COLLEGE OF ENGINEERING INDUSTRY PROGRAM

LIBRARY AGREEMENT

Materials issued under the College of Engineering Industry Program are distributed to subscribers only. However, with restrictions to protect the authors and subscribers, certain Industry Program materials are available for students to read in the Engineering Library. Any copying must involve only short passages or specific data to be used in connection with classwork, and with no intention of publication. Also, information must be kept confidential when there appears any possibility of prejudicing the proprietary rights of authors or sponsoring agencies.

College of Engineering Industry Program issue entitled:
General procedure in the specifications for structural engineering as applied to chemical plant construction.

by H.A. Ohlgren, J.J. Lewis, & Mary Wack, has been used in the Library by the following persons, whose signatures attest their acceptance of the above restrictions:

Name and Address	Date

COLLEGE OF ENGINEERING

UNIVERSITY OF MICHIGAN

ANN ARBOR

GENERAL PROCEDURE AND SPECIFICATIONS FOR STRUCTURAL ENGINEERING AS APPLIED TO CHEMICAL PLANT CONSTRUCTION

by

H. A. Ohlgren

J. G. Lewis

Marx Weech

November 1, 1954

ACKNOWLEDGMENT

An effort has been made to collect a vast amount of information in a complex field of construction and building activity, so that general procedures and guideposts can be made available to engineers throughout American industry in various phases of research, development, design, and plant operation dealing with civil engineering and structural engineering aspects of plant additions, modifications, and new construction.

The authors have not endeavored to discuss the specifics of structural engineering since it is felt that there are many expert specialists in the country better qualified to present such information. This manual has been prepared so that the engineering aspects in this area can be coordinated with areas of engineering in vessel design, mechanical equipment, piping, electrical, and other general engineering subjects.

We wish to express appreciation to Mr. Charles King, Structural Engineer, for the excellent contribution he has made in providing basic information on reinforced concrete as well as other structural aspects; Mr. Henry LaCroix, Foster Wheeler Corporation, for advice and suggestions in construction and detailed design engineering; and Mr. George Kopetz, Vice President, Chemical Plants Division, Blaw-Knox Company, for much of the background and philosophy orginally portrayed.

The issuance of this manual has been possible only through the secretarial efforts of Miss Joan Kinne and Miss Jean Bennett as well as the Reports Office of the Engineering Research Institute, University of Michigan.

D. STRUCTURAL

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

D. STRUCTURAL D1.00

D1.00 GENERAL CONDITIONS FOR ENGINEERING CONSTRUCTION

1.01--DEFINITIONS

(a) The Contract Documents consist of the Argeement, the General Conditions of the Contract, the Drawings and Specifications, including all modifications thereof incorporated in the documents before their execution. These form the Contract.

(b) The Owner, the Contractor and the Engineer are those mentioned as such in the Agreement. They are treated throughout the Contract Documents as if each were of the singular number and masculine gender.

(c) Wherever in this Contract the word Engineer is used it shall be understood as referring to the Engineer of the owner, acting personally or through an assistant duly authorized in writing for such act by the Engineer.

(d) Written notice shall be deemed to have been duly served if delivered in person to the individual or to a member of the firm or to an officer of the corporation for whom it is intended, or if delivered at or sent by registered mail to the last business address known to him who gives the notice.

(e) The term Subcontractor, as employed herein, includes only those having a direct contact with the Contractor and it includes one who furnishes material worked to a special design according to the plans or specifications of this work, but does not include one who merely furnishes material not so worked.

(f) The term "work" of the Contractor or Subcontractor includes labor or materials or both, equipment, transportation, or other facilities necessary to complete the Contract.

(g) All time limits stated in the Contract Documents are of the essence of the Contract.

1.02--EXECUTION, CORRELATION AND INTENT OF DOCUMENTS

The Contract Documents shall be signed in duplicate by the Owner and the Contractor. In case the Owner and the Contractor fail to sign the General Conditions, Drawings, or Specifications, the Engineer shall identify them.

The Contract Documents are complementary, and what is called for by any one shall be as binding as if called for by all. The intention of the documents is to include all labor and materials, equipment and transportation necessary for the proper execution of the work. It is not intended, however, that materials or work not covered by or properly inferable from any heading, branch, class or trade of the specifications shall be supplied unless distinctly so noted on the drawings. Materials or work described in words which so applied have a well-known technical or trade meaning shall be held to refer to such recognized standards.

1.03--DETAIL DRAWINGS AND INSTRUCTIONS

The Engineer shall furnish with reasonable promptness additional instructions, by means of drawings or otherwise, necessary for the proper execution of the work. All such drawings and instructions shall be consistent with the Contract Documents, true developments thereof, and reasonably inferable therefrom.

1.04--COPIES OF DRAWINGS FURNISHED

Unless otherwise provided in the Contract Documents the Engineer will furnish to the Contractor, free of charge, all copies of drawings and specifications reasonably necessary for the execution of the work.

1.05--ORDER OF COMPLETION

The Contractor shall submit, at such times as may be requested by the Engineer, schedules which shall show the order in which the Contractor proposes to carry on the work with dates at which the Contract will start the several parts of the work and estimated dates of completion of the several parts.

1.06--DRAWINGS AND SPECIFICATIONS ON THE WORK

The Contractor shall keep one copy of all drawings and specifications on the work, in good order, available to the Engineer and to his representatives.

1.07--OWNERSHIP OF DRAWINGS

All drawings, specifications and copies thereof furnished by the Engineer are his property. They are not to be used on other work and, with the exception of the signed Contract set, are to be returned to him on request at the completion of the work. All models are the property of the Owner.

1.08--CONTRACTOR'S UNDERSTANDING

It is understood and agreed that the Contractor has, by careful examination, satisfied himself as to the nature and location of the work, the conformation of the ground, the character, quality and quantity of the materials to be encountered, the character of equipment and facilities needed preliminary to and during the prosecution of the work, the general and local conditions, and all other matters which can in any way affect the work under this Contract. No verbal agreement or conversation with any officer, agent or employee of the Owner, either before or after the execution of this contract, shall affect or modify any of the terms or obligations herein contained.

1.09--MATERIALS, APPLIANCES, EMPLOYEES

Unless otherwise stipulated, the Contractor shall provide and pay for all materials, labor, water, tools, equipment, light, power, transportation and other facilities necessary for the execution and completion of the work.

Unless otherwise specified, all materials shall be new and both workmanship and materials shall be of a good quality. The Contractor shall, if required, furnish satisfactory evidence as to the kind and quality of materials.

The Contractor shall at all times enforce strict discipline and good order among his employees, and shall not employ on the work any unfit person or any one not skilled in the work assigned to him.

1.10--ROYALTIES AND PATENTS

The Contractor shall pay all royalties and license fees. He shall defend all suits or claims for infringement of any patent rights and shall save the Owner harmless from loss on account thereof, except that the Owner shall be responsible for all such loss when a particular process or the product of a particular manufacturer or manufacturers is specified, but if the Contractor has information that the process or article specified is an infringement of a patent he shall be responsible for such loss unless he promptly gives such information to the Engineer.

1.11--SURVEYS, PERMITS AND REGULATIONS

The Owner shall furnish all surveys unless otherwise specified. Permits and licenses of a temporary nature necessary for the prosecution of the work shall be secured and paid for by the Contractor. Permits, licenses and easements for permanent structures or permanent changes in existing facilities shall be secured and paid for by the Owner, unless otherwise specified.

The Contractor shall give all notices and comply with all laws, ordinances, rules and regulations bearing on the conduct of the work as drawn and specified. If the Contractor observes that the drawings and specifications are at variance therewith, he shall promptly notify the Engineer in writing, and any necessary changes shall be adjusted as provided in the Contract for changes in the work. If the Contractor performs any work knowing it to be contrary to such laws, ordinances, rules and regulations, and without such notice to the Engineer, he shall bear all costs arising therefrom.

1.12--PROTECTION OF WORK AND PROPERTY

The Contractor shall continuously maintain adequate protection of all his work from damage and shall protect the Owner's property from injury or loss arising in connection with this Contract. He shall make good any such damage, injury or loss, except such as may be directly due to errors in the Contract Documents or caused by agents or employees of the Owner. He shall adequately protect adjacent property as provided by law and Contract Documents. He shall provide and maintain all passage ways, guard fences, lights and other facilities for protection required by public authority or local conditions.

In an emergency affecting the safety of life or of the work or of adjoining property, the Contractor, without special instruction or authorization from the Engineer, is hereby permitted to act, at his

discretion, to prevent such threatened loss or injury, and he shall so act, without appeal, if so instructed or authorized. Any compensation claimed by the Contractor on account of emergency work, shall be determined by agreement or arbitration.

1.13--INSPECTION OF WORK

The Engineer and his representatives shall at all times have access to work wherever it is in preparation or progress and the Contractor shall provide proper facilities for such access and for inspection.

If the specifications, the Engineer's instructions, laws, or ordinances or any public authority require any work to be specially tested or approved, the Contractor shall give the Engineer timely notice of its readiness for inspection, and if the inspection is by another authority than the Engineer, of the date fixed for such inspection. Inspections by the Engineer shall be promptly made, and where practicable at the source of supply. If any work should be covered up without approval or consent of the Engineer, it must, if required by the Engineer, be uncovered for examination at the Contractor's expense.

Re-examination of questioned work may be ordered by the Engineer and if so ordered the work must be uncovered by the Contractor. If such work be found in accordance with the Contract Documents the Owner shall pay the cost of re-examination and replacement. If such work be found not in accordance with the Contract documents the Contractor shall pay such

cost, unless he shall show that the defect in the work was caused by another Contractor, and in that event the Owner shall pay the cost.

1.14--SUPERINTENDENCE: SUPERVISION

The Contractor shall keep on his work during its progress a competent superintendent and any necessary assistants, all satisfactory to the Engineer. The superintendent shall not be changed except with the consent of the Engineer, unless the superintendent proves to be unsatisfactory to the Contractor and ceases to be in his employ. The superintendent shall represent the Contractor in his absence and all directions given to him shall be as binding as if given to the Contractor. Important directions shall be confirmed in writing to the Contractor. Other directions shall be so confirmed on written request in each case. The Contractor shall give efficient supervision to the work, using his best skill and attention.

If the Contractor, in the course of the work, finds any discrepancy between the drawings and the physical conditions of the locality, or any errors or omissions in drawings or in the layout as given by points and instructions, it shall be his duty to inform immediately the Engineer, in writing, and the Engineer shall promptly verify the same. Any work done after such discovery, until authorized, will be done at the Contractor's risk.

Neither party shall employ or hire any employee of the other party without his consent.

1.15--CHANGES IN THE WORK

The Owner, without invalidating the Contract, may order extra work or make changes by altering, adding to or deducting from the work; the Contract Sum being adjusted accordingly. All such work shall be executed under the conditions of the original Contract except that any claim for extension of time caused thereby shall be adjusted at the time of ordering such change.

In giving instructions, the Engineer shall have authority to make minor changes in the work, not involving extra cost, and not inconsistent with the purpose of the work, but otherwise, except in an emergency endangering life or property, no extra work or change shall be made unless in pursuance of a written order by the Engineer, and no claim for an addition to the Contract Sum shall be valid unless so ordered.

The value of any such extra work or change shall be determined in one or more of the following ways:

(a) By estimate and acceptance in a lump sum.

(b) By unit prices named in the Contract or subsequently agreed upon.

(c) By cost and percentage or by cost and a fixed fee.

If none of the above methods is agreed upon, the Contractor, provided he receives an order as above, shall proceed with the work. In such case and also under case (c), he shall keep and present in such form

as the Engineer may direct, a correct account of the net cost of labor and materials, together with vouchers. In any case, the Engineer shall certify to the amount, including reasonable allowance for overhead and profit, due to the Contractor. Pending final determination of value, payments on account of changes shall be made on the Engineer's estimate.

1.16--CLAIMS FOR EXTRA COST

If the Contractor claims that any instructions by drawings or otherwise involve extra cost under this Contract, he shall give the Engineer written notice thereof within a reasonable time after the receipt of such instructions, and in any event before proceeding to execute the work, except in emergency endangering life or property, and the procedure shall then be as provided for changes in the work. No such claim shall be valid unless so made.

1.17--DEDUCTIONS FOR UNCORRECTED WORK

If the Engineer deems it expedient to correct work injured or done not in accordance with the Contract, an equitable deduction from the Contract price shall be made therefor.

1.18--DELAYS AND EXTENSION OF TIME

If the Contractor be delayed at any time in the progress of the work by any act or neglect of the Owner or of his employees, or by any other Contractor employed by the Owner, or by changes ordered in the work,

or by strikes, lockouts, fire, unusual delay in transportation, unavoidable casualties or any causes beyond the Contractor's control, or by delay authorized by the Engineer pending arbitration, or by any case which the Engineer shall decide to justify the delay, then the time of completion shall be extended for such reasonable time as the Engineer may decide.

No such extension shall be made for delay occurring more than seven days before claim therefor is made in writing to the Engineer. In the case of a continuing cause of delay only one claim is necessary.

If no schedule or agreement stating the dates upon which drawings shall be furnished is made then no claim for delay shall be allowed on account of failure to furnish drawings until two weeks after demand for such drawings and not then unless such claim be reasonable.

This article does not exclude the recovery of damages for delay by either party under other provisions in the Contract Documents.

1.19--CORRECTION OF WORK BEFORE FINAL PAYMENT

The Contractor shall promptly remove from the premises all materials condemned by the Engineer as failing to conform to the Contract, whether incorporated in the work or not, and the Contractor shall promptly replace and re-execute his own work in accordance with the Contract and without expense to the Owner and shall bear the expense of making good all work of other contractors destroyed or damaged by such removal or replacement.

If the Contractor does not remove such condemned work and materials within a reasonable time, fixed by written notice, the Owner may remove them and may store the material at the expense of the Contractor. If the Contractor does not pay the expense of such removal within ten days' time thereafter, the Owner may, upon ten days' notice, sell such materials at auction or at private sale and shall account for the net proceeds thereof, after deducting all the costs and expenses that should have been borne by the Contractor.

1.20--SUSPENSION OF WORK

The Owner may at any time suspend the work, or any part thereof by giving a days' notice to the Contractor in writing. The work shall be resumed by the Contractor within ten (10) days after the date fixed in the written notice from the Owner to the Contractor so to do. The Owner shall reimburse the Contractor for expense incurred by the Contractor in connection with the work under this Contract as a result of such suspension.

But if the work or any part thereof shall be stopped by the notice in writing aforesaid, and if the Owner does not give notice in writing to the Contractor to resume work at a date within __ days of the date fixed in the written notice to suspend, then the Contractor may abandon that portion of the work so suspended and he will be entitled to the estimates and payments for all work done on the portions so abandoned, if any.

1.21--THE OWNER'S RIGHT TO DO WORK

If the Contractor should neglect to prosecute the work properly or fail to perform any provision of this Contract, the Owner, after three days' written notice to the Contractor, may, without prejudice to any other remedy he may have, make good such deficiencies and may deduct the cost thereof from the payment then or thereafter due the Contractor.

1.22--THE OWNER'S RIGHT TO TERMINATE CONTRACT

If the Contractor should be adjudged a bankrupt, or if he should make a general assignment for the benefit of his creditors, or if a receiver should be appointed on account of his insolvency, or if he should persistently or repeatedly refuse or should fail, except in cases for which extension of time is provided, to supply enough properly skilled workmen or proper materials, or if he should fail to make prompt payment to subcontractors or for material or labor, or persistently disregard laws, ordinances or the instructions of the Engineer, or otherwise be guilty of a substantial violation of any provision of the contract, then the Owner upon the certificate of the Engineer that sufficient cause exists to justify such action, may without prejudice to any other right or remedy and after giving the Contractor seven days' written notice, terminate the employment of the Contractor and take possession of the premises and of all materials, tools, and appliances thereon and finish the work by whatever method he may deem expedient. In such case the Contractor shall not

be entitled to receive any further payment until the work is finished. If the unpaid balance of the Contract price shall exceed the expense of finishing the work, including compensation for additional managerial and administrative services, such excess shall be paid to the Contractor. If such expense shall exceed such unpaid balance, the Contractor shall pay the difference to the Owner. The expense incurred by the Owner as herein provided, and the damage incurred through the Contractor's default, shall be certified by the Engineer.

1.23--CONTRACTOR'S RIGHT TO STOP WORK OR TERMINATE CONTRACT

If the work should be stopped under an order of any court, or other public authority, for a period of three months, through no act or fault of the Contractor or of anyone employed by him, or if the Engineer should fail to issue any estimate for payment within seven days after it is due, or if the Owner should fail to pay the Contractor within seven days of its maturity and presentation, any sum certified by the Engineer or awarded by arbitrators, then the Contractor may, upon seven days' written notice to the Owner and the Engineer, stop work or terminate this Contract and recover from the Owner payment for all work executed and any loss sustained upon any plant or materials and reasonable profit and damages.

1.24--REMOVAL OF EQUIPMENT

In the case of annulment of this Contract before completion from any cause whatever, the Contractor, if notified to do so by the Owner, shall promptly remove any part or all of his equipment and supplies from the property of the Owner, failing which the Owner shall have the right to remove such equipment and supplies at the expense of the Contractor.

1.25--USE OF COMPLETED PORTIONS

The Owner shall have the right to take possession of and use any completed or partially completed portions of the work, notwithstanding the time for completing the entire work or such portions may not have expired but such taking possession and use shall not be deemed an acceptance of any work not completed in accordance with the Contract Documents. If such prior use increases the cost of or delays the work, the Contractor shall be entitled to such extra compensation, or extension of time, or both, as the Engineer may determine.

1.26--PAYMENT WITHHELD

The Owner may withhold or, on account of subsequently discovered evidence, nulify the whole or a part of any certificate to such extent as may be necessary to protect himself from loss on account of:

(a) Defective work not remedied.

(b) Claims filed or reasonable evidence indicating probable filing of claims.

(c) Failure of the Contractor to make payments properly to subcontractors or for material or labor.

(d) A reasonable doubt that the Contract can be completed for the balance then unpaid.

(e) Damage to another Contractor.

When the above grounds are removed payment shall be made for amounts withheld because of them.

1.27--CONTRACTOR'S LIABILITY INSURANCE

The Contractor shall maintain such insurance as will protect him from claims under workmen's compensation acts and from any other claims for damages for personal injury, including death, which may arise from operations under this Contract, whether such operations be by himself or by any subcontractor or anyone directly or indirectly employed by either of them. Certificates of such insurance shall be filed with the Engineer, if he so require, and shall be subject to his approval for adequacy of protection.

1.28--INDEMNITY

The Contractor shall indemnify and save harmless the Owner from and against all losses and all claims, demands, payments, suits, actions, recoveries and judgments of every nature and description brought or recovered against him, by reason of any act or omission of the said Contract, his agents or employees, in execution of the work or in the guarding of it.

The Contractor shall, and is hereby authorized to, maintain and pay for such insurance, issued in the name of the Owner, as will protect the Owner from his contingent liability under this Contract, and the Owner's right to enforce against the Contractor any provision of this article shall be contingent upon the full compliance by the Owner with the terms of such insurance policy or policies, a copy of which shall be deposited with the Owner.

1.29--FIRE INSURANCE

The Contractor shall secure, in the name of the Owner, policies of fire insurance in amount, form and companies satisfactory to the Engineer, upon such structures and material as shall be specified by the latter, payable to the Owner for the benefit of the Contractor or the Owner, as the Engineer shall find their interests to appear.

1.30--GUARANTY BONDS

The Owner shall have the right, prior to the signing of the Contract, to require the Contractor to furnish bond covering the faithful performance of the Contract and the payment of all obligations arising thereunder, in such form as the Owner may prescribe and with such sureties as he may approve. If such bond is required by instructions given previous to the receipt of bids, the premium shall be paid by the Contractor; if subsequent thereto, it shall be paid by the Owner.

1.31--DAMAGES

Any claim for damage arising under this Contract shall be made in writing to the party liable within a reasonable time of the first observance of such damage and not later than the time of final payment, except as expressly stipulated otherwise in the case of faulty work or materials, and shall be adjusted by agreement or arbitration.

1.32--LIENS

Neither the final payment nor any part of the retained percentage shall become due until the Contractor, if required, shall deliver to the Owner a complete release of all liens arising out of this Contract, or receipts in full lieu thereof and, if required in either case, an affidavit that so far as he has knowledge or information the releases and receipts include all the labor and material for which a lien could be filed; but the Contractor may, if any subcontractor refuses to furnish a release or receipt in full, furnish a bond satisfactory to the Engineer to indemnify the Owner against any lien. If any lien remains unsatisfied after all payments are made the Contractor shall refund to the Owner all money that the latter may be compelled to pay in discharging such a lien, including all costs and a reasonable attorney's fee.

1.33--ASSIGNMENT

Neither party to the Contract shall assign the Contract or sublet it as a whole without the written consent of the other, nor shall the Contractor assign any moneys due or to become due to him hereunder, without the previous written consent of the Engineer.

1.34--RIGHTS OF VARIOUS INTERESTS

Wherever work being done by the Owner's forces or by other contractors if contiguous to work covered by this Contract the respective rights of the various interests involved shall be established by the Engineer, to secure the completion of the various portions of the work in general harmony.

1.35--SEPARATE CONTRACTS

The Owner reserves the right to let other contracts in connection with this work. The Contractor shall afford other contractors reasonable opportunity for the introduction and storage of their materials and the execution of their work, and shall properly connect and coordinate his work with theirs.

If any part of the Contractor's work depends for proper execution or results upon the work of any other contractor, the Contractor shall inspect and promptly report to the Engineer any defects in such work that render it unsuitable for such proper execution and results. His failure so to inspect and report shall constitute an acceptance of

the other contractor's work as fit and proper for the reception of his work except as the defects which may develop in the other contractor's work after the execution of his work.

To insure the proper execution of his subsequent work the Contractor shall measure work already in place and shall at once report to the Engineer any discrepancy between the executed work and the drawings.

