be in direct contact with unconditioned outside air shall have a wall thickness of at least 1 mm. (.04 inch). Coils in all other locations shall have a minimum 0.9 mm. (.035 inch) wall thickness. Thinner materials will burn through when sufficient heat is applied during brazing or soldering, especially when working in difficult positions.

No coil shall have more than 8 rows of depth. If more than 8 rows are required, two or more coils in series shall be provided.

Fin spacing for cooling coils shall not be closer than 3.2 fins per cm. (8 fins per inch). More fins may be specified for heating coils, but never more than 5 fins per cm. (12 fins per inch). Dirt collection upon fin surfaces is accelerated and fins are difficult to clean when closer spacings are used. High efficiency filters (i.e., 90 percent ASHRAE minimum dust spot efficiency) must be provided before the coil if closer fin spacing cannot be avoided and fan specifications (e.g., static pressure) increased as required.

There are two basic types of fins available: spiral wound and plate fins. Spiral wound fins have the advantage of gripping the tube more tightly than plate fins. Plate fins have the advantages of channeling the condensate to the drain and providing better support for the tubes. Spiral wound fins are available in 0.25 mm. (.010 inch) or 0.28 mm. (.011 inch) thicknesses. Plate fins are available in 0.23 mm. (.009 inch) or .24 mm. (.0095 inch) thicknesses. Plate fins, however, are inherently stiffer because of their design. Aluminum fins of a minimum 0.4 mm. (.016 inch) thickness shall be mechanically bonded to the tubes.

Both types of fins can be purchased either flat or corrugated. Flat fins are preferred. Corrugated fins provide more heat transfer per cm^2, but are very difficult to clean and should not be used unless space is very limited.

Headers shall be close grained cast iron, formed welded steel accurately drilled and machined to receive the tubes, or extra strong wall copper pipe with brazed fittings. A corrosion-resistant coating must be applied to the exterior surface if welded steel is used. Tube ends shall be rolled into the header tube sheet to form a mechanically tight joint. U-bend ends shall be made up of formed copper Ubends with high temperature silver-brazed joints. The fitting wall thickness shall be the same as the tubes.

Headers shall be provided with a plugged drain at the lowest point in the coil and a vent opening fitted with an air elimination device at the highest point in the coil. Connections to coils shall be threaded with thread protectors (caps or plugs) furnished with the coils.

Tubes, fins, headers, spacers, etc., shall be mounted in a die-formed galvanized steel casing of not less than No. 16 (1.6 mm.) gauge. Casing frames shall be provided with punched flanges for duct connections with holes around their entire periphery for connecting to ductwork or air handling unit housing sheet metal. Coils over 106 cm. in length shall have a center galvanized steel coil support, and coils over 244 cm. in length shall have two supports.

To prevent air bypass and condensate leakage at the top and bottom of the casing, provide sealing strips or the equivalent. Where coils are split, provide a filler strip on both sides of the coil to form airtight connections between coils.

Heating Coils (Hot Water)

Face velocity over the coils shall not exceed 260 m. (850 feet) per minute. Energy conservation could reduce this velocity. Water tubing circuiting should be adjusted to avoid the installation of internal turbulators. Dirt and silt collect at the turbulators and reduce heat exchange efficiency.

Cooling Coils (Chilled Water)

Face velocity shall not exceed 122 m. per minute (400 ft./min.).

B. IDENTIFICATION

Each coil shall have a nondestructible identification tag permanently fastened to the supply header end of the coil. All counter flow coils shall have the direction of air flow marked clearly on the exterior of the casing.

EXECUTION

A. INSTALLATION

Coils shall be installed by the air handling unit manufacturer in the air handling unit. Allow sufficient space below each coil for drainage to the drain pan. Insulate the trap and drain lines to prevent condensation.

FANS AND FAN DRIVES

GENERAL

A. SCOPE

This specification covers the centrifugal fans and fan drives of units to be installed in air handling units and other independent units relating to miscellaneous exhaust systems. It provides criteria for their selection, design, fabrication, and installation.

B. RELATED WORK SPECIFIED ELSEWHERE

M-01 Air Handling Units
M-04 Vibration Isolation
M-09 Controls and Instrumentation
M-16 Balancing Air, Chilled, and Hot Water Systems

C. CODES AND STANDARDS

Centrifugal fans and fan drives shall be designed, fabricated, and installed in conformance with the applicable standards of AMCA (Air Movement and Control Association, 30 W. University Dr., Arlington Heights, IL 60004, USA), ASHRAE (American Society of Heating, Refrigeration, and Air Conditioning Engineers, 1791 Tullie Circle, N.E., Atlanta, GA 30329, USA), ACRI (Air Conditioning and Refrigeration Institute, 1815 N. Fort Myers Drive, Arlington, VA 22209, USA), and SMACNA (Sheet Metal & Air Conditioning Contractors National Association, Inc., 1611 N. Kent Street, Arlington, VA 22209, USA).

D. SUBMITTALS

Certified shop drawings and related data shall be provided to the architect/engineer for review and approval. All shop drawings shall be identified with part numbers as shown on the Equipment Schedule in the drawings.

All fans shall be certified by the manufacturer with respect to model number, operating speed, maximum allowable speed, performance curves at specified operating points, bearing types and model numbers, brake horsepower (BHP), and motor horsepower (HP). Performance testing shall be in conformance with AMCA Bulletin 210 Standard Test Code for Air Moving Devices.

E. PRODUCT DELIVERY, STORAGE, AND HANDLING

Fans and fan drives shall be delivered to the air handling unit manufacturer for installation prior to shipment.

MATERIALS/PRODUCTS

A. CENTRIFUGAL FANS

All fans shall bear a metal identification plate indicating CFM, HP, RPM, static pressure, and size. Fans shall have capacities not less than those shown on the drawings when operating at the static pressure indicated at 21° C and altitude corrected from sea level. The sizes and types of fans shall be as scheduled on the drawings.

The fans and fan motors shall be directly connected by means of flexible couplings or indirectly through

approved V-belt drives, as shown on the drawings. Fan wheels shall be heavily and rigidly constructed and accurately balanced, both dynamically and statically. Vibration is not to exceed .076 mm. (3 mils.) for 600 to 1000 RPM units, .051 mm. (2 mils) for 1000 to 2000 RPM units, and .025 mm. (1 mil) for units over 2000 RPM. Bearings shall be the grease-lubricated type complete with grease fittings located in accessible location, and are to be self-aligning ball or roller types. Tapered roller type bearings mounted in split pillow blocks are preferred.

The fan wheel shall be of steel construction with backwardly inclined or air foil blades. The fan shaft shall be of steel, provided with keys and keyways for the fan wheel hub and fan pulley. The fan outlet shall be of ample proportions so that the actual outlet velocity shall not exceed that listed in the Equipment Schedule. Outlets shall be fitted with removable angles and bolts for attaching flexible connections. The fan housing shall be provided with variable inlet vanes where indicated on the drawings. The fan housing shall be of steel plate construction suitably reinforced with structural steel shaped for required rigidity. Inlets shall be formed to provide smooth, quiet, directed air flow. The entire housing shall be mounted on a structural steel base that shall include as an integral part slide rails for mounting of the motor. The entire base shall be mounted on vibration isolators.

B. VENTILATION AND VENT FANS

These fans shall basically meet the requirements stated for centrifugal fans. The entire unit consisting of fan, motor, drive, stand, and bearings shall be a factory assembled unit.

Fan bearings shall be mounted on a strong welded steel boxtype mounting plate. The motor shall be mounted on a rigid adjustable base attached to a heavy sheet steel stand. The stand shall be completed by welded steel support on the inlet side of the fan scroll. The entire unit shall be mounted on vibration isolators.

C. EXHAUST FANS

Industrial exhaust fans shall be belt-driven factory-assembled units consisting of motor, fan, bearings, blower, etc., all mounted on a common steel or cast iron base. The scroll shall be of steel plate construction with flanged inlet and outlet connections. The inlet plate shall be interchangeable with the shaft side plate and bolted to the scroll.

Bearing blocks shall be rigidly bolted to the base. Bolt openings in bearing blocks shall be slotted to enable proper alignment.

The motor shall be rigidly bolted to the base with proper provision for alignment and belt length adjustments.

The base shall be mounted on vibration isolators.

The fans shall be manufactured by Buffalo Forge Co., 490 Broadway, Buffalo, NY 14240, USA, or approved equal.

D. FAN DRIVES

Fan drives up to 15 horsepower shall consist of one cast iron variable pitch sheave mounted on the motor shaft and one cast iron fixed sheave mounted on the fan shaft. The selection of the variable pitch sheave shall permit the fan to operate at the design RPM with the pitch diameter at approximately midrange. The belt speed shall not be in excess of 1500 m./minute. The variable pitch sheave range shall be a minimum of 15 percent of the fan design RPM. Drives shall be rated at 150 percent of the motor nameplate horsepower. The belts shall be matched, static electric conducting Types A, B, C, D, or E only.

Fan drives over 15 horsepower, shall consist of cast iron fixed sheaves. The drives shall be rated at 150 percent of the motor nameplate horsepower. The belts shall be of the multiple type with a common back (preferred) or matched (acceptable).

Removable metal belt guards shall be provided to enclose all V-belt drives. The guard shall be constructed of a minimum of No. 20 gauge (1.0 mm.) galvanized or enameled steel with tachometer openings for fan and motor RPM determinations.

The motors shall be in accordance with the latest NEMA (National Electrical Manufacturers' Association, 2101 L Street, N.W., Washington, D.C. 20037, USA) standards for continuous duty and shall be open drip-proof, squirrel cage induction type for across-the-line starting. Motors below 1/3 HP shall be at 120 volt single

phase. Motors 1/3 HP to 75 HP shall be 460 volts, 3 phase. Motors shall be energy efficient with cast iron frames and end bells.

EXECUTION

A. INSTALLATION

The centrifugal fans, fan drives, and motor assembly shall be installed in the air handling unit by the air handling unit manufacturer.

VIBRATION ISOLATION

GENERAL

A. SCOPE

This specification covers the various types of mounting bases pads, springs, etc., that are required to minimize transmission of vibrations from rotary equipment to buildings. It provides criteria for selection and installation of vibration isolation devices.

B. RELATED WORK SPECIFIED ELSEWHERE

M-01 Air Handling Units
M-02 Central System Coils
M-03 Fan and Fan Drives
M-07 Duct Work
M-10 Refrigeration Equipment
M-12 Pipe and Pipe Fittings

C. CODES AND STANDARDS

Vibration isolation devices shall be selected, designed, and installed in conformance with the applicable standards of AMCA (Air Movement and Control Association, 30 W. University Dr., Arlington Heights, IL 60004, USA), ASHRAE (American Society of Heating, Refrigeration, and Air Conditioning Engineers, 1791 Tullie Circle, N.E., Atlanta, GA 30329, USA), ACRI (Air Conditioning and Refrigeration Institute, 1815 N. Fort Myers Drive, Arlington, VA 22209, USA), and SMACNA (Sheet Metal & Air Conditioning Contractors National Association, Inc., 1611 N. Kent Street, Arlington, VA 22209, USA).

All isolation devices shall be selected for uniform static deflections according to distribution of weight. The minimum isolation efficiencies using an empirical calculation method shall be as follows:

- 800 RPM and higher — 90 to 95 percent
- 350 to 800 RPM — 80 to 90 percent

The isolation devices chosen shall perform to the highest efficiency predictable by the calculation method without resorting to supplemental isolation means.

The minimum deflection of spring isolators shall be as follows:

Operating Speed (RPM)	Minimum Deflection (Millimeters)
300	89
500	42
800	25
1200 and Higher	20

D. SUBMITTALS

Certified shop drawings and selection criteria for each device for each application shall be provided to the

architect/engineer for review and approval where required on the Equipment Schedule, in the drawings, or in the specifications.

MATERIALS/PRODUCTS

At least twelve different types of isolation techniques and devices are commonly used in an industrial environment:

A. VIBRATION PADS

Pads of corrugated oil-resistant neoprene or stabilized fiberglass with neoprene jacket capable of loads up to 5.0 kg/cm^2. Use a pad with a steel plate bonded to the top, if the equipment base does not provide a uniform load surface.

B. NEOPRENE-IN-SHEAR

Neoprene cylinders with provision for bolting to the equipment and the structure, if required.

C. SPRING MOUNTING

Free standing device with sound deadening pads and leveling bolts. Spring diameter to compressed operating spring height ratio of 1 to 1. Spring loaded minimum additional available travel is 50 percent of rated deflection.

D. SPRING MOUNTING WITH VERTICAL LIMIT STOPS

Similar to C above, except with limit stops for wind loading or for maintaining a constant height when liquid weight is removed from equipment.

E. NEOPRENE AND SPRING

A combination spring and double deflection neoprene element in series. The spring diameter to compressed operating spring height ratio is 0.8 or greater. The spring loaded minimum additional available travel is 50 percent of the rated deflection. The spring diameter and hanger box hole are large enough to permit a hanger rod to swing through a 30 degree arc before contacting the box.

F. PRECOMPRESSED NEOPRENE AND SPRING

A combination spring and double deflection neoprene hanger in series, precompressed by the manufacturer to the rated deflection to keep piping or equipment at a fixed elevation during installation. Deflection shall be indicated by means of a scale. Spring diameter to compressed operating spring height ratio is 0.8 or greater. The spring loaded minimum additional travel is 50 percent of the rated deflection. The spring diameter and hanger box hole are large enough to permit a hanger rod to swing through a 30 degree arc before contacting the box.

G. BEAM AND RAIL DEVICES

Steel support members tailored to cradle the machine with built-in isolator mounting brackets to minimize equipment mounting heights. The minimum beam height-to-length ratio is 8 percent of the longest dimension but not less than 10 cm.

H. RIGID BASE

A structural steel base designed to accommodate the equipment, including an electric motor slide base, with built-in isolator mounting brackets to minimize the equipment mounting height. The minimum beam height-to-length ratio is 10 percent of the longest dimension but not less than 15 cm.

I. INERTIA BASE

A reinforced concrete inertia base tailored to accommodate the equipment, shipped ready to receive concrete, complete with welded steel frame, prelocated equipment anchor bolts and sleeves, electric motor slide base, integral height-saving isolator mounting brackets, $^1/_2$ inch diameter reinforcing bars welded on 15 cm. centers both ways, 3.8 cm. above the bottom. The minimum channel depth is 8 percent of the longest dimension but not less than 15 cm.

J. BRAIDED HOSE

A flexible stainless steel (Type 321) hose and braided cover with carbon steel ends. Pipe sizes $2^1/_2$ inch diameter and smaller have male fittings, and sizes 3 inch diameter and larger have flanged fittings. Hose lengths for pipe up to and including $1^1/_2$ inch diameter are 30 cm. long; 3 inch diameter pipe are 45 cm. long;

6 inch diameter pipe are 61 cm. long; and 8 inch diameter pipe and over, 91 cm. long. Also, a flexible bronze braided hose with copper tube ends for use with freon is available.

Install the braided hose horizontally and, where possible, on the equipment side of the isolation valves.

K. NEOPRENE CONNECTOR

Flexible neoprene connectors manufactured from multiple plies of nylon tire cord fabric and neoprene without steel wire or rings for pressure reinforcement with 2 inch diameter and smaller-threaded ends and $2^1/_2$ inch diameter and larger flanged fittings. Connector configurations available are straight line and 903 elbows.

L. THRUST RESTRAINTS

Horizontal thrust restraints consisting of a spring element and neoprene pad. A spring diameter with a minimum 0.8 of the spring's operating distance. The minimum additional spring travel before going solid is 50 percent of the rated deflection. The spring element is preadjusted at the factory to limit maximum motion to 6.4 mm.

Isolation devices shall be manufactured by Mason Industries, Inc., 350 Rabro Drive, Hauppage, NY 11788, USA; Vibration Elimination Co., Inc. 10-28 47th Ave., Long Island City, NY 11101, USA; or equal.

EXECUTION

A. INSTALLATION OF INERTIA BASES

Fill the bases, in accordance with the manufacturer's instructions, to full frame height with 220 kg/cm^2, 28 day strength concrete. The concrete shall cure for not less than 7 days before equipment is mounted to the base.

AIR FILTERS

GENERAL

A. SCOPE

This specification covers materials and techniques to be used in the selection and installation of air filters in mechanical ventilation and air-conditioning systems.

B. RELATED WORK SPECIFIED ELSEWHERE

F-08 Fire Dampers
M-01 Air Handling Units
M-06 Air Filter Gauges
M-07 Duct Work
M-16 Balancing Air, Chilled, and Hot Water Systems
M-17 Room Differential Pressure Measurement

C. CODES AND STANDARDS

The efficiency of an air filter is considered a measure of that filter's ability to remove a given percentage of dust and particles from an air stream. The ability of the filter to arrest, or capture, these particles is a function of particle size and the properties of the filter media. A filter rated at a 50 percent efficiency for atmospheric dust may be only 2 percent efficient for dust composed of finer particulate matter; therefore, consideration must always be given to the particle size that has been used to establish the filter's efficiency.

Air filter materials and installations shall comply with the applicable standards of AMCA (Air Movement and Control Association, 30 W. University Dr., Arlington Heights, IL 60004, USA), ASHRAE (American Society of Heating, Refrigeration, and Air Conditioning Engineers, 1791 Tullie Circle, N.E., Atlanta, GA 30329, USA), ACRI (Air Conditioning and Refrigeration Institute, 1815 N. Fort Myers Drive, Arlington, VA 22209, USA), and SMACNA (Sheet Metal and Air Conditioning Contractors National Association, Inc., 1611 N. Kent Street, Arlington, VA 22209, USA).

Because the efficiencies of air filters vary with the size of the airborne particulates to which they are exposed, and because manufacturers use an array of test methods to establish efficiency claims for their air filtration products, the test method must always be stated (viz., 50 percent ASHRAE) when specifying a filter's efficiency. The use of the ASHRAE efficiency designation is preferred.

D. SUBMITTALS

The contractor shall provide certified shop drawings to the architect/engineer for review and approval for all air filters specified on the Filter Schedule in the drawings. The shop drawings shall contain the name of the manufacturer, filter model number, dimensions, frame and holding device model numbers and certified performance ratings. The contractor shall present a schedule for all filter installations as specified herein to the owner's representative for acceptance.

MATERIALS/PRODUCTS

A. FILTER FRAMES AND FILTER MOUNTING DEVICES

Filters with the same ratings supplied by different manufacturers many times are not interchangeable because of the mechanism used to hold the filters in the mounting frame. Care should be taken to specify filter mounting devices when ordering air handling units.

B. PREFILTRATION OF AIR

Prefilters are used as a means of extending final filter life. A 5 cm. thick 25 percent efficient (ASHRAE) filter is less expensive than a 50 percent efficient filter. Therefore, by placing the 5 cm. thick, 25 percent efficient filter before the 50 percent efficient filter, the life of the final filter is extended since it is not exposed to 25 percent of the particles entering the filtration unit. Likewise, as filtration efficiency requirements increase, so does the justification for higher efficiency prefiltration of air.

C. PREFILTERS AND FILTERS

Frame type disposable prefilters and filters shall be specified for all installations. Filter efficiencies (ASHRAE) shall be as follows:

Room Class	Name	Prefilter	Filter
I	Fill Rooms	25%	50%
II	Repackaging	25%	25%
IV	Office	25%	25%
VII	Warehouse	25%	25%
XIII	Computer	25%	50%

D. OWNER'S STOCK

Two air filters for each air filter installed shall be provided for the owner's maintenance inventory.

EXECUTION

A. JOB CONDITIONS

Ventilation systems shall be cleaned and purged for a minimum of 24 hours prior to filter installation.

B. INSPECTION

Filters shall be visually inspected for physical damage prior to installation.

C. INSTALLATION

Filters shall be installed in accordance with the recommendations of the filter and air handling unit's manufacturers.

D. TESTING

Ventilation air filter tests shall be performed by the contractor in the presence of the owner's representative for each installation as follows:

Visual Inspection

The installed air filter shall be visually inspected to verify that the filter is undamaged and is properly mounted in the frame of the air handling unit.

Differential Pressure Test

A mamometer is connected upstream and downstream of the filter section in a ventilation unit. The pressure drop in either inches or millimeters of water (i.e., water gauge) is measured and recorded. When the pressure drop (differential pressure) across the filter exceeds the recommended change point, the filter must be replaced. **The recommended change point is the maximum pressure drop across the filter that will still allow the ventilation system to deliver the minimum design flow rate (CFM).** The filter should be able to withstand higher differential pressures so that it will not collapse in the event of total plugging.

The contractor shall prepare and present to the owner's representative a filter differential pressure schedule reflecting the above information.

E. REPAIR

Reinstall any filters that are improperly installed.

F. MAINTENANCE

Replace **all the filters in a filter bank** when the differential pressure exceeds the operating limits indicated on the air filter gauge.

AIR FILTER GAUGES

GENERAL

A. SCOPE

This specification covers materials and techniques to be used in the selection and installation of air filter gauges in mechanical ventilation and air-conditioning systems. Air filter gauges are used to measure the difference in pressure between the upstreams and downstreams sides of the filter. This measurement when related to other data indicates when the filter is dirty and must be replaced. Permissible operating limits can be also marked directly on the gauges to facilitate rapid inspection of filter conditions.

B. RELATED WORK SPECIFIED ELSEWHERE

M-01 Air Handling Units
M-05 Air Filters
M-07 Duct Work
M-16 Balancing Air, Chilled, and Hot Water Systems
M-17 Room Differential Pressure Measurement

C. CODES AND STANDARDS

Air filter gauges shall be designed, fabricated, and installed in conformance with the applicable standards of AMCA (Air Movement and Control Association, 30 W. University Dr., Arlington Heights, IL 60004, USA), ASHRAE (American Society of Heating, Refrigeration, and Air Conditioning Engineers, 1791 Tullie Circle, N.E., Atlanta, GA 30329, USA), and ACRI (Air Conditioning and Refrigeration Institute 1815 N. Fort Myers Drive, Arlington, VA 22209, USA).

D. SUBMITTALS

The contractor shall provide certified shop drawings and performance test results specified for each model to the architect/engineer for review and approval.

MATERIAL/PRODUCT

A one-piece filter gauge of molded plastic containing a manometer with an inclined-vertical indicating tube with a range from zero to 3 inches water gauge shall be provided for each filter bank. The filter gauge shall be furnished with plastic tubing, two probe-type static pressure tips, and a bottle of red gauge fluid. The gauge shall be Model 25 of the F.W. Dwyer Manufacturing Company, P.O. Box 373, Michigan City, IN 46360, USA, or equal.

EXECUTION

A. INSTALLATION

The air filter gauge shall be located at a point that can easily be observed. The point of observation shall be from floor level wherever possible. Mount the gauge on a nonvibrating surface as indicated on the approved construction and shop drawing, and in accordance with the manufacturer's instructions.

The contractor shall mark the permissible operating pressure range on each filter gauge on each filter bank upon acceptance of the filter differential pressure schedule (see Specification M-05) by the owner's representative.

DUCT WORK

GENERAL

A. SCOPE

This specification covers all sheet metal materials and related work and techniques to be used in the design, fabrication, installation, and testing of duct work for mechanized ventilation, air-conditioning, and exhaust systems.

B. RELATED WORK SPECIFIED ELSEWHERE

F-08 Fire Dampers
M-01 Air Handling Units
M-03 Fans and Fan Drives
M-05 Air Filters
M-06 Air Filter Gauges
M-08 Duct Insulation
M-16 Balancing Air, Chilled, and Hot Water Systems
M-17 Room Differential Pressure Measurement

C. CODES AND STANDARDS

Duct work shall be designed, fabricated, and installed in conformance with the applicable standards of AMCA (Air Movement and Control Association, 30 W. University Dr., Arlington Heights, IL 60004, USA), ASHRAE (American Society of Heating, Refrigeration, and Air Conditioning Engineers, 1791 Tullie Circle, N.E., Atlanta, GA 30329, USA), ACRI (Air Conditioning and Refrigeration Institute, 1815 N. Fort Myers Drive, Arlington, VA 22209, USA), and SMACNA (Sheet Metal and Air Conditioning Contractors National Association, Inc., 1611 N. Kent Street, Arlington, VA 22209, USA).

For additional information and details not shown on the drawings, refer to the latest editions of the Low Pressure Duct Construction Standards and High Pressure Duct Construction Standards published by SMACNA.

Medium or high pressure duct construction shall be used in any duct with a velocity over 2,000 feet per minute (610 meters per minute) or static pressure of 2 to 6 inches and 6 to 10 inches water gauge, respectively. All terminally filtered duct systems or systems where terminal filters may be installed in the future shall have, at the minimum, medium pressure duct construction. Leakage at 2 inches water gauge pressure greater than the design pressure shall not exceed 5 percent for low pressure duct work systems and 1 percent for medium or high pressure systems.

D. SUBMITTALS

The contractor shall prepare and submit shop drawings to the architect/engineer for review and approval. Shop drawings shall be prepared for each of the prefabricated elements and accessories required. Samples of the materials to be used in fabrication of the duct work system shall also be submitted for approval.

The contractor shall supply certified test data for duct silencers that indicate the net insertion loss data, the

self-generated noise, and the pressure drop. The tests shall report on the performance for at least four air flow velocities representative of the typical applications and must include both forward and reverse test conditions.

E. ACCEPTANCE TESTS

All duct work systems installed shall be field tested for leakage at 2 inches water gauge pressure greater than the design pressure as specified herein.

MATERIALS/PRODUCTS

A. DUCT MATERIAL

- **Galvanized Steel.** Except as otherwise specified, new prime, low carbon, galvanized steel of lock-forming quality, with galvanizing at a minimum of .43 kg/m^2 equivalent to ASTM (American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19013, USA) A 525 standards.
- **Aluminum.** New alloy 1100 or 3003-0 equivalent to ASTM B 209 standards.
- **Stainless Steel.** New type 304 LC, or type 316 if required for superior corrosion resistance, equivalent to ASTM A 240 standards.

Ducts of different materials shall be connected with gasketed flanges.

All materials for fabricating galvanized steel ducts such as sheet metal slides, slips, angles, and bars, shall be completely galvanized.

Duct hanger materials do not need to be galvanized; however, they shall be painted to resist corrosion. Painted carbon steel or galvanized No. 16 gauge (1.6 mm.) closure angles shall be riveted to exposed ducts that penetrate wall openings.

EXECUTION

A. FABRICATION

All work shall be performed in conformance with the specifications and approved construction and shop drawings.

Supply Air Duct Work

Round Duct Work-Medium and High Pressure

The gauge of the duct sheet metal shall be as shown for round duct construction on the drawings. Fittings shall be fabricated with continuous, corrosion-resistant welds in accordance with the following schedule:

Duct Diameter (Inches)	**Gauge No.**
3 to 36	20 (1.0 mm.)
37 to 50	18 (1.3 mm.)
51 and over	16 (1.6 mm.)

Elbows shall have a minimum center line radius of 1.5 times the diameter.

