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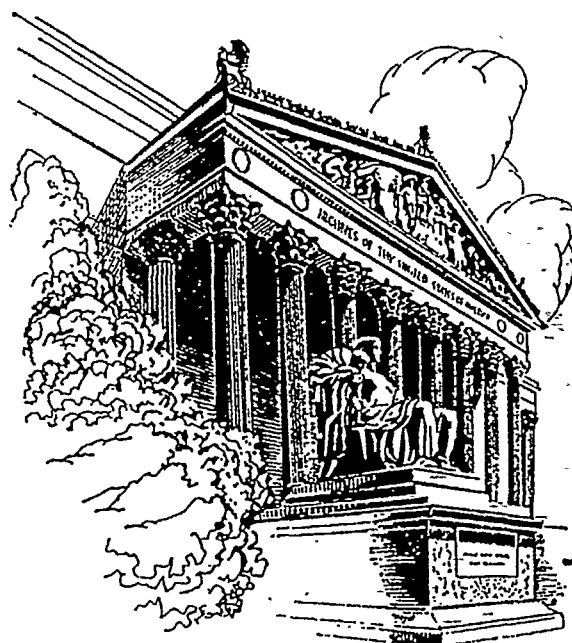
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PART II

DEPARTMENT OF LABOR

Bureau of Labor Standards

Safety and Health Regulations
for Construction



EGS 17797

RULES AND REGULATIONS

Title 29—LABOR

Chapter XIII—Bureau of Labor Standards, Department of Labor

PART 1518—SAFETY AND HEALTH REGULATIONS FOR CONSTRUCTION

By notice of proposed rule making published on February 2, 1971 (36 F.R. 1802), the Secretary of Labor invited the submission of written views, data, and arguments concerning proposed regulations to implement section 107 of the Contract Work Hours and Safety Standards Act (86 Stat. 96; 40 U.S.C. 327), commonly known as the Construction Safety Act. Six informal regional hearings were held for the purpose of receiving oral and written comments on the proposed rules.

At the hearings, numerous persons presented oral and written comments concerning the desirability and efficacy of the proposed rules. In addition, some comments were received from persons who did not attend the hearings.

All comments have been reviewed by the Advisory Committee on Construction Safety and Health, which has transmitted its recommendations to the Secretary of Labor.

After careful consideration of all comments and the recommendations of the Advisory Committee, the following rules are issued pursuant to section 107 of the Contract Work Hours and Safety Standards Act.

Except to the extent that notice and public participation in this rulemaking proceeding are required by section 107 of the Contract Work Hours and Safety Standards Act (40 U.S.C. 333), the proceeding is considered within the exemptions to 5 U.S.C. 553 for matters relating to public loans, benefits, and contracts. Nevertheless, good cause is hereby found for having these rules, to the extent that they are substantive, effective within a period of less than 30 days following publication except where longer periods are specifically provided. The rules are applied only to new construction contracts which are advertised on or after the seventh day following publication of this document in the FEDERAL REGISTER. In the case of negotiated construction contracts, the rules shall be effective as to new contracts of this nature for which negotiations are commenced on or after 10 days following publication of this document in the FEDERAL REGISTER. The time lag in the procurement process, together with the time periods specified, are considered sufficient to afford affected persons reasonable time to take such action as may be necessary to comply with the rules.

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AUTHORITY: The provisions of this Part 1518 issued under sec. 1, 83 Stat. 96, 97, adding sec. 107 to Public Law 87-581, 76 Stat. 357; 40 U.S.C. 333.

Subpart A—General

§ 1518.1 Purpose and scope.

(a) This part sets forth the safety and health standards promulgated by the Secretary of Labor under section 107 of the Contract Work Hours and Safety Standards Act. The standards are published in Subpart C of this part and following subparts.

(b) Subpart B of this part contains statements of general policy and interpretations of section 107 of the Contract Work Hours and Safety Standards Act having general applicability.

§ 1518.2 Variations from safety and health standards.

(a) In case of substantial engineering or other practical difficulties, a contractor or subcontractor may request a

variation from any of the safety and health standards published in Subpart C of this part and following subparts.

(b) Any contractor or subcontractor desiring a variation shall file with the Director of the Bureau of Labor Standards a written application in triplicate containing the following:

(1) The name and address of the applicant;

(2) A reference to the applicable standard, including the applicable provisions of this part;

(3) A full description of the proposed variation from the standard;

(4) A statement of how the variation would provide for protecting the surroundings or working conditions of the laborers or mechanics sought to be protected by the standard; and

(5) A statement of the substantial engineering or other practical difficulties which are asserted.

(c) The Director may require the applicant to furnish additional information.

(d) If the Director finds that the variation will not prejudice the safety or health of the laborers or mechanics sought to be protected by the standard, he shall grant the variation with such modifications, restrictions, or qualifications as he may consider to be necessary or appropriate.

(e) The terms and conditions of the variation may be modified at the discretion of the Director or upon application of the contractor or subcontractor or other interested person.

(f) The Director may cancel the variation for cause.

(g) Notice of the granting or cancellation of a variation shall be published in the FEDERAL REGISTER.

(h) In considering any request for a variation, the Director shall provide procedural safeguards equivalent to those prescribed in section 6(d) of the Occupational Safety and Health Act of 1970 (84 Stat. 1596). Pending the adoption of rules of procedure applying the aforementioned section 6(d), the applicable rules of procedure shall be specified in the notice of any hearing which may be provided.

§ 1518.3 Inspections—right of entry.

(a) It shall be a condition of each contract which is subject to section 107 of the Contract Work Hours and Safety Standards Act that the Secretary of Labor or any authorized representative shall have a right of entry to any site of contract performance for the following purposes:

(1) To inspect or investigate the matter of compliance with the safety and health standards contained in Subpart C of this part and following subparts; and

(2) To carry out the duties of the Secretary under section 107(b) of the Act.

(b) For the purpose of carrying out his investigative duties under the Act, the Secretary of Labor may, by agreement, use with or without reimbursement the services, personnel, and facilities of any State or Federal agency. Any agreements with States under this section shall be

similar to those provided for under the Walsh-Healey Public Contracts Act under 41 CFR Part 50-205.

§ 1518.4 Rules of practice for administrative adjudications for enforcement of safety and health standards.

(a) The rules of practice for administrative adjudications for the enforcement of the safety and health standards contained in Subpart C of this part and the following subparts shall be the same as those published in Part 6 of this title with respect to safety and health violations of the Service Contract Act of 1965 (69 Stat. 1035), except as provided in paragraph (b) of this section.

(b) In the case of debarment, the findings required by section 107(d) of the Act shall be made by the hearing examiner or the Director, as the case may be. Whenever, as provided in section 107(d) (2), a contractor requests termination of debarment before the end of the 3-year period prescribed in that section, the request shall be filed in writing with the Director who shall publish a notice in the FEDERAL REGISTER that the request has been received and afford interested persons an opportunity to be heard upon the request, and thereafter the provisions of Part 6 of this title shall apply with respect to prehearing conferences, hearings and related matters, and decisions and orders.

Subpart B—General Interpretations

§ 1518.10 Scope of subpart.

(a) This subpart contains the general rules of the Secretary of Labor interpreting and applying the construction safety and health provisions of section 107 of the Contract Work Hours and Safety Standards Act (83 Stat. 96). Section 107 requires as a condition of each contract which is entered into under legislation subject to Reorganization Plan Numbered 14 of 1950 (64 Stat. 1267), and which is for construction, alteration, and/or repair, including painting and decorating, that no contractor or subcontractor contracting for any part of the contract work shall require any laborer or mechanic employed in the performance of the contract to work in surroundings or under working conditions which are unsanitary, hazardous, or dangerous to his health or safety, as determined under construction safety and health standards promulgated by the Secretary by regulation.

§ 1518.11 Coverage under section 103 of the act distinguished.

(a) Coverage under section 103. It is important to note that the coverage of section 107 differs from that for the overtime requirements of the Contract Work Hours and Safety Standards Act. The application of the overtime requirements is governed by section 103, which, subject to specific exemptions, includes (1) Federal contracts requiring or involving the employment of laborers or mechanics (thus including, but not limited to, contracts for construction), and (2) contracts assisted in whole or in part by Federal loans, grants, or guarantees under any statute "providing wage

standards for such work." The statutes "providing wage standards for such work" include statutes for construction which require the payment of minimum wages in accordance with prevailing wage findings by the Secretary of Labor in accordance with the Davis-Bacon Act. A provision to section 103 excludes from the overtime requirements work where the Federal assistance is only in the form of a loan guarantee or insurance.

(b) *Coverage under section 107.* To be covered by section 107 of the Contract Work Hours and Safety Standards Act, a contract must be one which (1) is entered into under a statute that is subject to Reorganization Plan No. 14 of 1950 (64 Stat. 1267); and (2) is for "construction, alteration, and/or repair, including painting and decorating."

§ 1518.12 Reorganization Plan No. 14 of 1950.

(a) *General provisions.* Reorganization Plan No. 14 of 1950 relates to the prescribing by the Secretary of Labor of "appropriate standards, regulations, and procedures" with respect to the enforcement of labor standards under Federal and federally assisted contracts which are subject to various statutes subject to the Plan. The rules of the Secretary of Labor implementing the Plan are published in Part 5 of this title. Briefly, the statutes subject to the Plan include the Davis-Bacon Act, including its extension to Federal-aid highway legislation subject to 23 U.S.C. 113, and other statutes subject to the Plan by its original terms, statutes by which the Plan is expressly applied, such as the Contract Work Hours Standards Act by virtue of section 104(d) thereof.

(b) *The Plan.* (1) The statutes subject to Reorganization Plan No. 14 of 1950 are cited and briefly described in the remaining subparagraphs of this paragraph. These descriptions are general in nature and not intended to convey the full scope of the work to be performed under each statute. The individual statutes should be resorted to for a more detailed scope of the work.

(2) *Federal-Aid Highway Acts.* The provisions codified in 23 U.S.C. 113 apply to the initial construction, reconstruction, or improvement work performed by contractors or subcontractors on highway projects on the Federal-aid systems, the primary and secondary, as well as their extensions in urban areas, and the Interstate System, authorized under the highway laws providing for the expenditure of Federal funds upon the Federal-aid system. As cited in 41 Op. A.G. 488, 496, the Attorney General ruled that the Federal-Aid Highway Acts are subject to Reorganization Plan No. 14 of 1950.

(3) *National Housing Act (12 U.S.C. 1713, 1715a, 1715c, 1715k, 1715l(d) (3) and (4), 1715v, 1715w, 1715x, 1743, 1747, 1748, 1748h-2, 1750g, 1715l(h) (1), 1715z (j) (1), 1715z-1, 1715y(d), Subchapter 1x-A and 1x-B, 1715z-7).* This act covers construction which is financed with assistance by the Federal Government through programs of loan and mortgage insurance for the following purposes:

(i) *Rental Housing—Section 1713* provides mortgage and insurance on rental housing of eight or more units and on mobile-home courts.

(ii) *Section 1715a—Repealed.*

(iii) *Cooperative Housing—Section 1715c* authorizes mortgage insurance on cooperative housing of five or more units as well as supplementary loans for improvement of repair or resale of memberships.

(iv) *Urban Renewal Housing—Section 1715k* provides mortgage insurance on single family or multifamily housing in approved urban renewal areas.

(v) *Low or Moderate Income Housing—Section 1715L(d) (3) and (4)* insures mortgages on low-cost single family or multifamily housing.

(vi) *Housing for Elderly—Section 1715v* provides mortgage insurance on rental housing for elderly or handicapped persons.

(vii) *Nursing Homes—Section 1715w* authorizes mortgage insurance on nursing home facilities and major equipment.

(viii) *Experimental Housing—Section 1715x* provides mortgage insurance on single family or multifamily housing with experimental design of materials.

(ix) *War Housing Insurance—Section 1743* not active.

(x) *Yield Insurance—Section 1747* insures investment returns on multifamily housing.

(xi) *Armed Services Housing—Section 1748b* to assist in relieving acute shortage and urgent need for family housing at or in areas adjacent to military installations.

(xii) *Defense Housing for Impacted Areas—Section 1748h-2* provides mortgage insurance on single family or multifamily housing for sale or rent primarily to military or civilian personnel of the Armed Services, National Aeronautics and Space Administration, or Atomic Energy Commission.

(xiii) *Defense Rental Housing—Section 1750g* provides for mortgage insurance in critical defense housing areas.

(xiv) *Rehabilitation—Section 1715L (h) (1)* provides mortgage insurance for nonprofit organizations to finance the purchase and rehabilitation of deteriorating or substandard housing for subsequent resale to low-income home purchasers. There must be located on the property five or more single family dwellings of detached, semidetached, or row construction.

(xv) *Homeowner Assistance—Section 1715Z(j) (1)* authorizes mortgage insurance to nonprofit organizations or public bodies or agencies executed to finance sale of individual dwellings to lower income individuals or families. Also includes the rehabilitation of such housing if it is deteriorating or substandard for subsequent resale to lower income home purchasers.

(xvi) *Rental Housing Assistance—Section 1715Z-1* authorizes mortgage insurance and interest reduction payments on behalf of owners of rental housing projects designed for occupancy by lower income families. Payments are also au-

thorized for certain State or locally aided projects.

(xvii) *Condominium Housing—Section 1715y(d)* provides mortgage insurance on property purchased for the development of building sites. This includes waterlines and water supply installations, sewer lines and sewage disposal installations, steam, gas, and electrical lines and installations, roads, streets, curbs, gutters, sidewalks, storm drainage facilities, and other installation or work.

(xviii) *Group Medical Practice Facilities—Subchapter LX-B* authorizes mortgage insurance for the financing of construction and equipment, of facilities for group practice of medicine, optometry, or dentistry.

(xix) *Nonprofit Hospitals—1715z-7* authorizes mortgage insurance to cover new and rehabilitated hospitals, including initial equipment.

(4) *Hospital Survey and Construction Act, as amended by the Hospital and Medical Facilities Amendments of 1964 (42 U.S.C. 291e).* The provisions of this Act cover construction contracts made by State or local authorities or private institutions under Federal grant-in-aid programs for the construction of hospitals and other medical facilities.

(5) *Federal Airport Act (49 U.S.C. 1114(b)).* The act provides grant-in-aid funds for airport construction limited to general site preparation runways, taxiways, aprons, lighting appurtenant thereto, and fire, rescue, and maintenance buildings. The act excludes construction intended for use as a public parking facility for passenger automobiles and the cost of construction of any part of an airport building except such of those buildings or parts of buildings to house facilities or activities directly related to the safety of persons at the airport.

(6) *Housing Act of 1949 (42 U.S.C. 1459).* Construction contracts awarded by local authorities financed with the assistance of loans and grants from the Federal Government. The construction programs are for slum clearance and urban renewal which includes rehabilitation grants, neighborhood development programs, neighborhood renewal plans, community renewal, demolition projects, and assistance for blighted areas. See the Housing Act of 1964, No. 21 below, concerning financial assistance for low-rent housing for domestic farm labor.

(7) *School Survey and Construction Act of 1950 (20 U.S.C. 636).* This act provides for a Federal grant-in-aid program to assist in the construction of schools in federally affected areas.

(8) *Defense Housing & Community Facilities & Services Act of 1951 (42 U.S.C. 1592i).* Inactive Program.

(9) *United States Housing Act of 1937 (42 U.S.C. 1416).* This statute covers the construction of low-rent public housing and slum clearance projects awarded by local authorities. These projects are financed with the assistance of loans and grants from the Federal Government. The slum clearance is the demolition and removal of buildings from any slum area to be used for a low-rent housing project.

States and their political subdivisions in the field of civil defense which includes procurement, construction, leasing, or renovating of materials and facilities.

(11) *Delaware River Basin Compact* (sec. 15.1, 75 Stat. 714). This joint resolution creates, by intergovernmental compact between the United States, Delaware, New Jersey, New York, and Pennsylvania, a regional agency for planning, conservation, utilization, development, management and control of the water and related sources of the Delaware River.

(12) *Cooperative Research Act* (20 U.S.C. 332a(c)). This act provides Federal grants to a university, college, or other appropriate public or nonprofit private agency or institution for part or all of the cost of constructing a facility for research or for research and related purposes. Research and related purposes means research, research training, surveys, or demonstrations in the field of education, or the dissemination of information derived therefrom, or all of such activities, including (but without limitation) experimental schools, except that such term does not include research, research training, surveys, or demonstrations in the field of sectarian instruction or the dissemination of information derived therefrom. Construction includes new buildings, and the acquisition, expansion, remodeling, replacement, and alteration of existing buildings and the equipping of new buildings and existing buildings.

(13) *Health Professions Educational Assistance Act of 1963* (42 U.S.C. 292d (c)(4), 293a(c)(5)). The provisions of this act provide for grants to assist public and nonprofit medical, dental, and similar schools for the construction, expansion, or renovation of teaching facilities.

(14) *Mental Retardation Facilities Construction Act* (42 U.S.C. 295(a)(2)(D), 2662(5), 2675(a)(5)). This act authorizes Federal financial assistance in the construction of centers for research on mental retardation and related aspects of human development, of university-affiliated facilities for the mentally retarded and of facilities for the mentally retarded.

(15) *Community Mental Health Centers Act* (42 U.S.C. 2635(a)(5)). This act authorizes Federal grants for the construction of public and other nonprofit community mental health centers.

(16) *Higher Education Facilities Act of 1963* (20 U.S.C. 753). This act authorizes the grant or loan of Federal funds to assist public and other nonprofit institutions of higher education in financing the construction, rehabilitation, or improvement of academic and related facilities in undergraduate and graduate schools.

(17) *Vocational Educational Act of 1963* (20 U.S.C. 35f). This act provides for Federal grants to the various States for construction of area vocational education school facilities.

various States for the construction of public libraries.

(18) *Urban Mass Transportation Act of 1954* (49 U.S.C. 1609). This act provides for grants and loans to assist States and local public bodies and agencies thereof in financing the acquisition, construction, reconstruction, and improvement of facilities and equipment for use, by operation or lease or otherwise, in mass transportation service in urban area and in coordinating such service with highway and other transportation in such areas.

(20) *Economic Opportunity Act of 1964* (42 U.S.C. 2947). This act covers construction which is financed with assistance of the Federal Government for the following purposes:

(i) Authorizes Federal assistance for construction of projects, buildings and works which will provide young men and women in rural and urban residential centers with education, vocational training, and useful work experience (Title I).

(ii) Authorizes financial assistance for construction work planned and carried out at the community level for anti-poverty programs (Title II):

(a) Authorizes loans to low income rural families by assisting them to acquire or improve real estate or reduce encumbrances or erect improvements thereon, and to participate in cooperative associations and/or to finance non-agricultural enterprises which will enable such families to supplement their income (Title III):

(b) Authorizes loans to local cooperative associations furnishing essential processing, purchasing, or marketing services, supplies, or facilities predominantly to low-income rural families (Title III):

(c) Authorizes financial assistance to States, political subdivisions of States, public and nonprofit agencies, institutions, organizations, farm associations, or individuals in establishing housing, sanitation, education, and child day-care programs for immigrants and other seasonally employed agricultural employees, and their families (Title III):

(iii) Authorizes loans or guarantees loans to small businesses for construction work (Title IV):

(iv) Authorizes the payment of the cost of experimental, pilot, or demonstration projects to foster State programs providing construction work experience or training for unemployed fathers and needy people (Title V).

(21) *Housing Act of 1964* (42 U.S.C. 1486(f); 42 U.S.C. 1452b(e)). Provides financial assistance for low-rent housing for domestic farm labor. The Act further provides for loans, through public or private agencies, where feasible, to owners or tenants of property in urban renewal areas to finance rehabilitation required to conform the property to applicable code requirements or carry out the objectives of the urban renewal plan for the area.

financial assistance to States for construction projects designed for the research and development of the commercial fisheries resources of the Nation.

(23) *The Nurse Training Act of 1964* (42 U.S.C. 296a(b)(5)). This act provides for grants to assist in the construction of new facilities for collegiate, associate degree, and diploma schools of nursing, or replacement or rehabilitation of existing facilities of such schools.

(24) *Elementary and Secondary Education Act of 1965* (20 U.S.C. 241i, 848). The purpose of the act is to provide financial assistance to local educational agencies serving areas with concentrations of children from low income families for construction in connection with the expansion or improvement of their educational programs.

(25) *Federal Water Pollution Control Act, as amended by the Water Quality Act of 1965* (3 U.S.C. 466e(g)). Provides for financial assistance to States or municipalities for construction of facilities in connection with the prevention and control of water pollution. This includes projects that will control the discharge into any waters of untreated or inadequately treated sewage.

(26) *Appalachian Regional Development Act of 1965* (40 U.S.C. App. 402). Authorizes Federal assistance in the construction of an Appalachian development highway system; construction of multi-county demonstration health facilities, hospitals, regional health, diagnostic and treatment centers, and other facilities for health; seal and fill voids in abandoned mines and to rehabilitate strip mine areas; construction of school facilities for vocational education; and to assist in construction of sewage treatment works.

(27) *National Technical Institute for the Deaf Act* (20 U.S.C. 684(b)(5)). Provides for financial assistance for institutions of higher education for the establishment, construction, including equipment and operation, of a National Institution for the Deaf.

(28) *Housing Act of 1959* (12 U.S.C. 1701(q)(c)(3)). This act authorizes loans to nonprofit corporations to be used for the construction of housing and related facilities for elderly families. Also, the provisions of the act provide for rehabilitation, alteration, conversion or improvement of existing structures which are otherwise inadequate for proposed dwellings used by such families.

(29) *College Housing Act of 1950, as amended* (12 U.S.C. 1749a(f)). This act provides for Federal loans to assist educational institutions in providing housing and other educational facilities for students and faculties.

(30) *Housing and Urban Development Act of 1965* (42 U.S.C. 1500c-3, 3107). This act provides for Federal assistance for the following purposes:

(i) Grants to States and local public bodies to assist in any construction work to be carried out under the open-space land and urban beautification provisions

contained therein. It provides for parks, recreation areas, conservation of and other natural resources, and historical and scenic purposes.

(ii) Grants to local public bodies and agencies to finance specific project for basic public water facilities (including works for the storage, treatment, purification, and distribution of water), and or basic public sewer facilities (other than "treatment works" as defined in the Federal Water Pollution Control Act).

(iii) Grants to any local public body or agency to assist in financing neighborhood facilities. These facilities must be necessary for carrying out a program of health, recreational, social, or similar community service and located so as to be available for the use of the area's low or moderate income residents.

(31) *National Foundation on the Arts and the Humanities Act of 1965* (20 U.S.C. 954(k)). The act establishes the National Foundation on the Arts and the Humanities which may provide matching grants to groups (nonprofit organizations and State and other public organizations) and to individuals engaged in creative and performing arts for the entire range of artistic activity, including construction of necessary facilities.

(32) *Public Works and Economic Development Act of 1965* (42 U.S.C. 3222). This act provides for Federal assistance for the following purposes:

(i) Grants for the acquisition or development of land or improvements in public works or development facilities in redevelopment areas. It authorizes loans to assist in financing the purchase or development of land for public works which will assist in the creation of long-term employment opportunities in the area.

(ii) Loans for the purchase or development of land and facilities (including machinery and equipment) for industrial or commercial usage within redevelopment areas; guarantee of loans for working capital made to private borrowers by private lending institutions in connection with direct loan projects; and to contract to pay to, or on behalf of, business entities locating in redevelopment areas, a portion of the interest costs which they incur in financing their expansions from private sources.

(iii) Loans and grants to create economic development centers within designated county economic development districts.

(33) *High-Speed Ground Transportation Study* (40 U.S.C. 1636(b)). This act provides for financial assistance for construction activities in connection with research and development of different forms of high-speed ground transportation and demonstration projects relating to intercity rail passenger service.

(34) *Heart Disease, Cancer and Stroke Amendments of 1965* (42 U.S.C. 991(b)(4)). This act provides for grants to public or nonprofit private universities, medical schools, research institutions, hospitals, and other public and nonprofit agencies and institutions, or

associations thereof to assist in construction and equipment of facilities in connection with research, training, demonstration of patient care, diagnostic and treatment related to heart disease, cancer, stroke, and other major diseases.

(35) *Mental Retardation Facilities and Community Mental Health Centers Construction Act Amendments of 1965* (20 U.S.C. 618(g)). These provisions provide for grants to institutions of higher education for construction of facilities for research or for research and related purposes relating to education for mentally retarded, hard of hearing, deaf, speech impaired, visually handicapped, seriously emotionally disturbed, crippled, or other health impaired children who by reason thereof require special education.

(36) *Vocational Rehabilitation Act Amendments of 1965* (29 U.S.C. 41a(b)(4)). This act authorizes grants to assist in meeting the costs of construction of public or other nonprofit workshops and rehabilitation facilities.

(37) *Clean Air and Solid Waste Disposal Acts* (42 U.S.C. 3256). This act provides for financial assistance to public (Federal, State, interstate, or local) authorities, agencies, and institutions, private agencies and institutions, and individuals in the construction of facilities for solid-waste disposal. The term construction includes the installation of initial equipment.

(38) *Medical Library Assistance Act of 1965* (42 U.S.C. 280b-3(b)(3)). This act provides for grants to public or private non-profit agencies or institutions for the cost of construction of medical library facility.

(39) *Veterans Nursing Home Care Act* (38 U.S.C. 5035(a)(8)). The construction industry health and safety standards do not apply to this act since it is not subject to Reorganization Plan No. 14 of 1950.

(40) *National Capital Transportation Act of 1965* (40 U.S.C. 682(b)(4)). This act provides for Federal assistance to the National Capital Transportation Agency for construction of a rail rapid transit system and related facilities for the Nation's Capital.

(41) *Alaska Centennial—1967* (80 Stat. 82). The program under this legislation has expired.

(42) *Model Secondary School for the Deaf Act* (80 Stat. 1028). This act provides for funds to establish and operate, including construction and initial equipment of new buildings, expansion, remodeling, and alteration of existing buildings and equipment thereof, a model secondary school for the deaf to serve the residents of the District of Columbia and nearby States.

(43) *Allied Health Professions Personnel Training Act of 1966* (42 U.S.C. 295h(b)(2)(E)). This act provides for grants to assist in the construction of new facilities for training centers for allied health professions, or replacement or rehabilitation of existing facilities for such centers.

(44) *Demonstration Cities and Metropolitan Development Act of 1966* (42 U.S.C. 3310; 12 U.S.C. 1715c; 42 U.S.C.

1416). This act provides for Federal assistance for the following purposes:

(i) Grants to assist in the construction, rehabilitation, alteration, or repair of residential property only if such residential property is designed for residential use for eight or more families to enable city demonstration agencies to carry out comprehensive city demonstration programs (42 U.S.C. 3310).

(ii) Amends the National Housing Act (12 U.S.C. 1715c) and the Housing Act of 1937 (42 U.S.C. 1416). See these acts for coverage.

(45) *Air Quality Act of 1967* (42 U.S.C. 1857j-3). This act provides for Federal assistance to public or nonprofit agencies, institutions, and organizations and to individuals, and contracts with public or private agencies, institutions, or persons for construction of research and development facilities and demonstration plants relating to the application of preventing or controlling discharges into the air of various types of pollutants.

(46) *Elementary and Secondary Education Amendments of 1967* (Title VII—*Bilingual Education Act*) (20 U.S.C. 880b-6). This act provides for Federal assistance to local educational agencies or to an institution of higher education applying jointly with a local educational agency for minor remodeling projects in connection with bilingual education programs to meet the special needs of children with limited English-speaking ability in the United States.

(47) *Vocational Rehabilitation Amendments of 1967* (29 U.S.C. 42a(c)(3)). This act authorizes Federal assistance to any public or nonprofit private agency or organization for the construction of a center for vocational rehabilitation of handicapped individuals who are both deaf and blind which shall be known as the National Center for Deaf-Blind Youths and Adults. Construction includes new buildings and expansion, remodeling, alteration and renovation of existing buildings, and initial equipment of such new, newly acquired, expanded, remodeled, altered, or renovated buildings.

(48) *National Visitor Center Facilities Act of 1968* (40 U.S.C. 808). This act authorizes agreements and leases with the owner of property in the District of Columbia known as Union Station for the use of all or a part of such property for a national visitor center to be known as the National Visitor Center. The agreements and leases shall provide for such alterations of the Union Station Building as necessary to provide adequate facilities for visitors. They also provide for the construction of a parking facility, including necessary approaches and ramps.

(49) *Juvenile Delinquency Prevention and Control Act of 1968* (42 U.S.C. 3843). This act provides for Federal grants to State, county, municipal, or other public agency or combination thereof for the construction of facilities to be used in connection with rehabilitation services for the diagnosis, treatment, and rehabilitation of delinquent youths and youths in danger of becoming delinquent.

(50) *Housing and Urban Development Act of 1968 (including New Communities Act of 1968) (42 U.S.C. 3909)*. This act provides for Federal assistance for the following purposes:

(i) Guarantees, and commitments to guarantee, the bonds, debentures, notes, and other obligations issued by new community developers to help finance new community development projects.

(ii) Amends section 212(a) of the National Housing Act, adding section 236 for "Rental Housing for Lower Income Families" and section 242 "Mortgage Insurance for Nonprofit Hospitals" thereto.

(51) *Public Health Service Act Amendment (Alcoholic and Narcotic Addict Rehabilitation Amendments of 1968) (42 U.S.C. 2681, et seq.)*. This act provides for grants to a public and nonprofit private agency or organization for construction projects consisting of any facilities (including post-hospitalization treatment facilities for the prevention and treatment of alcoholism or treatment) of narcotic addicts.

(52) *Vocational Education Amendments of 1968 (20 U.S.C. 1246)*. This act provides for grants to States for the construction of area vocational education school facilities. The act further provides grants to public educational agencies, organizations, or institutions for construction of residential schools to provide vocational education for the purpose of demonstrating the feasibility and desirability of such schools. The act still further provides grants to State boards, to colleges and universities, to public educational agencies, organizations or institutions to reduce the cost of borrowing funds for the construction of residential schools and dormitories.

(53) *Postal Reorganization Act (39 U.S.C. 410(d)(2))*. This Act provides for construction, modification, alteration, repair, and other improvements of postal facilities located in leased buildings.

(54) *Airport and Airway Development Act of 1970 (Public Law 91-258, section 52(b)(7))*. This Act provides for Federal financial assistance to States and localities for the construction, improvement, or repair of public airports.

(55) (i) *Public Law 91-230*. This Act provides for federal financial assistance to institutions of higher learning for the construction of a National Center on Educational Media and Materials for the Handicapped. The program under this statute expires on July 1, 1971. Public Law 91-230, section 662(1).

(ii) *Education of the Handicapped Act (20 U.S.C. 12326, 1404(a))*. This Act provides for financial assistance to States for construction, expansion, remodeling, or alteration of facilities for the education of handicapped children at the pre-school, elementary school, and secondary school levels.

(56) *Housing and Urban Development Act of 1970 (Public Law 91-609, section 707(b))*. This Act provides for grants to States and local public agencies to help finance the development of open-space or other land in urban areas for open-space uses. This Act becomes effective on July 1, 1971.

(57) *Developmental Disabilities Services and Facilities Construction Amendments of 1970 (Public Law 91-517, section 135(a)(5))*. This Act authorizes grants to States for construction of facilities for the provision of services to persons with developmental disabilities who are unable to pay for such services.

(58) *Rail Passenger Service Act of 1970 (Public Law 91-518, section 405(d))*. This statute provides that the National Railroad Passenger Corporation may construct physical facilities necessary to intercity rail passenger operations within the basic national rail passenger system designated by the Secretary of Transportation.

(c) *VA and FHA housing*. In the course of the legislative development of section 107, it was recognized that section 107 would not apply to housing construction for which insurance was issued by the Federal Housing Authority and Veterans' Administration for individual home ownership. Concerning construction under the National Housing Act, Reorganization Plan No. 14 of 1950 applies to construction which is subject to the minimum wage requirements of section 212(a) thereof (12 U.S.C. 1715c).

§ 1518.13 Interpretation of statutory terms.

(a) The terms "construction," "alteration," and "repair" used in section 107 of the Act are also used in section 1 of the Davis-Bacon Act (40 U.S.C. 276a), providing minimum wage protection on Federal construction contracts, and section 1 of the Miller Act (40 U.S.C. 270a), providing performance and payment bond protection on Federal construction contracts. Similarly, the terms "contractor" and "subcontractor" are used in those statutes, as well as in Copeland (Anti-Kickback) Act (40 U.S.C. 276c) and the Contract Work Hours and Safety Standards Act itself, which apply concurrently with the Miller Act and the Davis-Bacon Act on Federal construction contracts and also apply to most federally assisted construction contracts. The use of the same or identical terms in these statutes which apply concurrently with section 107 of the Act have considerable precedential value in ascertaining the coverage of section 107.

(b) It should be noted that section 1 of the Davis-Bacon Act limits minimum wage protection to laborers and mechanics "employed directly" upon the "site of the work." There is no comparable limitation in section 107 of the Act. Section 107 expressly requires as a self-executing condition of each covered contract that no contractor or subcontractor shall require "any laborer or mechanic employed in the performance of the contract to work in surroundings or under working conditions which are unsanitary, hazardous, or dangerous to his health or safety" as these health and safety standards are applied in the rules of the Secretary of Labor.

(c) The term "subcontractor" under section 107 is considered to mean a person who agrees to perform any part of the labor or material requirements of a

contract for construction, alteration or repair. Cf. *MacEvoy Co. v. United States*, 322 U.S. 102, 108-9 (1944). A person who undertakes to perform a portion of a contract involving the furnishing of supplies or materials will be considered a "subcontractor" under this part and section 107 if the work in question is to be performed: (1) Directly on or adjacent to the construction site, or (2) by the employer for the specific project on a customized basis. Thus, a supplier of materials which will become an integral part of the construction is a "subcontractor" if the supplier fabricates the goods or materials in question specifically for the construction project. If the goods or materials in question are ordinarily sold to other customers from regular inventory, the supplier is not a "subcontractor". An example of material supplied "for the specific project on a customized basis" as that phrase is used in this section would be ventilating ducts, fabricated in a shop away from the construction jobsite and specifically cut for the project according to design specifications. On the other hand, a supplier furnishing steel beams would not be a "subcontractor" if the beams are of a size and type manufactured for general construction use and not specifically made for the particular construction contract. Ordinarily, a contract for the supplying of construction equipment to a contractor would not, in and of itself, be considered a "subcontractor" for purposes of this part.

§ 1518.14 Federal contract for "mixed" types of performance.

(a) It is the intent of the Congress to provide safety and health protection of Federal, federally financed, or federally assisted construction. See, for example, H. Report No. 91-241, 91st Cong., first session, p. 1 (1969). Thus, it is clear that when a Federal contract calls for mixed types of performance, such as both manufacturing and construction, section 107 would apply to the construction. By its express terms, section 107 applies to a contract which is "for construction, alteration, and/or repair." Such a contract is not required to be exclusively for such services. The application of the section is not limited to contracts which permit an overall characterization as "construction contracts." The text of section 107 is not so limited.

(b) When the mixed types of performances include both construction and manufacturing, see also § 1518.15(b) concerning the relationship between the Walsh-Healey Public Contracts Act and section 107.

§ 1518.15 Relationship to the Service Contract Act; Walsh-Healey Public Contracts Act.

(a) A contract for "construction" is one for nonpersonal service. See, e.g., 41 CFR 1-1.208. Section 2(e) of the Service Contract Act of 1965 requires as a condition of every Federal contract (and bid specification therefor) exceeding \$2,500, the "principal purpose" of which is to furnish services to the United States.

through the use of "service employees," that certain safety and health standards be met. See 29 CFR Part 1516, which contains the Department rules concerning these standards. Section 7 of the Service Contract Act provides that the Act shall not apply to "any contract of the United States or District of Columbia for construction, alteration, and/or repair, including painting and decorating of public buildings or public works." It is clear from the legislative history of section 107 that no gaps in coverage between the two statutes are intended.

(b) The Walsh-Healey Public Contracts Act requires that contracts entered into by any Federal agency for the manufacture or furnishing of materials, supplies, articles, and equipment in any amount exceeding \$10,000 must contain, among other provisions, a requirement that "no part of such contract will be performed nor will any of the materials, supplies, articles or equipment to be manufactured or furnished under said contract be manufactured or fabricated in any plants, factories, buildings, or surroundings or under working conditions which are unsanitary or hazardous or dangerous to the health and safety of employees engaged in the performance of said contract." The rules of the Secretary concerning these standards are published in 41 CFR Part 50-204, and express the Secretary of Labor's interpretation and application of section 1(e) of the Walsh-Healey Public Contracts Act to certain particular working conditions. None of the described working conditions are intended to deal with construction activities, although such activities may conceivably be a part of a contract which is subject to the Walsh-Healey Public Contracts Act. Nevertheless, such activities remain subject to the general statutory duty prescribed by section 1(e). Section 103(b) of the Contract Work Hours and Safety Standards Act provides, among other things, that the Act shall not apply to any work required to be done in accordance with the provisions of the Walsh-Healey Public Contracts Act.

§ 1518.16 Rules of construction.

(a) The prime contractor and any subcontractors may make their own arrangements with respect to obligations which might be more appropriately treated on a jobsite basis rather than individually. Thus, for example, the prime contractor and his subcontractors may wish to make an express agreement that the prime contractor or one of the subcontractors will provide all required first-aid or toilet facilities, thus relieving the subcontractors from the actual, but not any legal, responsibility (or, as the case may be, relieving the other subcontractors from this responsibility). In no case shall the prime contractor be relieved of overall responsibility for compliance with the requirements of this part for all work to be performed under the contract.

(b) By contracting for full performance of a contract subject to section 107

of the Act, the prime contractor assumes all obligations prescribed as employer obligations under the standards contained in this part, whether or not he subcontracts any part of the work.

(c) To the extent that a subcontractor of any tier agrees to perform any part of the contract, he also assumes responsibility for complying with the standards in this part with respect to that part. Thus, the prime contractor assumes the entire responsibility under the contract and the subcontractor assumes responsibility with respect to his portion of the work. With respect to subcontracted work, the prime contractor and any subcontractor or subcontractors shall be deemed to have joint responsibility.

(d) Where joint responsibility exists, both the prime contractor and his subcontractor or subcontractors, regardless of tier, shall be considered subject to the enforcement provisions of the Act.

Subpart C—General Safety and Health Provisions

§ 1518.20 General safety and health provisions.

(a) *Contractor requirements.* (1) Section 107 of the Act requires that it shall be a condition of each contract which is entered into under legislation subject to Reorganization Plan Number 14 of 1950 (64 Stat. 1267), as defined in § 1518.12, and is for construction, alteration, and/or repair, including painting and decorating, that no contractor or subcontractor for any part of the contract work shall require any laborer or mechanic employed in the performance of the contract to work in surroundings or under working conditions which are unsanitary, hazardous, or dangerous to his health or safety.

(b) *Accident prevention responsibilities.* (1) It shall be the responsibility of the employer to initiate and maintain such programs as may be necessary to comply with this part.

(2) Such programs shall provide for frequent and regular inspections of the job sites, materials, and equipment to be made by competent persons designated by the employers.

(3) The use of unsafe machinery, tools, materials, or equipment is prohibited. Unsafe tools, materials, or equipment shall be identified as unsafe by tagging or by locking the controls to render them inoperable, or they shall be removed from service.

(4) The employer shall permit only those employees qualified by training or experience to operate equipment and machinery.

§ 1518.21 Safety training and education.

(a) *General requirements.* The Director shall, pursuant to section 107(f) of the Act, establish and supervise programs for the education and training of employers and employees in the recognition, avoidance and prevention of unsafe conditions in employments covered by the act.

(b) *Employer responsibility.* (1) The employer should avail himself of the

safety and health training programs the Director provides.

(2) The employer shall instruct each employee in the recognition and avoidance of unsafe conditions and the regulations applicable to his work environment to control or eliminate any hazards or other exposure to illness or injury.

(3) Employees required to handle or use poisons, caustics, and other harmful substances shall be instructed regarding the safe handling and use, and be made aware of the potential hazards, personal hygiene, and personal protective measures required.

(4) In job site areas where harmful plants or animals are present, employees who may be exposed shall be instructed regarding the potential hazards, and how to avoid injury, and the first aid procedures to be used in the event of injury.

(5) Employees required to handle or use flammable liquids, gases, or toxic materials shall be instructed in the safe handling and use of these materials and made aware of the specific requirements contained in Subparts D, F, and other applicable subparts of this part.