1.36--SUBCONTRACTS

The Contractor shall, as soon as practicable after the signature of the Contract, notify the Engineer in writing of the names of subcontractors proposed for the work and shall not employ any that the Engineer may within a reasonable time object as incompetent or unfit.

The Contractor agrees that he is fully responsible to the Owner for the acts and omissions of his subcontractors and of persons either directly or indirectly employed by them, as he is for the acts and omissions of persons directly employed by him.

Nothing contained in the Contract Documents shall create any contractural relation between any subcontractor and the Owner.

1.37--POINTS AND INSTRUCTIONS

The Contractor shall provide reasonable and necessary opportunities and facilities for setting points and making measurements. He shall not proceed until he has made timely demand upon the Engineer for, and has received from him, such points and instructions as may be necessary

as the work progresses. The work shall be done in strict conformity with such points and instructions.

The Contractor shall carefully preserve bench marks, reference points and stakes, and in case of willful or careless destruction, he shall be charged with the resulting expense and shall be responsible for any mistakes that may be caused by their unnecessary loss or distrubance.

1.38--ENGINEER'S STATUS

The Engineer shall have general supervision and direction of the work. He has authority to stop the work whenever such stoppage may be necessary to insure the proper execution of the Contract. He shall also have authority to reject all work and materials which do not conform to the Contract, to direct the application of forces to any portion of the work, as in his judgment is required, and to order the force increased and diminished, and to decide questions which arise in the execution of the work.

1.39--ENGINEER'S DECISIONS

The Engineer shall, within a reasonable time after their presentation to him, make decisions in writing on all claims of the Owner or the Contractor and on all other matters relating to the execution and progress of the work or the interpretation of the Contract Documents.

All such decisions of the Engineer shall be final except in cases where time and/or financial considerations are involved, which, if no agreement in regard thereto is reached, shall be subject to arbitration.

1.40--ARBITRATION

(a) Demand for Arbitration. Any decision of the Engineer which is subject to arbitration shall be submitted to arbitration upon the demand of either party to the dispute.

The Contractor shall not cause a delay of the work because of the pendency of arbitration proceedings, except with the written permission of the Engineer, and then only until the arbitrators shall have an opportunity to determine whether or not the work shall continue until they decide the matters in dispute.

The demand for arbitration shall be delivered in writing to the Engineer and the adverse party, either personally or by registered mail to the last known address of each, within ten days of the receipt of the Engineer's decision, and in no case after final payment has been accepted except as otherwise expressly stipulated in the Contract Documents. If the Engineer fails to make a decision within a reasonable time, a demand for arbitration may be made as if his decision had been rendered against the demanding party.

(b) Arbitrators. No one shall be nominated or act as an arbitrator who is in any way financially interested in this Contract or in the

business affairs of the Owner, or the Contractor, or the Engineer, or otherwise connected with any of them. Each arbitrator shall be a person generally familiar with the work or the problem involved in the dispute submitted to arbitration.

Unless otherwise provided by controlling statutes, the parties may agree upon one arbitrator; otherwise there shall be three, one named in writing, by each party to this Contract, to the other party, and the third chosen by those two arbitrators or if they should fail to select a third within fifteen days, then he shall be appointed by the presiding officer, if a disinterested party, of the Bar Association nearest to the location of the work.* Should the party demanding arbitration fail to name an arbitrator within ten days of his demand, his right to arbitrations shall lapse. Should the other party fail to name an arbitrator within said ten days then said* presiding officer shall appoint such arbitrator within ten days, and upon his failure so to do then such arbitrator shall be appointed on the petition of the party demanding arbitration by a judge of the Federal Court in the district where such arbitration is to be held.

---

*To provide some other agency for appointing arbitrators strike out reference to presiding officer of the Bar Association and insert desired designation. In the vicinity of New York, the Arbitration Society of American, Inc., and the Chamber of Commerce of the State of New York have Arbitration Committees which often act in this capacity.

The said* presiding officer shall have the power to declare the position of any arbitrator vacant by reason or refusal or inability to act, sickness, death, resignation, absence or neglect. Any vacancy shall be filled by the party making the original appointment, and unless so filled within five days after the same has been declared, it shall be filled by the said* presiding officer. If testimony has been taken before a vacancy has been filled, the matter must be reheard unless a rehearing is waived in the submission or by the written consent of the parties.

If there be one arbitrator his decision shall be binding; if three, the decision of any two shall be binding in respect to both the matters submitted to and the procedure followed during the arbitration. Such decision shall be a condition precedent to any right of legal action.

(c) Arbitration Procedure. The arbitrators shall deliver a written notice to each of the parties and to the Engineer, either personally or by registered mail to the last known address of each, of the time and place for the beginning of the hearing of the matters submitted to them. Each party may submit to the arbitrators such evidence and argument as he may desire and the arbitrators may consider pertinent.

---

*See footnote on page 23.

The arbitrators shall, however, be the judges of all matters of law and fact relating to both the subject matters of and the procedure during arbitration and shall not be bound by technical rules of law or procedure. They may hear evidence in whatever form they desire. The parties may be represented before them by such person as each may select, subject to the disciplinary power of the arbitrators if such representative shall interfere with the orderly or speedy conduct of the proceedings.

Each party and the Engineer shall supply the arbitrators with such papers and information as they may demand, or with any witness whose movements are subject to their respective control, and upon refusal or neglect to comply with such demands the arbitrators may render their decision without the evidence which might have been elicited therefrom, and the absence of such evidence shall afford no ground for challenge of the award by the party refusing or neglecting to comply with such demand.

The submission to arbitration (the statement of the matters in dispute between the parties to be passed by the arbitrators) shall be in writing duly acknowleged before a notary. Unless waived in writing by both parties to the arbitration, the arbitrators, before hearing testimony, shall be sworn by an officer authorized by law to administer an oath, faithfully and fairly to hear and examine the matters in controversy and to make a just award according to the best of their understanding.

The arbitrators, if they deem the case demands it, are authorized to award to the party whose contention is sustained such sums as they shall consider proper for the time, expense and trouble incident to the arbitration, and if the arbitration was demanded without reasonable cause, damages for delay and other losses. The arbitrators shall fix their own compensation, unless otherwise provided by agreement, and shall assess the costs and charges of the arbitration upon either or both parties.

The award of the arbitrators shall be in writing and acknowledged like a deed to be recorded, and a duplicate shall be delivered personally or by registered mail, forthwith upon its rendition, to each of the parties to the controversy and to the Engineer. Judgment may be rendered upon the award by the Federal Court or the highest State Court having jurisdiction to render same.

The award of the arbitrators shall not be open to objection on account of the form of the proceedings or the award, unless otherwise provided by the controlling statutes. In the event of such statutes providing on any matter covered by this Article otherwise than as hereinunder specified, the method of procedure throughout and the legal effect of the award shall be wholly in accord with said statutes, it being the intention hereby to lay down a principle of action to be followed, leaving its local application to be adapted to the legal requirements of the jurisdiction having authority over the arbitration.

The Engineer shall not be deemed a party to the dispute. He is given the right to appear before the arbitrators to explain the basis of his decision and give such evidence as they may require.

1.41--LANDS FOR WORK

The Owner shall provide the lands upon which the work under this Contract is to be done, except that the Contractor shall provide land required for the erection of temporary construction facilities and storage of his material, together with right of access to same.

1.42--CLEANING UP

The Contractor shall, as directed by the Engineer, remove from the Owner's property and from all public and private property, at his own expense, all temporary structures, rubbish and waste materials resulting from his operation.

D2.00 PREPARATION OF PROCEDURES

2.1--GENERAL

When it is recognized that drawings and/or specifications can be used again to advantage in future contracts, design and construction activities, they shall be submitted as proposed procedures. Necessary sketches and supporting data shall be submitted to clarify said procedure.

Subject Classification

Procedures shall be developed under definite subject classifications. If for instance one is developed for "girder-to-column connections", the appropriate subject heading shall be Buildings. "Buildings" would in turn be placed under the subheading of "Structural Steel".

Editing and Approval

A preliminary draft shall be prepared. Three copies shall be submitted.

Illustrations accompanying a preliminary draft shall be in pencil with all pertinent data shown thereon. These sketches will be redrawn on 8-1/2" x 11" forms. Upon editing, they shall be reproduced and copies distributed for general interplant comment.

Following the receipt of all comments, the proposed Procedures shall be modified as required and approved. Distribution to all interested parties shall follow.

Distribution

In addition to those released to engineering groups, Procedures shall also be distributed to other departments. All such manuals shall be numbered and noted to whom assigned. They are to be regarded as information which remains the property of the Company.

2.2--BILL OF MATERIALS

A Bill of Materials shall be prepared and clearly indicated on all drawings where possible. The responsibility for its preparation shall rest with the squad leader. Where a number of drawings occur for any one unit or group of units, a Bill of Materials may be prepared on one or more separate sheets as required. However, a policy of cross-referencing must be followed.

2.3--PURCHASE REQUISITIONS

As quickly as bills of material and required specifications are completed, corresponding purchase requisitions shall be prepared in rough draft form. This rough draft together with required specifications and necessary explanatory drawings which have been approved for construction shall be attached and submitted to the design engineer for approval and subsequent processing.

The rough draft purchase requisition must give the following information:

1. Date
2. Suggested Vendor

3. Destination of Shipment
4. Date required
5. Project Number
6. Name of Individual proposing the Purchase Requisition
7. Materials designation for all items
8. Use to which items will be put
9. Approval by department head
10. Purchase Requisition No.

After the design engineer's approval, necessary revisions, additions, and corrections having been made, the purchase requisition shall be prepared in final form and submitted together with illustrative drawings and specifications to the procurement section.

The squad leader should make it his duty to keep an up-to-date record of every purchase requisition and its status. He need be concerned only with requisitions from his own section or with those he prepares.

D3.00 CIVIL ENGINEERING

3.01--SITE PREPARATION AND GRADING

These detailed specifications on "Site Preparation and Grading" are hereby incorporated in and made a part of the general specifications on Civil Engineering to which they are attached.

Section I. Site Preparation

Scope of Work. The scope of work shall be that as shown on the plans and as outlined further in the invitation to bidders.

Relocation or Demolition of Existing Buildings or Structures. This specification shall state precisely the nature of the work, safeguards to be observed, the disposition of debris as well as of salvageable material, if any, and such other applicable provisions as apply to the specific project.

Clearing and Grubbing. The area within limits shown on the plans shall be cleared of fences, trees, logs, stumps, brush, vegetation, rubbish, and other perishable or objectionable matter. Stumps and roots between slope stakes in cuts and in embankments 3 feet or less in depth shall be removed to a depth of 18 inches below subgrade. Outside of slope limits and under embankments more than 3 feet deep, all trees, stumps, brush, etc. shall be cut off approximately level with the surface, except growth designated for preservation.

Spoiled material shall be burned or removed to approved disposal areas. Ashes shall be spread or removed as the engineer may direct.

Section II. Boring for Structures

Scope of Work. This contract shall include the making of all borings at points shown on the plot plans and as specified herein.

Work not included in this contract will be test pits.

Workmanship and Methods. Location of borings shall be approximately as shown on the plans.

The depth of borings shall be designated on the plans. However, if rock is encountered before reaching the required depth, core borings shall be made to a depth carrying the boring 5 feet into the rock.

Boring through earth shall be made with a 2-1/2 inch extra heavy casing in five foot lengths. Earth shall be removed by jetting or blowing, and dry samples shall be taken by driving sample spoon one foot and 0 inch below the casing. If this does not produce sample on account of softness of ground, the sample shall be driven deeper and a slotted-hole-type spoon used.

Boring in hard strata or rock shall be made by the chilled shot or diamond drill method. If material is soft rock, a diamond drill equipped with a double core barrel of such construction that the drilling water is fed to the bit without coming in contact with the core shall be used.

Samples. Samples of earth shall be taken every 5 feet and 0 inch and at any point where material changes in character.

Rock cores shall not be less than 1-1/8 inches in diameter.

Samples shall be sealed in watertight containers and shipped to office of the engineer. They shall have labels giving the following information; number of boring, elevations of sample, and material.

Drawings. The contractor shall furnish a boring plan showing location and numbers of holes, and he shall plot vertical sections showing material encountered referred to datum, number of blows per linear foot, weight of casing, weight of hammer and drop of hammer, and groundwater level for all holes when encountered.

Section III. Excavation and Grading for Structures

Scope of Work. The scope of work shall be all excavation and grading for structures, pits, trenches, and other work as shown on the plans. Not included will be preparation of site, excavation, trenching and backfilling for utility systems.

Borings and Exploration Pits. Borings and subsurface data shown on plans shall be for general information only, and variation therefrom shall not affect the terms of the contract.

Stripping of Topsoil. See applicable portions of specifications for "Grading for Roads, and Railroads".

Excavation Limits for Structures. Excavation and shoring shall be kept within 2 feet of the neat lines of structure foundations. Depending upon the area of work involved the Engineer will specify the angle that shall be used for embankment slopes. Where required, special shoring shall be specified.

Excavation Below Elevations Shown on the Plan. If filling is not authorized by the engineer, the excavation shall be filled with 1:3:6 stone concrete by the contractor without cost to the owner.

Drainage of Excavated Areas. Grading in vicinity of structures shall be controlled to prevent surface water from running into excavated areas.

Protection of Adjacent Buildings and Existing Structures. Excavations will not be permitted below existing building foundations until underpinning and shoring to be performed by others or by this contractor have been completely installed and inspected. All existing structures, pipes, and foundations which are to be incorporated into the final work shall be adequately protected or replaced by the contractor without cost to the owner.

Stockpiles. Excavated material to be used for backfill shall be stockpiled. Stockpiling shall take place in a manner designated by the engineer.

Waste. Excess material from excavation not suitable or required for backfill or filling shall be wasted in accordance with directions from the engineer.

Rock Excavation. Blasting shall be done in accordance with local ordinances by skilled operators, and precautions shall be taken to avoid damage. Rock shall be removed by line drilling where called for on the plans and where directed by the engineer.

Classification of Excavated Materials. All excavated materials shall be classified as earth or rock. Earth shall be classed as all material except rock. Rock shall be classes as ledge rock, concrete or masonry structures which require drilling or blasting, and boulders larger than 1/3 cu yd in volume.

Grading. See applicable specification for "Grading for Roads and Railroads".

Base for Slabs on Fill. Fill to support paving may or may not be made from excavated material. Soil containing organic matter is unsuitable. Fill shall be compacted in 8 inch layers with a 5-ton roller. Hand or mechanical tampers shall be used for places inaccessible to roller. All walls liable to be disturbed by tamping or rolling shall be shored.

Backfilling. All timber shall be removed and all trash shall be cleaned out from the excavation. Backfill shall be excavated material or other material as directed by the engineer. Backfill shall be placed in 8 inch layers and compacted by hand tamping. Backfill may be puddled if it contains less than 10% clay. Surface of backfill shall be left 6 inches above final grade to allow for settlement. After 3 months the contractor shall return and fill low spots.

Clean-up. All trash shall be removed. All excavated area shall be raked clean.

3.02--RAILROADS

These detailed specifications on "Railroads" are hereby incorporated in and made a part of the specifications on "Civil Engineering" to which they are attached.

Section I. Scope of Work

Work Included. This contract shall include preparation of site, excavation, grading, furnishing and installing drainage pipes and structures, ballast, ties, rails, and accessories as shown on the plans.

Section II. Preparation of Site

Site preparation shall be in accordance with D3.01 of this specification.

Section III. Excavation and Grading

Excavation and Grading shall be done in accordance with D3.01, D3.03, and D3.04 as outlined in the relevant detailed Civil Engineering Specification.

Section IV. Drainage and Drainage Structures

All culverts under embankments shall be placed before any filling is done. All culverts under tracks shall be in place before track laying is begun. Drainage pipes shall be laid upon firm earth conforming to the established grade. For bell and spigot pipe the trench shall be shaped to

accommodate the bell portion of the pipe. Backfilling by hand to provide adequate cover and cushion, and designated by the engineer, shall be done.

In no case shall drainage structures or pipes be placed upon fills without compliance with directions to be given by the Owner.

Section V. Materials

All materials shall conform to applicable specifications of the A.R.E.A. manual, latest edition, or specifications of using railroad, and as follows:

Ballast. Ballast shall be crushed stone, gravel, cinders, or slag. Maximum size of stone or gravel shall pass through 2-1/2 inch ring; minimum size shall not pass a 1/2 inch ring. Gravel shall contain min. 15% max. 30% sand.

Cross Ties. Cross ties shall be treated oak or pine. They shall be treated with 10 pounds of creosote per cubic foot of material. Their minimum dimensions shall be 8 inches wide by 6 inches thick for sidings and temporary work. Minimum dimensions for permanent work shall conform to the standards set forth by the using railroad. Their length shall be 8 foot and 6 inches.

Switch Ties. Switch ties shall be treated oak or pine. They shall be treated with 10 pounds of creosote per cubic foot of material. Their minimum dimensions shall be 9 inches wide by 7 inches deep and the tie shall have the length as specified on the drawings at switch and frog locations.

Rails shall be new or relayer. Use relayer for sidings only. Rails shall conform to the weight shown on the plans. Relayer rail shall be free from physical defects, flat spots, wheel burns, and excessive head flow and shall be reasonably straight with fairly smooth surfaces. The rails shall be in standard lengths with not more than 10% of shorts varying in length by 1 foot. Topwear, measured at the center, shall not exceed 1/4 inch. Side wear shall not exceed 15% of the original dimension.

Splice Bars, Track Bolts, and Nutlocks. Splice bar, track bolts, and nutlocks shall be new or used and of size, shape, and drilling to fit the rail.

Tie Plates. Tie plates shall be new or used and fit the base of the rail.

Track-spikes shall be cut spikes. For use with 100-lb. rail and over shall be 5/8 inch by 6 inches; under 100-lb. rail, may be 9/16 inch by 5-1/2 inches.

Turnouts and Crossovers. All switches, switch stands, frogs, guard rails, etc. shall be new or used as specified on the plans.

Section VI. Railroad-Track Construction

Placing Ties. Ties shall be spaced as shown on the plans; ties shall be laid with wider heartwood face down and normal to the center line of the track. Space shall be equidistant from rail joints and support rails at end of splice bars. One end of the ties shall be aligned.

Ties shall be moved only with tongs. Ties shall not be moved or placed beneath rails with picks, mauls, sledges, or spiking hammers.

Track Laying. Rail shall be laid with staggered joints; i.e., the joints on rail shall be located as nearly as possible opposite the middle of the other rail. Temporary shims shall be used to secure proper spacing between ends of rail, and the rail temperature at the time of laying shall determine the number and thickness of shims required. Rail joints shall not be located nearer than 5 feet from either end of a trestle or bridge.

Tie Plates. Tie plates shall be set in correct position on the ties, true to gage, and with shoulders in full contact with the rail. Where tie plates are not required, the rail will make full contact with the tie. Tie plates to be used on curves, turnouts, crossovers, and in the cases of heavy loading shall be set and aligned according to the plans.

Splice bars shall be secured in place with the full number of bolts, nuts, and nutlocks. Bolts shall be staggered, with heads placed inside and outside alternately, and shall be drawn tight before spiking. After the track has been put into service, and before acceptance of the work, all bolts shall be checked and tightened as required.

Spiking. Rails shall be fully spiked promptly after laying. Spikes shall be set vertically and driven with the face of the spike in contact with the base of the rail to full bearing on the rail base.

On tangents, 2 spikes to the rail shall be used on each tie. On curves, 3 spikes to the rail for each tie shall be used, the extra spike being place on the side of the rail facing the centerline of the track. Spikes shall be staggered to avoid splitting ties. Track shall be gaged at joints, centers, and quarters as the spikes are driven, and the gage shall not be removed until the spikes are driven home. Gaging shall be accurate in all respects.

Turnouts. Turnouts shall conform dimensionally and be installed to the standards of American Railway Engineers' Association for the frog number used. Low switch stands shall be used and securely fastened to head blocks laid normal to the track, with targets clearly lined.

Ballasting. After track is laid ballast shall be placed to bring track to grade. If ballast is shipped in hopper cars it may be unloaded and spread by having one or more hoppers open and allowing the required material to flow as the car moves slowly along the track. Ties or timber may be placed across the tracks in front of the car wheels just behind the the open hopper to facilitate spreading.

Surfacing. After track has been ballasted, it shall promptly be brought to final grade and surfaced. Jacks for raising track shall be placed close enough together to prevent bending of the rail or strain on joints. Both rails shall be raised uniformly. All ties pulled loose shall be spiked securely in proper position with full bearing on tie

plates. Each tie shall be thoroughly tamped between a point 15 inches inside each rail and the end of the tie.

Final Adjustments. Two months after the track has been accepted and put in operation, the contractor shall perform necessary resurfacing adjustments without cost to owner to leave the track in alignment and on grade.

Connections to Main-Line Tracks. Connection to main-line tracks shall be made in accordance with any supplementary plans furnished, and in general shall comply with the using railroad's standards.

Section VII. Grade Crossings

Grade crossings shall be constructed as shown on the plans. Timber shall be oak, gum, or yellow pine, creosoted with 10 pounds per cubic foot. Paving (if used) shall be bituminous concrete.

Section VIII. Bumpers and Wheel Stops

Bumpers and wheel stops shall be constructed as shown on the plans.

Section IX. Cribbing

Cribbing shall be constructed as shown on the plans.

Section X. Clean-Up

All surplus material and trash shall be cleared from the right-of-way and removed from the site.

3.03--HIGHWAYS AND ROADS

These detailed specifications on "Highways and Roads" are hereby incorporated in and made a part of the general specifications on Civil Engineering to which they are attached.

Section I. Location

Location of all highways and roads shall be made only after thorough study of existing travel data and expected additional use. Complete studies shall include reconnaissance, preliminary lines and mass diagrams.

Rights-of-Way. Rights-of-way shall be of dimension which will accommodate future widening without involving added difficult construction problems. Minimum widths for highway right-of-ways shall be 150 feet, and for secondary and feeder roads the minimum width shall be 60 feet. Said widths shall be shown clearly on the plans.