FLAT OVAL DUCT WORK-MEDIUM AND HIGH PRESSURE

The gauge of the sheet metal shall be as shown for flat oval duct construction on the drawings. Duct shall be fabricated as spiral lockseam duct through 20 inch (51 cm.) minor axis and longitudinal welded seam duct for minor axis of 22 inch (56 cm.) and larger. Fittings shall be manufactured with continuous welds and shall be the standard product of the duct manufacturer and in accordance with the following schedule:

Major Axis (Inches)	**Gauge No.**
Up to 36	20 (1.0 mm.)
37 to 50	18 (1.3 mm.)
51 and over	16 (1.6 mm.)

Reinforcement of this duct work shall be of the double trapeze type where possible. Internal tie rods shall not be used. Negative pressure duct work shall be especially reinforced as shown on the approved shop drawings.

RECTANGULAR DUCT WORK-LOW PRESSURE

Material, gauge, joints, seams, and stiffeners shall be as shown in the drawings and as specified herein. For corner closures of pocket lock joints, spot weld or rivet the metal. Do not staple. If angle-reinforced pocket locks or companion angles are used, miter the angles at corners and weld them. Cross break all ducts larger than 18 inches (46 cm.) diameter in either dimension, between joints and reinforcing. Machine-made transverse beading in lieu of cross breaking is permitted for low pressure rectangular duct only.

Volume Dampers

Provide volume dampers and deflectors in the duct work where indicated and where required to permit adjustment of air quantitites. Deflectors shall be used only in conjunction with dampers below, if used.

Provide butterfly dampers with an internal 25 mm. x 4.8 mm. frame with stops at the top and bottom and a blade 30 cm. wide up to 61 cm. long, single thickness sheet metal with hemmed edges on all sides. For blades over 61 cm. long, provide a continuous rod across the center of the blade, with metal on both sides of the rod to form a streamlined blade. For each damper, provide a dial type regulator.

For ducts larger than 30 cm. measured perpendicular to the damper shaft, provide multiple blade dampers with blades not more than 30 cm. wide. Provide dial type regulators as specified above for each blade, except if a damper linkage is indicated, in which case provide the linkage and one regulator. For throttling service, set or link the blades for opposed action. For shut-off service with a linkage, provide parallel blade action with one dial type regulator.

Elbows

Construct elbows with a minimum inside radius equal to the width and without splitters. Use vaned square turns only if the building construction does not permit the minimum inside radius specified above. Vanes are to be constructed using additional welding and bracing. Factory-constructed acoustical turning vanes are acceptable.

Branch Connections

Make branch connections using blind rivets instead of sheet metal screws, and seal the rivets with mastic.

Constant Volume Dampers

Constant volume dampers shall be installed in an accessible location. They shall be constructed of the same material as the duct in which they are installed. The unit shall operate over an inlet velocity range of 0 to 3000 fpm (900 m./min.), have adjustable minimum and maximum cfm limits and adjustable reset span (throttling range) to match any pneumatic thermostat, and be factory-adjusted for a reset span of 5 psi (36 g/cm^2) unless otherwise specified (there is always a constant span of 5 psi [or whatever the span setting] between the minimum and maximum cfm limits, regardless of any adjustments of these limits).

The constant volume damper's controller shall be set to operate with either a direct acting or a reverse acting thermostat. The damper can be furnished either normally open or normally closed, as specified.

The unit shall have screwdriver adjustments for cfm limits and self-storing hex key for all other adjustments, and the adjustment devices shall be easily accessible from the bottom of the assembly through a ceiling opening. Gauge tees shall be provided for flow measurement and balancing.

The housing shall be No. 22 (0.9 mm.) gauge galvanized steel that is mechanically sealed and gasketed to provide leak resistant construction. Insulation shall be heavy-duty, $1^1/_2$ pound density, coated to resist air erosion, and listed by Underwriters Laboratories (333 Pfingsten Road, Northbrook, IL 60062, USA). The inlet duct must be of the same size as the assembly inlet.

The damper shall be heavy gauge metal with Delrin self lubricating bearings capable of tight close-off. Damper leakage shall be less than 2 percent of nominal cfm at 6 inches water gauge static pressure.

The pneumatic damper actuator is an integral part of the constant volume damper assembly. It can be furnished or deleted and be provided by others, as specified.

Constant volume control dampers shall be manufactured by Titus Manufacturing Company, 990 Security Road, Richardson, TX 75081, USA, or equal.

Fire Dampers

Fire dampers shall be installed in accordance with NFPA (National Fire Protection Association, Battery

March Park, Quincy, MA 02269, USA) recommendations and local codes, whichever are more restrictive.

Fan/Duct Connections

For duct connections at the inlet and outlet of each fan and each air handling unit, use neoprene-coated glass fabric. Sew any joint in the fabric and make it airtight with sealer. The connection is to be not less than 10 cm. long, installed in angle or sheet metal frames securely fastened to the ducts and the equipment. Provide angle flanges on all duct and equipment connections larger than 45 cm. in width, height or diameter.

Access Panels and Doors

Provide an access panel at each automatic damper, fire damper, duct-type humidity controller, or transmitter. Provide an access door at the entering air side of each coil installed in a field-fabricated casing. Also provide additional access panels and doors where indicated in the drawings. Provide structural steel angles at each side of the door opening, extending from the bottom to the top of the casing or plenum. Around each door opening in insulated surfaces, provide a No. 24 gauge (0.7 mm.) flange, 7.5 cm. wide, extending over the insulation. All doors and panels shall be provided with hardware.

Joints

Except for welded or soldered joints, thoroughly seal casings, plenums, and duct work to prevent air leakage. Apply sealer to every joint inside the casings and plenums, including the joints between the casing base angles and the floor. Apply sealer between the mating flanges of flanged duct work. Smooth the sealer on the inside of the ducts after the joints are pulled up tight. Set all damper frames, coils, bypasses, and interior casing blank-off sheets in sealer. The sealer shall have a flame-spread rating of less than 25 and a smoke-development rating of less than 50.

Seal absolute and terminal filter frame joints as shown on the drawings. Caulk all air handling unit filter frame joints on the leaving air side with an approved sealant.

Supports

Provide 50 mm. x 50 mm. x 6 mm. angle clips on all ducts 1.50 x .60 m. and larger to fasten the duct to the trapeze shelf angle supports. For vertical supports, use 50 mm. x 50 mm. x 3 mm. angles for lengths up to 2 m. from the overhead structure, 50 mm. x 50 mm. x 6 mm. angles for lengths to 2 to 3 m., and 75 mm. x 75 mm. x 6 mm. for lengths over 3.0 m.

Use rivets to fasten hangers to the ducts. **Sheet metal screws are not permitted.**

Return and Exhaust Air Duct Work

Return air duct work for low and high pressure systems shall be constructed of materials specified for the corresponding supply air system and the duct work construction details specified for low pressure supply air duct work systems.

Exhaust air duct work shall be constructed of materials and to details as specified for low pressure duct work.

Industrial Exhaust Duct Work and Exhaust Hoods

Unless otherwise specified, sheet metal shall be of the following weights:

Diameter of Straight Duct (Inches)	**Maximum Size of Rectangular Duct (Inches)**	**Gauge No.**
Up to 8	Up to 12	24 (0.7 mm.)*
Over 8 to 18	Over 12 to 30	22 (0.9 mm.)*
Over 18 to 30	Over 30 to 54	20 (1.0 mm.)*
Over 30	Over 54 to 84	18 (1.3 mm.)

Elbows and angles shall be at least two gauges heavier than straight lengths of equal diameter. Hoods shall be at least two gauges heavier than the straight section of connecting branches. Elbows and angles shall have an inside radius of two times the duct diameter. Transformations in round ducts should have a maximum of

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* *Minimum No. 18 gauge (1.3 mm.) required, if material is stainless steel to support heliarc butt welded joints.*

2.5 cm. change in diameter per 12.7 cm. length of transition, unless otherwise dimensioned on the drawings. Solder all cross joints, end joints and horizontal seams with 50-50 solder for galvanized steel systems. For stainless steel systems, heliarc weld all cross joints, end joints, and horizontal seams. Heliarcing of butt joints requires a minimum of No. 18 (1.3 mm.) gauge metal.

In duct work to dust collectors and from grinder hoods, provide cleanouts at least every 6.0 m. Install a dead-end cap within 15 cm. of the last branch of each main and submain.

Fire dampers shall be installed in accordance with NFPA (National Fire Protection Association, Battery March Park, Quincy, MA 02269, USA) recommendations and codes, whichever are more restrictive.

Blast gates shall be installed in each riser and as otherwise indicated. They should be located near the connection of the branch to the main. They are to be manufactured with full diameter cast aluminum body, full gate, and machine screw for locking the gate to the body.

Construct hoods in accordance with the Industrial Ventilation Manual published by the American Conference of Governmental Industrial Hygienists, Committee on Industrial Ventilation, P.O. Box 16153, Lansing, MI 48901, USA, or as shown on the drawings.

Duct silencers should be used for private offices, personnel departments, conference rooms, and, in general, where privacy is required.

Outer casings of rectangular silencers shall be of No. 22 gauge (0.9 mm.) galvanized steel. Interior baffles shall be made of not less than No. 26 gauge (0.55 mm.) galvanized steel sheets.

The outer casings of round duct silencers shall be made of the following gauges:

Duct Diameter (Inches)	**Gauge No.**
12 to 22	22 gauge (0.9 mm.)
24 to 48	20 gauge (1.0 mm.)
52 to 60	18 gauge (1.3 mm.)

All the seams in the outer casing shall be lock formed and mastic filled. The casings shall be leak proof to a pressure differential of 8 inches water gauge. Acoustical filler material shall be glass fiber, packed under compression of at least 5 percent.

The entire silencer shall be nonflammable, moisture resistant, and impart no odor to the air. The combustion rating for the silencer's acoustic fill material shall be no greater than the following when tested in accordance with NFPA Standard 255 of UL Test 723:

- flame spread classification 25
- smoke development rating 0
- fuel contribution 20

When multiple duct silencer modules are used to make up the required cross section, they shall be properly sealed together at each end to prevent leakage between the modules. The contractor shall provide a total sheet metal enclosure for all multiple duct silencer modules that shall become part of the duct work. Strapping of modules is not acceptable.

B. INSTALLATION

Seal all duct work against leakage. Low pressure duct work shall have all transverse joints and fitting connections sealed with not more than one unsealed longitudinal seam. Medium and high pressure duct work shall have all seams, joints, fastener penetrations, equipment, and piping connections sealed.

All grilles, registers, and diffusers are to be tight against the wall or ceiling in which they are installed. Exhaust grilles and diffusers are to have their vanes turned against the line of sight into the duct.

Suitably lubricate all adjusting linkages on registers, dampers, and diffusers.

As installation of duct work progresses, remove temporary interior braces put in place during erection and all scraps of metal and insulation and all other debris from the interior of the ducts. Replace any sections of duct work in which seams are damaged.

C. TESTING

Pressure leak test each low, medium, and high pressure duct work system at 2 inches water gauge pressure greater than the design pressure. Low pressure duct work leakage shall not exceed 5 percent; medium and high pressure duct work leakage shall not exceed 1 percent. Test in accordance with SMACNA's procedure as follows:

Test Equipment

- portable rotary blower or tank type vacuum cleaner.
- flow measuring device-usually an orifice assembly consisting of straightening vanes and an orifice plate mounted in a straight tube with properly located pressure taps, calibration curve, and U-tube manometers.

Test Method

1. Close and seal all openings in the duct section to be tested.
2. Start the test blower with the inlet damper closed.
3. Slowly open the inlet damper until the duct pressure reaches 2 inches water gauge pressure in excess of the duct's design pressure.
4. Survey all joints for audible leaks. Mark each leak. Turn off the blower. Repair all leaks with an approved sealant. After the sealants have properly set, retest and repair until all audible leaks are eliminated.
5. Retest the system and measure leakage using the orifice section of the test apparatus. Record results.
6. If leakage exceeds one percent of the system's design flow (cfm), reseal and retest until the maximum leakage is less than one percent.
7. The tested section of duct work shall be visually marked by the testing contractor with a certification sticker and the initials of the field test inspector. Tests shall be completed before duct sections are insulated or concealed.
8. Provide written certification to the owner's representative in a report as follows:

DUCT WORK LEAKAGE TEST REPORT

Location _____ System No. _____

Bldg. No. _____ Tested By: _____

		Duct Section leak tested			Desing (Inches	Tested (inches			
Teste Date	Test No.	From	To	Desing CFM	Water Gauge)	Water Gauge)	Allowable Leakage (CFM)	Actual Leakage (CFM)	Percent Actual Leakage

Remarks:

Ductwork installed & tested, complies with specifications.

Resident Engineer _____ Date _____

DUCT INSULATION

GENERAL

A. SCOPE

This specification covers materials and techniques to be used in the design, selection, and installation of insulation for duct work systems. External thermal insulation shall be applied to all duct work supplying cooled air if the duct passes through non-conditioned spaces or to the exterior of a building.

B. RELATED WORK SPECIFIED ELSEWHERE

M-07 Duct Work

C. CODES AND STANDARDS

Insulation shall be designed, fabricated, and installed in conformance with the applicable standards of ASHRAE (American Society of Heating, Refrigeration, and Air Conditioning Engineers, 1791 Tullie Circle, N.E., Atlanta, GA 30329, USA), ACRI (Air Conditioning and Refrigeration Institute, 1815 N. Fort Myers Drive, Arlington, VA 22209, USA), SMACNA (Sheet Metal & Air Conditioning Contractors National Association, Inc., 1611 N. Kent Street, Arlington, VA 22209, USA), NFPA (National Fire Protection Association, Battery March Park, Quincy, MA 02269, USA), and MIL-1-24244B (the United States Department of Defense Military Standards, United States Government Printing Office, Washington, D.C. 20402, USA) for stress and chemical corrosion.

Flame spread, smoke developed, and fuel contributed index values indicated for the specified materials shall be determined in accordance with ASTM's (American Society for Testing & Materials, 1916 Race Street, Philadelphia, PA 19013, USA) Standard E84 Surface Burning Characteristics of Building Materials.

D. SUBMITTALS

The contractor shall provide shop drawings, manufacturer's data, including certified ratings by an independent laboratory, and samples to the architect/engineer for review and approval.

E. PRODUCT DELIVERY, STORAGE, AND HANDLING

Every package or standard container of insulation, adhesive, and coating delivered to the job site must have the manufacturer's label attached stating his name and the brand name.

MATERIALS/PRODUCTS

A. DEFINITIONS

- **exposed** refers to duct work in working areas, service shafts, equipment rooms, or other spaces where the insulation **may be exposed to physical abuse.**
- **concealed** refers to ductwork above suspended ceilings, and in other locations where the duct work **will not be exposed to physical abuse.**
- **exterior** refers to duct work exposed to the weather. This is a practice recommended only for boiler and incinerator(s) chimneys, etc., and not for air-conditioning duct work.

B. INSULATION

The temperature rating of insulation must always exceed the duct surface temperature. The following are

material and thickness requirements.

Exposed Insulation (Surface temperature of -30° C to 232° C)

For rectangular duct work use 96 kg/m^3 density glass fiber insulating board with a bleached Kraft paper laminated to a foil vapor barrier. The insulation shall meet the requirements of NFPA 90A and NFPA 90B. The insulation board shall not exceed a 25 flame spread, 50 fuel contributed, or a 50 smoke developed rating. The vapor barrier shall have a maximum vapor transmission rate of .02 perms or less. For round duct work, use insulation similar to the above, except that the glass fibers shall be adhered perpendicularly to the jacket to allow the required flexibility. The thickness shall be:

Temperature Difference	**Thickness**
Less than 20° C	3.8 cm.
20° C or greater	5.1 cm.

The insulating board shall be Type 705 as manufactured by Owen Corning Fiberglass Corporation (2215 Saunders Road, Northbrook, IL 60062, USA), or approved equal. The flexible insulation for round ductwork shall be Owens-Corning Pipe Wrap Insulation, or approved equal.

Concealed (Insulation surface temperatures 2° C to 121° C)

Insulate all concealed duct work with 16 kg/m^3 density flexible glass fiber with a foil-skrim-Kraft vapor barrier. The insulation shall meet the requirements of NFPA 90A and NFPA 90B. The insulation shall not exceed a 25 flame spread, a 50 fuel contributed, or a 50 smoke developed rating. The vapor barrier shall have a maximum vapor permeability of .02 perms. The thickness shall be:

Temperature Difference	**Thickness**
Less than 20° C	3.8 cm.
20° C or greater	5.1 cm.

The insulating blanket shall be Owens-Corning All Service Faced Duct Wrap, or approved equal.

Exterior (Insulation surface temperature up to 149° C)

Insulate all exposed duct work with 32 kg/m^3 density urethane foam board insulation. The insulation board shall not exceed a 25 flame spread, a 25 fuel contributed, or a 50 smoke developed rating. An all weather vapor barrier of aluminum, stainless steel, or rubber sheeting shall be field applied. The thickness of the board shall be 2.5 cm. for all applications. The insulating board shall be TRYMER CPR as manufactured by the Upjohn Company (CPR Division, 7000 Portage Road, Kalamazoo, MI 49001, USA), or approved equal.

C. PROTECTIVE JACKETS

All exterior duct work shall receive protective jacketing. Exposed duct work subject to potential damage by materials handling operations or equipment shall also receive protective jacketing.

D. ALUMINUM JACKETING

The material shall be 0.4 mm. thick, smooth, Type 3003 aluminum with a factory applied internal continuous polyethylene Kraft paper laminated moisture barrier as manufactured by the Childers Product Company (3555 Curtis Blvd., East Lake, OH 44094, USA), or approved equal.

E. STAINLESS STEEL JACKETING

The material shall be 0.25 mm. thick, smooth, Type 304 stainless steel with a factory applied internal continuous polyethylene Kraft paper moisture barrier as manufactured by the Childers Product Company, or approved equal.

F. EPDM* RUBBER MEMBRANE ELASTIC SHEET JACKETING

The material shall be white or black 1.15 mm. thick EPDM* sheeting as manufactured by Carlisle SysTec Systems (P.O. Box 7000, Carlisle, PA 17013, USA), or approved equal. This jacketing material is to be used where appearance is secondary to weather resistance.

G. ADHESIVES, SEALANTS, AND MASTICS

Use manufacturer's recommended adhesives, sealants, and mastics only.

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* *EPDM is ethylene propylene diene monomer.*

EXECUTION

A. JOB CONDITIONS

Do not apply any insulation to duct work until it has been leaked tested and test results have been accepted by the owner's representative.

B. INSTALLATION

All products shall be installed in accordance with the manufacturer's instructions. Specified adhesives, mastics, and coatings shall be applied at the manufacturer's recommended coverage per liter. Exercise caution in the storage and application of flammable adhesives.

Clean all duct work of oil, grease, loose dirt, and other foreign matter before the insulation is applied.

Bevel exposed ends of insulation to the insulated surface, and seal the jacket and/or vapor barrier to the duct's surface. Cutouts in the insulation for Pitot tube openings, nameplates, control devices, and equipment tags shall have all edges tapered to the duct's surface and the jacket and/or vapor barrier sealed to the surface. Special care must be taken in applying insulation around such accessories as coils, flexible connections, control devices, access doors, etc. Removal of these items must be possible without in any way removing the insulation or breaking the vapor seal.

Seal all joints, cracks, and breaks including holes for the fasteners in the vapor barrier with a vapor barrier jacket material similar to the vapor barrier jacket on the rest of the insulation. Also seal breaks in the vapor barrier caused by the attachment of tubing or control devices. Vapor barrier laps shall also be sealed with an approved adhesive mastic. Apply the mastic at a rate of 2 to 2.5 m^2 per liter or as recommended by the manufacturer. Pressure sensitive tape, self-adhesive laps, or other types of factory applied adhesives of any kind are **not acceptable**.

Apply glass fiber insulating board to the duct by use of stick pins. The pins shall be applied to the duct by welding or an alternating pattern of weld pins and self-sticking pins. The use of self-sticking pins only is not acceptable. Apply the pins to the duct sides and duct bottoms, 30 cm. on center starting 7.5 cm. from the butt joints. Clip washers are to be installed on the pins and depressed below the surface of the insulation. Cut off the pin flush with the washer. Corners may be formed by butting the insulating board together, covering with vapor barrier tape, and coating the entire corner with a vapor barrier mastic, or by using a kerfing tool to form the corner by folding the insulating board.

Apply glass fiber insulation to round ducts by wrapping the insulation around the duct and forming a lap seal at the joint. Sections are to be butted together and the joint covered with a vapor barrier material and coated with a vapor barrier mastic.

Apply flexible duct wrap by use of the staple stitch method or the butt joint method. With either method, use mechanical fasteners on the bottoms and sides of ducts 45 cm. or wider. The fasteners shall be weld pins or an alternating pattern of self-stick and weld pins. Use of self-stick pins only will not be allowed. Place the pins 7.5 cm. from the butt joints and 30 cm. on center. Clip washers are to be installed on the pins and depressed below the surface of the insulation. Cut off the pin flush with the washer. With the butt joint method, longitudinal joints are to be lap joints having a minimum of a 5 cm. lap and coated with vapor barrier mastic. Using the staple stitch method, the longitudinal joint shall be lapped and folded to form a seam. The seam shall then be stapled using clinch type staples not more distant than 5 cm. on center. With both methods, the butt joints shall be covered with vapor barrier material adhered by a vapor barrier mastic or may be a 5 cm. lap coated with a vapor barrier mastic. Care shall be taken in installation of flexible duct insulation wrap to minimize the amount of compression of the insulation. No more than 20 percent compression shall be allowed.

Cover standing seams, hangers, and other protrusions on ducts that are insulated with insulating board using one of the methods listed below:

- If the specified thickness of the insulating board material is sufficient to cover the protrusion by a minimum of 6 mm., use a kerfing tool to cut a notch in the insulating board that will cover the protrusion and allow the board to lie flat on the duct's surface.
- Cut a piece of the specified insulating board to size to cover the protrusion. The material must overlap the duct insulating board on either side of the protrusion by at least 5 cm. Use a kerfing tool to notch the insulating board material to allow the board to lie flat against the duct's insulating

board. Seal the joints.

On ducts with surface temperatures below 35° C, a 15 cm. wide piece of 32 kg/m^3 density urethane foam board (as specified for exterior use) shall be inserted between the duct channel hangers. The foam board shall be covered with a vapor barrier jacket to match the duct insulation and shall be fully sealed with vapor barrier mastic to form a vapor-proof seal.

Apply urethane foam board insulation to the duct with welding type pins or fasteners 30 cm. on center in both directions. Fasteners shall be located 5 cm. from the edge of the duct. No surface shall have fewer than two rows of fasteners. Apply cap strips of insulation over all stiffener angles to provide an insulation thickness of 13 mm. over the protrusion. The cap strips shall be minimum 7.5 cm. wide.

Aluminum jacketing shall be installed with 5 cm. circumferential and longitudinal laps, with longitudinal laps being turned down to shed water. Apply with self sealing pop rivets that have a stainless steel mandrel and $^3/_4$ inch diameter backup washer. Pop rivets are to be installed 2.5 cm. from the end of the jacket material and on 5 cm. centers. After riveting, caulk all joints with material approved by the jacketing manufacturer.

Stainless steel jacketing shall be installed in the same manner as aluminum jacketing.

EPDM rubber membrane elastic sheet jacketing shall be lapped a minimum of 5 cm., and the lap shall be sealed using lap splicing cement manufactured by Carlisle. Edges of the membrane shall be sealed with edge sealant manufactured by Carlisle.

Fittings for round duct work insulated with insulating board shall be insulated either by mitering the board to the form of the fitting or by use of a molded PVC cover. If PVC covers are used, the joint must first be covered with a double layer of 16 kg/m^3 density unfaced flexible fiberglass blanket 2.5 cm. thick. The insulation is to be held securely in place by twine. The fitting cover is then to be placed over the fitting and sealed with an approved mastic on all joints and seams. If mitered fittings are used, cover all joints and seams with an aluminum foil backed vapor barrier material, and coat with a vapor barrier mastic.

CONTROLS AND INSTRUMENTATION

GENERAL

A. SCOPE

This specification covers the materials and techniques to be used in system design, installation, and testing of the controls and instrumentation of the environmental control systems such as thermometers, thermostats, humidistats, pressure gauges, special valves and switches, meters, compressed air supply and piping for controls, pressure regulators, damper operators and automatic dampers, and control panels.

B. RELATED WORK SPECIFIED ELSEWHERE

M-01 Air Handling Units
M-02 Central System Coils
M-03 Fans and Fan Drives
M-06 Air Filter Gauges
M-07 Duct Work
M-10 Refrigeration Equipment
M-11 Pumps
M-12 Pipe and Pipe Fittings
M-16 Balancing Air, Chilled, and Hot Water Systems
M-17 Room Differential Pressure Measurement

C. CODES AND STANDARDS

Controls, instruments, and systems shall be designed, fabricated, and installed in conformance with the applicable standards of AMCA (Air Movement and Control Association, 30 W. University Dr., Arlington Heights, IL 60004, USA), ASHRAE (American Society of Heating, Refrigeration, and Air Conditioning Engineers, 1791 Tullie Circle, N.E., Atlanta, GA 30329, USA), ACRI (Air Conditioning and Refrigeration Institute, 1815 N. Fort Myers Drive, Arlington, VA 22209, USA), and ISA (Instrument Society of America, 400 Stanwix Street, Pittsburgh, PA 15222, USA).

After installation, the entire low pressure control air system shall be field leak tested at 2.0 kg/cm^2 as specified herein. The air pressure, with no additional supply, shall decrease by not more than 5 percent in 24 hours.

D. SUBMITTALS

The contractor shall provide manufacturers' shop drawings, certified performance data, and calibration data sheets where applicable for each instrument for review and approval by the architect/engineer. He shall also provide the manufacturers' recommended spare parts list for each item.

E. ACCEPTANCE TESTS

Equipment and installation shall be leak and performance tested as specified herein in the presence of the owner's representative.

MATERIALS/PRODUCTS

A. THERMOMETERS AND PRESSURE GAUGES

Thermometers, pressure gauges, etc., shall be installed where required for adequate monitoring of system conditions and for troubleshooting. Typical examples would be pressure gauges on the suction and discharge of pumps and on the inlet and outlet of filters and thermometers on both sides of heat exchangers and coils. Their position shall be such that they can be read from normal operating levels. Location of thermometers shall be carefully planned so that they will give representative readings; e.g., they should be in the flowing stream rather than in a dead pocket. Ranges shall be appropriate for the variables being measured.

Thermometers should normally be bimetallic dial type 12.7 cm. in diameter. Thermometers shall be installed in separate brass wells that are designed for the thermometers specified, except that stainless steel wells should be used where corrosion or erosion conditions require. Wells installed for test measurement only, without thermometers, should be set vertically or inclined so as to hold a heat transfer fluid.