(6) All employees required to enter into confined or enclosed spaces shall be instructed as to the nature of the hazards involved, the necessary precautions to be taken, and in the use of protective and emergency equipment required. The employer shall comply with any specific regulations that apply to work in dangerous or potentially dangerous areas.

§ 1518.22 Recording and reporting of injuries. [Reserved]

§ 1518.23 First aid and medical attention.

First aid services and provisions for medical care shall be made available by the employer for every employee covered by these regulations. Regulations prescribing specific requirements for first aid, medical attention, and emergency facilities are contained in Subpart D of this part.

§ 1518.24 Fire protection and prevention.

The employer shall be responsible for the development and maintenance of an effective fire protection and prevention program at the job site throughout all phases of the construction, repair, alteration, or demolition work. The employer shall ensure the availability of the fire protection and suppression equipment required by Subpart F of this part.

§ 1518.25 Housekeeping.

(a) During the course of construction, alteration, or repairs, form and scrap lumber-with protruding nails, and all other debris, shall be kept cleared from work areas, passageways, and stairs, in and around buildings or other structures.

(b) Combustible scrap and debris shall be removed at regular intervals during the course of construction. Safe means shall be provided to facilitate such removal.

(c) Containers shall be provided for the collection and separation of waste, trash, oily and used rags, and other refuse. Containers used for garbage and

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other oily, flammable, or hazardous wastes, such as caustics, acids, harmful dusts, etc. shall be equipped with covers. Garbage and other waste shall be disposed of at frequent and regular intervals.

§ 1518.26 Illumination.

Construction areas, aisles, stairs, ramps, runways, corridors, offices, shops, and storage areas where work is in progress shall be lighted with either natural or artificial illumination. The minimum illumination requirements for work areas are contained in Subpart D of this part.

§ 1518.27 Sanitation.

Health and sanitation requirements for drinking water are contained in Subpart D of this part.

§ 1518.28 Personal protective equipment.

(a) The employer is responsible for requiring the wearing of appropriate personal protective equipment in all operations where there is an exposure to hazardous conditions and where this part indicates the need for using such equipment to reduce the hazards to the employees.

(b) Regulations governing the use, selection, and maintenance of personal protective and lifesaving equipment are described under Subpart E of this part.

§ 1518.29 Acceptable certifications.

(a) *Pressure vessels.* Current and valid certification by an insurance company or regulatory authority shall be deemed as acceptable evidence of safe installation, inspection, testing of pressure vessels provided by the employer.

(b) *Boilers.* Boilers provided by the employer shall be deemed to be in compliance with the requirements of this part when evidence of current and valid certification by an insurance company or regulatory authority attesting to the safe installation, inspection, and testing is presented.

(c) *Other requirements.* Regulations prescribing specific requirements for other types of pressure vessels and similar equipment are contained in Subparts F and O of this part.

§ 1518.30 Shipbuilding and ship repairing.

(a) *General.* Shipbuilding, ship repairing, alterations, and maintenance performed on ships under Government contract, except naval ship construction, is work subject to the Act.

(b) *Applicable safety and health standards.* For the purpose of work carried out under this section, the safety and health regulations promulgated by the Secretary of Labor shall apply: Part 1501 of this title, Safety and Health Regulations for Ship Repairing, and Part 1502 of this title, Safety and Health Regulations for Shipbuilding.

§ 1518.31 Incorporation by reference.

(a) The specifications, standards and codes of agencies of the U.S. Government and organizations which are not agencies of the U.S. Government, to the

extent they are legally incorporated by reference in this part, have the same force and effect as other standards in this part. The locations where these specifications, standards, and codes may be examined are as follows:

(1) Offices of the Bureau of Labor Standards, U.S. Department of Labor, Railway Labor Building, Washington, DC 20210.

(2) The Regional and Field Offices of the Bureau of Labor Standards which are listed in the U.S. Government Manual 1970-71, at page 324.

(b) Any changes in the specifications, standards and codes incorporated by reference in this part and an official historic file of such changes are available at the offices referred to in paragraph (a) of this section. All questions as to the applicability of such changes should also be referred to these offices.

§ 1518.32 Definitions.

The following definitions shall apply in the application of the regulations in this part:

(a) "Act" means section 107 of the Contract Work Hours and Safety Standards Act, commonly known as the Construction Safety Act (86 Stat. 96; 40 U.S.C. 333).

(b) "ANSI" means American National Standards Institute.

(c) "Approved" means sanctioned, endorsed, accredited, certified, or accepted as satisfactory by a duly constituted and nationally recognized authority or agency.

(d) "Authorized person" means a person approved or assigned by the employer to perform a specific type of duty or duties or to be at a specific location or locations at the jobsite.

(e) "Bureau" means the Bureau of Labor Standards.

(f) "Competent person" means one who is capable of identifying existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.

(g) "Defect" means any characteristic or condition which tends to weaken or reduce the strength of the tool, object, or structure of which it is a part.

(h) "Designated person" means "authorized person" as defined in § 1518.40 (c).

(i) "Employee" means every laborer or mechanic under the Act regardless of the contractual relationship which may be alleged to exist between the laborer and mechanic and the contractor or subcontractor who engaged him. "Laborer and mechanic" are not defined in the Act, but the identical terms are used in the Davis-Bacon Act (40 U.S.C. 276a), which provides for minimum wage protection on Federal and federally-assisted construction contracts. The use of the same term in a statute which often applies concurrently with section 107 of the Act has considerable precedential value in ascertaining the meaning of "laborer and mechanic" as used in the Act. Gen-

erally speaking, "laborer and mechanic" means any person employed on a construction site. "Laborer" generally means one who performs manual labor or who labors at an occupation requiring physical strength; "mechanic" generally means a worker skilled with tools. See 18 Comp. Gen. 341.

(j) "Employer" means contractor or subcontractor within the meaning of the Act and of this part.

(k) "Hazardous substance" means a substance which, by reason of being explosive, flammable, poisonous, corrosive, oxidizing, irritating, or otherwise harmful, is likely to cause death or injury.

(l) "Qualified" means one who, by possession of a recognized degree, certificate, or professional standing, or who by extensive knowledge, training, and experience, has successfully demonstrated his ability to solve or resolve problems relating to the subject matter, the work, or the project.

(m) "Safety factor" means the ratio of the ultimate breaking strength of a member or piece of material or equipment to the actual working stress or safe load when in use.

(n) "Secretary" means the Secretary of Labor.

(o) "SAE" means Society of Automotive Engineers.

(p) "Shall" means mandatory.

(q) "Should" means recommended.

(r) "Suitable" means that which fits, and has the qualities or qualifications to meet a given purpose, occasion, condition, function, or circumstance.

Subpart D—Occupational Health and Environmental Controls

§ 1518.50 Medical services and first aid.

(a) The employer shall ensure the availability of medical personnel for advice and consultation on matters of occupational health.

(b) In the absence of an infirmary, clinic, or hospital in proximity to the worksite which is available for the treatment of injured employees, a person or persons who have a valid certificate in first aid training from the U.S. Bureau of Mines or the American Red Cross shall be available to render first aid.

(c) (1) First aid supplies recommended by the consulting physician shall be easily accessible when required.

(2) The first aid kit shall consist of materials recommended by the consulting physician in a weatherproof container with individual sealed packages for each type of item. The contents of the first aid kit shall be checked by the employer before being sent out on each job and at least weekly on each job to ensure that the expended items are replaced.

(d) Provisions shall be made prior to commencement of the project for prompt medical attention in case of serious injury.

(e) Proper equipment for prompt transportation of the injured person to a physician or hospital, or a communication system for contacting necessary ambulance service, shall be provided.

(f) The telephone numbers of the doctors, hospital and ambulances shall be conspicuously posted.

(g) There shall be at least one person, with a valid certificate in first aid training from the U.S. Bureau of Mines or the American Red Cross, to administer emergency first aid at any isolated location, or area of difficult access, and where medical treatment is not available.

§ 1518.51 Sanitation.

(a) *Potable water.* (1) An adequate supply of potable water shall be provided in all places of employment.

(2) Portable containers used to dispense drinking water shall be capable of being tightly closed, and equipped with a tap. Water shall not be dipped from containers.

(3) Any container used to distribute drinking water shall be clearly marked as to the nature of its contents and not used for any other purpose.

(4) The common drinking cup is prohibited.

(5) Where single service cups (to be used but once) are supplied, both a sanitary container for the unused cups and a receptacle for disposing of the used cups shall be provided.

(b) *Nonpotable water.* (1) Outlets for nonpotable water, such as water for industrial or firefighting purposes only, shall be identified by signs meeting the requirements of Subpart G of this part, to indicate clearly that the water is unsafe and is not to be used for drinking, washing, or cooking purposes.

(2) There shall be no cross-connection, open or potential, between a system furnishing potable water and a system furnishing nonpotable water.

(c) *Toilets at construction job sites.* (1) Toilets shall be provided for employees according to the following table:

TABLE D-1

	Minimum number of facilities
20 or less.....	1.
20 or more.....	1 toilet seat and 1 urinal per 40 workers.
200 or more.....	1 toilet seat and 1 urinal per 50 workers.

(2) Under temporary field conditions, provisions shall be made to assure not less than one toilet facility is available.

(3) Job sites, not provided with a sanitary sewer, shall be provided with one of the following toilet facilities unless prohibited by local codes:

- (i) Privies (where their use will not contaminate ground or surface water);
- (ii) Chemical toilets;
- (iii) Recirculating toilets;
- (iv) Combustion toilets.

(d) *Food handling.* All employees' food service facilities and operations shall meet the applicable laws, ordinances, and regulations of the jurisdictions in which they are located.

(e) *Temporary sleeping quarters.* When temporary sleeping quarters are

provided, they shall be heated, ventilated, and lighted.

(f) *Washing facilities.* The employer shall provide adequate washing facilities for employees engaged in the application of paints, coating, herbicides, or insecticides, or in other operations where contaminants can, by ingestion or absorption, be detrimental to the health of the employees.

(g) Waste disposal shall not cause ground contamination and shall comply with local sanitary health laws.

§ 1518.52 Occupational noise exposure.

(a) Protection against the effects of noise exposure shall be provided when the sound levels exceed those shown in Table D-2 of this section when measured on the A-scale of a standard sound level meter at slow response.

(b) When employees are subjected to sound levels exceeding those listed in Table D-2 of this section, feasible administrative or engineering controls shall be utilized. If such controls fail to reduce sound levels within the levels of the table, personal protective equipment as required in Subpart E, shall be provided and used to reduce sound levels within the levels of the table.

(c) If the variations in noise level involve maxima at intervals of 1 second or less, it is to be considered continuous.

(d) (1) In all cases where the sound levels exceed the values shown herein, a continuing, effective hearing conservation program shall be administered.

TABLE D-2—PERMISSIBLE NOISE EXPOSURES

Duration per day, hours:	Sound level dBA slow Response
8	90
6	92
4	95
3	97
2	100
1½	102
1	105
½	110
¼ or less.....	115

(2) When the daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered, rather than the individual effect of each. If the sum of the following fractions:

$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \dots + \frac{C_n}{T_n}$$

exceeds unity, then the mixed exposure should be considered to exceed the limit value. C_n indicates the total time of exposure at a specified noise level, and T_n indicates the total time of exposure permitted at that level.

(e) Exposure to impulsive or impact noise should not exceed 140 dB peak sound pressure level.

§ 1518.53 Ionizing radiation.

(a) In construction and related activities involving the use of sources of ionizing radiation, the pertinent provisions of the Atomic Energy Commission's Standards for Protection Against Radiation (10 CFR Part 20), relating to protection against occupational radiation exposure, shall apply.

(b) Any activity which involves the use of radioactive material or X-ray, whether or not under license from the Atomic Energy Commission, shall be performed by competent persons specially trained in the proper and safe operation of such equipment. In the case of materials used under Commission license, only persons actually licensed, or competent persons under direction and supervision of the licensee, shall perform such work.

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§ 1518.54 Nonionizing radiation.

(a) Only qualified and trained employees shall be assigned to install, adjust, and operate laser equipment.

(b) Proof of qualification of the laser equipment operator shall be available and in possession of operator at all times.

(c) Employees, when working in areas in which a potential exposure to direct or reflected laser light greater than 0.005 watts (5 milliwatts) exists, shall be provided with antilaser eye protection devices as specified in Subpart E of this part.

(d) Areas in which lasers are used shall be posted with standard laser warning placards.

(e) Beam shutters or caps shall be utilized, or the laser turned off, when laser transmission is not actually required. When the laser is left unattended for a substantial period of time, such as during lunch hour, overnight, or at change of shifts, the laser shall be turned off.

(f) Only mechanical or electronic means shall be used as a detector for guiding the internal alignment of the laser.

(g) The laser beam shall not be directed at employees.

(h) When it is raining or snowing, or when there is dust or fog in the air, the operation of laser systems shall be prohibited where practicable; in any event, employees shall be kept out of range of the area of source and target during such weather conditions.

(i) Laser equipment shall bear a label to indicate maximum output.

(j) Employees shall not be exposed to light intensities above:

(1) Direct staring: 1 micro-watt per square centimeter;

(2) Incidental observing: 1 milliwatt per square centimeter;

(3) Diffused reflected light: $2\frac{1}{2}$ watts per square centimeter.

(k) Laser unit in operation should be set up above the heads of the employees, when possible.

(l) Employees shall not be exposed to microwave power densities in excess of 10 milliwatts per square centimeter.

§ 1518.55 Gases, vapors, fumes, dusts, and mists.

(a) Exposure of employees to inhalation, ingestion, skin absorption, or contact with any material or substance at a concentration above those specified in the "Threshold Limit Values of Airborne Contaminants for 1970" of the American Conference of Governmental Industrial Hygienists, shall be avoided.

(b) When engineering or administrative controls cannot be employed to reduce or eliminate the exposure, protective equipment, as required in Subpart E of this part, shall be used.

§ 1518.56 Illumination.

(a) *General.* Construction areas, ramps, runways, corridors, offices, shops, and storage areas shall be lighted to not less than the minimum illumination intensities listed in Table D-3 while any work is in progress:

TABLE D-3—MINIMUM ILLUMINATION INTENSITIES IN FOOT-CANDLES

Foot-candles:	Area or operation
5-----	General construction area lighting.
3-----	General construction areas, concrete placement, excavation and waste areas, accessways, active storage areas, loading platforms, refueling, and field maintenance areas.
5-----	Indoors: warehouses, corridors, hallways, and exitways.
5-----	Tunnels, shafts, and general underground work areas: (Exception: minimum of 10 foot-candles is required at tunnel and shaft heading during drilling, mucking, and scaling. Bureau of Mines approved cap lights shall be acceptable for use in the tunnel heading.)
10-----	General construction plant and shops (e.g., batch plants, screening plants, mechanical and electrical equipment rooms, carpenter shops, rigging lofts and active store-rooms, barracks or living quarters, locker or dressing rooms, mess halls, and indoor toilets and workrooms).
30-----	First aid stations, infirmaries, and offices.

(b) *Other areas.* For areas or operations not covered above, refer to the American National Standard A11.1-1965, R1970, Practice for Industrial Lighting, for recommended values of illumination.

§ 1518.57 Ventilation.

(a) *General.* Whenever harmful dusts, fumes, mists, vapors, or gases exist, or are produced in the course of construction-work, in quantities giving rise to

harmful exposure of employees, and prevention or elimination of such hazards is not practicable, such hazards shall be controlled by the application of general ventilation, local exhaust ventilation, or other effective mechanical means.

(b) *Local exhaust ventilation.* Local exhaust ventilation when used as described in (a) shall be designed to prevent dispersion into the air of dusts, fumes, mists, vapors, and gases in concentrations causing harmful exposure. Such exhaust systems shall be so designed that dusts, fumes, mists, vapors, or gases are not drawn through the work area of employees.

(c) *Design and operation.* Exhaust fans, jets, ducts, hoods, separators, and all necessary appurtenances, including refuse receptacles, shall be so designed, constructed, maintained and operated as to ensure the required protection by maintaining a volume and velocity of exhaust air sufficient to gather dusts, fumes, vapors, or gases from said equipment or process, and to convey them to suitable points of safe disposal, thereby preventing their dispersion in harmful quantities into the atmosphere where employees work.

(d) *Duration of operations.* (1) The exhaust system shall be in operation continually during all operations which it is designed to serve. If the employee remains in the contaminated zone, the system shall continue to operate after the cessation of said operations, the length of time to depend upon the individual circumstances and effectiveness of the general ventilation system.

(2) Since dust capable of causing disability is, according to the best medical opinion, of microscopic size, tending to remain for hours in suspension in still air, it is essential that the exhaust system be continued in operation for a time after the work process or equipment served by the same shall have ceased, in order to ensure the removal of the harmful elements to the required extent. For the same reason, employees wearing respiratory equipment should not remove same immediately until the atmosphere seems clear.

(c) *Disposal of exhaust materials.* The air outlet from every dust separator, and the dusts, fumes, mists, vapors, or gases collected by an exhaust or ventilating system shall discharge to the outside atmosphere. Collecting systems which return air to work area may be used if concentrations which accumulate in the work area air do not result in harmful exposure to employees. Dust and refuse discharged from an exhaust system shall be disposed of in such a manner that it will not result in harmful exposure to employees.

§ 1518.58 Definitions applicable to this subpart.

(a) "dBA" means decibels of sound measured on an A-scale.

(b) "Decibel" means a unit for measuring the relative loudness of sounds.

(c) "Exposed", as applied to toxic contaminants, means contact by inhalation, ingestion, skin absorption, or con-

tact with any material or substance which may have immediate or latent harmful effects on health.

(d) "Ionizing radiation" means radiant energy emitted by way of radioactive materials or X-ray devices.

(e) "Nonionizing radiation" means an amplification of light through ultraviolet and infrared rays by means of instruments such as the laser. Nonionizing radiation includes microwave frequencies beginning at approximately 100 megahertz (10^8) and extending to 100 gigahertz (10^{11}) and the infrared and ultraviolet and visible light frequencies as may be utilized in microwave, maser, and laser equipment.

(f) "Potable" means suitable for drinking.

(g) "Radiation" means the process of emitting radiant energy in the form of waves or particles.

(h) "Toxic" means poisonous.

Subpart E—Personal Protective and Life Saving Equipment

§ 1518.100 Head protection.

(a) Employees working in areas where there is a danger of head injury from impact, or from falling or flying objects, or from electrical shock and burns, shall be protected by protective helmets.

(b) Helmets for the protection of employees against impact and penetration of falling and flying objects shall meet the specifications contained in American National Standards Institute, Z89.1-1969, Safety Requirements for Industrial Head Protection.

(c) Helmets for the head protection of employees exposed to high voltage electrical shock and burns shall meet the specifications contained in American National Standards Institute, Z89.2-1970.

§ 1518.101 Hearing protection.

(a) Wherever it is not feasible to reduce the noise levels or duration of exposures to those specified in Table D-2, Permissible Noise Exposures, in § 1518.52, ear protective devices shall be provided and used.

(b) Ear protective devices inserted in the ear shall be fitted or determined individually by competent persons.

(c) Plain cotton is not an acceptable protective device.

§ 1518.102 Eye and face protection.

(a) *General.* (1) Employees shall be provided with eye and face protection equipment when machines or operations present potential eye or face injury from physical, chemical, or radiation agents.

(2) Eye and face protection equipment required by this Part shall meet the requirements specified in American National Standards Institute, Z87.1-1968, Practice for Occupational and Educational Eye and Face Protection.

(3) Employees whose vision requires the use of corrective lenses in spectacles, when required by this regulation to wear eye protection, shall be protected by goggles or spectacles of one of the following types:

TABLE E-3—SELECTING LASER SAFETY GLASSES

INTENSITY	ATTENUATION
(W) maximum power density (watts/cm ²)	(Optical density (Q.D.))
10 ⁻²	5
10 ⁻¹	6
1.0	7
10.0	8

Output levels falling between lines in this table shall require the higher optical density.

(ii) All protective goggles shall bear a label identifying the following data:

(a) The laser wavelengths for which use is intended;

(b) The optical density of those wavelengths;

(c) The visible light transmission.

§ 1518.103 Respiratory protection.

(a) General. (1) In emergencies, or when controls required by Subpart D of this part either fail or are inadequate to prevent harmful exposure to employees, appropriate respiratory protective devices shall be provided by the employer and shall be used.

(2) Respiratory protective devices shall be approved by the U.S. Bureau of Mines or acceptable to the U.S. Department of Labor for the specific contaminant to which the employee is exposed.

(b) Respirator selection. (1) The chemical and physical properties of the contaminant, as well as the toxicity and concentration of the hazardous material, shall be considered in selecting the proper respirators.

(2) The nature and extent of the hazard, work requirements, and conditions, as well as the limitations and characteristics of the available respirators, shall also be factors considered in making the proper selection.

(3) The following table lists the types of respirators required for protection in dangerous atmospheres:

TABLE E-4.—SELECTION OF RESPIRATORS

Hazard	Respirator (See Note)
Oxygen deficiency.....	Self-contained breathing apparatus. If use with blower, combination air-line respirator with auxiliary self-contained air supply or an air-storage receiver with alarm.

(b) Protection against radiant energy—(1) Selection of shade numbers for welding filter. Table E-2 shall be used as a guide for the selection of the proper shade numbers of filter lenses or plates used in welding. Shades more dense than those listed may be used to suit the individual's needs.

TABLE E-2.—FILTER LENS SHADE NUMBERS FOR PROTECTION AGAINST RADIANT ENERGY

Welding operation	Shade number
Shielded metal-arc welding $\frac{1}{16}$ "- $\frac{3}{32}$ "	10
$\frac{1}{8}$ "- $\frac{5}{16}$ "-1 $\frac{1}{2}$ " diameter electrodes	
Gas-shielded arc welding (nonferrous)	
$\frac{1}{16}$ "- $\frac{3}{32}$ "- $\frac{1}{8}$ "- $\frac{5}{16}$ "-1 $\frac{1}{2}$ " diameter electrodes	11
Gas-shielded arc welding (ferrous)	
$\frac{1}{16}$ "- $\frac{3}{32}$ "- $\frac{1}{8}$ "- $\frac{5}{16}$ "-1 $\frac{1}{2}$ " diameter electrodes	12
Shielded metal-arc welding $\frac{1}{16}$ "- $\frac{3}{32}$ "	12
1 $\frac{1}{2}$ "-inch diameter electrodes	14
$\frac{1}{8}$ "- $\frac{5}{16}$ "-1 $\frac{1}{2}$ " diameter electrodes	10-14
Atomic hydrogen welding	14
Carbon-arc welding	2
Soldering	3 or 4
Torch brazing	3 or 4
Light cutting, up to 1 inch	3 or 4
Medium cutting, 1 inch to 6 inches	4 or 5
Heavy cutting, over 6 inches	5 or 6
Gas welding (light), up to $\frac{1}{8}$ -inch	4 or 5
Gas welding (medium), $\frac{1}{8}$ -inch to $\frac{1}{2}$ -inch	5 or 6
Gas welding (heavy), over $\frac{1}{2}$ -inch	6 or 8

TABLE E-4. SELECTION OF RESPIRATORS—Continued

Hazard	Respirator (See Note)
Gas and vapor contaminants immediately dangerous to life and health.	Self-contained breathing apparatus. Ifose mask with blower. Air-purifying, full facepiece respirator with chemical canister (gas mask). Self-rescue mouthpiece respirator (for escape only). Combination air-line respirator with auxiliary self-contained air supply or an air-storage receiver with alarm.
Not immediately dangerous to life and health.	Air-line respirator. Ifose mask without blower. Air-purifying, half-mask or mouthpiece respirator with chemical cartridge.
Particulate contaminants immediately dangerous to life and health.	Self-contained breathing apparatus. Ifose mask with blower. Air-purifying, full facepiece respirator with appropriate filter. Self-rescue mouthpiece respirator (for escape only). Combination air-line respirator with auxiliary self-contained air supply or an air-storage receiver with alarm.
Not immediately dangerous to life and health.	Air-purifying, half-mask or mouthpiece respirator with filter pad or cartridge. Air-line respirator. Air-line abrasive-blasting respirator. Ifose mask without blower.
Combination gas, vapor, and particulate contaminants immediately dangerous to life and health.	Self-contained breathing apparatus. Ifose mask with blower. Air-purifying, full facepiece respirator with chemical canister and appropriate filter (gas mask with filter). Self-rescue mouthpiece respirator (for escape only). Combination air-line respirator with auxiliary self-contained air supply or an air-storage receiver with alarm.
Not immediately dangerous to life and health.	Air-line respirator. Ifose mask without blower. Air-purifying, half-mask or mouthpiece respirator with chemical cartridge and appropriate filter.

NOTE: For the purpose of this part, "immediately dangerous to life and health" is defined as a condition that either poses an immediate threat to life and health or an immediate threat of severe exposure to contaminants, such as radioactive materials, which are likely to have adverse delayed effects on health.

(c) *Selection, issuance, use and care of respirators.* (1) Employees required to use respiratory protective equipment approved for use in atmospheres immediately dangerous to life shall be thoroughly trained in its use. Employees required to use other types of respiratory protective equipment shall be instructed in the use and limitations of such equipment.

(2) Respiratory protective equipment shall be inspected regularly and maintained in good condition. Gas mask canisters and chemical cartridges shall be replaced as necessary so as to provide complete protection. Mechanical filters shall be cleaned or replaced as necessary so as to avoid undue resistance to breathing.

(3) Respiratory protective equipment which has been previously used shall be cleaned and disinfected before it is issued by the employer to another employee. Emergency rescue equipment shall be cleaned and disinfected immediately after each use.

§ 1518.104 Safety belts, lifelines, and lanyards.

(a) Lifelines, safety belts, and lanyards shall be used only for employee safeguarding. Should any of these items be subjected to actual loading or load testing, they shall be immediately removed from service and destroyed.

(b) Lifelines shall be secured above the point of operation to an anchorage or structural member capable of supporting a minimum dead weight of 5,400 pounds.

(c) Lifelines used on rock-scaling operations, or in areas where the lifeline may be subjected to cutting or abrasion, shall be a minimum of ⅜-inch wire core manila rope. For all other lifeline applications, a minimum of ¾-inch manila or equivalent, with a minimum breaking strength of 5,400 pounds, shall be used.

(d) Safety belt lanyard shall be a minimum of ½-inch nylon, or equivalent, with a maximum length to provide

for a fall of no greater than 6 feet. The rope shall have a nominal breaking strength of 5,400 pounds.

(e) All safety belt and lanyard hardware shall be drop forged or pressed steel, cadmium plated in accordance with type 1, Class B plating specified in Federal Specification QQ-P-416. Surface shall be smooth and free of sharp edges.

(f) All safety belt and lanyard hardware, except rivets, shall be capable of withstanding a tensile loading of 4,000 pounds without cracking, breaking, or taking a permanent deformation.

§ 1518.105 Safety nets.

(a) Safety nets shall be provided when workplaces are more than 25 feet above the ground or water surface, or other surfaces where the use of ladders, scaffolds, catch platforms, temporary floors, safety lines, or safety belts are impractical.

(b) Where safety net protection is required by this part, operations shall not be undertaken until the net is in place and has been tested.

(c) Nets shall extend 8 feet beyond the edge of the work surface where employees are exposed.

(d) The maximum mesh size of nets shall be 6 inches by 6 inches of ⅜-inch diameter, No. 1 grade, pure manila, ¼-inch nylon, or ⅝-inch polypropylene rope.

(e) Forged steel safety hooks or shackles shall be used to fasten the net to its supports.

(f) Connections between net panels shall develop the full strength of the net.

§ 1518.106 Working over or near water.

(a) Employees working over or near water, where the danger of drowning exists, shall be provided with U.S. Coast Guard-approved life jacket or buoyant work vests.

(b) Prior to and after each use, the buoyant work vests or life preservers

shall be inspected for defects which would alter their strength or buoyancy. Defective units shall not be used.

(c) Ring buoys with at least 90 feet of line shall be provided and readily available for emergency rescue operations. Distance between ring buoys shall not exceed 200 feet.

(d) At least one lifesaving skiff shall be immediately available at locations where employees are working over or adjacent to water.

§ 1518.107 Definitions applicable to this subpart.

(a) "Contaminant" means any material which by reason of its action upon, within, or to a person is likely to cause physical harm.

(b) "Lanyard" means a rope, suitable for supporting one person. One end is fastened to a safety belt or harness and the other end is secured to a substantial object or a safety line.

(c) "Lifeline" means a rope, suitable for supporting one person, to which a lanyard or safety belt (or harness) is attached.

(d) "O.D." means optical density and refers to the light refractive characteristics of a lens.

(e) "Radiant energy" means energy that travels outward in all directions from its sources.

(f) "Safety belt" means a device, usually worn around the waist which, by reason of its attachment to a lanyard and lifeline or a structure, will prevent a worker from falling.

Subpart F—Fire Protection and Prevention

§ 1518.150 Fire protection.

(a) *General requirements.* (1) The employer shall be responsible for the development of a fire protection program to be followed throughout all phases of the construction and demolition work, and he shall provide for the firefighting equipment as specified in this subpart. As fire hazards occur, there shall be no delay in providing the necessary equipment.

(2) Access to all available firefighting equipment shall be maintained at all times.

(3) All firefighting equipment, provided by the employer, shall be conspicuously located.

(4) All firefighting equipment shall be periodically inspected and maintained in operating condition. Defective equipment shall be immediately replaced.

(5) As warranted by the project, the employer shall provide a trained and equipped firefighting organization (Fire Brigade) to assure adequate protection to life.

(b) *Water supply.* (1) A temporary or permanent water supply, of sufficient volume, duration, and pressure, required to properly operate the firefighting equipment shall be made available as soon as combustible materials accumulate.

(2) Where underground water mains are to be provided, they shall be in-

stalled, completed, and made available for use as soon as practicable.

(c) **Portable firefighting equipment—**

(i) **Fire extinguishers.** (i) A fire extinguisher, rated not less than 2A, shall be provided for each 3,000 square feet of the protected building area, or major fraction thereof. Travel distance from any point of the protected area to the nearest fire extinguisher shall not exceed 100 feet.

(ii) One 55-gallon open drum of water with two fire pails may be substituted for a fire extinguisher having a 2A rating.

(iii) One or more fire extinguishers, rated not less than 2A, shall be provided on each floor. In multistory buildings, at least one fire extinguisher shall be located adjacent to stairway.

(iv) Extinguishers and water drums, subject to freezing, shall be protected from freezing.

(v) Where more than 5 gallons of flammable or combustible liquids or 5 pounds of flammable gas are being used, a fire extinguisher, rated not less than 10B, shall be provided within 50 feet, unless required otherwise.

(vi) Carbon tetrachloride and other toxic vaporizing liquid fire extinguishers are prohibited.

(vii) Portable fire extinguishers shall be inspected periodically and maintained in accordance with Maintenance and Use of Portable Fire Extinguishers, NFPA No. 10A-1970.

(viii) Fire extinguishers, which have been listed or approved by a nationally recognized testing laboratory, shall be used to meet the requirements of this subpart.

(ix) Table F-1 may be used as a guide for selecting the appropriate portable fire extinguishers.

Table F-1 FIRE EXTINGUISHERS DATA

FEDERAL BUREAU OF INVESTIGATION U.S. DEPARTMENT OF JUSTICE	WATER TYPE				FOAM	CARBON DIOXIDE	SODIUM OR POTASSIUM BICARBONATE		DRY CHEMICAL	
	STANDARD PRESSURE	CHARGED WATER	WATER PUMP	WATER TANK	FOAM	CO ₂	DRY CHEMICAL	DRY CHEMICAL	DRY CHEMICAL	DRY CHEMICAL
CLASS A FIRES WOOD, PAPER, TRASH HEAVY, ULTIMATE, EMERGENCY CLASS A FIRES	YES	YES	YES	YES	YES	NO	NO	NO	YES	YES
CLASS B FIRES FLAMMABLE LIQUIDS, FLAMMABLE SOLIDS, FLAMMABLE GASES, OILS, GREASE, ETC.	NO	NO	NO	NO	YES	YES	YES	YES	YES	YES
CLASS C FIRES ELECTRICAL EQUIPMENT CLASS C FIRES	NO	NO	NO	NO	NO	YES	YES	YES	YES	YES
SPECIAL EXTINGUISHING AGENTS APPROVED BY RECOGNIZED TESTING LABORATORIES										
METHOD OF OPERATION	PULL PIN— ROTATE HANDLE	PULL PIN— ROTATE HANDLE	PUMP HANDLE	PUMP HANDLE	PUMP HANDLE	PULL PIN— ROTATE HANDLE	PULL PIN— ROTATE HANDLE	PULL PIN— ROTATE HANDLE	PULL PIN— ROTATE HANDLE	PULL PIN— ROTATE HANDLE
RANGE	30' - 40'	30' - 40'	30' - 40'	30' - 40'	30' - 40'	5' - 8'	5' - 20'	5' - 20'	5' - 20'	5' - 20'
MAINTENANCE	CHECK AIR PRESSURE MONTHLY	RECHARGE CARTRIDGE— ADD WATER IF REQUIRED ANNUALLY	DISCHARGE AND FILL WITH WATER ANNUALLY	DISCHARGE ANNUALLY RECHARGE	DISCHARGE ANNUALLY RECHARGE	RECHARGE ANNUALLY	RECHARGE CARTRIDGE— CHECK PRESSURE ANNUALLY	RECHARGE CARTRIDGE— CHECK PRESSURE ANNUALLY	RECHARGE CARTRIDGE— CHECK PRESSURE ANNUALLY	RECHARGE CARTRIDGE— CHECK PRESSURE ANNUALLY

(2) **Fire hose and connections.** (i) One hundred feet, or less, of 1½-inch hose, with a nozzle capable of discharging water at 25 gallons or more per minute, may be substituted for a fire extinguisher rated not more than 2A in the designated area provided that the hose line can reach all points in the area.

(ii) If fire hose connections are not compatible with local firefighting equipment, the contractor shall provide adapters, or equivalent, to permit connections.

(iii) During demolition involving combustible materials, charged hose lines, supplied by hydrants, water tank trucks with pumps, or equivalent, shall be made available.

(d) **Fixed firefighting equipment—**

(i) **Sprinkler protection.** (i) If automatic sprinkler protection is to be provided, the installation shall closely follow the construction and be placed in service before or immediately following completion of each story.

(ii) During demolition or alterations, existing automatic sprinkler installations shall be retained in service as long as

reasonable. The operation of sprinkler control valves shall be permitted only by properly authorized persons. Modification of sprinkler systems to permit alterations or additional demolition should be expedited so that the automatic protection may be returned to service as quickly as possible. Sprinkler control valves shall be checked daily at close of work to ascertain that the protection is in service.

(2) **Standpipes.** (i) In all structures in which standpipes are required, or where existing in structures being altered or demolished, they shall be brought up or maintained as construction progresses in such a manner that they are always ready for fire protection use. The standpipes should be provided with siamese fire department connections on the outside of the structure, at the street level, conspicuously marked and have at least one standard hose outlet at each floor.

(e) **Fire alarm devices.** (1) An alarm system, e.g., telephone system, siren, etc., shall be established by the employer whereby employees on the site and the local fire department can be alerted for an emergency.

(2) The alarm code and reporting instructions shall be conspicuously posted at phones and at employee entrances.

(f) **Fire cutoffs.** (1) Fire walls and exit stairways, required for the completed buildings, shall be given construction priority. Fire doors, with automatic closing devices, shall be hung on openings as soon as practicable.

(2) Fire cutoffs shall be retained in buildings undergoing alterations or demolition until operations necessitate their removal.

§ 1518.151 Fire prevention.

(a) **Ignition hazards.** (1) Electrical wiring and equipment for light, heat, or power purposes shall be installed in compliance with the requirements of the National Electrical Code, NFPA No. 70-1970, and the requirements of Subpart K of this part.

(2) Internal combustion engine powered equipment shall be so located that the exhausts are well away from combustible materials. When the exhausts are piped to outside the building under construction, a clearance of at least 6 inches shall be maintained between such piping and combustible material.

(3) Smoking shall be prohibited or in the vicinity of operations which constitute a fire hazard, and shall be conspicuously posted: "No Smoking or Open Flame."

(4) Portable battery powered lighting equipment, used in connection with the storage, handling, or use of flammable gases or liquids, shall be of the type approved for the hazardous locations.

(5) The nozzle of air, inert gas, and steam lines or hoses, when used in the cleaning or ventilation of tanks and vessels that contain hazardous concentrations of flammable gases or vapors, shall be bonded to the tank or vessel shell. Bonding devices shall not be attached or detached in hazardous concentrations of flammable gases or vapors.

(b) **Temporary buildings.** (1) No temporary building shall be erected where it will adversely affect any means of exit.

(2) Temporary buildings, when located within another building or structure, shall be of either noncombustible construction or of combustible construction having a fire resistance of not less than 1 hour.

(3) Temporary buildings, located other than inside another building and not used for the storage, handling, or use of flammable or combustible liquids, flammable gases, explosives, or blasting agents, or similar hazardous occupancies, shall be located at a distance of not less than 10 feet from another building or structure. Groups of temporary buildings, not exceeding 2,000 square feet in aggregate, shall, for the purposes of this part, be considered a single temporary building.

(c) **Open yard storage.** (1) Combustible materials shall be piled with due regard to the stability of piles and in no case higher than 20 feet.

(2) Driveways between and around combustible storage piles shall be at least 15 feet wide and maintained free from

accumulation of rubbish, equipment, or other articles or materials. Driveways shall be so spaced that a maximum grid system unit of 50 feet by 150 feet is produced.

(3) The entire storage site shall be kept free from accumulation of unnecessary combustible materials. Weeds and grass shall be kept down and a regular procedure provided for the periodic cleanup of the entire area.

(4) When there is a danger of an underground fire, that land shall not be used for combustible or flammable storage.

(5) Method of piling shall be solid wherever possible and in orderly and regular piles. No combustible material shall be stored outdoors within 10 feet of a building or structure.

(6) Portable fire extinguishing equipment, suitable for the fire hazard involved, shall be provided at convenient, conspicuously accessible locations in the yard area. Portable fire extinguishers, rated not less than 2A, shall be placed so that maximum travel distance to the nearest unit shall not exceed 100 feet.

(d) *Indoor storage.* (1) Storage shall not obstruct, or adversely affect, means of exit.

(2) All materials shall be stored, handled, and piled with due regard to their fire characteristics.

(3) Noncompatible materials, which may create a fire hazard, shall be segregated by a barrier having a fire resistance of at least 1 hour.

(4) Material shall be piled to minimize the spread of fire internally and to permit convenient access for firefighting. Stable piling shall be maintained at all times. Aisle space shall be maintained to safely accommodate the widest vehicle that may be used within the building for firefighting purposes.

(5) Clearance of at least 36 inches shall be maintained between the top level of the stored material and the sprinkler deflectors.

(6) Clearance shall be maintained around lights and heating units to prevent ignition of combustible materials.

(7) A clearance of 24 inches shall be maintained around the path of travel of fire doors unless a barricade is provided, in which case no clearance is needed. Material shall not be stored within 36 inches of a fire door opening.

§ 1518.152 Flammable and combustible liquids.

(a) *General requirements.* (1) Only approved containers and portable tanks shall be used for storage and handling of flammable and combustible liquids. Approved metal safety cans shall be used for the handling and use of flammable liquids in quantities greater than one gallon, except that this shall not apply to those flammable liquid materials which are highly viscous (extremely hard to pour), which may be used and handled in original shipping containers. For quantities of one gallon or less, only the original container or approved metal safety cans shall be used for storage, use, and handling of flammable liquids.

(2) Flammable or combustible liquids shall not be stored in areas used for exits, stairways, or normally used for the safe passage of people.

(b) *Indoor storage of flammable and combustible liquids.* (1) No more than 15 gallons of flammable or combustible liquids shall be stored in a room outside of an approved storage cabinet.

(2) Quantities of flammable and combustible liquid in excess of 15 gallons shall be stored in an acceptable or approved cabinet meeting the following requirements:

(i) Acceptable wooden storage cabinets shall be constructed in the following manner, or equivalent: The bottom, sides, and top shall be constructed of an exterior grade of plywood at least 1 inch in thickness, which shall not break down or delaminate under standard fire test conditions. All joints shall be rabbeted and shall be fastened in two directions with flathead wood screws. When more than one door is used, there shall be a rabbeted overlap of not less than 1 inch. Steel hinges shall be mounted in such a manner as to not lose their holding capacity due to loosening or burning out of the screws when subjected to fire. Such cabinets shall be painted inside and out with fire retardant paint.

(ii) Approved metal storage cabinets will be acceptable.

(iii) Cabinets shall be labeled in conspicuous lettering, "Flammable—Keep Fire Away."