Grades. In locations for primary highways the ruling grade shall be 5%. An absolute maximum grade shall be 7%. However, this maximum grade shall be used only if substantial savings are possible by its use. This maximum grade shall only be used for distances less than 1500 feet. Where level grades are used the ditches shall have a minimum grade of 0.5 of one percent.

Sight Distances. Sight distances for highways shall be not less than 800 feet. Only in exceptional cases shall grade undulations on tangents allow oncoming vehicles to disappear completely within a section of

the road immediately visible to the driver. In these cases a close study of ideal construction and economical construction shall be made to determine the best alignment.

Curvature. Curvature shall be made standard, care being exercised not to mislead traffic by sudden variations. Minimum radii of curvature shall be used commensurate with terrain and construction costs. In general, the curvature shall conform to the natural swing or directional bend of the country through which the right-of-way passes.

Section II. Design of the Roadway

Roadway design shall be governed by the location, use, availability of materials selected and type of surfacing. In general, the design shall conform to local standards. In areas where the roadway will be subject to drifting snow it shall be constructed primarily on fill to simplify snow removal problems.

Width of Lanes. The minimum width of lanes shall be 20 feet for main highways. Widths may be reduced for feeder and secondary roads with the consent of the engineer.

Drainage. Adequate drainage shall be provided as shown on the plans. Slopes of embankments, cuts, fills, etc. shall be designed so that a minimum of erosion will occur. Where required in earthen ditches used for drainage seeding or sodding shall be done to prevent erosive action.

Section. The roadway section shall be designed according to the standards adopted by the American Society of State Highway Engineers.

Landscaping shall be considered on all locations. Planting and seeding shall be done to aid in roadside appearance. Ragged borrow pits and undesirable outside prisms shall be avoided. Care shall be exercised to maintain and use any existing greenery such as trees, shrubs, etc., transplanting where possible.

Landscaping shall be done in accordance with the standards adopted by the American Society of State Highway Officials.

3.04--GRADING FOR ROADS AND RAILROADS

These specifications on grading for roads and railroads are hereby incorporated in and made a part of the specifications on "Civil Engineering" to which they are attached.

Section I. Scope of Work

Construction of embankment and grading shall be in accordance with the plans and specifications.

Section II. Stripping and Spreading of Topsoil

All topsoil shall be stripped from areas to be paved, excavated, or filled, and from other areas as shown on plans. If possible, the depth of topsoil to stripped shall be indicated. Topsoil shall be stored in stockpiles, the location of which shall be selected by the engineer or as shown on the plans.

On areas shown on plans to receive topsoil, the subgrade shall be scarified to a depth of 2 inches for the bonding of the topsoil with the subsoil. Hand shoveling and raking will be required, followed by rolling with one pass of a flat roller weighing not more than 100 pounds per linear foot and not less than 25 pounds per linear foot. On slopes steeper than 4:1 the topsoil shall be rammed or tamped in place as directed by the engineer.

Areas to be sodded shall receive 3 inches of topsoil; areas to be seeded shall receive 6 inches of topsoil.

Section III. Excavation

Excavation shall conform to limits indicated on the plans or specified herein.

Excavation shall not be made below grade except where rock or stone masonry is encountered or removal of unstable material is directed by the engineer.

Excavated material suitable for embankments or fills shall be stored, if required, to minimize the use of borrow.

Borrow. Where required to complete the embankment or fill, the contractor shall provide the necessary additional material. The source and quality of borrow material shall be approved by the engineer.

The contractor shall give the engineer at least 5 days' notice before removing borrow material from any unapproved borrow area.

Rock Excavation. Rock excavation shall include removal of ledge rock, concrete or masonry structures which require drilling of blasting, and boulders larger than 1/3 cubic yard in volume.

Rock shall be conserved if required for purposes shown on the plans, or for any other purpose, as the engineer may direct.

Ledge rock, boulders, concrete or masonry structures shall be removed to a minimum depth of 12 inches below subgrade and backfilled with approved material thoroughly compacted.

Drainage. Spring or seepage water encountered shall be reported to the engineer if drainage is not provided for by the plans. The

contractor shall keep the excavation free from water at all times by pumping or otherwise.

Excess of Disapproved Excavated Material shall be disposed of as directed by the engineer.

Section IV. Embankment and Fills

Fills shall not be started until the area has been inspected and approved by the engineer.

Embankment and fill material shall be free from frost, stumps, trees, roots, sod, or such. Only approved material from excavation or borrow pits shall be used.

Preparing Ground Surface. Sloped surfaces steeper than 4:1 shall be scarified or stepped and compacted to provide bond on new material.

When existing roadways are to be covered with less than 1 foot of fill the surface shall be scarified and compacted to the same density as adjacent areas.

When fill is to be placed over wet ground that will not support the weight of trucks or other equipment, the lower part of the fill shall be made with sand gravel, or other selected material deposited in a blanket layer no deeper than necessary to support the operating equipment. Top 9 inches of blanket layer shall be compacted to required density before subsequent layers are placed.

Construction Methods. Excavated material shall be so handled, conserved, stored, and placed as to have the least desirable material at the bottom of embankments, grading up to the best material at the top.

Sandy Soils. Sandy soils shall be placed in 4 inch to 6 inch layers and compacted with caterpillar tractor, tamping roller, or smooth-wheel roller weighing 8 to 10 tons.

Clay Soils. Clay soils shall be placed in 8 inch maximum layers and compacted with light tamping roller.

Glacial Till. Glacial till shall be placed in 8 inch maximum layers and compacted with heavy tamping roller.

The contractor may use other equipment if approved.

Places inaccessible to roller shall be compacted with mechanical or hand tampers.

Final rolling of top layer shall be with a smooth-wheel power roller weighing 8 to 10 tons.

Stones in earth fill shall be well distributed. No stones over 4 inch diameter shall be within 12 inches of finished subgrade.

Each layer shall be free of ruts and shall meet compaction requirements before succeeding layer is placed. Layers shall be maintained with crown or slope to provide drainage and prevent erosion.

At least the top 6 inches of pavement subgrade shall be of selected granular material.

Rock Fill. In embankments or fills, rock may be any maximum size if uniformly graded. All voids shall be completely filled with fine material and compacted to form a dense mass.

The fill for a thickness of at least 2 feet below the finished subgrade shall be selected earth material placed and compacted in layers to the degree specified below.

Operation of Equipment. Operation of equipment shall be distributed to avoid rutting and unequal compaction.

Protection of Structures. Culverts, headwalls, and other structures shall be constructed before fill is placed. Fill around culverts, headwalls, or other structures shall be carefully and symmetrically placed in 6- to 8-inch layers and shall be compacted to the degree specified below.

Section V. Compaction Requirements (Specify one of the following)

Test-Controlled Compaction. (Use for large or important projects.) In construction of embankments and preparation of subgrades, all soils shall be compacted to 90% of maximum density at optimum moisture as determined by A.S.T M. D-698, except that soils for a depth of 9 inches below pavement subgrades in both cuts and embankments shall be compacted to not less than 95%.

Soils which weigh less than 100 lb. per cu. ft. shall be wasted or mixed with heavier soils to obtain the required weight.

When material varies from optimum moisture content, it shall be treated as follows:

When wet it shall be drained or worked until optimum moisture content is attained. When dry it shall be sprinkled with water and mixed until optimum moisture content is attained.

Practical Control. (Use only where test control is not warranted by size or importance of project.) In construction of embankments and preparation of subgrades the soil shall be treated and worked so as to be damp but not wet.

If tamping rollers are used, 10 or more passes will be required on each layer as directed by the engineer.

When smooth-wheel power rollers weighing 8 to 10 tons are approved and used, the layer shall be rolled until no weaving or creeping appears ahead of the roller.

Section VI. Subgrade Preparation (Specify one of the following)

In cut areas the subgrade shall be scarified and compacted to 95% of maximum unit weight at optimum moisture for a depth of at least 6 inches. See paragraph V above.

In cut areas the subgrade shall be scarified and compacted for a depth of at least 6 inches by rolling with a 3-wheel power roller weighing 8 to 10 tons.

Rough subgrades shall be formed and compacted in accordance with the plans within a tolerance of 1-1/2 inches.

Soft areas in subgrade shall be reinforced with crushed stone, gravel, or telford as directed by the engineer. These areas shall be drained as directed by the engineer.

Final rolling of subgrade shall be with 3-wheel power rollers weighing 8 to 10 tons.

Rough subgrades, including slopes and ditches, shall be formed and maintained to provide proper drainage.

Section VII. Fine Grading of Subgrade (This item may be included as part of the contract covering the construction of the base course or pavement.)

Rough subgrade shall be cleaned of all loose or foreign material and reshaped if rutted. Approved material shall be added to meet required grade. Shaping and compacting shall be done with blade graders and a 3-wheel power roller weighing 8 to 10 tons. Soft spots shall be reinforced and drained as specified in Section VI above.

Tolerances. Finished surface shall be smooth and even and shall not vary more than 3/8 inch in 10 feet from true profile and cross section or more than 1/2 inch from true elevation.

Section VIII. Shoulder Construction

Where trench method of construction is to be used for pavement, sides shall be cut to vertical face at proposed edge of pavement.

Shoulder material shall be placed in uniform layers for full width and thickness. Each layer shall be compacted by rolling. Roller shall overlap shoulder when rolling both base course and pavement. Finished shoulder shall be firm against pavement.

Drainage shall be provided for pavement subgrade at low points.

Section IX. Finishing Slopes and Surfaces

All areas shall be finished to smooth, compact surfaces in conformity with the plans.

Slopes. Blade grader or scraper finish will or will not be allowed. Hand shovel finish will or will not be required.

Shoulders, Ditches, and Gutters. Hand shovel and raking finish will be required.

Maintenance. Finished work shall be drained and maintained in accordance with the plans until final acceptance.

Section X. Tests (For test-controlled compaction, see Section V above.)

The contractor shall provide labor, material, and transportation for the following tests and sampling. The engineer shall provide expert services and testing and sampling equipment.

Sampling. The engineer shall follow A.S.T.M. methods of sampling.

Laboratory Tests. Methods of test shall be the latest revision of the following:

Dry weights when compacted at optimum moisture of various types of soil.	A.S.T.M. D-698	No. of tests as required to provide a control for moisture and density field tests.

Field Tests

Measure content. Dryweight of compacted soil.	At least one for every 500 sq. yd. on each layer or sufficient number of tests to insure thorough and uniform compaction. Additional tests if soil or moisture conditions change.

Auger boring shall be made as directed by the engineer when there are indications of poor material underlying subgrade.

3.05--PILING

These detailed specifications on "Piling" are hereby incorporated in and made a part of the general specifications on "Civil Engineering" to which they are attached.

Section I. Scope

Work Included: This contract shall include the furnishing and driving of all piles shown on the drawings.

Work not Included: Pile caps.

Section II. Type of Piles

Cast-in-Place Concrete Piles. Type A. These piles shall be formed by driving a shell to the required bearing, leaving the shell permanently in place, and filling it with concrete. Shells shall have sufficient strength and rigidity to permit their being driven and not to be distorted by soil pressure or the driving of adjacent piles; they shall be sufficiently watertight to exclude water during placing of concrete. Piles may be tapered or cylindrical. If tapered they shall increase uniformly in diameter or the diameter shall increase in uniform steps. The minimum diameter of tapered piles shall be 8 inches at the point and 14 inches at the head. The average diameter shall not be less than 11 inches. The minimum diameter of cylindrical piles shall be 12-3/8 inches.

Cast-in-Place Concrete Piles. Type B. These piles shall be placed by driving a heavy steel pipe casing with an interior core or point to required depth, removing the core and inserting a permanent steel shell, filling it with concrete and then withdrawing the driving casing. Shells shall have sufficient strength and rigidity not to be distorted by soil pressure or the driving of adjacent piles, and they shall be sufficiently watertight to exclude water during the placing of concrete. Shells shall have a minimum diameter of 12-3/8 inches.

Cast-in-Place Concrete Piles. Type C. These piles shall be placed by driving a heavy steel pipe casing with an interior core or point to the required depth, removing the core, and filling the driving casing with concrete while withdrawing same. The inside of the driving pipe shall be at least 14 inches in diameter, and no driving pipe shall be withdrawn until all piles within 10 feet, center-to-center, have been driven.

Steel Pipe Piles Filled with Concrete. Steel pipe piles shall conform to the A.S.T.M. Specs. A252-42T. Piles shall have a minimum inside diameter of 10 inches and a minimum shell thickness of 3/8 inch except that the 10 inch and 12 inch piles may have a shell of 5/16 inch. They shall be driven without point but with open or with cast-steel point. Piles up to 20 feet in length shall be in one piece. Piles from 20 to 40 feet shall have not more than one splice. For longer piles, splices shall not be closer together than 20 feet.

Precast Concrete Piles. Precast concrete piles shall be of size and detail shown on plans. The concrete used in precast concrete piles shall have a compressive strength at 28 days of 4000 psi. In general, the concrete shall be prepared and handled according to the applicable specification and structural concrete.

No high-early-strength cement shall be used. Forms must be tight and rigid. Piles shall be marked with casting date and shall be cured for 30 days without handling or moving and at minimum temperature of 50°F.

The contractor shall drive enough test piles to determine the length of pile required to secure the specified bearing and to determine required penetrations in the various areas of the work. These tests shall be made sufficiently in advance of the pile driving to prevent delay in the progress of work and so that the contractor will have on hand, at all times, piles of proper length to meet any conditions that may arise.

Composite Piles. Composite piles shall consist of a concrete section from the cut-off to 1 foot and 0 inch below water level superimposed upon a wood pile. Details of splice and dimensions of pile shall be in accordance with the drawings.

Wood Piles. Wood piles shall be sound, free from sharp crooks or bends or decay, and sufficiently straight so that a line drawn from the

center of the head to the point of the pile shall be wholly within the pile. The diameter of the point shall not be less than 7 inches for piles up to 40 feet in length and not less than 6 inches for piles longer than 40 feet. At a point 2 feet and 0 inch from the butt, piles less than 25 feet long shall have a minimum diameter of 10 inches; piles over 25 feet long shall have a minimum diameter of 12 inches. All measurements shall be made under bark.

Steel H Piles. Material shall conform to A.S.T.M. Spec. A7-36. Piles shall be structural steel sections as shown on the plans.

Section III. Lines and Levels

The contractor shall establish and locate all lines and levels and be responsible for the correct location of all piles.

Section IV. Concrete

The compressive strength of cast-in-place piles shall be 2500 psi after a period of 28 days. Control and ingredients shall conform to the applicable Owner's specification on Concrete Work. Concrete shall be placed by bottom-dump bucket device in piles well cleaned of material and water by blowing.

Section V. Records

The contractor shall keep a record of each pile driven and shall furnish signed typewritten copies daily. The records shall have the diameter, length, location, type, safe load, penetration under last five blows of hammer and the results of any other tests that may be performed.

Section VI. Drawings

The contractor shall submit for approval, before the award of the contract, complete detailed drawings and specifications of the different type of piles estimated upon and a written statement describing equipment to be used.

Section VII. Driving

Piles shall be driven with a drop hammer or with a single-acting steam hammer of Vulcan type, the weight of whose striking part times its fall is at least 15,000 foot pounds, to a safe bearing value of _____ tons, or to refusal for piles driven to rock or hard pan. The double-acting steam hammer of the standard McKierman-Terry type may be used when driving piles to refusal but shall not be used for other piles except with special permission of the owner.

The ratio of the weight of pile F and the weight of the striking part of the hammer W shall be between the following limits; F÷W = 1/10 minimum to F/W = 10 maximum.

The safe value of piles shall be determined by the following formula;

$$P = \frac{2WH}{S + 1} \text{ for drop hammer,}$$

$$P = \frac{2WH}{S + 0.1} \text{ for single-acting hammer,}$$

$$P = \frac{2(W + Ap)H}{S + 0.1} \text{ for double-acting steam hammer ,}$$

where P is the safe load in pounds, W is the weight of the striking part of the hammer in pounds, H is the fall in feet of the striking part of the hammer or stroke, S is the average penetration per blow in inches under the last five blows, A is the area of piston in square inches, and p is the mean effective steam pressure.

Driving shall be done with fixed leads which will hold the pile firmly in position and alignment and in axial alignment with the hammer. Suitable anvils or cushions, depending on the type of pile, shall be used to prevent undue damage of the pile butts.

Driving of all piles shall be continuous without intermission until the pile has been driven to final resistance. The tops of piles shall be cut off true and level at the elevations indicated on the drawings. All portions battered, split, warped or buckled, or damaged or imperfect in any way shall be removed.

Shells and casings shall have sufficient excess length to allow the complete removal of working tops. No tube or part of a tube that has been previously subjected to driving shall be used as a part of a pile.

After each group of casings is driven to the required resistances, all water and other material shall be removed and the shell shall be inspected with a light. The casings shall be free from water when the concrete is being placed. No piles in a cluster shall be filled until all the piles in the cluster are driven. Piles shall not be jetted except with the approval of the engineer. After jetting, piles shall be driven to the required resistance.

An upheaval of piling shall be corrected without extra cost to the owner and to the satisfaction of the engineer. The average pile length in a group shall be at least 10 feet.

Section VIII. Damaged and Misdriven Piles

Broken or shattered piles will not be accepted. Piles shall not be more than 2% out of plumb and not more than 3 inches out of place. Should any pile be damaged by overdriving or not conform to the tolerances of the specification, an extra pile or piles shall be driven in its place.

Piles rejected after driving may remain in the ground at the discretion of the engineer, be filled with concrete, and be cut off as directed. When rejected piling is withdrawn, the space, if another pile is not driven into it, shall be filled solid with gravel or broken stone without payment thereof.

Section IX. Obstructions

Where boulders or other obstructions make it impossible to drive certain piles in the location shown and to the proper bearing strata, the contractor shall resort to all usual method to install piles as required, including spudding, jetting, or other feasible means. If, in the judgment of the engineer, the contractor is unable to complete properly any pile by resorting to such methods, the engineer may order an additional pile or piles driven for which the contractor will be paid in accordance with unit prices in the contract. Piles abandoned because of obstructions encountered before reaching the accepted bearing strata shall be filled with concrete and be paid for as completed piles.

Where directed by the engineer, excavation operations will be conducted to remove obstructions at the owner's expense as covered in Section X, "Basis of Payment".

Section X. Basis of Payment

The contractor shall be paid for work within limits shown on the plan by lump sum or unit costs given in the contract. The contractor shall include in his bid unit prices for the following:

Both increase and decrease of the number of piles shown on the drawings, quoting a price per pile.

Both increase and decrease of total length of piling shown on the drawings, quoting a price per linear foot.

Use of pile driver for extra work such as spudding, jetting, etc., quoting a price per hour of operation.

Where obstructions require excavation or use of different type of piles, the contractor shall do the work on a time and material basis agreed upon in the contract.

Section XI. Tests

Laboratory Tests. Tests of cement, concrete, and aggregates shall conform to applicable portions of specifications for "Concrete Work".

Field Tests. One load test will be included in this contract. It shall be conducted as outlined in additional specifications supplied with the contract.

D4.00 CONCRETE WORK

4.01--GENERAL

These specifications cover the materials, quality, proportioning, testing, mixing, conveying, forms, reinforcement, depositing, and surface finish of structural concrete (including heavy duty and light duty concrete floor finishes) and constitute an integral part of purchase inquiries and contracts for concrete work.

Materials and workmanship shall be in strict accordance with these specifications and with the drawings covering the work to be performed. No changes or deviations will be permitted unless written approval is obtained from the contracting officer.

When the drawings indicate that connections are to be made to existing work, the Contractor shall perform all necessary cutting, patching and fitting required to make satisfactory connections with the proposed work and shall remove any materials called for on the drawings. It shall be the Contractor's responsibility to visit the job prior to accepting the contract to thoroughly familiarize himself with the work involved.

Depths of foundations shown on the drawings are assumed to be at an elevation for a sound bearing. However, before proceeding with any concrete form work, the Contractor must obtain approval from the Contracting Officer that the bearing surface satisfies design requirements. Additional cost resulting from changes in design or foundations shall be charged to the Contracting Officer on a unit price basis as agreed to prior to signing the Contract.

The contractor shall provide and install all pipe sleeves, castings, drainage cleanouts and other inserts and fixtures required by the drawings. All such sleeves, inserts and fixtures shall be accurately located and firmly held in position to prevent displacement during the placing of concrete. All items to be furnished by other than the Contractor will be noted on the drawings.

References to Standard Specifications of the American Society for Testing Materials (A.S.T.M.) are to the latest issue including all official amendments and revisions applying thereto, unless otherwise designated.

The "Detailed Specifications" on Concrete Work which are attached hereto are hereby incorporated in and made a part of these "General Specifications" on Concrete Work.

4.02--MATERIALS

These "Detailed Specifications" on materials are hereby incorporporated in and made a part of the "General Specifications" on Concrete Work to which they are attached.

All materials shall be of the respective qualities specified herein and shall be delivered, stored, and handled so as to prevent the inclusion of foreign materials, damage by water, breakage, etc. Packaged materials shall be delivered and stored in the original packages until ready for use. Materials showing evidence of deterioration, damage, etc. shall not be used and must be removed by the Contractor from the job site.

Portland cement shall conform to the Standard Specification for "Portland Cement" (A.S.T.M. designation C150).

Concrete aggregates shall conform to the Standard Specifications for "Concrete Aggregates" (A.S.T.M. designation C33). The size of the aggregate shall not be larger than one-fifth of the narrowest dimension between forms of the member for which the concrete is to be used and not larger than three-fourths of the minimum clear spacing between reinforcing bars.

Lightweight concrete aggregates shall conform to the Standard Specifications for "Lightweight Aggregates for Concrete" (A.S.T.M. designation C130).

Water used in mixing concrete shall be clean and free from injurious amounts of oil, acid, alkali, organic matter or other deleterious substances.

Concrete reinforcement bars shall be billet-steel deformed bars of intermediate grade and shall conform to the Standard Specifications for "Billet-Steel Bars for Concrete Reinforcement" (A.S.T.M. designation A185).

Expansion joint filler shall be premolded "Elastite" as manufactured by The Philip Carey Manufacturing Company, Inc., Cincinnati, Ohio, or approved equal.