Pressure gauges for water, compressed air, and steam should normally be 11.4 cm. in diameter and bottom connected. All gauges to be installed shall be installed with isolation valves as specified in the materials list.

B. METERS

Meters should be provided for water, power and other services, as required, to determine use and accountability. Sufficient meters should be installed to aid in good cost accounting. A small single-purpose building may need only one meter for each service, while a multi-department building such as a central warehousing, distribution, and repackaging center may need meters at the point of supply to various departments.

The manufacturer's recommendations shall be followed where the accuracy of a meter requires a minimum length of straight pipe ahead of it or any other special installation details.

C. PNEUMATIC ENVIRONMENTAL SYSTEMS CONTROLS AND INSTRUMENTS

The control system shall be of the pneumatic type except as otherwise shown on the drawing or specified. Controls and instruments shall be furnished and installed in accordance with the specifications and approved construction and shop drawings by Honeywell, Inc., 2701 Fourth Ave., South Minneapolis, MN 55408, USA; Johnson Controls, P.O. Box 423, Milwaukee, WI 52201, USA; or approved equal.

Compressed Air Supply

The compressed air for the pneumatic control system shall be supplied from a self-contained, duplex type oil-free air compressor; provided with a refrigerated air dryer; and located in the plant room.

All compressed air piping for the control system shall be hard drawn, Type L copper tubing, equivalent to ASTM B 88 (American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19013, USA) with wrought copper fittings, tin-antimony 95-TA solder (equivalent to ASTM B 32), and sized in accordance with the manufacturer's recommendations. All piping and capillary tubing shall be adequately strapped and supported from the building structure. Exposed pipes shall be neatly arranged, straight and parallel and at right angles to walls and shall not be field cabled. Concealed piping shall be labeled at the ends for easy identification. Piping shall not be concealed under duct insulation or inside of duct work or be in direct contact with surfaces colder than room temperature. Compression fitting instead of unions shall be used only at connections to valves, damper operators, and other equipment.

Virgin polyethylene tubing may be used for final connections within accessible control panels and shall be color-coded in accordance with ISA recommendations. Tubing shall have a temperature range of -51° C to 100° C. Polyethylene tubing is acceptable only if it is supported in conduit or trays and is not near any heat sources. Copper tubing must be used in concealed areas.

The air filter and pressure reducing assembly shall be sized to filter and reduce the line air pressure. Gauges and safety valves shall be installed between the regulators as shown on the drawings.

Room Thermostats. Room thermostats shall have a bimetallic or bellows actuating element and shall be either direct or reverse acting relay type proportional acting, with adjustable sensitivity, concealed adjustments, a mercury or dial indicating thermometer in the cover, and be surface mounted. Provision shall be made at each room thermostat so that a test gauge can be easily installed to read control pressure. Throttling range shall be adjustable from 1 to 4 psi per degree F.

Room or Insertion Transmitter-Receiver Temperature or Humidity Controllers. These thermostats shall have a relay type controlling element and a remote bulb capillary type measuring element, either direct or reverse acting as shown on the drawings.

Capillary thermostats shall be provided with liquid or vapor filled fully compensated thermal measuring elements. Thermostats shall be of proportional action and with a readily field adjustable throttling range from 0.5 to 3 psig per degree F. The thermostats shall be provided with a pneumatic feedback bellows to increase signal stability. The adjustable range shall be as required for the duty specified on the drawings. The capillary tube shall be of sufficient length for mounting as designated by the owner's representative and shall be provided with a bulb socket for insertion into a pipe or tank, or without a socket for insertion into an air duct. Bulbs shall be of the averaging type where so indicated on the drawings.

Room Humidistats. The room humidistat needed in Room Classes I and II shall have a relay type controlling element and a membrane or hair type hygroscopic measuring element, either reverse or direct acting as shown on the drawings. Provision shall be made at each room humidistat so that a test gauge can be easily installed to read the control pressure. The throttling range shall be adjustable from 0.7 psi to 2.0 psi per percent of relative humidity.

Static Pressure Regulators. The static pressure regulators shall have a relay type controlling element and a slack diaphragm measuring element, either reverse or direct acting as shown on the drawings. The static pressure regulators shall be proportional acting and with a field adjustable throttling range of 0.009 to .038 inches of water per one psig. The adjustable range shall be as required for the duty specified on the drawings.

Pressure Regulators (water, air, refrigerants, etc.). The pressure regulators shall have a relay type controlling element, a measuring element consisting of a metallic bellows, or a bourdon tube, either reverse or direct acting as shown on the drawings. The pressure regulators shall be proportional acting and with a field adjustable throttling range from 0.25 psig to 1.2 psig per 1 psig. The adjustable range shall be as required for the duty specified on the drawings.

The pressure regulators shall be mounted within 30 cm. of the instrument. The pressure regulator shall act as the pilot actuator for the relay. The relay shall control the controlled device.

Damper Operators. Damper operators for all automatic dampers shall be of the piston type with molded rubber diaphragm operator(s). Damper operators, when used for proportional control, shall be sized to cause movement with a $^1/_2$ psig pressure change or less. A damper pilot positioner shall be provided for the damper operator as necessary to accomplish the above accuracy of movement. Damper operators shall be installed outside of the duct work and connected to an extended shaft. Damper operators for inlet vane dampers, unless otherwise shown on the drawings, shall be floor-mounted by attachment to an angle frame.

Automatic Dampers. The automatic temperature control contractor shall furnish all the control dampers of the types and sizes indicated in the drawings for installation by the sheet metal contractor. All two-position control dampers shall be sized for minimum pressure drop at the specified duct size.

All modulating dampers shall be sized for an effective linear air flow control within the angle of rotation and maximum pressure drops where specified or approximately 2,000 ft/min. (610 m./min.).

Damper frames shall be of not less than No. 13 gauge (2.4 mm.) steel, formed for extra strength, with mounting holes for flanged and enclosed duct mounting.

All damper blades shall be of not less than No. 16 gauge (1.6 mm.) galvanized steel or double formed No. 22 gauge (0.9 mm.) for strength and high velocity performance. Blades on all dampers must be of not more than 20 cm. in width. Blades shall be secured to $^1/_2$ inch diameter zinc plated steel shafts by fastening them to the axle with zinc plated bolts and nuts. All blade bearings shall be nylon or oil-impregnated bronze. Blade side edges shall seal off against spring stainless steel seals or elastomeric stops. Teflon-coated thrust bearings shall be provided at each end of every blade to minimize torque requirements and assure smooth operation. All blade linkage hardware shall be constructed of corrosion-resistant zinc plated steel and brass.

Dampers shall be supplied in standard sizes in even 5 cm. increments, both in width and length. If, for any reason, nonstandard sizes are supplied, the damper shall be shipped with galvanized adjustable baffles for installation by the sheet metal contractor.

Dampers shall be suitable for operation from zero to 93° C. Damper frames shall be caulked airtight to the duct work.

All control dampers shall be inherent linear characteristic parallel blade dampers with inflatable seal edging or with blade and edge seals for ultra low leakage application. Alternately, they shall be inherent equal percentage characteristic opposed blade dampers with inflatable seal edging or with blade and edge seals for ultra low leakage applications. The control manufacturer shall submit leakage and flow characteristic data for all control dampers, including actual leakage data at actual close-off torques for the ultra low leakage applications specified. Leakage shall not exceed 1 percent of design cfm at 3 inch water gauge differential static pressure.

3-Way Water Valves. All hot and cold water 3-way valves with linear flow characteristics shall have composition disc seating and stainless steel or bronze trim.

Three-way valves shall be equipped with a synthetic rubber diaphragm and piston motor operators of sufficient size to insure smooth positive operation over the operating range, without chatter, and to provide tight shut-off against the system pressure at either end position.

Valves 2 inches in diameter and smaller shall have iron bodies with screwed ends. Valves $2^1/_2$ inches in diameter and larger shall have iron bodies with flanged ends. Three-way valve(s) shall have sufficient stuffing box protection to insure against leakage at the operating pressure without causing sticking or binding of the valve stem. Packing shall be Teflon.

Control Panels

Control panels shall be provided to mount the instrumentation specified or indicated for each system. Panels shall be supported with suitable brackets for either wall or floor mounting and shall be located near the controlled components of the system within the plant room. Control panels shall be fabricated from at least No. 12 (2.8 mm.) gauge furniture steel with 25 mm. turnbacks on all four sides and welded corners or metal cabinets with hinged doors. Mounted in these panels shall be all the temperature controllers, static pressure controllers, pressure controllers, switches, timers, relays, remote reading dial thermometers, air gauges for the indication of main air and controller air pressure, and other miscellaneous devices associated with the system.

Where it is not practical to locate controls on the control panels, subpanels shall be furnished for mounting of all duct and immersion type thermostats and associated thermometers in a location near the controlled component of the system. These subpanels shall be fabricated from steel sheets with suitable brackets for wall mounting. Controls shall not be mounted on vibrating equipment or on duct work.

Every regulator, switch, thermometer, or gauge in the control panel shall be identified by a nameplate of black acrylic or phenolic engraving stock with engraved white lettering. Identification shall be specifically related to a control diagram that shall be mounted in a metal frame, under glass, adjacent to the system control panel.

Duct Thermometers

Duct thermometers shall be provided in the locations shown on the drawings and/or as specified for the following locations:

- outside air intake of the supply system
- temperature at the discharge of the preheat coils
- temperature at the discharge of the cooling coils
- temperature at the discharge of the heating and/or reheat coils
- temperature of return air
- temperature of mixed air

The duct thermometer shall be a remote indicating dial type with a dial face 8.9 cm. diameter or larger. The temperature range shall be a minimum of -10° C to 43° C to a maximum of -10° C to 49° C with dial graduations in equal divisions of 1°.C for the entire temperature range. The thermal system shall be a liquid filled capillary and bulb type element with a capillary length of 3.0 m. or longer as required to enable control panel mounting. Bulbs shall be of the averaging type where so indicated. The accuracy of the thermometer shall be plus or minus 1 percent of the temperature range.

All thermometers shall be tested in place for accurate indication of the temperature at the bulb location and shall be calibrated, repaired, and/or replaced as necessary.

Duct thermometers will not be necessary in those locations where indicating controllers are provided.

Compressed Air Pressure Gauges. Air pressure gauges shall have a dial face of 3.8 cm. diameter and shall be stem mounted with a 0 to 2.0 kg/cm^2 pressure range. The gauge shall have a steel case. Air pressure gauges shall be supplied where indicated on the drawings and at least shall be provided for the branch compressed air line connection at all control devices and at all controlled devices.

Electric-pneumatic Switches (Solenoid Air Valves). Solenoid three-way air valves of packless construction shall be used where a pneumatically operated device is controlled by an electric circuit, as shown on the drawings or as specified. Solenoid air valves shall be furnished for two-position action and have three pipe connections for switching of compressed air control lines. Voltage shall be 120 volts unless otherwise noted. Valve bodies shall be suitable for operation to 1.5 kg/cm^2 air pressure. Valves shall be supplied with valve mounting brackets.

Pneumatic-electric Switches. Pressure electric switches shall be single pole, single-throw, mercury switch construction. External knobs shall be provided to permit independent adjustment of the high and low pressure limits over the entire range. A locking device or cover shall be provided for the adjustment knobs. The operating range of the instrument shall be 0 to 1.5 kg/cm^2.

Proportioning Switches. Proportioning switches shall be a pressure reducing valve suitable for positioning air operated valve or damper motors. The switch dial shall be marked open and closed, with intermediate graduations to indicate position.

EXECUTION

A. INSTALLATION

Except as otherwise specified, the automatic temperature control system contractor shall install all instruments and controls.

B. TESTING AND ADJUSTING

After the entire control system has been installed, all low pressure control air shall be tested to 30 psig (2.17 kg/cm^2) air pressure. The pressure shall be maintained for 24 hours without pumping, during which time the pressure shall not drop more than 5 percent. Leaks shall be corrected by remaking the joints. Caulking will not be permitted.

All equipment shall be tested and adjusted so that it will perform as specified and as required to give satisfactory operation. The testing of the components installed under this section shall be coordinated with the testing required under the specification M-16 for Balancing Air, Chilled, and Hot Water Systems.

REFRIGERATION EQUIPMENT

GENERAL

A. SCOPE

This specification describes the central refrigeration equipment, equipment controls and instruments, and air cooled condensor to produce chilled water for the environmental control systems. Chilled water systems that are correctly designed have the following two major advantages over direct expansion refrigeration systems:

- higher load diversification factors enable fewer tons of installed refrigeration capacity to meet identical design conditions.
- they can be easily expanded.

B. RELATED WORK SPECIFIED ELSEWHERE

M-01 Air Handling Units
M-02 Central System Coils
M-09 Controls and Instrumentation
M-11 Pumps
M-12 Pipe and Pipe Fittings
M-13 Pipe Insulation
M-15 Cleaning and Testing Piping Systems
M-16 Balancing Air, Chilled, and Hot Water Systems
M-18 Piping Identification

C. CODES AND STANDARDS

Chilled water refrigeration equipment shall be designed, fabricated, and installed in conformance with the applicable standards of AMCA (Air Movement and Control Association, 30 W. University Dr., Arlington Heights, IL 60004, USA), ASHRAE (American Society of Heating, Refrigeration, and Air Conditioning Engineers, 1791 Tullie Circle, N.E., Atlanta, GA 30329, USA), ACRI (Air Conditioning and Refrigeration Institute, 1815 N. Fort Myers Drive, Arlington, VA 22209, USA), and SMACNA (Sheet Metal & Air Conditioning Contractors National Association, Inc., 1611 N. Kent Street, Arlington, VA 22209, USA).

D. SUBMITTALS

Shop drawings shall be provided so that equipment foundations can be designed. Certified equipment and equipment control schematics, sequence of operations, and actual factory test performance results including capacity, power consumption, control and options operations shall also be provided. Shop drawings and submittal data shall be provided to the owner by the successful supplier within ten (10) working days of notice of contract award. Shop drawings shall be reviewed and returned by the owner within 15 working days of receipt.

The successful supplier shall also deliver to the owner the required copies of operating and maintenance data on all equipment furnished. This shall include the model and serial number of all equipment; performance data; the manufacturer's written instructions for the operation and maintenance of the

component equipment; and a lubrication schedule indicating all equipment to be lubricated, recommended lubrication interval, and the type and quality of lubricant to be used.

The refrigeration unit's manufacturer shall provide a warranty for the equipment manufactured by him and all purchased components. Said warranty shall be for a period of one year from the date of final acceptance of the building by the owner.

E. ACCEPTANCE TESTS

Factory tests shall be made as specified herein in the presence of the architect/engineer and owner's representative prior to shipping.

MATERIALS/PRODUCTS

Provide _____ model _____ open type reciprocating liquid chillers with an air cooled cold generator. Each unit shall have _____ tons of evaporator capacity and _____ tons of cooling capacity. The entering water temperature shall be _____° C and leaving chilled water temperature _____° C at a flow rate of _____ lpm with an evaporator water pressure drop of _____ cm. Compressor power input shall be _____ kw and the unit Energy Efficiency Ratio (EER) _____. The EER includes compressor(s), fans, and control power input. Each unit shall have completely independent refrigerant circuits. When in the heat recovery mode, the compressor's heat shall be rejected to an external heat exchanger (heat recovery bundle) that is factory mounted on top of each refrigeration unit. **(When selecting equipment be sure to incorporate the altitude adjustment factors recommended by the manufacturer.)**

The unit shall be mounted on a 6 mm. steel frame that is coated with a chlorinated vinyl lacquer and shall be shipped with a full operating charge of refrigerant and oil. The components of the chiller shall be as follows:

A. EVAPORATOR

The evaporator shall be tube-in-shell design with seamless copper tubes roller expanded into tube sheets and dual refrigerant circuits with gasketed heads. The evaporator shall be designed, tested, and stamped in accordance with ASME (American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017, USA) code, or equal, for refrigerant side working pressure of 16 kg/cm^2 and waterside working pressure of 11 kg/cm^2. There shall be one water pass with a series of internal baffles. Each shell shall include a drain connection and flare connections on the water inlet and outlet for pressure drop measurements. The shell shall be completely covered with 20 mm. thick expanded polyvinyl chloride insulation (K = 0.26).

B. CONDENSER

The condenser shall have dual circuited vertical condenser coils consisting of aluminum fins mechanically bonded to $^5/_8$ inch outside diameter seamless copper tubes. A subcooler circuit with liquid accumulator shall be standard. The condenser and subcooler coils shall be tested under water at 30.8 kg/cm^2 air pressure.

Belt-driven vertical discharge condenser fans shall be statically and dynamically balanced for quiet, vibration free operation. The condenser fans shall be driven by three-phase motors with permanently lubricated ball bearings and three-phase thermal overload protection.

C. COMPRESSOR AND MOTOR

Each unit shall have two direct drive, 1750 rpm, open type reciprocating compressors, including spring loaded heads, replaceable cylinder liners, positive displacement oil pump, oil filter and magnetic plugs, foam breaker, oil level sight glass, oil charging valve, two double mesh suction inlet screens, high strength-nonflexing ring-type suction and discharge valves, solenoid actuated cylinder unloaders, removable discharge heads and hand hold covers, suction and discharge service valves, and rubber-in-shear vibration isolators. The motor shall be suction gas cooled and suitable for voltage fluctuations up to 10 percent of the nameplate voltage.

D. CONTROL PANEL

All controls shall be panel mounted in a weather-tight enclosure. Separate sections shall be provided for the refrigeration and electrical controls. The starter section shall have the main unit single point power connection, starting controls. for either part winding or across-the-line types of start, and noncycling compressor overloads and oil pressure cutouts. The refrigeration section shall contain the reset relay, compressor service switches, motor protector, differential oil pressure control, high and low pressure controls,

and central unit microprocessor. The microprocessor shall control the compressor anti-recycle function, compressor lead-lag, low water temperature cutout, loss of charge protection, leaving chilled water temperature control, load limiting with timed periodic pumpout, chilled water set point reset, and hot gas bypass logic. Control panels and access doors shall be constructed of 12 gauge (2.8 mm.) and 14 gauge (2.0 mm.) painted sheet steel.

E. REFRIGERANT CIRCUIT

Each unit shall have two completely independent refrigerant circuits, one compressor per circuit. Each circuit shall contain a liquid line solenoid valve, removable core filter drier, liquid line sight glass, thermal expansion valve, $^1/_4$ inch diameter flare charging port, and full operating charge of R-22 refrigerant.

F. CAPACITY MODULATION AND TEMPERATURE CONTROL

The units shall be furnished with a six-step unit capacity control that responds to leaving chilled water temperature. The compressor unloaders shall be electric solenoid actuated and oil pressure operated. This feature provides cost-effective, continuously available refrigeration cooling.

G. ALARMS

The alarm system shall include an electronic horn with a loudness rating of 103 db - 3500 Hz at 3 m. distance and pilot lights to indicate loss of evaporator flow, low leaving chilled water temperature, power on, compressor on, and compressor malfunction. A push-to-test circuit shall test the alarm bell and indicating lights.

H. HOT GAS BYPASS

Each unit shall have a hot gas bypass feature that allows unit operation below the minimum step of unit unloading. The regulator valve, along with all the associated refrigerant piping and electrical wiring, shall be factory installed and tested. The hot gas bypass shall allow unit operation down to approximately 10 percent of full unit capacity. If the unit operates in the bypass mode for a period of 30 minutes without demand for cooling, the unit shall pump down and stop. The unit shall start immediately on demand for cooling. Regulator valves shall be provided on both refrigerant circuits for lead-lag sequencing of the compressors.

I. POWER SUPPLY MONITOR

Each unit shall have protection against phase loss, reversal, unbalance, incorrect phase sequence, and low line voltage. The protection device shall automatically reset and restore power to the unit when the fault condition is corrected.

J. PERIODIC PUMPOUT CONTROL

This feature shall prevent the accumulation of liquid refrigerant in the evaporator during an off cycle. The microprocessor-based control shall allow the compressor to pump out the evaporator once an hour if the low pressure control contacts close, indicating the presence of liquid in the evaporator.

K. CYCLE COUNTER AND HOUR METER

These devices shall record the number of compressor starts and hours of operation for each compressor.

L. GAUGES

A gauge board shall be provided with manual shut-off valves to monitor discharge, suction, and oil pressure for each refrigerant circuit.

M. UNIT MOUNTED DISCONNECT

A molded case disconnect switch shall be provided for disconnecting the main unit power.

N. COIL GUARDS

Protective grills shall be placed over the condenser coil to protect the fins from damage. Specify factory or field installation.

O. VIBRATION ISOLATORS

Spring isolators for field installation under the unit's frame shall be provided by the unit's manufacturer. The liquid chiller shall be manufactured by the Trane Company, Commercial Systems Group, 3600 Pammel Creek Road, LaCrosse, WI 54601, USA, or approved equal.

EXECUTION

A. INSTALLATION

The unit(s) shall be installed in accordance with approved construction and shop drawings and the manufacturer's recommendations.

B. TESTING

Prior to shipment to the site, each unit shall be factory tested in the presence of the architect/engineer and the owner's representative. All factory test and actual test results shall be compared to the performance ratings in the certified documentation.

PUMPS

GENERAL

A. SCOPE

This specification covers the materials and techniques to be used in the selection and installation of chilled and hot water centrifugal pumps required for the environmental control systems.

B. RELATED WORK SPECIFIED ELSEWHERE

M-01 Air Handling Units
M-02 Central System Coils
M-04 Vibration Isolation
M-09 Controls and Instrumentation
M-10 Refrigeration Equipment
M-12 Pipe and Pipe Fittings
M-13 Pipe Insulation
M-14 Piping Supports and Hangers
M-15 Cleaning and Testing Piping Systems
M-16 Balancing Air, Chilled, and Hot Water Systems

C. CODES AND STANDARDS

Pump and pumping systems shall be designed and installed in conformance with the applicable standards of AMCA (Air Movement and Control Association, 30 W. University Dr., Arlington Heights, IL 60004, USA), ASHRAE (American Society of Heating, Refrigeration, and Air Conditioning Engineers, 1791 Tullie Circle, N.E., Atlanta, GA 30329, USA), and ACRI (Air Conditioning and Refrigeration Institute, 1815 N. Fort Myers Drive, Arlington, VA 22209, USA).

D. SUBMITTALS

The contractor shall provide certified manufacturer's technical information including pump dimensions, construction characteristics, and performance curves to the architect/engineer for review and approval.

MATERIALS/PRODUCTS

The pumps shall be 1750 rpm, 12.7 kg/cm^2 working pressure, single-stage split case design in cast iron with bronze mountings and cast iron companion flanges for direct in line vertical or horizontal mounting. The pump body shall have gauge ports at the nozzles and vent and drain ports. The pump's internal components shall be capable of being serviced without disturbing the piping. The impeller shall be of the enclosed type, cast bronze construction, hydraulically and dynamically balanced, keyed to the shaft, and appropriately secured by a locking cap screw. The pump shall have an internally flushed mechanical seal with a carbon seal ring and ceramic seat suitable for operations up to 104° C. A bronze shaft sleeve shall cover completely the wetted area under the shaft seal. The bearing frame assembly of the pump shall be fitted with oil lubricated, bronze journal bearings and a hardened alloy steel shaft.

A flexible spring-type coupling capable of absorbing starting torque and torsional vibration shall be

provided between the shaft and the motor, and the motor shall be resilient mounted to the pump. The motor shall meet NEMA (National Electrical Manufacturer's Association, 2101 L Street, N.W., Washington, D.C. 20037, USA) specifications and, shall be the size, voltage, and enclosure called for in the drawings and specifications. All pumps shall be factory tested, thoroughly cleaned, and painted with at least one coat of machinery enamel prior to shipping.

The pumps shall be Series 60 manufactured by Bell and Gossett, Fluid Handling Division, 8200 N. Austin Ave., Morton Grove, IL 60053, USA, or approved equal. (Should larger diameter connections be required, use Series 80 pumps that are quite similar.) Furnish pumps with capacities as shown in the drawings.

EXECUTION

A. INSTALLATION

Install the pumps as shown in the drawings and in accordance with the manufacturer's recommendations.

B. TESTING

See specification M-15, Cleaning and Testing Water Piping Systems.

PIPE AND PIPE FITTINGS

GENERAL

A. SCOPE

This specification covers the materials and techniques to be used in the design, fabrication, and installation of indoor and outdoor aboveground piping systems and piping in tunnels for potable fresh water, hot water/hot water return, chilled water/chilled water return, and compressed air. Related information on underground pressure piping systems is in specification F-03, Fire Main Pipe Systems. This specification excludes instrumentation and control piping for environmental control systems.

B. RELATED WORK SPECIFIED ELSEWHERE

A-19 Plumbing Fixtures and Trim
F-03 Fire Main Pipe Systems
M-01 Air Handling Units
M-02 Central System Coils
M-09 Controls and Instrumentations
M-10 Refrigeration Equipment
M-11 Pumps
M-13 Pipe Insulation
M-14 Piping Supports and Hangers
M-15 Cleaning and Testing Water Piping Systems
M-16 Balancing Air, Chilled, and Hot Water Systems
M-18 Piping Identification

C. CODES AND STANDARDS

The materials, system design, and installations shall be in accordance with local codes and the applicable standards from the latest editions of ANSI (American National Standards Institute, 1430 Broadway, New York, NY 10017, USA), ASME (American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017, USA), the National Plumbing Code (Building Officials and Code Administrators International, Inc., 4051 Flossmoor Road, Country Club Hills, IL 60477, USA), and ASTM (American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19013, USA).

D. SUBMITTALS

Shop drawings and manufacturer's literature shall be submitted for the items listed in the contract documents. Samples of all of the different types of welded pipe connecting that the job requires shall be prepared by the contractor's prequalified welders in the presence of the owner's representative and submitted to the architect/engineer for inspection, testing, and approval prior to starting any other piping work.

MATERIALS/PRODUCTS

A. GALVANIZED STEEL PIPE

Application

Compressed air, hot and cold potable and environmental control system reheat water with temperatures up

to 82° C and pressures to 10.0 kg/cm^2.

Item	Diameter	Specification
Pipe	$^1/_4$ inch to 4 inch	Galvanized steel pipe Schedule 40, butt or electric welded
	5 inch and over	Galvanized steel pipe standard weight, seamless or electric welded
Joints	$^1/_4$ inch to 4 inch	Screwed
	5 inch and over	Flanged
Fittings	$^1/_4$ inch to 4 inch	Galvanized malleable iron, threaded, 150 pound class
	5 inches and over	Galvanized cast iron, flanged, 125 pound class
Nipples	$^1/_4$ inch to 4 inch	Galvanized steel pipe standard weight
Unions	$^1/_4$ inch thru 2 inch	Galvanized malleable iron with brass seats, 250 pound class, railroad type
Flanges	$2^1/_2$ inch and over	Companion flanges black cast iron, threaded, flat face, 125 pound class
Gaskets	$2^1/_2$ inch and over	Teflon 1.6 mm. full face type
Thread Sealant		Teflon tape for water systems. Teflon paste for compressed air piping systems shall be Loctite PST as manufactured by Loctite Corporation, 705 North Mountain Road, Newington, CT 06111, USA, or approved equal.
Steel/Copper Connections		Dielectric unions.