(3) Not more than 60 gallons of flammable or 120 gallons of combustible liquids shall be stored in any one storage cabinet. Not more than three such cabinets may be located in a single storage area. Quantities in excess of this shall be stored in an inside storage room.

(4) (i) Inside storage rooms shall be constructed to meet the required fire-resistive rating for their use. Such construction shall comply with the test specifications set forth in Standard Methods of Fire Test of Building Construction and Material, NFPA 251-1969.

(ii) Where an automatic extinguishing system is provided, the system shall be designed and installed in an approved manner. Openings to other rooms or buildings shall be provided with non-combustible liquid-tight raised sills or ramps at least 4 inches in height, or the floor in the storage area shall be at least 4 inches below the surrounding floor. Openings shall be provided with approved self-closing fire doors. The room shall be liquid-tight where the walls join the floor. A permissible alternate to the sill or ramp is an open-grated trench, inside of the room, which drains to a safe location. Where other portions of the building or other buildings are exposed, windows shall be protected as set forth in the Standard for Fire Doors and Windows, NFPA No. 80-1970, for Class E or F openings. Wood of at least 1-inch nominal thickness may be used for shelving, racks, dunnage, scuffboards, floor overlay, and similar installations.

(iii) Materials which will react with water and create a fire hazard shall not

be stored in the same room with flammable or combustible liquids.

(iv) Storage in inside storage rooms shall comply with Table F-2 following:

TABLE F-2

Fire protection provided	Fire resistance	Maximum size	Total allowable quantities, gals./sq. ft./ floor area
Yes.....	2 hrs.....	500 sq. ft.....	10
No.....	2 hrs.....	500 sq. ft.....	4
Yes.....	1 hr.....	150 sq. ft.....	5
No.....	1 hr.....	150 sq. ft.....	2

NOTE: Fire protection system shall be sprinkler, water spray, carbon dioxide or other system approved by a nationally recognized testing laboratory for this purpose.

(v) Electrical wiring and equipment located in inside storage rooms shall be approved for Class 1, Division 1, Hazardous Locations. For definition of Class 1, Division 1, Hazardous Locations, see § 1518.404.

(vi) Every inside storage room shall be provided with either a gravity or a mechanical exhausting system. Such system shall commence not more than 12 inches above the floor and be designed to provide for a complete change of air within the room at least 6 times per hour. If a mechanical exhausting system is used, it shall be controlled by a switch located outside of the door. The ventilating equipment and any lighting fixtures shall be operated by the same switch. An electric pilot light shall be installed adjacent to the switch if flammable liquids are dispensed within the room. Where gravity ventilation is provided, the fresh air intake, as well as the exhausting outlet from the room, shall be on the exterior of the building in which the room is located.

(vii) In every inside storage room there shall be maintained one clear aisle at least 3 feet wide. Containers over 30 gallons capacity shall not be stacked one upon the other.

(viii) Flammable and combustible liquids in excess of that permitted in inside storage rooms shall be stored outside of buildings in accordance with paragraph (c) of this section.

(c) *Storage outside buildings.* (1) Storage of containers (not more than 60 gallons each) shall not exceed 1,100 gallons in any one pile or area. Piles or groups of containers shall be separated by a 5-foot clearance. Piles or groups of containers shall not be nearer than 20 feet to a building.

(2) Within 200 feet of each pile of containers, there shall be a 12-foot-wide access way to permit approach of fire control apparatus.

(3) The storage area shall be graded in a manner to divert possible spills away from buildings or other exposures, or shall be surrounded by a curb or earth dike at least 12 inches high. When curbs or dikes are used, provisions shall be made for draining off accumulations of ground or rain water, or spills of flammable or combustible liquids. Drains shall terminate at a safe location and

shall be accessible to operation under fire conditions.

(4) Outdoor portable tank storage: (i) Portable tanks shall not be nearer than 20 feet from any building. Two or more portable tanks, grouped together, having a combined capacity in excess of 2,200 gallons, shall be separated by a 5-foot-clear area. Individual portable tanks exceeding 1,100 gallons shall be separated by a 5-foot-clear area.

(ii) Within 200 feet of each portable tank, there shall be a 12-foot-wide access way to permit approach of fire control apparatus.

(5) Storage areas shall be kept free of weeds, debris, and other combustible material not necessary to the storage.

(6) Portable tanks, not exceeding 660 gallons, shall be provided with emergency venting and other devices, as required by chapters III and IV of NFPA 30-1969, The Flammable and Combustible Liquids Code.

(7) Portable tanks, in excess of 660 gallons, shall have emergency venting and other devices, as required by chapters II and III of The Flammable and Combustible Liquids Code, NFPA 30-1969.

(d) *Fire control for flammable or combustible liquid storage.* (1) At least one portable fire extinguisher, having a rating of not less than 20-B units, shall be located outside of, but not more than 10 feet from, the door opening into any room used for storage of more than 60 gallons of flammable or combustible liquids.

(2) At least one portable fire extinguisher having a rating of not less than 20-B units shall be located not less than 25 feet, nor more than 75 feet, from any flammable liquid storage area located outside.

(3) When sprinklers are provided, they shall be installed in accordance with the Standard for the Installation of Sprinkler Systems, NFPA 13-1969.

(4) At least one portable fire extinguisher having a rating of not less than 20-B:C units shall be provided on all tank trucks or other vehicles used for transporting and/or dispensing flammable or combustible liquids.

(e) *Dispensing liquids.* (1) Areas in which flammable or combustible liquids are transferred at one time, in quantities greater than 5 gallons from one tank or container to another tank or container, shall be separated from other operations by 25-foot distance or by construction having a fire resistance of at least 1 hour. Drainage or other means shall be provided to control spills. Adequate natural or mechanical ventilation shall be provided to maintain the concentration of flammable vapor at or below 10 percent of the lower flammable limit.

(2) Transfer flammable liquids from one container to another shall be done only when containers are electrically interconnected (bonded).

(3) Flammable or combustible liquids shall be drawn from or transferred into vessels, containers, or tanks within a building or outside only through a closed

pipng system, from safety cans, by means of a device drawing through the top, or from a container, or portable tanks, by gravity or pump, through an approved self-closing valve. Transferring by means of air pressure on the container or portable tanks is prohibited.

(4) The dispensing units shall be protected against collision damage.

(5) Dispensing devices and nozzles for flammable liquids shall be of an approved type.

(f) *Handling liquids at point of final use.* (1) Flammable liquids shall be kept in closed containers when not actually in use.

(2) Leakage or spillage of flammable or combustible liquids shall be disposed of promptly and safely.

(3) Flammable liquids may be used only where there are no open flames or other sources of ignition within 50 feet of the operation, unless conditions warrant greater clearance.

(g) *Service and refueling areas.* (1) Flammable or combustible liquids shall be stored in approved closed containers, in tanks located underground, or in aboveground portable tanks.

(2) The tank trucks shall comply with the requirements covered in the Standard for Tank Vehicles for Flammable and Combustible Liquids, NFPA No. 385-1966.

(3) The dispensing hose shall be an approved type.

(4) The dispensing nozzle shall be an approved automatic-closing type without a latch-open device.

(5) Underground tanks shall not be abandoned.

(6) Clearly identified and easily accessible switch(es) shall be provided at a location remote from dispensing devices to shut off the power to all dispensing devices in the event of an emergency.

(7) (i) Heating equipment of an approved type may be installed in the lubrication or service area where there is no dispensing or transferring of flammable liquids, provided the bottom of the heating unit is at least 18 inches above the floor and is protected from physical damage.

(ii) Heating equipment installed in lubrication or service areas, where flammable liquids are dispensed, shall be of an approved type for garages, and shall be installed at least 8 feet above the floor.

(8) There shall be no smoking or open flames in the areas used for fueling, servicing fuel systems for internal combustion engines, receiving or dispensing of flammable or combustible liquids.

(9) Conspicuous and legible signs prohibiting smoking shall be posted.

(10) The motors of all equipment being fueled shall be shut off during the fueling operation.

(11) Each service or fueling area shall be provided with at least one fire extinguisher having a rating of not less than 20BC located so that an extinguisher will be within 75 feet of each

pump, dispenser, underground fill pipe opening, and lubrication or service area.

§1518.154 Liquefied petroleum gas (LP-Gas).

(a) *Approval of equipment and systems.* (1) Each system shall have containers, valves, connectors, manifold valve assemblies, and regulators of an approved type.

(2) All cylinders shall meet the Department of Transportation specification identification requirements published in 49 CFR Part 178, Shipping Container Specifications.

(b) *Welding on LP-Gas containers.* Welding is prohibited on containers.

(c) *Container valves and container accessories.* (1) Valves, fittings, and accessories connected directly to the container, including primary shut off valves, shall have a rated working pressure of at least 250 p.s.i.g. and shall be of material and design suitable for LP-Gas service.

(2) Connections to containers, except safety relief connections, liquid level gauging devices, and plugged openings, shall have shutoff valves located as close to the container as practicable.

(d) *Safety devices.* (1) Every container and every vaporizer shall be provided with one or more approved safety relief valves or devices. These valves shall be arranged to afford free vent to the outer air with discharge not less than 5 feet horizontally away from any opening into a building which is below such discharge.

(2) Shutoff valves shall not be installed between the safety relief device and the container, or the equipment or piping to which the safety relief device is connected, except that a shutoff valve may be used where the arrangement of this valve is such that full required capacity flow through the safety relief device is always afforded.

(3) Container safety relief devices and regulator relief vents shall be located not less than 5 feet in any direction from air openings into sealed combustion system appliances or mechanical ventilation air intakes.

(e) *Dispensing.* (1) Filling of fuel containers for trucks or motor vehicles from bulk storage containers shall be performed not less than 10 feet from the nearest masonry-walled building, or not less than 25 feet from the nearest building or other construction and, in any event, not less than 25 feet from any building opening.

(2) Filling of portable containers or containers mounted on skids from storage containers shall be performed not less than 50 feet from the nearest building.

(f) *Requirements for appliances.* (1) LP-Gas consuming appliances shall be approved types.

(2) Any appliance that was originally manufactured for operation with a gaseous fuel other than LP-Gas, and is in good condition, may be used with LP-Gas only after it is properly converted,

adapted, and tested for performance with LP-Gas before the appliance is placed in use.

(g) *Containers and regulating equipment installed outside of buildings or structures.* Containers shall be upright upon firm foundations or otherwise firmly secured. The possible effect on the outlet piping of settling shall be guarded against by a flexible connection or special fitting.

(h) *Containers and equipment used inside of buildings or structures.* (1) When operational requirements make portable use of containers necessary, and their location outside of buildings or structures is impracticable, containers and equipment shall be permitted to be used inside of buildings or structures in accordance with subparagraphs (2) through (11) of this paragraph.

(2) "Containers in use" means connected for use.

(3) Systems utilizing containers having a water capacity greater than 2½ pounds (nominal 1 pound LP-Gas capacity) shall be equipped with excess flow valves. Such excess flow valves shall be either integral with the container valves or in the connections to the container valve outlets.

(4) Regulators shall be either directly connected to the container valves or to manifolds connected to the container valves. The regulator shall be suitable for use with LP-Gas. Manifolds and fittings connecting containers to pressure regulator inlets shall be designed for at least 250 p.s.i.g. service pressure.

(5) Valves on containers having water capacity greater than 50 pounds (nominal 20 pounds LP-Gas capacity) shall be protected from damage while in use or storage.

(6) Aluminum piping or tubing shall not be used.

(7) Hose shall be designed for a working pressure of at least 250 p.s.i.g. Design, construction, and performance of hose, and hose connections shall have their suitability determined by listing by a nationally recognized testing agency. The hose length shall be as short as practicable. Hoses shall be long enough to permit compliance with spacing provisions of subparagraphs (1)-(13) of this paragraph, without kinking or straining, or causing hose to be so close to a burner as to be damaged by heat.

(8) Portable heaters, including salamanders, shall be equipped with an approved automatic device to shut off the flow of gas to the main burner, and pilot if used, in the event of flame failure. Such heaters, having inputs above 50,000 B.t.u. per hour, shall be equipped with either a pilot, which must be lighted and proved before the main burner can be turned on, or an electrical ignition system. **NOTE:** The provisions of this subparagraph do not apply to portable heaters under 7,500 B.t.u. per hour input when used with containers having a maximum water capacity of 2½ pounds.

(9) *Container valves, connectors, regulators, manifolds, piping, and tubing*

shall not be used as structural supports for heaters.

(10) Containers, regulating equipment, manifolds, pipe, tubing, and hose shall be located to minimize exposure to high temperatures or physical damage.

(11) Containers having a water capacity greater than 2½ pounds (nominal 1 pound LP-Gas capacity) connected for use shall stand on a firm and substantially level surface and, when necessary, shall be secured in an upright position.

(12) The maximum water capacity of individual containers shall be 245 pounds (nominal 100 pounds LP-Gas capacity).

(13) For temporary heating, heaters (other than integral heater-container units) shall be located at least 6 feet from any LP-Gas container. This shall not prohibit the use of heaters specifically designed for attachment to the container or to a supporting standard, provided they are designed and installed so as to prevent direct or radiant heat application from the heater onto the containers. Blower and radiant type heaters shall not be directed toward any LP-Gas container within 20 feet.

(14) If two or more heater-container units, of either the integral or nonintegral type, are located in an unpartitioned area on the same floor, the container or containers of each unit shall be separated from the container or containers of any other unit by at least 20 feet.

(15) When heaters are connected to containers for use in an unpartitioned area on the same floor, the total water capacity of containers, manifolded together for connection to a heater or heaters, shall not be greater than 735 pounds (nominal 300 pounds LP-Gas capacity). Such manifolds shall be separated by at least 20 feet.

(16) Storage of containers awaiting use shall be in accordance with paragraphs (j) and (k) of this section.

(i) *Container valves and accessories.*

(1) Valves in the assembly of multiple container systems shall be arranged so that replacement of containers can be made without shutting off the flow of gas in the system. This provision is not to be construed as requiring an automatic changeover device.

(2) Heaters shall be equipped with an approved regulator in the supply line between the fuel cylinder and the heater unit. Cylinder connectors shall be provided with an excess flow valve to minimize the flow of gas in the event the fuel line becomes ruptured.

(3) Regulators and low-pressure relief devices shall be rigidly attached to the cylinder valves, cylinders, supporting standards, the building walls, or otherwise rigidly secured, and shall be so installed or protected from the elements.

(j) *Storage of LPG containers.* Storage of LPG within buildings is prohibited.

(k) *Storage outside of buildings.* (1) Storage outside of buildings, for containers awaiting use, shall be located

from the nearest building or group of buildings, in accordance with the following:

TABLE F-3

Quantity of LP-Gas stored:	Distance (feet)
500 lbs. or less.....	0
501 to 6,000 lbs.....	10
6,001 to 10,000 lbs.....	20
Over 10,000 lbs.....	25

(2) Containers shall be in a suitable ventilated enclosure or otherwise protected against tampering.

(1) *Fire protection.* Storage locations shall be provided with at least one approved portable fire extinguisher having a rating of not less than 20-B:C.

§ 1518.154 Temporary heating devices.

(a) *Ventilation.* (1) Fresh air shall be supplied in sufficient quantities to maintain the health and safety of workmen. Where natural means of fresh air supply is inadequate, mechanical ventilation shall be provided.

(2) When heaters are used in confined spaces, special care shall be taken to provide sufficient ventilation in order to ensure proper combustion, maintain the health and safety of workmen, and limit temperature rise in the area.

(b) *Clearance and mounting.* (1) Temporary heating devices shall be installed to provide clearance to combustible material not less than the amount shown in Table F-4.

(2) Temporary heating devices, which are listed for installation with lesser clearances than specified in Table F-4, may be installed in accordance with their approval.

TABLE F-4

Heating appliances	Minimum clearance, (inches)		
	Sides	Rear	Chimney connector
Room heater, circulating type.....	12	12	18
Room heater, radiant type.....	36	36	18

(3) Heaters not suitable for use on wood floors shall not be set directly upon them or other combustible materials. When such heaters are used, they shall rest on suitable heat insulating material or at least 1-inch concrete, or equivalent. The insulating material shall extend beyond the heater 2 feet or more in all directions.

(4) Heaters used in the vicinity of combustible tarpaulins, canvas, or similar coverings shall be located at least 10 feet from the coverings. The coverings shall be securely fastened to prevent ignition or upsetting of the heater due to wind action on the covering or other material.

(c) *Stability.* Heaters, when in use, shall be set horizontally level, unless otherwise permitted by the manufacturer's markings.

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(d) *Solid fuel heaters.* Solid fuel heaters and oil-fired salamanders are prohibited in buildings and on scaffolds.

(e) *Oil-fired heaters.* (1) Flammable liquid-fired heaters shall be equipped with a primary safety control to stop the flow of fuel in the event of flame failure. Barometric or gravity oil feed shall not be considered a primary safety control.

(2) Heaters designed for barometric or gravity oil feed shall be used only with the integral tanks.

(3) Heaters which are not designed for flue connection shall be equipped with integral tanks having capacity of not more than 2 gallons.

(4) Heaters specifically designed and approved for use with separate supply tanks may be directly connected for gravity feed, or an automatic pump, from a supply tank.

§ 1518.155 Definitions applicable to this subpart.

(a) "Approved", for the purpose of this subpart, means equipment that has been listed or approved by a nationally recognized testing laboratory such as Factory Mutual Engineering Corp., or Underwriters' Laboratories, Inc., or Federal agencies such as Bureau of Mines, or U.S. Coast Guard, which issue approvals for such equipment.

(b) "Closed container" means a container so sealed by means of a lid or other device that neither liquid nor vapor will escape from it at ordinary temperatures.

(c) "Combustible liquids" mean any liquid having a flash point at or above 140° F. (60° C.), and below 200° F. (93.4° C.).

(d) "Combustion" means any chemical process that involves oxidation sufficient to produce light or heat.

(e) "Fire brigade" means an organized group of employees that are knowledgeable, trained, and skilled in the safe evacuation of employees during emergency situations and in assisting in fire fighting operations.

(f) "Fire resistance" means so resistant to fire that, for specified time and under conditions of a standard heat intensity, it will not fail structurally and will not permit the side away from the fire to become hotter than a specified temperature. For purposes of this part, fire resistance shall be determined by the Standard Methods of Fire Tests of Building Construction and Materials, NFPA 251-1969.

(g) "Flammable" means capable of being easily ignited, burning intensely, or having a rapid rate of flame spread.

(h) "Flammable liquids" means any liquid having a flash point below 140° F.

and having a vapor pressure not exceeding 40 pounds per square inch (absolute) at 100° F.

(i) "Flash point" of the liquid means the temperature at which it gives off vapor sufficient to form an ignitable mixture with the air near the surface of the liquid or within the vessel used as determined by appropriate test procedure and apparatus as specified below.

(1) The flash point of liquids having a viscosity less than 45 Saybolt Universal Second(s) at 100° F. (37.8° C.) and a flash point below 175° F. (79.4° C.) shall be determined in accordance with the Standard Method of Test for Flash Point by the Tag Closed Tester, ASTM D-56-69.

(2) The flash point of liquids having a viscosity of 45 Saybolt Universal Second(s) or more at 175° F. (79.4° C.) or higher shall be determined in accordance with the Standard Method of Test for Flash Point by the Pensky Martens Closed Tester, ASTM D-93-69.

(j) "Liquefied petroleum gases," "LPG" and "LP Gas" mean and include any material which is composed predominantly of any of the following hydrocarbons, or mixtures of them, such as propane, propylene, butane (normal butane or iso-butane), and butylenes.

(k) "Portable tank" means a closed container having a liquid capacity more than 60 U.S. gallons, and not intended for fixed installation.

(l) "Safety can" means an approved closed container, of not more than 5 gallons capacity, having a flash-arresting screen, spring-closing lid and spout cover and so designed that it will safely relieve internal pressure when subjected to fire exposure.

(m) "Vapor pressure" means the pressure, measured in pounds per square inch (absolute), exerted by a volatile liquid as determined by the "Standard Method of Test for Vapor Pressure of Petroleum Products (Reid Method)." (ASTM D-323-58).

Subpart G—Signs, Signals, and Barricades

§ 1518.200 Accident prevention signs and tags.

(a) *General.* Signs and symbols required by this subpart shall be visible at all times when work is being performed, and shall be removed or covered promptly when the hazards no longer exist.

(b) *Danger signs.* (1) Danger signs (see Figure G-1) shall be used only where an immediate hazard exists.

(2) Danger signs shall have red as the predominating color for the upper panel; black outline on the borders; and a white lower panel for additional sign wording.

(c) *Caution signs.* (1) Caution signs (see Figure G-2) shall be used only to warn against potential hazards or to caution against unsafe practices.

(2) Caution signs shall have yellow as the predominating color; black upper panel and borders; yellow lettering of "caution" on the black panel; and the lower yellow panel for additional sign wording. Black lettering shall be used for additional wording.

Figure G-1



Figure G-2



(d) *Exit signs.* Exit signs, when required, shall be lettered in legible red letters, not less than 6 inches high, on a white field and the principal stroke of the letters shall be at least three-fourths inch in width.

(e) *Safety instruction signs.* Safety instruction signs, when used, shall be white with green upper panel with white letters to convey the principal message. Any additional wording on the sign shall be black letters on the white background.

(f) *Directional signs.* Directional signs, other than automotive traffic signs specified in paragraph (g) of this section, shall be white with a black panel and a white directional symbol. Any additional wording on the sign shall be black letters on the white background.

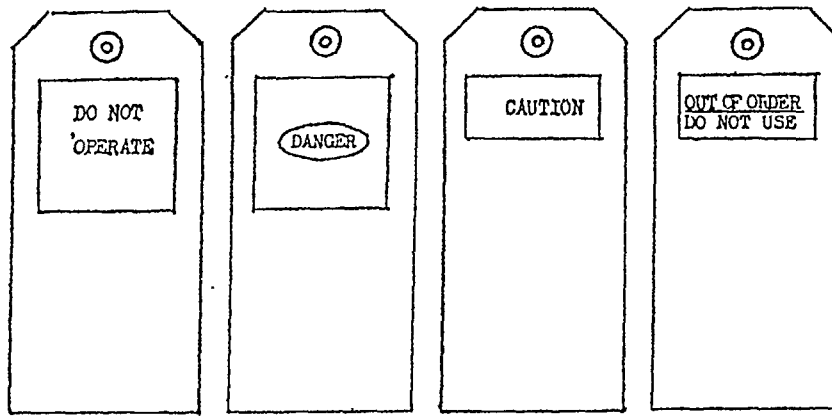
(g) *Traffic signs.* (1) Construction areas shall be posted with legible traffic signs at points of hazard.

(2) All traffic control signs or devices used for protection of construction workmen shall conform to American National Standards Institute D6.1-1961. Manual on Uniform Traffic Control Devices for Streets and Highways.

(h) *Accident prevention tags.* (1) Accident prevention tags shall be used as a temporary means of warning employees of an existing hazard, such as defective tools, equipment, etc. They shall not be used in place of, or as a substitute for, accident prevention signs.

(2) Specifications for accident prevention tags similar to those in Table G-1 shall apply.

Table C-1



White tag - White letters on red square

White tag - White letters on red oval with a black square

Yellow tag - Yellow letters on a black background

White tag - White letters on black background

Basic Stock (Background)	Safety Colors (Ink)	Copy Specification (Letters)
White	Red	Do Not Operate
White	Black and Red	Danger
Yellow	Black	Caution
White	Black	Out of Order Do Not Use

(i) *Additional rules.* American National Standards Institute (ANSI) Z35.1-1968, Specifications for Accident Prevention Signs, and Z35.2-1968, Specifications for Accident Prevention Tags, contain rules which are additional to the rules prescribed in this section. The employer shall comply with ANSI Z35.1-1968 and Z35.3-1968 with respect to rules not specifically prescribed in this subpart.

§ 1518.201 Signaling.

(a) *Flagmen.* (1) When operations are such that signs, signals, and barricades do not provide the necessary protection on or adjacent to a highway or street, flagmen or other appropriate traffic controls shall be provided.

(2) Signaling directions by flagmen shall conform to American National Standards Institute D6.1-1961, Manual

on Uniform Traffic Control Devices for Streets and Highways.

(3) Hand signaling by flagmen shall be by use of red flags at least 18 inches square or sign paddles, and in periods of darkness, red lights.

(4) Flagmen shall be provided with and shall wear a red or orange warning garment while flagging. Warning garments worn at night shall be of reflectorized material.

(b) *Crane and hoist signals.* Regulations for crane and hoist signaling will be found in applicable American National Standards Institute standards.

§ 1518.202 Barricades.

Barricades for protection of employees shall conform to the portions of the American National Standards Institute

D6.1-1961, Manual on Uniform Traffic Control Devices for Streets and Highways, relating to barricades.

§ 1518.203 Definitions applicable to this Subpart.

(a) "Barricade" means an obstruction to deter the passage of persons or vehicles.

(b) "Signs" are the warnings of hazard, temporarily or permanently affixed or placed, at locations where hazards exist.

(c) "Signals" are moving signs, provided by workers, such as flagmen, or by devices, such as flashing lights, to warn of possible or existing hazards.

(d) "Tags" are temporary signs, usually attached to a piece of equipment or part of a structure, to warn of existing or immediate hazards.

Subpart H—Materials Handling, Storage, Use, and Disposal

§ 1518.250 General requirements for storage.

(a) *General.* (1) All materials stored in tiers shall be stacked, racked, blocked, interlocked, or otherwise secured to prevent sliding, falling or collapse.

(2) Maximum safe load limits of floors within buildings and structures, in pounds per square foot, shall be conspicuously posted in all storage areas, except for floor or slab on grade. Maximum safe loads shall not be exceeded.

(3) Aisles and passageways shall be kept clear to provide for the free and safe movement of material handling equipment or employees. Such areas shall be kept in good repair.

(4) When a difference in road or working levels exist, means such as ramps, blocking, or grading shall be used to ensure the safe movement of vehicles between the two levels.

(b) *Material storage.* (1) Material stored inside buildings under construction shall not be placed within 6 feet of any hoistway or inside floor openings, nor within 10 feet of an exterior wall which does not extend above the top of the material stored.

(2) Employees required to work on stored material in silos, hoppers, tanks, and similar storage areas shall be equipped with lifelines and safety belts meeting the requirements of Subpart E of this part.

(3) Noncompatible materials shall be segregated in storage.

(4) Bagged materials shall be stacked by stepping back the layers and cross-keying the bags at least every 10 bags high.

(5) Materials shall not be stored on scaffolds or runways in excess of supplies needed for immediate operations.

(6) Brick stacks shall not be more than 7 feet in height. When a loose brick stack reaches a height of 4 feet, it shall be tapered back 2 inches in every foot of height above the 4-foot level.

(7) When masonry blocks are stacked higher than 6 feet, the stack shall be tapered back one-half block per tier above the 6-foot level.

(8) Lumber:

(i) Used lumber shall have all nails withdrawn before stacking.

(ii) Lumber shall be stacked on level and solidly supported sills.

(iii) Lumber shall be so stacked as to be stable and self-supporting.

(iv) Lumber piles shall not exceed 20 feet in height provided that lumber to be handled manually shall not be stacked more than 16 feet high.

(9) Structural steel, poles, pipe, bar stock, and other cylindrical materials, unless racked, shall be stacked and blocked so as to prevent spreading or tilting.

§ 1518.251 Rigging equipment for material handling.

(a) *General.* (1) Rigging equipment for material handling shall be inspected prior to use on each shift and as necessary during its use to ensure that it is safe. Defective rigging equipment shall be removed from service.

(2) Rigging equipment shall not be loaded in excess of its recommended safe working load, as prescribed in Tables H-1 through H-20 in this subpart: (Following § 1518.252(c)) for the specific equipment.

(3) Rigging equipment, when not in use, shall be removed from the immediate work area so as not to present a hazard to employees.

(b) *Alloy steel chains.* (1) Welded alloy steel chain slings shall have permanently affixed durable identification stating size, grade, rated capacity, and sling manufacturer.

(2) Hooks, rings, oblong links, pear-shaped links, welded or mechanical coupling links, or other attachments, when used with alloy steel chains, shall have a rated capacity at least equal to that of the chain.

(3) Job or shop hooks and links, or makeshift fasteners, formed from bolts, rods, etc., or other such attachments, shall not be used.

(4) Rated capacity (working load limit) for alloy steel chain slings shall conform to the values shown in Table H-1.

(5) Whenever wear at any point of any chain link exceeds that shown in Table H-2, the assembly shall be removed from service.

(c) *Wire rope.* (1) Tables H-3 through H-14 shall be used to determine the safe

working loads of various sizes and classifications of improved plow steel wire rope and wire rope slings with various types of terminals. For sizes, classifications, and grades not included in these tables, the safe working load recommended by the manufacturer for specific, identifiable products shall be followed, provided that a safety factor of not less than 5 is maintained.

(2) Protruding ends of strands in splices on slings and bridles shall be covered or blunted.

(3) Wire rope shall not be secured by knots, except on haul back lines on scrapers.

(4) The following limitations shall apply to the use of wire rope:

(i) An eye splice made in any wire rope shall have not less than three full tucks. However, this requirement shall not operate to preclude the use of another form of splice or connection which can be shown to be as efficient and which is not otherwise prohibited.

(ii) Except for eye splices in the ends of wires and for endless-rope slings, each wire rope used in hoisting or lowering, or in pulling loads, shall consist of one continuous piece without knot or splice.

(iii) Eyes in wire rope bridles, slings, or bull wires shall not be formed by wire rope clips or knots.

(iv) Wire rope shall not be used if, in any length of eight diameters, the total number of visible broken wires exceeds 10 percent of the total number of wires, or if the rope shows other signs of excessive wear, corrosion, or defect.

(5) When U-bolt wire rope clips are used to form eyes, Table H-20 shall be used to determine the number and spacing of clips.

(i) When used for eye splices, the U-bolt shall be applied so that the "U" section is in contact with the dead end of the rope.

(d) *Natural rope, and synthetic fiber—* (1) *General.* When using natural or synthetic fiber rope slings, Tables H-15, 16, 17, and 18 shall apply.

(2) All splices in rope slings provided by the employer shall be made in accordance with fiber rope manufacturers' recommendations.

(i) In manila rope, eye splices shall contain at least three full tucks, and short splices shall contain at least six full tucks (three on each side of the centerline of the splice).

(ii) In layed synthetic fiber rope, eye splices shall contain at least four full tucks, and short splices shall contain at least eight full tucks (four on each side of the centerline of the splice).

(iii) Strand end tails shall not be trimmed short (flush with the surface of the rope) immediately adjacent to the full tucks. This precaution applies to both eye and short splices and all types of fiber rope. For fiber ropes under 1-inch diameter, the tails shall project at least six rope diameters beyond the last full tuck. For fiber ropes 1-inch diameter and larger, the tails shall project at least 6

inches beyond the last full tuck. In applications where the projecting tails may be objectionable, the tails shall be tapered and spliced into the body of the rope using at least two additional tucks (which will require a tail length of approximately six rope diameters beyond the last full tuck).

(iv) For all eye splices, the eye shall be sufficiently large to provide an included angle of not greater than 60° at the splice when the eye is placed over the load or support.

(v) Knots shall not be used in lieu of splices.

(e) *Synthetic webbing (nylon, polyester, and polypropylene).* (1) The employer shall have each synthetic web sling marked or coded to show:

(i) Name or trademark of manufacturer.

(ii) Rated capacities for the type of hitch.

(iii) Type of material.

(2) Rated capacity shall not be exceeded.

(f) *Shackles and hooks.* (1) Table H-19 shall be used to determine the safe working loads of various sizes of shackles, except that higher safe working loads are permissible when recommended by the manufacturer for specific, identifiable products, provided that a safety factor of not less than 5 is maintained.

(2) The manufacturer's recommendations shall be followed in determining the safe working loads of the various sizes and types of specific and identifiable hooks. All hooks for which no applicable manufacturer's recommendations are available shall be tested to twice the intended safe working load before they are initially put into use. The employer shall maintain a record of the dates and results of such tests.

§ 1518.252 Disposal of waste materials.

(a) Whenever materials are dropped to any point lying outside the exterior walls of the building, an enclosed chute of wood, or equivalent material, shall be used.

(b) When debris is dropped through holes in the floor without the use of chutes, the area onto which the material is dropped shall be completely enclosed with barricades not less than 42 inches high and not less than 6 feet back from the projected edge of the opening above. Signs warning of the hazard of falling materials shall be posted at each level. Removal shall not be permitted in this lower area until debris handling ceases above.

(c) All scrap lumber, waste material, and rubbish shall be removed from the immediate work area as the work progresses.

(d) Disposal of waste material or debris by burning shall comply with local fire regulations.

(e) All solvent waste, oily rags, and flammable liquids shall be kept in fire resistant covered containers until removed from worksite.

Table H-1
RATED CAPACITY (WORKING LOAD LIMIT), FOR ALLOY STEEL CHAIN SLINGS*
RATED CAPACITY (WORKING LOAD LIMIT), POUNDS

Chain Size, Inches	Single Branch Sling - 90 degree Loading	Double Sling Vertical Angle (1)			Triple and Quadruple Sling Vertical Angle (1)		
		30 degree	45 degree	60 degree	30 degree	45 degree	60 degree
		Horizontal Angle (2)		30 degree	Horizontal Angle (2)		30 degree
1/4	3,250	5,560	4,550	3,250	8,400	6,800	4,900
3/8	6,600	11,400	9,300	6,600	17,000	14,000	9,900
1/2	11,250	19,500	15,900	11,250	29,000	24,000	17,000
5/8	16,500	28,500	23,300	16,500	43,000	35,000	24,500
3/4	23,000	39,800	32,500	23,000	59,500	48,500	34,500
7/8	28,750	49,800	40,600	28,750	74,500	61,000	43,000
1	38,750	67,100	54,800	38,750	101,000	82,000	58,000
1-1/8	44,500	77,000	63,000	44,500	115,500	94,500	66,500
1-1/4	57,500	99,500	81,000	57,500	149,000	121,500	86,000
1-3/8	67,000	116,000	94,000	67,000	174,000	141,000	100,500
1-1/2	80,000	138,000	112,500	80,000	207,000	169,000	119,500
1-3/4	100,000	172,000	140,000	100,000	258,000	210,000	150,000

(1) Rating of multileg slings adjusted for angle of loading measured as the included angle between the inclined leg and the vertical.

(2) Rating of multileg slings adjusted for angle of loading between the inclined leg and the horizontal plane of the load.

*Other grades of proof tested steel chain include Proof Coil, BBB Coil and Hi-Test Chain. These grades are not recommended for overhead lifting and therefore are not covered by this code.

TABLE H-2—MAXIMUM ALLOWABLE WEAR AT ANY POINT OF LINK

Chain size (inches)	Maximum allowable wear (inch)	Chain size (inches)	Maximum allowable wear (inch)
1/4	3/64	1	11/64
3/8	5/64	1 1/8	3/16
1/2	7/64	1 1/4	1/4
5/8	9/64	1 3/8	9/32
3/4	11/64	1 1/2	5/16
		1 3/4	11/32

Table H-3
RATED CAPACITIES FOR SINGLE LEG SLINGS
6 x 19 AND 6 x 37 CLASSIFICATION IMPROVED FLOW STEEL GRADE ROPE
WITH FIBER CORE (FC)

Rope Dia (Inches)	Constr	Rated Capacities, Tons (2,000 lb)								
		Vertical			Choker			Vertical Basket ^a		
		HT	MS	S	HT	MS	S	HT	MS	S
1/4	6 x 19	0.49	0.51	0.55	0.37	0.38	0.41	0.99	1.0	1.1
5/16	6 x 19	0.76	0.79	0.85	0.57	0.59	0.64	1.5	1.6	1.7
3/8	6 x 19	1.1	1.1	1.2	0.80	0.85	0.91	2.1	2.2	2.4
7/16	6 x 19	1.4	1.5	1.6	1.1	1.1	1.2	2.9	3.0	3.3
1/2	6 x 19	1.8	2.0	2.1	1.4	1.5	1.6	3.7	3.9	4.3
9/16	6 x 19	2.3	2.5	2.7	1.7	1.9	2.0	4.6	5.0	5.4
5/8	6 x 19	2.8	3.1	3.3	2.1	2.3	2.5	5.6	6.2	6.7
3/4	6 x 19	3.9	4.4	4.8	2.9	3.3	3.6	7.8	8.8	9.5
7/8	6 x 19	5.1	5.9	6.4	3.9	4.5	4.8	10.0	12.0	13.0
1	6 x 19	6.7	7.7	8.4	5.0	5.8	6.3	13.0	15.0	17.0
1-1/8	6 x 19	8.4	9.5	10.0	6.3	7.1	7.9	17.0	19.0	21.0
1-1/4	6 x 37	9.8	11.0	12.0	7.4	8.3	9.2	20.0	22.0	25.0
1-3/8	6 x 37	12.0	13.0	15.0	8.9	10.0	11.0	24.0	27.0	30.0
1-1/2	6 x 37	14.0	16.0	17.0	10.0	12.0	13.0	28.0	32.0	35.0
1-5/8	6 x 37	16.0	18.0	21.0	12.0	14.0	15.0	33.0	37.0	41.0
1-3/4	6 x 37	19.0	21.0	24.0	14.0	16.0	18.0	38.0	43.0	48.0
2	6 x 37	25.0	28.0	31.0	18.0	21.0	23.0	49.0	55.0	62.0

HT = Hand Tucked Splice and Hidden Tuck Splice

For hidden tuck splice (HT) use values in HT columns.

MS = Mechanical Splice

S = Swaged or Zinc Poured Socket

^aThese values only apply when the D/d ratio for HT slings is 10 or greater, and for MS and S slings is 20 or greater where:
D = Diameter of curvature around which the body of the sling is bent.
d = Diameter of rope.

Table H-4
RATED CAPACITIES FOR SINGLE LEG SLINGS
6 x 19 AND 6 x 37 CLASSIFICATION IMPROVED PLOW STEEL GRADE ROPE
WITH INDEPENDENT WIRE ROPE CORE (IWRC)

Rope		Rated Capacities, Tons (2,000 lb)								
Dia (Inches)	Constr	Vertical			Choker			Vertical Basket*		
		HT	MS	S	HT	MS	S	HT	MS	S
1/4	6 x 19	0.53	0.56	0.59	0.40	0.42	0.44	1.0	1.1	1.2
5/16	6 x 19	0.81	0.87	0.92	0.61	0.65	0.69	1.6	1.7	1.8
3/8	6 x 19	1.1	1.2	1.3	0.86	0.93	0.98	2.3	2.5	2.6
7/16	6 x 19	1.5	1.7	1.8	1.2	1.3	1.3	3.1	3.4	3.5
1/2	6 x 19	2.0	2.2	2.3	1.5	1.6	1.7	3.9	4.4	4.6
9/16	6 x 19	2.5	2.7	2.9	1.8	2.1	2.2	4.9	5.5	5.8
5/8	6 x 19	3.0	3.4	3.6	2.2	2.5	2.7	6.0	6.8	7.2
3/4	6 x 19	4.2	4.9	5.1	3.1	3.6	3.8	8.4	9.7	10.0
7/8	6 x 19	5.5	6.6	6.9	4.1	4.9	5.2	11.0	13.0	14.0
1	6 x 19	7.2	8.5	9.0	5.4	6.4	6.7	14.0	17.0	18.0
1-1/8	6 x 19	9.0	10.0	11.0	6.8	7.8	8.5	18.0	21.0	23.0
1-1/4	6 x 37	10.0	12.0	13.0	7.9	9.2	9.9	21.0	24.0	26.0
1-3/8	6 x 37	13.0	15.0	16.0	9.6	11.0	12.0	25.0	29.0	32.0
1-1/2	6 x 37	15.0	17.0	19.0	11.0	13.0	14.0	30.0	35.0	38.0
1-5/8	6 x 37	18.0	20.0	22.0	13.0	15.0	17.0	35.0	41.0	44.0
1-3/4	6 x 37	20.0	24.0	26.0	15.0	18.0	19.0	41.0	47.0	51.0
2	6 x 37	26.0	30.0	33.0	20.0	23.0	25.0	53.0	61.0	66.0

HT = Hand Tucked Splice

For hidden tuck splice (IWRC) use Table H-3 values in HT column.

MS = Mechanical Splice.

S = Swaged or Zinc Plated Socket.

*These values only apply when the D/d ratio for HT slings is 10 or greater, and for MS and S slings is 20 or greater where:
D = Diameter of curvature around which the body of the sling is bent,
d = Diameter of rope.