Anchor bolts for steel columns, equipment, etc. shall be set in 20 gauge galvanized sheet steel or standard iron pipe sleeves, except where noted, having a length as called for on the drawing and an inside diameter approximately twice the diameter of the anchor bolt. After the columns, equipment, etc. have been set to alignment, cement grout shall be poured into the sleeves. Before concrete is poured the location of all sleeves shall be checked and metal or wooden covers shall be installed.

4.03--PROPORTIONING

These "Detailed Specifications" on proportioning are hereby incorporated in and made a part of the "General Specifications" on Concrete Work to which they are attached.

The allowable stresses for the design are based on the required minimum 28-day compressive strength of the concrete, or on the required minimum compressive strength at the earlier age at which the concrete may be expected to receive its full load. The strength of concrete at which the concrete may be expected to receive its full load. The strength of concrete at designated ages shall be specified on the drawings.

No concrete which will be permanently exposed to freezing weather shall have a water content exceeding 6 gallons per sack of cement.

The determination of the proportions of cement, aggregate and water to attain the required strengths shall be made by one of the two following methods. In most cases the method to be used will be indicated on the drawings. However, where no preference is shown, the contractor may select either method "A" or "B" and his bid must state the method selected.

METHOD "A" Concrete Made from Average Materials

When no preliminary tests of the materials are to be made, the water content per sack of cement shall not exceed the values in the following table:

*Water content U.S. Gal. per 94-lb. Sack of Cement	Assumed Compressive Strength at 28 Days, (lbs. per sq. in.)
6-3/4	2500
6	3000
5	3750

*In interpreting this table, surface water carried by the aggregate shall be included as a part of the mixing water.

In addition to the foregoing water requirements the concrete mix shall not contain less than 5-1/2 sacks of cement per yard of concrete for 2500 lb. strength, and 6 sacks for 3000 and 3750 lb. strengths.

METHOD "B" Controlled Concrete

Proportions of material and water content other than those shown in table under Method "A" may be used provided the required strength-quality of the concrete is established by tests. These tests shall be made before the start of operations, using the consistencies suitable for the work and in accordance with the Standard Method of "Making and Curing Concrete Compression and Flexure Test Specimens in the Laboratory" (A.S.T.M. designation C192) and the Standard Method of Test for "Compressive Strength of Molded Concrete Cylinders" (A.S.T.M. designation C39). A curve representing the relation between the water content and the average 28-day

compressive strength, or earlier strength at which the concrete is to receive its full working load, shall be prepared for a range of values which includes all the compressive strengths required by the drawings. The curve shall be plotted from at least three points with each point representing average values from a minimum of four test specimens. The amount of water used in the concrete, as determined from the curve, shall correspond to a strength which is 15 percent greater than that designated on the drawings. Substitution of material shall not be made unless tests made in accordance with the Specification indicate that the quality of the concrete will be satisfactory.

The Contractor shall submit the results of tests made and certified to by a recognized testing laboratory. Fine and coarse aggregates and water used with the proportions of cement shall be included. These tests shall be made at the Contractor's expense.

The proportions of the various materials in the concrete shall be approved by the Contracting Officer before any concrete is mixed. The Contracting Officer may require the proportions to be varied to secure concrete of proper consistency and strength.

The aggregate to cement proportions for any concrete shall be such as to produce a mixture which will work readily into the corners and angles of the forms and around the reinforcement without permitting the materials to segregate or excess free water to collect on the surface.

The combined aggregate shall be of such composition of sizes that when sifted on the No. 4 standard sieve, the weight passing the sieve (fine aggregate) shall not be less than 30 percent nor more than 50 percent of the total unless otherwise required by the Contracting Officer. These proportions may not necessarily apply to lightweight aggregates.

The methods of measuring concrete materials shall be accurately controlled and easily checked. Measurement of materials for ready-mixed concrete shall conform to the Standard Specifications for "Ready-Mixed Concrete" (A.S.T.M. designation C94).

The consistency shall be controlled by the slump tests described in the Standard Method of "Slump Test for Consistency of Portland-Cement-Concrete" (A.S.T.M. designation C143). The measured slump should range between a 3 inch minimum to a 5 inch maximum. However, if it is necessary and approved by the Contracting Officer the slump may be increased by the addition of water and cement in the same ratio as in the basic mix.

4.04--TESTING

These "Detailed Specifications" of Testing are hereby incorporated in and made a part of the "General Specifications" on Concrete Work to which they are attached.

Unless otherwise stipulated, all testing of materials shall be done by a testing laboratory to be appointed by the Contracting Officer.

When requested by the Contracting Officer, the Contractor shall provide for testing purposes representative samples of cement, fine aggregate, coarse aggregate mixed concrete, reinforcing steel or other materials to be used in the work. He shall also notify the testing laboratory of the sources and dates of shipment of the various materials with such notices to be given sufficiently in advance to permit the proper inspection and testing before shipment.

When concrete materials, proportions or consistency are to be inspected, the Contractor shall notify the testing laboratory sufficiently in advance of the date when such materials are to be used and mixed to permit proper inspections and tests.

The Contractor shall notify the testing laboratory each day that concrete is to be placed in order that an inspector may be at the site to secure samples of the mixed concrete.

In general, tests shall be made as hereinafter described although additional tests may be ordered by the Contracting Officer.

A minimum of three 6" x 12" cylinders will be molded by the testing laboratory each day that concrete is being placed. Not less than one 6" x 12" cylinder shall be made for each 100 cubic yards of concrete placed in a 24 hour period. Concrete for cylinders will be taken as it leaves the mixer or after it is placed in the work, as the Contracting Officer may direct. Two of each three cylinders shall be crushed after 7 days and the third 28 days after being molded. The Contracting Officer may order a change in the concrete proportions if the strength of the concrete is not up to requirements.

The taking and testing of concrete test cylinders shall conform to the standard method of "Making and Curing Concrete Compression and Flexure Test Specimens in the Field" (A.S.T.M. designation C31) and the standard method of "Compressive Strength of Molded Concrete Cylinders" (A.S.T.M. designation C39).

4.05--MIXING AND CONVEYING

These "Detailed Specifications" on mixing are hereby incorporated in and made a part of the "General Specifications" on Concrete Work to which they are attached.

The concrete shall be mixed until there is a uniform distribution of the materials and shall be discharged completely before the mixer is recharged.

For job-mixed concrete, the mixer shall be rotated at a speed recommended, by the manufacturer of the mixer. Mixing shall be continued for at least 1 minute after all materials are in the mixer.

Ready-mixed concrete shall be mixed and delivered in accordance with the requirements set forth in the Standard Specifications for "Ready-Mixed Concrete" (A.S.T.M. designation C94).

Concrete shall be conveyed from the mixer to the place of final deposit by methods which will prevent separation or loss of the material.

Equipment for chuting, pumping and pneumatically conveying concrete shall be of such size and design as to insure a practically continuous flow of concrete during depositing without separation of the material.

4.06--FORMS

These "Detailed Specifications" on forms are hereby incorporated in and made a part of the "General Specifications" on Concrete Work to which they are attached.

Forms shall conform to the shape, lines grades and dimensions of the concrete as shown on the drawings and shall be constructed of wood, steel or other approved material. Forms shall be of a type and strength that will produce true and smooth lines and surfaces. Lumber used for exposed surfaces of concrete shall be dressed to a uniform thickness; rough lumber may be used for unexposed surfaces. Forms may be omitted for foundations concrete if, in the opinion of the Contracting Officer, the sides of the excavation are sufficiently firm to permit taping of the concrete without yielding of the adjacent earth. If forms are omitted, design requirements must be insured by making the actual dimensions of the excavation slightly greater than the drawing dimensions of the foundations in order to compensate for the irregularity of the excavation.

Bolts, rods or other approved devices used for internal ties shall be so arranged that no metal will be within one inch of any surface after the forms are removed. Wire ties shall be used only on light work and shall not be used where discoloration would be objectionable.

Before concrete is placed, the inside of forms shall be thoroughly wetted with water. However, if subject to freezing a nonstaining mineral oil or other approved material shall be substituted. Any coating other than water shall be applied before reinforcement is placed.

Suitable moldings or bevels shall be placed in the angles of forms to round or bevel the edges of the concrete.

The removal of forms shall not be started until the concrete has attained the strength necessary to support its own weight, plus any construction live loads. Forms shall not be removed until the Contracting Officer's approval has been obtained and then in such a manner as not to injure the concrete.

4.07--REINFORCEMENT

These "Detailed Specifications" on reinforcement are hereby incorporated in and made a part of the General Specifications on Concrete Work to which they are attached.

At the time concrete is placed, metal reinforcement shall be free from rust, scale or other coating which will destroy or reduce the bond. Bends for stirrups and ties shall be made around a pin having a diameter not less than two times the minimum thickness of the bar. Hooks shall be a complete semicircular turn with a radius of bend on the axis of the bar of not less than three and not more than six bar diameters plus an extension of at least four bar diameters at the free end of the bar. Bends for other bars shall be made around a pin having a diameter not less than six times the minimum thickness of the bar, except that for bars larger than 1 inch the pin shall not be less than eight times the minimum thickness of the bar. All bars shall be bent cold.

Metal reinforcement shall be accurately placed in accordance with the drawings and adequately secured in position by concrete or metal chairs and spacers.

Splices of reinforcement at points of maximum stress shall generally be avoided in slabs, beams, and girders. Splices shall provide sufficient lap to transfer the stress between bars by bond and shear.

Where necessary, reinforcement may be offset but the slope of the inclined portion shall be not more than 1 in 6. Such offsets when used in column construction shall be located where lateral support is afforded by a concrete capital or floor slab.

Metal reinforcement shall be protected by the thickness of concrete shown on the drawings. Unless otherwise shown, the thickness of concrete over the reinforcement shall be as follows:

A. Where concrete is deposited against the ground without the use of forms, not less than 3 inches.

B. Where concrete is exposed to the weather or the ground, and placed in forms, not less than 2 inches for bars more than 5/8-inch diameter and 1-1/2 inches for bars 5/8-inch diameter or less.

C. In slabs and walls not exposed to the ground or weather, not less than 3/4 inch.

D. In beams, girders and columns not exposed to the ground or weather, not less than 1-1/2 inches.

Exposed reinforcement bars intended for bonding with future extensions or additions shall be protected from corrosion by an adequate covering approved by the Contracting Officer.

4.08--DEPOSITION

These "Detailed Specifications" on deposition are hereby incorporated in and made a part of the "General Specifications" on Concrete Work to which they are attached.

Concrete shall be deposited as nearly as practicable in its final position to avoid segregation due to rehandling or flowing. Concreting shall be carried on at a rate such that the concrete is at all times plastic and flows readily into the space between the bars. Concrete that has partially hardened or been contaminated by foreign material shall not be deposited in the work, nor shall retempered concrete be used.

When concreting is started, it shall be carried on as a continuous operation until the placing of the panel or section is completed. The top surface shall generally be level. When construction joints are necessary they shall be made as hereinafter described.

All concrete shall be thoroughly compacted by suitable approved means (such as internal vibrators, form vibrators, hand rodding, or tamping) thoroughly worked around reinforcement and embedded fixtures and in the corners of the forms.

Where conditions make compacting difficult, or where the reinforcement is congested, batches of mortar containing the same proportion of cement to sand as used in the concrete shall first be deposited in the forms.

Provision shall be made for maintaining concrete in a moist condition for at least 7 days after the placement. However, for high-early-strength concrete, moist curing shall be provided for at least the first 3 days.

Adequate equipment shall be provided for heating the concrete materials and protecting the concrete during freezing or near-freezing weather. No frozen materials or materials containing ice shall be used.

All concrete materials and all reinforcement, form fillers and the ground with which the concrete is to come in contact shall be free from frost. Whenever the temperature of the surrounding air is below 40°F all concrete when placed in the forms shall have a temperature of between 70°F and 80°F. Adequate means shall thereafter be provided for maintaining a temperature of not less than 70°F for 3 days or 50°F for 5 days. When high-early-strength concrete is used, the temperature shall be maintained at not less than 70°F for 2 days or 50°F for 3 days or for as much more time as is necessary to insure proper curing of the concrete. The housing, covering or other protection used in connection with curing shall remain in place and intact at least 24 hours after the artificial heating is discontinued. No dependence shall be placed on salt or other chemicals for the prevention of freezing.

Manure when used for protection shall not be allowed to come in contact with the concrete.

At least 2 hours must elapse after depositing concrete in the columns or walls before depositing beams girders or slabs supported thereon. Beams, girders, brackets, column capitals and haunches shall be considered a part of the floor system and shall be placed integrally therewith.

Construction joints other than those shown on the drawings shall be made and located in such a manner as to impair least the strength of the structure. Where a joint is to be made, the surface of the concrete shall be thoroughly cleaned and all laitance removed. In addition, all joints shall be thoroughly wetted and slushed with a coat of neat cement grout immediately before the placing of new concrete.

If construction joints in floors, other than those shown in the drawings are required, they shall be located near the middle of the spans of slabs, beams or girders unless a beam intersects a girder at this point. In the latter case the joints in the girders shall be offset a distance equal to twice the width of the beam. In this last case provision shall be made for shear by use of inclined reinforcement.

4.09--SURFACE FINISH

These "Detailed Specifications" on surface finish are hereby incorporated in and made a part of the "General Specifications" on Concrete Work to which they are attached.

Voids which appear on removal of the forms shall be drenched with water and filled immediately with mortar of the same composition as that used in the body of the concrete and smoothed with a wooden float. Fins, bulges or offsets shall be nearly removed and finished as directed. Exposed surfaces of concrete shown on the drawings to receive other finishes shall be smoothed with a wooden float.

If, on removal of forms, the concrete is found to be so honeycombed or otherwise defective as to impair its strength, all defective portions shall be removed and replaced in a manner approved by the Contracting Officer.

4.10--HEAVY DUTY FLOOR FINISH

These "Detailed Specifications" on heavy duty floor finish are hereby incorporated in and made a part of the "General Specifications" on Concrete Work to which they are attached.

In locations where the drawings call for a heavy duty floor finish it is intended that a finish be provided which will successfully withstand heavy trucking or similar severe usage without dusting, disintegrating or cracking to any appreciable extent.

In general, the finish shall be composed of a low water cement ratio dry mix of practically no slump, placed by tamping or rolling with a very minimum of troweling and cured over a prolonged period.

The surface of the structural base slab shall be finished reasonably true and struck off at a level not less than 1 inch below the required finish grade.

When the wearing course is to be placed on the same day as the base slab, this paragraph shall not apply. As soon as the condition of the concrete base permits and before it has fully hardened, all dirt, laitance and loose aggregate shall be removed from the surface by means of a wire broom, which shall either leave the coarse aggregate slightly exposed or the surface otherwise roughened to improve bond with the topping. When it is impossible to remove laitance and roughen the slab by brooming, the surface shall be cleaned and prepared for bond by chipping after the

base has hardened. Immediately prior to placing the finish, the base slab shall be thoroughly cleaned by scrubbing and all loose debris and fine particles shall be removed by thorough high pressure flushing.

Portland cement shall conform to the Standard Specifications for "Portland Cement" (A.S.T.M. designation C150).

Aggregates shall conform to the Standard Specifications for "Concrete Aggregates" (A.S.T.M. designation C33), except that grading and hardness shall be as follows:

A. Fine aggregate shall consist of clean, hard sand or crushed stone screenings free from dust, clay, loam or vegetable matter. It shall be graded from coarse to fine to meet the following requirements:

	Percent
Passing 3/8 inch sieve	100
Passing No. 4 sieve	95 to 100
Passing No. 16 sieve	45 to 65
Passing No. 50 sieve	5 to 15
Passing No. 100 sieve	0 to 5

B. Coarse aggregate shall consist of clean, hard gravel or crushed stone free from dust, clay, loam, vegetable matter or coatings which tend to weaken the bond. It shall contain no soft, flat or elongated fragments and shall be graded to meet the following requirements:

Passing 1/2 inch sieve	100
Passing 3/8 inch sieve	95 to 100
Passing No. 4 sieve	40 to 60
Passing No. 8 sieve	0 to 5

All aggregates shall be carefully selected and shall be silica, trap rock, granite or other material of equivalent hardness. Samples of proposed material shall be submitted to the Contracting Officer for approval prior to use.

The nominal mixture shall be 1 part of cement, 1 part of fine aggregate and 2 parts of coarse aggregate by volume. This nominal mix may be slightly varied, depending upon the local conditions and as the Contracting Officer may direct. If the aggregate is very coarse, the gravel or stone may be reduced but in no case shall the volume of the coarse material be less than 1-1/2 times the volume of the fine.

The mixture shall be approved by the Contracting Officer and once established shall not be changed except upon written order from the Contracting Officer.

Not more than 3.5 gal. of mixing water, including the moisture in the aggregate, shall be used for each sack of cement in the mixture.

The mixing of the concrete shall continue for at least 1-1/2 minutes after all ingredients are in the mixer.

The concrete shall be of the driest consistency possible to work with a sawing motion of the strike-off board or straight edge. Changes in consistency shall be obtained by adjusting the proportions of fine and coarse aggregate within the limits specified. In no case shall the specified amount of mixing water be exceeded.

The base slab shall be thoroughly wetted prior to the placing of the finish. No pools of water shall be left standing on the wetted surface. A thin coat of neat cement grout shall be broomed into the surface of the slab for a short distance ahead of the topping. The wearing course shall be applied before the grout has hardened and brought to the established

grade, it shall be compacted by rolling or tamping and then floated with a wood float or power floating machine. The surface shall be tested with a straight edge to detect high and low spots, which shall be eliminated.

When the wearing course is to be placed on the same day as the base slab, the water and laitance which rise to the surface of the base slab shall be removed before applying the wearing course. After concrete in the base slab has settled sufficiently so that water does not rise to the surface (but within 2 hours after placing the base slab), the wearing course will be applied and brought to the established grade with a straight edge.

Floating shall be followed by steel troweling after the concrete has hardened sufficiently to prevent excess fine material from working to the surface. The finish shall be brought to a smooth surface free from defects and blemishes. Neither dry cement nor a mixture of dry cement and sand shall be sprinkled directly on the surface of the wearing course to absorb moisture or to stiffen the mix. After the concrete has further hardened, additional troweling may be required as directed by the Contracting Officer.

All freshly placed concrete shall be protected from the elements and defacement. The Contractor shall provide and use tarpaulins when necessary to cover completely or enclose all freshly finished concrete.

If at any time during the progress of work the temperature of the surrounding air is below 40°F, the water aggregate shall be heated and precautions taken to maintain the temperature of the concrete above 70°F for at least 3 days or above 50°F for at least 5 days when using normal Portland cement.

As soon as the concrete has hardened sufficiently to prevent damage thereby, it shall be covered with at least 1 inch of wet sand or other covering satisfactory to the Contracting Officer, and shall be kept continually wet by sprinkling with water for at least 7 days when using normal Portland cement or for at least 3 days when using high-early-strength Portland cement. In lieu of other curing methods, the concrete may be covered with a colorless curing compound or with asphalt-impregnated, waterproofed paper. All seams of such paper shall be overlapped and sealed with tape.

The use of patented or trade name cement floor finishes will be permitted, as an alternate to the heavy duty cement floor finish specified herein if approved by the Contracting Officer. Contractors in proposing alternates must state complete and particulars concerning materials, method of process intended for use which, if approved, shall constitute and become a part of the contract.

Where nonslip surfacing is specified, the amount, kind, type, etc. of nonslip abrasive to be used in the finish shall be as indicated

on the drawings. The aggregate shall be scattered uniformly over the unhardened concrete immediately prior to compacting and shall be worked into the surface during finishing. After the floor has hardened, the surface shall be ground or scrubbed with floor scrubbing machines using pads of steel wool until the film of cement on the surface is removed and the non-slip aggregate is exposed.

4.11--LIGHT DUTY FLOOR FINISH

These "Detailed Specifications" on light duty floor finish are hereby incorporated in and made a part of the "General Specifications" on Concrete Work to which they are attached.

A dry top finish 1/8" to 1/4" thick shall be applied in locations where a light duty floor finish is specified on the drawings and also where linoleum asphalt tile, rubber tile or other similar floor covering is to be installed. This dressing shall be thoroughly floated and troweled only long enough to make it smooth.

Base concrete shall contain not more than 5 gal. of water per bag of cement. The finish shall be 1 part cement to 2-1/2 parts dry sand by volume, and mixed in a dry mixer.

For floors where the finish is to be the wearing surface, three coats of an approved hardener of the magnesium fluosilicate and zinc fluosilicate type shall be applied in accordance with the manufacturer's specifications.

Curing and protection shall be the same as specified for "Heavy Duty Floor Finish".

Where nonslip surfacing is specified, the amount, kind, type, etc. of nonslip abrasive to be used in the finish shall be as indicated on the drawings. The aggregate shall be scattered uniformly over the unhardened concrete immediately prior to compacting and shall be worked into the

surface during finishing. After the floor has hardened, the surface shall be ground or scrubbed with floor scrubbing machines using pads of steel wool until the film of cement on the surface is removed and the nonslip aggregate is exposed.

D5.00 BUILDINGS

5.01--GENERAL

In general the design and erection of buildings shall conform to the standards as outlined in the specifications which are attached hereto and as follows:

Section I. Stairways

Stairways shall be provided from one structural level to another. They shall provide access to elevated equipment or to points where sampling, gaging, adjusting, etc., may take place. Stairways shall also be provided for the purpose of carrying heavy tools, equipment or sampling containers.

Where platforms are used for operating, gaging or other routine work where there is a possibility of isolation of any portions thereof by a barrier of fire, acid, gas, steam, etc. developed through accident in the equipment, then such platforms shall be provided with at least one additional stairway so placed as to provide safe escape.

Spiral or Winding Stairways. Spiral or winding stairways shall not be installed in buildings. They may be used on outside tanks where the inside radius of the stairway is not less than 8 feet.

Construction. Stairways shall be of sufficient strength to carry safely a live load of at least 100 pounds per square foot.

Stairways shall have a minimum width of 24 inches (preferably 30 inches) between the inside faces of the handrailing.