B. COPPER TUBING

Application

Hot and cold potable and reheat water with temperatures up to 120° C and 10.0 kg/cm^2, if compatible with the water.

Item	Diameter	Specification
Pipe	All sizes	Copper tubing, Type L, hand-drawn
Joints	$^1/_4$ inch to $^1/_2$ inch	Soldered or compression type, except soldered at terminal points
	$^5/_8$ inch and over	Soldered
Fittings	All sizes	Soldered fittings, wrought copper or cast bronze
	$^1/_4$ inch to $^1/_2$ inch	Compression fittings, brass
Unions	$^1/_4$ inch to 2 inch	Solder joint union of wrought copper or cast bronze
Flanges	All sizes	Solder joint copper, raised or flat face to match equipment, 150 pound class
Gaskets	All	Teflon 1.6 mm. thick, solid, full face type for flat or ring type for raised-face flanges
Solder		95-5 Solder

Thread Sealant	Teflon tape
Copper/Steel Connections	Dielectric unions

Smaller diameter copper tubing may be bent with a bending tool to the following minimum radii: $^1/_4$ inch - 9/16 inch radius and $^3/_8$ inch - 15/16 inch radius. All other tubing shall be straight sections with fittings.

C. PLASTIC PIPE

Application

Hot and cold potable and reheat water with temperatures up to 66° C and pressures up to 10 kg/cm^2.

Item	Diameter	Specification
Pipe	$^1/_2$ inch to 6 inch	PVC Type I, Schedule 80, ASTM-D7785
Joints	$^1/_2$ inch to 6 inch	Solvent welded
Fittings	$^1/_2$ inch to 6 inch	PVC, Schedule 80, socket type ASTM-D-2467
Flanges	$^1/_2$ inch to 6 inch	PVC, Schedule 80, socket type, flat face, 150 pound class
Gaskets	$^1/_2$ inch to 6 inch	Teflon 1.6 mm. thick, solid, full face type

D. CARBON STEEL PIPE

Application

Chilled water supply and return.

Item	Diameter	Specification
Pipe	$^1/_4$ inch to 4 inch	Carbon steel, Schedule 40, butt or electric welded ASTM A 120
	5 inch and over	Carbon steel, standard weight ASTM A53 (Standard weight and Schedule 40 are the same up to 10 inch diameter, thickness varies above 10 inch diameter)
Joints	$^1/_4$ inch to 2 inch	Screwed
	$2^1/_2$ inch and over	Welded
Fittings	$^1/_4$ inch to 2 inch	Black malleable iron, threaded, 150 pound class, ANSI B-16.3
	$2^1/_2$ inch and over	Carbon steel, standard weight, butt welded, ANSI B-16.9
Nipples	$^1/_4$ inch to 2 inch	Carbon steel, extra strong, ASTM A-120 or A-53
Unions	$^1/_4$ inch to 2 inch	Black malleable iron with brass seats, railroad type, 250 pound class
Flanges	$2^1/_2$ inch and over	Carbon steel, raised face, weld neck, 150 pound class, ANSI B-16.5; flat face only if matching cast iron flanges
Gaskets	$2^1/_2$ inch and over	Ring type, 1.6 mm. thick, Style 3200 Garlock Blue-Gard manufactured by Garlock Gasket Co. (1666 Division Street, Palmyra, NY 14522, USA), or approved equal
Thread Sealant		Insoluble plastic lead seal sealant

EXECUTION

A. DESIGN CONSIDERATIONS

Pipe sizing calculations showing velocities and pressure losses are generally required for each pipe system to determine that sufficient pressure is available and/or to determine the required pump discharge heads. Such calculations must be based on peak flow and must account for possible future additions to the system. In general, fluid velocities must not exceed 2.50 m./sec. for water mains. Lower values must be used for smaller lines because of their higher friction losses.

The locations of small piping may be shown on the plans slightly out of scale if necessary for drawing clarity. However, larger-scale details, complete with dimensions, should be made for critical locations where the arrangment is important to operation, maintenance, etc.

Where a number of utility services pass through an area, it is generally preferred that the mains be grouped together on trapeze hangers and run at a constant elevation, except for those lines that must be sloped. Generally, north-south runs should be grouped at a different elevation than east-west runs. In order to conserve space, branch lines generally are connected to the top of these mains and run laterally at some other preassigned elevation.

In order to avoid costly field change orders because of interferences, it is necessary that attention be given to piping, HVAC, electrical, and structural designs. Many interferences can be avoided by assigning levels at which various services will be routed early in the design phase. Thorough coordination and checking by the various design disciplines is obviously necessary.

Minor changes authorized in the field must be marked at the time of approval on the resident engineer's set of drawings so that they are incorporated on the "as built" drawings when the work is completed. Major changes normally require a drawing revision.

In the layout and dimensioning of piping, the designer must consider the extreme projections of flanges, fittings, valves, and the like, plus allowances for insulation and pipe expansion. Normally, there should be a minimum clearance of 3 cm. between headers for the extreme condition.

In closed recirculating hot water systems, the design should consider inclusion of bypass filtration taking water from the circulating pump discharge through a small replaceable cartridge filter and flow indicator and back to the pump suction. The filter should be 30 micron porosity with a corrosion-resistant housing, sized for a flow equivalent to the system volume in 24 hours. The flow indicator, placed downstream of the filter, can be a simple rotometer of corrosion-resistant material such as a variable area dial type flow indicator. Flow should be set at a specified level and the filter cartridge changed when flow drops to about half the original setting. Frequent filter cartridge changes may be required initially, but only occasionally after the system has been operated for several weeks. In addition, some chemical inhibitor is normally added to the system as recommended by the water consultant. A simple feeder can be installed for this purpose.

B. INSTALLATION

Alignment and Arrangment

The installation of piping systems shall be coordinated with other work, and/or with existing facilities, to avoid obstructing building openings, light fixtures, etc. Piping shall not interfere with access to valves or equipment and shall not obstruct passageways. In general, the minimum headroom clearance above the floor shall be 2.20 m. clear under all piping, covering, and appurtenances. Piping shall be installed to provide the working clearances required for operations and maintenance.

All piping shall be arranged and aligned in accordance with the drawings. Elevations as given must be maintained. Floor elevations where given are to high points of the floor. All dimensions are to be field checked for accuracy before pipe is fabricated.

Install all piping straight and direct as possible, generally forming right angles with or running parallel with walls or adjacent piping. All piping shall be neatly spaced with risers and drops running plumb and true. Run piping in wall chases, pipe shafts, above suspended ceilings, etc., where same are provided. Do not run service piping in the floor slab fill unless specifically indicated in the drawings. Piping shall not be covered or concealed until testing is completed and covering is authorized by the owner's representative.

Drawings for small piping are in general diagrammatic, and the exact location of these lines shall be determined by the contractor from field measurements. The actual arrangement of the small size piping, when erected, shall follow the general locations shown on the drawings as far as practicable. The installation made in this way shall be neat in appearance, convenient to operate, and shall provide for proper expansion and drainage.

Modifications to the arrangement of the piping systems may be required to suit structural conditions or to avoid interference with the work of other trades. The contractor shall furnish all offsets, additional fittings, etc., as required to meet installation conditions whether detailed on the drawings or not.

Pipe Clearances

Install piping to provide a minimum clearance of at least 3 cm. between the extreme projections of all piping, flanges, fittings, valves, etc., allowing for insulation, pipe expansion, and the like.

Pipe Expansion

Special attention shall be given to the installation of hot and cold piping lines that have an appreciable movement so that they will not contact other pipes, structural members, etc., when they heat up or cool. Locate and install anchors where indicated on the drawings.

Drainage and Venting

Where lines are purposely pitched for drainage or venting, an accurate grade shall be maintained. Support lines in such a manner as to prevent deflection of the piping that could be sufficient to create low points in the lines.

Pipe Runs

Water piping, when run together with other piping on trapeze hangers, need not be sloped. Chilled water and reheat hot water, when run separately, shall be pitched upward in the direction of the flow. The pitch shall be 20 cm. in 100 m. where conditions permit.

Provide vents at all high points of chilled water and reheat hot water piping where air might collect. Manual vents shall have a $^1/_2$ inch diameter ball valve and shall be piped to a drain or arranged so that blow-off water can be caught in a bucket as directed by the owner's representative. Automatic vents, where used, shall be installed with $^1/_4$ inch diameter tubing to a suitable drain.

Pipe and Fittings

Full lengths of pipe shall be used wherever possible. Short lengths of pipe with couplings will not be permitted. All pipe shall be cut to exact measurement and shall be installed without forcing, (except where cold springing is specifically called for). After cutting, ends shall be reamed and cleaned to eliminate foreign matter and burrs.

Cutting or other weakening of the building structure to facilitate piping installation will not be permitted.

Make all changes in size and direction of piping with fittings. Do **not** use bends, miter fittings, face or flush bushings, street elbows, or field-fabricated reducers. Close nipples shall not be permitted; use only shoulder nipples. Shoulder nipples with a shoulder length less than 3.8 cm. shall be of heavy wall pipe; nipples having shoulder lengths of 3.8 cm. or larger shall be of the same schedule as the connected pipe.

Unless otherwise shown on the drawings, install all supply piping to coils, pumps, and other equipment, including valves and strainers therein, at line size. If a reduction is required at a pump or control valve, the reducer shall be installed abutting the inlet and/or outlet of the pump or valve.

Unions/Flanges

Provide unions or flanges at all piping connections to coils, equipment, control valves, pressure reducing valves, etc., at all locations as shown on the drawings and generally as required to disconnect piping from equipment and specialties. Arrange the connections so that the equipment serviced may be removed without disturbing the piping. Where valves serve to isolate equipment or specialties, the unions or flanges shall be located between the valves and the equipment or specialties. Unions shall generally be used for pipe sizes of 2 inch diameter and smaller and flanges for pipe sizes of $2^1/_2$ inch diameter and over.

Dielectric Connections

Provide dielectric fittings between ferrous and copper piping. Provide dielectric fittings between buried

piping and aboveground piping where shown on the drawings.

Valves, Traps, Gauges, Strainers, etc.

System components that require observation, operation, or maintenance such as valves, traps, gauges, strainers, cleanouts, unions, flanges, etc., shall be located whenever possible so as to be readily accessible. They shall not be concealed in chases or above ceilings without provision for access. Valves that require frequent operation, or that may require emergency operation and that are not accessible from normal working levels, shall be installed with appropriate provisions such as chain wheels, extension stems, ladders, or platforms. If the drawings fail to provide accessibility, the discrepancy shall be called to the attention of the owner's representative for clarification prior to fabrication or erection.

Install all valves with stems in either an upright (preferred) or horizontal position, except for diaphragm valves in applications where good drainage is required. All control valves shall be installed with the works upright unless specifically shown otherwise.

Globe valves should be installed to seat against the direction of flow.

Instruments (i.e., pressure gauges, thermometers, orifice plates, etc.) are shown on the drawings in their approximate locations. The installed location shall consider visibility and any special installation requirements and shall be as approved by the owner's representative.

Pipe Sleeves

Provide all pipe openings through walls, partitions, and slabs with sleeves having an internal diameter of at least 1 inch diameter larger than the outside diameter of the pipe for uninsulated lines or of the insulation for insulated lines. Holes for pipe sleeves are to be neatly cut. Install sleeves through interior walls and partitions flush with the finished surfaces; sleeves through outside walls are to project 1.3 cm. on the outside of the finished wall. Floor sleeves are to project 5 cm. above the finished floor. Set sleeves in place before pouring concrete or securely fasten and grout with cement.

Sleeve construction shall be:

- No. 22 gauge (0.9 mm.) galvanized sheet steel with soldered joints for interior partitions
- Schedule 40 galvanized steel pipe, or stainless steel where shown on drawings, for exterior walls, interior masonry walls, and floors.

For interior walls, the space between the outside of the pipe or insulation and the inside of the sleeve or framed opening shall be filled with fiber glass. For exterior walls, pack the space with oakum, seal with lead, and cover with a watertight mastic or asphalt.

Provide escutcheon plates on both sides of the penetration through the structure for all pipes exposed to view passing through walls, floors, ceilings, and partitions, whether or not insulated. For pipes passing through floors, the escutcheon plates shall fit over the sleeve.

Screwed Joints

Cut threads full and clean with sharp dies. To remove burrs, ream the ends of the pipe after threading and before assembly. Use the specified joint sealant or tape on the male threads only. Prevent the sealant from entering the pipe.

Flanged Joints

Use steel bolts with square heads and hard-pressed steel hexagon nuts. Where a cast iron, flat-faced flange joins a steel flange, the steel flange must also have full, flat face. Use full face gaskets only. Raised-faced flanges shall also be used only in pairs and only with ring type gaskets.

Soldered and Brazed Joints

All soldered and/or brazed joints shall be made with the tube ends square cut and reamed and straightened and rounded with straightening tools as necessary. Fittings and tube surfaces shall be properly cleaned with steel wool, or emery cloth, and a specified flux shall be used in accordance with the manufacturer's recommendations. Uniform heat shall be applied by the use of a blowtorch or oxyacetylene torch. Adequate cooling time shall be allowed before washing or quenching. Appurtenances that are fragile or heat sensitive shall be protected against overheating, or the sensitive parts shall be removed during this application of heat (viz., when soldering ball valves into a line, keep the valve body cool). Reference to soldered herein indicates a

metal requiring a melting temperature of approximately 232° C to 315° C.

Compression Joints

Cut ends of the pipe square. Remove all burrs on the inside and outside of the pipe. Clean the joint contact surfaces with steel wool before assembly. Assemble the joint in accordance with the manufacturer's recommendations.

Carbon Steel Welded Joints

Welding on carbon steel pipe and fittings shall be done by the metal arc process. Welding operations shall conform to Chapter V, of the Code for Pressure Piping, ANSI B-31.3, latest edition, and be performed only by welders prequalified by the architect/engineer.

Tack welds used in assembling pipe, fittings, etc., shall be removed.

The manufacturer's standard angle of bevel for butt weld fittings shall be acceptable provided it is in accordance with ANSI B-16.25, or is not less than 30° nor more than 40°. No weld shall be covered by a jacket. All welds shall be full penetration, homogeneous, and with no voids. The welding procedure used shall be one that produces a weld having an inside surface that is, within practical limits, smooth and free from cracks or crevices. All slag of flux remaining on any bead of welding shall be removed before laying down the next successive bead. The finished pass shall be cleaned thoroughly of all flux by first wire brushing, then lightly chipping, and then wire brushing the weld for final cleaning. Any cracks or blow holes that appear on the surface of any bead of welding shall be removed by chipping, grinding, or gouging before depositing the next successive bead of welding.

Heating of pipe and fittings for straightening will not be permitted without the prior approval of the owner's representative. The owner's representative shall have the right to inspect all welding at any time. If there is a reasonable doubt of the quality of a weld, he may inspect a portion or all of the weld to determine if it complies with the specifications. If the weld is found to be faulty, it shall be replaced as designated by the owner's representative.

C. PROTECTION OF INSTALLATIONS

The accumulation of dirt and debris in piping systems during construction is a recurring problem. Flushing systems after erection often does not completely remove dirt, especially in the case of large diameter pipe where high velocity flushing may be difficult. It is important that work areas and storage areas be kept clean and that all exposed ends of incomplete or unconnected piping be temporarily plugged as each phase of work is completed. The resident engineer shall monitor the work.

Testing

Installed work shall be cleaned and tested in accordance with specification M-15,

PIPE INSULATION

GENERAL

A. SCOPE

This specification covers materials and techniques to be used in the design, selection, and installation of pipe insulation for interior and exterior aboveground cold and hot piping systems.

B. RELATED WORK SPECIFIED ELSEWHERE

M-01 Air Handling Units
M-02 Central System Coils
M-09 Controls and Instrumentation
M-10 Refrigeration Equipment
M-11 Pumps
M-12 Pipe and Pipe Fittings
M-14 Pipe Supports and Hangers
M-15 Cleaning and Testing Water Piping Systems
M-18 Piping Identification

C. CODES AND STANDARDS

Insulation shall be designed, fabricated, and installed in conformance with local codes and the applicable standards of: ASHRAE (American Society of Heating, Refrigeration, and Air Conditioning Engineers, 1791 Tullie Circle, N.E., Atlanta, GA 30329, USA), ACRI (Air Conditioning and Refrigeration Institute, 1815 N. Fort Myers Drive, Arlington, VA 22209, USA), NFPA (National Fire Protection Association, Battery March Park, Quincy, MA 02269, USA), and MIL-1-24244 A (the United States Department of Defense Military Standards, United States Government Printing Office, Washington, D.C. 20402, USA). Flame spread, smoke developed, and fuel contributed index values indicated for the specified materials shall be determined in accordance with ASTM's (American Society of Testing & Materials, 1916 Race Street, Philadelphia, PA 19013, USA) Standard E84 Surface Burning Characteristics of Building Materials.

D. SUBMITTALS

The contractor shall provide shop drawings, manufacturer's data including certified ratings by an independent laboratory, and samples as specified to the architect/engineer for review and approval.

E. PRODUCT DELIVERY, STORAGE, AND HANDLING

Every package or standard container of insulation, adhesive, and coating delivered to the job site must have the manufacturer's label attached stating his name and the brand name.

MATERIALS/PRODUCTS

A. INSULATION

The temperature rating of insulation must always exceed the pipe surface temperature. The following are material and thickness requirements:

Insulation for Cold Lines

Insulation shall be preformed with a vapor barrier jacket or foamed-in-place urethane. Foam cell urethane insulation, jacketed or unjacketed, shall be fire-resistant and have a flame spread rating of 25 or less. Prefoamed jacketed insulations shall also be UL (Underwriters Laboratories, 333 Pfingsten Road, Northbrook, IL 60062, USA) listed.

The following are specific material and thickness requirements for urethane foam:

Temperature Range (° C)	Pipe Diameter (Inches)	Thickness (cm.)
Where required indoors to prevent sweating of fresh water, potable water, and condensate drains from air-conditioning piping.	1/2 to 6	2.5
Other systems such as chilled water, condensate drain piping from freezers, etc.		
7° C and over	1/2 to 4	2.5
	5 to 18	3.8
2° C to 7° C	1/2 to 1	2.5
	1 1/4 to 18	3.8
-9° C to 2° C	1/2 to 4	3.8
	5 to 18	5.1
-17° C to -10° C	1/2 to 2 1/2	3.8
	3 to 12	5.1
-26° C to -18° C	1/2	3.8
	3/4 to 3	5.1
	4 to 12	6.4
-40° C to -27° C	1/2	3.8
	3/4 to 2 1/2	5.1
	3 to 8	6.4

Preformed urethane insulation shall be supplied by Armstrong World Industry, Inc. (Gables One Tower Building, 1320 South Dixie Hwy., Coral Gables, FL 33146, USA), Owens Corning Corporation (2215 Saunders Road, Northbrook, IL 60062, USA), the Manville Corporation (P.O. BoX 5108, Denver, CO 80217, USA), or approved equal.

Foamed-in-place urethane shall be Expando-Foam R 110/ R 223, Insta-Foam Froth-Pak kit as manufactured by the Stephan Chemical Company (22 Frontage Road, Northfield, IL 60093, USA), or approved equal.

Foam plastic sheeting, preformed unslit tubing, and tape insulation 13 mm. thick shall be Armaflex as manufactured by Armstrong World Industry, Inc., and may be substituted for 2.5 cm. prefoamed or foamed-in-place urethane.

Insulation for Hot Lines

Glass fiber insulation, where specified, shall be UL rated, noncombustible sectional pipe insulation of heavy density 64 kg/cm^3 glass fiber with a pre-sized, fire resistant jacket having a rating not to exceed 25 flame spread and 50 smoke developed. Insulation that will be in contact with stainless steel must have a low chloride content complying with MIL-I-24244A.

Urethane, where specified, shall be fire-resistant, UL rated preformed urethane foam pipe insulation with a vapor barrier jacket.

The following are specific material and thickness requirements:

Temperature Range (° C)	Pipe Diameter (Inches)	Material	Thickness (cm.)
94° C and below	1/2 to 2	Glass fiber	2.5
(Interior only)	2 1/2 and over	Glass fiber	3.8

94° C and below	1/2 to 4	Urethane	2.5
(Exterior only)	5 and over	Urethane	3.8

B. ADHESIVES, SEALANTS, AND MASTICS

Use manufacturer's recommended adhesives, sealants, and mastics only.

C. PROTECTIVE JACKETS

Provide aluminum jacketing for all insulated exterior piping and indoor piping where shown on the drawings, unless otherwise specified.

Aluminum Jacketing

The material shall be 0.4 mm. thick, smooth, Type 3003 aluminum with manufacturer's strapping as manufactured by the Childers Product Company (3555 Curtis Blvd., East Lake, OH 44094, USA), or approved equal.

Stainless Steel Jacketing

The material shall be 0.4 mm. thick, smooth, Type 304 stainless steel with manufacturer's strapping as manufactured by the Childers Product Company,.or approved equal.

EXECUTION

A. JOB CONDITIONS

Do not apply any insulation to pipe work until it has been leaked tested and the test results have been accepted by the owner's representative.

B. INSTALLATION

All products shall be installed in accordance with the manufacturer's instructions. Specified adhesives, mastics, and coatings shall be applied at the manufacturer's recommended coverage per liter. Exercise caution in the storage and application of flammable adhesives.

Clean all pipe work of oil, grease, loose dirt, and other foreign matter before the insulation is applied. All surfaces must be dry before and during application of all insulation components. Comply with the manufacturer's installation instructions. The surfaces of the insulation covering shall be smooth, even, and substantially flush with adjacent pipe covering.

Do **not** apply insulation over pipe plugs, traps, strainers, blind nipples, nameplates, inspection stamps, or identification tags without the owner's representative's prior written approval.

Installation of Pipe Insulation

In general, interior piping should be installed with clevis type hangers, and insulation shall be fitted tightly around the pipe and hangers. Hangers for exterior piping generally will fit on the outside of the insulation's protective jacketing.

For pipe 2 inches in diameter and smaller, the bottom clevis strap shall be closely fitted to distribute the load uniformly. On pipes larger than 2 inches in diameter using clevis hangers, and on all piping supported by trapeze hangers, No. 12 gauge (2.8 mm.) curved metal shields or protection saddles shall be used between the hanger and the insulation or jacketing. The length of these shields shall be 3 times the nominal pipe diameter but not less than 25 cm. or more than 45 cm. Insulation shall be fitted up to and inside of saddles.

Butt adjoining insulation sections firmly together and seal the longitudinal lap with an approved white vapor barrier lap adhesive. Seal end joints with factory furnished 7.6 cm. vapor barrier strips applied with the above white vapor barrier lap adhesive. Where the insulation ends, bevel the insulation and seal the vapor barrier to the pipe.

Plastic foam insulation shall have all seams and joints sealed with Armstrong 520 adhesive or approved equal. At hanger locations of either the clevis or trapeze type, use rigid type insulation together with metal shields as specified above.

Outdoor hangers shall have shields between clevis or trapeze hangers and metal jacketing.

Insulation of Fittings, Valves, and Flanges for Temperatures of 2° C and Above

Insulate **cold** valves and fittings (except unions) 3 inches in diameter and smaller by wrapping with a glass

fiber blanket with vapor barrier to a thickness equal to the adjoining pipe insulation. Secure the blanket with jute twine as needed, and wrap with vapor barrier tape as necessary to form a complete vapor barrier. Apply a 6 mm. layer of a combination insulating and finishing mastic over the insulation.

Insulate **hot** valves and fittings with an insulation finishing cement, applied to a smooth flush finish with the adjoining pipe covering (K value less than 0.87 at 93° C).

Insulate all fittings 4 inches in diameter and larger with commercially available molded fitting covers or with nested and/or mitered sectional pipe covering of the same material and thickness as the adjacent pipe insulation. Valves 4 inches in diameter and larger shall have the bodies up to the bonnets insulated with nesting (i.e., independently installed sectional insulation) pipe insulation of the appropriate size and of the same material and thickness as the adjacent pipe insulation. Flanges shall be insulated with nesting pipe insulation as indicated for valves 4 inches in diameter and larger. The flange insulation shall extend not less than 5 cm. over the adjacent pipe insulation on each side of the flange. Insulation on pipes is to be stopped short of flanges to permit removal of flange bolts. Apply the flange nesting insulation in such a manner that it may be removed without damage to the adjacent pipe insulation. Cover unions with nesting pipe insulation as specified for flanges for **cold** piping and leave the flanges exposed and uninsulated for **hot** piping.

Wherever a nesting size sectional covering is used, cut it to fit in a neat workmanlike manner with all joints butted and held securely in place with jute or glass fiber twine. Point up the joints with an approved insulating cement prior to installing the surface finish.

Finish all interior insulated fittings, valves, etc., with canvas by dipping the canvas in approved lagging adhesive diluted with one part of water to five parts of lagging adhesive. Squeeze out any excess adhesive and immediately set the saturated lagging fabric in place, smoothing and lapping all fabric seams at least 7.5 cm. Immediately apply a uniform coat of lagging adhesive over the entire surface at the rate of 3 m^2 per liter.

The surface finish of exterior insulated fittings, valves, etc., shall consist of a tack coat of asphaltic mastic vapor barrier applied over the insulation cement to a thickness of not less than 1.5 mm. wet film. Into this wet coat, embed a single layer of fiberglas lagging tape of knit construction. Draw it smooth and tight. Apply a final coat of aluminum gray asphaltic mastic to an additional thickness of 1.5 mm. The mastic and reinforcing membrane shall overlap the weatherproof jacket of adjacent pipe covering by at least 7.5 cm. The junction between the insulation and the valve bonnet must also be adequately sealed.

Aluminum jacketing shall be installed with 5 cm. circumferential and longitudinal laps, with the longitudinal laps turned down to shed water. Secure the jacketing with self sealing pop rivets or manufacturer's strapping. Remove all burrs and sharp edges from the metal jacketing around valves and other manually operated devices to avoid injuring the operator.

Stainless steel jacketing shall be installed in the same manner as aluminum jacketing.

PIPING SUPPORTS AND HANGERS

GENERAL

A. SCOPE

This specification covers materials and techniques to be used in the design, selection, fabrication, and installation of pipe supports and hangers for suspended piping.