Table H-5
RATED CAPACITIES FOR SINGLE LEG SLINGS
CABLE LAID ROPE - MECHANICAL SPLICE ONLY
7 x 7 x 7 & 7 x 7 x 19 CONSTRUCTIONS GALVANIZED AIRCRAFT GRADE ROPE
7 x 6 x 19 IWRC CONSTRUCTION IMPROVED PLOW STEEL GRADE ROPE

Rope		Rated Capacities, Tons (2,000 lb)		
Dia (Inches)	Constr	Vertical		
		Vertical	Choker	Vertical Basket*
1/4	7 x 7 x 7	0.50	0.38	1.0
3/8	7 x 7 x 7	1.1	0.81	2.2
1/2	7 x 7 x 7	1.8	1.4	3.7
5/8	7 x 7 x 7	2.8	2.1	5.5
3/4	7 x 7 x 7	3.8	2.9	7.6
5/8	7 x 7 x 19	2.9	2.2	5.8
3/4	7 x 7 x 19	4.1	3.0	8.1
7/8	7 x 7 x 19	5.4	4.0	11.0
1	7 x 7 x 19	6.9	5.1	14.0
1-1/8	7 x 7 x 19	8.2	6.2	16.0
1-1/4	7 x 7 x 19	9.9	7.4	20.0
3/4	7 x 6 x 19 IWRC	3.8	2.8	7.6
7/8	7 x 6 x 19 IWRC	5.0	3.8	10.0
1	7 x 6 x 19 IWRC	6.4	4.8	13.0
1-1/8	7 x 6 x 19 IWRC	7.7	5.8	15.0
1-1/4	7 x 6 x 19 IWRC	9.2	6.9	18.0
1-5/16	7 x 6 x 19 IWRC	10.0	7.5	20.0
1-3/8	7 x 6 x 19 IWRC	11.0	8.2	22.0
1-1/2	7 x 6 x 19 IWRC	13.0	9.6	26.0

*These values only apply when the D/d ratio is 10 or greater where:
D = Diameter of curvature around which the body of the sling is bent,
d = Diameter of rope.

Table H-6
RATED CAPACITIES FOR SINGLE LEG SLINGS
8-PART AND 6-PART BRAIDED ROPE
6 x 7 AND 6 x 19 CONSTRUCTION IMPROVED PLOW STEEL GRADE ROPE
7 x 7 CONSTRUCTION GALVANIZED AIRCRAFT GRADE ROPE

Component Ropes		Rated Capacities, Tons (2,000 lb)					
Diameter (Inches)	Constr	Vertical		Choker		Basket Vertical to 30 degree*	
		8-Part	6-Part	8-Part	6-Part	8-Part	6-Part
3/32	6 x 7	0.42	0.32	0.32	0.24	0.74	0.55
1/8	6 x 7	0.76	0.57	0.57	0.42	1.3	0.98
3/16	6 x 7	1.7	1.3	1.3	0.94	2.9	2.2
3/32	7 x 7	0.51	0.39	0.38	0.29	0.89	0.67
1/8	7 x 7	0.95	0.71	0.71	0.53	1.6	1.2
3/16	7 x 7	2.1	1.5	1.5	1.2	3.6	2.7
3/16	6 x 19	1.7	1.3	1.3	0.98	3.0	2.2
1/4	6 x 19	3.1	2.3	2.3	1.7	5.3	4.0
5/16	6 x 19	4.8	3.6	3.6	2.7	8.3	6.2
3/8	6 x 19	6.8	5.1	5.1	3.8	12.0	8.9
7/16	6 x 19	9.3	6.9	6.9	5.2	16.0	12.0
1/2	6 x 19	12.0	9.0	9.0	6.7	21.0	15.0
9/16	6 x 19	15.0	11.0	11.0	8.5	26.0	20.0
5/8	6 x 19	19.0	14.0	14.0	10.0	32.0	24.0
3/4	6 x 19	27.0	20.0	20.0	15.0	46.0	35.0
7/8	6 x 19	36.0	27.0	27.0	20.0	62.0	47.0
1	6 x 19	47.0	35.0	35.0	26.0	81.0	61.0

*These values only apply when the D/d ratio is 20 or greater where:
D = Diameter of curvature around which the body of the sling is bent,
d = Diameter of component rope.

Table H-7
RATED CAPACITIES FOR 2-LEG & 3-LEG BRIDLE SLINGS
6 x 19 AND 6 x 37 CLASSIFICATION IMPROVED PLOW STEEL GRADE ROPE
WITH FIBER CORE (FC)

Rope		Rated Capacities, Tons (2,000 lb)											
		2-Leg Bridle Slings						3-Leg Bridle Slings					
		Vert 30 degree Horz 60 degree		45 degree Angle		Vert 60 degree Horz 30 degree		Vert 30 degree Horz 60 degree		45 degree Angle		Vert 60 degree Horz 30 degree	
Dia (Inches)	Constr	HT	MS	HT	MS	HT	MS	HT	MS	HT	MS	HT	MS
1/4	6 x 19	0.85	0.88	0.70	0.72	0.49	0.51	1.3	1.3	1.0	1.1	0.74	0.7
5/16	6 x 19	1.3	1.4	1.1	1.1	0.76	0.79	2.0	2.0	1.6	1.7	1.1	1.2
3/8	6 x 19	1.8	1.9	1.5	1.6	1.1	1.1	2.8	2.9	2.3	2.4	1.6	1.7
7/16	6 x 19	2.5	2.6	2.0	2.2	1.4	1.5	3.7	4.0	3.0	3.2	2.1	2.3
1/2	6 x 19	3.2	3.4	2.6	2.8	1.8	2.0	4.8	5.1	3.9	4.2	2.8	3.0
9/16	6 x 19	4.0	4.3	3.2	3.5	2.3	2.5	6.0	6.5	4.9	5.3	3.4	3.7
5/8	6 x 19	4.8	5.3	4.0	4.4	2.8	3.1	7.3	8.0	5.9	6.5	4.2	4.6
3/4	6 x 19	6.8	7.6	5.5	6.2	3.9	4.4	10.0	11.0	8.3	9.3	5.8	6.6
7/8	6 x 19	8.9	10.0	7.3	8.4	5.1	5.9	13.0	15.0	11.0	13.0	7.7	8.9
1	6 x 19	11.0	13.0	9.4	11.0	6.7	7.7	17.0	20.0	14.0	16.0	10.0	11.0
1-1/8	6 x 19	14.0	16.0	12.0	13.0	8.4	9.5	22.0	24.0	18.0	20.0	13.0	14.0
1-1/4	6 x 37	17.0	19.0	14.0	16.0	9.8	11.0	25.0	29.0	21.0	23.0	15.0	17.0
1-3/8	6 x 37	20.0	23.0	17.0	19.0	12.0	13.0	31.0	35.0	25.0	28.0	18.0	20.0
1-1/2	6 x 37	24.0	27.0	20.0	22.0	14.0	16.0	36.0	41.0	30.0	33.0	21.0	24.0
1-5/8	6 x 37	28.0	32.0	23.0	26.0	16.0	18.0	43.0	48.0	35.0	39.0	25.0	28.0
1-3/4	6 x 37	33.0	37.0	27.0	30.0	19.0	21.0	49.0	56.0	40.0	45.0	28.0	32.0
2	6 x 37	43.0	48.0	35.0	39.0	25.0	28.0	64.0	72.0	52.0	59.0	37.0	41.0

HT = Hand Tucked Splice,
MS = Mechanical Splice

Table H-8
RATED CAPACITIES FOR 2-LEG & 3-LEG BRIDLE SLINGS
6 x 19 and 6 x 37 CLASSIFICATION IMPROVED PLOW STEEL GRADE ROPE
WITH INDEPENDENT WIRE ROPE CORE (IWRC)

Rope		Rated Capacities, Tons (2,000 lb)											
		2-Leg Bridle Slings						3-Leg Bridle Slings					
		Vert 30 degree Horz 60 degree		45 degree Angle		Vert 60 degree Horz 30 degree		Vert 30 degree Horz 60 degree		45 degree Angle		Vert 60 degree Horz 30 degree	
Dia (Inches)	Constr	HT	MS	HT	MS	HT	MS	HT	MS	HT	MS	HT	MS
1/4	6 x 19	0.92	0.97	0.75	0.79	0.53	0.56	1.4	1.4	1.1	1.2	0.79	0.84
5/16	6 x 19	1.4	1.5	1.1	1.2	1.81	0.87	2.1	2.3	1.7	1.8	1.2	1.3
3/8	6 x 19	2.0	2.1	1.6	1.8	1.1	1.2	3.0	3.2	2.4	2.6	1.7	1.9
7/16	6 x 19	2.7	2.9	2.2	2.4	1.5	1.7	4.0	4.4	3.3	3.6	2.3	2.5
1/2	6 x 19	3.4	3.8	2.8	3.1	2.0	2.2	5.1	5.7	4.2	4.6	3.0	3.3
9/16	6 x 19	4.3	4.8	3.5	3.9	2.5	2.7	6.4	7.1	5.2	5.8	3.7	4.1
5/8	6 x 19	5.2	5.9	4.2	4.8	3.0	3.4	7.8	8.8	6.4	7.2	4.5	5.1
3/4	6 x 19	7.3	8.4	5.9	6.9	4.2	4.9	11.0	13.0	8.9	10.0	6.3	7.3
7/8	6 x 19	9.6	11.0	7.8	9.3	5.5	6.6	14.0	17.0	12.0	14.0	8.3	9.9
1	6 x 19	12.0	15.0	10.0	12.0	7.2	8.5	19.0	22.0	15.0	18.0	11.0	13.0
1-1/8	6 x 19	16.0	18.0	13.0	15.0	9.0	10.0	23.0	27.0	19.0	22.0	13.0	16.0
1-1/4	6 x 37	18.0	21.0	15.0	17.0	10.0	12.0	27.0	32.0	22.0	26.0	16.0	18.0
1-3/8	6 x 37	22.0	25.0	18.0	21.0	13.0	15.0	33.0	38.0	27.0	31.0	19.0	22.0
1-1/2	6 x 37	26.0	30.0	21.0	25.0	15.0	17.0	39.0	45.0	32.0	37.0	23.0	26.0
1-5/8	6 x 37	31.0	35.0	25.0	29.0	18.0	20.0	46.0	53.0	38.0	43.0	27.0	31.0
1-3/4	6 x 37	35.0	41.0	29.0	33.0	20.0	24.0	53.0	61.0	43.0	50.0	31.0	35.0
2	6 x 37	46.0	53.0	37.0	43.0	26.0	30.0	68.0	79.0	56.0	65.0	40.0	46.0

HT = Hand Tucked Splice
MS = Mechanical Splice

Table H-9
RATED CAPACITIES FOR 2-LEG & 3-LEG BRIDLE SLINGS
CABLE LAID ROPE - MECHANICAL SPICE ONLY
7 x 7 x 7 AND 7 x 7 x 19 CONSTRUCTIONS GALVANIZED AIRCRAFT GRADE ROPE
7 x 6 x 19 IWRC CONSTRUCTION IMPROVED PLOW STEEL GRADE ROPE

Rope		Rated Capacities, Tons (2,000 lb)						
		2-Leg Bridle Sling			3-Leg Bridle Sling			
		Vert 30 deg Horz 60 deg	45 degree Angle	Vert 60 deg Horz 30 deg	Vert 30 deg Horz 60 deg	45 degree Angle	Vert 60 deg Horz 30 deg	
1/4	7 x 7 x 7	0.87	0.71	0.50	1.3	1.1	0.75	
3/8	7 x 7 x 7	1.9	1.5	1.1	2.8	2.3	1.6	
1/2	7 x 7 x 7	3.2	2.6	1.8	4.8	3.9	2.8	
5/8	7 x 7 x 7	4.8	3.9	2.8	7.2	5.9	4.2	
3/4	7 x 7 x 7	6.6	5.4	3.8	9.9	8.1	5.7	
5/8	7 x 7 x 19	5.0	4.1	2.9	7.5	6.1	4.3	
3/4	7 x 7 x 19	7.0	5.7	4.1	10.0	8.6	6.1	
7/8	7 x 7 x 19	9.3	7.6	5.4	14.0	11.0	8.1	
1	7 x 7 x 19	12.0	9.7	6.9	18.0	14.0	10.0	
1-1/8	7 x 7 x 19	14.0	12.0	8.2	21.0	17.0	12.0	
1-1/4	7 x 7 x 19	17.0	14.0	9.9	26.0	21.0	15.0	
3/4	7 x 6 x 19 IWRC	6.6	5.4	3.8	9.9	8.0	5.7	
7/8	7 x 6 x 19 IWRC	8.7	7.1	5.0	13.0	11.0	7.5	
1	7 x 6 x 19 IWRC	11.0	9.0	6.4	17.0	13.0	9.6	
1-1/8	7 x 6 x 19 IWRC	13.0	11.0	7.7	20.0	16.0	11.0	
1-1/4	7 x 6 x 19 IWRC	16.0	13.0	9.2	24.0	20.0	14.0	
1-5/8	7 x 6 x 19 IWRC	17.0	14.0	10.0	26.0	21.0	15.0	
1-3/8	7 x 6 x 19 IWRC	19.0	15.0	11.0	28.0	23.0	16.0	
1-1/2	7 x 6 x 19 IWRC	22.0	18.0	13.0	33.0	27.0	19.0	

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Table H-10
 RATED CAPACITIES FOR 2-LEG AND 3-LEG BRIDLE SLINGS
 8-PART AND 6-PART BRAIDED ROPE
 6 x 7 AND 6 x 19 CONSTRUCTION IMPROVED PLOW STEEL GRADE ROPE
 7 x 7 CONSTRUCTION GALVANIZED AIRCRAFT GRADE ROPE

Component Rope		Rated Capacities, Tons (2,000 lb)											
		2-Leg Bridle Slings						3-Leg Bridle Slings					
		Vert 30 degree		45 degree		Vert 60 degree		Vert 30 degree		45 degree		Vert 60 degree	
		Horz 60 degree	Angle	Horz 60 degree	Angle	Horz 30 degree	Angle	Horz 60 degree	Angle	Horz 60 degree	Angle	Horz 30 degree	Angle
Dia (Inches)	Constr	8-Part	6-Part	8-Part	6-Part	8-Part	6-Part	8-Part	6-Part	8-Part	6-Part	8-Part	6-Part
3/32	6 x 7	0.74	0.55	0.60	0.45	0.42	0.32	1.1	0.83	0.90	0.68	0.64	0.48
1/8	6 x 7	1.3	0.98	1.1	0.80	0.76	0.57	2.0	1.5	1.6	1.2	1.1	0.85
3/16	6 x 7	2.9	2.2	2.4	1.8	1.7	1.3	4.4	3.3	3.6	2.7	2.5	1.9
3/32	7 x 7	0.89	0.67	0.72	0.55	0.51	0.39	1.3	1.0	1.1	0.82	0.77	0.58
1/8	7 x 7	1.6	1.2	1.3	1.0	0.95	0.71	2.5	1.8	2.0	1.5	1.4	1.1
3/16	7 x 7	3.6	2.7	2.9	2.2	2.1	1.5	5.4	4.0	4.4	3.3	3.1	2.3
3/16	6 x 19	3.0	2.2	2.4	1.8	1.7	1.3	4.5	3.4	3.7	2.8	2.6	1.9
1/4	6 x 19	5.3	4.0	4.3	3.2	3.1	2.3	8.0	6.0	6.5	4.9	4.6	3.4
5/16	6 x 19	8.3	6.2	6.7	5.0	4.8	3.6	12.0	9.3	10.0	7.6	7.1	5.4
3/8	6 x 19	12.0	8.9	9.7	7.2	6.8	5.1	18.0	13.0	14.0	11.0	10.0	7.7
7/16	6 x 19	16.0	12.0	13.0	9.8	9.3	6.9	24.0	18.0	20.0	15.0	14.0	10.0
1/2	6 x 19	21.0	15.0	17.0	13.0	12.0	9.0	31.0	23.0	25.0	19.0	18.0	13.0
9/16	6 x 19	26.0	20.0	21.0	16.0	15.0	11.0	39.0	29.0	32.0	24.0	23.0	17.0
5/8	6 x 19	32.0	24.0	26.0	20.0	19.0	14.0	48.0	36.0	40.0	30.0	28.0	21.0
3/4	6 x 19	46.0	35.0	38.0	28.0	27.0	20.0	69.0	52.0	56.0	42.0	40.0	30.0
7/8	6 x 19	62.0	47.0	51.0	38.0	36.0	27.0	94.0	70.0	76.0	57.0	54.0	40.0
1	6 x 19	81.0	61.0	66.0	50.0	47.0	35.0	122.0	91.0	99.0	74.0	70.0	53.0

Table H-11
 RATED CAPACITIES FOR STRAND LAID GROMMET - HAND TUCKED
 IMPROVED PLOW STEEL GRADE ROPE

ROPE BODY		RATED CAPACITIES, TONS (2,000 lb)		
Dia (Inches)	Constr			
1/4	7 x 19	0.85	0.64	1.7
5/16	7 x 19	1.3	1.0	2.6
3/8	7 x 19	1.9	1.4	3.8
7/16	7 x 19	2.6	1.9	5.2
1/2	7 x 19	3.3	2.5	6.7
9/16	7 x 19	4.2	3.1	8.4
5/8	7 x 19	5.2	3.9	10.00
3/4	7 x 19	7.4	5.6	15.0
7/8	7 x 19	10.0	7.5	20.0
1	7 x 19	13.0	9.7	26.0
1-1/8	7 x 19	16.0	12.0	32.0
1-1/4	7 x 37	18.0	14.0	37.0
1-3/8	7 x 37	22.0	16.0	44.0
1-1/2	7 x 37	26.0	19.0	52.0

* These values only apply when the D/d ratio is 5 or greater where:
 D = Diameter of curvature around which rope is bent.
 d = Diameter of rope body.

Table H-12
 RATED CAPACITIES FOR CABLE LAID GROMMET - HAND TUCKED
 7 x 6 x 7 AND 7 x 6 x 19 CONSTRUCTIONS IMPROVED PLOW STEEL GRADE ROPE
 7 x 7 x 7 CONSTRUCTION GALVANIZED AIRCRAFT GRADE ROPE

CABLE BODY		RATED CAPACITIES, TONS (2,000 lb)		
Dia (Inches)	Constr			
3/8	7 x 6 x 7	1.3	0.95	2.5
9/16	7 x 6 x 7	2.8	2.1	5.6
5/8	7 x 6 x 7	3.8	2.8	7.6
3/8	7 x 7 x 7	1.6	1.2	3.2
9/16	7 x 7 x 7	3.5	2.6	6.9
5/8	7 x 7 x 7	4.5	3.4	9.0
5/8	7 x 6 x 19	3.9	3.0	7.9
3/4	7 x 6 x 19	5.1	3.8	10.0
15/16	7 x 6 x 19	7.9	5.9	16.0
1-1/8	7 x 6 x 19	11.0	8.4	22.0
1-5/16	7 x 6 x 19	15.0	11.0	30.0
1-1/2	7 x 6 x 19	19.0	14.0	39.0
1-11/16	7 x 6 x 19	24.0	18.0	49.0
1-7/8	7 x 6 x 19	30.0	22.0	60.0
2-1/4	7 x 6 x 19	42.0	31.0	84.0
2-5/8	7 x 6 x 19	56.0	42.0	112.0

* These values only apply when the D/d ratio is 5 or greater where:
 D = Diameter of curvature around which cable body is bent.
 d = Diameter of cable body.

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Table H-13
RATED CAPACITIES FOR STRAND LAID ENDLESS SLINGS-MECHANICAL JOINT
IMPROVED PLOW STEEL GRADE ROPE

ROPE BODY		RATED CAPACITIES, TONS (2,000 lb)		
Dia (Inches)	Const	 Vertical	 Choker	 Vertical Basket*
1/4	6 x 19 IWRC	0.92	0.69	1.8
3/8	6 x 19 IWRC	2.0	1.5	4.1
1/2	6 x 19 IWRC	3.6	2.7	7.2
5/8	6 x 19 IWRC	5.6	4.2	11.0
3/4	6 x 19 IWRC	8.0	6.0	16.0
7/8	6 x 19 IWRC	11.0	8.1	21.0
1	6 x 19 IWRC	14.0	10.0	28.0
1-1/8	6 x 19 IWRC	18.0	13.0	35.0
1-1/4	6 x 37 IWRC	21.0	15.0	41.0
1-3/8	6 x 37 IWRC	25.0	19.0	50.0
1-1/2	6 x 37 IWRC	29.0	22.0	54.0

* These values only apply when the D/d ratio is 5 or greater where:
D = Diameter of curvature around which rope is bent.
d = Diameter of rope body.

Table H-14
RATED CAPACITIES FOR CABLE LAID ENDLESS SLINGS-MECHANICAL JOINT
7 x 7 x 7 AND 7 x 7 x 19 CONSTRUCTIONS GALVANIZED AIRCRAFT GRADE ROPE
7 x 6 x 19 IWRC CONSTRUCTION IMPROVED PLOW STEEL GRADE ROPE

CABLE BODY		RATED CAPACITIES, TONS (2,000 lb)		
Dia (Inches)	Const	 Vertical	 Choker	 Vertical Basket*
1/4	7 x 7 x 7	0.83	0.62	1.6
3/8	7 x 7 x 7	1.8	1.3	3.5
1/2	7 x 7 x 7	3.0	2.3	6.1
5/8	7 x 7 x 7	4.5	3.4	9.1
3/4	7 x 7 x 7	6.3	4.7	12.0
5/8	7 x 7 x 19	4.7	3.5	9.5
3/4	7 x 7 x 19	6.7	5.0	13.0
7/8	7 x 7 x 19	8.9	6.6	18.0
1	7 x 7 x 19	11.0	8.5	22.0
1-1/8	7 x 7 x 19	14.0	10.0	28.0
1-1/4	7 x 7 x 19	17.0	12.0	33.0
3/4	7 x 6 x 19 IWRC	6.2	4.7	12.0
7/8	7 x 6 x 19 IWRC	8.3	6.2	16.0
1	7 x 6 x 19 IWRC	10.0	7.9	21.0
1-1/8	7 x 6 x 19 IWRC	13.0	9.7	26.0
1-1/4	7 x 6 x 19 IWRC	16.0	12.0	31.0
1-3/8	7 x 6 x 19 IWRC	18.0	14.0	37.0
1-1/2	7 x 6 x 19 IWRC	22.0	16.0	43.0

* These values only apply when the D/d value is 5 or greater where:
D = Diameter of curvature around which cable body is bent.
d = Diameter of cable body.

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Table H-15
MANILA ROPE SLINGS

ROPE DIA- METER	Nominal Weight Per 100 ft In Pounds	Minimum Breaking Strength In Pounds	RATED CAPACITY IN POUNDS (Safety Factor = 5)											
			EYE AND EYE SLING								ENDLESS SLING			
			VERTICAL HITCH	CHOKER HITCH	BASKET HITCH				VERTICAL HITCH	CHOKER HITCH	BASKET HITCH			
					Angle of Rope to Horizontal						Angle of Rope to Horizontal			
					90 deg	60 deg	45 deg	30 deg			90 deg	60 deg	45 deg	30 deg
					Angle of Rope to Vertical						Angle of Rope to Vertical			
0 deg	30 deg	45 deg	60 deg	0 deg	30 deg	45 deg	60 deg							
1/2	7.5	2,650	550	250	1,100	900	750	550	950	500	1,900	1,700	1,400	950
9/16	10.4	3,450	700	350	1,400	1,200	1,000	700	1,200	600	2,500	2,200	1,800	1,200
5/8	13.3	4,400	900	450	1,800	1,500	1,200	900	1,600	800	3,200	2,700	2,200	1,600
3/4	16.7	5,400	1,100	550	2,200	1,900	1,500	1,100	2,000	950	3,900	3,400	2,800	2,000
13/16	19.5	6,500	1,300	650	2,600	2,300	1,800	1,300	2,300	1,200	4,700	4,100	3,300	2,300
7/8	22.5	7,700	1,500	750	3,100	2,700	2,200	1,500	2,800	1,400	5,600	4,800	3,900	2,800
1	27.0	9,000	1,800	900	3,600	3,100	2,600	1,800	3,200	1,600	6,500	5,600	4,600	3,200
1 1/16	31.3	10,500	2,100	1,100	4,200	3,600	3,000	2,100	3,800	1,900	7,600	6,600	5,400	3,800
1 1/8	36.0	12,000	2,400	1,200	4,800	4,200	3,400	2,400	4,300	2,200	8,600	7,500	6,100	4,300
1 1/4	41.7	13,500	2,700	1,400	5,400	4,700	3,800	2,700	4,900	2,400	9,700	8,400	6,900	4,900
1 5/16	47.9	15,000	3,000	1,500	6,000	5,200	4,300	3,000	5,400	2,700	11,000	9,400	7,700	5,400
1 1/2	59.9	18,500	3,700	1,850	7,400	6,400	5,200	3,700	6,700	3,300	13,500	11,500	9,400	6,700
1 5/8	74.6	22,500	4,500	2,300	9,000	7,800	6,400	4,500	8,100	4,100	16,000	14,000	11,500	8,000
1 3/4	89.3	26,500	5,300	2,700	10,500	9,200	7,500	5,300	9,500	4,800	19,000	16,500	13,500	9,500
2	107.5	31,000	6,200	3,100	12,500	10,500	8,800	6,200	11,000	5,600	22,500	19,500	16,000	11,000
2 1/3	125.0	36,000	7,200	3,600	14,500	12,500	10,000	7,200	13,000	6,500	26,000	22,500	18,500	13,000
2 1/4	146.0	41,000	8,200	4,100	16,500	14,000	11,500	8,200	15,000	7,400	29,500	25,500	21,000	15,000
2 1/2	166.7	46,500	9,300	4,700	18,500	16,000	13,000	9,300	16,500	8,400	33,500	29,000	23,500	16,500
2 5/8	190.8	52,000	10,500	5,200	21,000	18,000	14,500	10,500	18,500	9,500	37,500	32,500	26,500	18,500

Table H-16
NYLON ROPE SLINGS

ROPE DIA- METER	Nominal Weight Per 100 ft In Pounds	Minimum Breaking Strength In Pounds	RATED CAPACITY IN POUNDS (Safety Factor = 9)											
			EYE AND EYE SLING								ENDLESS SLING			
			VERTICAL HITCH	CHOKER HITCH	BASKET HITCH				VERTICAL HITCH	CHOKER HITCH	BASKET HITCH			
					Angle of Rope to Horizontal						Angle of Rope to Horizontal			
					90 deg	60 deg	45 deg	30 deg			90 deg	60 deg	45 deg	30 deg
					Angle of Rope to Vertical						Angle of Rope to Vertical			
0 deg	30 deg	45 deg	60 deg	0 deg	30 deg	45 deg	60 deg							
1/2	6.5	6,080	700	350	1,400	1,200	950	700	1,200	600	2,400	2,100	1,700	1,200
9/16	8.3	7,600	850	400	1,700	1,500	1,200	850	1,500	750	3,000	2,600	2,200	1,500
5/8	10.5	9,880	1,100	550	2,200	1,900	1,600	1,100	2,000	1,000	4,000	3,400	2,800	2,000
3/4	14.5	13,490	1,500	750	3,000	2,600	2,100	1,500	2,700	1,400	5,400	4,700	3,800	2,700
13/16	17.0	16,150	1,800	900	3,600	3,100	2,600	1,800	3,200	1,600	6,400	5,600	4,600	3,200
7/8	20.0	19,000	2,100	1,100	4,200	3,700	3,000	2,100	3,800	1,900	7,600	6,600	5,400	3,800
1	26.0	23,750	2,600	1,300	5,300	4,600	3,700	2,600	4,800	2,400	9,500	8,200	6,700	4,800
1 1/16	29.0	27,360	3,000	1,500	6,100	5,300	4,300	3,000	5,500	2,700	11,000	9,500	7,700	5,500
1 1/8	34.0	31,350	3,500	1,700	7,000	6,000	5,000	3,500	6,300	3,100	12,500	11,000	9,000	6,300
1 1/4	40.0	35,625	4,000	2,000	7,900	6,900	5,600	4,000	7,100	3,600	14,500	12,500	10,000	7,100
1 5/16	45.0	40,850	4,500	2,300	9,100	7,900	6,400	4,500	8,200	4,100	16,500	14,000	12,000	8,200
1 1/2	55.0	50,350	5,600	2,800	11,000	9,700	7,900	5,600	10,000	5,000	20,000	17,500	14,000	10,000
1 5/8	68.0	61,750	6,900	3,400	13,500	12,000	9,700	6,900	12,500	6,200	24,500	21,500	17,500	12,500
1 3/4	83.0	74,100	8,200	4,100	16,500	14,500	11,500	8,200	15,000	7,400	29,500	27,500	21,000	15,000
2	95.0	87,400	9,700	4,900	19,500	17,000	13,500	9,700	17,500	8,700	35,000	30,500	24,500	17,500
2 1/8	109.0	100,700	11,000	5,600	22,500	19,500	16,000	11,000	20,000	10,000	40,500	35,000	28,500	20,000
2 1/4	129.0	118,750	13,000	6,600	26,500	23,000	18,500	13,000	24,000	12,000	47,500	41,000	33,500	24,000
2 1/2	149.0	138,000	15,000	7,400	29,500	25,500	21,000	15,000	26,500	13,500	53,000	46,000	37,500	26,500
2 5/8	169.0	153,900	17,100	8,600	34,000	29,500	24,000	17,000	31,000	15,500	61,500	53,500	43,500	31,000

Table H-17
POLYESTER ROPE SLINGS

ROPE DIA- METER	Nominal Weight Per 100 ft In Pounds	Minimum Breaking Strength In Pounds	RATED CAPACITY IN POUNDS (Safety Factor = 9)											
			EYE AND EYE SLING						ENDLESS SLING					
			VERTICAL HITCH	CHOKER HITCH	BASKET HITCH				VERTICAL HITCH	CHOKER HITCH	BASKET HITCH			
					Angle of Rope to Horizontal						Angle of Rope to Horizontal			
					90 deg	60 deg	45 deg	30 deg			90 deg	60 deg	45 deg	30 deg
					Angle of Rope to Vertical						Angle of Rope to Vertical			
0 deg	30 deg	45 deg	60 deg	0 deg	30 deg	45 deg	60 deg							
1/2	8.0	6,080	700	350	1,400	1,200	950	700	1,200	600	2,400	2,100	1,700	1,200
9/16	10.2	7,600	850	400	1,700	1,500	1,200	850	1,500	750	3,000	2,600	2,200	1,500
5/8	13.0	9,500	1,100	550	2,100	1,800	1,500	1,100	1,900	950	3,800	3,300	2,700	1,900
3/4	17.5	11,875	1,300	650	2,600	2,300	1,900	1,300	2,400	1,200	4,800	4,100	3,400	2,400
13/16	21.0	14,725	1,600	800	3,300	2,800	2,300	1,600	2,900	1,500	5,900	5,100	4,200	2,900
7/8	25.0	17,100	1,900	950	3,800	3,300	2,700	1,900	3,400	1,700	6,800	5,900	4,800	3,400
1	30.5	20,900	2,300	1,200	4,600	4,000	3,300	2,300	4,200	2,100	8,400	7,200	5,900	4,200
1 1/16	34.5	24,225	2,700	1,300	5,400	4,700	3,800	2,700	4,800	2,400	9,700	8,400	6,900	4,800
1 1/8	40.0	28,025	3,100	1,600	6,200	5,400	4,400	3,100	5,600	2,800	11,000	9,700	7,900	5,600
1 1/4	46.3	31,540	3,500	1,800	7,000	6,100	5,000	3,500	6,300	3,200	12,500	11,000	8,900	6,300
1 5/16	52.5	35,625	4,000	2,000	7,900	6,900	5,600	4,000	7,100	3,600	14,500	12,500	10,000	7,100
1 1/2	66.8	44,460	4,900	2,500	9,900	8,600	7,000	4,900	8,900	4,400	18,000	15,500	12,500	8,900
1 5/8	82.0	54,150	6,000	3,000	12,000	10,400	8,500	6,000	11,000	5,400	21,500	19,000	15,500	11,000
1 3/4	98.0	64,410	7,200	3,600	14,500	12,500	10,000	7,200	13,000	6,400	26,000	22,500	18,000	13,000
2	118.0	76,000	8,400	4,200	17,000	14,500	12,000	8,400	15,000	7,600	30,500	26,500	21,500	15,000
2 1/8	135.0	87,400	9,700	4,900	19,500	17,000	13,500	9,700	17,500	8,700	35,000	30,500	24,500	17,500
2 1/4	157.0	101,650	11,500	5,700	22,500	19,500	16,000	11,500	20,500	10,000	40,500	35,000	29,000	20,500
2 1/2	181.0	115,900	13,000	6,400	26,000	22,500	18,000	13,000	23,000	11,500	46,500	40,000	33,000	23,000
2 5/8	205.0	130,150	14,500	7,200	29,000	25,000	20,500	14,500	26,000	13,000	52,000	45,000	37,000	26,000

Table H-18
POLYPROPYLENE ROPE SLINGS

ROPE DIA- METER	Nominal Weight Per 100 ft In Pounds	Minimum Breaking Strength In Pounds	RATED CAPACITY IN POUNDS (Safety Factor = 6)											
			EYE AND EYE SLING								ENDLESS SLING			
			VERTICAL HITCH	CHOKER HITCH	BASKET HITCH				VERTICAL HITCH	CHOKER HITCH	BASKET HITCH			
					Angle of Rope to Horizontal						Angle of Rope to Horizontal			
					90 deg	60 deg	45 deg	30 deg			90 deg	60 deg	45 deg	30 deg
Angle of Rope to Vertical				Angle of Rope to Vertical										
0 deg				30 deg	45 deg	60 deg	0 deg				30 deg	45 deg	60 deg	
1/2	4.7	3,990	650	350	1,300	1,200	950	650	1,200	600	2,400	2,100	1,700	1,200
9/16	6.1	4,845	800	400	1,600	1,400	1,100	800	1,500	750	2,900	2,500	2,100	1,500
5/8	7.5	5,890	1,000	500	2,000	1,700	1,400	1,000	1,800	900	3,500	3,100	2,500	1,800
3/4	10.7	8,075	1,300	700	2,700	2,300	1,900	1,300	2,400	1,200	4,900	4,200	3,400	2,400
13/16	12.7	9,405	1,600	800	3,100	2,700	2,200	1,600	2,800	1,400	5,600	4,900	4,000	2,800
7/8	15.0	10,925	1,800	900	3,600	3,200	2,600	1,800	3,300	1,600	6,600	5,700	4,600	3,300
1	18.0	13,300	2,200	1,100	4,400	3,800	3,100	2,200	4,000	2,000	8,000	6,900	5,600	4,000
1 1/16	20.4	15,200	2,500	1,300	5,100	4,400	3,600	2,500	4,600	2,300	9,100	7,900	6,500	4,600
1 1/8	23.7	17,385	2,900	1,500	5,800	5,000	4,100	2,900	5,200	2,600	10,500	9,000	7,400	5,200
1 1/4	27.0	19,950	3,300	1,700	6,700	5,800	4,700	3,300	6,000	3,000	12,000	10,500	8,500	6,000
1 5/16	30.5	22,325	3,700	1,900	7,400	6,400	5,300	3,700	6,700	3,400	13,500	11,500	9,500	6,700
1 1/2	38.5	28,215	4,700	2,400	9,400	8,100	6,700	4,700	8,500	4,200	17,000	14,500	12,000	8,500
1 5/8	47.5	34,200	5,700	2,900	11,500	9,900	8,100	5,700	10,500	5,100	20,500	18,000	14,500	10,500
1 3/4	57.0	40,850	6,800	3,400	13,500	12,000	9,600	6,800	12,500	6,100	24,500	21,000	17,500	12,500
2	69.0	49,400	8,200	4,100	16,500	14,500	11,500	8,200	15,000	7,400	29,500	25,500	21,000	15,000
2 1/8	80.0	57,950	9,700	4,800	19,500	16,500	13,500	9,700	17,500	8,700	35,000	30,100	24,500	17,500
2 1/4	92.0	65,550	11,000	5,500	22,500	19,000	15,500	11,000	19,500	9,900	39,500	34,000	28,000	19,500
2 1/2	107.0	76,000	12,500	6,300	25,500	22,000	18,000	12,500	23,000	11,500	45,500	39,500	32,500	23,000
2 5/8	120.0	85,500	14,500	7,100	28,500	24,500	20,000	14,500	25,500	13,000	51,500	44,500	36,500	25,500

TABLE H-20—SAFE WORKING LOADS FOR SHACKLES
(In tons of 2000 pounds)

Material size (inches)	Pin diameter (inches)	Safe working load
1 1/2	5/8	1.4
1 3/4	3/4	2.2
2	7/8	3.2
2 1/4	1	4.3
2 3/4	1 1/8	5.6
3	1 1/4	6.7
3 1/4	1 1/2	8.2
3 3/4	1 3/4	10.0
4	2	11.9
4 1/4	2 1/8	13.2
4 3/4	2 1/4	21.2

TABLE H-21—NUMBER AND SPACING OF U-BOLT WIRE
ROPE CLIPS

Improved alloy steel, type diameter inches	Number of clips		Minimum spacing (inches)
	Drop forged	Other material	
1 1/2	3	4	3
1 3/4	3	4	3 1/2
2	4	5	4 1/2
2 1/4	4	5	5 1/2
2 3/4	5	6	6 1/2
3	6	6	6 3/4
3 1/4	6	7	7 1/2
3 3/4	7	7	8 1/2
4	7	8	9

(Delete Fig. H-1)

(Delete Fig. H-2)

Subpart I—Tools—Hand and Power

§ 1518.300 General requirements.

(a) *Condition of tools.* All hand and power tools and similar equipment, whether furnished by the employer or the employee, shall be maintained in a safe condition.

(b) *Guarding.* (1) When power operated tools are designed to accommodate guards, they shall be equipped with such guards when in use.

(2) Belts, gears, shafts, pulleys, sprockets, spindles, drums, fly wheels, chains, or other reciprocating, rotating or moving parts of equipment shall be guarded if such parts are exposed to contact by employees or otherwise create a hazard. Guarding shall meet the requirements as set forth in American National Standards Institute, B15.1-1953 (R1958), Safety Code for Mechanical Power-Transmission Apparatus.

(c) *Personal protective equipment.* Employees using hand and power tools and exposed to the hazard of falling, flying, abrasive, and splashing objects, or exposed to harmful dusts, fumes, mists, vapors, or gases shall be provided with the particular personal protective equipment necessary to protect them from the hazard. All personal protective equipment shall meet the requirements and be maintained according to Subparts D and E of this part.

(d) *Constant pressure switch.* All hand-held power tools shall be equipped with a constant pressure switch that will shut off the power when the pressure is released.

§ 1518.301 Hand tools.

(a) Employers shall not issue or permit the use of unsafe hand tools.

(b) Wrenches, including adjustable,

pipe, end, and socket wrenches shall not be used when jaws are sprung to the point that slippage occurs.

(c) Impact tools, such as drift pins, wedges, and chisels, shall be kept free of mushroomed heads.

(d) The wooden handles of tools shall be kept free of splinters or cracks and shall be kept tight in the tool.

§ 1518.302 Power-operated hand tools.

(a) *Electric power-operated tools.* (1) Electric power operated tools shall either be of the approved double-insulated type or grounded in accordance with Subpart K of this part.

(2) The use of electric cords for hoisting or lowering tools shall not be permitted.

(b) *Pneumatic power tools.* (1) Pneumatic power tools shall be secured to the hose or whip by some positive means to prevent the tool from becoming accidentally disconnected.

(2) Safety clips or retainers shall be securely installed and maintained on pneumatic impact (percussion) tools to prevent attachments from being accidentally expelled.

(3) All pneumatically driven nailers, staplers, and other similar equipment provided with automatic fastener feed, which operate at more than 100 p.s.i. pressure at the tool shall have a safety device on the muzzle to prevent the tool from ejecting fasteners, unless the muzzle is in contact with the work surface.

(4) Compressed air shall not be used for cleaning purposes except where reduced to less than 30 p.s.i. and then only with effective chip guarding and personal protective equipment which meets the requirements of Subpart E of this part. The 30 p.s.i. requirement does not apply for concrete form, mill scale and similar cleaning purposes.

(5) The manufacturer's safe operating pressure for hoses, pipes, valves, filters, and other fittings shall not be exceeded.

(6) The use of hoses for hoisting or lowering tools shall not be permitted.