Stringers made of wood shall be of sound material not less than 2" x 10" nominal dimension. Treads shall be recessed into stringers 1/2 inch. Metal stringers shall be of sufficient strength to support a loading of 100 pounds per square foot safely.

The angle of rise shall be no less than 32 degrees nor more than 45 degrees. Treads shall not be narrower than eight inches with the product of riser and tread ranging between 64 and 75.

Tread nosing shall extend from 5/8 inch to 1 inch beyond the riser face.

Metal treads shall not have a smooth or slippery surface. Nosings shall have an even leading edge.

Wooden treads shall have a minimum nominal thickness of 2 inches with leading edge of nosing rounded to 1/4 inch radius.

Concrete treads shall be float finished with abrasive materials included to insure secure footing. Carborundum No. 12-30 at the rate of 1 pound per 44 inch tread is recommended.

Headroom. Minimum headroom in stairways and crossovers shall be at least 80 inches and preferably 84 inches in the clear between the floor, landing or tread and the ceiling level or any projection below the ceiling level.

Hose reel brackets, pivoted window sash and similar items projecting beyond the wall surface on a landing shall be located at least 3 feet from the head of the stairway and shall not encroach on minimum width of "line of travel".

Illumination. Stairways and landings shall be provided with a minimum level of illumination of five foot candles.

Toeboards. Toeboards shall be placed at the open sides of all platforms and wallways more than 6 feet high and above the stringers of stairways more than 6 feet high where such stringers do not themselves serve the purpose of toeboards. They shall also be placed on such structures less than 6 feet high if process equipment or machinery is located underneath or if walkways are used as catwalks in locations exposed to the weather.

Toeboards shall fit snugly with the top surface of the platform, walkway, or stringer. The top of the toeboard shall be at least 4 inches above walking surface.

Section II. Platforms

The maximum vertical rise in a single flight of stairs, unbroken by landings or platforms shall be 12 feet. Stairway platforms in the run of a flight shall be at least 36 inches long measured between topmost riser of lower flight and bottom riser of upper flight. They shall be at least as wide as the flights they service.

Where piping etc. cross platforms or stairways they shall be painted alternately black and yellow.

Section III. Handrailings

Handrailings shall be provided on the open sides of all platforms and stairways. The only exception shall be for rail and truck loading platforms.

Handrails shall be 42 inches high on platforms and 32 inches above the nosings on stairways. One intermediate rail shall be provided and no rail shall project beyond terminal posts.

Openings designed for delivery shall be kept at a minimum with chains provided when not in use.

Stairways greater than 44 inches in width shall have handrails on each side. Those wider than 88 inches shall have a center rail as well.

Handrails shall be designed to support a load of 200 pounds applied at any point in any direction. There shall be at least 1-1/2 inches of clearance between the rail and any obstruction.

Handrails or other members shall meet the following requirements:

Maximum Post Spacing	6' - 0"	6' - 0"
Size of Post	2 x 2 x 1/4 angles	4" x 4"
Size of Top Rail	1-1/4 I.P.S.	2-2" x 4" or 3" x 4"
Size of Mid-Rail	7/8" Diam. Rod	1" x 6" or 2" x 4"

Section IV. Finished Hardware

Materials. Schedule below as prepared indicates catalog numbers of _____ Company. Hardware of other manufacturer's shall be acceptable on the approval of the owner.

Finish. Finishes shall be as shown on the drawings.

Keying. There shall be three master keys for all cylinder locks and two change keys for each lock.

Templates. The hardware manufacturer shall furnish all necessary templates required for the fabrication of the various metal doors and locks and for any other accurate setting and fitting of such material. Hardware shall be furnished with either wood, machine or other type screws or fastenings to suit job conditions. All templates shall be provided in ample time so as not to cause delay in the fabrication of the work concerned.

Packing and Delivery. All hardware shall be packed so as to facilitate the handling, and each container shall be properly tagged or labeled for its respective floor and location so as to be identified easily. Material shall be delivered in the order required by the progress schedule, and full delivery shall be completed in ample time to permit application within the time required for the completion of the building. Checking schedules in duplicate shall accompany all shipments.

Section V. Glass and Glazing

Materials. Each light of glass shall bear the manufacturer's labels as to quality, weight, and thickness. Sheet glass shall be double-strength, "B" quality, flat-drawn glass.

Obscure glass shall be hammered 1/8 inch thick, or approved equal. Glass shall be reasonably free from waves and defects. Where any waves occur, glass shall be set so that waves are horizontal.

Polished plate shall be as specified on the drawings.

Thermo-pane shall be as manufactured by Libby Owens Ford or approved equal. Specify thickness of 1/2", 5/8", 3/4", or 1" and type of glass.

Corrugated wire glass shall be as shown on the plans.

Flat wire glass shall be 1/4 inch thick with hexagonal wire. Wire glass shall be hammered pattern where obscure is specified, and clear polished plate where clear is specified.

Putty shall be an approved glazing compound, color as selected to match finish paint.

Setting. Exterior glass shall be set in putty, back-puttied, and faced. All glass in steel sash shall be secured with metal spring clips furnished by the glazing contractor and set in putty approved for use with steel sash. All glass shall be set in such a manner as to avoid rattling on liability of breakage.

Corrugated wire glass shall be set as shown on the drawings and in accordance with approved details of manufacturer. All fittings shall be furnished by the manufacturer.

The contractor shall replace all broken glass and all glass that is rejected or imperfect.

Samples. Samples of all glass shall be submitted to the owner for approval before proceeding with the work.

Section VI. Plastering, Metal Furring, and Lathing

Cutting and Patching. The Contractor shall do all cutting or other work as required for the installation of the work shown on the plans, and all cutting and fitting of the work specified to accommodate the work of other trades including the mechanical trades.

The Contractor shall do all patching of the work specified. This shall be done after other trades have completed their work and shall consist of repairing all cracks, mars, and defects, no matter by whom or what caused, and the Contractor shall leave all metal furring, lathing, and plastering in first-class condition.

Inserts. Throughout finished ceiling areas, except where attached ceilings with acoustical tile are required, inserts shall be installed in the soffits of long-span tee beams and poured slab construction. These inserts shall be for the reception of lath for the construction of the attached plaster ceiling, and shall also serve as hangers for all

suspended ceilings. These inserts shall be spaced as required. Inserts shall be of the tee-toggle type for hung ceilings and shall be formed nails for attached ceilings.

Metal Furring. Masonry Walls. The Contractor shall furnish and install an approved system of metal furring. Shields of copper-bearing steel shall be built into walls at intervals of not over 4 feet horizontally and 5 feet vertically. Shields shall be furnished to the mason in advance of the time when they will be required. Proper instructions for use shall be furnished at the same time. The Contractor shall furnish and install adjustable brackets built to receive shields, pins, and horizontal V strips not over 5 feet apart for the purpose of receiving furring bars. Furring bars shall be 3/4 inch hot-rolled channels, placed 12 inches on centers and secured to V strips with clips of "Aeroplane" type rigidly secured top and bottom. No tie wires shall be used for securing furring. All the above material except the furring bars shall be adjustable, hot-dip galvanized copper-bearing steel.

Attached Ceilings for Lath and Plaster. Metal lath shall be secured crosswise to joists. The ribbed lath shall be lapped by resting at the sides and shall be lapped 1 inch at ends. Metal lath shall be secured at the resting using single turns of 18-gauge Monel tie wire, spaced 6 inches on centers and twisted tight.

Suspended Ceilings for Plaster. The Contractor shall furnish and install suspended ceilings with 1-inch by 3/16-inch hangers spaced 48 inches on centers both directions. Carrying bars of 1-1/2 inch hot-or-cold-rolled channels,shall be spaced 48 inches on centers. Furring channel shall be clipped to carrying bars on 12 inch centers. Lath shall be wired every 6 inches on sides and secured to channels with tie wires. First and last carrying bars shall be approximately 2 inches from parallel walls, and all bars shall be secured to hangers at proper levels and shall be brought to the same elevation as measured by means of a spirit-level.

Special conditions created by lighting and ventilating outlets shall be adjusted by all necessary alignment and spacing of furring.

Attached Ceilings for Acoustical Tile. The Contractor shall furnish and install nailing channels embedded in the soffits of every second concrete joist. These nailing channels shall be for the reception of screw-holding gypsum board. Channels shall be of the same manufacture as those for suspended ceilings.

Suspended Ceilings for Acoustical Tile. The Contractor shall propose a complete method of suspended ceiling construction. The proposed method shall employ a manufacturer's standard assembly of nailing channels, clips, splines, edge moldings, etc., or the equivalent of such devices. In addition, the proposed method shall include the use of gypsum board or a mechanical suspension system for the support of acoustical tile.

All units shall be of sufficient size and shall be properly spaced and assembled to carry the construction load to be imposed. The proposed method shall be approved by the engineer before being put into use.

Falsework. Brackets for falsework shall be 1 x 3/16-inch flats, bent to conform to the finished work, and shall be reinforced and held in position with 1-inch hot-rolled channels.

Soffits and Curtain Walls. Soffits and curtain walls shall be supported by means of 1-inch hot-rolled channels, spaced 12 inches apart on centers; such channels shall be rigidly braced and secured with purlins or brackets at intervals of 4 feet, secured with hairpin clips or bolts, and reinforced at fan edges with 1-1/2 x 1-1/2 x 1/8 inch angles.

All metal furring shall be coated with approved asphaltum paint except where furring is shown to be galvanized or is otherwise specified.

Tie Wire. All tie wire shall be 18-gauge Monel or stainless steel wire.

Metal Lath. For use with Portland cement plaster metal lath shall be woven wire mesh with 18-gauge wire and with 2 x 2 meshes to the inch. V stiffeners galvanized after fabrication shall be included.

For use in attached ceilings under concrete joist construction, metal lath shall have 3/8-inch ribs, shall be painted and expanded, and shall weigh not less than 4 lb. per sq. yd.

For all other purposes metal lath shall be of an expanded type, shall be made of 24-gauge material, shall weigh 3.4 lb. per sq. yd., and shall be coated with asphaltum paint by dipping. All metal lath shall be lapped 1 inch, and shall be wired to each support at intervals of 6 inches with tie wire.

At all intersections of walls with ceilings or of walls with walls such that different materials are adjacent to each other in locations where finished surfaces are to be plastered the following procedure shall apply. The Contractor shall erect strips of expanded metal lath extending not less than 6 inches on each surface in such a manner that cracks in the finished plaster will be eliminated.

Corner Beads. Corner beads shall be perforated 26-gauge steel, galvanized by hot-dipping. The Contractor shall use full length pieces where possible and these shall extend along the full dimension. In addition, such pieces shall be set to line and rigidly secured with galvanized nails. Corner beads placed over ceramic, terra-cotta, or structural facing-tile wainscots shall be bullnose beads; fabricated of 26-gauge hot-dipped galvanized stock. The beads shall have a 3/4-inch radius and shall be secured with galvanized nails. Casing beads with expanded flanges shall be used where shown on drawings.

Base Screeds. Base screeds shall be fabricated of 26-gauge steel, and shall be hot-dipped galvanized, and shall be of the perforated type. Such screeds shall be set in line and rigidly secured with galvanized nails.

Setting of Frames. The Contractor shall construct and set frames for all recessed light frames, access doors, and hand holes furnished under other sections of these specifications.

Plastering Materials. Gypsum plaster shall conform to A.S.T.M. specification C28 and shall contain not less than 60.5% calcined gypsum by weight. Calcined gypsum shall be used for the finishing white coat. Gypsum molding plaster shall conform to A.S.T.M. C59 for cast and run work. Bond plaster shall be used where applied directly to concrete surfaces.

Portland cement shall conform to A.S.T.M. C150 type I.

Keene's cement shall conform to A.S.T.M. C61.

Hydrated lime shall conform to A.S.T.M. C6 and shall be soaked for 24 hours. Quicklime shall conform to A.S.T.M. C5 and shall be thoroughly soaked and allowed to stand 24 hours after action has ceased. Lime putty shall be kept moist and screened through a No. 10 sieve before use.

Hair shall be clean, long winter hair beaten and soaked in water.

Sand shall be fine granular material, free from injurious amounts of saline, alkaline, organic, or other deleterious matter and shall conform to A.S.T.M. C35.

Mixing Plaster. Plaster shall be mixed in accordance with directions of the manufacturer of the plaster. Mixing shall be done at the building and shall be done by machine or by hand and in clean tight boxes.

Plaster shall be mixed only as required for immediate use and shall be in place within one hour after the cement is added.

Preparation of Surfaces for Plaster. Masonry surfaces shall be cleaned and prepared for the application of plaster by removing loose particles, dust, adhering mortar, grease, oil, efflorescence, or other foreign matters, and shall be wet down before the plaster is applied. Concrete surfaces shall be prepared and plastered with bond plaster in accordance with directions of the manufacturer of the plaster used.

Application of Plaster. Gypsum plaster shall be applied as follows: Three coats of plaster shall be applied to lath surfaces and two coats shall be applied to masonry. A scratch coat shall contain sufficient hair to provide a bond for the brown coat. A brown coat shall be brought flush with grounds and shall be screeded and broomed to form a bond for the finish coat. Plaster shall extend close to all pipes and openings and shall extend back of all wood base, wainscoting, trim and other wood finish.

White-coat finish shall be applied as follows: Three parts of lime putty, one part of calcined gypsum, and a small quantity of white sand shall be mixed. No retarder, dope, or neat plaster shall be added. The finish shall be troweled to a smooth, hard surface. Soft or porous surfaces and surfaces showing brush marks or cat faces will not be accepted.

Plaster shall be applied in accordance with the schedule of finishes as hereinafter specified, or as shown on the drawings.

Keene's cement finish shall be applied as follows: A Keene's cement finish shall consist of application of neat Keene's cement over the scratch and the brown coats of gypsum plaster. The Keene's cement shall be finished and troweled to a smooth, hard surface. This finish shall be applied where shown on the drawings.

Portland cement plaster shall be mixed as follows: Portland cement plaster shall consist of one part of Portland cement and 2-1/2 parts of sand by volume. A maximum of 20% lime putty may be added. Portland cement plaster shall be applied in three coats. The final coat shall be finished with a float, and shall be sponged to a fine, even texture, and shall be lightly troweled with a steel trowel. Each coat shall be kept moist and shall be thoroughly set before any succeeding coat is applied. The scratch coat on lath shall contain 7-1/2 lb. of fiber to each cubic yard of plaster.

The scratch coat for tile shall consist of one part of Portland cement and three parts of sand. This coat shall be brought to within 1-1/4 inches of the finished face of the tile, and shall be scratched horizontally.

Sprayed Insulation. Materials for sprayed insulation shall be approved by the owner and shall have a thermal conductivity of approximately 0.264 Btu. per hour per square foot per degree of temperature per inch of

thickness. The material shall consist of mineral and asbestos fibers and of a suitable synthetic binder. This synthetic binder must not be affected by steam, water, condensation, or moisture after it is set.

Application shall be in layers 1-1/2 inch thick. Application shall be by means of a spray gun and shall be made directly to a binder applied to the under side of the concrete ceiling construction in accordance with the manufacturer's directions. The finished surface shall be tamped and sprayed with binder.

5.02--STEEL FRAME BUILDINGS

These specifications on steel frame buildings are hereby incorporated into and made a part of the specifications on Buildings to which they are attached.

Section I. Scope

The purpose of this specification is to outline the design and use of structural steel in building construction. The standards adopted by the American Institute of Steel Construction are hereby incorporated into and made a part of this specification on Steel Frame Buildings.

Section II. Design and Detailing

Design. Design shall be consistent with accepted design procedures. Any reasonable design procedure may be used, subject to the approval of the structural squad leader.

Earthquake. See the applicable portion of Specification D5.03 for earthquake design procedure.

Rigid Frame Construction and Design. Where rigid frame construction is used, the design shall conform to the methods outlined in publications by the American Institute of Steel Construction. Prefabricated sections purchased directly from vendors shall be checked for stress by the structural squad.

Detailing. Detailing shall be done in a neat manner, consistent with accepted engineering practice, and shall conform to the standards adopted by the American Institute of Steel Construction.

Section III. Corrugated Asbestos

Corrugated asbestos cement roofing and siding may be used and must conform to the following requirements.

Application. Corrugated asbestos cement sheets shall be applied on roof and sidewalls in various lengths as required and as suitable for the steel or wood structures designated.

Roof-Pitch. The minimum roof-pitch shall be at least a 3 inch rise per foot and should preferably be a 4 inch rise per foot.

Dimensions. Sheets of asbestos shall be approximately 42 inches in width and of suitable length so that all end laps shall face over a purlin or girt.

Lap. Sheets shall be applied by the staggered joint or straight joint method. Sheets 42 inches in width shall have a minimum of 6 inches end of lap of one corrugation side lap.

Support Spacing. Corrugated asbestos cement roofing and siding shall not be applied on wood or steel structures with purlin spacings greater than 4'-6" on roofing or with girt spacings greater than 5'-6" on siding.

Sealing Compound. Black plastic compound shall be used on all side and end laps of roofing only and shall be applied by the continuous and unbroken bead or rope method. The compound on the side laps should be applied to the crest of the under corrugation and on end laps it should be applied as high up on the under sheet as practical.

Expansion Joints. Expansion joints shall be used in corrugated asbestos cement roofing and siding at the same point as they occur in the supporting structure. (See standard drawing No. SFB-1.) In no case shall unbroken areas of corrugated asbestos cement sheets be longer than approximately 200 feet. Buildings subject to a high internal temperature shall have expansion joints placed in the siding and roofing on approximately 150 foot centers.

Fasteners. Fasteners of approved type recommended by the various manufacturers shall be used to secure the corrugated asbestos. Two fasteners shall be used per sheet per purlin or girt on steel or wood structures. Three fasteners shall be used per sheet per purlin or girt at the eave line.

One seam bolt shall be used between purlin and girt spacings on both roof and side walls at side laps.

Overhang. Overhang shall not exceed 9 inches at the eave line and at the gables.

Accessories. Accessories such as finishing ridge roll, corner roll, eave and gable trim and louvre blades shall be applied in accordance with the respective manufacturer's standard specifications. Pre-formed asphalt filler strip shall be used to close openings in the corrugated asbestos cement sheets when required at window heads, eaves, etc. Metal flashing shall be applied (see standard drawing No. SFB-2) as indicated on the drawings and in accordance with standard practice. Materials for flashing shall be noted on the plans.

Precautions. In applying corrugated asbestos cement roofing walk planks and chicken ladders must be used. Workmen must never walk between spans, but shall walk on laps, and directly over the purlins.

Storage. Sheets shall be stacked in a level place, using 2" x 4" lumber on approximately 18" centers at right angles to corrugations, and stacks shall be not more than 4'-0" high. They shall be kept covered and protected from weather.

5.03--REINFORCED CONCRETE BUILDINGS

These specifications on reinforced concrete buildings are hereby incorporated in and made a part of the specifications on Buildings to which they are attached.

Section I. Scope

The purpose of this specification is to outline the design and use of plain and reinforced concrete in any structure. The ACI Building Code is hereby incorporated in and made a part of these specifications on Reinforced Concrete Buildings. Reinforced concrete design and use shall also be in accordance with the following.

Section II. Design and Detailing

Design. Design shall be consistent with accepted design procedures. Design of flexural concrete members shall be in accordance with the ACI Building Code or may be otherwise designed by methods of continuity as outlined in Portland Cement Association's publication, "Continuity in Concrete Building Frames".

In all cases 3 copies of design computations shall be submitted to the structural squad for review and approval. These copies shall be submitted on a standard 8-1/2 x 11 sheet in a neat fashion.

Earthquake. Earthquake consideration shall be given in all design when so specified by the owner. Buildings shall be considered as being in Earthquake Zone No. 2 and said design shall be modified as outlined in the Building Code.

Removable Pan Forms. Removable pan forms may be used where concrete-joist construction is used for floors and/or roofs. In using pan forms care shall be exercised to maintain tight connections between pans and soffits in order to prevent burrs and other irregularities. Pans which are slightly dented or bent may be used after careful straightening. Shores and joist supports shall be adequate to give the proper grade and dimension to the finished concrete structure.

Detailing. Detailing shall be done in accordance with the American Concrete Institute's publication (315-51), "Manual of Standard Practice for Detailing Reinforced Concrete Structures".

Section III. Pozzolith Concrete

Where it is deemed necessary by the owner and approved cement dispersing agent such as "Pozzolith" may be used. The concrete shall be designed in accordance with the current ACI Code with normal Portland cement. The strengths, slumps, water-cement ratio, and top size aggregate of the different classes of concrete shall be as called for on plans and as indicated elsewhere in these specifications.

Such a dispersing agent shall be used in accordance with the manufacturer's directions, the concrete being so designed that the materials will not segregate and so that excessive bleeding will not occur.

Section IV. Fire Proofing

To protect structural steel and reinforcing in concrete from fire the following precautions shall be observed.

Steel framework shall be fireproofed with reinforced concrete, brick, tiles of burnt clay, or terra cotta. For columns, trusses, girders or other very important members at least 2 inches of concrete outside of the metal reinforcement shall be provided. At least 1 inch of concrete outside of metal reinforcement shall be provided in short span floor arches, slabs, partitions, and walls.

For columns and beams less than 15 inches in depth a maximum aggregate size of 1/2" shall be used. For columns and beams with depths greater than 15 inches maximum aggregate size shall be 3/4".

Brick, tile or terra cotta fireproofing shall have a thickness of not less than 4 inches for columns and other main framework. Metal flanges shall be protected with not less than 2 inches of fireproofing at any point.

For concrete foundations and other concrete structure next to the ground the minimum concrete cover shall be 3 inches. All structures fireproofed with concrete shall be chamfered and shall have mesh placement as shown on any drawings attached.

5.04--FURNISHING AND FABRICATION OF STRUCTURAL STEEL

General

These specifications on furnishing and fabrication of structural steel are hereby incorporated in and made a part of the specifications on Buildings to which they are attached.

The Contractor shall furnish and fabricate all structural steel in accordance with these specifications and in accordance with design drawings and purchase orders. All necessary field rivets and permanent field bolts shall be supplied by the Contractor.