B. RELATED WORK SPECIFIED ELSEWHERE

M-02 Central System Coils
M-04 Vibration Isolation
M-10 Refrigeration Equipment
M-11 Pumps
M-12 Pipe and Pipe Fittings
M-13 Pipe Insulation
M-15 Cleaning and Testing Water Piping Systems

C. CODES AND STANDARDS

Pipe hangers and supports shall be designed, fabricated, and installed in conformance with local codes and the applicable standards of ASHRAE (American Society of Heating, Refrigeration, and Air Conditioning Engineers, 1791 Tullie Circle, N.E., Atlanta, GA 30329, USA), ACRI (Air Conditioning and Refrigeration Institute, 1815 N. Fort Myers Drive, Arlington, VA 22209, USA), and MSS Standard Practice-69 (Manufacturers Standardization Society of the Valve and Fittings Industry, Inc., 127 Park Street, N.E., Vienna, VA 22180, USA), Pipe Hangers and Supports - Selection and Application. An excellent source of additional information on pipe hangers is the Piping Handbook (McGraw Hill, Inc., 1221 Avenue of the Americas, New York, NY 10020, USA).

D. SUBMITTALS

The contractor shall submit to the architect/engineer shop drawings and materials lists for all specially designed hanger assemblies and manufacturer's data sheets for all other hanger and support components to be used for review and approval.

MATERIALS/PRODUCTS

It is anticipated that the contractor will fabricate some of the specified types of supports and hanger assemblies based on approved shop drawings and purchase others as specified in the contract drawings. The hanger and support type numbers cited below correspond to the various styles of devices described in MSS SP-69.

A. INSERTS AND ANCHORS

This section includes devices for supporting piping and pipe hanging assemblies from ceiling and roof slabs, concrete walls, girders, beams, columns, and other building masonry. Piping supported from the floor is excluded.

Where the support rod size exceeds $^{7}/_{8}$ inch diameter or where the load exceeds the recommended load for

the insert or anchor, use two inserts or anchors with a trapeze-type connecting member below. Use Type 18 inserts where installation can be made before the concrete is placed. Where installation is made after the concrete is in place, use Phillips **Red Head** expansion anchors (Phillips Red Head Anchors, P.O. Box 364, Michigan City, IN 46360, USA), Rawl Studs and Rawl Self-drilling Anchors (The Rawl Plug Company, 200 Petersville Road, New Rochelle, NY 10802, USA), or approved equal. Plastic, lead, or fiber screw anchors; lag screws; and expansion shields are **not** acceptable for this application.

Where continuous inserts are required, they shall be formed from not less than 12 gauge (2.8 mm.) galvanized steel with anchors spaced on not less than 15 cm. centers, and with end caps, splice plates, bolts, and nuts as required by conditions. In rooms with defined environmental control requirements, more sanitary provisions must be made as called for on the drawings or elsewhere in the specifications.

B. FLOOR ANCHORS

Use cast-in-place anchors of heavy structural steel or cast iron where possible in new construction. For installation in existing concrete, use Phillips **Red Head** expansion anchors, Rawl Self-drilling Anchors, Rawl Lok/Bolts, or approved equal.

C. HANGER RODS

Hanger rods shall be hot rolled steel with cut coarse threads. Where the rod sizes are listed in a manufacturer's catalogue for a type of fitting, that size shall govern. Where rod sizes are not listed, the rod size shall conform to the following table. The quantity shall be based on the spacing criteria shown in the EXECUTION section B of this specification.

Pipe Diameter (Inches)	**Rod Diameter (Inches)**
2 and smaller	$^3/_8$
$2^1/_2$ to $3^1/_2$	$^1/_2$
4 and 5	$^5/_8$
6	$^3/_4$
8 to 12	$^7/_8$
14 to 18	1

D. HANGERS AND SUPPORTS

Hangers and supports shall be specified by the engineers in order to be appropriate for the service and load. Hangers and supports that are in direct contact with copper shall be copper-plated or plastic-coated to prevent any electrolytic reaction.

The types of steel hangers and steel or malleable iron supports and accessories illustrated in Figure M-14-1 are generally appropriate for the classes of service noted:

Ambient Conditions (16° C to 49° C)

- Bare Horizontal Pipe Attachments
  Types 1, 3-7, 9-12, 24, 26, 35-38, 41, 43-46.
- Insulated Horizontal Pipe Attachments
  Types 3, 24, 26, 35, 39, 40; 1, 5, 7, 9 and 10 with saddles or shields; and 41, 43-46 with saddles.
- Bare or Insulated Vertical Pipe Attachments
  Types 8 and 42.
- Hanger Rod Fixtures
  Types 13-17.
- Building Structure Attachments
  Types 18-23, 25, 27-34, 57, 58.

Cold Conditions (1° C to 15° C)

- Bare Horizontal Pipe Attachments
  Types 1, 3-7, 9-12, 24, 26, 36-38, 41, 43-46.
- Insulated Horizontal Pipe Attachments
  Types 3 and 40; 1, 5, 7, 9, 10, 36-38, 41, 43-46 with shields.

- Bare or Insulated Vertical Pipe Attachments
  Types 8 and 42.
- Hanger Rod Fixtures
  Types 13-17.
- Building Structure Attachments
  Types 18-23, 25, 27-34, 57, 58.
  Figure M-14-1

Insulated with Thermal Movement (49° C to 232° C)

Applies where thermal movement will cause the hanger rod to deviate more than 53 from the vertical, or where longitudinal expansion causes a movement of more than 13 mm. in the piping supported from below.

Pipe protection saddles Type 40 welded to the pipe; tube protection shields Type 41; hangers (inside use only) Types 41 and 43; supports (inside use only) Types 44 to 46; and pipe slide assembly (inside and outside use) carbon steel tee with stainless steel slide plate, or carbon steel base with filled Teflon pad.

Horizontal pipe supports generally shall be installed on trapeze hangers consisting of substantial iron angle or channel construction with suspended adjustable steel threaded rods and nuts. Installations in environmentally controlled areas may require special provisions as described on the drawings.

Pipe hanger assemblies for cast iron pipe shall be the same as steel pipe at ambient temperatures with size in accordance with the outside diameter of the pipe.

Pipe hanger assemblies for automatic sprinkler piping systems shall be UL (Underwriters Laboratories, 333 Pfingsten Road, Northbrook, IL 60062, USA) listed; not fabricated locally based on shop drawings; and as manufactured by the Grinnell Fire Protection Systems Company (3 Tyco Park, Exeter, NH 03833, USA), The Viking Corporation (210 N. Industrial Park Road, Hastings, MI 49058, USA), or approved equal.

Spring supports for light to medium loads and 6 mm. maximum vertical movement should be Types 48 and 51 spring cushions. For a wider range of loads (from 25 kg. to 13,000 kg.) with large thermal movements, and where variations to ± 25 percent in support load can be tolerated, use Types 51 to 53 variable support hangers. Use Types 54 to 56 constant support hangers for similar loads where there are large thermal movements and where support variability cannot exceed ± 6 percent.

For all plastic pipe supports, verify requirements with the pipe manufacturer. Generally, rigid plastic pipe requires intermittent supports at closer intervals than steel pipe, and flexible plastic pipe requires continuous support along its entire length.

EXECUTION

A. DESIGN CONSIDERATIONS

The capacity of structural members (columns, roof joists, etc.) that will be used to support a piping system must be designed to provide support for current and potential future piping additions. A 6 inch diameter steel pipe filled with water weighs approximately 40 kg/m. A bank of such pipelines could easily overload light-duty structures. When lines are being added to an existing pipe rack, it is also very easy to overload light-duty building structures with this kind of installation.

In addition to load considerations, the pipe support requirements for each piping system should be carefully designed to provide proper pitch, allowance for expansion and contraction, the ability to handle anticipated vibration, and potentially powerful seismic loads. Hangers and supports must be sized for all loads including not only the expected pipe, fitting, and valve loads but also insulation, special connections, suspended equipment such as filters, pipe contents, and anything else not supported independently. For lines that normally do not contain liquids (e.g. compressed air, steam), the hangers must be sized to include the water used in hydrostatic testing. If spring hangers are used, additional supports will generally be required during the hydrostatic tests.

Locate pipes whenever possible so that hangers can be attached to the building structure without requiring extra supporting steel. Leave sufficient room between pipe runs for installation of supports, fittings, insulation, etc.

The recommended maximum spans between hangers in this specification are based on 2.5 mm. deflection of straight steel water-filled pipes. Additional hangers must be provided for valves, fittings, etc., and also where the pipe changes direction. Hanger locations for other pipe materials and contents should be determined based on the different deflection requirements and the total allowable pipe stress.

Simple rod hangers can be used when little or no movement of the piping is expected, since they can tolerate angular displacement up to about 4°. Use of longer rods will permit greater movement.

A pipe roll or slide plate should be installed when greater horizontal movement is anticipated. Pipe rolls should be used only inside of buildings because exposure to outside weather will rapidly degrade the roller assembly. Slide plates are suitable for installation either inside or outside.

A bank of pipes may be supported on single trapeze-type hangers or in tiers. For this to be practical, the pipes must be either uninsulated or covered with rigid insulation and fitted with saddles so that their weight rests directly on the crosspieces of the supports. Pipes run in this fashion must be spaced far enough apart to permit maintenance, painting, etc. This spacing must be maintained by restraining each pipe with clamps or clips, as required, to guide the pipe and to prevent lateral movement. The choice of anchoring methods must also take into account seismic and thermal effects, if any.

Horizontal piping that is subject to vertical movement must be properly supported with spring cushions, variable springs, or constant support units. Constant support units are typically used only where the movement is great or where there are critical support requirements. For example, piping connected to equipment that could be damaged by distortion or misalignment such as pumps, chillers, compressors, etc., must be supported in such a manner that no undue forces are transmitted to the equipment. This could dictate independent supports, flexible connections, and/or constant support units.

In the consideration of thermal expansion and contraction, careful attention must be given to anchoring points so that the direction of thermal expansion, thermal contraction, and seismic movements are controlled. Excessive anchoring produces too tight a confinement of the pipe with resultant high stresses and possible failure. Expansion joints should not be used unless they are absolutely necessary. Normally, expansion should be taken care of by loops or piping offsets. Where expansion joints are installed, they must be properly guided according to the manufacturer's recommendations.

The weight of the riser can be supported at the top and/or bottom for short lengths and/or small diameters. The architect/engineer should design and locate the anchors and guides required for larger sizes or longer lengths. When thermal expansion will cause vertical pipe movement, the pipe may have to be supported by springs.

When pipe supports are exterior mounted or on an exterior building surface and are subject to atmospheric corrosion, measures should be taken to prevent deterioration of the support and rust staining the structure. Typical solutions include thoroughly coating all support surfaces, including those that are inaccessible after installation, use of corrosion-resistant material for the supports and their hardware, or installation of a corrosion-resistant flashing with a drip lip behind the support to direct water away from the side of the building.

B. INSTALLATION

The contractor shall furnish and install all structural supports, anchors, and hangers required for the suspension and placement of the piping required. Pipe hangers and supports shall be installed to allow for expansion and contraction and shall be placed close to the fittings, valves, and heavy equipment. Hangers and supports shall be installed so that the piping will be free from vibration, sagging, or movement other than that caused by thermal expansion or contraction. Piping shall be pitched as specified and shown on the drawings.

There shall be no cutting, drilling, or welding on the building structure except as shown on the drawings or as instructed by the owner's representative. Piping shall be supported directly from the building structure and not from the equipment or supporting systems of other trades. Pipe may be supported by trapeze hangers and/or in tiers. Sufficient clearance for installation of fittings, insulation, etc., and for future rearrangement work or maintenance shall be provided.

Maximum spans between hangers for straight horizontal runs of steel pipe shall be as follows:

Nominal Pipe Diameter (Inches)	Maximum Span (Meters)	Nominal Pipe Diameter (Inches)	Maximum Span (Meters)
1/2	2.10	3 1/2	4.00
1	2.10	4	4.30
1 1/2	2.70	5	4.90
2	3.00	6	5.20
2 1/2	3.40	8	5.80
3	3.70	10	6.10

Additional hangers shall be provided where concentrated weights such as valves or heavy fittings occur and where changes in direction of the piping system occur between hangers. Cast iron pipe shall be supported at every joint and at not more than 1.52 m. intervals on straight sections.

Hanger rods shall be connected to beam clamps, concrete inserts, or expansion anchors. C-clamps and/or offset suspension by hangers are not allowed. Hanger rods shall be installed with double nut arrangements both at the lower end where the hanger is attached and at the top where it fastens to the clamp or insert. Inserts shall be provided as specified. When through-bolts are used, plates or large washers shall be provided under the insert.

Vertical pipes shall be installed as shown on the drawings.

Piping-related equipment (viz., meters, filters) shall be located as shown on drawings. All such equipment that must be secured to concrete walls, ceiling or roof slabs, columns, other building masonry, and floors shall be attached by means of approved hangers and supports as listed in this specification.

References:

Portions of this guideline specification were extracted from MSS SP-69, 1983, with permission of the publisher, the Manufacturers Standardization Society.

CLEANING/TESTING PIPING SYSTEMS

GENERAL

A. SCOPE

This specification covers the materials and techniques to be used in testing, purging, flushing, cleaning, and disinfecting installed piping systems for fresh water (i.e., city or well water), cold and hot potable water, chilled and hot water supply and return systems, and oil-free compressed air systems, as applicable. Variations to the procedures below because of site conditions, and when authorized in writing by the owner's representative, are permitted. This specification excludes testing, purging, and cleaning of instrumentation and control oil-free compressed air systems.

B. RELATED WORK SPECIFIED ELSEWHERE

A-19 Plumbing Fixtures and Trim
F-03 Fire Main Pipe Systems
M-02 Central Systems Coils
M-10 Refrigeration Equipment
M-11 Pumps
M-12 Pipe and Pipe Fittings
M-13 Pipe Insulation
M-14 Piping Supports and Hangers
M-16 Balancing Air, Chilled, and Hot Water Systems

C. CODES AND STANDARDS

Cleaning and testing methods shall conform with local requirements and as specified herein including the applicable standards of the AWWA's (American Water Works Association, 666 West Quincy Avenue, Denver, CO 80235, USA) Standard for Disinfecting Water Mains.

D. SUBMITTALS

The contractor shall present a detailed schedule for testing, cleaning, and disinfecting each system, as applicable, to the owner's representative for review and approval. No system shall be tested, cleaned, or disinfected until written authorization is provided by the owner's representative. Field test results shall be submitted for acceptance by the owner's representative.

E. ACCEPTANCE TESTS

Field tests shall be made in the presence of the owner's representative as specified and the results recorded.

MATERIALS/PRODUCTS

The contractor shall provide all the materials and equipment required for testing, cleaning, and disinfecting the systems specified herein.

EXECUTION

A. JOB CONDITIONS

No work shall be tested, cleaned, or disinfected until written authorization to do so is provided by the owner's representative. The contractor for each system shall exert maximum effort to keep piping systems clean as they are being installed. The amount of dirt, foreign objects, etc., in the installed piping systems will to a significant degree determine the relative ease, or difficulty, the contractor may have in complying with testing, cleaning, and disinfecting specifications. Piping shall be tested and cleaned after erection and before installation of insulation or painting of pipe. Verify that compressed air piping has been installed with a 6 percent slope to low points in the system, venting devices at high points, and drain valves at low points and ahead of risers so that they can be drained or blown free of water after testing, purging, and cleaning.

B. TESTING, CLEANING, AND DISINFECTING

Generally, piping systems will be treated as follows:

	Fresh Water	Potable Hot and Cold Water	Recirculating Hot Water	Recirculating Chilled Water	Compressed Air Oil-Free
Hydrostatic test	X	X	X	X	X
Flushed	X	X	X	X	
Purged					X
Detergent cleaned					X
Disinfected	X	X			

Hydrostatic Testing

All pressure piping systems covered by this specification shall be hydrostatically tested with water at a temperature below 38° C. Equipment, instruments, etc., such as pressure gauges, tanks, pumps, coils, compressors, chillers, boilers, etc., shall be isolated or removed prior to testing the piping system to avoid damaging them. Relief valves shall be removed or isolated. Orifice plates shall not be installed until after testing is completed.

Lines containing check valves shall have the source of test pressure on the upstream side of the check valve. Control valves shall be set in a fully open position during the test period. Lines supported by springs shall be blocked up temporarily as needed to sustain the liquid load during hydrostatic testing and flushing.

The test pressure shall be 1.5 times the maximum working pressure. Vent all air from the system. The test pressure shall be held for a minimum of 3 hours. All joints shall be inspected. There shall be no noticeable loss of pressure nor visible leaks.

Water System Flushing

The procedure below generally describes the methods to be used in flushing fresh, potable, and recirculating chilled and hot water systems. Normally, sufficient connections must be opened to assure a velocity of 128 m./sec. to 183 m./sec. in each part of the system.

Fresh and Potable Water System Flushing

If a back flow preventer is installed, install a temporary strainer ahead of it, or install a temporary spool piece in place of it during the flushing operation. Remove screens from all in-line strainers except those at the pumps' suction. Provide hoses from hydrants, valves, and faucets to a suitable drainage point as approved by the owner's representative.

Open all control valves to a fully open position. Open all faucets, valves and/or hydrants connected to each branch supply header to a fully open position to obtain maximum flow for flushing header. Flush until clear flow is obtained from each outlet. The owner's representative shall have sole responsibility for determining that maximum flow is reached and when clear flow is achieved. The contractor shall make all necessary corrections to attain flow and clarity conditions. If any faucet, valve, or hydrant is not flowing full, determine the cause and make the necessary corrections.

Close all faucets, valves, and hydrants. Open each of the above outlets independently to a fully open position to

obtain maximum flow in the supply pipe to each point of use. Flush as required to obtain a flow of clear water.

When flushing has been completed to the satisfaction of the owner's representative, replace the screens in the strainers and backflow preventer. Place the system into operating condition.

All potable water piping shall be disinfected after flushing.

Recirculating Hot and Chilled Water System Flushing

Provide temporary piping or hoses from the fresh water main, or some other source of clean water that has been approved by the owner's representative, to the outlet piping from the chiller and the boiler. Where pressure is less than 2.9 kg/cm^2, connect the line to the circulating pumps' suction and provide a temporary bypass around the chiller and boiler. Use the pump as a booster. The size of the temporary pipe or hose shall be not less than one pipe diameter smaller than the largest branch header in the system or of the main header if there are no branch headers.

Provide temporary bypass lines with ball or butterfly valves from the end of each branch supply header to the corresponding branch return header. Temporary connections shall be the same pipe diameter as the branch headers. Provide temporary piping or hoses from the return line near the circulating pump to a drainage point approved by the owner's representative.

Remove screens from all in-line strainers except those at the pumps' suction.

Open all control valves to a fully open position. Close all isolation valves to coils and other equipment.

Open each of the temporary bypass valves at the end of each branch header, one at a time. Flush the branch header as required to obtain a maximum clear flow of water. Close the bypass valves after flushing each branch header. Repeat the process until all branch headers are flushed.

Close all temporary bypass valves at the ends of all branch headers, and, one at a time, open the valves to each coil or other equipment to be flushed. Flush each individual item until a maximum clear flow of water is obtained.

Repeat flushing of the branch headers as described above after all coils and equipment have been flushed.

Open all of the above bypass valves to obtain maximum flow in the main header, and flush until a clear maximum flow of water is obtained.

If, during the flushing, there is any indication that any part of the system is not flowing full, the contractor shall determine the cause and make the necessary corrections.

When flushing has been completed to the satisfaction of the owner's representative, replace the screens in the strainers and place system into operating condition.

After the system has been in operation for a week, the contractor shall remove and clean all strainers in the new piping.

For an addition to an existing piping system, the contractor shall completely flush the new piping prior to connecting to the existing system. The procedure shall be similar to the above, except temporary flush water supply and drain lines shall be made to the supply and return headers at the point of connection to the existing system.

Disinfection of City and Potable Water Systems

The disinfecting agent shall be sodium hypochlorite solution (commercially available bleach), calcium hypochlorite granules or tablets, or chlorine gas. The agent of choice for a particular job depends on the configuration of the system to be treated, the convenience, and the safety factors involved. Careful calculation of the chlorine concentration must be made. The disinfecting procedure must assure that adequate chlorine reaches all points of the system. The disinfecting agent and procedure shall be as indicated by the owner's representative.

The contractor shall provide nipples, valves, and equipment as required to introduce the disinfectant solution or disinfectant and water, to vent air, and to drain the solution, whether or not these items are shown on the drawings. To disinfect long isolated runs of pipe, a nipple and valve, normally $^3/_4$ inch diameter, are installed just after the main shut-off valve, plus a nipple and valve at the downstream end of the run. On

horizontal runs, these valves and nipples should be situated at either the top or the bottom of the pipe and arranged so that the total configuration provides for introducing the disinfectant solution or disinfectant (viz. chlorine gas) and adding water, venting air, and draining the solution.

After flushing the system as specified above, fill the system **uniformly** with a disinfectant solution containing 100 ppm available (free) chlorine. Vent high points to remove air. The disinfectant solution shall be retained in the entire system no less than 24 hours. As an alternative, a solution containing 300 ppm available (free) chlorine held for 3 hours is also acceptable.

After the holding period, a test for free residual chlorine shall be made at each point of use. If none is found, the system shall be drained and the disinfection procedure repeated. When a system free residual chlorine level of at least 50 ppm is present at the end of the holding period, the system can be considered disinfected.

The system and all points of use shall be flushed with potable water until all the residual chlorine levels at all waste flush water discharge points are the same as that of the incoming fresh water. The system shall then be placed into operation.

Purging Oil-free Compressed Air Systems

Close the valve to the main supply header at the compressed air source and all valves in the small branch lines supplying air to equipment or to using areas. Remove the cap or flange at the end of main supply header. (Be sure the header is completely relieved of pressure before removing the cap.) Install temporary piping at the end of the header as required to direct the air discharge so that it will not injure personnel or damage property. Open the valve in the supply header near the compressed air source to blow dirt and debris from the main header.

Replace the cap. Repeat the above procedure for each of the larger branch headers throughout the system.

When purging has been completed to the satisfaction of the owner's representative, a special detergent solution shall be prepared for cleaning the lines.

Detergent Cleaning of Oil-free Compressed Air Systems

Prepare a sufficient quantity of detergent solution containing Alconox 0.2 percent and sodium dihydrogen phosphate 0.005 percent in 65° C potable water. (Alconox is a mildly alkaline anionic detergent in solid powder form with interspersed flakes composed of alkyl aryl sulphonates and lauryl alcohol sulfate wetting agents and carbonate and phosphate sequestering and synergistic agents. It is manufactured by Alconox, Inc. (215 Park Avenue, New York, NY 10003, USA).

Prepare the piping system for either recirculation or flushing using temporary piping, hoses, and a pump. Recirculate the detergent solution through the piping for at least 2 hours. Vent the system at high points to remove trapped air.

If recirculation is not feasible, flush the system for 2 hours with a continuous stream of the detergent solution. A third alternative is to fill the piping system with detergent solution, maintain the solution in the system for 15 minutes of contact time, drain the solution to the sewer, and repeat the procedure 7 additional times.

Drain the detergent solution to the sewer. Flush the piping system with potable water directly to the sewer for one hour. Flushing shall include the vent and drain valves. Terminate flushing and retain the water in the system for one hour. Flush again for 15 minutes with potable water. Drain the system at all discharge points.

Blow the system for a 24 hour period to completely dry it with dry oil-free compressed air or compressed nitrogen gas. Bleed all points of use frequently. When the detergent cleaning, flushing, draining, and drying is completed to the owner's representative's satisfaction, shut all valves and place the system into operation.

BALANCING AIR AND WATER SYSTEMS

GENERAL

A. SCOPE

This specification covers the work and techniques to be used in field testing, balancing, and adjusting all environmental control air and recirculating hot and chilled water systems and devices as indicated on the drawings and in the specifications. This work shall be performed by an independent test and balance contractor (TBC) under the direct supervision of a qualified heating and ventilating engineer approved by the owner. All instruments used shall be in good working order and have been recently calibrated. Calibration dates, methods, and the party performing the calibration work shall be furnished to the owner's representatives upon request.

B. RELATED WORK SPECIFIED ELSEWHERE

M-01 Air Handling Units
M-02 Central System Coils
M-03 Fans and Fan Drives
M-04 Vibration Isolation
M-05 Air Filters
M-06 Air Filter Gauges
M-07 Duct Work
M-08 Duct Insulation
M-09 Controls and Instrumentation
M-10 Refrigeration Equipment
M-11 Pumps
M-12 Pipe and Pipe Fittings
M-13 Pipe Insulation
M-15 Cleaning and Testing Water Piping Systems
M-17 Room Differential Pressure Measurement
M-18 Piping Identification

C. CODES AND STANDARDS

Testing, balancing, and adjusting shall be performed in conformance with the applicable standards of AMCA (Air Movement and Control Association, 30 W. University Dr., Arlington Heights, IL 60004, USA), ASHRAE (American Society of Heating, Refrigeration, and Air Conditioning Engineers, 1791 Tullie Circle, N.E., Atlanta, GA 30329, USA), ACRI (Air Conditioning and Refrigeration Institute, 1815 N. Fort Myers Drive, Arlington, VA 22209, USA), and SMACNA (Sheet Metal & Air Conditioning Contractors National Association, Inc., 1611 N. Kent Street, Arlington, VA 22209, USA).

The installed systems shall meet the design values and systems test conditions specified.

D. SUBMITTALS

The architect/engineer shall furnish the TBC flow diagrams indicating test parameters, design values and the system test conditions required and forms for recording and reporting results of the TBC's work. The TBC

shall be responsible for obtaining all information to fill the blanks left on the form for the testing results. Compiling the test data and the formats for these reports shall be similar to the sample forms enclosed with this specification (architect/engineer to provide proforma forms) and shall include the following:

- Duct traverse data sheet
- Circulating water pump data sheet
- Water balance data sheet
- Diffuser and grille data sheet
- Air moving equipment data sheet
- Exhaust fan data sheet
- Air system and hydronic system schematic diagrams for each system installed
- Legend of symbols and abbreviations used in the schematic diagrams
- Permissible high and low pressure operating limits for each filter installation

The TBC shall include an extended warranty of 90 days after completion of test and balance work and submission of his final report, during which time the owner's representative, at his discretion, may request a recheck or resetting of any outlet, supply air fan, exhaust fan, control valves, or balance valves to adjust flows as required to meet design conditions. The TBC shall provide technicians to assist him in making all tests he may require during this period.

E. ACCEPTANCE TESTS

All installations covered by this specification shall be field tested. All tests shall be conducted in the presence of the architect/engineer and the owner's representative.

MATERIALS/PRODUCTS

The TBC shall furnish all test equipment and miscellaneous materials required.

EXECUTION

A. SCOPE OF WORK

The work shall consist of testing, balancing, and adjusting all air and water systems and components called for in the drawings and/or in the other contract documents. This shall be accomplished by:

- obtaining the required air quantities at the various specified operating conditions of the system to demonstrate compliance with the design, which will require simulation of maximum pressure drops due to dirty filters and wet cooling coils, and, in the case of variable air volume systems, variation of air volume through the range from minimum to maximum
- obtaining the hot and/or chilled water quantities required by the various components, equipment, and devices and the operating conditions specified
- compiling and reporting the results as specified herein.

The TBC and the owner's representative shall meet at least 2 weeks prior to the anticipated start of testing and balancing to develop final procedures and to assure a complete understanding of the methods to be used.