(7) All hoses exceeding 1/2-inch inside diameter shall have a safety device at the source of supply or branch line to reduce pressure in case of hose failure.

(8) Airless spray guns of the type which atomize paints and fluids at high pressures (1,000 pounds or more per square inch) shall be equipped with automatic or visible manual safety devices which will prevent pulling of the trigger to prevent release of the paint or fluid until the safety device is manually released.

(9) In lieu of the above, a diffuser nut which will prevent high pressure, high velocity release, while the nozzle tip is removed, plus a nozzle tip guard which will prevent the tip from coming into contact with the operator, or other equivalent protection, shall be provided.

(c) *Fuel powered tools.* (1) All fuel powered tools shall be stopped while being refueled, serviced, or maintained, and fuel shall be transported, handled, and stored in accordance with Subpart F of this part.

(2) When fuel powered tools are used in enclosed spaces, the applicable requirements for concentrations of toxic gases and use of personal protective equipment, as outlined in Subparts D and E of this part, shall apply.

(d) *Hydraulic power tools.* (1) the fluid used in hydraulic powered tools shall be fire-resistant fluids approved under Schedule 30 of the U.S. Bureau of Mines, Department of the Interior, and shall retain its operating characteristics at the most extreme temperatures to which it will be exposed.

(2) The manufacturer's safe operating pressures for hoses, valves, pipes, filters, and other fittings shall not be exceeded.

(e) *Powder-actuated tools.* (1) Only employees who have been trained in the operation of the particular tool in use shall be allowed to operate a powder-actuated tool.

(2) The tool shall be tested each day before loading to see that safety devices are in proper working condition. The method of testing shall be in accordance with the manufacturer's recommended procedure.

(3) Any tool found not in proper working order, or that develops a defect during use, shall be immediately removed from service and not used until properly repaired.

(4) Personal protective equipment shall be in accordance with Subpart E of this part.

(5) Tools shall not be loaded until just prior to the intended firing time. Neither loaded nor empty tools are to be pointed at any employees. Hands shall be kept clear of the open barrel end.

(6) Loaded tools shall not be left unattended.

(7) Fasteners shall not be driven into very hard or brittle materials including, but not limited to, cast iron, glazed tile, surface-hardened steel, glass block, live rock, face brick, or hollow tile.

(8) Driving into materials easily penetrated shall be avoided unless such materials are backed by a substance that will prevent the pin or fastener from passing completely through and creating a flying missile hazard on the other side.

(9) No fastener shall be driven into a spalled area caused by an unsatisfactory fastening.

(10) Tools shall not be used in an explosive or flammable atmosphere.

(11) All tools shall be used with the correct shield, guard, or attachment recommended by the manufacturer.

(12) Powder-actuated tools used by employees shall meet all other applicable requirements of American National Standards Institute, A10.3-1970, Safety Requirements for Explosive-Actuated Fastening Tools.

§ 1518.303 Abrasive wheels and tools.

(a) *Power.* All grinding machines shall be supplied with sufficient power to maintain the spindle speed at safe levels under all conditions of normal operation.

(b) *Guarding.* Grinding machines shall be equipped with safety guards in conformance with the requirements of

American National Standards Institute, B7.1-1964, Safety Code for the Use, Care and Protection of Abrasive Wheels, and paragraph (d) of this section.

(c) *Use of abrasive wheels.* (1) Floor stand and bench mounted abrasive wheels, used for external grinding, shall be provided with safety guards (protection hoods). The maximum angular exposure of the grinding wheel periphery and sides shall be not more than 90°, except that when work requires contact with the wheel below the horizontal plane of the spindle, the angular exposure shall not exceed 125°. In either case, the exposure shall begin not more than 65° above the horizontal plane of the spindle. Safety guards shall be strong enough to withstand the effect of a bursting wheel.

(2) Floor and bench-mounted grinders shall be provided with work rests which are rigidly supported and readily adjustable. Such work rests shall be kept at a distance not to exceed one-eighth inch from the surface of the wheel.

(3) Cup type wheels used for external grinding shall be protected by either a revolving cup guard or a band type guard in accordance with the provisions of the American National Standards Institute, B7.1 1970 Safety Code for the Use, Care, and Protection of Abrasive Wheels. All other portable abrasive wheels used for external grinding, shall be provided with safety guards (protection hoods) meeting the requirements of subparagraph (5) of this paragraph, except as follows:

(i) When the work location makes it impossible, a wheel equipped with safety flanges, as described in subparagraph (6) of this paragraph, shall be used;

(ii) When wheels 2 inches or less in diameter which are securely mounted on the end of a steel mandrel are used.

(4) Portable abrasive wheels used for internal grinding shall be provided with safety flanges (protection flanges) meeting the requirements of subparagraph (6) of this paragraph, except as follows:

(i) When wheels 2 inches or less in diameter which are securely mounted on the end of a steel mandrel are used;

(ii) If the wheel is entirely within the work being ground while in use.

(5) When safety guards are required, they shall be so mounted as to maintain proper alignment with the wheel, and the guard and its fastenings shall be of sufficient strength to retain fragments of the wheel in case of accidental breakage. The maximum angular exposure of the grinding wheel periphery and sides shall not exceed 180°.

(6) When safety flanges are required, they shall be used only with wheels designed to fit the flanges. Only safety flanges, of a type and design and properly assembled so as to ensure that the pieces of the wheel will be retained in case of accidental breakage, shall be used.

(7) All abrasive wheels shall be closely inspected and ring-tested before mounting to ensure that they are free from cracks or defects.

(8) Grinding wheels shall fit freely on the spindle and shall not be forced on. The spindle nut shall be tightened only enough to hold the wheel in place.

(9) All employees using abrasive wheels shall be protected by eye protection equipment in accordance with the requirements of Subpart E of this part, except when adequate eye protection is afforded by eye shields which are permanently attached to the bench or floor stand.

(d) *Other requirements.* All abrasive wheels and tools used by employees shall meet other applicable requirements of American National Standards Institute, B7.1-1964, Safety Code for the Use, Care and Protection of Abrasive Wheels.

§ 1518.304 Woodworking tools.

(a) *Disconnect switches.* All fixed power driven woodworking tools shall be provided with a disconnect switch that can either be locked or tagged in the off position.

(b) *Speeds.* The operating speed shall be etched or otherwise permanently marked on all circular saws over 20 inches in diameter or operating at over 10,000 peripheral feet per minute. Any saw so marked shall not be operated at a speed other than that marked on the blade. When a marked saw is retensioned for a different speed, the marking shall be corrected to show the new speed.

(c) *Self-feed.* Automatic feeding devices shall be installed on machines whenever the nature of the work will permit. Feeder attachments shall have the feed rolls or other moving parts covered or guarded so as to protect the operator from hazardous points.

(d) *Guarding.* All portable, power-driven circular saws shall be equipped with guards above and below the base plate or shoe. The upper guard shall cover the saw to the depth of the teeth, except for the minimum arc required to permit the base to be tilted for bevel cut. The lower guard shall cover the saw to the depth of the teeth, except for the minimum arc required to allow proper retraction and contact with the work. When the tool is withdrawn from the work, the lower guard shall automatically and instantly return to the covering position.

(e) *Personal protective equipment.* All personal protective equipment provided for use shall conform to Subpart E of this part.

(f) *Other requirements.* All woodworking tools and machinery shall meet other applicable requirements of American National Standards Institute, 01.1-1961, Safety Code for Woodworking Machinery.

§ 1518.305 Jacks—lever and ratchet, screw, and hydraulic.

(a) *General requirements.* (1) The manufacturer's rated capacity shall be legibly marked on all jacks and shall not be exceeded.

(2) All jacks shall have a positive stop to prevent overtravel.

(b) *Lift slab construction.* (1) Hydraulic jacks used in lift slab construction shall have a safety device which will cause the jacks to support the load in any position in the event the jack malfunctions.

(2) If lift slabs are automatically controlled, a device shall be installed which will stop the operation when the ½-inch leveling tolerance is exceeded.

(c) *Blocking.* When it is necessary, to provide a firm foundation, the base of the jack shall be blocked or cribbed. Where there is a possibility of slippage of the metal cap of the jack, a wood block shall be placed between the cap and the load.

Subpart J—Welding and Cutting

§ 1518.350 Ventilation and protection in welding, cutting, and heating.

(a) *Transporting, moving, and storing compressed gas cylinders.* (1) Valve protection caps shall be in place and secured.

(2) When cylinders are hoisted, they shall be secured on a cradle, slingboard, or pallet. They shall not be hoisted or transported by means of magnets or choker slings.

(3) Cylinders shall be moved by tilting and rolling them on their bottom edges. They shall not be intentionally dropped, struck, or permitted to strike each other violently.

(4) When cylinders are transported by powered vehicles, they shall be secured in a vertical position.

(5) Valve protection caps shall not be used for lifting cylinders from one vertical position to another. Bars shall not be used under valves or valve protection caps to pry cylinders loose when frozen. Warm, not boiling, water shall be used to thaw cylinders loose.

(6) Unless cylinders are firmly secured on a special carrier intended for this purpose, regulators shall be removed and valve protection caps put in place before cylinders are moved.

(7) A suitable cylinder truck, chain, or other steadying device shall be used to keep cylinders from being knocked over while in use.

(8) When work is finished, when cylinders are empty, or when cylinders are moved at any time, the cylinder valve shall be closed.

(9) Compressed gas cylinders shall be secured in an upright position at all times except, if necessary, for short periods of time while cylinders are actually being hoisted or carried.

(b) *Placing cylinders.* (1) Cylinders shall be kept far enough away from the actual welding or cutting operation so that sparks, hot slag, or flame will not reach them. When this is impractical, fire resistant shields shall be provided.

(2) Cylinders shall be placed where they cannot become part of an electrical circuit. Electrodes shall not be struck against a cylinder to strike an arc.

(3) Fuel gas cylinders shall be placed with valve end up whenever they are in use. They shall not be placed in a location where they would be subject to open flame, hot metal, or other sources of artificial heat.

(4) Cylinders containing oxygen or acetylene or other fuel gas shall not be taken into confined spaces.

(c) *Treatment of cylinders.* (1) Cylinders, whether full or empty, shall not be used as rollers or supports.

(2) No person other than the gas supplier shall attempt to mix gases in a cylinder. No one except the owner of the cylinder or person authorized by him, shall refill a cylinder. No one shall use a cylinder's contents for purposes other than those intended by the supplier. All cylinders used shall meet the Department of Transportation requirements published in 49 CFR Part 178, Subpart C, Specification for Cylinders.

(3) No damaged or defective cylinder shall be used.

(d) *Use of fuel gas.* The employer shall thoroughly instruct employees in the safe use of fuel gas, as follows:

(1) Before a regulator to a cylinder valve is connected, the valve shall be opened slightly and closed immediately. (This action is generally termed "cracking" and is intended to clear the valve of dust or dirt that might otherwise enter the regulator.) The person cracking the valve shall stand to one side of the outlet, not in front of it. The valve of a fuel gas cylinder shall not be cracked where the gas would reach welding work, sparks, flame, or other possible sources of ignition.

(2) The cylinder valve shall always be opened slowly to prevent damage to the regulator. For quick closing, valves on fuel gas cylinders shall not be opened more than 1½ turns. When a special wrench is required, it shall be left in position on the stem of the valve while the cylinder is in use so that the fuel gas flow can be shut off quickly in case of an emergency. In the case of manifolded or coupled cylinders, at least one such wrench shall always be available for immediate use. Nothing shall be placed on top of a fuel gas cylinder, when in use, which may damage the safety device or interfere with the quick closing of the valve.

(3) Fuel gas shall not be used from cylinders through torches or other devices which are equipped with shutoff valves without reducing the pressure through a suitable regulator attached to the cylinder valve or manifold.

(4) Before a regulator is removed from a cylinder valve, the cylinder valve shall always be closed and the gas released from the regulator.

(5) If, when the valve on a fuel gas cylinder is opened, there is found to be a leak around the valve stem, the valve shall be closed and the gland nut tightened. If this action does not stop the leak, the use of the cylinder shall be discontinued, and it shall be properly tagged and removed from the work area. In the event that fuel gas should leak from the cylinder valve, rather than from the valve stem, and the gas cannot be shut off, the cylinder shall be properly tagged and removed from the work area. If a regulator attached to a cylinder valve will effectively stop a leak through the valve seat, the cylinder need not be removed from the work area.

(6) If a leak should develop at a fuse plug or other safety device, the cylinder shall be removed from the work area.

(e) *Fuel gas and oxygen manifolds.*

(1) Fuel gas and oxygen manifolds shall

bear the name of the substance they contain in letters at least 1-inch high which shall be either painted on the manifold or on a sign permanently attached to it.

(2) Fuel gas and oxygen manifolds shall be placed in safe, well ventilated, and accessible locations. They shall not be located within enclosed spaces.

(3) Manifold hose connections, including both ends of the supply hose that lead to the manifold, shall be such that the hose cannot be interchanged between fuel gas and oxygen manifolds and supply header connections. Adapters shall not be used to permit the interchange of hose. Hose connections shall be kept free of grease and oil.

(4) When not in use, manifold and header hose connections shall be capped.

(5) Nothing shall be placed on top of a manifold, when in use, which will damage the manifold or interfere with the quick closing of the valves.

(f) *Hose.* (1) Fuel gas hose and oxygen hose shall be easily distinguishable from each other. The contrast may be made by different colors or by surface characteristics readily distinguishable by the sense of touch. Oxygen and fuel gas hoses shall not be interchangeable. A single hose having more than one gas passage shall not be used.

(2) When parallel sections of oxygen and fuel gas hose are taped together, not more than 4 inches out of 12 inches shall be covered by tape.

(3) All hose in use, carrying acetylene, oxygen, natural or manufactured fuel gas, or any gas or substance which may ignite or enter into combustion, or be in any way harmful to employees, shall be inspected at the beginning of each working shift. Defective hose shall be removed from service.

(4) Hose which has been subject to flashback, or which shows evidence of severe wear or damage, shall be tested to twice the normal pressure to which it is subject, but in no case less than 300 p.s.i. Defective hose, or hose in doubtful condition, shall not be used.

(5) Hose couplings shall be of the type that cannot be unlocked or disconnected by means of a straight pull without rotary motion.

(6) Boxes used for the storage of gas hose shall be ventilated.

(7) Hoses, cables, and other equipment shall be kept clear of passageways, ladders and stairs.

(g) *Torches.* (1) Clogged torch tip openings shall be cleaned with suitable cleaning wires, drills, or other devices designed for such purpose.

(2) Torches in use shall be inspected at the beginning of each working shift, for leaking shutoff valves, hose couplings, and tip connections. Defective torches shall not be used.

(3) Torches shall be lighted by friction lighters or other approved devices, and not by matches or from hot work.

(h) *Regulators and gauges.* Oxygen and fuel gas pressure regulators, including their related gauges, shall be in proper working order while in use.

(i) *Oil and grease hazards.* Oxygen cylinders and fittings shall be kept away from oil or grease. Cylinders, cylinder caps and valves, couplings, regulators, hose, and apparatus shall be kept free from oil or greasy substances and shall not be handled with oily hands or gloves. Oxygen shall not be directed at oily surfaces, greasy clothes, or within a fuel oil or other storage tank or vessel.

(j) *Additional rules.* For additional details not cover in this subpart, applicable technical portions of American National Standards Institute, Z49.1-1967, Safety in Welding and Cutting, shall apply.

§ 1518.354 Arc welding and cutting.

(a) *Manual electrode holders.* (1) Only manual electrode holders which are specifically designed for arc welding and cutting, and are of a capacity capable of safely handling the maximum rated current required by the electrodes, shall be used.

(2) Any current-carrying parts passing through the portion of the holder which the arc welder or cutter grips in his hand, and the outer surfaces of the jaws of the holder, shall be fully insulated against the maximum voltage encountered to ground.

(b) *Welding cables and connectors.* (1) All arc welding and cutting cables shall be of the completely insulated, flexible type, capable of handling the maximum current requirements of the work in progress, taking into account the duty cycle under which the arc welder or cutter is working.

(2) Only cable free from repair or splices for a minimum distance of 10 feet from the cable end to which the electrode holder is connected shall be used, except that cables with standard insulated connectors or with splices whose insulating quality is equal to that of the cable are permitted.

(3) When it becomes necessary to connect or splice lengths of cable one to another, substantial insulated connectors of a capacity at least equivalent to that of the cable shall be used. If connections are effected by means of cable lugs, they shall be securely fastened together to give good electrical contact, and the exposed metal parts of the lugs shall be completely insulated.

(4) Cables in poor repair shall not be used. When a cable, other than the cable lead referred to in subparagraph (2) of this paragraph, becomes worn to the extent of exposing bare conductors, the portion thus exposed shall be protected by means of rubber and friction tape or other equivalent insulation.

(c) *Ground, returns and machine grounding.* (1) A ground return cable shall have a safe current carrying capacity equal to or exceeding the specified maximum output capacity of the arc welding or cutting unit which it services. When a single ground return cable services more than one unit, its safe current-carrying capacity shall equal or exceed the total specified maximum output capacities of all the units which it services.

(2) Pipelines containing gases or flammable liquids, or conduits containing electrical circuits, shall not be used as a ground return. For welding on natural gas pipelines, the technical portions of regulations issued by the Department of Transportation, Office of Pipeline Safety, 49 CFR Part 192, Minimum Federal Safety Standards for Gas Pipelines shall apply.

(3) When a structure or pipeline is employed as a ground return circuit, it shall be determined that the required electrical contact exists at all joints. The generation of an arc, sparks, or heat at any point shall cause rejection of the structures as a ground circuit.

(4) When a structure or pipeline is continuously employed as a ground return circuit, all joints shall be bonded, and periodic inspections shall be conducted to ensure that no condition of electrolysis or fire hazard exists by virtue of such use.

(5) The frames of all arc welding and cutting machines shall be grounded either through a third wire in the cable containing the circuit conductor or through a separate wire which is grounded at the source of the current. Grounding circuits, other than by means of the structure, shall be checked to ensure that the circuit between the ground and the grounded power conductor has resistance low enough to permit sufficient current to flow to cause the fuse or circuit breaker to interrupt the current.

(6) All ground connections shall be inspected to ensure that they are mechanically strong and electrically adequate for the required current.

(d) *Operating instructions.* Employers shall instruct employees in the safe means of arc welding and cutting as follows:

(1) When electrode holders are to be left unattended, the electrodes shall be removed and the holders shall be so placed or protected that they cannot make electrical contact with employees or conducting objects.

(2) Hot electrode holders shall not be dipped in water; to do so may expose the arc welder or cutter to electric shock.

(3) When the arc welder or cutter has occasion to leave his work or to stop work for any appreciable length of time, or when the arc welding or cutting machine is to be moved, the power supply switch to the equipment shall be opened.

(4) Any faulty or defective equipment shall be reported to the supervisor.

(5) Other requirements, as outlined in Article 630, National Electric Code, Electric Welders, shall be used when applicable.

(e) *Shielding.* Whenever practicable, all arc welding and cutting operations shall be shielded by noncombustible or flameproof screens which will protect employees and other persons working in the vicinity from the direct rays of the arc.

§ 1518.351 Fire prevention.

(a) When practical, objects to be welded, cut, or heated shall be moved to a designated safe location or, if the ob-

jects to be welded, cut, or heated cannot be readily moved, all movable fire hazards in the vicinity shall be taken to a safe place, or otherwise protected.

(b) If the object to be welded, cut, or heated cannot be moved and if all the fire hazards cannot be removed, positive means shall be taken to confine the heat, sparks, and slag, and to protect the immovable fire hazards from them.

(c) No welding, cutting, or heating shall be done where the application of flammable paints, or the presence of other flammable compounds, or heavy dust concentrations creates a hazard.

(d) Suitable fire extinguishing equipment shall be immediately available in the work area and shall be maintained in a state of readiness for instant use.

(e) When the welding, cutting, or heating operation is such that normal fire prevention precautions are not sufficient, additional personnel shall be assigned to guard against fire while the actual welding, cutting, or heating operation is being performed, and for a sufficient period of time after completion of the work to ensure that no possibility of fire exists. Such personnel shall be instructed as to the specific anticipated fire hazards and how the firefighting equipment provided is to be used.

(f) When welding, cutting, or heating is performed on walls, floors, and ceilings, since direct penetration of sparks or heat transfer may introduce a fire hazard to an adjacent area, the same precautions shall be taken on the opposite side as are taken on the side on which the welding is being performed.

(g) For the elimination of possible fire in enclosed spaces as a result of gas escaping through leaking or improperly closed torch valves, the gas supply to the torch shall be positively shut off at some point outside the enclosed space whenever the torch is not to be used or whenever the torch is left unattended for a substantial period of time, such as during the lunch period. Overnight and at the change of shifts, the torch and hose shall be removed from the confined space. Open end fuel gas and oxygen hoses shall be immediately removed from enclosed spaces when they are disconnected from the torch or other gas-consuming device.

(h) Except when the contents are being removed or transferred, drums, pails, and other containers, which contain or have contained flammable liquids, shall be kept closed. Empty containers shall be removed to a safe area apart from hot work operations or open flames.

(i) Drums, containers, or hollow structures which have contained toxic or flammable substances shall, before welding, cutting, or heating is undertaken on them; either be filled with water or thoroughly cleaned of such substances and ventilated and tested. For welding, cutting and heating on steel pipelines containing natural gas, the pertinent portions of regulations issued by the Department of Transportation, Office of Pipeline Safety, 49 CFR Part 192, Minimum Federal Safety Standards for Gas Pipelines, shall apply.

(j) Before heat is applied to a drum, container, or hollow structure, a vent or opening shall be provided for the release of any built-up pressure during the application of heat.

§ 1518.353 Ventilation and protection in welding, cutting, and heating.

(a) *Mechanical ventilation.* For purposes of this section, mechanical ventilation shall meet the following requirements:

(1) Mechanical ventilation shall consist of either general mechanical ventilation systems or local exhaust systems.

(2) General mechanical ventilation shall be of sufficient capacity and so arranged as to produce the number of air changes necessary to maintain welding fumes and smoke within safe limits, as defined in Subpart D of this part.

(3) Local exhaust ventilation shall consist of freely movable hoods intended to be placed by the welder or burner as close as practicable to the work. This system shall be of sufficient capacity and so arranged as to remove fumes and smoke at the source and keep the concentration of them in the breathing zone within safe limits as defined in Subpart D of this part.

(4) Contaminated air exhausted from a working space shall be discharged into the open air or otherwise clear of the source of intake air.

(5) All air replacing that withdrawn shall be clean and respirable.

(6) Oxygen shall not be used for ventilation purposes, comfort cooling, blowing dust from clothing, or for cleaning the work area.

(b) *Welding, cutting, and heating in confined spaces.* (1) Except as provided in subparagraph (2) of this paragraph and paragraph (c) (2) of this section, either general mechanical or local exhaust ventilation meeting the requirements of paragraph (a) of this section shall be provided whenever welding, cutting, or heating is performed in a confined space.

(2) When sufficient ventilation cannot be obtained without blocking the means of access, employees in the confined space shall be protected by air line respirators in accordance with the requirements of Subpart E of this part, and an employee on the outside of such a confined space shall be assigned to maintain communication with those working within it and to aid them in an emergency.

(c) *Welding, cutting, or heating of metals of toxic significance.* (1) Welding, cutting, or heating in any enclosed spaces involving the metals specified in this subparagraph shall be performed with either general mechanical or local exhaust ventilation meeting the requirements of paragraph (a) of this section:

(i) Zinc-bearing base or filler metals or metals coated with zinc-bearing materials.

(ii) Lead base metals;

(iii) Cadmium-bearing filler materials;

(iv) Chromium-bearing metals or metals coated with chromium-bearing materials.

(2) Welding, cutting, or heating in any enclosed spaces involving the metals specified in this subparagraph shall be performed with local exhaust ventilation in accordance with the requirements of paragraph (a) of this section, or employees shall be protected by air line respirators in accordance with the requirements of Subpart E of this part:

(i) Metals containing lead, other than as an impurity, or metals coated with lead-bearing materials;

(ii) Cadmium-bearing or cadmium-coated base metals;

(iii) Metals coated with mercury-bearing metals;

(iv) Beryllium-containing base or filler metals. Because of its high toxicity, work involving beryllium shall be done with both local exhaust ventilation and air line respirators.

(3) Employees performing such operations in the open air shall be protected by filter-type respirators in accordance with the requirements of Subpart E of this part, except that employees performing such operations on beryllium-containing base or filler metals shall be protected by air line respirators in accordance with the requirements of Subpart E of this part.

(4) Other employees exposed to the same atmosphere as the welders or burners shall be protected in the same manner as the welder or burner.

(d) *Inert-gas metal-arc welding.* (1) Since the inert-gas metal-arc welding process involves the production of ultraviolet radiation of intensities of 5 to 30 times that produced during shielded metal-arc welding, the decomposition of chlorinated solvents by ultraviolet rays, and the liberation of toxic fumes and gases, employees shall not be permitted to engage in, or be exposed to the process until the following special precautions have been taken:

(i) The use of chlorinated solvents shall be kept at least 200 feet, unless shielded, from the exposed arc, and surfaces prepared with chlorinated solvents shall be thoroughly dry before welding is permitted on such surfaces.

(ii) Employees in the area not protected from the arc by screening shall be protected by filter lenses meeting the requirements of Subpart E of this part. When two or more welders are exposed to each other's arc, filter lens goggles of a suitable type, meeting the requirements of Subpart E of this part shall be worn under welding helmets. Hand shields to protect the welder against flashes and radiant energy shall be used when either the helmet is lifted or the shield is removed.

(iii) Welders and other employees who are exposed to radiation shall be suitably protected so that the skin is covered completely to prevent burns and other damage by ultraviolet rays. Welding helmets and hand shields shall be free of leaks and openings, and free of highly reflective surfaces.

(iv) When inert-gas metal-arc welding is being performed on stainless steel, the requirements of paragraph (c) (2) of this section shall be met to protect

against dangerous concentrations of nitrogen dioxide.

(e) *General welding, cutting, and heating.* (1) Welding, cutting, and heating, not involving conditions or materials described in paragraph (b), (c), or (d) of this section, may normally be done without mechanical ventilation or respiratory protective equipment, but where, because of unusual physical or atmospheric conditions, an unsafe accumulation of contaminants exists, suitable mechanical ventilation or respiratory protective equipment shall be provided.

(2) Employees performing any type of welding, cutting, or heating shall be protected by suitable eye protective equipment in accordance with the requirements of Subpart E of this part.

§ 1518.352 *Welding, cutting, and heating in way of preservative coatings.*

(a) Before welding, cutting, or heating is commenced on any surface covered by a preservative coating whose flammability is not known, a test shall be made by a competent person to determine its flammability. Preservative coatings shall be considered to be highly flammable when scrapings burn with extreme rapidity.

(b) Precautions shall be taken to prevent ignition of highly flammable hardened preservative coatings. When coatings are determined to be highly flammable, they shall be stripped from the area to be heated to prevent ignition.

(c) Protection against toxic preservative coatings: (1) In enclosed spaces, all surfaces covered with toxic preservatives shall be stripped of all toxic coatings for a distance of at least 4 inches from the area of heat application, or the employees shall be protected by air line respirators, meeting the requirements of Subpart E of this part.

(2) In the open air, employees shall be protected by a respirator, in accordance with requirements of Subpart E of this part.

(d) The preservative coatings shall be removed a sufficient distance from the area to be heated to ensure that the temperature of the unstripped metal will not be appreciably raised. Artificial cooling of the metal surrounding the heating area may be used to limit the size of the area required to be cleaned.

Subpart K—Electrical

§ 1518.400 *General Requirements.*

(a) All electrical work, installations, and wire capacities shall be in accordance with pertinent provisions of the National Fire Protection Association No. 70-1968, National Electrical Code, and the National Electric Safety Code, National Bureau of Standards, Part 4 (ANSI C2.4), unless otherwise provided by regulations of this part.

(b) *Applicability.* These regulations apply only to electrical installations used on the jobsite, both temporary and permanent. For power distribution and transmission lines, see Subpart V of this part.

(c) *Protection of employees:* (1) No employer shall permit an employee to

work in such proximity to any part of an electric power circuit that he may contact the same in the course of his work unless the employee is protected against electric shock by deenergizing the circuit and grounding it or by guarding it by effective insulation or other means. In work areas where the exact location of underground electric power lines is unknown, workmen using jack-hammers, bars, or other hand tools which may contact a line shall be provided with insulated protective gloves.

(2) Before work is begun the employer shall ascertain by inquiry or direct observation, or by instruments, whether any part of an electric power circuit, exposed or concealed, is so located that the performance of the work may bring any person, tool, or machine into physical or electrical contact therewith. The employer shall post and maintain proper warning signs where such a circuit exists. He shall advise his employees of the location of such lines, the hazards involved and the protective measures to be taken.

(d) *Passageways and open spaces:* Suitable barriers or other means shall be provided to ensure that workspace for electrical equipment will not be used as a passageway during periods when energized parts of electrical equipment are exposed.

(e) *Workspace around equipment:* Sufficient space shall be provided and maintained in the area of electrical equipment to permit ready and safe operation and maintenance of such equipment. When parts are exposed, the minimum clearance for the workspace shall be not less than 6¼ feet high, nor less than a radius of 3 feet wide, and there shall be clearance sufficient to permit at least a 90° opening of all doors or hinged panels. All working clearances shall be maintained in accordance with Article 110-16, National Electrical Code, NFPA No. 70-1968.

(f) *Load ratings:* In existing installations no changes in circuit protection shall be made to increase the load in excess of the load rating of the circuit wiring, as specified in National Electric Code, Article 310.

(g) *Lockout and tagging of circuits:* (1) Equipment or circuits that are deenergized shall be rendered inoperative and have tags attached at all points where such equipment or circuits can be energized.

(2) Controls that are to be deactivated during the course of work on energized or deenergized equipment or circuits shall be tagged.

(3) Tags shall be placed to identify plainly the equipment or circuits being worked on.

§ 1518.401 *Grounding and bonding.*

(a) *Portable and/or cord and plug-connected equipment.* (1) The noncurrent-carrying metal parts of portable and/or plug-connected equipment shall be grounded.

(2) Portable tools and appliances protected by an approved system of double insulation, or its equivalent, need not be

grounded. Where such an approved system is employed, the equipment shall be distinctively marked.

(b) *Fixed equipment.* Exposed noncurrent-carrying metal parts of fixed electrical equipment, including motors, generators, frames and tracks of electrically operated cranes, electrically driven machinery, etc., shall be grounded.

(c) *Effective grounding.* The path from circuits, equipment, structures, and conduit or enclosures to ground shall be permanent and continuous; have ample carrying capacity to conduct safely the currents liable to be imposed on it; and have the impedance sufficiently low to limit the potential above ground and to result in the operation of the overcurrent devices in the circuit.

(d) *Ground resistance.* Driven rod electrodes shall, where practicable, have a resistance to ground not to exceed 25 ohms. Where the resistance is not as low as 25 ohms, two or more electrodes connected in parallel shall be used.

(e) *Testing of grounds.* Grounding circuits shall be checked to ensure that the circuit between the ground and the grounded power conductor has a resistance which is low enough to permit sufficient current to flow to cause the fuse or circuit breaker to interrupt the current.

(f) *Extension cords.* Extension cords used with portable electric tools and appliances shall be of three-wire type.

(g) *Bonding.* (1) Conductors used for bonding and grounding stationary and moveable equipment shall be of ample size to carry the anticipated current.

(2) When attaching bonding and grounding clamps or clips, a secure and positive metal-to-metal contact shall be made. Such attachments shall be made before closures are opened and material movements are started and shall not be broken until after material movements are stopped and closures are made.

(h) *Temporary wiring.* All temporary wiring shall be effectively grounded in accordance with the National Electrical Code, NFPA No. 70-1968, Articles 300-23 and 310.

(i) *Construction site.* Every precaution shall be taken to make any necessary open wiring inaccessible to unauthorized personnel. Lighting on barricades, fences, or sidewalks coverings shall be encased in a metal raceway.

(j) *Temporary lighting.* (1) Temporary lights shall be equipped with guards to prevent accidental contact with the bulb, except that guards are not required when the construction of the reflector is such that the bulb is deeply recessed.

(2) Temporary lights shall be equipped with heavy duty electric cords with connections and insulation maintained in safe condition. Temporary lights shall not be suspended by their electric cords unless cords and lights are designed for this means of suspension. Splices shall have insulation equal to that of the cable.

(3) Cords shall be kept clear of working spaces and walkways or other locations in which they are readily exposed to damage.

(4) Portable electric lighting used in wet and/or other hazardous locations,

as for example, drums, tanks, and vessels shall be operated at a maximum of 12 volts.

§ 1518.402 Equipment installation and maintenance.

(a) *Flexible cable and cords.* (1) Receptacles for attachment plugs shall be of approved, concealed contact type with a contact for extending ground continuity and shall be so designed and constructed that the plug may be pulled out without leaving any live parts exposed to accidental contact.

(2) Where different voltages, frequencies, or types of current (a.c. or d.c.) are to be supplied by portable cords, receptacles shall be of such design that attachment plugs used on such circuits are not interchangeable.

(3) Attachment plugs or other connectors supplying equipment at more than 300 volts shall be of the skirted type or otherwise so designed that arcs will be confined.

(4) Attachment plugs for use in work areas shall be so constructed that they will endure rough use and be equipped with a suitable cord grip to prevent strain on the terminal screws.

(5) Flexible cord shall be used only in continuous lengths without splice, except suitable molded or vulcanized splices may be used where properly made, and the insulation shall be equal to the cable being spliced and wire connections soldered.

(6) Trailing cables shall be protected from damage.

(7) Splices in trailing cable shall be mechanically strong components and insulated to retain the mechanical and dielectric strength of the original cable.

(8) Cable passing through work areas shall be covered or elevated to protect it from damage which would create a hazard to employees.

(9) Handlamps of the portable type shall be of the molded composition or other type approved for the purpose. Brass-shell, paper-lined lampholders shall not be used. Handlamps shall be equipped with a handle and a substantial guard over the bulb and attached to the lampholder or the handle.

(10) Worn or frayed electric cables shall not be used.

(11) Extension cords shall be protected against accidental damage as may be caused by traffic, sharp corners, or projections and pinching in doors or elsewhere.

(12) Extension cords shall not be fastened with staples, hung from nails, or suspended by wire.

(b) *Overcurrent protection.* (1) Overcurrent protection shall be provided by fuses or circuit breakers for each feeder and branch-circuit, and shall be based on the current-carrying capacity of the conductors supplied and the power load being used.

(2) No overcurrent device shall be placed in any permanently grounded conductor, except where the overcurrent device simultaneously opens all conductors of the circuit or for motor running protection.

(3) When fuses are installed or removed with one or both terminals ener-

gized, special tools insulated for the voltage shall be used.

(c) *Switches, circuit breakers, and disconnecting means.* (1) Each disconnecting means for motors and appliances, and each service feeder or branch circuit at the point where it originates, shall be legibly marked to indicate its purpose unless located and arranged so the purpose is evident.

(2) Disconnecting means shall be located or shielded so that employees will not be injured.

(3) Boxes for disconnecting means shall be securely and rigidly fastened to the surface upon which they are mounted and fitted with covers.

(4) Boxes and disconnecting means installed in damp or wet locations shall be waterproof to the extent that water does not enter or accumulate.

(d) *Transformers.* (1) Energized transformers over 150 volts to ground shall be provided with enclosures. Enclosures made of metal shall be grounded.

(2) Entrance to such locations shall be kept locked.

(3) Signs indicating danger and prohibiting unauthorized entrance shall be displayed at entrances.

(e) *Welding and cutting equipment.* Welding and cutting equipment shall meet the requirements specified in Subparts F and J of this part.

§ 1518.403 Battery rooms and battery charging.

(a) *General requirements.* (1) Batteries of the nonseal type shall be located in enclosures with outside vents or in well ventilated rooms, so arranged as to prevent the escape of fumes, gases, or electrolyte spray into other areas.

(2) Ventilation shall be provided to ensure diffusion of the gases from the battery to prevent the accumulation of an explosive mixture.

(3) Racks and trays shall be substantial and treated to be resistant to the electrolyte.

(4) Floors shall be of acid resistant construction or be protected from acid accumulations.

(5) Face shields, aprons, and rubber gloves shall be provided for workmen handling acids or batteries.

(6) Facilities for quick drenching of the eyes and body shall be provided within 25 feet of the work area for emergency use.

(7) Facilities shall be provided for flushing and neutralizing spilled electrolyte, for fire protection, for protecting charging apparatus from damage by trucks, and for adequate ventilation for dispersal of fumes from gassing batteries.

(b) *Charging.* (1) Battery charging installations shall be located in areas designated for that purpose.

(2) When charging batteries, the vent caps shall be kept in place to avoid electrolyte spray. Care shall be taken to assure that vent caps are functioning.

§ 1518.404 Hazardous locations.

(a) *General:* For the purpose of this section, hazardous locations are defined as follows:

(1) *Class I Locations—Class I Locations* are those in which flammable gases,

or vapors are or may be present in quantities sufficient to produce explosive or ignitable mixtures.

(2) Class II Locations—Class II Locations are those which are hazardous because of the presence of combustible dust.

(3) Class III Locations—Class III Locations are those which are hazardous because of the presence of easily ignitable fibers or flyings, but in which such fibers or flyings are not likely to be in suspension in air in quantities sufficient to produce ignitable mixtures.

(4) See the National Electrical Code for further definition of divisions 1 and 2 for each class.

(b) All components, and utilization equipment used in a hazardous location shall be listed by the Underwriters' Laboratories Inc., or approved by the Factory Mutual Engr. Corp. for the use in the applicable class location.

(c) Equipment approved for a specific hazardous location shall not be installed or intermixed with equipment approved for another specific hazardous location.

(d) Employer shall ensure that all wiring components and utilization equipment are maintained as vapor, dust, or fiber tight as contemplated by their approvals. There shall be no loose or missing screws, gaskets, threaded connections, or other impairments to this tight condition.

§ 1518.405 Definitions applicable to this subpart.

(a) "Approved"—electrical wire, apparatus, and equipment in temporary or permanent use shall be of a type approved by the Underwriters' Laboratories, Inc., or Factory Mutual Engr. Corp. for the specific application. In the absence of an enforcing authority, compliance with the applicable requirements of the National Electrical Code shall constitute approval for equipment and installation.

(b) "Bonding jumper"—a conductor to assure the required electrical conductivity between metal parts required to be electrically connected.

(c) "Branch circuits"—that portion of a wiring system extending beyond the final overcurrent device protecting the circuit. (A device not approved for branch circuit protection, such as thermal cutout or motor overload protective device, is not considered as the overcurrent device protecting the circuit.)

(d) "Circuit breaker"—a device designed to open and close a circuit by hand or automatically and to open the circuit automatically on a predetermined overload of current, without injury to itself when properly applied within its rating.

(e) "Exposed" (as applied to live parts)—means that a live part can be inadvertently touched or approached nearer than a safe distance by a person. This term applies to parts not suitably guarded, isolated, or insulated.

(f) "Ground"—a conducting connection, whether intentional or accidental, between an electrical circuit or equipment and earth, or to some conducting body which serves in place of the earth.

(g) "Grounded"—connected to earth or to some conducting body which serves in place of the earth.

(h) "Hazard"—is considered to include casualty, fire, and shock when applicable.

(i) "Isolated" means not readily accessible to person unless special means of access are used.

(j) "Raceway"—any channel for loosely holding wires or cables in interior work which is designed expressly and used solely for this purpose. Raceways may be of metal, wood, or insulating material, and the term includes wood and metal moldings consisting of a backing and capping, and also metal ducts into which wires are to be pulled.

(k) "Shock hazard"—considered to exist at an accessible part in a circuit between the part and ground, or other accessible parts if the potential is more than 42.4 volts peak and the current through a 1,500-ohm load is more than 5 milliamperes.

(l) "Weatherproof"—so constructed or protected that exposure to the weather shall not interfere with successful operation.

Subpart L—Ladders and Scaffolding § 1518.450 Ladders.

(a) General requirements. (1) Except where either permanent or temporary stairways or suitable ramps or runways are provided, ladders described in this subpart shall be used to give safe access to all elevations.

(2) The use of ladders with broken or missing rungs or steps, broken or split side rails, or other faulty or defective construction is prohibited. When ladders with such defects are discovered, they shall be immediately withdrawn from service. Inspection of metal ladders shall include checking for corrosion of interiors of open end hollow rungs.

(3) Manufactured portable wood ladders provided by the employer shall be in accordance with the provisions of the American National Standards Institute, A 14.1-1968, Safety Code for Portable Wood Ladders.