Structural steel as referred to in this specification shall consist of all structural steel items required by the design drawing listed as Class "A" in the American Institute of Steel Construction", Code of Standard Practice for Steel Bridges and Buildings", as amended to date. Miscellaneous steel and/or iron items not Class "A" but which are shown on the drawings shall not be furnished by the Contractor unless specifically stated on the purchase order.

The Contractor shall not place orders for specific items of material or start detailed drawings prior to the receipt of the owner's written authorization or design drawings properly identified as being "For Construction". This identification may consist either of a stamp on the drawings or of approval in the letter of transmittal.

The Contractor shall not substitute sections for those shown on the design drawings unless prior written approval is obtained from the owner for each proposed substitution.

Structural steel shall conform to the standard specification for "Steel for Bridges and Buildings", serial designation A7, of the American Scciety for Testing Materials, as amended to date, unless exceptions or additions are clearly defined on the owner's drawings.

Rivet steel shall conform to the specification for "Structural Rivet Steel", A.S.T.M. designation A141, as amended to date.

Section I. Shop Drawings

Immediately upon receipt of the owner's purchase order and approved construction drawings, the Contractor shall prepare erection diagrams and detailed shop drawings of all structural steel to be furnished. These drawings shall give complete information necessary for the fabrication and erection of the structure.

All connection details shall be made so that the type of connection is clearly defined. Notes shall be provided to outline clearly the welding sequence in order to prevent locked-up stresses and distortion. Unit stresses as specified in the "American Institute of Steel Construction Specifications" shall be used.

Prints of all Contractor's checked detail drawings and erection diagrams, including index sheets and field rivet and bolt lists shall be submitted in duplicate for the owner's approval. Such approval does not relieve the Contractor of full responsibility for the accuracy of dimensions shown thereon or for providing adequate erection and field rivet clearances.

Prints of final approved Contractor's drawings, including index sheets and field rivet and bolt lists, shall be furnished to the owner. The number of sets of said approved drawings shall be stipulated in the owner's purchase order.

Section II. Workmanship

Fabrication, unless otherwise specified in the owner's purchase orders or drawings, shall conform to the specifications for "Design, Fabrication and Erection of Steel for Buildings" of the "American Institute of Steel Construction", as amended to date, and as follows:

A. Bearing surfaces - all columns and bearing stiffeners shall be milled to give full bearing over the cross section.

B. All parts of riveted members shall be well pinned and bolted and rigidly held together while riveting or welding.

C. Drift pins shall be used only for bringing component parts into position and not to enlarge or distort holes.

D. All rivets shall be driven by power riveters of either the compression or manually operated type, employing pneumatic, hydraulic, or electric power. Rivets shall be uniformly heated to a temperature not to exceed 1950°F and hot driven. Rivets shall not be

driven if their temperature has fallen below 1000°F. Rivets shall have approximately hemispherical finished heads unless otherwise noted. These heads shall be of uniform size throughout the work for the same size rivet and shall be full, neatly finished, and concentric with the holes in adjoining members. Rivets after being driven shall be tight and with the heads in full contact with the member surfaces.

Permanent bolts shall be drawn up tight and the threads so butted that the nuts cannot come loose.

Where welding is permitted the following conditions shall apply:

A. The technique, quality, and appearance of welds and the methods of correcting defective work shall conform to Section IV, entitled "Workmanship" of the AWS code for Arc Welding in Building Construction.

B. Welds shall be 1/4 inch minimum unless otherwise specified or noted on design drawings.

C. Welding shall conform to Sections 24 and 25 of the American Institute of Steel Construction Specifications, as amended to date.

D. All arc welding electrodes shall conform to the requirements of the American Welding Society for "Iron and Steel Arc Welding Electrodes", as ammended to date. Electrodes shall be of classification numbers E-6011, E-6012, E-6013, E-6020, and E-6030 and shall be suitable for positions and other conditions of intended use in accordance with the instructions supplied with each container.

E. Welding equipment shall be of a type which will produce the proper current required to make satisfactory welds. The welding machine shall be of 200-400 amperes, 25-40 volt capacity.

F. Welding shall be done by operators who have been previously qualified to do the specified work by tests prescribed by the American Welding Society's "Standard Qualification Procedure".

G. Welded members, when finished, shall be true to line and free from twists, bends, and open joints.

H. No welding shall be done when the temperature of base metal is lower than 0°F. At temperatures between 32 and 0°F, the surfaces of all area within 3 inches of a point where a weld is to be started shall be heated to a minimum temperature of 140°F immediately before welding is started.

I. Surfaces to be welded shall be free from loose scale, rust, grease, paint, and other foreign material except scale which withstands vigorous wire brushing. A light film of linseed oil may be disregarded. Joint surfaces shall be free from fins and tears.

Section III. Painting and Inspection

Painting. Where shop painting is specified on the drawings, the paint shall be applied in accordance with Section 34 of the latest revision of the American Institute of Steel Construction Specifications. Paint shall be as specified on the drawings and shall be delivered to the shop in the original sealed containers clearly marked with the manufacturer's name and identifying brand or number. Paint shall be applied in accordance with the manufacturer's directions.

Shop contact surfaces of structural steel shall not be painted.

The Contractor shall notify the owner in advance of the date when the steel will be ready for fabrication and furnish such facilities as required for inspections. Material and workmanship not conforming to these specifications or the drawings shall be cause for rejection at any time during fabrication and erection.

Material and workmanship shall be subjected at all times to inspection by the owner or an authorized representative.

Records of tests shall be available when called for by the owner.

Inspection of contract work shall in no way relieve the Contractor of his responsibility to complete the entire contract according to these specifications.

D6.00 EXHAUST SYSTEMS

6.01--STEEL STACKS

These detailed specifications on steel stacks are hereby incorporated in and made a part of the specifications on Exhaust Systems to which they are attached.

Section I. Definition

A chimney made of steel plates and supported on a foundation shall be termed a self-supporting stack. In this stack the live loads and dead loads are transmitted by direct bearing and by cantilever action to the foundation. The economical ratio of the diameter of the cylindrical stack to the diameter of the base of the flare will vary from 3/4 to 4/5. The plates in the conical or bell-mouth flare shall not be thinner than the thickness of the lower course in the cylindrical stack. Stacks may or may not be lined.

Section II. Loads

Dead Load. Dead load shall consist of the weight of the plates and structural steel, the top ring and ladder, the angles to support the lining and the weight of the lining with its reinforcement.

Wind Pressure. Wind pressure shall be taken as 30 pounds per square foot over the projected area of the stack surface.

Section III. Unit Stresses

All parts of the structure shall be proportioned so that the maximum stresses, except as specified in the latter part of this section, shall not exceed the following, expressed in psi.

Tension on stack plates, net section	12,000
Tension in anchor bolts and other structural parts, net section	16,000
Compression on stack plates, gross section	10,000
Shear on shop rivets	12,000
Shear on field rivets	9,000
Shear on plates	10,000
Bearing pressure on shop rivets and plates	24,000
Bearing pressure on field rivets	18,000
Bending stresses on shapes and built girders	16,000
Bending stresses in pins	24,000

For compression members the allowable stress shall be given by the formula

$$p - 16{,}000 - 70\ l/r\ ,$$

where p is the allowable stress in psi, l is the length of the member, and r is the least radius of gyration of the section, the latter two in inches. For compression members the ratio l/r shall not exceed 125 for main members and 200 for secondary members.

In combining the wind-load stresses and the dead-load stresses due to the weight of the stack and lining, the dead-load stresses may be neglected in designing the stack plates and joints if the dead-load stresses are not more than 10% of the stresses due to wind load. If the dead-load stresses in the plates and joints exceed 10% of the wind stresses, the sum of the stresses due to dead and wind loads shall be used, but with

allowable stresses 10% in excess of those permitted when dead-load stresses are not considered. The section shall not be less in the latter case than when dead load is not considered.

The compressive stresses in plates due to wind pressure and dead loads shall not exceed 10,000 psi on the gross section of the plate.

Pressure on Masonry. The pressures of bearing plates on masonry shall not exceed the following in psi.

Brick masonry laid in cement mortar	200
Portland cement concrete, 1-2-4	400
First-class sandstone	300
First-class limestone	400
First-class granite	600

Section IV. Details of Construction

The plates forming the sides of the stack shall have the upper diameter less than the lower diameter so that each course shall telescope over the course below it.

Vertical Joints. The vertical joints in the cylindrical stack and conical flare shall preferably be lap joints. The vertical joints in the bell mouth flare of large stacks shall be butt joints. Vertical butt joints shall be used on plates having horizontal butt joints.

Horizontal Joints. For horizontal joints single-riveted lap joints shall be used for 1/4 inch plates, double-riveted lap joints for 5/16 inch, 3/8 inch, and 7/16 inch plates, and triple-riveted lap joints for 1/2 inch, 9/16 inch, and 5/8 inch plates. Butt joints should be used for plates thicker than 5/8 inch.

Rivets. Rivets 5/8 inch in diameter shall be used for 1/4 inch plates, rivets 3/4 inch in diameter shall be used for 5/16 inch and 3/8 inch plates, 7/8 inch rivets shall be used for 1/2 inch, 9/16 inch and 5/8 inch plates. Rivets which are 1 inch in diameter shall be used for plates thicker than 5/8 inch.

Rivets shall be spaced so as to make the most economical seams.

In no case shall the spacing of the rivets along the caulked edges of plates be more than 10 times the thickness of the plates. The rivet spacing shall never be less than 2-1/2 times the diameter of the rivet.

Plates more than 5/8 inch in thickness and not more than 7/8 inch in thickness shall be subpunched with a punch 3/16 inch smaller than the nominal size of rivet, and shall be reamed to a diameter of 1/16 inch larger than the rivet. Plates that are thicker than 7/8 inch shall be drilled.

Minimum Sections. The minimum thickness of plates in the stack shall be 1/4 inch and preferable stack plates shall not be less than 5/16 inch thick.

Caulking. All stack plates shall be sheared or planed to a proper bevel for caulking.

All stack plates shall be caulked from the inside of the stack, and with a round nosed caulking tool. The use of foreign material for caulking will not be permitted.

Painter's Trolley Track. Near the top of the stack there shall be provided a z-bar to act as a track for the painter's trolley, and to stiffen the top of the stack. The section modulus of this stiffening ring shall not be less than $d^2/250$, where d is the diameter of ths stack in feet.

Stiffened Angles. On large stacks, or where n is less than 25 as calculated by formula (2) below, circular stiffening angles shall be provided in order to prevent buckling due to wind pressure. The distance between angles shall not be greater in feet than the value of n in formula (2):

$$n = 99t^{1/2}/d \qquad (2)$$

where t is the thickness of the plate in inches and d is the diameter of the stack in feet.

Cap Ring. The top of the stack shall generally have a cast iron cap ring. The ring shall be bolted to the top of the stack with corrosion-resisting bolts.

Ladder. There shall be a ladder 1 foot and 3 inches wide extending from a point 8 feet above the foundations to the top of the stack. Each ladder shall be made of 2-1/2 x 3/8 inch bars, braced on the outside with one 2 x 3/8 inch vertical bar. These rings shall have an inside clearance of not less than 24 inches in width and depth, and shall have a spacing of not more than 10 feet vertically.

Flue Connections. The connections for flues and breeching shall be reinforced with plates and angles so that the strength of the stack section will not be reduced.

Cleanout. Where a cleanout is not provided in the foundation a cleanout door 18 inches by 24 inches shall be provided near the bottom of the stack. The openings for the cleanout door shall be properly reinforced.

Base Plates. The lower stack plates shall be connected to a bottom flange made of built plates and angles, or of cast steel. The flanges shall be riveted to the vertical plates and shall be fully bedded on the masonry.

Lining. The stack shall be lined or unlined as specified on the plans. If lined the lining shall be supported on curved angles riveted at the horizontal joints. The horizontal angles shall be spaced vertically at distances not greater than one-half the diameter of the stack. Brick lining shall ordinarily be 4 inches thick. Fire brick shall be laid in fire clay while ordinary brick shall be laid in cement mortar. The space between the brick work and the steel shell shall be grouted with 1 to 2 Portland cement mortar.

Materials. The steel for plates and shapes and bars shall be made by the open-hearth process and shall comply with the Specifications for Structural Steel for Buildings of the American Society for Testing Materials. If specified the steel for plates and shapes shall contain 0.30 percent copper.

Section V. Workmanship

The workmanship and finish shall be equal to the best in modern shop practice.

All material shall be thoroughly straightened in the shop by methods that will not injure it, before being laid off or worked in any way.

The shearing shall be neatly done and all portions exposed to view shall have a neat and workmanlike finish.

The size of each rivet shall be understood to be the actual size of the cold rivet before it is heated.

All plates and shapes shall be shaped to the proper curves by cold rolling, heating or hammering for straightening or curving will not be allowed.

Plates to be scarfed may be heated to a cherry red color, but not hot enough to ignite a piece of dry wood when applied to it.

All plates and shapes shall be punched before being bevel-sheared for caulking.

The diameter of the die used in punching rivet holes shall not exceed that of the punch by more than 1/16 inch.

All punched and reamed holes shall be clean cut without torn or ragged edges.

Rivet holes shall be accurately spaced; poorly matched holes if not sufficient for rejection shall be reamed and a larger rivet used in the hole thus reamed.

The use of drift pins will be allowed only for bringing the parts of the structure together. Sufficient force shall not be used to enlarge rivet holes by drifting.

Plates and other parts to be riveted shall be closely drawn together before driving the rivets. In stack plates not less than one-third of the holes shall be filled with erection bolts well drawn up before driving the rivets.

Rivets shall be driven by power tools wherever possible. Pneumatic hammers shall be used in preference to hand driving. All rivet heads shall be concentric with the holes.

All caulking shall be done with a round nosed tool, and only by experienced and skilled men. Caulking around rivet holes will not be allowed.

All loose rivets shall be cut out and be redriven. All fractured material shall be replaced free of cost to the purchaser.

The inspector shall have free access at all times to all parts of the structure where the material is being fabricated. If the inspector through oversight or otherwise has accepted material or work which is defective or contrary to these specifications, this material, no matter at what stage of completion, may be rejected by the purchaser.

Painting. Before leaving the shop all steel work shall receive one coat of approved paint or boiled linseed oil mixed with one ounce of lampblack to each gallon of oil.

After the structure is erected and all seams are caulked, the steel work shall be painted both inside and outside with two coats of approved paint. Painting done in the open air shall never be done in wet or freezing weather.

Masonry Foundations. The allowable pressure on firm clay or gravel should not ordinarily exceed 3000 lbs. per sq. ft. In all cases a thorough examination should be made of the ground and site before designing or constructing the foundations. For high self-supporting steel stacks if there is any question about the bearing power of the soil, the masonry should be carried on piles.

All foundations shall be carried well below frost line, and the anchor bolts shall be placed deep enough to develop their full strength.

Foundations shall be made of 1 part Portland cement, 2 parts sand and 4 parts gravel or broken stone. The concrete shall be mixed and placed in accordance with the most approved practice.

6.02--HOODS

These detailed specifications on hoods are hereby incorporated in and made a part of the specifications on Exhaust Systems to which they are attached.

General. The following general rules shall govern the design and construction of hoods.

1. Hoods shall be of adequate size and type.
2. Air velocities shall be sufficient to control and convey the materials collected.
3. Hoods shall be so placed that they do not interfere with the operations of machinery.
4. The system shall be designed to function with the least consumption of power.
5. Metal hoods shall be grounded to prevent dust explosions caused by static electricity.
6. Special provisions shall be made to prevent hood corrosion. This may be accomplished by special materials of construction or by protective coating.
7. Hoods shall be designed so that a minimum volume of air is necessary to produce the desired effect.

Section I. Capture Velocity and Hood Suction

For most dusty operations velocities shall be taken not less than 200 fpm at the point of origin. Recommended minimum capture velocities are recorded in Table I.

TABLE I

Condition of Generation of Contaminant	Min. Capture Velocity, fpm	Process
Released without noticeable movement	100	Evaporation of vapors, exhaust from pickling, washing, degreasing, plating, welding, etc.
Released with low velocity	100-200	Paint spraying in booth, inspection, sooting, weighing, packaging, barrel filling, etc.
Active generation	200-500	Foundry shakeout, crushers, screens, etc.
Released with great force	500-2000	Grinding, tumbling mills, abrasive cleaning.

In order to produce the velocities indicated in Table I, the following formula should be used:

$$Q = V(10x^2 + A)$$

where

Q = quantity of air exhausted in cu. ft. per min.

V = air velocity in ft. per min. at x distance in feet from the hood and on the centerline of the hood

x = distance in feet, along the hood centerline, from the face of the hood to the point where the air velocity is V ft. per min.

A = area in square feet of the hood opening.

Axial Velocity Formula. When the normal flow of air into a hood is unobstructed, the following equation shall be used to determine the air velocity at any point along the axis.

$$V = \frac{0.1Q}{x + 0.1A}$$

where

V = velocity at point in ft. per min.

Q = quantity of air exhausted in cu. ft. per min.

x = distance along axis in feet

A = area of opening in sq. ft.

Canopy Hoods. Where canopy hoods are used they shall extend 6 inches laterally from the tank for every 12 inches elevation, and wherever possible, they shall have side and rear aprons so as to prevent short circuiting of air from spaces not directly over vats or tanks.

The quantity of air which must be exhausted to obtain any given capture velocity shall be determined by the following formula:

$$Q = 1.4\ PDV$$

where

Q = quantity of air exhausted by hood in cu. ft. per min.

P = perimeter of tank in feet

D = distance between tank and hood opening in feet

V = capture velocity in ft. per min.

The minimum capture velocity for canopy hoods shall not be less than 100 fpm.

Chemical Laboratory Hoods. Hoods used in chemical laboratories shall be provided with sliding windows to permit positive fumes and vapor control. Their design shall offer easy access for the installation of chemical equipment. Hoods shall be well lighted.

Air velocities shall not exceed 100 fpm where the window is fully open.

6.03--FANS

These detailed specifications on fans are hereby incorporated in and made a part of the specifications on Exhaust Systems to which they are attached.

In general the selection of fans for exhaust system shall be governed by the Heating Ventilating and Air Conditioning Guide published by the American Society of Heating and Ventilating Engineers.

Definitions. Design for any given fan performance shall be done on a basis of volume, total pressures, static pressure, speed, power input, mechanical and static efficiency, and required density. The following definitions shall apply.

1. Volume handled by a fan is the number of cubic feet of air per minute expressed at fan outlet conditions.

2. Total Pressure of a fan is the rise of pressure from the fan inlet to the fan outlet.

3. Velocity Pressure of a fan is the pressure corresponding to the average velocity determination from the volume of air flow at the fan outlet area.

4. Static Pressure of a fan is the total pressure diminished by the fan velocity pressure.

5. Power Output of a fan is expressed in horsepower and is based on fan volume and fan total pressure.

6. Power Input to a fan is expressed in horsepower and is measured horsepower delivered to the shaft.

7. Mechanical Efficiency of a fan is the ratio of power output to power input.

8. Static Efficiency of a fan is the mechanical efficiency multiplied by the ratio of static pressure to total pressure.

9. Fan Outlet area is the inside area of the fan outlet.

10. Fan Inlet area is the inside area of the inlet collar.

Section I. Fan Laws

The following fan laws shall govern the design of fans for exhaust systems. In these laws P = static, velocity or total pressure, and Q = air volume.

These laws shall apply only to fans geometrically similar, i.e., those in which all dimensions are proportional to some linear dimension denoted as size. If the size number is also linearly proportional, it may be used; otherwise, wheel diameter shall be used as a size criterion.

1. Variation in Fan Speed:

   Constant Air Density - Constant System

   (a) Q: Varies as fan speed
   (b) P: Varies as square of fan speed
   (c) Power: Varies as cube of fan speed

2. Variation in Fan Size:

   Constant Tip Speed - Constant Air Density

   Constant Fan Proportions - Fixed Point of Rating

   (a) Q: Varies as square of wheel diameter
   (b) P: Remains constant
   (c) RPM: Varies inversely as wheel diameter
   (d) Power: Varies as square of wheel diameter

3. Variation of Fan Size:

At Constant RPM - Constant Air Density

Constant Fan Proportions - Fixed Point of Rating

(a) Q: Varies as cube of wheel diameter
(b) P: Varies as square of wheel diameter
(c) Tip Speed: Varies as wheel diameter
(d) Power: Varies as fifth power of diameter

4. Variation in Air Density

Constant Volume - Constant System

Fixed Fan Size - Constant Fan Speed

(a) Q: Constant
(b) P: Varies as density
(c) Power: Varies as density

5. Variation in Air Density

Constant Pressure - Constant System

Fixed Fan Size - Variable Fan Speed

(a) Q: Varies inversely as square root of density
(b) P: Constant
(c) RPM: Varies inversely as square root of density
(d) Power: Varies inversely as square root of density

6. Variation in Air Density

Constant Weight of Air - Constant System

Fixed Fan Size - Variable Fan Speed

(a) Q: Varies inversely as density
(b) P: Varies inversely as density
(c) RPM: Varies inversely as density
(d) Power: Varies inversely as square of density

Section II. Painting and Assembly

Prior to assembly, all manufacturing waste, metal clips, filings, welding rod, stubs, rags, debris, etc. shall be removed from the interior. Prior to painting, all mill scale, rust, oil, grease, chalk, crayon, paint marks and other deleterious material shall be removed from all surfaces. Paint shall be applied on clean, dry surfaces. At the time of shipment, fans shall be clean inside and out.

The exterior surfaces of all fan housings shall be painted prior to shipment according to specific instructions applicable thereto. Interiors of fan housings shall be painted with red oxide paint and the exterior with machinery gray paint. Fans assembled at the factory shall have all interior surfaces, including fan parts, coated with three (3) applications of Amercoat No. 33.

Section III. Shipping

All openings, flanges, threads, collars, casings, shafts, etc. shall be protected during shipment to prevent corrosion and entrance of foreign matter. Adequate precautions shall be taken to prevent dents and damage.