B. JOB CONDITIONS

Testing and balancing shall not begin until the systems have been completed, leak tested, flushed, and are in full working order. The mechanical or heating/ventilating/air-conditioning contractor shall place all heating, ventilating, and air-conditioning equipment into full operation and shall continue the operation of same during each working day of testing and balancing.

C. AIR SYSTEM TESTING AND BALANCING

Air system balancing shall be completed and shall meet the design requirements before the water systems are tested and balanced. The TBC may vary the sequence of testing and balancing; however, the TBC shall be responsible for developing all of the information required for submittal and perform all work indicated in this section.

Preparation of Systems

Set all supply and return air duct dampers at the full open position (not required for self-powered automatic air volume control regulators). Use the factory setting as a starting point. Set all diffusers and side wall grilles

to a full open position. Set outside air dampers at the minimum position (not required for systems with automatic air volume regulators on the outside air supply). Set branch line splitter dampers, extractors, and distribution grids to full open positions.

In cooperation with the controls system contractor, set and adjust all the control dampers and automatic air control devices to achieve specified design performance conditions.

Determine that all air moving equipment is operating within design range.

Drill all probe holes 11.1 mm. in diameter for static pressure readings, Pitot tube traverse readings, and temperature readings. Indicate the test points on the duct drawing and identify the test point on the duct work. After completion of balancing, the holes shall be plugged with airtight hole plugs.

Check the supply of electrical power and the rated running amperage of all fan motors. Check fan and motor speeds, including the available adjustment range.

Balancing Procedure

Conduct all tests with supply, return, and exhaust systems operating, and all doors, windows, etc., closed or under planned actual operating conditions.

Make the first complete air distribution test throughout the entire system with simulated dirty air filters and wet coil resistances so that static pressure conditions shall be at their maximum. Balance the supply systems on full load for cooling. Determine the total volume of air required to flow across cooling and heating coils during maximum load conditions. Simulate dirty filter resistance by providing temporary resistance in the duct work. Obtain the total system air volumes and conditions for dirty filters by adjustment of the fan operating speed. Record the test statistics for submission.

Traverse the supply and return main and branch ducts using a Pitot tube. Proportion all air to the main branch runs using duct volume control devices.

Make a second complete air distribution test throughout the entire system to obtain data on the proper proportions of air. Adjust the fan's speeds to deliver the total specified air flow.

Set all main line dampers to deliver the proper air volumes to all areas using a Pitot tube traverse.

Set all branch line dampers to deliver the proper air volumes to the diffusers and side wall supply grilles in each zone using a Pitot tube traverse.

Read the air volume at each outlet and adjust the dampers to meet requirements.

Test and record all items as listed.

Repeat the above steps for clean filter conditions.

Permanently mark all damper positions after air balancing is complete.

Mark the permissible clean filter/dirty filter pressure operating limits on each filter gauge at each installation where there is an air filter.

Test These Items and Record Actual Conditions

- — Test and adjust each fan's RPMs to meet design requirements
- — Test and record each motor's full load amperage.
- — Make a Pitot tube traverse of the main supply ducts and record results.
- — Test and record coil face velocities.
- — Test and record system static pressures; i.e., filter "clean" and filter "dirty," cooling and heating coils, fan suction and discharge, CVRs, sound attenuators, air flow measuring stations, moisture eliminators, air blenders, etc.
- — Test and adjust the system for design recirculated air volume.
- — Test and adjust the system for design outside air volume.
- — Test and record dry bulb heating and cooling entering air temperatures.
- — Test and record wet bulb cooling entering air temperatures.
- — Test and record dry bulb heating and cooling leaving air temperatures.
- — Test and record wet bulb cooling leaving air temperatures.

- Adjust all main supply and return air ducts to the design air volume.
- Adjust all zones to the design volumes of supply and return air.
- Test and adjust each diffuser, grille, and register to within 10 percent of the design requirements for the system.
- Identify each grille, diffuser, and register's location and area (i.e., cm^2).
- Identify and list the size, type, and the manufacturer of diffusers, grilles, registers, and all tested equipment. Use the manufacturer's nameplate data.
- Test and record the values obtained in rooms requiring pressure or flow differentials between rooms.
- Report the required velocity and test velocity, and the required volume and test volume after adjustments of diffusers, grilles, and registers.
- Set the adjustments of automatically operated dampers to operate as specified, indicated, and/or noted in cooperation with the control manufacturer's representative. **The TBC shall check all controls for proper calibration and list all controls requiring adjustment by the control contractor's installers.**
- Adjust all diffusers, grilles, and registers to minimize drafts in all areas.

Methods of Measurement

Measure the air flow in duct work in the following manner with a Pitot tube and inclined gauge manometer. Make a complete traverse using the above instruments. Locate traverse points at least four equivalent duct diameters from the nearest transition, duct, or other obstruction. Where this is not possible, note the traverse point as not being within this tolerance.

Mark off the cross section of the duct into areas of equal proportions with maximum dimensions not exceeding 15 cm. on a side (225 cm^2 maximum). Insert the Pitot tube so as to be in the center of each area, and note the gauge reading for each. For readings of 700 ft./min. (213 m./min.) or below, a **micromanometer** ($^1/_4$ inch diameter gauge with .005 inch water column graduations) shall be used. (The inclined gauge manometer or magnehelic gauge are not accurate at this low velocity and are, therefore, unacceptable.) Make not less than 16 nor more than 64 readings. Read the static pressure and record the results at each traverse point.

Measure the air flow from diffusers with a deflecting vane anemometer. For each diffuser tested, mark the locations of test readings taken on the face or vane of the diffuser. Place the velocity meter inlet jet in the vena contracta of the face or vane of the diffuser. Take a minimum of 6 readings to determine the average velocity in feet per minute. Make all future readings, and check readings at the same marked locations on each diffuser.

Measure air flow from grilles and registers with either a 4 inch diameter rotating vane anemometer or deflecting vane anemometer. Obtain the average anemometer reading by marking off the grille in sections, taking a reading in front of each section and averaging the results. **Readings made by moving the instrument back and forth across the face of the grill or register are NOT acceptable!** Use the manufacturer's published correction factors to determine the total air volumes being discharged. Note that different factors must be used for supply grilles and return and exhaust grilles.

Measure the static pressure in duct work, plenum chambers, across filters, and across coils using an inclined gauge manometer in conjunction with a static pressure probe. **Insertion of the end of a tube or the use of suction cups is NOT acceptable.** Make measurements in areas considered to have a stabilized pressure. Two or more readings should be taken.

Measure motor amperage using an amprobe meter. Take readings on all three legs of three-phase motors. Whenever possible, take readings at the motor terminals. If the motor terminals are not readily accessible, take readings at the motor's starter or control point. Before any final reading is taken, set the fan driver or vanes in the final operating position. Do not take readings until the motor reaches a constant speed.

Measure fan air volumes by making a Pitot tube traverse to determine the total air volume. **Fan air volumes should NOT be determined by using published fan rating data.**

The sum of the individual diffuser volumes may be used to assure proper balancing for a given branch only where it is not feasible to obtain velocity pressure traverses in the branch ducts to determine branch line volumes. After all diffusers on a given branch duct have been balanced to deliver the volumes of air that are all

in a constant relation to the actual design value (be it above or below the optimum point), readjust the branch line dampers to increase or decrease the entire branch duct volume. Then, retest the individual diffusers to assure that they are now delivering the designed volume of air according to their individual requirements. Adjust the deflection pattern of all supply outlets to assure proper and uniform air distribution throughout the areas served by such outlets.

Measure coil face velocities with a 4 inch diameter rotating vane type anemometer. Attach a long narrow handle to the instrument to avoid blocking any air flow with parts of the body. **Readings made by moving the instrument back and forth across the face of the coil is NOT allowed.** Make individual spot readings at set intervals to establish averages. Take all final readings and make all final settings with the cooling coils operating (wet) so that static pressure conditions shall be at their maximum.

Outside and Return Air Quantities

Final balanced system conditions include the setting of outside air and return air volumes. Set the outside air volumes by adjusting the dampers using direct air flow readings obtained by a Pitot tube duct traverse, wherever possible, or by a 4 inch diameter rotating vane anemometer reading across the outside air intake louver. When conditions of the duct work or the installation would result in incorrect or erratic readings, use the temperature percentage method of calculation. If this method is used, the temperature measurement must be by duct traverse. Permanently mark all damper positions after air balancing is complete.

Differential Pressure Condition

The final balanced condition of the building includes the testing and adjustment of pressure conditions. In most cases the percentage of air introduced by a supply system and exhausted by an exhaust system will provide for pressurization. Check these percentages before final completion of the work to verify actual pressure conditions. Check doors, exits, shafts, etc., for air flow so that exterior conditions do not cause excessive or abnormal pressure conditions. Permanently mark all damper positions after air balancing is complete.

D. WATER SYSTEM TESTING AND BALANCING

Air systems balancing shall be completed and meet with design requirements before the water systems are balanced. The TBC may vary the sequence of testing and balancing; however, the TBC shall be responsible for developing all of the information required for submittal and perform all work indicated in this section.

The TBC will utilize instruments and devices such as one set of pressure gauges and fittings, a dry bulb thermometer, a wet bulb thermometer, a thermocouple unit and thermocouples, amprobe meter, a set of balancing valve and/or cock adjustment wrenches, and portable flowmeters.

Preparation of Systems

Open all valves to the fully open position, including coil isolation valves. Close all bypass valves, and open all line balancing valves or cocks. Remove and clean all strainers.

Examine the water in the system to verify that it is clean and that it has been treated.

Check the direction of rotation of all pumps. Check the expansion tanks to make sure they are not airbound and that the system is full of water. Check all air vents at high points of the water systems to make sure they are installed and are operating properly. Make certain that all air is removed from the circulating water systems.

Set all temperature controls so that all coils are calling for full cooling. This should cause all automatic bypass valves to close.

Set the system to call for full heating to balance hot water coils. Verify the proper operation of all automatic bypass valves.

Measure and set the operating temperatures of the heat exchangers and other devices to comply with design requirements. Measure the chilled water supply and return temperatures.

Test and Balance Procedure

Set the hot water and chilled water pumps to the proper flow rates. Adjust the flow of chilled water and hot water through the heat exchangers and other devices.

Check the leaving water temperatures and system return water temperatures and the pressure drops across

the heat exchangers and other devices. Readjust to the correct design temperatures.

Check the water temperatures at the inlet side of the cooling and heating coils. Note the rise or drop in temperature from each source. Balance each chilled water and hot water coil to meet design requirements. Use venturies and calibrated orifices with portable or permanent type flow meters to measure the water flow where specified. If this equipment is not specified, obtain the proper water balance by using the "Cv" of the control valves as described in the ASHRAE Guide.

Balance personnel comfort condition chilled water equipment system elements from 90 to 100 percent of design flow, industrial humidity control systems from 100 to 110 percent of design flow, and hot water heating and reheating elements from 70 to 100 percent of design flow. Upon completion of the flow readings and adjustments, mark all settings and record all data on the appropriate forms.

Recheck the flow rates at the pumps after making adjustments to the coils. Readjust as required.

Install test gauges on each coil. Set the flow rate on call for full cooling and full heating, respectively, and read the pressure drops across each coil. Set the pressure drops across the bypass valves, where applicable.

Mark all balancing valve settings, unless the valve has a "memory" feature, upon completion of the flow readings and adjustments.

Adjust the differential pressure valves for the reheat and chilled water systems, where used, to provide a minimum pump flow for satisfactory pump operation when the system control valves are in a closed position.

Using the circulating water pump and water balance element data sheets, complete and record all data requirements indicated therein. Properly identify all systems and the locations of all individual readings on the diagram. Check and record the following items at each cooling and heating element:

- inlet water and air temperatures
- leaving water and air temperatures
- pressure drop of each piece of equipment
- pressure drops across bypass valves
- pump operating suction and discharge pressures and final total dynamic head
- mechanical specifications of the pumps
- rated and actual running amperages of pump motors
- rated and actual voltages of pump motors

Prepare a neatly typed list of all nonconforming items, if any, required in the drawings and specifications and not provided by the heating/ventilating/air-conditioning and controls contractors.

MEASURING ROOM PRESSURE DIFFERENCES

GENERAL

A. SCOPE

This specification covers equipment and techniques to be used in the design, selection, and installation of differential pressure measurement gauges. These types of gauges are permanently installed and used to monitor the room pressure relationship of two rooms. Typically, they would be furnished for certain environmental Class I and II installations when there is a need to contain airborne particulates (viz., repackaging of contraceptive tablets) through the use of negative room pressures, or to protect an area from contaminants through the use of positive room pressures (viz., the filling room for repackaging liquid pharmaceuticals).

B. RELATED WORK SPECIFIED ELSEWHERE

A-14 Cleanable Suspended Ceilings
M-01 Air Handling Units
M-02 Central System Coils
M-03 Fans and Fan Drives
M-05 Air Filters
M-06 Air Filter Gauges
M-07 Duct Work
M-09 Controls and Instrumentation
M-16 Balancing Air, Chilled, and Hot Water Systems

C. CODES AND STANDARDS

Differential pressure measuring systems shall be designed, fabricated, and installed in conformance with the applicable standards of AMCA (Air Movement and Control Association, 30 W. University Dr., Arlington Heights, IL 60004, USA), ASHRAE (American Society of Heating, Refrigeration, and Air Conditioning Engineers, 1791 Tullie Circle, N.E., Atlanta, GA 30329, USA), and ACRI (Air Conditioning and Refrigeration Institute, 1815 N. Fort Myers Drive, Arlington, VA 22209, USA).

D. SUBMITTALS

The contractor shall submit manufacturer's data and certified calibration tests for each instrument to the architect/engineer for review and approval.

MATERIALS/PRODUCTS

The simplest means, but not a satisfactory or practical means, to determine differential pressures between two rooms is to install a thread, short piece of thread, or a bracket for a burning cigarette to indicate the direction of air flow. A permanently mounted simple gauge type system to sense, transmit, and indicate pressure or flow is required. The type used in any situation shall be the simplest device available to satisfy operational needs. The following devices manufactured by F.W. Dwyer Instruments, Inc. (P.O. Box 373, Michigan City, IN 46360, USA) provide the measuring capability required at varying levels of sophistication.

- Dwyer 460 Air Meter
- Dwyer 115 Inclined Manometer
- Dwyer 2000 or 2001 Magnehelic Differential Pressure Gauge

The Model 460 kit is the simplest direct reading instrument that is useful for both air velocity and static pressure measurement in inches water column. Its dual ranges are 0.5 to 1.0 inches and 0.005 to 0.09 inches and 1000 to 4000 ft./min. and 260 to 1200 ft./min. It normally does not require periodic recalibration.

EXECUTION

A. INSTALLATION

Permanently wall mount the gauge as shown in the drawings and as recommended by the manufacturer in the less restricted room with the sensor in the more restricted room. Furnish suitable isolation valves on both sides of the gauge so that the gauge can be removed for calibration. Because of these gauges' high level of sensitivity, extreme care must be taken to assure there are no leaks in the sensing tubing.

PIPING IDENTIFICATION

GENERAL

A. SCOPE

This specification covers the materials and techniques to be used in the selection and application of identification labels on service piping systems. All distribution piping and drain lines shall be identified with the appropriate tape labels properly placed to indicate the:

- name or symbol for the material being handled
- direction of flow, and
- operating pressure, when more than one pressure for a service is provided.

B. RELATED WORK SPECIFIED ELSEWHERE

M-01 Air Handling Units
M-02 Central System Coils
M-09 Controls and Instrumentation
M-10 Refrigeration Equipment
M-11 Pumps
M-12 Pipe and Pipe Fittings
M-13 Pipe Insulation
M-14 Piping Supports and Hangers

C. CODES AND STANDARDS

Names, symbols, and characteristic colors shall be standardized for an entire site. The names of hazardous materials including compressed gasses (viz., natural gas, propane, etc.), if any, shall be spelled out. Sufficient pipe labels shall be installed so that pipe lines can be traced readily through a building or pipe rack system when read from the floor or another normal viewing point. A letter height of 19 mm. shall be used on pipe or insulation 2 inches in outside diameter and smaller and a letter height of 32 mm. for larger diameters. The lettering shall be black and the background shall be yellow for all hazardous materials. Green provides a good background for other services.

D. SUBMITTALS

The contractor shall submit samples of all materials to the architect/engineer for review and approval.

E. ACCEPTANCE TEST

The installation shall be inspected by the owner's representative prior to acceptance.

MATERIALS/PRODUCTS

Pipe identification labels shall be 75 mm. wide printed cloth tape with a laminated 0.10 mm. thick protective vinyl plastic covering and color field length of 30.5 cm. and/or 50 mm. wide and color field length of 20.3 cm. for smaller pipe diameters, with a pressure sensitive adhesive backing for interior use only, or preprinted vinyl film 0.13 mm. thick with pressure sensitive adhesive backing and similar dimensions for exterior and interior

use. The labels shall be suitable for use at temperatures up to 90° C, or as otherwise specified. The labels shall be Model 550 and/or Model 946 (vinyl) supplied in rolls or on cards, as manufactured by W.H. Brady Co. (SignMark Division, P.O. Box 571, Milwaukee, WI 53201, USA), or approved equal.

EXECUTION

A. JOB CONDITIONS

Piping shall be tested, cleaned, disinfected, insulated, and painted before labeling. Surfaces on which labels are to be placed shall be free of dirt, oil, and other materials that may interfere with adhesion.

B. INSTALLATION

Labels shall be applied so that they may be read from the floor or other normal vantage point such as an access panel or mezzanine. The intent is to allow a particular line to be easily traced through a building or pipe rack. Labels shall be located on both sides of all visual obstructions such as floors, walls, ceiling, crossovers in pipe racks, offsets, jogs, etc. On open pipe runs, the labels shall be spaced at intervals of not closer than 6 m. or further apart than 12 m. Labels shall be provided near all valves and at all branch connections unless the connection is within 3 m. of a labeled pipe near a valve.

For general applications apply by folding back the starting end of the label about 20 mm. from its backing, affixing it to the pipe, removing the backing material, and then wrapping the other end around the pipe so it overlaps the first end by approxiamely 5 cm.

For small, bare pipes of $^1/_2$ inch diameter and smaller, place the center of the label on the pipe and wrap it around the pipe to adhere the adhesive backs of the label adhesive-to-adhesive and with the label projecting out from the pipe so the letters can be read on the "ear" of the applied label.

Testing

All installed labels shall be subject to field inspection and acceptance by the owner's representative.

HORIZONTAL FIRE PUMP (DIESEL)

GENERAL

A. SCOPE

This specification covers materials and techniques for a diesel driven horizontal fire pump, electric motor driven jockey pump, controls, and connection fittings.

B. RELATED WORK SPECIFIED ELSEWHERE

F-03 Fire Main Pipe Systems
F-04 Fire Hose Cabinets and Accessories
F-05 Automatic Sprinkler Systems

C. CODES AND STANDARDS

The fire pump, diesel engine, and controls shall be UL (Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL 60062, USA) listed for fire protection service and installed in accordance with the recommendations of the NFPA's (National Fire Protection Association, Battery March Park, Quincy, MA 02269, USA) Pamphlet 20 for the Installation of Centrifugal Fire Pumps and acceptable to the local authorities having jurisdiction. Should installation requirements conflict, the approving authority's requirements shall take precedence.

D. SUBMITTALS

Manufacturer's test results Field test results

E. ACCEPTANCE TESTS

Manufacturer's Factory Tests

The pump shall be hydrostatically tested and run tested prior to shipment. The pump shall be hydrostatically tested at a pressure of not less than one and one-half times the no flow (shut off) head of the pump's maximum diameter impeller plus the maximum allowable suction head, but in no case at less than 18 kg/cm^2.

Field Test

A field acceptance performance test shall be conducted upon completion of the pump installation. The test shall be made by flowing water through calibrated nozzles, approved flow meters, or other such accurate devices as may be selected by the authority having jurisdiction. The test shall be conducted as recommended in NFPA Pamphlet 20 by the owner's representative in the presence of the authority having jurisdiction and with that authority's final approval and acceptance. Failure to submit documentation of factory and field tests shall be just cause for equipment and installation rejection.

MATERIAL/PRODUCTS

A. HORIZONTAL CENTRIFUGAL FIRE PUMP

The fire pump shall be designed to deliver _____ liters per minute at a total head of _____ meters. The fire pump shall also be capable of delivering not less than 150 percent of the rated flow at not less than 65 percent

of the rated head pressure. The shut off (no flow) head pressure shall not exceed 120 percent of the rated head pressure. Pump model _____ shall be furnished with the drive, controls, and accessories as detailed in this specification.

The fire pump shall be of horizontal, centrifugal, multistage construction specifically labeled for fire service and shall be connected to the underground fire main system. The suction supply for the fire pump shall be from a semi-underground reservoir at a maximum pressure of _____ kg/cm^2 and a minimum pressure of _____ kg/cm^2. The pump casing shall be cast iron with _____ inch diameter 9 kg/cm^2 rating suction and _____ inch diameter 18 kg/cm^2 rating discharge flanges machined to American National Standards Institute (ANSI) dimensions.

Pumps shall be equivalent to the fire pumps of Peerless Pumps (2005 Northwestern Ave., Indianapolis, IN 46206, USA) or Viking Pumps (406 State, Cedar Falls, IA 50613, USA).

B. DIESEL ENGINE

The pump driver shall be a horizontal shaft open type diesel internal combustion engine Model _____ manufactured by _____, rated at _____ rpm, clockwise rotation viewed from the end opposite the pump. The engine shall be provided by the pump manufacturer with, at a minimum, the following accessories for automatic operation:

- a UL listed emergency manual operator, factory wired and mounted on the engine juction box for standby engine starting and operation in case of main controller or interconnecting wiring malfunction
- cooling waterlines, pressure regulator, strainer, bypass lines, and necessary fittings for the engine cooling system, prepiped and factory mounted
- flexible exhaust connector
- residential exhaust silencer
- engine jacket water heater, factory installed
- one set of dual batteries, lead acid storage type
- fuel system as recommended in NFPA Pamphlet 20
- fuel storage tank sized to provide a minimum supply of 3.78 l. of fuel per engine maximum rated horsepower plus 5 percent for a sump area plus 5 percent for an expansion area. The tank shall be furnished with legs for floor mounting and with a direct reading level gauge.

The engine shall be run tested with the pump by the pump manufacturer prior to shipment. Engines shall be equivalent to the engines for fire pumps of Cummings (Cummings Engine Company, Inc., P.O. Box 3005, Columbus, IN 47202-3005, USA) or Caterpillar (Caterpillar Tractor Co., 100 N.E. Adams Street, Peoria, IL 61629, USA).

C. ENGINE CONTROLLER

The automatic engine controller shall be UL listed and approved specifically for fire pump service. The controller must be capable of performing or contain the following features:

- built-in battery charger
- time clock for weekly automatic test
- system pressure recorder
- timing relay for automatic stop
- power failure start
- low fuel level switch
- pump room alarm audible and visual signals
- terminals for connection of alarms to an annunciator panel.

The controller shall be wired to the corresponding engine function terminals and shall be mounted on a common base with the engine and pump. A complete running test of the base mounted controller, engine, and pump shall be performed by the pump manufacturer.

D. JOCKEY PUMP

An electric motor driven jockey pump shall be furnished to maintain normal line pressures in the fire main system. The centrifugal pump shall be multi-stage, cast iron, bronze fitted with a _____ rpm, _____ volt,

_____ phase motor. It shall have a capacity for handling water at _____ ° C at liters per minute at _____ kg/cm^2 discharge pressure, not including suction pressure. The pump shall have a stainless steel shaft, packed stuffing box, and screwed piping connections. It shall be connected to and controlled by the controller for the fire pump.

E. FITTINGS

The pump manufacturer shall furnish piping accessory items for the pump installation that will adapt the pump connection to the fire protection and test connection as follows. Fire pump fittings that are subjected to pump discharge pressure shall be 18 kg/cm^2 rated and consist of the following:

- hose valves with caps and chains
- automatic air release valve
- discharge pressure gauge
- water level gauge device

EXECUTION

A. INSTALLATION

Install the material as shown in the drawings and specifications in accordance with NFPA Pamphlet 20.

B. TESTING

Acceptance shall be based on factory and field test results' conformance with specifications based on NFPA Pamphlet 20 testing procedures.

VERTICAL FIRE PUMP (ELECTRIC)

GENERAL

A. SCOPE

This specification covers materials and techniques for an electrically driven vertical fire pump, electric motor driven jockey pump, controls, and connection fittings.

B. RELATED WORK SPECIFIED ELSEWHERE

F-03 Fire Main Pipe Systems
F-04 Fire Hose Cabinets and Accessories
F-05 Automatic Sprinkler Systems

C. CODES AND STANDARDS

The fire pump, electric motor, and controls shall be UL (Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL 60062, USA) listed for fire protection service and installed in accordance with the recommendations of the NFPA's (National Fire Protection Association, Battery March Park, Quincy, MA 02269, USA) Pamphlet 20 for the Installation of Centrifugal Fire Pumps and acceptable to the local authorities having jurisdiction. Should installation requirements conflict, the approving authority's requirements shall take precedence.

D. SUBMITTALS

Manufacturer's test results
Field test results

E. ACCEPTANCE TESTS

Manufacturer's Factory Tests

The pump shall be run tested prior to shipment. The vertical turbine bowl and discharge head assemblies shall be hydrostatically tested at a pressure of not less than one and one-half times the no flow (shut off) head of the pump's maximum diameter impeller plus the maximum allowable suction head, but in no case at less than 18 kg/cm^2.

Field Tests

A field acceptance performance test shall be conducted upon completion of the pump installation. The test shall be made by flowing water through calibrated nozzles, approved flow meters, or other such accurate devices as may be selected by the authority having jurisdiction. The test shall be conducted as recommended in NFPA Pamphlet 20 by the owner's representative in the presence of the authority having jurisdiction and with that authority's final approval and acceptance. Failure to submit documentation of factory and field tests shall be just cause for equipment and installation rejection.

MATERIAL/PRODUCTS

A. VERTICAL TURBINE FIRE PUMP

The fire pump shall be designed to deliver _____ liters per minute at a total head of _____ meters. The fire

pump shall also be capable of delivering not less than 150 percent of the rated flow at not less than 65 percent of the rated head pressure. The shut off (no flow) head pressure shall not exceed 120 percent of the rated head pressure. Pump model _____ shall be furnished with the drive, controls, and accessories as detailed in this specification.