(4) Portable metal ladders shall be of strength equivalent to that of wood ladders. Manufactured portable metal ladders provided by the employer shall be in accordance with the provisions of the American National Standards Institute, A 14.2-1956, Safety Code for Portable Metal Ladders.

(5) Fixed ladders shall be in accordance with the provisions of the American National Standards Institute, A 14.3-1956, Safety Code for Fixed Ladders.

(6) Portable ladder feet shall be placed on a substantial base, and the area around the top and bottom of the ladder shall be kept clear.

(7) Portable ladders shall be used at such a pitch that the horizontal distance from the top support to the base will not be greater than one-fourth the vertical distance between these points.

(8) Ladders shall not be placed in passageways, doorways, driveways, or any location where they may be displaced by activities being conducted on any other work, unless protected by barricades or guards.

(9) The side rails shall extend not less than 36 inches above the landing. When

this is not practical, grab rails, which provide a secure grip for an employee moving to or from the point of access, shall be installed.

(10) Portable ladders in use shall be tied, blocked, or otherwise secured to prevent their being displaced.

(11) Portable metal ladders shall not be used for electrical work or where they may contact electrical conductors.

(b) Job-made ladders. (1) Job-made ladders shall be constructed for intended use. If a ladder is to provide the only means of access or exit from a working area for 25 or more employees, or simultaneous two-way traffic is expected, a double cleat ladder shall be installed.

(2) Double cleat ladders shall not exceed 24 feet in length.

(3) Single cleat ladders shall not exceed 30 feet in length between supports (base and top landing). If ladders are to connect different landings, or if the length required exceeds this maximum length, two or more separate ladders shall be used, offset with a platform between each ladder. Guardrails and toeboards shall be erected on the exposed sides of the platforms. (See § 1518.451 (a) (5).)

(4) The width of single cleat ladders shall be at least 15 inches, but not more than 20 inches between rails at the top.

(5) Side rails shall be parallel or flared top to bottom by not more than one-quarter of an inch for each 2 feet of length.

(6) Wood side rails of ladders having cleats shall be not less than 1½ inches thick and 3½ inches deep (2 inches by 4 inches nominal) when made of Group 2 or Group 3 woods (see Table L-1). Wood side rails of Group 4 woods (see Table L-1) may be used in the same cross-section of dimensions for cleat ladders up to 20 feet in length.

TABLE L-1

AVERAGE DENSITIES OF VARIOUS SPECIES OF WOOD FOR USE IN LADDERS

GROUP 1			
Species	Density (lbs./ft. ³)	Species	Density (lbs./ft. ³)
White ash	41	Hard maple	42
Beech	43	Red maple	36
Birch	44	Red oak	43
Rock elm	43	White oak	46
Hickory	50	Pecan	48
Locust	47	Perseimmon	50
GROUP 2			
Douglas fir (coast region)	34	Southern yellow pine	37
Western larch	38		
GROUP 3			
Red alder	28	Gum	34
Oregon ash	38	West Coast hem- lock	30
Pumpkin ash	37	Magnolia	35
Alaska cedar	31	Oregon maple	34
Port Orford cedar	30	Norway pine	31
Cucumber	34	Poplar	28
Cypress	32	Redwood	25
Soft elm	36	Eastern spruce	28
Douglas fir (Rocky Moun- tain type)	30	Sitka spruce	28
Noble fir	27	Sycamore	35
		Tamarack	37
		Tupelo	35

TABLE L-1—Continued

GROUP 4			
Aspen	27	Eastern hemlock	28
Basswood	25	Holly	39
Buckeye	25	Soft maple.....	33
Butternut	27	Lodgepole pine..	29
Incense cedar..	25	Idaho white	
Western red		pine	28
Cedar	23	Northern white	
Black		pine	25
cottonwood ..	24	Ponderosa pine..	28
White fir.....	26	Sugar pine.....	26
Hackberry	37		

(7) It is preferable that side rails be continuous. If splicing is necessary to attain the required length however, the splice must develop the full strength of a continuous side rail of the same length.

(8) 2-inch by 4-inch lumber shall be used for side rails of single cleat ladders up to 16 feet long; 3-inch by 6-inch lumber shall be used for single cleat ladders from 16 to 30 feet in length.

(9) 2-inch by 4-inch lumber shall be used for side and middle rails of double cleat ladders up to 12 feet in length; 2-inch by 6-inch lumber for double cleat ladders from 12 to 24 feet in length.

(10) Wood cleats shall have the following minimum dimensions when made of Group 1 woods (see Table L-1):

TABLE L-2

Length of cleat (inches)	Thickness (inches)	Width (inches)
Up to and including 20.....	3/4	3
Over 20 and up to and including 30.....	3/4	3 1/4

(11) Cleats may be made of species of any other group of wood (see Table L-1) provided equal or greater strength is maintained.

(12) Cleats shall be inset into the edges of the side rails one-half inch, or filler blocks shall be used on the rails between the cleats. The cleats shall be secured to each rail with three 10d common wire nails or other fasteners of equivalent strength. Cleats shall be uniformly spaced, 12 inches top-to-top.

§ 1518.451 Scaffolding.

(a) *General requirements.* (1) Scaffolds shall be erected in accordance with requirements of this section.

(2) The footing or anchorage for scaffolds shall be sound, rigid, and capable of carrying the maximum intended load without settling or displacement. Unstable objects such as barrels, boxes, loose brick, or concrete blocks, shall not be used to support scaffolds or planks.

(3) No scaffold shall be erected, moved, dismantled, or altered except under the supervision of competent persons.

(4) Guardrails and toeboards shall be installed on all open sides and ends of platforms more than 6 feet above the ground or floor, except needle beam scaffolds and floats. Scaffolds 4 feet to 6 feet

in height, having a minimum horizontal dimension in either direction of less than 45 inches, shall have standard guardrails installed on all open sides and ends of the platform.

(5) Guardrails shall be 2- x 4-inches, or the equivalent, approximately 42 inches high, with a midrail, when required. Supports shall be at intervals not to exceed 8 feet. Toeboards shall be a minimum of 4 inches in height.

(6) Where persons are required to work or pass under the scaffold, scaffolds shall be provided with a screen between the toeboard and the guardrail, extending along the entire opening, consisting of No. 18 gauge U.S. Standard wire 1/2-inch mesh, or the equivalent.

(7) Scaffolds and their components shall be capable of supporting without failure at least 4 times the maximum intended load.

(8) Any scaffold including accessories such as braces, brackets, trusses, screw legs, ladders, etc. damaged or weakened from any cause shall be immediately repaired or replaced.

(9) All load-carrying timber members of scaffold framing shall be a minimum of 1,500 fiber (Stress Grade) construction grade lumber. All dimensions are nominal sizes as provided in the American Lumber Standards, except that where rough sizes are noted, only rough or undressed lumber of the size specified will satisfy minimum requirements.

(10) All planking shall be Scaffold Grade as recognized by approved grading rules for the species of wood used. The maximum permissible spans for 2- x 10-inch or wider planks shall be as shown in the following:

TABLE L-3

MATERIAL

	Full thickness undressed lumber			Nominal thickness lumber ¹		
	25	50	75	25	50	75
Working load (p.s.f.).....	25	50	75	25	50	75
Permissible span (ft.).....	10	8	6	8	6	5

¹ Nominal thickness lumber not recommended for heavy duty use.

(11) The maximum permissible span for 1 1/4- x 9-inch or wider plank of full thickness shall be 4 feet with medium duty loading of 50 p.s.f.

(12) All planking or platforms shall be overlapped (minimum 12 inches), or secured from movement.

(13) An access ladder or equivalent safe access shall be provided.

(14) Scaffold planks shall extend over their end supports not less than 6 inches nor more than 12 inches.

(15) The poles, legs, or uprights of scaffolds shall be plumb, and securely and rigidly braced to prevent swaying and displacement.

(16) Overhead protection shall be provided for men on a scaffold exposed to overhead hazards.

(17) Slippery conditions on scaffolds shall be eliminated as soon as possible after they occur.

(18) No welding, burning, riveting, or open flame work shall be performed on any staging suspended by means of fiber or synthetic rope. Only treated or protected fiber or synthetic ropes shall be used for or near any work involving the use of corrosive substances or chemicals.

(19) Wire, synthetic, or fiber rope used for scaffold suspension shall be capable of supporting at least 6 times the rated load.

(20) The use of shore pump jack, or lean-to scaffolds is prohibited.

(21) Lumber sizes, when used in this subpart, refer to nominal sizes except where otherwise stated.

(b) *Wood pole scaffolds.* (1) Scaffold poles shall bear on a foundation of sufficient size and strength to spread the load from the pole over a sufficient area to prevent settlement. All poles shall be set plumb.

(2) Where wood poles are spliced, the ends shall be squared and the upper section shall rest squarely on the lower section. Wood splice plates shall be provided on at least two adjacent sides and shall be not less than 4 feet in length, overlapping the abutted ends equally, and have the same width and not less than the cross-sectional area of the pole. Splice plates or other materials of equivalent strength may be used.

(3) Independent pole scaffolds shall be set as near to the wall of the building as practicable.

(4) All pole scaffolds shall be securely guyed or tied to the building or structure. Where the height or length exceeds 25 feet, the scaffold shall be secured at intervals not greater than 25 feet vertically and horizontally.

(5) Putlogs or bearers shall be set with their greater dimension vertical, long enough to project over the ledgers of the inner and outer rows of poles at least 3 inches for proper support.

(6) Every wooden putlog on single pole scaffolds shall be reinforced with a 3/4- x 2-inch steel strip, or equivalent, secured to its lower edge throughout its entire length.

(7) Ledgers shall be long enough to extend over two pole spaces. Ledgers shall not be spliced between the poles. Ledgers shall be reinforced by bearing blocks securely nailed to the side of the pole to form a support for the ledger.

(8) Diagonal bracing shall be provided to prevent the poles from moving in a direction parallel with the wall of the building, or from buckling.

(9) Cross bracing shall be provided between the inner and outer sets of poles in independent pole scaffolds. The free ends of pole scaffolds shall be cross braced.

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(10) Full diagonal face bracing shall be erected across the entire face of pole scaffolds in both directions. The braces shall be spliced at the poles. The inner row of poles on medium and heavy duty scaffolds shall be braced in a similar manner.

(11) Platform planks shall be laid with their edges close together so the platform will be tight with no spaces through which tools or fragments of material can fall.

(12) Where planking is lapped, each plank shall lap its end supports at least 12 inches. Where the ends of planks abut each other to form a flush floor, the butt joint shall be at the centerline of a pole. The abutted ends shall rest on separate bearers. Intermediate beams shall be provided where necessary to prevent dislodgment of planks due to deflection, and the ends shall be secured to prevent their dislodgment.

(13) When a scaffold materially changes its direction, the platform planks shall be laid to prevent tipping. The planks that meet the corner putlog at an angle shall be laid first, extending over the diagonally placed putlog far enough to have a good safe bearing, but not far enough to involve any danger from tipping. The planking running in the opposite direction at an angle shall be laid so as to extend over and rest on the first layer of planking.

(14) When moving platforms to the next level, the old platform shall be left undisturbed until the new putlogs or bearers have been set in place, ready to receive the platform planks.

(15) Guardrails, not less than 2 x 4 inches or the equivalent, approximately 42 inches high, with a midrail of 1- x 6-inch lumber or equivalent, and toeboards, shall be installed at all open sides and ends on all scaffolds more than 6 feet above the ground or floor. Toeboards shall be a minimum of 4 inches in height. Wire mesh shall be installed in accordance with paragraph (a)(6) of this section, when required.

(16) All wood pole scaffolds 60 feet or less in height shall be constructed and erected in accordance with Tables L-4 to 10. If they are over 60 feet in height, they shall be designed by a licensed qualified engineer competent in this field, and it shall be constructed and erected in accordance with such design.

TABLE L-4—MINIMUM NOMINAL SIZE AND MAXIMUM SPACING OF MEMBERS OF SINGLE POLE SCAFFOLDS, LIGHT DUTY

	Maximum height of scaffold	
	20 ft.	60 ft.
Uniformly distributed load.....	Not to exceed 25 p.s.f.	
Poles or uprights.....	2 x 4 in.	4 x 4 in.
Pole spacing (longitudinal).....	0 ft. 0 in.	10 ft. 0 in.
Maximum width of scaffold.....	5 ft. 0 in.	5 ft. 0 in.
Bearers or putlogs to 3 ft. 0 in. width.....	2 x 4 in.	2 x 4 in.
Bearers or putlogs to 5 ft. 0 in. width.....	2 x 6 in. or 3 x 4 in.	2 x 6 in. or 3 x 4 in. (rough).
Ledgers.....	1 x 4 in.	1½ x 9 in.
Planking.....	1½ x 9 in. (rough)	2 x 10 in.
Vertical spacing of horizontal members.....	7 ft. 0 in.	9 ft. 0 in.
Bracing, horizontal and diagonal.....	1 x 4 in.	1 x 4 in.
Tie-ins.....	1 x 4 in.	1 x 4 in.
Toeboards.....	4 in. high (minimum)	4 in. high (minimum).
Guardrail.....	2 x 4 in.	2 x 4 in.

All members except planking are used on edge.

TABLE L-5—MINIMUM NOMINAL SIZE AND MAXIMUM SPACING OF MEMBERS OF SINGLE POLE SCAFFOLDS—MEDIUM DUTY

	Not to exceed 50 p.s.f.
Uniformly distributed load.....	60 ft.
Maximum height of scaffold.....	
Poles or uprights.....	4 x 4 in.
Pole spacing (longitudinal).....	8 ft. 0 in.
Maximum width of scaffold.....	5 ft. 0 in.
Bearers or putlogs.....	2 x 10 in. or 3 x 4 in.
Spacing of bearers or putlogs.....	8 ft. 0 in.
Ledgers.....	2 x 9 in.
Vertical spacing of horizontal members.....	7 ft. 0 in.
Bracing, horizontal.....	1 x 6 in. or 1½ x 4 in.
Bracing, diagonal.....	1 x 4 in.
Tie-ins.....	1 x 4 in.
Planking.....	2 x 10 in.
Toeboards.....	4-in. high (minimum).
Guardrail.....	2 x 4 in.

All members except planking are used on edge.

TABLE L-6—MINIMUM NOMINAL SIZE AND MAXIMUM SPACING OF MEMBERS OF SINGLE POLE SCAFFOLDS—HEAVY DUTY

	Not to exceed 75 p.s.f.
Uniformly distributed load.....	60 ft.
Maximum height of scaffold.....	
Poles or uprights.....	4 x 6 in.
Pole spacing (longitudinal).....	6 ft. 0 in.
Maximum width of scaffold.....	5 ft. 0 in.
Bearers or putlogs.....	2 x 10 in. or 3 x 5 in.
Spacing of bearers or putlogs.....	6 ft. 0 in.
Ledgers.....	2 x 10 in.
Vertical spacing of horizontal members.....	6 ft. 6 in.
Bracing, horizontal and diagonal.....	2 x 4 in.
Tie-ins.....	1 x 4 in.
Planking.....	2 x 10 in.
Toeboards.....	4-in. high (minimum).
Guardrail.....	2 x 4 in.

All members except planking are used on edge.

TABLE L-7—MINIMUM NOMINAL SIZE AND MAXIMUM SPACING OF MEMBERS OF INDEPENDENT POLE SCAFFOLD LIGHT DUTY

	Maximum height of scaffold	
	20 ft.	60 ft.
Uniformly distributed load.....	Not to exceed 25 p.s.f.	
Poles or uprights.....	2 x 4 in.....	4 x 4 in.....
Pole spacing (longitudinal).....	0 ft. 0 in.....	10 ft. 0 in.....
Pole spacing (transverse).....	6 ft. 0 in.....	10 ft. 0 in.....
Ledgers.....	1½ x 4 in.....	1½ x 9 in.....
Bearers to 3 ft. 0 in. span.....	2 x 4 in.....	2 x 4 in.....
Bearers to 10 ft. 0 in. span.....	2 x 6 in. or 3 x 4 in.....	2 x 10 (rough) or 3 x 8 in.....
Planking.....	1½ x 9 in.....	2 x 10 in.....
Vertical spacing of horizontal members.....	7 ft. 0 in.....	7 ft. 0 in.....
Bracing, horizontal and diagonal.....	1 x 4 in.....	1 x 4 in.....
Tie-ins.....	1 x 4 in.....	1 x 4 in.....
Toeboards.....	4 in. high.....	4 in. high (minimum).....
Guardrail.....	2 x 4 in.....	2 x 4 in.....

All members except planking are used on edge.

TABLE L-8—MINIMUM NOMINAL SIZE AND MAXIMUM SPACING OF MEMBERS OF INDEPENDENT POLE SCAFFOLDS—MEDIUM DUTY

Uniformly distributed load.	Not to exceed 50 p.s.f.
Maximum height of scaffold.	60 ft.
Poles or uprights.	4 x 4 in.
Pole spacing (longitudinal).	8 ft. 0 in.
Pole spacing (transverse).	8 ft. 0 in.
Ledgers.	2 x 10 in.
Vertical spacing of horizontal members.	6 ft. 0 in.
Spacing of bearers.	8 ft. 0 in.
Bearers.	2 x 10 in.
Bracing, horizontal.	1 x 6 in. or 1 1/4 x 4 in.
Bracing, diagonal.	1 x 4 in.
Tie-ins.	1 x 4 in.
Planking.	2 x 10 in.
Toeboards.	4-in. high (minimum).

Guardrail 2 x 4 in.
All members except planking are used on edge.

TABLE L-9—MINIMUM NOMINAL SIZE AND MAXIMUM SPACING OF MEMBERS OF INDEPENDENT POLE SCAFFOLDS—HEAVY DUTY

Uniformly distributed load.	Not to exceed 75 p.s.f.
Maximum height of scaffold.	60 ft.
Poles or uprights.	4 x 4 in.
Pole spacing (longitudinal).	6 ft. 0 in.
Pole spacing (transverse).	8 ft. 0 in.
Ledgers.	2 x 10 in.
Vertical spacing of horizontal members.	6 ft. 0 in.
Bearers.	2 x 10 in. (rough).
Bracing, horizontal and diagonal.	2 x 4 in.
Tie-ins.	1 x 4 in.
Planking.	2 x 10 in.
Toeboards.	4-in. high (minimum).
Guardrail.	2 x 4 in.

All members except planking are used on edge.

(c) *Tube and coupler scaffolds.* (1) A light duty tube and coupler scaffold shall have all posts, bearers, runners, and bracing of nominal 2-inch O.D. steel tubing. The posts shall be spaced no more than 6 feet apart by 10 feet along the length of the scaffold. Other structural metals when used must be designed to carry an equivalent load. No dissimilar metals shall be used together.

(2) A medium duty tube and coupler scaffold shall have all posts, runners, and bracing of nominal 2-inch O.D. steel tubing. Posts spaced not more than 6 feet apart by 8 feet along the length of the scaffold shall have bearers of nominal 2 1/2-inch O.D. steel tubing. Posts spaced not more than 6 feet apart by 8 feet along the length of the scaffold shall have bearers of nominal 2-inch O.D. steel tubing. Other structural metals, when used, must be designed to carry an equivalent load. No dissimilar metals shall be used together.

(3) A heavy duty tube and coupler scaffold shall have all posts, runners, and bracing of nominal 2-inch O.D. steel tubing, with the posts spaced not more than 6 feet by 6 feet 6 inches. Other structural metals, when used, must be designed to carry an equivalent load. No dissimilar metals shall be used together.

(4) Tube and coupler scaffolds shall be limited in heights and working levels to those permitted in Tables L-10, 11, and 12. Drawings and specifications of all tube and coupler scaffolds above the limitations in Tables L-10, 11, and 12 shall be designed by a qualified engineer competent in this field.

(5) All tube and coupler scaffolds shall be constructed and erected to support four times the maximum intended loads, as set forth in Tables L-10, 11, and 12, or as set forth in the specifications by a licensed professional engineer competent in this field.

TABLE L-10—TUBE AND COUPLER SCAFFOLDS LIGHT DUTY

Uniformly distributed load.	Not to exceed 25 p.s.f.
Post spacing (longitudinal).	10 ft. 0 in.
Post spacing (transverse).	6 ft. 0 in.

Working levels	Additional planked levels	Maximum height
1	8	125 ft.
2	4	125 ft.
3	0	91 ft. 0 in.

TABLE L-11—TUBE AND COUPLER SCAFFOLDS MEDIUM DUTY

Uniformly distributed load.	Not to exceed 50 p.s.f.
Post spacing (longitudinal).	8 ft. 0 in.
Post spacing (transverse).	6 ft. 0 in.

Working levels	Additional planked levels	Maximum height
1	6	125 ft.
2	0	78 ft. 0 in.

TABLE L-12—TUBE AND COUPLER SCAFFOLDS HEAVY DUTY

Uniformly distributed load.	Not to exceed 75 p.s.f.
Post spacing (longitudinal).	6 ft. 6 in.
Post spacing (transverse).	6 ft. 0 in.

Working levels	Additional planked levels	Maximum height
1	6	125 ft.

(6) Posts shall be accurately spaced, erected on suitable bases, and maintained plumb.

(7) Runners shall be erected along the length of the scaffold, located on both the inside and the outside posts at even height. Runners shall be interlocked to the inside and the outside posts at even heights. Runners shall be interlocked to form continuous lengths and coupled to each post. The bottom runners shall be located as close to the base as possible. Runners shall be placed not more than 6 feet 6 inches on centers.

(8) Bearers shall be installed transversely between posts and shall be securely coupled to the posts bearing on the runner coupler. When coupled directly to the runners, the coupler must be kept as close to the posts as possible.

(9) Bearers shall be at least 4 inches but not more than 12 inches longer than the post spacing or runner spacing.

(10) Cross bracing shall be installed across the width of the scaffold at least every third set of posts horizontally and every fourth runner vertically. Such bracing shall extend diagonally from the

inner and outer runners upward to the next outer and inner runners.

(11) Longitudinal diagonal bracing on the inner and outer rows of poles shall be installed at approximately a 45° angle from near the base of the first outer post upward to the extreme top of the scaffold. Where the longitudinal length of the scaffold permits, such bracing shall be duplicated beginning at every fifth post. In a similar manner, longitudinal diagonal bracing shall also be installed from the last post extending back and upward toward the first post. Where conditions preclude the attachment of this bracing to the posts, it may be attached to the runners.

(12) The entire scaffold shall be tied to and securely braced against the building at intervals not to exceed 30 feet horizontally and 26 feet vertically.

(13) Guardrails, not less than 2 x 4 inches or the equivalent, approximately 42 inches high, with a midrail of 1- x 6-inch lumber or equivalent, and toeboard, shall be installed at all open sides and ends on all scaffolds more than 6 feet above the ground or floor. Toeboards shall be a minimum of 4 inches in height. Wire mesh shall be installed in accordance with paragraph (a) (6) of this section.

(d) *Tubular welded frame scaffolds.*

(1) Metal tubular frame scaffolds, including accessories such as braces, brackets, trusses, screw legs, ladders, etc., shall be designed, constructed, and erected to safely support four times the maximum rated load.

(2) Spacing of panels or frames shall be consistent with the loads imposed.

(3) Scaffolds shall be properly braced by cross bracing or diagonal braces, or both, for securing vertical members together laterally, and the cross braces shall be of such length as will automatically square and align vertical members so that the erected scaffold is always plumb, square, and rigid. All brace connections shall be made secure.

(4) Scaffold legs shall be set on adjustable bases or plain bases placed on mud sills or other foundations adequate to support the maximum rated load.

(5) The frames shall be placed one on top of the other with coupling or stacking pins to provide proper vertical alignment of the legs.

(6) Where uplift may occur, panels shall be locked together vertically by pins or other equivalent suitable means.

(7) To prevent movement, the scaffold shall be secured to the building or structure at intervals not to exceed 30 feet horizontally and 26 feet vertically.

(8) Maximum permissible spans of planking shall be in conformity with paragraph (a) (11) of this section.

(9) Drawings and specifications for all frame scaffolds over 125 feet in height above the base plates shall be designed by a registered professional engineer.

(10) Guardrails, not less than 2 x 4 inches or the equivalent, and approximately 42 inches high, with a midrail, of 1- x 6-inch lumber or equivalent, and toeboards, shall be installed at all open sides and ends on all scaffolds more than 6 feet above the ground or floor. Toeboards shall be a minimum of 4 inches

in height. Wire mesh shall be installed in accordance with paragraph (a)(6) of this section.

(c) *Manually propelled mobile scaffolds.* (1) When free-standing mobile scaffold towers are used, the height shall not exceed four times the minimum base dimension.

(2) Casters shall be properly designed for strength and dimensions to support four times the maximum intended load. All casters shall be provided with a positive locking device to hold the scaffold in position.

(3) Scaffolds shall be properly braced by cross bracing and horizontal bracing conforming with paragraph (d)(3) of this section.

(4) Platforms shall be tightly planked for the full width of the scaffold except for necessary entrance opening. Platforms shall be secured in place.

(5) A ladder or stairway shall be provided for proper access and exit and shall be affixed or built into the scaffold and so located that when in use it will not have a tendency to tip the scaffold. A landing platform must be provided at intervals not to exceed 35 feet.

(6) The force necessary to move the mobile scaffold shall be applied near or as close to the base as practicable and provision shall be made to stabilize the tower during movement from one location to another. Scaffolds shall only be moved on level floors, free of obstructions and openings.

(7) The employer shall not allow employees to ride on manually propelled scaffolds unless the following conditions exist:

(i) The floor or surface is within 3° of level, and free from pits, holes, or obstructions;

(ii) The minimum dimension of the scaffold base when ready for rolling, is at least one-half of the height. Outriggers, if used, shall be installed on both sides of staging;

(iii) The wheels are equipped with rubber or similar resilient tires;

(iv) All tools and materials are secured or removed from the platform before the mobile scaffold is moved.

(8) Scaffolds in use by any persons shall rest upon a suitable footing and shall stand plumb. The casters or wheels shall be locked to prevent any movement.

(9) Mobile scaffolds constructed of metal members shall also conform to applicable provisions of paragraphs (b), (c), or (d) of this section, depending on the material of which they are constructed.

(10) Guardrails not less than 2 x 4 inches or the equivalent, approximately 42 inches high, with a midrail, of 1- x 6-inch lumber or equivalent, and toeboards, shall be installed at all open sides and ends on all scaffolds more than 6 feet above the ground or floor. Toeboards shall be a minimum of 4 inches in height. Wire mesh shall be installed in accordance with paragraph (a)(6) of this section.

(f) *Elevating and rotating work platforms.* Applicable requirements of American National Standards Institute

A92.2-1969, Vehicle Mounted Elevating and Rotating Work Platforms, shall be met for such equipment in use.

(g) *Outrigger scaffolds.* (1) Outrigger beams shall extend not more than 6 feet beyond the face of the building. The inboard end of outrigger beams, measured from the fulcrum point to anchorage point, shall be not less than 1½ times the outboard end in length. The beams shall rest on edge, the sides shall be plumb, and the edges shall be horizontal. The fulcrum point of the beam shall rest on a secure bearing at least 6 inches in each horizontal dimension. The beam shall be secured in place against movement and shall be securely braced at the fulcrum point against tipping.

(2) The inboard ends of outrigger beams shall be securely anchored either by means of struts bearing against sills in contact with the overhead beams or ceiling, or by means of tension members secured to the floor joists underfoot, or by both if necessary. The inboard ends of outrigger beams shall be secured against tipping and the entire supporting structure shall be securely braced in both directions to prevent any horizontal movement.

(3) Unless outrigger scaffolds are designed by a registered professional engineer competent in this field, they shall be constructed and erected in accordance with Table L-13. Outrigger scaffolds, designed by a registered professional engineer, shall be constructed and erected in accordance with such design.

TABLE L-13—MINIMUM NOMINAL SIZE AND MAXIMUM SPACING OF MEMBERS OF OUTRIGGER SCAFFOLDS

Maximum scaffold load.	Light duty		Medium duty	
	25 p.s.f.		50 p.s.f.	
Outrigger size.....	2 x 10 in.	10 ft. 0 in.	3 x 10 in.	6 ft. 0 in.
Maximum outrigger spacing.....	2 x 10 in.	2 x 10 in.	2 x 10 in.	2 x 4 in.
Planking.....	2 x 4 in.	2 x 4 in.	2 x 4 in.	2 x 4 in.
Guardrail.....	2 x 4 in.	2 x 4 in.	2 x 4 in.	2 x 4 in.
Guardrail uprights.....	4 in. (minimum).	4 in. (minimum).	4 in. (minimum).	4 in. (minimum).
Toeboards.....	4 in. (minimum).	4 in. (minimum).	4 in. (minimum).	4 in. (minimum).

(4) Planking shall be laid tight and shall extend to within 3 inches of the building wall. Planking shall be secured to the beams.

(5) Guardrails, not less than 2 x 4 inches or the equivalent, approximately 42 inches high, with a midrail of 1- x 6-inch lumber or equivalent, and toeboards, shall be installed at all open sides and ends on all scaffolds more than 6 feet above the ground or floor. Toeboards shall be a minimum of 4 inches in height. Wire mesh shall be installed in accordance with paragraph (a)(6) of this section.

(h) *Masons' adjustable multiple-point suspension scaffolds.* (1) The scaffold shall not be loaded in excess of that figure.

(2) The scaffold shall be provided with hoisting machines that meet the requirements of Underwriters' Laboratories or Factory Mutual Engineering Corporation.

(3) The platform shall be supported by wire ropes, capable of supporting at least 6 times the intended load, sus-

pended from overhead outrigger beams.

(4) The scaffold outrigger beams shall consist of structural metal securely fastened or anchored to the frame or floor system of the building or structure.

(5) Each outrigger beam shall be equivalent in strength to at least a standard 7-inch, 15.3-pound steel I-beam, at least 15 feet long, and shall not project more than 6 feet 6 inches beyond the bearing point.

(6) Where the overhang exceeds 6 feet 6 inches, outrigger beams shall be composed of stronger beams or multiple beams and be installed under the supervision of a competent person.

(7) All outrigger beams shall be set and maintained with their webs in a vertical position.

(8) A stop bolt shall be placed at each end of every outrigger beam.

(9) The outrigger beam shall rest on suitable wood bearing blocks.

(10) The free end of the suspension wire ropes shall be equipped with proper size thimbles and secured by splicing or other equivalent means. The running ends shall be securely attached to the hoisting drum and at least four turns of wire rope shall at all times remain on the drum. The use of fiber rope is prohibited.

(11) Where a single outrigger beam is used, the steel shackles or clevises with which the wire ropes are attached to the outrigger beams shall be placed directly over the hoisting drums.

(12) The scaffold platform shall be equivalent in strength to at least 2-inch planking. (For maximum planking spans, see paragraph (a)(11) of this section.)

(13) When men are at work on the scaffold and an overhead hazard exists, overhead protection shall be provided on the scaffold, not more than 9 feet above the platform, consisting of 2-inch planking, or material of equivalent strength, laid tight, and extending not less than the width of the scaffold.

(14) Each scaffold shall be installed or relocated under the supervision of a competent person.

(15) Guardrails, not less than 2 x 4 inches or the equivalent, approximately 42 inches high, with a midrail, and toeboards, shall be installed at all open sides and ends on all scaffolds more than 6 feet above the ground or floor. Toeboards shall be a minimum of 4 inches in height. Wire mesh shall be installed in accordance with paragraph (a)(6) of this section.

(i) *(Swinging scaffolds) two-point suspension.* (1) Two-point suspension scaffold platforms shall be not less than 20 inches nor more than 36 inches wide overall. The platform shall be securely fastened to the hangers by U-bolts or by other equivalent means.

(2) The hangers of two-point suspension scaffolds shall be made of mild steel, or other equivalent materials, having a cross-sectional area capable of sustaining 4 times the maximum rated load, and shall be designed with a support for guardrail, intermediate rail, and toeboard.

TABLE L-14—SCHEDULE FOR LADDER TYPE PLATFORMS

	Length of platform (feet)				
	12	14 and 16	18 and 20	22 and 24	28 and 30
Side Stringers, minimum cross section (finished sizes)					
At ends (inches)	1½ x 2½	1½ x 2½	1½ x 3	1½ x 3	1½ x 3½
At middle (inches)	1½ x 3½	1½ x 3½	1½ x 4	1½ x 4½	1½ x 5
Reinforcing strip (minimum)	A ½ x ½-inch steel reinforcing strip or its equivalent shall be attached to the side or underside, full length.				
Rungs	Rungs shall be 1½-inches minimum diameter with at least ¾-inch diameter tenons, and the maximum spacing shall be 12 inches center to center.				
Tie rods:					
Number (minimum)	3	4	5	6	6
Diameter (minimum)	½ in.	½ in.	½ in.	½ in.	½ in.
Flooring, minimum finished size (inches)	½ x 2½	½ x 2½	½ x 2½	½ x 2½	½ x 2½

(3) When hoisting machines are used on two-point suspension scaffolds, such machines shall be of a design tested and approved by Underwriters' Laboratories or Factory Mutual Engineering Corporation.

(4) The roof irons or hooks shall be of mild steel, or other equivalent material, of proper size and design, securely installed and anchored. Tiebacks of ¾-inch manila rope, or the equivalent, shall serve as a secondary means of anchorage, installed at right angles to the face of the building, whenever possible, and secured to a structurally sound portion of the building.

(5) Two-point suspension scaffolds shall be suspended by wire, synthetic, or fiber ropes capable of supporting at least 6 times the rated load. All other components shall be capable of supporting at least four times the rated load.

(6) The sheaves of all blocks, consisting of at least one double and one single block, shall fit the size and type of rope used.

(7) All wire ropes, fiber and synthetic ropes, slings, hangers, platforms, and other supporting parts shall be inspected before every installation. Periodic inspections shall be made while the scaffold is in use.

(8) On suspension scaffolds designed for a working load of 500 pounds, no more than two men shall be permitted to work at one time. On suspension scaffolds with a working load of 750 pounds, no more than three men shall be permitted to work at one time. Each employee shall be protected by an approved safety life belt attached to a lifeline. The lifeline shall be securely attached to substantial members of the structure (not scaffold), or to securely rigged lines, which will safely suspend the employee in case of a fall. In order to keep the lifeline continuously attached, with a minimum of slack, to a fixed structure, the attachment point of the lifeline shall be appropriately changed as the work progresses.

(9) Two-point suspension scaffolds shall be securely lashed to the building or structure to prevent them from swaying. Window cleaners' anchors shall not be used for this purpose.

(10) The platform of every two-point suspension scaffold shall be one of the following types:

(i) *Ladder-type platforms.* The side stringer shall be of clear straight-grained spruce or materials of equivalent strength and durability. The rungs shall be of straight-grained oak, ash, or hickory, at least 1½ inch in diameter, with ¾-inch tenons mortised into the side stringers at least seven-eighths inch. The stringers shall be tied together with tie rods not less than one-quarter inch in diameter, passing through the stringers and riveted up tight against washers on both ends. The flooring strips shall be spaced not more than five-eighths inch apart except at the side rails where the space may be 1 inch. Ladder-type platforms shall be constructed in accordance with Table L-14.

(ii) *Plank-type platforms.* Plank-type platforms shall be composed of not less than nominal 2- x 10-inch unspliced planks, properly cleated together on the underside, starting 6 inches from each end; intervals in between shall not exceed 4 feet. The plank-type platform shall not extend beyond the hangers more than 12 inches. A bar or other effective means shall be securely fastened to the platform at each end to prevent its slipping off the hanger. The span between hangers for plank-type platforms shall not exceed 8 feet.

(iii) *Beam-type platforms.* Beam platforms shall have side stringers of lumber not less than 2 x 6 inches set on edge. The span between hangers shall not exceed 12 feet when beam platforms are used. The flooring shall be supported on 2- x 6-inch cross beams, laid flat and set into the upper edge of the stringers with a snug fit, at intervals of not more than 4 feet, securely nailed in place. The flooring shall be of 1- x 6-inch material properly nailed. Floor boards shall not be spaced more than one-half inch apart.

(iv) *Light metal-type platforms.* When used, shall be tested and listed according to Underwriters' Laboratories or Factory Mutual Engineering Corporation.

(11) Guardrails, not less than 2 x 4 inches, or the equivalent, approximately 42 inches high, with a midrail, and toeboards, shall be installed at all open sides and ends on all scaffolds more than 6 feet above the ground or floor. Toeboards shall be a minimum of 4 inches in height. Wire mesh shall be installed in accordance with paragraph (a)(6) of this section.

(j) *Stone setters' adjustable multiple-point suspension scaffolds.* (1) The scaffold shall be capable of sustaining a working load of 25 pounds per square foot and shall not be overloaded. Scaffolds shall not be used for storage of stone or other heavy materials.

(2) When used, the hoisting machine and its supports shall be of a type tested and listed by Underwriters' Laboratories or Factory Mutual Engineering Corporation.

(3) The platform shall be securely fastened to the hangers by U-bolts or other equivalent means. (For materials and spans, see subdivision (ii) of paragraph (i)(10), Plank-Type Platforms, and Table L-14 of this section.)

(4) The scaffold unit shall be suspended from metal outriggers, iron brackets, wire rope slings, or iron hooks.

(5) Outriggers, when used, shall be set with their webs in a vertical position, securely anchored to the building or structure and provided with stop bolts at each end.

(6) The scaffold shall be supported by wire rope capable of supporting at least 6 times the rated load. All other components shall be capable of supporting at least 4 times the rated load.

(7) The free ends of the suspension wire ropes shall be equipped with proper size thimbles, secured by splicing or other equivalent means. The running ends shall be securely attached to the hoisting drum and at least four turns of wire rope shall remain at the drum at all times.

(8) When two or more scaffolds are used on a building or structure, they shall not be bridged one to the other, but shall be maintained at even height with platforms abutting closely.

(9) Guardrails, not less than 2 x 4 inches or the equivalent, approximately 42 inches high, with a midrail, and toeboards, shall be installed at all open sides and ends on all scaffolds more than 6 feet above the ground or floor. Toeboards shall be a minimum of 4 inches in height. Wire mesh shall be installed in accordance with paragraph (a)(6) of this section.

(k) *Single-point adjustable suspension scaffolds.* (1) The scaffolding, including power units or manually operated winches, shall be of a type tested and listed by Underwriters' Laboratories or Factory Mutual Engineering Corporation.

(2) The power units may be either electrically or air motor driven.

(3) All power-operated gears and brakes shall be enclosed.

(4) In addition to the normal operating brake, all power-driven units shall have an emergency brake which engages automatically when the normal speed of descent is exceeded.

(5) The hoisting machines, cables, and equipment shall be regularly serviced and inspected.

(6) The units may be combined to form a two-point suspension scaffold. Such scaffold shall then comply with paragraph (i) of this section.

(7) The supporting cable shall be vertical for its entire length, and the basket shall not be swayed nor the cable fixed to

any intermediate points to change the original path of travel.

(8) Suspension methods shall conform to applicable provisions of paragraphs (h) and (i) of this section.

(9) Guards, midrails, and toeboards shall completely enclose the cage or basket. Guardrails shall be no less than 2 x 4 inches or the equivalent, approximately 42 inches above the platform. Midrails shall be 1 x 6 inches or the equivalent, installed equidistant between the guardrail and the platform. Toeboards shall be a minimum of 4 inches in height.

(10) For additional details not covered in this paragraph, applicable technical portions of American National Standards Institute, A120, 1970, Power-Operated Devices for Exterior Building Maintenance Powered Platforms, shall be used.

(1) *Boatswain's chairs.* (1) The chair seat shall not be less than 12 x 24 inches, and 1-inch thickness. The seat shall be reinforced on the underside by cleats securely fastened to prevent the board from splitting.

(2) The two fiber rope seat slings shall be of $\frac{3}{4}$ -inch diameter, reeved through the four seat holes so as to cross each other on the underside of the seat.

(3) Seat slings shall be of at least $\frac{3}{4}$ -inch wire rope when an employee is conducting a heat-producing process, such as gas or arc welding.

(4) The employee shall be protected by a safety belt and lifeline in accordance with § 1518.104. The attachment point of the lifeline to the structure shall be appropriately changed as the work progresses.

(5) The tackle shall consist of correct size ball bearing or bushed blocks and properly spliced $\frac{3}{4}$ -inch diameter first-grade manila rope, or equivalent.

(6) The roof irons, hooks, or the object to which the tackle is anchored, shall be securely installed. Tiebacks, when used, shall be installed at right angles to the face of the building and securely fastened.