All packages and crates shall be tagged according to instructions received.

6.04--DUCT WORK

Section I. General

Exhaust systems shall be constructed with materials hereinafter specified and shall be installed in a permanent and workmanlike manner. Every effort shall be made to have the interiors of all parts of the system smooth and free of obstructions in order to minimize the resistance to air flow. Insofar as possible all parts of the system shall be free from ingoing and outgoing leakage so that air enters and is discharged only at the intended points.

All interferences such as piping and other obstructions shall be moved from the path of ducts wherever it is possible and practical. Pipes containing steam or hot fluids shall not pass through the ducts unless specific permission is given. Where obstructions cannot be moved, they must be treated with an easement as shown on Standard Drawing No. _____. If the obstruction causes a decrease greater than 10% of the free area of the duct, it shall be enlarged at that point sufficiently to maintain a constant cross-sectional area.

Where ducts pass through masonry openings such as partitions, floors, etc. a continuous 1-1/2" x 1-1/2" galvanized or an approved painted angle iron flange riveted around the perimeter of the duct on both sides of the opening shall be provided. The angle iron flange shall be securely bolted to the masonry work and made tight thereto with caulking compound.

Section II. Sheet Metal Thickness

These detailed specifications on sheet metal ducts, fume and dust systems are hereby incorporated in and made a part of the General Specifications on Sheet Metal Ducts, Fume and Dust Exhaust Systems to which they are attached.

All duct work and hoods, unless otherwise shown on details of plans, shall be constructed of prime tight-coated galvanized sheets as manufactured by U.S. Steel Corporation, Bethlehem Steel Co., Wheeling Steel Corporation, or approved equal. Sheets shall be of the following minimum thicknesses.

TABLE "A"

THICKNESS OF METAL DUCTS - U.S. STANDARD GAUGE

Diameter of Round Pipe or of Largest Dimensions of Rectangular Pipe	"A" Abrasive Dusts	"B" Corrosive and Flammable Fumes	"C" Nonabrasive Dusts and Noncorrosive Fumes
Up to 8"	20 (.0375")	20 (.0375")	22 (.0312")
Over 8" to 18"	18 (.0500")	18 (.0500")	20 (.0375")
Over 18" to 30"	16 (.0625")	16 (.0625")	18 (.0500")
Over 30" to 45"	14 (.0781")	16 (.0625")	16 (.0625")

Where aluminum is specified, all ducts, etc. shall be constructed of 2S half-hard sheets as manufactured by the Aluminum Corporation of America, Reynolds Metal Company, or Permanente Metals Corporation. All construction details shall be followed as outlined herein, and the thicknesses of aluminum sheet metal shall not be less than those shown above for galvanized iron.

Where black iron, stainless steel, copper, lead covered copper, etc. are specified, all construction details shall be followed as outlined herein, and thicknesses of each respective metal shall not be less than those shown above for galvanized iron.

Section III. Fume and Dust Exhaust Systems

Longitudinal Joints. Round pipe duct shall be fabricated having the longitudinal joints lapped and fastened with rivets on 3" maximum centers. Grooved seam construction may be used with metals of No. 20 U.S. gauge or lighter. The width of lap and size of rivets shall be as follows.

TABLE "B"

Sheet Metal Thickness U.S. Std. Gauge No.	Width of Lap Inches	Size of Tinners Rivets to be used lb./1000
22 (.0312")	7/8	2
20 (.0375")	1	3
18 (.0500")	1	5
16 (.0625")	1	6
14 (.0781")	1	8

Rectangular ducts shall be fabricated of lap and riveted construction with rivets spaced not greater than 3" on centers. Grooved or Pittsburgh joint construction may be used with metal thicknesses of 20 U.S. gauge or lighter. The width of lap and size of rivets shall correspond to Table "B".

Girth Joints. Girth joints for round pipe shall be made so that the outlet end of one length fits into the inlet end of the next length in the direction of air flow unless otherwise noted. The minimum lap, size of rivets and rivet spacing for girth joints shall be as follows.

TABLE "C"

Diameter of Pipe Inches	Length of Lap in Girth Joint Inches	Number of Rivets per Joint
Up to 6	1	4 (minimum)
Over 6 to 12	1	
Over 12 to 18	1-1/4	Center to Center of
Over 18 to 24	1-1/2	Rivets - 4-1/2 (maximum)
Over 24	2	

TABLE "D"

Sheet Metal Thickness U.S. Std. Gauge No.	Size of Tinners Rivets to be Used lb./1000
22 (.0312")	3
20 (.0375")	4
18 (.0500")	6
16 (.0625")	8
14 (.0781")	10

Girth joints for rectangular ducts shall be lapped the same distance as required for round pipe whose diameter is equivalent to the largest rectangular dimension. Rivets shall be spaced not more than four inches on center.

Flanged Joints. Flanged joints for round pipe shall be of angle or loose flat steel ring construction with 1/8" thick rubber gaskets. The minimum number and size of bolts and the minimum size of angle iron or flange dimension shall be as follows.

TABLE "E"

Diameter of Pipe, Inches	No. of Bolts in Flanges	Size of Bolts, Inches	Size of Angle Irons, Inches	Loose Flat Rings Gauge of Sheet Steel	Loose Flat Rings Width of Flange, Inches
Up to 4	4	3/8	$1\frac{1}{2} \times 1\frac{1}{2} \times \frac{1}{8}$	10	1-1/2
Over 4 to 6	5	3/8	" " "	10	1-1/2
Over 6 to 8	8	3/8	" " "	10	1-1/2
Over 8 to 10	8	3/8	" " "	10	1-1/2
Over 10 to 16	12	3/8	" " "	10	1-1/2
Over 16 to 25	12	1/2	$2 \times 2 \times \frac{3}{16}$	7	2
Over 26 to 30	16	1/2	" " "	7	2

Flanged joints for rectangular ducts shall be of angle iron construction with 1/8" thick rubber gaskets. The minimum size angle iron, bolts, and maximum center-to-center bolt spacing shall be as follows.

TABLE "F"

Duct Dimensions, Inches	Size of Angle Iron, Inches	Size of Bolts, in. dia.	Max. C. to C. of Bolts Inches
Up to 24	1-1/2 x 1-1/2 x 1/8	3/8	4
Over 24	2 x 2 x 3/16	1/2	4

Section IV. Elbows and Bends

All elbows and bends under classifications "A" and "B" in Table "A" shall be made of materials at least two gauges heavier than is required for straight piping of the same diameter or greatest dimension of rectangular pipe.

Round pipe duct elbows shall have a throat radius of not less than 1.5 pipe diameters, unless otherwise noted.

Rectangular duct elbows shall have a throat radius of not less than 1.5 cheek widths, unless otherwise noted.

Round pipe 90° elbows shall be of the following gore construction, unless otherwise noted.

TABLE "G"

Up to 6-inch diameter	5 gores
Above 6-inch diameter	7 gores

Elbows other than 90° shall have a proportional number of gores.

Elbows of riveted construction shall be fabricated with at least the minimum number and size of rivets as required for the corresponding pipe diameter and thickness of sheet steel used.

Section V. Supports, Bracing, and Reinforcing

Supports for Piping System. All horizontal runs of piping shall be level, unless otherwise noted, and securely supported by fastening to some substantial portion of the building structure or other permanent member. Piping shall be supported on not over 10 foot centers. Such piping, where possible, shall be not less than 6 feet above floor at any point or less than 6 feet below ceiling at any point. The supports securely attached to the building structure or other permanent members shall be constructed as shown on Standard Drawings No. _____.

Each horizontal run of branch pipe extending more than three feet horizontally from the trunk shall be supported by means of band steel secured to the building structure or other permanent member as described above.

Branch pipes subject to vibration and movement caused by the equipment being exhausted shall be supported laterally by band steel or rods to prevent displacement.

Vertical runs of piping shall be plumb unless otherwise noted and supported laterally to prevent vibration and displacement.

Anchorage. Depending on the nature of the structure, the hangers and supports shall be fastened as follows:

Concrete slabs and beams by means of expansion shields and bolts or other approved methods.

Structural steel by means of beam clamps, additional steel strung between the building steel or by welding.

Wood floor beams or joists by means of lag screws or other approved methods.

Pipe Reinforcement. Pipe and duct work shall not be reinforced internally for any reason. If reinforcement is necessary, it shall be located on the outside of the piping. Beads shall not be formed or rolled into piping about the girth.

Section VI. Soldering and Welding

Soldering and Sealing. All galvanized sheet metal piping for exhaust systems operating at temperatures less than 400°F shall have all pipe joints soldered air tight. Where field conditions do not permit the use of flame or fire, all joints and construction shall be made air tight with joint cement. For outdoor installations such a sealing medium shall have weatherproof qualities.

Welding. It shall be permissible to spot weld longitudinal and girth joints of galvanized or black steel piping by electrical resistance methods provided the welds produce good adhesion of steel to steel and the number of weld spots corresponds to the number of rivets required.

Fusion butt welding may be used for pipe joints when using metals of No. 18 U.S. gauge or heavier.

Galvanized steel piping carrying corrosive matter shall not be welded.

Section VII. Branches, Transformation Pieces and Distribution Dampers

Branch Connections to Trunk. Branch pipes shall be connected to the trunk line at a center line angle not greater than 30° unless otherwise noted.

Such branch connections shall be made on a transformation piece, except when the magnitude of the branch line is very small as compared with the trunk load or when it may be necessary for the proper balance of the system, the transformation piece may be omitted.

Transformation Pieces. Wherever a section of piping joins another section of larger diameter, it shall be accomplished by means of a transformation piece. The length of transformer shall be at least five times the difference between the diameters of the two pipes. These pieces shall be made from material not less in thickness than that required for the larger straight pipe section it joins.

Dampers. On dust exhaust systems, no dampers shall be permitted unless otherwise noted. If dampers are essential, half body or full body blast gates shall be used and installed where shown on the drawings.

On fume exhaust systems, all adjustable dampers shall be equipped with position locking devices and located as noted on the drawings. The position locking device shall be a young "Valcalox" key operated type 401A, surface damper regulator with standard bearing. The damper blade shall be of the same gauge metal as the duct in which it is mounted.

Section VIII. Cleanouts, Header Caps

Piping Cleanout Facilities. Hand Holes. All horizontal runs of piping shall be provided with cleanout and inspection hand holes which afford access to the entire interior of the pipe. They shall be located near bends or elbows and vertical runs and at points on the pipe which permit cleaning and inspection. They must not interpose any obstruction on the inside of pipe and shall be constructed in accordance with Standard Drawing No. _____.

Header Caps. The ends of headers shall terminate in a cleanout and inspection hand-hold cap. The cap shall be equipped with a band iron handle and shall fit tightly into the pipe to prevent air leakage.

Section IX. Fan Connection Draw Bands

A draw band shall be made of material similar to and two gauges heavier than the duct to which it is attached.

The draw band shall be securely fitted and, if necessary, sealed with proper sealing compound to prevent air leakage.

The least distance between connecting ducts shall be equal to the width of the fan housing, unless otherwise noted.

Connecting ducts shall be installed rigidly in place, independent of the draw band.

Other details shall conform to the following:

TABLE "J"

Pipe Size Inches	Girth Lap Inches	Longitudinal Lap Inches	Angle Iron Inches	Bolts Inches	Max. Bolt Centers Inches
Up to 8	4	2	3/4 x 3/4 x 1/8	3/16	4
Over 8 to 13	4	2	1 x 1 x 1/8	1/4	4
Over 13 to 21	4	3	1 x 1 x 1/8	5/16	5
Over 21	4	3	1-1/2 x 1-1/2 x 1/8	3/8	5

Section X. Fire and Explosion Prevention

Fire Dampers. Ducts shall not pass through a fire wall unless it is absolutely necessary.

Where ducts do pass through fire walls, the ducts shall be provided with approved automatic fire doors on both sides of the wall through which they pass and be constructed as shown on Standard Drawings Nos. _____ and _____.

On openings not exceeding 18" dia. 3/8" steel plates may be used in lieu of tin clad shutters and constructed as shown on Standard Drawings Nos. _____ and _____.

Where ducts pass through walls, floors, or partitions the space around the duct shall be sealed with rope asbestos, mineral wool or other noncombustible material to prevent the passage of flame and smoke.

Fire dampers shall be arranged to close automatically and remain tightly closed upon the operation of a fusible link or other approved heat actuated device which is readily affected by an abnormal rise of temperature in the duct. The fusible links shall have a temperature rating approximately 50°F above the maximum temperature normally encountered in the duct system.

Access doors of suitable size and construction shall be provided at each fire door for inspection, resetting and cleanout purposes.

Fire and Explosive Hazards. Electrical Ground. Any exhaust system handling matter of an explosive nature shall have the piping and other equipment permanently grounded through electrical conductors.

Nonferrous Construction. Exhaust systems handling highly inflammable or explosive matter shall have the parts of the system subject to abrasion and impact by metallic objects made of nonferrous materials to prevent sparking.

Fan impellers in such installations shall be made entirely of nonferrous material. In extremely hazardous operations fan housings also shall be constructed of nonferrous material.

Section XI. Discharge Stacks and Weather Caps

Discharge Stack. Discharge stacks shall be securely fastened to the building structure.

If the stack is located on the outside wall of the structure, it shall be securely strapped to the structure with heavy band steel not less than 2" x 3/16" in size or supported by properly designed knee brackets.

Discharge stacks located where it is impossible to fasten them to the building structure shall be guyed to resist wind pressure with heavy galvanized wire or cable connected to permanent anchorage. The guy wire or cable shall be provided with a galvanized turnbuckle for adjusting the slack. As an alternate, heavy angle iron braces may be substituted

for guy wires or cables provided the braces are permanently attached to a substantial anchorage. The band around the stack to which the guy lines or cable braces are attached shall be not less than 2" x 3/16" band steel.

All types of exhaust systems discharging outdoors shall have the outlet of stack at least 10 feet above the roof line of any adjacent buildings.

Weather Caps. Stacks and vents shall discharge upwards and vertically. Weather caps shall be used only on such outlets where it is absolutely necessary to protect equipment below from the weather. They shall be constructed as shown on Standard Drawing No. _____.

Weather caps shall not be used on stacks connected directly to wet collectors or other equipment that will not be damaged from moisture.

D7.00 HEATING, VENTILATING, AND AIR CONDITIONING

7.01--GENERAL REQUIREMENTS

Air conditioning design and construction shall be done in accordance with the current standards as outlined in the Heating, Ventilating, and Air Conditioning Guide published by the American Society of Heating and Ventilating Engineers and as follows.

Section I. Design Data

Accurate load estimates of the space to be air conditioned shall be based on careful and comprehensive surveys. This shall be done to insure economical selection of equipment.

When drawings of the space to be air conditioned are not available, sketches shall be made incorporating essential information. The following is a list of essential information which shall be included.

DESIGN DATA

1. Building orientation indicating compass points and any unusual exposures.
2. Wall and ceiling area and construction indicating exposure dimensions type and thickness of material from inside to out.
3. Window, skylight and door types, dimensions and fits.
4. Stairway and elevator location and description.
5. Interior dimensions.

6. Machinery and fixture locations and dimensions as possible obstruction to air circulation.

7. Structural, piping, and other possible obstructions and their locations.

8. Light usage, type and location.

9. Information on all heat liberating equipment such as motors, piping, steam equipment, etc.

10. Location and description of exhaust system and appurtenances.

11. Number, time of occupancy, degree of activity, and percentage of men and women.

12. Sources and expected volumes of fumes, smoke, dust, odor, vapor, etc.

13. Operating schedule for heat requirements.

DATA FOR PLACING EQUIPMENT

1. Construction, size, location and layout of the building.

2. Availability of power service, steam, water and waste facilities.

3. Pumping requirements for utilities.

4. Extent of required duct work under different ventilating plans.

5. Allowable floor loading.

6. Effect of noise of air conditioning operation on occupancy.

7. Available members for supporting air conditioning equipment.

8. Possible location for outside air intake and exhaust.

Industrial systems shall be designed for continuous year-round operation. The designer must carefully check the relative humidity to be

maintained for winter operation against outside winter design temperature, and specify the installation of multiple glazing and/or insulation for walls to eliminate condensation, if required.

In addition to the preceding data the following information also must be determined for industrial units.

1. Nature of specific process involving conditioned air.

    a. Constant temperature (dry bulb)
    b. Constant relative humidity
    c. Constant absolute humidity

2. Physical properties of materials.

    a. Vapor pressure properties, including toxic limits
    b. Moisture regain
    c. Maximum moisture content tolerated
    d. Hygroscopicity
    e. Efflorescence

3. Nature of chemical reaction.

    a. Exothermic
    b. Endothermic

Section II. Selection of Indoor Design Temperatures

Comfort Installations. Generally, all installations in various plants and offices are for the benefit of employees who remain in the conditioned area for a period more than 40 minutes. A comfort installation designed for this type of occupancy is known as a CLASS A job. The maximum allowable room conditions acceptable for comfort are:

80°F D.B.
67°F W.B.

50%	Relative humidity
77.9	Grains per pound

All comfort systems shall be designed to maintain the above indoor conditions.

Industrial Installations. The maximum allowable room conditions for design are dictated by the nature of the process or the material exposed to the atmosphere. The design atmospheric conditions shall be specified by the process engineer or a research department. Decisions regarding this problem shall be made by the coordinated effort of the research section, the process engineer, and the structural engineer.

Every industrial installation is a special and individual problem and must be studied thoroughly. The structural engineer must, therefore, obtain all the required data which is necessary to design a system giving the desired results.

Section III. Selection of Outdoor Design Temperatures

Comfort Installations. Use "Normal Design Temperatures". Wet bulb temperatures shown are those occurring coincident with the design dry bulb temperatures. Corresponding dewpoint temperatures must be taken from the psychrometric chart.

Industrial Systems. The selection of outdoor design conditions for industrial systems is dependent solely on the specific process. Processes may be divided into three classifications, each with its corresponding outside design temperatures.

Class I. Processes in which deviation in temperature and/or humidity cannot be tolerated, and where a curtailment of production due to abnormal outside conditions may result in heavy losses and damage to other equipment. Use normal maximum outside temperatures for Class I.

Class II. Processes in which a deviation in temperature and/or humidity cannot be tolerated but a relatively short shut-down will not be costly and damaging. For Class II use a mean between normal design and normal maximum outdoor temperatures.

Class III. Processes in which a deviation in temperature and/or humidity can be tolerated and where a relatively short shut-down will not be costly and damaging. For this class use normal design outdoor temperatures.

Regional design temperatures shall conform to those listed in any supplementary specifications which may be provided.

Section IV. Heat Transmission Coefficients

Calculation of Coefficients. The rate of heat transferred through a building structure such as a wall, floor, or ceiling is known as the heat transmission coefficient, U. This is expressed in Btu per hour per square foot of surface per degree F difference between the air temperature on either side of the structure.

Heat transmission coefficients can be calculated for any combination of layers of different materials used in building structures if the thermal conductivity (k) of each material is known.

The following is a general equation used to calculate overall coefficients of built-up sections.

$$U = \frac{1}{\frac{1}{f_1} + \frac{1}{a} + \frac{1}{C} + \frac{x_1}{k_1} + \frac{x_2}{k_2} \ldots + \frac{x_n}{k_n} + \frac{1}{f_o}} ,$$

where k is the thermal conductivity (Btu transmitted per hour per square foot per degree F per inch thickness, for a homogeneous material), x is the thickness of homogeneous material in inches, and C is the thermal conductance (Btu transmitted per hour per square foot per degree F for the thickness or type of material under consideration). This term is commonly used for materials such as hollow clay tile.

The thermal conductance of air space is a, heat transmitted by radiation, conduction and convection (Btu per hour per square foot per degree F for the thickness of air space under consideration). Normally a is taken at 1.1 for air spaces exceeding 3/4 inch in thickness where the surfaces have no reflective insulation such as aluminum foil.

The air film coefficient or surface conductance is f, heat transmitted by radiation, conduction and convection (Btu per hour per square foot per degree F difference between the surface and surrounding air or

vice versa). The surface conductance on inside surface is f_1 and f_o is the surface conductance on outside surface.

SURFACE CONDUCTANCE (f) FOR BUILDING STRUCTURES

Surface	Exposure	f	
		Winter	Summer
Ceilings	inside	1.65	1.20
Roofs	outside	6.00	4.00
Walls	inside	1.65	1.65
Walls	outside	6.00	4.00

7.02--DUCT WORK

Section I. General Considerations

Supply and exhaust systems shall be constructed with materials hereinafter specified and shall be installed in a permanent and workmanlike manner. The interiors of all parts of the system shall be smooth and free of obstructions in order to minimize the resistance to air flow. As far as possible, all parts of the system shall be free from ingoing and outgoing leakage, so that air may enter and be discharged only at the points intended.

Insofar as practically possible, all piping and obstructions in the path of ducts shall be moved. Pipes containing steam or hot fluids must not pass through the ducts unless specific permission is given. Where obstructions cannot be moved, they must be treated with an easement as shown on Standard Drawing No. _____. Where the obstruction results in a decrease greater than 10% of the free area of the duct, the duct shall be increased at that point sufficiently to maintain a constant cross-sectional area.

Where ducts pass through masonry openings such as partitions, floors, etc., a continuous 1-1/2" x 1-1/2" galvanized or approved painted angle iron flange riveted around the perimeter of the duct on both sides of the opening shall be provided. The angle iron flange shall be securely bolted to the masonry work and made tight thereto with caulking compound.

Openings shall be provided in the duct system for the insertion of air measuring instruments at the locations shown on the drawings. Each opening shall be equipped with a 1-inch galvanized iron, railing type, floor flange, complete with a screwed square-head plug.

Section II. Sheet Metal Thickness

All ducts, casings, plenums, etc., unless otherwise shown on details or plans, shall be constructed of tight coated galvanized sheets, as manufactured by U.S. Steel Corporation, Bethlehem Steel Company, Wheeling Steel Corporation or approved equal, and shall be of the following minimum thicknesses.