The fire pump shall be a vertical shaft turbine type specifically labeled for fire service and shall be connected to the underground fire main system. The suction supply for the fire pump shall be from a sump structure in a semi-underground reservoir of a style, dimension, and water capacity as recommended in NFPA Pamphlet 20. The total installed length of the pump from the bottom of the base plate to the bottom of the suction inlet shall be _____ cm. The pump discharge head assembly shall be cast iron fitted with _____ inch diameter 18 kg/cm^2 rating discharge connections machined to American National Standards Institute (ANSI) dimensions. The pump discharge head shall provide rigid mounting support for the complete pump assembly and for the vertical hollow shaft motor. The pump lineshaft bearings shall be oil lubricated with bronze bearings contained in enclosing tubing. The pump column pipe and oil tube shall be in sections not longer than 3.0 m. each. Pump bowl assemblies shall include cast iron bowls and bronze impellers and shall be submerged as recommended in NFPA Pamphlet 20. The pump shall be installed with a cast or fabricated nonferrous metal strainer having a free area of not less than four times the suction inlet area. Strainer openings shall be sized to restrict the passage of objects 12.5 mm. sphere size.

Pumps shall be equivalent to the fire pumps of Peerless Pumps (2005 Northwestern Ave., Indianapolis, IN 46206, USA) or Viking Pumps (406 State, Cedar Falls, IA 50613, USA).

B. Electric Motor

The pump driver shall be a vertical hollow shaft induction motor rated _____ horsepower, 3 phase, 60 hertz, with Weather Protected Type 1 NEMA enclosure for operation on _____ volt service. The motor locked rotor current shall not exceed the values stated in NFPA Pamphlet 20. The motor shall be constructed so that the total hydraulic and static thrust of the pump's rotating assembly can be carried by the motor thrust bearing(s). The motor shall mount directly on the pump discharge head assembly with a registered fit for correct shaft alignment. The motor shall be equipped with a top drive coupling and nut for axial adjustment of the pump impellers and shall have a nonreverse ratchet to prevent pump back-spin.

The motor shall be run tested with the pump by the pump manufacturer prior to shipment. Motors shall be equivalent to the motors for fire pumps of Reliance (Reliance Electric, 2401 Euclid Ave., Cleveland, OH 44117, USA) or Siemens (Siemens, Inc., 4620 Forest Ave., Norwood, OH 45212, USA).

C. Motor Controller

The automatic electric motor controller shall be UL listed and approved specifically for fire pump service. It shall be designed for primary resistance reduced voltage type starting. The controller shall be rated for the horsepower specified in this specification section on Electric Motors. The controller shall be capable of interrupting a short circuit current at least equal to the available short circuit current in the controller supply circuit. This fire pump controller installation requires an interrupting capacity rating of not less than _____ amps symmetrical at an operating voltage of _____ volts. The controller shall be mounted on a common base with the fire pump and wired to the motor by the pump manufacturer. The controller must be capable of performing or contain the following features:

- time clock for weekly automatic test
- system pressure recorder
- pump room alarm audible and visual signals
- terminals for connection of alarms to an annunciator panel

The controller shall be wired to the corresponding motor. A complete running test of the base mounted controller, motor, and pump shall be performed by the pump manufacturer.

D. JOCKEY PUMP

An electric motor driven jockey pump shall be furnished to maintain normal line pressures in the fire main system. The centrifugal pump shall be multi-stage, cast iron, bronze fitted with a _____ rpm, _____ V, _____ phase motor. It shall have a capacity for handling water at _____ ° C at liters per minute at _____ kg/cm^2 discharge pressure, not including suction pressure. The pump shall have a stainless steel shaft, packed stuffing box, and screwed piping connections. It shall be connected to and controlled by the controller

for the fire pump.

E. FITTINGS

The pump manufacturer shall furnish piping accessory items for the pump installation that will adapt the pump connection to the fire protection and test connection as follows. Fire pump fittings that are subjected to pump discharge pressure shall be 18 kg/cm^2 rated and consist of the following:

- hose valves with caps and chains
- automatic air release valve
- discharge pressure gauge
- water level gauge device

EXECUTION

A. INSTALLATION

Install the material as shown in the drawings and specifications in accordance with NFPA Pamphlet 20.

B. TESTING

Acceptance shall be based on factory and field test results' conformance with specifications based on NFPA Pamphlet 20 testing procedures.

FIRE MAIN PIPE SYSTEMS

GENERAL

A. SCOPE

This specification covers materials and techniques for the design and construction of the fire main piping system including pressure piping, fittings, sectionalizing and post indicating valves, hydrants, and cathodic protection.

B. RELATED WORK SPECIFIED ELSEWHERE

A-17 Trenching, Compacting, and Backfilling
F-01 Horizontal Fire Pump (Diesel)
F-02 Vertical Fire Pump (Electric)
F-04 Fire Hose Cabinets and Accessories
F-05 Automatic Sprinkler Systems
M-12 Pipe and Pipe Fittings
M-14 Piping Supports and Hangers
M-16 Cleaning and Testing Water Piping Systems
M-18 Piping Identification

C. CODES AND STANDARDS

Materials and installation shall conform to the NFPA's (National Fire Protection Association, Battery March Park, Quincy, MA 02269, USA) Pamphlets 13 and 20, and materials shall be listed by UL (Underwriters Laboratories, 333 Pfingsten Road, Northbrook, IL 60062, USA) in the Fire Protection Equipment Directory. All materials and installations shall be acceptable to the local authorities having jurisdiction. Should installation requirements conflict, the approving authority's requirements shall take precedence.

Hydrostatic test leakage during a 2-hour period shall not exceed 2.0 liters per hour per 100 gaskets or joints, irrespective of pipe diameter.

D. SUBMITTALS

The contractor shall submit to the architect/engineer for review and approval the manufacturer's product data and installation instructions for pipe, fittings, valves, hydrants, indicator posts, and accessories. Calculations that provide the basis for materials selection and sizing shall also be submitted. Shop drawings shall be submitted for the fire main system showing the conduit type, size, location, and elevations. Details of the underground structures, fittings, connection, anchors, and thrust blocks shall be included in the shop drawings.

The results of field tests shall be submitted to the owner's representative for acceptance.

E. ACCEPTANCE TESTS

Operational testing of all valves and hydrants shall be as specified herein.

Field acceptance flushing and hydrostatic testing of the fire main piping system shall be in accordance with NFPA Pamphlet 24 Standard for Outside (Fire) Protection, and as specified herein, and performed in the

presence of the owner's representative and any local authorities having jurisdiction. Three sets of certified test results shall be submitted to the owner's representative.

MATERIALS/PRODUCTS

Underground pressure pipe may be either ductile iron, cast iron, or specially treated polyvinyl chloride (PVC) plastic. Ductile iron, because of its higher quality and ease of installation, has, where cost-effective and available, almost entirely replaced cast iron pipe. Similarly, in jurisdictions where its use is permitted, heavy-duty PVC pipe is beginning to displace ductile iron pipe because it is easier to handle and install, less expensive, and is immune to electrolytic corrosion, thereby eliminating the probable requirement for cathodic protection that iron pipe generally requires.

A. PVC PRESSURE PIPE

Pressure pipe is made from virgin unplasticized compounds that meet the specifications of ASTM D 1784 (Formally Type I Grade 1) and ASTM D-2241 Standard Specification for PVC Plastic Pipe. Plastic pipe with a locked-in gasket joint that meets the specifications of AWWA's (American Water Works Association, 6666 West Quincy Avenue, Denver, CO 80235, USA) C-900 for Pressure Pipe, or equal, is suitable for underground fire main piping. It is available in standard 6.1 m. lengths and in diameters from 4 to 12 inches. The pipe is comparatively light in weight (viz., 154 kg. per 6.1 m. length of a 10 inch diameter). A working pressure rating of not less than 14.5 kg/cm^2 at 23° C is required.

The compression gasket is factory installed and has a steel reinforcement within an elastomeric gasket material that is "locked" into the bell of the pipe during manufacturing when the bell hub is formed around the gasket. No field insertion of gaskets is required. This makes a permanent joint that is an integral part of the pipe. This lock-in type of joint is called the RSS joint (Rieber Sealing System patented by Rieber and Sons Plastic Industri A/s, Norway). This product shall be as manufactured by Can-Tex Industries, P.O. Box 340, Mineral Wells, TX 76067, USA, or approved equal.

B. PVC PIPE LUBRICANTS AND PIPE AND FITTING COMPOUNDS

The lubricants for joint components and sealant compound for pipe and fittings shall be furnished exclusively by the PVC pipe manufacturer for the use specified.

C. DUCTILE IRON PIPE

The pipe shall be 14.5 kg/cm^2 working pressure rated, have mechanical joints, and be cement mortar lined in accordance with ANSI's (American National Standard Institute, 1430 Broadway, New York, NY 10017, USA) A21.11, A21.4, and A21.51. The pipe thickness shall be designed in accordance with the principles applicable to a flexible pipe ANSI A21.50 and shall be based on laying conditions, internal pressure, earth load including an allowance for truck super load, beam load, service allowance, and foundry tolerances.

D. FITTINGS

Ductile iron with mechanical joints, cement mortar lined, and seal coating, where applicable, in accordance with ANSI A21.10 and A21.21 to match the pipe. Where a pipe enters a building, use a special fitting having a standard flange on one end. Flanges where required shall conform to ANSI B16.1. Bolts shall be the best quality mild steel, square head, hexagonal cold pressed nuts, and of a diameter and length per ANSI B16.1.

E. GASKETS

Neoprene in accordance with ANSI A21.11.

F. VALVES AND "T" WRENCHES

Gate valves, also known as sectionalizing, control, and key valves depending on where they are installed, shall be suitably rated at 12.7 kg/cm^2 working pressure; shall have an iron body, bronze mountings, and nonrising stem valves with 5 cm. operating nuts; and shall be provided as shown in the drawings. Not less than two each "T"-handled operating wrenches shall be furnished in the lengths suitable for valve depths for valves not requiring post indicators. Valves shall have threaded connections up to 2 inches in diameter and flanged connections for $2^1/_2$ inch diameters and larger.

G. POST INDICATORS

Post indicators enable operation of an underground valve while providing an aboveground indication of the open or closed position of the valve to which it is attached. Typically, post indicators used are in an exterior

location on all valves between the interior automatic sprinkler system risers and the exterior or on valves installed in the fire main piping system that are provided to isolate sections of the exterior fire main. Post indicators shall be provided as shown on the drawings and at a suitable length for valve depths.

H. HYDRANTS

Hydrants shall be cast iron with two threaded nozzles and a 6 inch diameter flanged connection for use with a key valve. The compression type main valve for 12.7 kg/cm^2 working pressure shall have a $5^1/_4$ inch diameter opening, drain valve, and 6 inch diameter inlet. The valve opening direction shall be counterclockwise and be indicated by an arrow and the word "OPEN" cast onto the hydrant's dome. The nozzles shall have standard $2^1/_2$ inch diameter fire hose threads compatible with new and existing equipment and as required by the local fire department authorities, unless otherwise indicated. Caps and chains shall be provided for the nozzles. Nozzle cap nuts shall match the hydrant's operating stem nuts. Provide hydrant wrenches as specified.

The length of the hydrant shall depend on the fire main depth; the bottom of the outlet shall be not less than 45 cm. from the finish grade as indicated in the drawings. Hydrant barrel extensions shall be provided as required.

Each hydrant shall be furnished with a flanged "key" non-rising stem gate valve and valve box (see Valves and "T" Wrenches above).

I. BACK FLOW PREVENTION

To avoid the possibility of contaminating the potable water system with water from the static water in the fire protection system, a flanged 12.7 kg/cm^2 rated working pressure back flow prevention device, UL listed for use in automatic fire protection systems, should be provided. This same device will also detect leaks in the fire main piping system. Use model 806 DCDA, Double Check Detector Assembly as manufactured by FEBCO, Division of CMB Industries, P.O. Box 8070, Fresno, CA 93747, USA, or approved equal.

J. ANCHORAGES

Provide anchorages for tees, plugs, caps, bends, and hydrants in accordance with NFPA Pamphlet 24 as follows:

- clamps, straps, and washers: steel ASTM A506
- rods: steel ASTM A575
- rod couplings: malleable iron ASTM A197
- bolts: steel ASTM A307
- washers: cast iron, ASTM A126, Class A

After installation, apply a full coat of asphalt or other acceptable corrosion-retarding material to the surfaces of all rods and clamps.

Metallic fire main system piping and components shall be manufactured by Clow Water Systems Corporation, P.O. Box 479, Coshocton, OH 43812, USA; Griffith Pipe Products Co., Florence, NJ 08518, USA; or approved equal.

K. CATHODIC PROTECTION AND PROTECTIVE COATINGS

For unprotected ductile iron or cast iron piping systems, premature pipe corrosion caused by current flow from the pipe to the soil must be a consideration. Investigate soil conditions, the surface area to be protected, and the proximity to power installations. Specify the cathodic protection equipment and installations required to provide adequate protection or a protective coating such as polyethylene encasing for the same purpose.

L. THRUST BLOCKS

Thrust blocks shall be installed where deflections occur in fire mains at elbows, tees and plug ends. Fittings shall be adequately braced to prevent their being blown off. Fittings shall be braced against the vertical face of the trench with cast-in-place concrete thrust blocks at bends, tees, and crosses. Use minimum 290 kg/cm^2 concrete; see the drawings for thrust block details and locations.

M. BACKFILL AND FILL MATERIALS

Provide backfill and fill materials free of debris, waste, vegetable matter, rock or gravel larger than 50 mm. in any dimension, and other deleterious matter. Provide pit run sand and gravel, unless otherwise indicated or

specified. The suitablity of all backfill and fill materials shall be subject to approval. Inorganic soil may be used in exterior trenches that do not cross existing or future paved areas, or existing underground utilities. Where trenching within a building is required for fire main system installation, provide pit run sand on gravel (aggregate not to exceed 50 mm. largest dimension).

EXECUTION

A. PVC PIPE INSTALLATION

Pipe Inspection

The pipe and accessories shall be carefully inspected prior to accepting it. The pipe shall be homogeneous throughout and essentially uniform in color, opacity, density, and other properties. The inside and outside surfaces shall be semi-matte or glossy in appearance and free of chalking, sticky, or tacky material. The surfaces shall be free of excessive bloom; slight bloom is acceptable. (Bloom or chalking may develop in pipe exposed to the direct rays of the sun [ultraviolet radiant energy] for extended periods. Consequently these requirements do not apply to pipe after extended exposure to the direct rays of the sun.) The pipe walls shall be free of cracks, holes, blisters, voids, foreign inclusion, or other defects that are visible to the naked eye and that may affect the wall integrity.

Unloading

Care shall be taken during unloading and handling to prevent damage to the pipe. **Never roll pipe off of a truck.**

Trench Preparation

Trench depth of PVC pipe should be a minimum of 1.5 m. and as indicated in the drawings. The trench bottom shall be smooth and regular, free of rocks, and all hard objects to allow uniform support of the pipe. Narrow trenches may be used if the trench width is sufficient to allow for adequate tamping of the soil around the pipe.

Assembly

Inspect the bell, gasket, and spigot to insure that they are clean and free of dirt or foreign objects. Lubricate the spigot end of the pipe with a factory supplied lubricant. **Do not lubricate the gasket.** Align the spigot with the bell and push the assembly together by hand or with a block and bar, until the assembly mark on the spigot is correctly aligned with the end of the bell.

Radius of Curvature

PVC pipe can be installed with gradual curves by uniformly deflecting the pipe barrel. The minimum radii of curvature shall be in accordance with the manufacturer's recommendations.

Joint Deflection

Joints are designed to permit 23 deflection without bell distortion. Fittings should be used to effect greater deflections.

Thrust Blocking

Care should be taken to provide adequate thrust blocking at all bends, intersections, ends, and reductions in accordance with the fire protection engineers' recommendations.

Backfilling

Backfilling of pipe sections should be done promptly after installing each length of pipe. Backfill shall contain no large rocks or hard clods. Tamp around and under the pipe to insure adequate soil suport. Do not cover joints until the installed pipe is tested.

B. DUCTILE IRON PIPE INSTALLATION

Inspection

Examine the areas and conditions where the fire main system work is to be performed. Do not proceed with the work until unsatisfactory conditions detrimental to the proper and timely completion of the work have been corrected.

Trenching

Perform required excavation to the depths indicated on the drawings. Unless otherwise shown on the

drawings, the minimum depth of cover for all lines shall be 1.5 m. In general, all excavation shall be made by open cut. Trench banks shall be kept as nearly vertical as practicable and, if necessary, shall be properly sheeted and braced. Pipe trenches shall be sufficiently straight between designated angle points to permit pipes to be laid true to line in the approximate center of the trench. Pipe trenches shall be sufficiently wide to provide free working space on each side of pipe as laid but shall not exceed the outside diameter of the pipe plus 40 cm. in width. The width of trench specified applies to the width at and below the level of the top of pipe. The width of the trench above that level may be made as wide as necessary for sheeting and bracing and proper installation of work.

Provide a compacted pit run gravel bed having a thickness of not less than 10 cm. under all iron pipe. The exterior of the pipe shall be bedded for not less than one-fourth ($^1/_4$) of its circumference with the same material. The 10 cm. cushion shall be maintained under the bell as well as under the barrel portion of the ductile iron pipe.

Wherever wet or otherwise unstable soil incapable of properly supporting pipe is encountered in the trench bottom, such soil shall be removed to a depth required and for lengths as designated and the trench backfilled to the trench bottom grade with pit run sand or gravel.

Grading and Stacking

All grading in the vicinity of the trench excavations shall be controlled to prevent surface water from flowing into the trenches. Any water accumulated in the trenches shall be removed by pumping or by other approved method. During excavation, material suitable for backfilling shall be stacked in an orderly manner and at a sufficient distance back from the edges of the trenches to avoid overloading, and to prevent slides or cave-ins. Material unsuitable for backfilling shall be disposed of as specified.

Shoring and Sheeting

Provide all shoring and sheeting required to protect the excavation and safeguard employees. For more details refer to the guideline specification A-17, Trenching, Compacting, and Backfilling.

Installation

A minimum depth of cover of 1.5 m. shall be maintained over all fire mains. Where a sewer line crosses below or above a fire main line, a minimum vertical separation of 50 cm. shall be provided. The pipe shall be installed in accordance with AWWA's C.900 specifications. Install post indicator valves and sectionalizing valves in accordance with manufacturer's instructions.

Install hydrants where shown on the drawings, at such elevations that connecting pipes will have a minimum cover of 1.5 m. The distance from the bottom of the hose connections to final grade shall be not less than 45 cm. Provide a solid concrete footing beneath the base of each hydrant. For drainage of each hydrant, place not less than 0.2 m^3 of clean, well graded 20 mm. gravel from the bottom of the hydrant to at least 15 cm. above the waste opening in the hydrant, and around the base for a distance of 30 cm. Secure the hydrants by anchoring them to tees on the main with bridle rods and rod collars. Bridle rods and rod collars shall be $^3/_4$ inch diameter steel stock painted with acid-resistant paint. Thoroughly clean all foreign material from the interior of all hydrants.

Joint Adaptors

Make joints between iron pipe and other types of pipe with standard manufactured iron adaptors and fittings.

Interior Inspection

Inspect the pipe's interior to determine whether line displacement or other damage has occurred. Correct poor alignment, debris, displaced pipe, infiltration, or other defects.

Placing and Laying of Pipe

All pipe shall be laid true to line and grade as shown on drawings or as directed. Any pipe line, fire hydrant, and/or valve whose alignment is found to be in excess of 150 mm. from the alignment as established by control points as shown on the drawings and/or whose grade is found to be 3 mm. above or below the grades shown on the drawings shall be removed and relaid, reinstalled and reset to the lines and grades as shown on the drawings, or as directed and within the limits specified hereinabove, without additional cost to owner. Any pipe that has the grade or joint disturbed after laying shall be removed and relaid.

Cleaning Laid Pipe

Clear the interior of pipe of all dirt and other materials as work progresses. Maintain a swab and drag in line in the laid pipe sections and pull it past each joint as it is completed. Place temporary plugs in the end of uncompleted or unconnected pipe at the end of day or whenever work stops.

C. TESTING

The entire system shall be tested, as specified herein. Make sure all lines are properly thrust blocked and anchored prior to testing.

The flushing and hydrostatic testing of the fire main system shall be done in strict accordance with NFPA Pamphlet 24, Standard for Outside Protection. Test certificates required in the referenced codes for testing the fire main system shall be completed in triplicate by the contractor and submitted to the owner's representative for acceptance.

Flushing

Underground mains and lead-in connection to each sprinkler system riser shall be flushed thoroughly before any connection is made to sprinkler, standpipe, or other fire protection system piping. The underground mains and supply connections to wet pipe systems shall be flushed at a flow rate not less than indicated in the following table:

	Flow Rate	
Pipe Size	**gpm**	**l/min.**
4" (101 mm.)	400	1514
6" (152 mm.)	750	2839
8" (203 mm.)	1000	3785
10" (254 mm.)	1500	5678
12" (304 mm.)	2000	7570

For all systems, the flushing operations shall be continued for a sufficient time to ensure thorough cleaning. When planning the flushing operations, consideration shall be given to disposal of the water discharging from the test outlets.

Before requesting final approval for the installation by the authority having jurisdiction, the contractor shall furnish a written statement, countersigned by the owner's representative, that the work has been completed in accordance with the contract documents.

Trenches shall be backfilled between joints before testing to prevent movement of pipe.

All permanent and temporary thrust blocks, and tie rods shall be in place.

Hydrostatic Test Requirements

All exterior piping shall be tested hydrostatically at not less than 14.5 kg/cm^2 pressure for two hours, or 3.6 kg/cm^2 in excess of the maximum static pressure when the maximum static pressure is in excess of 10.9 kg/cm^2.

The amount of leakage from the piping shall be measured at the specified test pressure by pumping from a calibrated container. The amount of leakage at the joints shall not exceed 2-1/h per 100 gaskets or joints, irrespective of pipe diameter.

Tests shall be made by the contractor in the presence of the authority having jurisdiction and the owner's representative. The test results shall be recorded and submitted to the owner's representative for acceptance.

Operating Test

Each hydrant shall be fully opened and closed under normal system water pressure. Where fire pumps are available, this shall be done with the pumps running. All control valves shall be fully closed and opened under system water pressure to ensure proper operation.

FIRE HOSE CABINETS

GENERAL

A. SCOPE

This specification covers materials and techniques to be used in the selection and installation of fire hose cabinets including accessory components. The supply of water to these units shall be from the fire protection piping system or, if present, from the sprinkler system.

B. RELATED WORK SPECIFIED ELSEWHERE

M-12 Pipe and Pipe Fittings
M-15 Cleaning and Testing Water Piping Systems
M-18 Piping Identification
F-01 Horizontal Fire Pump (Diesel)
F-02 Vertical Fire Pump (Electric)
F-03 Fire Main Pipe Systems
F-05 Automatic Sprinkler Systems

C. CODES AND STANDARDS

The materials shall be UL (Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL 60062, USA) listed and shall be installed in accordance with the recommendations of the NFPA's (National Fire Protection Association, Battery March Park, Quincy, MA 02269, USA) Pamphlet 14 for the Installation of Hose Cabinets and Hose Stations. Should installation requirements conflict, the approving authority's requirements shall take precedence.

D. SUBMITTALS

The contractor shall submit certified shop drawings to the architect/engineer for review and approval and field test results to the owner's representative for acceptance.

E. ACCEPTANCE TESTS

The installations shall be field tested at the same time the other elements of the fire protection system are tested. Tests shall conform to NFPA Pamphlet 14 and shall be acceptable to the owner and to the local authorities having jurisdiction.

MATERIALS/PRODUCTS

A. HOSE CABINET

UL approved No. 18 gauge (1.3 mm.) steel tub, finished baked white enamel interior, gray exterior primer coat, duo-wire glass panel door, flat trim, surface or recess mounted. Surface mounted cabinets shall, in addition, have a baked enamel exterior finish of red paint.

B. FIRE HOSE RACK AND ACCESSORIES

UL approved semiautomatic swing hose rack unit, 30 m. capacity for $1^1/_2$ inch diameter hose, one piece construction of No. 16 gauge (1.6 mm.) steel, 25 rack pins steel cadmium plated, brass supporting nipple, and

a $1^1/_2$ inch diameter angle valve with a 21.8 kg/cm^2 test rating and rough brass finish.

C. FIRE HOSE

UL approved $1^1/_2$ inch diameter, 21.8 kg/cm^2 test rating, lightweight single woven polyester jacket, rubber lined fire hose, 30 m. in length with threaded couplings, and pin lugs.

D. NOZZLE

UL approved $1^1/_2$ inch diameter adjustable fog nozzle, industrial type, 170 to 230 lpm discharge at 3.5 to 7 kg/cm^2, satin brass finish.

E. THREADS

Threads for all threaded components to be compatible for both new and existing equipment.

EXECUTION

A. INSTALLATION

Install the hose cabinets and accessories at the locations shown on the drawings, surface mounted or recessed as specified. The mounting height shall be 1.50 m. from the finished floor to the top of the cabinet and in accordance with NFPA's Pamphlet 14.

B. TESTING

Conform to NFPA Pamphlet 14 test methods.

AUTOMATIC SPRINKLER SYSTEMS

GENERAL

A. SCOPE

This specification covers materials and techniques to be used in the design, installation, and testing of automatic fire protection systems. It assumes that the system will be designed by an expert fire protection system designer and/or qualified fire protection system contractor who will also install, or supervise the installation, of the sprinkler systems.

B. RELATED WORK SPECIFIED ELSEWHERE

M-12 Pipe and Pipe Fittings
M-15 Cleaning and Testing Water Piping Systems
M-18 Piping Identification
F-01 Horizontal Fire Pump (Diesel)
F-02 Vertical Fire Pump (Electric)
F-03 Fire Main Pipe Systems
F-04 Fire Hose Cabinets and Accessories

C. CODES AND STANDARDS

Materials and installation shall conform to the NFPA's (National Fire Protection Association, Battery March Park, Quincy, MA 02269, USA) Pamphlet 13, 14, 24 and 20. All materials and installations shall be acceptable to the local authorities having jurisdiction. Should installation requirements conflict, the approving authority's requirements shall take precedence. All electrical work shall be in accordance with the NFPA's National Electrical Code and materials be UL (Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL 60062, USA) listed, or equal.

D. SUBMITTALS

Drawings and Calculations

The contractor shall submit for review _____ sets of preliminary drawings within 30 days after contract award and before proceeding with any work at the site, showing the location of all mains, risers, branches, valves and specialities, and the proposed sprinkler head arrangments.

Upon receipt of the architect/engineer's, the insurer's, and the owner's representative's approval, submit for review _____ sets of complete working drawings and hydraulic calculations. Obtain their final approval before proceeding further.

Furnish _____ complete sets of all approved drawings and calculations. Drawings marked "approved as noted" shall not be accepted.

Field Test Results

Furnish 3 sets of field test results to the owner's representative for acceptance.

Operating and Maintenance Instructions

The contractor shall furnish three complete sets of typed or printed maintenance and operating instructions

for the systems installed.

E. ACCEPTANCE TESTS

Field acceptance NFPA performance tests shall be conducted by the contractor as recommended in the NFPA pamphlets in the presence of the owner's representative and the authority having jurisdiction for final system approval and acceptance upon completion of the installation. The test shall be made by flowing water through the system and taking measurements with proper accurate devices as may be selected by the authority having jurisdiction, the owner, the insurer, and the architect/engineer. Failure to submit documentation of field tests, operating instructions, or of the completed installation's conformance with specifications shall be just cause for rejection.