(m) *Carpenters' bracket scaffolds.* (1) The brackets shall consist of a triangular wood frame not less than 2 x 3 inches in cross section, or of metal of equivalent strength. Each member shall be properly fitted and securely joined.

(2) Each bracket shall be attached to the structure by means of one of the following:

(i) A bolt, no less than five-eighths inch in diameter, which shall extend through to the inside of the building wall;

(ii) A metal stud attachment device;

(iii) Welding to steel tanks;

(iv) Hooking over a well-secured and adequately strong supporting member.

(3) The brackets shall be spaced no more than 8 feet apart.

(4) No more than two employees shall occupy any given 18 feet of a bracket scaffold at any one time. Tools and materials shall not exceed 75 pounds in addition to the occupancy.

(5) The platform shall consist of not less than two 2- x 10-inch nominal size planks extending not more than 12 inches or less than 6 inches beyond each end support.

(6) Guardrails, not less than 2 x 4 inches or the equivalent, approximately 42 inches high, with a midrail, or 1- x 6-inch lumber or equivalent, and toeboards, shall be installed at all open sides and ends on all scaffolds more than 6 feet above the ground or floor. Toeboards shall be a minimum of 4 inches in height. Wire mesh shall be installed in accordance with paragraph (a) (6) of this section.

(n) *Bricklayers' square scaffolds.* (1) The squares shall not exceed 5 feet in width and 5 feet in height.

(2) Members shall be not less than those specified in Table L-15.

TABLE L-15—MINIMUM DIMENSIONS FOR BRICKLAYERS' SQUARE SCAFFOLD MEMBERS

Members	Dimensions
Bearers or horizontal members	2 x 6 in.
Legs	2 x 6 in.
Braces at corners	1 x 6 in.
Braces diagonally from center frame	1 x 8 in.

(3) The squares shall be reinforced on both sides of each corner with 1- x 6-inch gusset pieces. They shall also have diagonal braces 1 x 8 inches on both sides running from center to center of each member, or other means to secure equivalent strength and rigidity.

(4) The squares shall be set not more than 5 feet apart for medium duty scaffolds, and not more than 8 feet apart for light duty scaffolds. Bracing, 1 x 8 inches, extending from the bottom of each square to the top of the next square, shall be provided on both front and rear sides of the scaffold.

(5) Platform planks shall be at least 2- x 10-inch nominal size. The ends of the planks shall overlap the bearers of the squares and each plank shall be supported by not less than three squares.

(6) Bricklayers' square scaffolds shall not exceed three tiers in height and shall be so constructed and arranged that one square shall rest directly above the other. The upper tiers shall stand on a continuous row of planks laid across the next lower tier and be nailed down or otherwise secured to prevent displacement.

(7) Scaffolds shall be level and set upon a firm foundation.

(o) *Horse scaffolds.* (1) Horse scaffolds shall not be constructed or arranged more than two tiers or 10 feet in height.

(2) The members of the horses shall be not less than those specified in Table L-16.

TABLE L-16—MINIMUM DIMENSIONS FOR HORSE SCAFFOLD MEMBERS

Members	Dimensions
Horizontal members or bearers	3 x 4 in.
Legs	1½ x 4½ in.
Longitudinal brace between legs	1 x 6 in.
Gusset brace at top of legs	1 x 8 in.
Half diagonal braces	1½ x 4½ in.

(3) Horses shall be spaced not more than 5 feet for medium duty and not more than 8 feet for light duty.

(4) When arranged in tiers, each horse shall be placed directly over the horse in the tier below.

(5) On all scaffolds arranged in tiers, the legs shall be nailed down or otherwise secured to the planks to prevent displacement or thrust and each tier shall be substantially cross braced.

(6) Horses or parts which have become weak or defective shall not be used.

(7) Guardrails, not less than 2 x 6 inches or the equivalent, approximately 42 inches high, with a midrail, of 1- x 4-inch lumber or equivalent, and toeboards, shall be installed at all open sides and ends on all scaffolds more than 6 feet above the ground or floor. Toeboards shall be a minimum of 4 inches in height. Wire mesh shall be installed in accordance with paragraph (a) (6) of this section.

(p) *Needle beam scaffold.* (1) Wood needle beams shall be not less than 4 x 6 inches in size, with the greater dimension placed in a vertical direction. Metal beams or the equivalent, conforming to paragraphs (a) (8) and (10) of this section, may be used and shall not be altered or moved horizontally while they are in use.

(2) Ropes or hangers shall be provided for supports. The span between supports on the needle beam shall not exceed 10 feet for 4- x 6-inch timbers. Rope supports shall be equivalent in strength to 1-inch diameter first-grade manila rope.

(3) The ropes shall be attached to the needle beams by a scaffold hitch or a properly made eye splice. The loose end of the rope shall be tied by a bowline knot or by a round turn and a half hitch.

(4) The scaffold hitch shall be arranged so as to prevent the needle beam from rolling or becoming otherwise displaced.

(5) The platform span between the needle beams shall not exceed 8 feet when using 2-inch scaffold plank. For spans greater than 8 feet, platforms shall be designed based on design requirements for the special span. The overhang of each end of the platform planks shall be not less than 6 inches and not more than 12 inches.

(6) When needle beam scaffolds are used, the planks shall be secured against slipping.

(7) All unattached tools, bolts, and nuts used on needle beam scaffolds shall be kept in suitable containers, properly secured.

(8) One end of a needle beam scaffold may be supported by a permanent structural member conforming to paragraphs (a) (8) and (10) of this section.

(9) Each employee working on a needle beam scaffold shall be protected by a safety belt and lifeline in accordance with § 1518.104.

(q) *Plasterers', decorators', and large area scaffolds.* (1) Plasterers', lathers', and ceiling workers' inside scaffolds shall be constructed in accordance with the general requirements set forth for independent wood pole scaffolds. (See paragraph (b) and Tables L-7, 8, and 9 of this section.)

(2) All platform planks shall be laid with the edges close together.

(3) When independent pole scaffold platforms are erected in sections, such

sections shall be provided with connecting runways equipped with substantial guardrails.

(4) Guardrails, not less than 2 x 4 inches or the equivalent, approximately 42 inches high, with a midrail of 1- x 6-inch lumber or equivalent, and toeboards, shall be installed on all open sides and ends on all scaffolds more than 6 feet above the ground or floor. Toeboards shall be a minimum of 4 inches in height. Wire mesh shall be installed in accordance with paragraph (a)(6) of this section.

(r) *Interior hung scaffolds.* (1) An interior hung scaffold shall be hung or suspended from the roof structure or ceiling beams.

(2) The suspending wire or fiber rope shall be capable of supporting at least 6 times the rated load. The rope shall be wrapped at least twice around the supporting members and twice around the bearers of the scaffold, with each end of the wire rope secured by at least three standard wire-rope clips properly installed.

(3) For hanging wood scaffolds, the following minimum nominal size material shall be used:

(i) Supporting bearers 2 x 10 inches on edge;

(ii) Planking 2 x 10 inches or 2 x 10 inches, with maximum span 7 feet for heavy duty and 10 feet for light duty or medium duty.

(4) Steel tube and coupler members may be used for hanging scaffolds with both types of scaffold designed to sustain a uniform distributed working load up to heavy duty scaffold loads with a safety factor of four.

(5) Guardrails, not less than 2 x 4 inches or the equivalent, approximately 42 inches high, with a midrail of 1- x 6-inch lumber or equivalent, and toeboards, shall be installed at all open sides and ends on all scaffolds more than 6 feet above the ground or floor. Toeboards shall be a minimum of 4 inches in height. Wire mesh shall be installed in accordance with paragraph (a)(6) of this section.

(s) *Ladder jack scaffolds.* (1) All ladder jack scaffolds shall be limited to light duty and shall not exceed a height of 20 feet above the floor or ground.

(2) All ladders used in connection with ladder jack scaffolds shall be heavy-duty ladders and shall be designed and constructed in accordance with American National Standards Institute A 14.1-1968, Safety Code for Portable Wood Ladders, and A 14.2-1968, Safety Code for Portable Metal Ladders. Cleated ladders shall not be used for this purpose.

(3) The ladder jack shall be so designed and constructed that it will bear on the side rails in addition to the ladder rungs, or if bearing on rungs only, the bearing area shall be at least 10 inches on each rung.

(4) Ladders used in conjunction with ladder jacks shall be so placed, fastened, held, or equipped with devices so as to prevent slipping.

(5) The wood platform planks shall be not less than 2 inches nominal in thickness. Both metal and wood platform planks shall overlap the bearing surface

not less than 12 inches. The span between supports for wood shall not exceed 8 feet. Platform width shall be not less than 18 inches.

(6) Not more than two employees shall occupy any given 8 feet of any ladder jack scaffold at any one time.

(t) *Window jack scaffolds.* (1) Window jack scaffolds shall be used only for the purpose of working at the window opening through which the jack is placed.

(2) Window jacks shall not be used to support planks placed between one window jack and another or for other elements of scaffolding.

(3) Window jack scaffolds shall be provided with guardrails unless safety belts with lifelines are attached and provided for employee.

(4) Not more than one employee shall occupy a window jack scaffold at any one time.

(u) *Roofing brackets.* (1) Roofing brackets shall be constructed to fit the pitch of the roof.

(2) Brackets shall be secured in place by nailing in addition to the pointed metal projections. When it is impractical to nail brackets, rope supports shall be used. When rope supports are used, they shall consist of first-grade manila of at least 3/4-inch diameter, or equivalent.

(3) A catch platform shall be installed below the working area of roofs more than 10 feet from the ground to eaves with a slope greater than 3 inches in 12 inches without a parapet. In width, the platform shall extend 2 feet beyond the projection of the eaves and shall be provided with a guardrail, midrail, and toeboard. This provision shall not apply where employees engaged in work upon such roofs are protected by a safety belt attached to a lifeline.

(v) *Crawling boards or chicken ladders.* (1) Crawling boards shall be not less than 10 inches wide and 1 inch thick, having cleats 1 x 1 1/2 inches. The cleats shall be equal in length to the width of the board and spaced at equal intervals not to exceed 24 inches. Nails shall be driven through and clinched on the underside. The crawling board shall extend from the ridge pole to the eaves when used in connection with roof construction, repair, or maintenance.

(2) A firmly fastened lifeline of at least 3/4-inch diameter rope, or equivalent, shall be strung beside each crawling board for a handhold.

(3) Crawling boards shall be secured to the roof by means of adequate ridge hooks or other effective means.

(w) *Float or ship scaffolds.* (1) Float or ship scaffolds shall not be used to support more than three men and a few light tools, such as those needed for riveting, bolting, and welding. They shall be constructed as designed in subparagraphs (2) through (6) of this paragraph, unless substitute designs and materials provide equivalent strength, stability, and safety.

(2) The platform shall be not less than 3 feet wide and 6 feet long, made of 3/4-inch plywood, equivalent to American Plywood Association Grade B-B, Group I, Exterior, or other similar material.

(3) Under the platform, there shall be two supporting bearers made from 2- x 4-inch, or 1- x 10-inch rough, "selected lumber," or better. They shall be free of knots or other flaws and project 6 inches beyond the platform on both sides. The ends of the platform shall extend 6 inches beyond the outer edges of the bearers. Each bearer shall be securely fastened to the platform.

(4) An edging of wood not less than 3/4 x 1 1/2 inches or equivalent shall be placed around all sides of the platform to prevent tools from rolling off.

(5) Supporting ropes shall be 1-inch diameter manila rope or equivalent, free from deterioration, chemical damage, flaws, or other imperfections. Rope connections shall be such that the platform cannot shift or slip. If two ropes are used with each float, they shall be arranged so as to provide four ends which are to be securely fastened to an overhead support. Each of the two supporting ropes shall be hitched around one end of bearer and pass under the platforms to the other end of the bearer where it is hitched again, leaving sufficient rope at each end for the supporting ties.

(6) Each employee shall be protected by an approved safety lifeline and lifeline, in accordance with § 1518.104.

(x) *Form scaffolds.* (1) Form scaffolds shall be constructed of wood or other suitable materials, such as steel or aluminum members of known strength characteristics. All scaffolds shall be designed and erected with a minimum safety factor of 4, computed on the basis of the maximum rated load.

(2) All scaffold planking shall be a minimum of 2- x 10-inch nominal Scaffold Grade, as recognized by approved grading rules for the species of lumber used, or equivalent material. Maximum permissible spans shall not exceed 8 feet on centers for 2- x 10-inch nominal planking. Scaffold planks shall be either nailed or bolted to the ledgers or of such length that they overlap the ledgers at least 6 inches. Unsupported projecting ends of scaffolding planks shall be limited to a maximum overhang of 12 inches.

(3) Scaffolds shall not be loaded in excess of the working load for which they were designed.

(4) Figure-four form scaffolds: (i) Figure-four scaffolds are intended for light duty and shall not be used to support loads exceeding 25 pounds per square foot unless specifically designed for heavier loading. For minimum design criteria, see Table L-17.

TABLE L-17—MINIMUM DESIGN CRITERIA FOR FIGURE-FOUR FORM SCAFFOLDS

Members	Dimensions
Uprights	2 x 4 in. or 2 x 6 in.
Outriggers—ledgers— (two).	1 x 6 in.
Braces	1 x 6 in.
Guardrails	2 x 4 in.
Guardrail height	Approximately 42 in.
Intermediate guard- rails.	1 x 6 in.
Toeboards	4 in. (minimum).
Maximum length of ledgers—	3 ft. 6 in. (unsup- ported).
Planking	2 x 10 in.
Upright spacing	8 ft. 0 in. (on cen- ters).

(ii) Figure-four form scaffold frames shall be spaced not more than 8 feet on centers and constructed from sound lumber, as follows: The outrigger ledger shall consist of two pieces of 1- x 6-inch or heavier material nailed on opposite sides of the vertical form support. Ledgers shall project not more than 3 feet 6 inches from the outside of the form support and shall be substantially braced and secured to prevent tipping or turning. The knee or angle brace shall intersect the ledger at least 3 feet from the form at an angle of approximately 45°, and the lower end shall be nailed to a vertical support. The platform shall consist of two or more 2- x 10-inch planks, which shall be of such length that they extend at least 6 inches beyond ledgers at each end unless secured to the ledgers. When planks are secured to the ledgers (nailed or bolted), a wood filler strip shall be used between the ledgers. Unsupported projecting ends of planks shall be limited to an overhang of 12 inches.

(5) Metal bracket form scaffolds: (1) Metal brackets or scaffold jacks which are an integral part of the form shall be securely bolted or welded to the form. Folding type brackets shall be either bolted or secured with a locking-type pin when extended for use.

(ii) "Clip-on" or "hook-over" brackets may be used, provided the form walers are bolted to the form or secured by snap ties or shea-bolt extending through the form and securely anchored.

(iii) Metal brackets shall be spaced not more than 8 feet on centers.

(iv) Scaffold planks shall be either bolted to the metal brackets or of such length that they overlap the brackets at each end by at least 6 inches. Unsupported projecting ends of scaffold planks shall be limited to a maximum overhang of 12 inches.

(v) Metal bracket form scaffolds shall be equipped with wood guardrails, intermediate rails, toeboards, and scaffold planks meeting the minimum dimensions shown in Table L-18. (Metal may be substituted for wood, providing it affords equivalent or greater design strength.)

TABLE L-18—MINIMUM DESIGN CRITERIA FOR METAL BRACKET FORM SCAFFOLDS

Members	Dimensions
Uprights	2 x 4 in.
Guardrails	2 x 4 in.
Guardrail height	Approximately 42 in.
Intermediate guard-rails	1 x 6 in.
Toeboards	4 in. (minimum).
Planking	2 x 9 in.

(6) Wooden bracket form scaffolds: (i) Wooden bracket form scaffolds shall be an integral part of the form panel. The minimum design criteria set forth herein and in Table L-19 cover scaffolding intended for light duty and shall not be used to support loads exceeding 25 pounds per square foot, unless specifically designed for heavier loading.

(ii) Scaffold planks shall be either nailed or bolted to the ledgers or of such length that they overlap the ledgers at each end by at least 6 inches. Unsupported projecting ends of scaffold planks

shall be limited to a maximum overhang of 12 inches.

TABLE L-19—MINIMUM DESIGN CRITERIA FOR WOODEN BRACKET FORM SCAFFOLDS

Members	Dimensions
Uprights	2 x 4 in. or 2 x 6 in.
Support ledgers	2 x 6 in.
Maximum scaffold width	3 ft. 6 in.
Braces	1 x 6 in.
Guardrails	2 x 4 in.
Guardrail height	Approximately 42 in.
Intermediate guard-rails	1 x 6 in.
Toeboards	4 in. (minimum).
Upright spacing	8 ft. 0 in. (on centers).

(iii) Guardrails and toeboard shall be installed on all open sides and ends of platforms and scaffolding over 6 feet above floor or ground. Guardrails shall be 2- x 4-inch nominal dimension or equivalent, approximately 42 inches high, supported at intervals not to exceed 8 feet. Guardrails shall be equipped with midrails constructed of 2- x 4-inch nominal lumber or equivalent. Toeboards shall be constructed of 1- x 6-inch nominal lumber or equivalent and shall extend not less than 4 inches above the scaffold plank.

§ 1518.152 Definitions applicable to this subpart.

(a) "Ladders"—(1) "Cleats"—Ladder crosspieces of rectangular cross section placed on edge on which a person may step in ascending or descending.

(2) "Single cleat ladder"—One which consists of a pair of side rails, usually parallel, but with flared side rails permissible, connected together with cleats that are joined to the side rails at regular intervals.

(3) "Double cleat ladder"—One that is similar to a single cleat ladder, but is wider, with an additional center rail which will allow for two-way traffic for workmen in ascending and descending.

(b) "Scaffolding"—(1) "Bearer"—A horizontal member of a scaffold upon which the platform rests and which may be supported by ledgers.

(2) "Boatswain's chair"—A seat supported by slings attached to a suspended rope, designed to accommodate one workman in a sitting position.

(3) "Brace"—A tie that holds one scaffold member in a fixed position with respect to another member.

(4) "Bricklayers' square scaffold"—A scaffold composed of framed wood squares which support a platform, limited to light and medium duty.

(5) "Carpenters' bracket scaffold"—A scaffold consisting of wood or metal brackets supporting a platform.

(6) "Coupler"—A device for locking together the component parts of a tubular metal scaffold. (The material used for the couplers shall be of a structural type, such as a drop-forged steel, malleable iron, or structural grade aluminum.)

(7) "Crawling board or chicken ladder"—A plank with cleats spaced and secured at equal intervals, for use by a worker on roofs, not designed to carry any material.

(8) "Double pole or independent pole scaffold"—A scaffold supported from the base by a double row of uprights, independent of support from the walls and constructed of uprights, ledgers, horizontal platform bearers, and diagonal bracing.

(9) "Float or ship scaffold"—A scaffold hung from overhead supports by means of ropes and consisting of a substantial platform having diagonal bracing underneath, resting upon and securely fastened to two parallel plank bearers at right angles to the span.

(10) "Guardrail"—A rail secured to uprights and erected along the exposed sides and ends of platforms.

(11) "Heavy duty scaffold"—A scaffold designed and constructed to carry a working load not to exceed 75 pounds per square foot.

(12) "Horse scaffold"—A scaffold for light or medium duty, composed of horses supporting a work platform.

(13) "Interior hung scaffold"—A scaffold suspended from the ceiling or roof structure.

(14) "Ladder jack scaffold"—A light duty scaffold supported by brackets attached to ladders.

(15) "Ledgers (stringer)"—A horizontal scaffold member which extends from post to post and which supports the putlogs or bearers forming a tie between the posts.

(16) "Light duty scaffold"—A scaffold designed and constructed to carry a working load not to exceed 25 pounds per square foot.

(17) "Manually propelled mobile scaffold"—A portable rolling scaffold supported by casters.

(18) "Masons' adjustable multiple-point suspension scaffold"—A scaffold having a continuous platform supported by bearers suspended by wire rope from overhead supports, so arranged and operated as to permit the raising or lowering of the platform to desired working positions.

(19) "Maximum rated load"—The total of all loads including the working load, the weight of the scaffold, and such other loads as may be reasonably anticipated.

(20) "Medium duty scaffold"—A scaffold designed and constructed to carry a working load not to exceed 50 pounds per square foot.

(21) "Midrail"—A rail approximately midway between the guardrail and platform, secured to the uprights erected along the exposed sides and ends of platforms.

(22) "Needle beam scaffold"—A light duty scaffold consisting of needle beams supporting a platform.

(23) "Outrigger scaffold"—A scaffold supported by outriggers or thrustouts projecting beyond the wall or face of the building or structure, the inboard ends of which are secured inside of such building or structure.

(24) "Putlog"—A scaffold member upon which the platform rests.

(25) "Roofing or bearer bracket"—A bracket used in slope roof construction.

having provisions for fastening to the roof or supported by ropes fastened over the ridge and secured to some suitable object.

(26) "Runner"—The lengthwise horizontal bracing or bearing members or both.

(27) "Scaffold"—Any temporary elevated platform and its supporting structure used for supporting workmen or materials, or both.

(28) "Single-point adjustable suspension scaffold"—A manually or power-operated unit designed for light duty use, supported by a single wire rope from an overhead support so arranged and operated as to permit the raising or lowering of platform to desired working positions.

(29) "Single-pole scaffold"—Platforms resting on pullogs or cross beams, the outside ends of which are supported on ledgers secured to a single row or posts or uprights, and the inner ends of which are supported on or in a wall.

(30) "Stone setters' adjustable multiple-point suspension scaffold"—A swinging type scaffold having a platform supported by hangers suspended at four points so as to permit the raising or lowering of the platform to the desired working position by the use of hoisting machines.

(31) "Toeboard"—A barrier secured along the sides and ends of a platform to guard against the falling of material.

(32) "Tube and coupler scaffold"—An assembly consisting of tubing which serves as posts, bearers, braces, ties, and runners, a base supporting the posts, and special couplers which serve to connect the uprights and to join the various members.

(33) "Tubular welded frame scaffold"—A sectional panel or frame metal scaffold substantially built up of prefabricated welded sections which consists of posts and horizontal bearer with intermediate members.

(34) "Two-point suspension scaffold (swinging scaffold)"—A scaffold, the platform of which is supported by hangers (stirrups) at two points, suspended from overhead supports so as to permit the raising or lowering of the platform to the desired working position by tackle or hoisting machines.

(35) "Window jack scaffold"—A scaffold the platform of which is supported by a bracket or jack which projects through a window opening.

(36) "Working load"—Load imposed by men, materials, and equipment.

Subpart M—Floor and Wall Openings, and Stairways

§ 1518.500 Guardrails, handrails, and covers.

(a) *General provision.* This subpart shall apply to temporary or emergency conditions where there is danger of employees or materials falling through floor, roof, or wall openings, or from stairways or runways.

(b) *Guarding of floor openings and floor holes.* (1) Floor openings shall be

guarded by a standard railing and toe boards or cover, as specified in paragraph (f) of this section. In general, the railing shall be provided on all exposed sides, except at entrances to stairways.

(2) Ladderway floor openings or platforms shall be guarded by standard railings with standard toe boards on all exposed sides, except at entrance to opening, with the passage through the railing either provided with a swinging gate or so offset that a person cannot walk directly into the opening.

(3) Hatchways and chute floor openings shall be guarded by one of the following:

(i) Hinged covers of standard strength and construction and a standard railing with only one exposed side. When the opening is not in use, the cover shall be closed or the exposed side shall be guarded at both top and intermediate positions by removable standard railings;

(ii) A removable standard railing with toe board on not more than two sides of the opening and fixed standard railings with toe boards on all other exposed sides. The removable railing shall be kept in place when the opening is not in use and should preferably be hinged or otherwise mounted so as to be conveniently replaceable.

(4) Skylight openings and holes shall be guarded by a cover or a fixed standard railing on all exposed sides, whether or not covered by glass.

(5) Pits and trap-door floor openings shall be guarded by floor opening covers of standard strength and construction. While the cover is not in place, the pit or trap openings shall be protected on all exposed sides by removable standard railings.

(6) Manhole floor openings shall be guarded by standard covers which need not be hinged in place. While the cover is not in place, the manhole opening shall be protected by standard railings.

(7) Temporary floor openings shall have standard railings.

(8) Floor holes, into which persons can accidentally walk, shall be guarded by either a standard railing with standard toe board on all exposed sides, or a floor hole cover of standard strength and construction that is secured against accidental displacement. While the cover is not in place, the floor hole shall be protected by a standard railing.

(9) Where doors or gates open directly on a stairway, a platform shall be provided, and the swing of the door shall not reduce the effective width of the platform to less than 20 inches.

(c) *Guarding of wall openings.* (1) Wall openings, from which there is a drop of more than 4 feet, and the bottom of the opening is less than 3 feet above the working surface, shall be guarded as follows:

(i) When the height and placement of the opening in relation to the working surface is such that either a standard rail or intermediate rail will effectively reduce the danger of falling, one or both shall be provided;

(ii) The bottom of a wall opening, which is less than 4 inches above the working surface, regardless of width, shall be protected by a standard toe-board or an enclosing screen either of solid construction or as specified in paragraph (f) (7) (ii) of this section.

(2) Extension platforms outside of wall openings onto which materials can be hoisted for handling shall have side rails or equivalent guards of standard specifications.

(3) When a chute is attached to an opening, the provisions of subparagraph (1) of this paragraph shall apply, except that a toeboard is not required.

(d) *Guarding of open-sided floors, platforms, and runways.* (1) Every open-sided floor or platform 6 feet or more above adjacent floor or ground level shall be guarded by a standard railing, or the equivalent, as specified in paragraph (f) (i) of this section, on all open sides, except where there is entrance to a ramp, stairway, or fixed ladder. The railing shall be provided with a standard toe-board wherever, beneath the open sides, persons can pass, or there is moving machinery, or there is equipment with which falling materials could create a hazard.

(2) Runways shall be guarded by a standard railing, or the equivalent, as specified in paragraph (f) (i) of this section, on all open sides, 4 feet or more above floor or ground level. Wherever tools, machine parts, or materials are likely to be used on the runway, a toe board shall also be provided on each exposed side.

(3) Runways used exclusively for special purposes may have the railing on one side omitted where operating conditions necessitate such omission, providing the falling hazard is minimized by using a runway not less than 18 inches wide.

(4) Where employees entering upon runways become thereby exposed to machinery, electrical equipment, or other danger not a falling hazard, additional guarding shall be provided.

(5) Regardless of height, open-sided floors, walkways, platforms, or runways above or adjacent to dangerous equipment, pickling or galvanizing tanks, degreasing units, and similar hazards, shall be guarded with a standard railing and toe board.

(c) *Stairway railings and guards.* (1) Every flight of stairs having four or more risers shall be equipped with standard stair railings or standard handrails as specified below, the width of the stair to be measured clear of all obstructions except handrails:

(i) On stairways less than 44 inches wide having both sides enclosed, at least one handrail, preferably on the right side descending;

(ii) On stairways less than 44 inches wide having one side open, at least one stair railing on the open side;

(iii) On stairways less than 44 inches wide having both sides open, one stair railing on each side;

(iv) On stairways more than 44 inches wide but less than 88 inches wide, one

handrail on each enclosed side and one stair railing on each open side;

(v) On stairways 88 or more inches wide, one handrail on each enclosed side, one stair railing on each open side, and one intermediate stair railing located approximately midway of the width.

(2) Winding stairs shall be equipped with a handrail offset to prevent walking on all portions of the treads having width less than 6 inches.

(f) *Standard specifications.* (1) A standard railing shall consist of top rail, intermediate rail, toeboard, and posts, and shall have a vertical height of approximately 42 inches from upper surface of top rail to floor, platform, runway, or ramp level. The top rail shall be smooth-surfaced throughout the length of the railing. The intermediate rail shall be halfway between the top rail and the floor, platform, runway, or ramp. The ends of the rails shall not overhang the terminal posts except where such overhang does not constitute a projection hazard. Minimum requirements for standard railings under various types of construction are specified in the following paragraphs:

(i) For wood railings, the posts shall be of at least 2-inch by 4-inch stock spaced not to exceed 8 feet; the top rail shall be of at least 2-inch by 4-inch stock; the intermediate rail shall be of at least 1-inch by 6-inch stock.

(ii) For pipe railings, posts and top and intermediate railings shall be at least 1½ inches nominal diameter with posts spaced not more than 8 feet on centers.

(iii) For structural steel railings, posts and top and intermediate rails shall be of 2-inch by 2-inch by ¾-inch angles or other metal shapes of equivalent bending strength, with posts spaced not more than 8 feet on centers.

(iv) The anchoring of posts and framing of members for railings of all types shall be of such construction that the completed structure shall be capable of withstanding a load of at least 200 pounds applied in any direction at any point on the top rail, with a minimum of deflection.

(v) Railings receiving heavy stresses from employees trucking or handling materials shall be provided additional strength by the use of heavier stock, closer spacing of posts, bracing, or by other means.

(vi) Other types, sizes, and arrangements of railing construction are acceptable, provided they meet the following conditions:

(a) A smooth-surfaced top rail at a height above floor, platform, runway, or ramp level of approximately 42 inches;

(b) A strength to withstand at least the minimum requirement of 200 pounds top rail pressure with a minimum of deflection;

(c) Protection between top rail and floor, platform, runway, ramp, or stair treads, equivalent at least to that afforded by a standard intermediate rail;

(d) Elimination of overhang of rail ends unless such overhang does not constitute a hazard;

(2) A stair railing shall be of construction similar to a standard railing, but the vertical height shall be not more than 34 inches nor less than 30 inches from upper surface of top rail to surface of tread in line with face of riser at forward edge of tread.

(3) (i) A standard toeboard shall be 4 inches minimum in vertical height from its top edge to the level of the floor, platform, runway, or ramp. It shall be securely fastened in place and have not more than ¼-inch clearance above floor level. It may be made of any substantial material, either solid, or with openings not over 1 inch in greatest dimension.

(ii) Where material is piled to such height that a standard toeboard does not provide protection, paneling, or screening from floor to intermediate rail or to top rail shall be provided.

(4) (i) A standard handrail shall be of construction similar to a standard railing except that it is mounted on a wall or partition, and does not include an intermediate rail. It shall have a smooth surface along the top and both sides of the handrail. The handrail shall have an adequate handhold for any one grasping it to avoid falling. Ends of the handrail shall be constructed so as not to constitute a projection hazard.

(ii) The height of handrails shall be not more than 34 inches nor less than 30 inches from upper surface of handrail to surface of tread, in line with face of riser or to surface of ramp.

(iii) All handrails and railings shall be provided with a clearance of approximately 3 inches between the handrail or railing and any other object.

(5) Floor opening covers shall be of any material that meets the following strength requirements:

(i) Conduits, trenches, and manhole covers and their supports, when located in roadways, and vehicular aisles, shall be designed to carry a truck rear-axle load of at least 2 times the maximum intended load;

(ii) The floor opening cover shall be capable of supporting the maximum intended load and so installed as to prevent accidental displacement.

(6) Skylight openings that create a falling hazard shall be guarded with a standard railing, or covered in accordance with subparagraph (5) (ii) of this paragraph.

(7) Wall opening protection shall meet the following requirements:

(i) Barriers shall be of such construction and mounting that, when in place at the opening, the barrier is capable of withstanding a load of at least 200 pounds applied in any direction (except upward), with a minimum of deflection at any point on the top rail or corresponding member.

(ii) Screens shall be of such construction and mounting that they are capable of withstanding a load of at least 200 pounds applied horizontally at any point on the near side of the screen. They may be of solid construction, of grill work with openings not more than 8 inches long, or of slat work with openings not more than 4 inches wide with length unrestricted.

§ 1518.501 Stairways.

(a) On all structures, two or more floors (20 feet or over) in height, stairways, ladders, or ramps shall be provided for employees during the construction period.

(b) Stairway railings and guardrails shall meet the requirements of § 1518.500 (c) and (f).

(c) All parts of stairways shall be free of hazardous projections, such as protruding nails.

(d) Debris, and other loose materials, shall not be allowed on or under stairways.

(e) Slippery conditions on stairways shall be eliminated as soon as possible after they occur.

(f) Permanent steel or other metal stairways, and landings with hollow pan-type treads that are to be filled with concrete or other materials, when used during construction, shall be filled to the level of the nosing with solid material. The requirement shall not apply during the period of actual construction of the stairways themselves.

(g) Wooden treads for temporary service shall be full width.

(h) Metal landings shall be secured in place before filling.

(i) Temporary stairs shall have a landing not less than 30 inches in the direction of travel at every 12 feet of vertical rise.

(j) Stairs shall be installed at angles to the horizontal of between 30° and 50°.

(k) Rise height and tread width shall be uniform throughout any flight of stairs including any foundation structure used as one or more treads of the stairs.

(l) All stairs shall be lighted in accordance with Subpart D of this part.

(m) Spiral stairways shall not be permitted except for special limited usage and secondary access situations where it is not practical to provide a conventional stairway.

§ 1518.502 Definitions applicable to this subpart.

(a) "Floor hole"—An opening measuring less than 12 inches but more than 1 inch in its least dimension in any floor, roof, or platform through which materials but not persons may fall, such as a belt hold, pipe opening, or slot opening.

(b) "Floor opening"—An opening measuring 12 inches or more in its least dimension in any floor, roof, or platform, through which persons may fall.

(c) "Handrail"—A bar or pipe supported on brackets from a wall or partition, as on a stairway or ramp, to furnish persons with a handhold in case of tripping.

(d) "Nose, nosing"—That portion of a tread projecting beyond the face of the riser immediately below.

(e) "Platform"—A working space for persons, elevated above the surrounding floor or ground, such as a balcony or platform for the operation of machinery and equipment.

(f) "Runway"—A passageway for persons, elevated above the surrounding floor or ground level, such as a footwalk along shafting or a walkway between buildings.

(g) "Rise"—The vertical distance from the top of a tread to the top of the next higher tread.

(h) "Stair platform"—An extended step or landing breaking a continuous run of stairs.

(i) "Stair railing"—A vertical barrier erected along exposed sides of a stairway to prevent falls of persons.

(j) "Stairs, stairways"—A series of steps leading from one level or floor to another, or leading to platforms, pits, boiler rooms, crossovers, or around machinery, tanks, and other equipment that are used more or less continuously or routinely by employees or only occasionally by specific individuals. For the purpose of this subpart, a series of steps and landings having three or more rises constitutes stairs or stairway.

(k) "Standard railing"—A vertical barrier erected along exposed edges of a floor opening, wall opening, ramp, platform, or runway to prevent falls of persons.

(l) "Standard strength and construction"—Any construction of railings, covers, or other guards that meets the requirements of this subpart.

(m) "Toe board"—A vertical barrier at floor level erected along exposed edges of a floor opening, wall opening, platform, runway, or ramp to prevent falls of materials.

(n) "Tread width"—The horizontal distance from front to back of tread, including nosing, when used.

Subpart N—Cranes, Derricks, Hoists, Elevators, and Conveyors

§ 1518.350 Cranes and derricks.

(a) *General requirements.* (1) The employer shall comply with the manufacturer's specifications and limitations applicable to the operation of any and all cranes and derricks. Where manufacturer's specifications are not available, the limitations assigned to the equipment shall be based on the determinations of a qualified engineer competent in this field and such determinations will be appropriately documented and recorded. Attachments used with cranes shall not exceed the capacity, rating, or scope recommended by the manufacturer.

(2) Rated load capacities, and recommended operating speeds, special hazard warnings, or instruction, shall be conspicuously posted on all equipment. Instructions or warnings shall be visible to the operator while he is at his control station.

(3) A boom angle indicator and a load indicating device in good working order shall be provided. A load moment device approved by a government or private agency recognized by the U.S. Department of Labor will be accepted in lieu of a boom angle indicator and a load-indicating device.

(4) Hand signals to crane and derrick operators shall be those prescribed by the applicable ANSI standard for the type of crane in use. An illustration of the signals shall be posted at the job site.

(5) The employer shall designate a

competent person who shall inspect all machinery and equipment prior to each use, and during use to make sure it is in safe operating condition. Any deficiencies shall be repaired, or defective parts replaced, before continued use.

(6) A thorough, annual inspection of the hoisting machinery shall be made by a competent person, or by a government or private agency recognized by the U.S. Department of Labor. The employer shall maintain a record of the dates and results of inspections for each hoisting machine and piece of equipment.

(7) Wire rope shall be taken out of service when any of the following conditions exist:

(i) In running ropes, six randomly distributed broken wires in one lay or three broken wires in one strand in one lay;

(ii) Wear of one-third the original diameter of outside individual wires. Kinking, crushing, bird caging, or any other damage resulting in distortion of the rope structure;

(iii) Evidence of any heat damage from any cause;

(iv) Reductions from nominal diameter of more than one-sixty-fourth inch for diameters up to and including five-sixteenths inch, one-thirty-second inch for diameters three-eighths inch to and including one-half inch, three-sixty-fourths inch for diameters nine-sixteenths inch to and including three-fourths inch, one-sixteenth inch for diameter seven-eighths inch to 1½ inches inclusive, three-thirty-seconds inch for diameters 1¼ to 1½ inches inclusive;

(v) In standing ropes, more than two broken wires in one lay in sections beyond end connections or more than one broken wire at an end connection.

(vi) Wire rope safety factors shall be in accordance with American National Standards Institute B 30.5-1968 or SAE J959-1966.

(8) Belts, gears, shafts, pulleys, sprockets, spindles, drums, fly wheels, chains, or other reciprocating, rotating, or other moving parts or equipment shall be guarded if such parts are exposed to contact by employees, or otherwise create a hazard. Guarding shall meet the requirements of the American National Standards Institute B 15.1-1958 Rev., Safety Code for Mechanical Power Transmission Apparatus.

(9) Accessible areas within the swing radius of the rear of the rotating superstructure of the crane, either permanently or temporarily mounted, shall be barricaded in such a manner as to prevent an employee from being struck or crushed by the crane.

(10) All exhaust pipes shall be guarded or insulated in areas where contact by employees is possible in the performance of normal duties.

(11) Whenever internal combustion engine powered equipment exhausts in enclosed spaces, tests shall be made and recorded to see that employees are not exposed to unsafe concentrations of toxic gases or oxygen deficient atmospheres.

(12) All windows in cabs shall be of safety glass, or equivalent, that introduces no visible distortion, that will interfere with the safe operation of the machine.

(13) (i) Where necessary for rigging or service requirements, a ladder, or steps, shall be provided to give access to a cab roof.

(ii) On cranes, guardrails, handholds and steps shall be provided for easy access to the car and cab conforming to American National Standards Institute B30.5.

(iii) Platforms and walkways shall have anti-skid surfaces.

(14) Fuel tank filler pipe shall be located in such a position, or protected in such manner, as to not allow spill or overflow to run onto the engine, exhaust, or electrical equipment of any machine being fueled.

(i) An accessible fire extinguisher of 5BC rating, or higher, shall be available at all operator stations or cabs of equipment.

(ii) All fuels shall be transported, stored, and handled to meet the rules of Subpart F of this part. When fuel is transported by vehicles on public highways, Department of Transportation rules contained in 49 CFR Parts 177 and 393 concerning such vehicular transportation are considered applicable.

(15) Except where electrical distribution and transmission lines have been deenergized and visibly grounded at point of work or where insulating barriers, not a part of or an attachment to the equipment or machinery, have been erected to prevent physical contact with the lines, equipment or machines shall be operated proximate to power lines only in accordance with the following:

(i) For lines rated 50 kV. or below, minimum clearance between the lines and any part of the crane or load shall be 10 feet;

(ii) For lines rated over 50 kV., minimum clearance between the lines and any part of the crane or load shall be 10 feet plus 0.4 inch for each 1 kV. over 50 kV., or use twice the length of the line insulator but never less than 10 feet;

(iii) In transit with no load and boom lowered, the equipment clearance shall be a minimum of 4 feet for voltages less than 50 kV., and 10 feet for voltages over 50 kV. up to and including 345 kV., and 16 feet for voltages up to and including 750 kV.

(iv) A person shall be designated to observe clearance of the equipment and give timely warning for all operations where it is difficult for the operator to maintain the desired clearance by visual means;

(v) Cage-type boom guards, insulating links, or proximity warning devices may be used on cranes, but the use of such devices shall not alter the requirements of any other regulation of this part even if such device is required by law or regulation;

(vi) Any overhead wire shall be considered to be an energized line unless and until the person owning such line

or the electrical utility authorities indicate that it is not an energized line and it has been visibly grounded;

(vii) Prior to work near transmitter towers where an electrical charge can be induced in the equipment or materials being handled, the transmitter shall be de-energized or tests shall be made to determine if electrical charge is induced on the crane. The following precautions shall be taken when necessary to dissipate induced voltages:

(a) The equipment shall be provided with an electrical ground directly to the upper rotating structure supporting the boom; and

(b) Ground jumper cables shall be attached to materials being handled by boom equipment when electrical charge is induced while working near energized transmitters. Crews shall be provided with nonconductive poles having large alligator clips or other similar protection to attach the ground cable to the load.