Largest Side of Rect. Duct Inches	Thickness U.S. Std. Gauge No.
Up to 12	24
13 to 48	22
49 to 72	20
Over 72 and casings	18

Where aluminum is specified, all ducts, etc. shall be constructed of 2S-H14 sheets, as manufactured by the Aluminum Corporation of America, Reynolds Metal Company, or Permanente Metals Corporation. All construction details shall be followed as outlined herein. The schedule of gauges of aluminum sheet metal shall correspond to thickness shown above for galvanized iron.

Round Ducts. For ventilation systems only, round ducts, unless otherwise shown on details or plans, shall be constructed of glavanized sheets manufactured by the mills named above for rectangular ducts, and shall be of the following minimum thicknesses.

Diameter of Duct Inches	Thickness U.S. Std. Gauge No.
Up to 7	24
8 to 15	22
16 to 30	20
Over 30	18

Where aluminum is specified, all ducts etc. shall be constructed of 2S-H14 sheets as manufactured by Aluminum Corporation of America, Reynolds Metal Company, or Permanente Metals Corporation. All construction details shall be followed as outlined herein, and the thicknesses of aluminum sheet metal shall correspond to those shown above for galvanized iron.

Copper Ducts. Where copper is specified for duct construction it shall conform to ASTM specification R152-type A and the following gauges shall be used.

Largest Side Inches	Weight/Sq Ft Ounces
Up to 24	20
25 to 48	24
49 and up	32

Supports, bracing angles, etc. shall be of brass and of equivalent size as shown in the schedule for galvanized ducts.

Section III. Joints and Reinforcing

Rectangular Ducts. Joints on all ducts shall be practically air tight. The sheet metal shall be fabricated according to the following instructions to form a stiff rigid duct, free from vibration, breathing, sag or distortion between hangers or points of support.

Longitudinal Joints. All ducts shall be constructed using Pittsburgh seams. All seams shall be hammered and made air tight.

Transverse Joints. Where each section of a duct is joined to its adjacent section, the connection shall be made using a pocket slip joint formed as a standing seam around the perimeter of the duct. This joint shall be reinforced with galvanized angle iron in accordance with duct size as specified below. Pocket slips shall be fastened to the ducts by button punching or riveting at fixed centers not greater than 6" spacing.

a. Ducts up to 24" largest side of duct shall be constructed of standard 8'-0" sections. The transverse joints shall be pocket slips, button punched or riveted, forming a standing seam 1" high around the perimeter of the duct. The intermediate section of the duct at the 4'-0" mark shall be reinforced with 1" x 1" x 1/8" galvanized or an approved painted angle iron, riveted or spot welded to the duct at 6" centers.

b. Ducts 25 to 36", largest side of duct, shall be constructed of standard 4'-0" sections. The transverse joints shall be pocket slips, button punched or riveted, forming a standing seam 1" high around the perimeter of the duct. Duct shall be further reinforced by backing up the standing seam with 1" x 1" x 1/8" galvanized or an approved painted angle iron around the perimeter of the duct.

c. Ducts 37" and above, largest side of duct, shall be constructed of standard 3'-0" sections. The tranverse joints shall be pocket slips, button punched or riveted, forming a standing seam 1-1/2" high around the perimeter of the duct. Duct shall be further reinforced by backing up the standing seam with 1-1/2" x 1-1/2" x 1/8" galvanized or an approved painted angle iron around the perimeter of the duct. Angle iron shall be fastened to the duct, but not to the standing seam, with rivets or spot welding on 6" centers.

d. Ducts 65" and larger, in addition to the above mentioned bracing, shall be further reinforced with one diagonal cross-brace of 1-1/2" x 1-1/2" x 1/8" galvanized or an approved painted angle iron on each of the four sides of the duct, fastened to the duct by riveting or spot welding on 6" centers.

Cross-Breaking. To insure additional strength, uninsulated panels are to be cross-broken. Cross-breaking shall be applied to all Four sides of the duct work between joints and reinforcing angles.

Round Ducts. Joints on all ducts shall be practically air tight.

Ducts shall be built up of sections not shorter than 30" nor longer than 48" between joints.

The sheet metal shall be fabricated according to the following instructions to form a stiff, rigid duct, free from vibrations, breathing, sag or distortion between hangers or points of support.

Longitudinal Joints. All ducts shall be constructed using counter sunk double lock seams. All seams shall be hammered and made air tight.

Circumferential Joints. Where each section of a duct is joined to its adjacent section, a lap joint shall be formed and so constructed that the outlet of one length of pipe enters the inlet of the next in the direction of air flow. The amount of lap forming the joint shall be as follows.

Diameter of Duct Inches	Thickness U.S. Gauge	Lap Inches	Circumferential Rivet Spacing, Inches
Up to 7	24	1	2-1/2
8 to 15	22	1-1/4	2-1/2
16 to 30	20	1-1/2	4
Over 30	18	2	4

The portions of those ducts, as shown on drawings, passing through toilets, kitchens and other air contaminated areas, and connected to the suction side of the fan, shall have all joints (longitudinal and circumferential) soldered air tight, unless otherwise specified.

Removable Sections. In order to facilitate dismantling of ducts for cleaning purposes, flanged joints shall be inserted at intervals of 12'-0" throughout the length of the duct. These joints shall consist of two galvanized angle iron rings bolted together with a 1/8" rubber gasket between the angles for tightness. The schedule of angle iron ring joints is as follows.

Diameter of Duct Inches	Angle Iron Rings Inches	Number and Size of Bolts Inches
Up to 7	1 x 1 x 1/8	6-1/4
8 to 15	1 x 1 x 1/8	8-1/4
16 to 30	1-1/4 x 1-1/4 x 1/8	12-3/8
Over 30	1-1/2 x 1-1/2 x 3/16	15-3/8

Section IV. Elbows and Bends

Rectangular Ducts. All elbows or turns, unless otherwise shown on drawings, shall have a throat radius not less than the width of duct in the plane of the bend.

Where space conditions or interferences do not permit the use of the above specified elbow, the following may be used.

Elbows with a throat radius equal to one-half of the duct width, in the plane of the bend, shall have one turning vane spaced

according to Standard Drawing No. _____. Elbows with a throat radius equal to one-quarter of the duct width, in the plane of the bend, shall have two turning vanes spaced according to Standard Drawing No. _____.

The upstream edges of vanes in elbows shall be stiffened by hemming. The blades must be installed straight and securely fastened to the ducts with rivets on not more than 3" centers. All raw and sharp edges must be removed from the blades. Blades must be made stiff enough to eliminate rattle or vibration in the air stream. Vanes shall be constructed of sheet metal, two gauges heavier than the duct, but not exceeding No. 18 U.S. gauge.

All elbows having a throat radius less than one quarter of the duct width shall be square. They shall be constructed with duct-turns as shown on Standard Drawing No. _____ or as manufactured by the Tuttle and Bailey Company, or approved equal.

Round Ducts. Elbows. Elbows on circular ducts shall be constructed as follows.

Diameter of Duct Inches	No. of Gores
Up to 11	5
12 to 23	7
24 and up	9

Section V. Supports and Bracing

Rectangular Ducts. All ducts shall be permanently hung from rigid supports with all horizontal runs level and all vertical runs plumb. Hangers shall be erected in a neat and workmanlike manner. Hangers for ducts up to 48" wide shall be spaced not to exceed 8'-0" on centers; for ducts 49" to 72" wide, not to exceed 5'-0" on centers; and for ducts over 72" wide, 3'-0" on centers with additional hangers if required for proper supporting of the duct.

The use of perforated band iron for supporting ducts is not permitted.

Hangers for ducts up to 24" wide shall be constructed of 1" x 1/8" galvanized or an approved painted band iron and shall extend not less than 12" down the sides of the ducts. On ducts 12" and less in depth, the hangers shall extend the full depth of duct. Hangers shall be attached to the duct by rivets or Parker screws on 3" centers.

Hangers for ducts 25" to 48" wide shall be constructed of 1" x 1" x 1/8" or an approved painted galvanized angle iron and shall extend down the sides for the full depth of the duct. They shall be attached to the duct by rivets or Parker screws on 3" centers.

Hangers for ducts 49" to 72" wide shall be saddles constructed of 2" x 2" x 1/8" galvanized or an approved painted angle iron and vertical hangers of 1-1/2" x 1/8" galvanized or an approved painted angle iron.

Hangers shall be attached to the duct by rivets or Parker screws on 6" centers.

Hangers for ducts 73" and over in width, shall be saddles constructed of 2" x 2" x 3/16" glavanized or an approved painted angle iron and vertical hangers of 1-1/2" x 1-1/2" x 3/16" galvanized or an approved painted angle iron. Hangers shall be attached to the duct by rivets or Parker screws on 6" centers.

Depending on the nature of the overhead structure, hangers shall be fastened as follows:

Concrete slabs and beams by means of expansion shields and bolts, or other approved methods.

Structural steel by means of beam clamps, additional steel strung between the building steel or welding.

Wood floor beams or joists by means of lag screws or bolts or other approved methods.

Round Ducts. All ducts shall be permanently hung from rigid supports, with all horizontal runs level and all vertical runs plumb; hangers shall be erected in a neat and workmanlike manner.

Hangers for ducts up to 15" diameter shall be on 8'-0" centers; for ducts 16" to 30" diameter, not to exceed 5'-0" on centers; and for ducts over 30" diameter, 3'-0" on centers with additional hangers if required for proper support.

Hangers for ducts up to 15" diameter shall be constructed of 1" x 1/8" galvanized or an approved painted iron "belly-strap" around the circumference of the duct and then hung from overhead structures with a 1/4" diameter rod in the center. The use of perforated band iron for supporting ducts is not permitted.

Hangers for ducts 16" to 30" shall be saddles made of 1-1/2" x 1-1/2" x 3/16" galvanized or an approved painted angle iron and vertical hangers of 5/16" diameter rods. For ducts 30" diameter and over, the saddle angle shall be 2" x 2" x 3/16" with 1/2" diameter vertical hanger rods.

Depending on the nature of the overhead structure, hangers shall be fastened as follows:

Concrete slabs and beams by means of expansion shields and bolts, or other approved methods.

Structural steel by means of beam clamps, additional steel strung between the building steel or welding.

Wood floor beams or joists by means of lag screws or other approved methods.

Section VI. Dampers, Transformation Pieces, and Flexible Connections

Dampers. All supply, return fresh air, and exhaust duct branches shall be furnished with dampers for controlling the air flow at points shown on the drawings.

Hand dampers shall be constructed of not less than No. 22 U.S. gauge up to 12" wide, No. 20 U.S. gauge up to 24", and No. 16 U.S. gauge above 24" sheet metal and shall be made according to Standard Drawing No. _____. Where installed in ducts up to 12" deep, dampers shall be single blade, and in ducts greater than 12" deep, dampers shall be multiblade unless otherwise shown. Each blade shall be not less than 6" nor more than 9" in width.

Access doors shall be provided at all dampers, as shown on drawings, for the purpose of determining the actual position of the dampers.

Single Blade Dampers. Single blade dampers for ducts 13" to 24" wide shall be constructed with a 1-1/2" channel frame. Dampers 25" wide and above shall have a 2" channel frame. Dampers 12" and less will not require frames.

Single blade dampers up to 12" in length shall be fastened to a 3/8" x 3/8" pivot rod by means of three (3) Parker-Kalon Damper clips or an approved equal.

Single blade dampers 13" to 24" in length shall be fastened to a 3/8" x 3/8" pivot rod by means of three (3) Parker-Kalon Damper clips or an approved equal and the blades shall be reinforced with 1-1/4" x 1/4" bar iron riveted to the blade.

Single blade dampers 25" to 36" in length shall be fastened to a 1/2" x 1/2" pivot rod by means of four (4) Parker-Kalon Damper clips or an approved equal and the blade shall be reinforced with 1" x 1" x 1/9" angle iron, riveted to the blade.

Single blade dampers over 36" in length shall be divided into two or more sections along their axes with vertical supports at the division points.

Louver Dampers. Louver dampers shall be of multiblade construction using not less than No. 16 U.S. gauge metal. The maximum length of each blade in one piece shall be 48. For dampers over 48" in length, the blades shall be made up of two or more sections with mullions and interconnections of blade tie rods. Each blade shall be reinforced by forming or crimping to increase strength and rigidity. Each blade shall pivot on brass pins and bearings. Individual blades are to be so connected by means of linkage that they work in unison and are to be operated by a quadrant and handle or automatic device as shown on the drawings.

Dampers under 10 square feet in area shall be mounted in a 2" x 1/2" x 1/8" channel iron frame. Dampers over 10 square feet in area shall have frames of 2" x 1" x 1/8" channel iron. Dampers exceeding 16" in any direction shall have frames reinforced with corner braces.

Opposed Action - Louver Dampers. The construction and materials of opposed action louver dampers will be the same as for standard louver dampers except for the interconnecting linkage, which shall be so constructed that each blade rotates in a direction opposite to the blade adjacent to it. Details are as shown on Standard Drawing No. _____.

Splitter Dampers. Splitter dampers are to be installed in the supply duct branches. Splitters shall be constructed of sheet metal, two gauges heavier than the duct, but not to exceed No. 18 U.S. gauge. All splitters shall be made the width of the branch duct opening plus 10%, as shown on Standard Drawing No. _____. The leading edge of the splitter shall be crimped over so as not to have a sharp edge against the air flow. Splitters up to 24" deep shall be provided with a single pivot rod. Splitters 25" and above shall be provided with two rods. The splitters must be securely fastened to the pivot rods so that there is no vibration or rattling. The rods shall pass through fittings with a swivel joint where they go through the ducts. This fitting shall be provided with a set screw locking device to hold the rod in position. A small access door shall be provided in the duct so as to determine the exact position of the splitter damper.

Damper Locking Devices. In all supply and return duct branches where the damper pivot rod does not exceed 3/8", Young Regulator Company

"Valcalox" damper regulators or equal are to be used unless otherwise shown on the drawings.

These regulators shall be type No. 401A key-operated with type No. 656 end bearing (riveted to the side of the duct opposite to the regulator). The contractor shall furnish and deliver the necessary number of type No. 04 keys to the owner's representative responsible for the construction project.

The regulators shall be securely riveted to the ducts.

Dampers with pivot rods exceeding 3/8" shall be operated by a Parker-Kalon quadrant or equal with handle marked "open-closed".

When damper operating mechanisms are installed on insulated duct work, the quadrant or other device shall be mounted on an extended bracket, as shown in Standard Drawing No. _____, so that the operating mechanism is on the surface of the insulation.

Transformation Pieces. Where a change in duct size takes place, a transition piece shall be installed, have a slope on each side not to exceed 1 to 5 and preferably 1 to 7 wherever possible, as shown on Standard Drawing No. _____.

Fire Dampers. Where ducts pass through fire walls and floors are shown on the drawings, fire dampers shall be installed and constructed as shown on Standard Drawing No. _____.

Fire dampers in ducts up to 18" width shall be constructed of No. 16 U.S. gauge metal; 19" to 36" of No. 12 U.S. gauge; and above 36" of No. 7 U.S. gauge. For ducts over 18" in depth, louver type dampers shall be installed with each blade not greater than 6" in width and stiffened by formed edges. Blade bearings shall be corrosion resistant material.

Fire dampers shall be arranged to close automatically and remain tightly closed upon the operation of a fusible link or other approved heat actuated device located where it will be readily affected by an abnormal rise of temperature in the duct. The fusible links should have a temperature rating approximately 50°F above the maximum temperature normally encountered in the duct system. Hinged dampers shall be equipped with spring catches, 1" angle iron stops, and hinges with pins of corrosion resistant material.

The opening in the partition through which the duct passes shall be lined with a No. 10 gauge sheet metal sleeve extending 6" beyond the face of each side of the partition.

Access doors of suitable size and construction shall be provided at each fire damper.

Flexible Connections. The inlet and outlet connection of all fans shall be provided with a flexible connection. These connections, as shown on Standard Drawing No. _____, shall be a maximum of 4" in width, constructed of "Vulcan rubber and securely fastened to the fan

ring and to the duct work by a 1" x 1/8" galvanized iron draw band provided with tightening screws.

Section VII. Apparatus Casing

The apparatus casings and plenum chambers connecting air washers, preheater and reheater coils, filters, cooling coil banks, etc. shall be constructed of No. 18 U. S. gauge sheet metal. The casing shall be sufficiently braced vertically and horizontally by standing seams backed up with angle irons of a size shown in the following schedule and Standard Drawing No. _____. Intermediate reinforcing angles back to back shall be on no greater than 48" centers bolted together and then riveted to the casing on 6" centers. A base angle running around the outer sides of the casing shall be securely anchored to the floor with inserts on 2'-0" centers. This base angle shall then be properly caulked at the bottom to make a tight joint with the floor. All joints in casings shall be tight and when so designated on the drawings, they shall be soldered. When a bottom sheet or flooring is required for the casing, it shall be made with flat seams with all seams and joints soldered.

SCHEDULE OF CASING REINFORCING ANGLES

Heighth or Width Inches	Side and Top Angles Inches	Base Angles Inches
Up to 8'-0"	1-1/2 x 1-1/2 x 1/8	3 x 2 x 3/16
8'-1" tp 9'-11"	2 x 2 x 1/8	3 x 2 x 3/16
10'-0" and over	2 x 2 x 3/16	3 x 2 x 3/16

Section VIII. Access Doors

As indicated on the drawings, walk-thru access doors shall be provided on both sides of cooling coils, heating coils, fresh air intakes, fans and filters or other apparatus casings of sizes as noted and constructed according to details shown on Standard Drawing No. _____. Doors shall be constructed with an external built-up frame and a 1-1/2" x 1-1/2" x 3/16" galvanized or an approved painted angle iron internal frame for stiffening. Doors on insulated casings shall be of double panel construction, provided with an approved type insulating filler of thickness as shown on drawing. Door frames on insulated casings shall have an extended metal collar flush with the face of the finished insulation. The doors shall pivot on not less than three galvanized iron hinges, set with brass pins and securely fastened to the door frame. A locking device similar to a regrigerator door catch shall be installed at the center of the door. This catch shall be operable from the inside of the casing by means of a plunger passing through the door. The casing against which the door closes shall be framed with a soft rubber gasket to make the door air tight.

Access doors shall be provided at locations in the duct system as indicated on the drawings and where required, for access to automatic dampers, thermostats, or any apparatus requiring inspection. The construction details shall be according to Standard Drawing No. _____.

The doors shall be constructed with an external built-up metal frame for stiffening. Doors on insulated duct work shall be of double panel construction, provided with an approved type insulating filler of thickness as shown on drawing. Door frames on insulated ducts shall have an extended metal collar flush with the face of the finished insulation. The doors shall pivot on no less than two galvanized iron hinges, set with brass pins and securely fastened to the door frame. The doors shall be provided with no less than two brass window sash type fasteners, and a metal drawer type handle. The duct against which the door closes shall be framed with a soft rubber gasket to make the door air tight.

Access doors of size and construction as shown on Standard Drawing No. _____ shall be provided at approximately 20-foot intervals in the duct system to facilitate cleaning of the ducts. Removable grilles of adequate size and accessibility may be accepted as clean-out openings.

Section IX. Fresh Air Inlets

All fresh air inlets through outside walls shall be provided with stationary type rain louvers constructed according to details as shown on Standard Drawing No. _____. The louvers shall be constructed of aluminum sheets unless specified otherwise of the size and thickness shown on the drawings, and mounted in a rigid frame suitable for installing in wall opening. All joints between louver frame and wall opening shall be caulked to insure a water-tight connection.

The maximum width of a single louver section shall not exceed 48 inches. Where louver opening is wider than 48 inches, louver shall be constructed in multiple sections.

The exterior side of the louver shall be covered with a 1/2" No. 16 BWG gauge aluminum mesh screen (2 x 2 mesh) mounted in a suitable frame and fastened to the louver.

When the drawings denote that copper is to be used as the material for construction of fresh air louvers, etc. there shall not be any direct contact between the copper and the galvanized iron. Lead sheets 1/16" thick shall be riveted to the galvanized iron ducts on not less than 4" centers where the louvers and ducts are joined, as shown on Standard Drawing No. _____.

Fresh air inlet ducts passing through roofs and terminating in a goose neck shall have the cross-sectional in-take area of the goose neck 25% greater than the cross-sectional area of the duct to which it is attached, as shown on Standard Drawing No. _____.

The elbow intake opening shall be covered with a 1/2" No. 16 BWG gauge galvanized iron mesh screen mounted in a rigid frame. The inside heel of the goose neck shall terminate not less than 3'-0" above the roof.

Where the duct passes through the roof, a weather skirt shall be furnished over the roof curb and a weather cap over the curbing, securely fastened to the duct and with all seams soldered.

Goose necks terminating in outside walls shall be constructed as outlined above and shall be properly flashed to the exterior masonry.

Section X. Grille Installation

All grilles must be rigidly fastened to the ducts in a neat and workmanlike manner as shown on Standard Drawing No. _____. The joint between the supply grilles and the ducts must be fitted with a felt or rubber gasket or other suitable means to make the joint air tight, so that air will not blow out between the grille frame and the duct opening producing dust streaks on the duct or wall.

On furred-in duct work, the sheet metal grille collar shall be suitably reinforced with a wood frame on the outside of the collar in order to prevent it from being forced out of shape.

Where drawings call for installation of "Santrols, Volocitrols", or other volume regulating devices, the inside of the grille collar shall be smooth and free of obstructions which would prevent the installation of these devices. See Standard Drawing No. _____ for details of installation.

Section XI. Acoustical Linings

Where so indicated on the drawings, acoustical linings shall be installed using "Airacoustic" sheets as manufactured by Johns-Manville Company or equal.

Sheets shall be 1/2" thick, unless otherwise specified, and shall be firmly attached to the metal surfaces. A cold adhesive cement shall be spread evenly over the entire surface of the sheet before it is placed in the duct.

In addition to the adhesive cement, through bolts with 1-1/2" diameter metal washers shall be provided to hold the acoustical sheets to the duct. The washers shall be placed on the sheet surfaces and the bolts shall be spaced on centers not greater than 18".

The "Airacoustic" sheets shall be installed as specified by the manufacturer using only adhesives and/or cement specified by him.