MATERIALS/PRODUCTS

All materials (viz., pipe, fittings, valves, hangers, guards, drains, gauges, etc.) shall comply with NFPA Standard 13 and be UL listed.

A. PIPE, FITTINGS, AND VALVES

Above ground sprinkler piping shall be Schedule 40, black steel meeting the standards of ASTM (American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19013, USA). Welded piping for the sprinkler systems will be acceptable for sections of cross mains, feed mains, or risers only. Field welding is not acceptable. Sections 3-12.4.3 through 3-12.4.7 of NFPA's Standard 13 shall be part of this specification applicable to "Welded Piping." Sections of piping shall be joined by means of screwed, flanged, or victaulic flexible gasketed joints or other approved fittings.

Fittings shall be cast iron, screwed flanged, or UL listed victaulic groove type with EPDM gaskets. Gate valves shall be bronze outside screw and yoke; globe valves shall be bronze screw; and check valves shall be cast iron body with bronze mountings.

B. PIPE HANGERS

Pipe hangers shall be of the types indicated as acceptable in the NFPA Standard 13. All C-clamps shall have locknuts or retaining straps, and pipe rings shall be of the solidring adjustable swivel type. Offsets in hanger rods will not be permitted. Pipe hangers and bracing in seismic regions shall be designed for that purpose.

C. GUARDS

Sprinkler heads that are so located as to be subject to mechanical damage (in either the upright or the pendant position) shall be protected with UL approved guards.

EXECUTION

Only qualified automatic fire protection designers and/or constructors such as Grinnell Fire Protection Systems Company, 3 Tyco Park, Exeter, NH 03833, USA; The Viking Corporation, 210 N. Industrial Park Road, Hastings, MI 49058, USA; or equal shall be considered for design and/or installation of these systems.

A. SCOPE OF WORK

Design and furnish all labor, materials, and equipment, and do all work necessary for the complete design and installation of the systems specified herein and as shown on the approved drawings. Design of the systems to be in accordance with the requirements of standards referred to herein.

In general, this work includes new wet type sprinkler systems, except in the low temperature storage areas serviced by dry type sprinkler system components. The wet system includes alarm devices, detector check valve, main piping, valved connections in underground piping for domestic water service, back flow preventors, wall hydrants, fire department connection, fire hose stations, fire hose cabinets, sprinkler cabinets, monitor nozzles, fire hydrants, roof hydrants, post indicator valves, sectional control valves, diesel fuel tank, piping, and tank filling pump. It also includes installation and all connections to the diesel engine driven fire pump, electric motor driven fire pump and jockey pump, fire pump and jockey pump controller, ground storage suction tank; excavating and backfilling; concrete foundations and pads not shown on the structural drawings; pipe identification; flushing and cleaning; tests and adjustments; and delivery of maintenance and operating instructions. It also includes new dry type sprinkler system components where required.

B. OWNER-FURNISHED EQUIPMENT

Furnish all labor, materials, and installation equipment, and handle and do all work necessary to install all owner-furnished equipment described hereinafter in conformance with any instructions included herein. (List owner-furnished equipment here if there will be any such items.)

C. SYSTEM DESCRIPTION

All areas of the building are to be protected by a wet type automatic sprinkler system hydraulically designed to produce a flow density of _____ liters per minute per square meter of floor area for any and the most remote _____ square meters of floor area, except in the low temperature storage areas where special dry type sprinkler system components are required.

A demand of _____ liters per minute for interior fire and _____ liters per minute for exterior fire hydrants is to be included in the design of the system.

Static pressure in the underground fire main shall be _____ kg/cm^2.

The attached sketches show the general desired arrangement of the sprinkler heads and the supply mains and branches. Within 30 days after contract award, and prior to any work at the site, submit for review and approval _____ sets of preliminary drawings showing the arrangement of feeders and branches.

D. INSTALLATION

The automatic sprinkler systems shall be provided by the contractor in accordance with the applicable requirements of NFPA Standard 13 and as herein specified.

Sprinkler heads shall be generally installed in an upright position, except in rooms with a suspended ceiling where pendant-type sprinklers with chromium-plated escutcheons shall be installed with the piping concealed above the suspended ceiling. Frost proof sprinkler heads shall be used in walk-in type cold rooms.

Provide sprinkler cabinets with spare sprinkler heads as required by NFPA Standard 13 at each riser. The sprinkler heads shall be stored in the cabinet and shall be representative of, and in proportion to, the number of each type and temperature rating of heads installed. In addition to the spare sprinkler heads, furnish not less than one special sprinkler-head wrench per cabinet. Install the cabinets at the locations shown on the drawings.

Main drains shall be provided on all main risers and auxiliary drains at all low points in the system. Inspector's test connections shall be provided on each sprinkler system as near the most distant end of the system as possible. Drain valves shall be piped to a safe place of discharge, and the discharge shall be visible either by open-end drain pipe or sight drain fittings. All drains and inspector's test connections through outside walls shall be run through the walls as close to the floor or grade line as possible, terminating with a 45-degree galvanized elbow turned down. Concrete splash blocks, minimum 50 cm. x 50 cm. x 10 cm. in size, shall be installed under each drain or test outlet. The top of the block shall be installed under each drain or test outlet and shall be 3.5 cm. above final grade with a slope of 10 percent away from the building wall.

Provide a 1-inch diameter test pipe at the highest and most remote point of the riser system. Unless otherwise indicated, extend the discharge through a sight glass to the outside of the building. Terminate the test pipe in a $^1/_2$ inch-diameter brass outlet at a point where it can be easily seen. Provide a control valve on the test pipe that is within easy reach of the floor. Provide and locate the pressure gauges so that each dial can be read from the floor.

Provide the following alarm devices at each riser: alarm check valve of the size shown on drawings, with retard chamber, water motor alarm, key switch, pilot light, and vane type flow actuated indicating device. The device shall be pneumatic with an adjustable retard of zero to 90 seconds with two single pole, double throw microswitches. The paddle shall be corrosion-free monel "K" metal or equivalent. Alarm wiring by others.

Sprinklers shall be installed in the computer room. Computer power shall be interlocked so that it will be automatically interrupted upon detection of water flow in the sprinkler system.

All control, drain, test, and alarm valves shall be provided with identification signs of the standard design adopted by the automatic-sprinkler industry, or their equivalent.

E. CLEANING

Flush all underground piping with water at the flow rate designated in NFPA Standard 13. Flush indoor

main piping using sufficient water to produce a minimum water velocity of 76 cm. per second through piping being flushed. Continue flushing until the discharge water shows no discoloration. Drain all low points.

F. TESTING

Upon completion and prior to the acceptance of the installation, the contractor shall, in the presence of the owner's representative, subject the systems to the tests required by NFPA Standard 13 and shall furnish the owner's representative with 3 copies of the test results.

AUTOMATIC SMOKE AND HEAT VENTS

GENERAL

A. SCOPE

This specification covers materials and techniques to be used in the selection and installation of automatic shrink-out smoke and heat vents. Automatic shrink-out heat vents may also be used to provide natural lighting.

B. RELATED WORK SPECIFIED ELSEWHERE

F-07 Fire Barriers

C. CODES AND STANDARDS

Automatic shrink-out smoke and heat vents shall be FM (Factory Mutual Engineering, P.O. Box 9102, Norwood, MA 02062, USA) labeled and comply with current FM standards for automatic shrink-out fire vents.

D. SUBMITTALS

The contractor shall submit the manufacturer's shop drawings for approval prior to placing purchase orders.

MATERIALS/PRODUCTS

The domes shall be of a rectangular 1.20 m. x 1.83 m. quadri-dome design Type 1 polyvinyl chloride shielded within an acrylic overlay. The dome and frame shall have quick manual release rods. Dome light transmission shall be 50 percent diffusing. Vent frames shall be constructed of extruded aluminum, mitered and heliarc welded with seepage ports. Fasteners shall be corrosion resistant. The integral curb shall be of single wall aluminum brake metal sheet with a mounting flange mechanically welded at the corners and 2.5 cm. x 10 cm. nailing strip to be fastened to a curb. Rigid insulations shall be secured to the curb. An exterior aluminum bar safety structure shall be welded to the retaining frame to resist impact loads in excess of 110 kg. Recommended brands and manufacturers are Model AFM or AFMD, Catalog Number 24 (APC Corporation, P.O. Box 515, Hawthorne, NJ 07507, USA), or equal.

EXECUTION

Installation

Provide domes for not less than 1 percent and up to 7 percent of the floor area as shown on the drawings. Fasten the domes to the roof structure with fasteners compatible with the roof system in accordance with the specifications and the manufacturer's instructions.

FIRE BARRIERS

GENERAL

A. SCOPE

This specification covers materials and techniques to be used in the design and construction of fire barriers.

B. RELATED WORK SPECIFIED ELSEWHERE

A-11 Block Masonry
A-14 Cleanable Suspended Ceilings
A-15 Hollow Metal Work
A-16 Finish Hardware
M-07 Ductwork
F-08 Fire Dampers

C. CODES AND STANDARDS

Fire wall ratings, estimated ratings, and equivalent thickness tables shall be as listed in the latest edition of the Fire Resistance Ratings published by the American Insurance Association (85 John Street, New York, NY 10038, USA) or in the Fire Resistance Directory published by Underwriters Laboratories, Inc. (333 Pfingsten Rd., Northbrook, IL 60062, USA). Fire barriers shall also comply with local codes and be acceptable to the authorities having jurisdiction.

All fire doors and profiled frames for hinged fire doors shall be factory labeled for the class of openings they are protecting. Rolling fire shutters shall have heat fusible linkages on both sides of the exposure protected. Hinged door closers with hold-open arms shall have heat fusible links in the arm mechanism. Sliding fire doors shall have self closing counterweight systems released by heat fusible links in weight support cables. The criteria for classification of openings is provided in Chapter 28, Fire Protection Systems.

A fire door temperature rise rating, when the temperature is shown on the factory label of a fire door, indicates the temperature developed on the unexposed face of the door when the door is subjected to a standard 30 minute fire test. The labels may indicate that the maximum transmitted temperatures are 121° C, 232° C, or 343° C. Factory labeled fire doors without a temperature rise rating indicates that the door's rating exceeds 343° C. Frames for labeled fire doors must be intended for that use to provide the degree of fire protection equivalent to the labeled door. Standard fire door frames generally are of a single or two section type consisting of profiled sheet metal or structural hot rolled steel channels, head and jamb members, including reinforced hardware, wall anchors, door stops, and provisions for anchoring the frame to the floor. Fire door units including hardware and frames shall be UL (Underwriters Laboratories, Inc., 333 Pfingsten Rd., Northbrook, IL 60062, USA) listed or FM (Factory Mutual Engineering Company, P.O. Box 9102, Norwood, MA 02062, USA) approved.

Construction and installation of components of fire barriers and openings shall comply with the recommendations of the NFPA (National Fire Protection Association, Battery March Park, Quincy, MA 02269, USA).

D. SUBMITTALS

The contractor shall submit shop drawings to the architect/engineer for review and approval for all fire door units listed on the door schedule.

Acceptance of the work is subject to field inspection as specified herein.

EXECUTION

A. DESIGN CONSIDERATIONS

Each installation where a fire wall is needed requires individual structural analysis and design with particular attention to the seismic loads and to the ability of the wall to remain in place during a fire where collapsing building frames and other structures are a possibility.

Fire Resistance

Fire walls must have insulating characteristics so that temperatures on the unexposed side of the wall will not reach incinerating or structurally damaging temperatures for the expected duration of an uncontrolled fire on the exposed side of the wall. Materials or assemblies bearing fire-resistance ratings by the ASTM (American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19013, USA) E119 fire-test procedure provide the needed insulation for the rated periods. Fire walls usually require between 3 and 6 hours of fire resistance — 3 hours where the hazard of the stored combustibles is moderate and up to 6 or even 8 hours where the hazard is severe.

Fire walls shall be free standing (structurally cantilevered from the foundations) where fire risks are equal in areas on both sides of the wall. Fire walls may be supported by the structure on the lower hazzard side of a fire wall.

Openings in Fire Walls

Openings in fire walls, even when properly protected, reduce the reliability of the fire wall. Openings must be kept to a minimum in both the number and sizes of the openings.

Door openings in fire walls rated at 4 hours or over should be protected with an automatic-closing 3 hours ("A" label) fire door on each side of the wall. For door openings in walls rated at 3 hours or less a single door having a rating equivalent to the fire wall may be used. Openings for conveyors passing through a wall also require equivalent protection. Positive provision must be made so that any material on a conveyor and the conveyor itself will not obstruct the closing of the fire door, whether or not the conveyor is operating.

Parapets

Fire walls in steel frame buildings with a roof deck have little value if the uncontrolled fire on one side of the wall can pass over the top, or around either end, to involve the other side. Parapets prevent the passage of fire over fire walls when the roof deck is combustible. Parapets are an upward extension of a wall below, passing through a slot in the roof deck or roof slab. They break the continuity of combustible materials and shield the roof on the protected side of the wall from some radiant heat. Parapets should be noncombustible, at least 75 cm. high, and shall break the continuity of the roof deck. Parapets are not needed when the roof is of noncombustible or fire-resistive construction (viz.; reinforced concrete) and the only continuity of combustibles over the wall is that of the weatherproof covering on the roof.

End Walls

End walls prevent the passage of fire around the ends of fire walls and are generally required for steel frame structures and buildings with potentially unstable, low strength, or combustible wall sections. They should be blank, noncombustible sections of exterior wall at least 2.0 m. long, preferably centered on each end of the fire wall. End walls generally would not be required in a reinforced concrete building or a building with a reinforced concrete structure and block masonry walls of appropriate design.

Strength and Stability

Strength and stability are the most important properties of a fire wall and, in many cases, the most difficult to achieve. Fire walls must have sufficient strength to resist, without significant damage, impact loads that might be expected from materials handling equipment working within the building. Reinforced concrete structures are types of construction that provide the required integrity for fire wall stability. In steel frame structures, the fire walls must also be capable of remaining in place when subject to the forces from collapsing

steel framing weakened by uncontrolled fire on either side of the wall. Considering stability, fire walls are in two general categories: tied walls, which are affected by expansion and collapse of steel framing, and freestanding walls.

Tied-wall Design

Tied walls are secured to the structural frame of a building and derive their ability to remain in place from this design. Their most appropriate use is between paired column lines at or near the center of a building having exposed steel frames on one or both sides of the expansion joints. The tied wall must be a continuous barrier of proper fire resistance, and it must provide the same protection for all structural elements located along the column line where the tied wall is placed (i.e., columns and trusses or beams between columns). With a major uncontrolled fire on either side of a tied wall, a reinforced concrete structure without expansion joints will be secure for several hours. In contrast, in steel frame structures the horizontal pull on the wall caused by collapsing steel must be adequately resisted by the overall lateral resistance of the several bays of "cold" steel on the other side of the wall.

Tied walls are not readily adaptable to situations where they must be installed near expansion joints in the building frame. Here the frame must be modified to make it continuous, or alternative double or freestanding walls must be considered.

Double Walls

Double walls are two one-way tied walls back to back. They may be used along expansion joints or where an addition to an existing building requires a fire wall between the existing and new structures. The existing walls, which would be expected to be secured to the existing frame, are modified to provide the proper fire resistance. A new fire-resistive wall is then constructed close to the existing one and secured to the new building's frame. In the case of an existing reinforced concrete structure an uncontrolled fire on one side of the upgraded exterior wall would not affect the other side. The situation is very different in the case of a steel structure, because should there be an uncontrolled fire on either side of this double wall, one building frame could collapse, pullings its wall with it. The other, being supported by steel on the protected side, will remain in place to stop the spread of fire.

Double-wall fire resistance requirements vary from normal requirements. Where a 3 to 6 hour barrier is needed, each of the two wall elements should have a 2 to 4 hour rating, respectively.

Freestanding Walls

Freestanding walls are untied and self-supporting and are used as fire barriers in reinforced concrete or steel buildings. They are usually of brick or block masonry construction, occuying the space between floor and roof slab extended to parapet height and between paired columns and beams and other stiffening elements. They do not allow for structural ties to adjacent framing, and they must not lie in the probable path of any collapsing building framing that might pull the wall over. In reinforced concrete structures, upsetting of these walls by framing collapse is not a factor.

Freestanding walls must be structurally sufficient to resist seismic loads without support from the building's structural frames. To accomplish this the wall must be internally reinforced or supported by pilasters and tie beams spaced so as not to exceed a factor of 30 times the thickness of brick walls or by a factor of 20 times the thickness of block masonry walls. Freestanding walls have limited lateral stability; hence, when used as fire walls, they require special design consideration to assure a vertical position when subject to lateral loads. These loads include unbalanced forces caused by (1) wind entering portions of the building, with an uncontrolled fire on one side; (2) the overturning forces created by unequal expansion of the wall itself or expansion of steel frames on the fire side of the wall; (3) the forces from flashings as they pull away from the wall when the building framing on the fire side fails; and (4) seismic loads.

Design for a minimum lateral force of 24 kg/m^2 is necessary. Seismic considerations frequently will exceed this minimum requirement. High freestanding walls should be avoided because of the difficulty and cost of providing adequate vertical strength. Double tied walls where fire divisions can be coordinated with double column expansion joints are usually more cost effective for high walls.

Clearance is another design consideration with freestanding walls in steel frame structures. To permit free expansion of steel framing under normal conditions, a 2.5 cm. to 5 cm. clear space must be provided on both sides of the wall between it and the structural framing. Under fire conditions, the space must be calculated

according to the perpendicular length of the unrestrained structure on each side of the wall and the maximum thermal expansion of the steel prior to stress failure. Tied wall pairs must be similarly spaced

MATERIALS/PRODUCTS

A. FIRE DOORS

Doorways and other openings in fire walls that separate important warehouse areas weaken the fire wall as a fire barrier and require the best protection available. Even well-protected openings offer less fire resistance than a solid wall. The number and size of openings in fire walls should be kept to a minimum. Floor openings, open stairways, and other direct openings between different levels of a building are difficult to protect, and they should also be avoided. Openings, when present, must be protected by appropriately rated fire doors that are factory labeled.

Vision panels may be installed in fire doors, depending upon the protection rating and where the doors are used. The maximum permissible exposed glass area for door types and applications can be found in the UL Building Materials Directory. The operating mechanisms used with a fire door is a critically important part of the overall door installation. Only UL listed or FM approved systems shall be used.

The quality of sliding fire doors shall be that of the Richard-Wilcox Manufacturing Company, 174 Third Street, Aurora, IL 60507, USA; and of coiling fire doors, the Cornell Iron Works, Crestwood Industrial Park, Mountain Top, PA 18707, USA, or Southwestern Rolling Steel Door Co., 9525 White Rock Trail, Dallas, TX 75238, USA; or equal. Swinging fire doors must be self-closing and self-latching with UL rated counterweight, spring hinge or hydraulic closers and latchbolts.

B. FIRE DOOR SELECTION CRITERIA

Selection of a suitable fire door is primarily dependent upon its intended use, available clearances, and appearance. The following steps are helpful in selecting the appropriate fire door:

- determine the fire resistance of the wall in which the opening will be located, and select a fire door assembly that has an equal or greater fire-protection rating
- fire walls having a rating of more than 3 hours require a 3 hour rated automatic-closing door on each side of the wall opening
- rolling-steel fire doors may be used where rigid doors having insulation value prove impractical because of space limitations
- single fire doors that close the entire opening without a center joint are preferred; the center joint of fire doors mounted in pairs is a weakness and it must be rabbeted or provided with an astragal
- paired fire doors are useful where wall space is limited and where conveyors or other obstructions in the opening are such that the doors can be arranged to close around them
- fire doors that also serve as exit doors must swing in the direction of the exit travel. Horizontal-sliding doors must not be used as emergency exit doors
- specify assemblies requiring simple closing hardware rather than those with complicated arrangements
- specify the hardware, frame, operator units, and related devices as part of the assembly when purchasing fire doors, because these items are a part of the standard fire door package and are vitally important to the overall installation

C. METHODS OF FIRE DOOR OPERATION

Sliding fire doors on **inclined tracks** are normally balanced by a counterweight for ease of operation. Either a single door at one side of the opening or two doors, one at each side of the opening, may be used. Closing is by gravity when the fusible link melts and releases the counterweight. The single slide installation is most commonly used because it is the simplest in construction and operation, easily maintained, and requires a minimum of floor space.

Sliding fire doors on **level tracks** are normally provided with a closing counterweight that engages a cable mounted device when a fusible link melts and releases the counterweight.

As with inclined-track installations, level-track installations may have single or two center-parting doors. The chief application of level track is where clearance above the doorway is minimal. Because of their more complicated closing equipment, particularly when mounted in pairs, these types of fire doors are potentially

less reliable than sliding fire doors on inclined tracks.

Swing type hollow-metal fire door assemblies are designed to accomodate fusible-link-operated door closers or magnetic door holders. The latter device is designed to release the door upon interruption of an electrical circuit, and it will fail safe. The interruption may be by approved smoke detectors or other devices responsive to heat or smoke. Appropriately rated swinging hollow-metal or metal-clad doors can be arranged for automatic closing under fire conditions. A fusible link releases a heavy closing weight that drops into a tensioning weight that is used to keep the closing chain taut, and both weights work to close the door. Doors arranged to swing in pairs are equipped with a coordinator that will permit the active leaf to close last. Hardware provisions for these double openings must include appropriate latch devices to maintain the doors in a closed position. Various types of approved fire-exit hardware, either flush or surface mounted, are available for this application.

Rolling-steel doors are designed to be used as both service and fire doors for closing a wall opening at any time. They are equipped with a mechanism that closes the door automatically from any position upon release of the fusible linkage. One or more coil torsion springs provide counterbalancing for normal use and under fire conditions drive the door to the closed position. Adjustments of the counterbalancing mechanism should be made by factory-trained servicemen or employees. Rolling steel doors cannot be used, in required emergency exit locations where swinging doors would be acceptable.

There is maximum size limitation on fire rated doors (12 m^2). Where larger openings are necessary and require protection, the practice is to use oversize doors that are of the same design and construction as those that have been fire-tested. Doors that bear the word "oversize" on the label are authorized for this use.

EXECUTION

A. FIRE DOOR INSTALLATION

Use fire-resistive construction for lintels and door framing, preferably block masonry, reinforced concrete, or protected steel.

All fire doors must be self-closing by means of weights. They may be held open by a fusible linkage or other heat or smoke-responsive device that will release the door automatically in case of fire. These quick-operating releases are preferred for openings other than exits. Install the releasing device where it will be promptly affected by heat or smoke passing through the opening and where it will be protected against mechanical damage.

Install doors in accordance with the manufacturer's instructions to insure proper operation and tightness. Doors that are designed for mounting on the face of the wall usually are sized to provide a 10 cm. or wider lap or rabbet at the top and sides of the opening. Provide proper clearance for rolling-steel fire doors or other types of fire doors that operate in channel guides to allow for expansion and to prevent buckling under fire conditions. Bolt channel guides and supporting brackets to the wall through slotted holes to permit thermal expansion. The bolts should be held tight by lead or fiber washers that melt or char in a fire, thus permitting movement. Use approved hardware, and if concrete jambs and lintels are not provided, extend all track-supporting bolts completely through the wall.

Provide protective posts, guards, or boxes where damage to fire doors and their accessories by supplies on pallets or materials handling equipment could make them inoperative. Provide slots in counterweight boxes to permit raising the weights manually for testing the doors. Hang counterweights on single, telescoping, and counterbalanced vertical-sliding doors by a chain or braided wire cable for reasons of personnel safety.

B. TESTING

An acceptance inspection shall be held with the contractor, architect, resident engineer, and any other designated owner's representative to review the function and operation of all fire doors installed.

FIRE DAMPERS

GENERAL

A. SCOPE

This specification covers materials and techniques to be used in establishing requirements for fire dampers installed in air duct systems to prevent the spread of fire, heat, and smoke throughout a building. Fire dampers are mechanical devices with fusible linkages that are installed in duct work at specified locations.

B. RELATED WORK SPECIFIED ELSEWHERE

A-14 Cleanable Suspended Ceilings
M-01 Air Handling Units
M-03 Fans and Fan Drives
M-07 Duct Work
M-08 Duct Insulation
F-07 Fire Barriers

C. CODES AND STANDARDS

Fire dampers shall be UL (Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL 60062, USA) listed, located where specified and in accordance with local codes, and properly installed in accordance with the manufacturer's recommendations. Should installation requirements conflict, the approving authority's requirements shall take precedence.

D. SUBMITTALS

The contractor shall submit the manufacturer's shop drawings to the architect/engineer for review and approval.

MATERIALS/PRODUCTS

Fire dampers equivalent to those of Air Balance, Inc., 260 N. Elm Street, Westfield, MA 01085, USA, shall be specified.

EXECUTION

Fire dampers shall be provided at the following duct work locations where a duct penetrates a:

- fire wall
- fire partition
- wall of a vertical fire-resistant shaft, both the inlet and outlet
- ceiling of a fire resistant-floor and ceiling assembly
- fire-resistant rated corridor wall unless the building is completely protected by an automatic sprinkler system

Fire dampers are also required:

- at each inlet or outlet to a vertical duct in a duct system that serves two or more floors, or at each

point the duct penetrates the floor it serves and at the point where each branch duct penetrates the enclosure (e.g., shaft) for a main vertical duct; or, if the vertical duct extends through one floor only, at each point where the floor is penetrated

- where an aluminum duct, regardless of size, passes through a fire-resistant floor unless encased in approved noncombustible walls
- where fresh air intakes are located, except where exposure to potentially drawing in a fire from an adjacent structure is very low
- where ducts installed above a fire-resistant ceiling (viz., certain types of suspended ceilings) penetrate the ceiling if required to maintain the fire-resistance rating of the floor, roof, or ceiling area above or below.

Recirculating type ventilation systems also require:

- a fire damper on the downstream side of the supply fan
- an exhaust fan arrangement that changes to 100 percent exhaust upon activation of a smoke detector or fire damper
- 100 percent exhaust of air containing flammable or potentially toxic gases or vapors or potentially toxic or combustible dusts

Fire dampers are not required for the following conditions:

- in duct work systems serving only one floor and used only to exhaust air to the exterior and not penetrating a fire wall, a fire partition, or passing through a vertical shaft.
- where a duct of less than 130 cm^2 in cross sectional area and not constructed of aluminum penetrates the floor only once and that only supplies an air-conditioning unit (i.e., fan coil unit), or where a branch duct of the same dimensions and materials that penetrates a fire rated shaft only supplies an air-conditioning unit that, in turn, discharges air at a level not higher than 1.2 m. above the floor

The following is an exception to the above criteria:

- exhausts of a single pass system to vertical ducts in shafts that penetrate floors may omit dampers