(c) Combustible and flammable materials shall be removed from the immediate area prior to operations.

(16) No modifications or additions which affect the capacity and operation of the equipment shall be made by the employer without the manufacturer's written approval. If such modifications or changes are made, the capacity, operation and maintenance instruction plates, tags, or decals, shall be changed accordingly. In no case shall the original safety factor of the equipment be reduced.

(17) The employer shall comply with Power Crane and Shovel Association, Mobile Hydraulic Crane Standard No. 2.

(18) Sideboom cranes mounted on wheel or crawler tractors shall meet the requirements of SAE J74a-1964.

(b) *Crawler, locomotive, and truck cranes.* (1) All jibs shall have positive stops to prevent their movement of more than 5° above the straight line of the jib and boom on conventional type crane booms. The use of cable type belly slings does not constitute compliance with this rule.

(2) All crawler, truck, or locomotive cranes in use shall meet the applicable requirements for design, inspection, construction, testing, maintenance and operation as prescribed in the ANSI B30.5-1968, Safety Code for Crawler, Locomotive and Truck Cranes.

(c) *Hammerhead tower cranes.* (1) Adequate clearance shall be maintained between moving and rotating structures of the crane and fixed objects to allow the passage of employees without harm.

(2) Employees required to perform duties on the horizontal boom of hammerhead tower cranes shall be protected against falling by guardrails or by safety belts and lanyards attached to lifelines in conformance with Subpart E of this part.

(3) Buffers shall be provided at both ends of travel of the trolley.

(4) Cranes mounted on rail tracks shall be equipped with limit switches limiting the travel of the crane on the track and stops or buffers at each end of the tracks.

(5) All hammerhead tower cranes in use shall meet the applicable requirements for design, construction, installation, testing, maintenance, inspection, and operation as prescribed by the manufacturer.

(d) *Overhead and gantry cranes.* (1) The rated load of the crane shall be plainly marked on each side of the crane, and if the crane has more than one hoisting unit, each hoist shall have its rated load marked on it or its load block, and this marking shall be clearly legible from the ground or floor.

(2) Bridge trucks shall be equipped with sweeps which extend below the top of the rail and project in front of the truck wheels.

(3) Except for floor-operated cranes, a gong or other effective audible warning signal shall be provided for each crane equipped with a power traveling mechanism.

(4) All overhead and gantry cranes in use shall meet the applicable requirements for design, construction, installation, testing, maintenance, inspection, and operation as prescribed in the ANSI B30.2.0-1967, Safety Code for Overhead and Gantry Cranes.

(e) *Derricks.* All derricks in use shall meet the applicable requirements for design, construction, installation, inspection, testing, maintenance, and operation as prescribed in American National Standards Institute B30.6-1967, Safety Code for Derricks.

(f) *Floating cranes and derricks.* (1) *Mobile cranes mounted on barges.* (i) When a mobile crane is mounted on a barge, the rated load of the crane shall not exceed the original capacity specified by the manufacturer.

(ii) A load rating chart, with clearly legible letters and figures, shall be provided with each crane, and securely fixed at a location easily visible to the operator.

(iii) When load ratings are reduced to stay within the limits for list of the barge with a crane mounted on it, a new load rating chart shall be provided.

(iv) Mobile cranes on barges shall be positively secured.

(2) *Permanently mounted floating cranes and derricks.* (i) When cranes and derricks are permanently installed on a barge the capacity and limitations of use shall be based on competent design criteria.

(ii) A load rating chart with clearly legible letters and figures shall be provided and securely fixed at a location easily visible to the operator.

(iii) Floating cranes and floating derricks in use shall meet the applicable requirements for design, construction, installation, testing, maintenance, and operation as prescribed by the manufacturer.

(3) *Protection of employees working on barges.* The employer shall comply with the applicable requirements for protection of employees working onboard marine vessels specified in § 1518.605.

§ 1518.551 Helicopters.

(a) Helicopter cranes when used shall be certified and conform to all applicable regulations of the FAA, 14 CFR Part 133.

(b) Rotorcraft pilots shall be licensed to conduct external-load operations in accordance with the FAA regulations, 14 CFR Part 133.

§ 1518.552 Material hoists, personnel hoists, and elevators.

(a) *General requirements.* (1) The employer shall comply with the manufacturer's specifications and limitations applicable to the operation of all hoists and elevators. Where manufacturer's specifications are not available, the limitations assigned to the equipment shall be based on the determinations of a professional engineer competent in the field.

(2) Rated load capacities, recommended operating speeds, and special hazard warnings or instructions shall be posted on cars and platforms.

(3) Wire rope shall be removed from service when any of the following conditions exists:

(i) In hoisting ropes, six randomly distributed broken wires in one rope lay or three broken wires in one strand in one rope lay;

(ii) Abrasion, scrubbing, flattening, or peening, causing loss of more than one-third of the original diameter of the outside wires;

(iii) Evidence of any heat damage resulting from a torch or any damage caused by contact with electrical wires;

(iv) Reduction from nominal diameter of more than three sixty-fourths inch for diameters up to and including three-fourths inch; one-sixteenth inch for diameters seven-eighths to 1½ inches; and three thirty-seconds inch for diameters 1¼ to 1½ inches.

(4) Hoisting ropes shall be installed in accordance with the wire rope manufacturer's recommendations.

(5) The installation of live booms on hoists is prohibited.

(6) The use of endless belt-type man lifts on construction shall be prohibited.

(b) *Material hoists.* (1) (i) Operating rules shall be established and posted at the operator's station of the hoist. Such rules shall include signal system and allowable line speed for various loads. Rules and notices shall be posted on the car frame or crosshead in a conspicuous location, including the statement "No Riders Allowed."

(ii) No person shall be allowed to ride on material hoists except for the purposes of inspection and maintenance.

(2) All entrances of the hoistways shall be protected by substantial gates or bars which shall guard the full width of the landing entrance. All hoistway entrance bars and gates shall be painted with diagonal contrasting colors, such as black and yellow stripes.

(i) Bars shall be not less than 2- by 4-inch wooden bars or the equivalent, located 2 feet from the hoistway line. Bars shall be located not less than 36

inches nor more than 42 inches above the floor.

(ii) Gates or bars protecting the entrances to hoistway shall be equipped with a latching device.

(3) Overhead protective covering of 2-inch planking, 3/4-inch plywood, or other solid material of equivalent strength, shall be provided on the top of every material hoist cage or platform.

(4) The operator's station of a hoisting machine shall be provided with overhead protection equivalent to tight planking not less than 2 inches thick. The support for the overhead protection shall be of equal strength.

(5) Hoist towers may be used with or without an enclosure on all sides. However, whichever alternative is chosen, the following applicable conditions shall be met:

(i) When a hoist tower is enclosed, it shall be enclosed on all sides for its entire height with a screen enclosure of 1/2-inch mesh, No. 18 U.S. gauge wire or equivalent, except for landing access.

(ii) When a hoist tower is not enclosed, the hoist platform or car shall be totally enclosed (caged) on all sides for the full height between the floor and the overhead protective covering with 1/2-inch mesh of No. 14 U.S. gauge wire or equivalent. The hoist platform enclosure shall include the required gates for loading and unloading. A 6-foot high enclosure shall be provided on the unused sides of the hoist tower at ground level.

(6) Car arresting devices shall be installed to function in case of rope failure.

(7) All material hoist towers shall be designed by a licensed professional engineer.

(8) All material hoists shall conform to the requirements of ANSI A10.5-1969, Safety Requirements for Material Hoists.

(c) *Personnel hoists.* (1) Hoist towers outside the structure shall be enclosed for the full height on the side or sides used for entrance and exit to the structure. At the lowest landing, the enclosure on the sides not used for exit or entrance to the structure shall be enclosed to a height of at least 10 feet. Other sides of the tower adjacent to floors or scaffold platforms shall be enclosed to a height of 10 feet above the level of such floors or scaffolds.

(2) Towers inside of structures shall be enclosed on all four sides throughout the full height.

(3) Towers shall be anchored to the structure at intervals not exceeding 25 feet. In addition to tie-ins, a series of guys shall be installed. Where tie-ins are not practical the tower shall be anchored by means of guys made of wire rope at least one-half inch in diameter, securely fastened to anchorages to ensure stability.

(4) Hoistway doors or gates shall be not less than 6 feet 6 inches high and shall be provided with mechanical locks which cannot be operated from the landing side, and shall be accessible only to persons on the car.

(5) Cars shall be permanently enclosed on all sides and the top, except

sides used for entrance and exit, which have car gates or doors.

(6) A door or gate shall be provided at each entrance to the car which shall protect the full width and height of the car entrance opening.

(7) Overhead protective covering of 2-inch planking, 3/4-inch plywood or other solid material of equivalent strength shall be provided on the top of every personnel hoist.

(8) Doors or gates shall be provided with electric contacts which do not allow movement of the hoist when door or gate is open.

(9) Safeties shall be capable of stopping and holding the car and rated load when traveling at governor tripping speed.

(10) Cars shall be provided with a capacity and data plate secured in a conspicuous place on the car or crosshead.

(11) Internal combustion engines shall not be permitted for direct drive.

(12) Normal and final terminal stopping devices shall be provided.

(13) An emergency stop switch shall be provided in the car and marked "Stop."

(14) Ropes: (i) The minimum number of hoisting ropes used shall be three for traction hoists and two for drum-type hoists.

(ii) The minimum diameter of hoisting and counterweight wire ropes shall be 1/2-inch.

(iii) Safety factors:

MINIMUM FACTORS OF SAFETY FOR SUSPENSION WIRE ROPES

Rope speed in feet per minute:	Minimum factor of safety
50-----	7.60
75-----	7.75
100-----	7.95
125-----	8.10
150-----	8.25
175-----	8.40
200-----	8.60
225-----	8.75
250-----	8.90
300-----	9.20
350-----	9.60
400-----	9.75
450-----	10.00
500-----	10.25
550-----	10.45
600-----	10.70

(15) Following assembly and erection of hoists, and before being put in service, an inspection and test of all functions and safety devices shall be made under the supervision of a competent person. A similar inspection and test is required following major alteration of an existing installation. All hoists shall be inspected and tested at not more than 3-month intervals. Records shall be maintained and kept on file for the duration of the job.

(16) All personnel elevators used by employees shall be constructed of materials and components which meet the specifications for materials, construction, safety devices, assembly, and structural integrity as stated in the American National Standard A10.4-1971, Safety Requirements for Personnel Hoists.

(17) (i) Personnel hoists used in bridge tower construction shall be approved by

a registered professional engineer and erected under the supervision of a qualified engineer competent in this field.

(ii) When a hoist tower is not enclosed, the hoist platform or car shall be totally enclosed (caged) on all sides for the full height between the floor and the overhead protective covering with 3/4-inch mesh of No. 14 U.S. gauge wire or equivalent. The hoist platform enclosure shall include the required gates for loading and unloading.

(iii) These hoists shall be inspected and maintained on a weekly basis. Whenever the hoisting equipment is exposed to winds exceeding 35 miles per hour it shall be inspected and put in operable condition before reuse.

(iv) Wire rope shall be taken out of service when any of the following conditions exist:

(a) In running ropes, six randomly distributed broken wires in one lay or three broken wires in one strand in one lay;

(b) Wear of one-third the original diameter of outside individual wires. Kinking, crushing, bird caging, or any other damage resulting in distortion of the rope structure;

(c) Evidence of any heat damage from any cause;

(d) Reductions from nominal diameter of more than three-sixty-fourths inch for diameters to and including three-fourths inch, one sixteenth inch for diameter seven-eighths inch to 1 1/4 inches inclusive, three-thirty-seconds inch for diameters 1 1/4 to 1 1/2 inches inclusive;

(e) In standing ropes, more than two broken wires in one lay in sections beyond end connections or more than one broken wire at an end connection.

(d) Permanent elevators under the care and custody of the employer and used by employees for work covered by this Act shall comply with the requirements of American National Standards Institute A17.1-1965 with addenda A17.1a-1967, A17.1b-1968, A17.1c-1969, A17.1d-1970, and inspected in accordance with A17.2-1960 with addenda A17.2a-1965, A17.2b-1967.

§ 1518.553 Base-mounted drum hoists.

(a) *General requirements.* (1) Exposed moving parts such as gears, projecting screws, setscrews, chain, cables, chain sprockets, and reciprocating or rotating parts, which constitute a hazard, shall be guarded.

(2) All controls used during the normal operation cycle shall be located within easy reach of the operator's station.

(3) Electric motor operated hoists shall be provided with:

(i) A device to disconnect all motors from the line upon power failure and not permit any motor to be restarted until the controller handle is brought to the "off" position;

(ii) Where applicable, an overspeed preventive device;

(iii) A means whereby remotely operated hoists stop when any control is ineffective.

(4) All base-mounted drum hoists in use shall meet the applicable requirements for design, construction, installation, testing, inspection, maintenance, and operation, as prescribed by the manufacturer.

(b) *Specific requirements.* [Reserved]

§ 1518.554 Overhead hoists.

(a) *General requirements.* (1) The safe working load of the overhead hoist, as determined by the manufacturer, shall be indicated on the hoist, and this safe working load shall not be exceeded.

(2) The supporting structure to which the hoist is attached shall have a safe working load equal to that of the hoist.

(3) The support shall be arranged so as to provide for free movement of the hoist and shall not restrict the hoist from lifting itself up with the load.

(4) The hoist shall be installed only in locations that will permit the operator to stand clear of the load at all times.

(5) Air hoists shall be connected to an air supply of sufficient capacity and pressure to safely operate the hoist. All air hoses supplying air shall be positively connected to prevent their becoming disconnected during use.

(6) All overhead hoists in use shall meet the applicable requirements for construction, design, installation, testing, inspection, maintenance, and operation, as prescribed by the manufacturer.

(b) *Specific requirements.* [Reserved]

§ 1518.555 Conveyors.

(a) *General requirements.* (1) Means for stopping the motor or engine shall be provided at the operator's station. Conveyor systems shall be equipped with an audible warning signal to be sounded immediately before starting up the conveyor.

(2) If the operator's station is at a remote point, similar provisions for stopping the motor or engine shall be provided at the motor or engine location.

(3) Emergency stop switches shall be arranged so that the conveyor cannot be started again until the actuating stop switch has been reset to running or "On" position.

(4) Screw conveyors shall be guarded to prevent employee contact with turning flights.

(5) Where a conveyor passes over work areas, aisles, or thoroughfares, suitable guards shall be provided to protect employees required to work below the conveyors.

(6) All crossovers, aisles, and passageways shall be conspicuously marked by suitable signs, as required by Subpart G of this part.

(7) Conveyors shall be locked out or otherwise rendered inoperable, and tagged out with a "Do Not Operate" tag, during repairs and when operation is hazardous to employees performing maintenance work.

(8) All conveyors in use shall meet the applicable requirements for design, construction, inspection, testing, maintenance, and operation, as prescribed in the ANSI B20.1-1957, Safety Code for

Conveyors, Cableways, and Related Equipment.

Subpart O—Motor Vehicles, Mechanized Equipment, and Marine Operations

§ 1518.600 Equipment.

(a) *General requirements.* (1) All equipment left unattended at night, adjacent to a highway in normal use, or adjacent to construction areas where work is in progress, shall have appropriate lights or reflectors, or barricades equipped with appropriate lights or reflectors, to identify the location of the equipment.

(2) A safety tire rack, cage, or equivalent protection shall be provided and used when inflating, mounting, or dismounting tires installed on split rims, or rims equipped with locking rings or similar devices.

(3) (i) Heavy machinery, equipment, or parts thereof, which are suspended or held aloft by use of slings, hoists, or jacks shall be substantially blocked or cribbed to prevent falling or shifting before employees are permitted to work under or between them. Bulldozer and scraper blades, end-loader buckets, dump bodies, and similar equipment, shall be either fully lowered or blocked when being repaired or when not in use. All controls shall be in a neutral position, with the motors stopped and brakes set, unless work being performed requires otherwise.

(ii) Parked equipment shall be chocked and parking brakes set. The controls shall be set according to manufacturer's recommendations.

(4) The use, care and charging of all batteries shall conform to the requirements of Subpart K of this part.

(5) All cab glass shall be safety glass, or equivalent, that introduces no visible distortion affecting the safe operation of any machine covered by this subpart.

(6) All equipment covered by this subpart shall comply with the requirements of § 1518.550(a)(15) when working or being moved in the vicinity of power lines or energized transmitters.

(b) *Specific requirements.* [Reserved]

§ 1518.601 Motor vehicles.

(a) *Coverage.* Motor vehicles as covered by this part are those vehicles that operate within an off-highway jobsite, not open to public traffic. The requirements of this section do not apply to crawler machines, for which rules are prescribed in § 1518.602.

(b) *General requirements.* (1) All vehicles shall have a service brake system, an emergency brake system, and a parking brake system. These systems may use common components, and shall be maintained in operable condition.

(2) (i) Whenever visibility conditions warrant additional light, all vehicles, or combinations of vehicles, in use shall be equipped with at least two headlights and two taillights in operable condition.

(ii) All vehicles, or combination of vehicles, shall have brake lights in opera-

ble condition regardless of light conditions.

(3) All vehicles shall be equipped with an adequate audible warning device at the operator's station and in an operable condition.

(4) No employer shall use any motor vehicle equipment having an obstructed view to the rear unless:

(i) The vehicle has a reverse signal alarm audible above the surrounding noise level or;

(ii) The vehicle is backed up only when an observer signals that it is safe to do so.

(5) All vehicles with cabs shall be equipped with windshields and powered wipers. Cracked and broken glass shall be replaced. Vehicles operating in areas or under conditions that cause fogging or frosting of the windshields shall be equipped with operable defogging or defrosting devices.

(6) All haulage vehicles, whose payload is loaded by means of cranes, power shovels, loaders, or similar equipment, shall have a cab shield and/or canopy adequate to protect the operator from shifting or falling materials.

(7) Tools and material shall be secured to prevent movement when transported in the same compartment with employees.

(8) Vehicles used to transport employees shall have seats firmly secured and adequate for the number of employees to be carried.

(9) Seat belts and anchorages meeting the requirements of 49 CFR Part 571 (Department of Transportation, Federal Motor Vehicle Safety Standards) shall be installed in all motor vehicles except in the case of off-highway vehicular equipment, where the requirements of § 1518.602 shall apply.

(10) Trucks with dump bodies shall be equipped with positive means of support, permanently attached, and capable of being locked in position to prevent accidental lowering of the body while maintenance or inspection work is being done.

(11) Operating levers, controlling hoisting or dumping devices on haulage bodies, shall be equipped with a latch or other device which will prevent accidental starting or tripping of the mechanism.

(12) Trip handles for tailgates of dump trucks shall be so arranged that, in dumping, the operator will be in the clear.

(13) All rubber-tired motor vehicle equipment shall be equipped with fenders.

(14) All vehicles in use shall be checked at the beginning of each shift to assure that the following parts, equipment, and accessories are in safe operating condition and free of apparent damage that could cause failure while in use: Service brakes, including trailer brake connections; parking system (hand brake); emergency stopping system (brakes); tires; horn; steering mechanism; coupling devices; seat belts; operating controls; and safety devices.

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All defects shall be corrected before the vehicle is placed in service. These requirements also apply to equipment such as lights, reflectors, windshield wipers, defrosters, fire extinguishers, etc., where such equipment is necessary.

§ 1518.602 Material handling equipment.

(a) Earthmoving equipment; general.

(1) These rules apply to the following types of earthmoving equipment: scrapers, loaders, crawler or wheel tractors, bulldozers, off-highway trucks, graders, agricultural and industrial tractors, and similar equipment. The promulgation of specific rules for compactors and rubber-tired "skid-steer" equipment is reserved pending consideration of standards currently being developed.

(2) **Seat belts.** (i) Seat belts shall be provided on all equipment covered by this section and shall meet the requirements of Society of Automotive Engineers, J386-1969. Seat belts for construction equipment, or agricultural and light industrial tractors shall meet the seat belt requirements of Society of Automotive Engineers J333a-1970, Operator Protection for Agricultural and Light Industrial Tractors.

(ii) Seat belts need not be provided for equipment which is designed only for standup operation.

(iii) Seat belts need not be provided for equipment which does not have roll-over protective structure (ROPS) or adequate canopy protection.

(3) **Roadway grades.** Roadway grades for construction equipment use shall be designed by a qualified engineer, competent in this field, and constructed to accommodate all of the equipment using the roadway. Emergency access ramps and berms shall be constructed to restrain and control runaway vehicles.

(4) **Brakes.** All earthmoving equipment mentioned in this § 1518.602(a) shall have a service braking system capable of stopping and holding the equipment fully loaded, as specified in Society of Automotive Engineers SAE-J237, Loader Dozer-1971, J236, Graders-1971, and J319b, Scrapers-1971. Brake systems for self-propelled rubber-tired off-highway equipment manufactured after January 1, 1972 shall meet the applicable minimum performance criteria set forth in the following Society of Automotive Engineers Recommended Practices:

Self-Propelled	
Scrapers	SAE J319b-1971
Self-Propelled	
Graders	SAE J236-1971
Trucks and	
Wagons	SAE J166-1971
Front End Loaders	
and Dozers	SAE J237-1971

(5) **Fenders.** All rubber-tired earthmoving equipment, such as trucks, scrapers, tractors, and trailing units, etc., whose maximum speed exceeds 15 miles per hour, shall be equipped with fenders on all wheels to meet the requirements of Society of Automotive Engineers SAE J321a-1970, Fenders for Pneumatic-tired Earthmoving Haulage

Equipment. An employer may, of course, at any time seek to show under § 1518.2, that the uncovered wheels present no hazard to personnel from flying materials.

(6) **Roll-over protection structures (ROPS).** The promulgation of standards requiring roll-over protective structures (ROPS) is reserved pending further study and development.

(7) **Off-highway trucks.** The promulgation of standards for off-highway trucks is reserved pending further study and development.

(8) **Specific effective dates—brakes and fenders.** Equipment mentioned in subparagraphs (4) and (5) of this paragraph, and manufactured after January 1, 1972, which is used by any employer after that date, shall comply with the applicable rules prescribed therein concerning brakes and fenders. Equipment mentioned in subparagraphs (4) and (5) of this paragraph, and manufactured before January 1, 1972, which is used by any employer after that date, shall meet the applicable rules prescribed herein not later than June 30, 1973. It should be noted that, as permitted under § 1518.2, employers may request variations from the applicable brakes and fender standards required by this subpart. Employers wishing to seek variations from the applicable brakes and fenders rules may submit any requests for variations after the publication of this document in the FEDERAL REGISTER. Any statements intending to meet the requirements of § 1518.2(b)(4), should specify how the variation would protect the safety of the employees by providing for any compensating restrictions on the operation of equipment.

(b) **Excavating and other equipment.** (1) Tractors covered in paragraph (a) of this section shall have seatbelts as required for the operators when seated in the normal seating arrangement for tractor operation, even though backhoes, breakers, or other similar attachments are used on these machines for excavating or other work.

(2) For the purposes of this Subpart and of Subpart N of this part, the nomenclatures and descriptions for measurement of dimensions of machinery and attachments shall be as described in Society of Automotive Engineers 1970 Handbook, pages 1088 through 1103.

(3) The safety requirements, ratios, or limitations applicable to machines or attachment usage covered in Power Crane and Shovel Association's Standards No. 1 and No. 2 of 1968, and No. 3 of 1969, shall be compiled with, and shall apply to cranes, machines, and attachments under this part.

(c) **Lifting and hauling equipment (other than equipment covered under Subpart N of this part).** (1) Industrial trucks shall meet the requirements of § 1518.600 and the following:

(i) Lift trucks, stackers, etc., shall have the rated capacity clearly posted on the vehicle so as to be clearly visible to the operator. When auxiliary removable counterweights are provided by the manufacturer, corresponding alternate

rated capacities also shall be clearly shown on the vehicle. These ratings shall not be exceeded.

(ii) No modifications or additions which affect the capacity or safe operation of the equipment shall be made without the manufacturer's written approval. If such modifications or changes are made, the capacity, operation, and maintenance instruction plates, tags, or decals, shall be changed accordingly. In no case shall the original safety factor of the equipment be reduced.

(iii) If a load is lifted by two or more trucks working in unison, the proportion of the total load carried by any one truck shall not exceed its capacity.

(iv) Steering or spinner knobs shall not be attached to the steering wheel unless the steering mechanism is of a type that prevents road reactions from causing the steering handwheel to spin. The steering knob shall be mounted within the periphery of the wheel.

(v) All high lift rider industrial trucks shall be equipped with overhead guards which meet the configuration and structural requirements as defined in paragraph 421 of American National Standards Institute B56.1-1969, Safety Standards for Powered Industrial Trucks.

(vi) All industrial trucks in use shall meet the applicable requirements of design, construction, stability, inspection, testing, maintenance, and operation, as defined in American National Standards Institute B56.1-1969, Safety Standards for Powered Industrial Trucks.

§ 1518.603 Pile driving equipment.

(a) **General requirements.** (1) Boilers and piping systems which are a part of, or used with, pile driving equipment shall meet the applicable requirements of the American Society of Mechanical Engineers, Powers Boilers (section I).

(2) All pressure vessels which are a part of, or used with, pile driving equipment shall meet the applicable requirements of the American Society of Mechanical Engineers, Pressure Vessels (section VIII).

(3) Overhead protection, which will not obscure the vision of the operator, meets the requirements of Subpart N of this part, shall be provided. Protection shall be the equivalent of 2-inch planking or other solid material of equivalent strength.

(4) Stop blocks shall be provided for the leads to prevent the hammer from being raised against the head block.

(5) A blocking device, capable of safely supporting the weight of the hammer, shall be provided for placement in the leads under the hammer at all times while employees are working under the hammer.

(6) Guards shall be provided across the top of the head block to prevent the cable from jumping out of the sheaves.

(7) When the leads must be inclined in the driving of batter piles, provisions shall be made to stabilize the leads.

(8) Fixed leads shall be provided with ladder, and adequate rings, or similar attachment points, so that the loft

worker may engage his safety belt lanyard to the leads. If the leads are provided with loft platform(s), such platform(s) shall be protected by standard guardrails.

(9) Steam hose leading to a steam hammer or jet pipe shall be securely attached to the hammer with an adequate length of at least 1/4-inch diameter chain or cable to prevent whipping in the event the joint at the hammer is broken. Air hammer hoses shall be provided with the same protection as required for steam lines.

(10) Safety chains, or equivalent means, shall be provided for each hose connection to prevent the line from thrashing around in case the coupling becomes disconnected.

(11) Steam line controls shall consist of two shutoff valves, one of which shall be a quick-acting lever type within easy reach of the hammer operator.

(12) Guys, outriggers, thrustouts, or counterbalances shall be provided as necessary to maintain stability of pile driver rigs.

(b) *Pile driving from barges and floats.* Barges or floats supporting pile driving operations shall meet the applicable requirements of § 1518.605.

(c) *Pile driving equipment.* (1) Engineers and winchmen shall accept signals only from the designated signalmen.

(2) All employees shall be kept clear when piling is being hoisted into the leads.

(3) When piles are being driven in an excavated pit, the walls of the pit shall be sloped to the angle of repose or sheet-piled and braced.

(4) When steel tube piles are being "blown out", employees shall be kept well beyond the range of falling materials.

(5) When it is necessary to cut off the tops of driven piles, pile driving operations shall be suspended except where the cutting operations are located at least twice the length of the longest pile from the driver.

(6) When driving jacked piles, all access pits shall be provided with ladders and bulkheaded curbs to prevent material from falling into the pit.

§ 1518.604 Site clearing.

(a) *General requirements.* (1) Employees engaged in site clearing shall be protected from hazards of irritant and toxic plants and suitably instructed in the first aid treatment available.

(2) All equipment used in site clearing operations shall be equipped with rollover guards meeting the requirements of this subpart. In addition, rider-operated equipment shall be equipped with an overhead and rear canopy guard meeting the following requirements:

(i) The overhead covering on this canopy structure shall be of not less than 1/8-inch steel plate or 1/4-inch woven wire mesh with openings no greater than 1 inch, or equivalent.

(ii) The opening in the rear of the canopy structure shall be covered with not less than 1/4-inch woven wire mesh with openings no greater than 1 inch.

(b) *Specific requirements.* [Reserved]

§ 1518.605 Marine operations and equipment.

(a) *Material handling operations.* (1) Operations fitting the definition of "material handling" shall be performed in conformance with applicable requirements of 29 CFR Part 1504, "Safety and Health Regulations for Longshoring." The term "longshoring operations" means the loading, unloading, moving, or handling of construction materials, equipment and supplies, etc. into, in, on, or out of any vessel from a fixed structure or shore-to-vessel, vessel-to-shore or fixed structure or vessel-to-vessel.

(b) *Access to barges.* (1) Ramps for access of vehicles to or between barges shall be of adequate strength, provided with side boards, well maintained, and properly secured.

(2) Unless employees can step safely to or from the wharf, float, barge, or river towboat, either a ramp, meeting the requirements of subparagraph (1) of this paragraph, or a safe walkway, shall be provided.

(3) Jacob's ladders shall be of the double rung or flat tread type. They shall be well maintained and properly secured.

(4) A Jacob's ladder shall either hang without slack from its lashings or be pulled up entirely.

(5) When the upper end of the means of access rests on or is flush with the top of the bulwark, substantial steps, properly secured and equipped with at least one substantial hand rail approximately 33 inches in height, shall be provided between the top of the bulwark and the deck.

(6) Obstructions shall not be laid on or across the gangway.

(7) The means of access shall be adequately illuminated for its full length.

(8) Unless the structure makes it impossible, the means of access shall be so located that the load will not pass over employees.

(c) *Working surfaces of barges.* (1) Employees shall not be permitted to walk along the sides of covered lighters or barges with coamings more than 5 feet high, unless there is a 3-foot clear walkway, or a grab rail, or a taut handline is provided.

(2) Decks and other working surfaces shall be maintained in a safe condition.

(3) Employees shall not be permitted to pass fore and aft, over, or around deckloads, unless there is a safe passage.

(4) Employees shall not be permitted to walk over deckloads from rail to coaming unless there is a safe passage. If it is necessary to stand at the outboard or inboard edge of the deckload where less than 24 inches of bulwark, rail, coaming, or other protection exists, all employees shall be provided with a suitable means of protection against falling from the deckload.

(d) *First-aid and lifesaving equipment.* (1) Provisions for rendering first aid and medical assistance shall be in accordance with Subpart D of this part.

(2) The employer shall ensure that there is in the vicinity of each barge in use at least one U.S. Coast Guard-approved 30-inch lifering with not less

than 90 feet of line attached, and at least one portable or permanent ladder which will reach the top of the apron to the surface of the water. If the above equipment is not available at the pier, the employer shall furnish it during the time that he is working the barge.

(3) Employees walking or working on the unguarded decks of barges shall be protected with U.S. Coast Guard-approved work vests or buoyant vests.

(e) *Diving operations.* [Reserved]

§ 1518.606 Definitions applicable to this subpart.

(a) "Apron"—The area along the waterfront edge of the pier or wharf.

(b) "Bulwark"—The side of a ship above the upper deck.

(c) "Coaming"—The raised frame, as around a hatchway in the deck, to keep out water.

(d) "Jacob's ladder"—A marine ladder of rope or chain with wooden or metal rungs.

(e) "Rail", for the purpose of § 1518.605, means a light structure serving as a guard at the outer edge of a ship's deck.

Subpart P—Excavations, Trenching, and Shoring

§ 1518.650 General protection requirements.

(a) Walkways, runways, and sidewalks shall be kept clear of excavated material or other obstructions and no sidewalks shall be undermined unless shored to carry a minimum live load of one hundred and twenty-five (125) pounds per square foot.

(b) If planks are used for raised walkways, runways, or sidewalks, they shall be laid parallel to the length of the walk and fastened together against displacement.

(c) Planks shall be uniform in thickness and all exposed ends shall be provided with beveled cleats to prevent tripping.

(d) Raised walkways, runways, and sidewalks shall be provided with plank steps on strong stringers. Ramps, used in lieu of steps, shall be provided with cleats to insure a safe walking surface.

(e) All employees shall be protected with personal protective equipment for the protection of the head, eyes, respiratory organs, hands, feet, and other parts of the body as set forth in Subpart E of this part.

(f) Employees exposed to vehicular traffic shall be provided with and shall be instructed to wear warning vests marked with or made of reflectorized or high visibility material.

(g) Employees subjected to hazardous dusts, gases, fumes, mists, or atmospheres deficient in oxygen, shall be protected with approved respiratory protection as set forth in Subpart D of this part.

(h) No person shall be permitted under loads handled by power shovels, derricks, or hoists. To avoid any spillage, employees shall be required to stand away from any vehicle being loaded.

(i) Daily inspections of excavations shall be made by a competent person. If evidence of possible cave-ins or slides is

apparent, all work in the excavation shall cease until the necessary precautions have been taken to safeguard the employees.

§ 1518.651 General excavation requirements.

- (a) Prior to opening an excavation, effort shall be made to determine whether underground installations; i.e., sewer, water, fuel, electric lines, etc., will be encountered, and, if so, where such underground installations are located. When the excavation approaches the estimated location of such an installation, the exact location shall be determined by careful probing or hand digging, and when it is uncovered, proper supports shall be provided for the existing installation. Utility companies shall be contacted and advised of proposed work prior to the start of actual excavation.
- (b) Trees, boulders, and other surface encumbrances, located so as to create a hazard to employees involved in excavation work or in the vicinity thereof at any time during operations, shall be removed or made safe before excavating is begun.
- (c) Excavations shall be inspected by a competent person after every rainstorm or other hazard-increasing occurrence, and the protection against slides and cave-ins shall be increased if necessary.
- (d) The determination of the angle of repose and design of the supporting system shall be based on careful evaluation of pertinent factors such as: Depth of cut; possible variation in water content of the material while the excavation is open; anticipated changes in materials from exposure to air, sun, water, or freezing; loading imposed by structures, equipment, overlying material, or stored material; and vibration from equipment, blasting, traffic, or other sources.
- (e) Supporting systems; i.e., piling, cribbing, shoring, etc., shall be designed by a qualified person and meet accepted engineering requirements. When tie rods are used to restrain the top of sheeting or other retaining systems, the rods shall be securely anchored well back of the angle of repose. When tight sheeting or sheet piling is used, full loading due to ground water table shall be assumed, unless prevented by weep holes or drains or other means. Additional stringers, ties, and bracing shall be provided to allow for any necessary temporary removal of individual supports.
- (f) All slopes shall be excavated to at least the angle of repose except for areas where solid rock allows for line drilling or presplitting.
- (g) The angle of repose shall be flattened when an excavation has water conditions, silty materials, loose boulders, and areas where erosion, deep frost action, and slide planes appear.
- (h) Excavated or other material shall not be stored nearer than 4 feet from the edge of any excavation and shall be so stored and retained as to prevent its falling or sliding back in to the excavation.
- (i) Sides, slopes, and faces of all excavations shall meet accepted engineering

requirements by scaling, benching, barricading, rock bolting, wire meshing, or other equally effective means. Special attention shall be given to slopes which may be adversely affected by weather or moisture content.

(j) Support systems shall be planned and designed by a qualified person when excavation is in excess of 20 feet in depth, adjacent to structures or improvements, or subject to vibration or ground water.

(k) Materials used for sheeting, sheet piling, cribbing, bracing, shoring, and underpinning shall be in good serviceable condition, and timbers shall be sound, free from large or loose knots, and of proper dimensions.

(l) Special precautions shall be taken in sloping or shoring the sides of excavations adjacent to a previously backfilled excavation or a fill, particularly when the separation is less than the depth of the excavation. Particular attention also shall be paid to joints and seams of material comprising a face and the slope of such seams and joints.

(m) Except in hard rock, excavations below the level of the base of footing of any foundation or retaining wall shall not be permitted, unless the wall is underpinned and all other precautions taken to ensure the stability of the adjacent walls for the protection of employees involved in excavation work or in the vicinity thereof.

(n) If the stability of adjoining buildings or walls is endangered by excavations, shoring, bracing, or underpinning shall be provided as necessary to ensure their safety. Such shoring, bracing, or underpinning shall be inspected daily or more often, as conditions warrant, by a competent person and the protection effectively maintained.

(o) Diversion ditches, dikes, or other suitable means shall be used to prevent surface water from entering an excavation and to provide adequate drainage of the area adjacent to the excavation. Water shall not be allowed to accumulate in an excavation.

(p) If it is necessary to place or operate power shovels, derricks, trucks, materials, or other heavy objects on a level above and near an excavation, the side of the excavation shall be sheet-piled, shored, and braced as necessary to resist the extra pressure due to such superimposed loads.

(q) Blasting and the use of explosives shall be performed in accordance with Subpart U of this part.

(r) When mobile equipment is utilized or allowed adjacent to excavations, substantial stop logs or barricades shall be installed. If possible, the grade should be away from the excavation.

(s) Adequate barrier physical protection shall be provided at all remotely located excavations. All wells, pits, shafts, etc., shall be barricaded or covered. Upon completion of exploration and similar operations, temporary wells, pits, shafts, etc., shall be backfilled.

(t) If possible, dust conditions shall be kept to a minimum by the use of water, salt, calcium chloride, oil, or other means.

(u) In locations where oxygen deficiency or gaseous conditions are possible,

air in the excavation shall be tested. Controls, as set forth in Subparts D and E of this part, shall be established to assure acceptable atmospheric conditions. When flammable gases are present, adequate ventilation shall be provided or sources of ignition shall be eliminated. Attended emergency rescue equipment, such as breathing apparatus, a safety harness and line, basket stretcher, etc., shall be readily available where adverse atmospheric conditions may exist or develop in an excavation.

(v) Where employees or equipment are required or permitted to cross over excavations, walkways or bridges with standard guardrails shall be provided.

(w) Where ramps are used for employees or equipment, they shall be designed and constructed by qualified persons in accordance with accepted engineering requirements.

(x) All ladders used on excavation operations shall be in accordance with the requirements of Subpart L of this part.

§ 1518.652 General trenching requirements.

(a) Banks more than four feet high shall be shored or sloped to the angle of repose where a danger of slides or cave-ins exists as a result of excavation.

(b) Sides of trenches in unstable or soft material, four feet or more in depth, shall be shored, sheeted, braced, sloped, or otherwise supported by means of sufficient strength to protect the employees working within them. See Tables P-1, P-2 [following paragraph (g) of this section.]

(c) Sides of trenches in hard or compact soil, including embankments, shall be shored or otherwise supported when the trench is more than 4 feet in depth and 8 feet or more in length. In lieu of shoring, the sides of the trench above the 4-foot level may be sloped to preclude collapse, but shall not be steeper than a 1-foot rise to each ½-foot horizontal. When the outside diameter of a pipe is greater than 6 feet, a bench of 4-foot minimum shall be provided at the toe of the sloped portion.

(d) Materials used for sheeting and sheet piling, bracing, shoring, and underpinning, shall be in good serviceable condition, and timbers used shall be sound and free from large or loose knots, and shall be designed and installed so as to be effective to the bottom of the excavation.

(e) Additional precautions by way of shoring and bracing shall be taken to prevent slides or cave-ins when excavations or trenches are made in locations adjacent to backfilled excavations, or where excavations are subjected to vibrations from railroad or highway traffic, the operation of machinery, or any other source.

(f) Employees entering bell-bottom pier holes shall be protected by the installation of a removable-type casing of sufficient strength to resist shifting of the surrounding earth. Such temporary protection shall be provided for the full depth of that part of each pier hole which is above the bell. A lifeline, suitable for instant rescue and securely

fastened to a shoulder harness, shall be worn by each employee entering the shafts. This lifeline shall be individually manned and separate from any line used to remove materials excavated from the bell footing.

(g) Minimum requirements for trench timbering shall be in accordance with Table P-2.

(h) Where employees are required to be in trenches 3 feet deep or more, ladders, extending from the floor of the trench excavation to at least 3 feet above the top of the excavation, shall be provided and so located as to provide means of exit without more than 25 feet of lateral travel.

Table P-1

APPROXIMATE ANGLE OF REPOSE FOR SLOPING OF SIDES OF EXCAVATIONS

Note: Clays, Silts, Loams or Non-Homogenous Soils Require Shoring and Bracing. The Presence of Ground Water Requires Special Treatment.

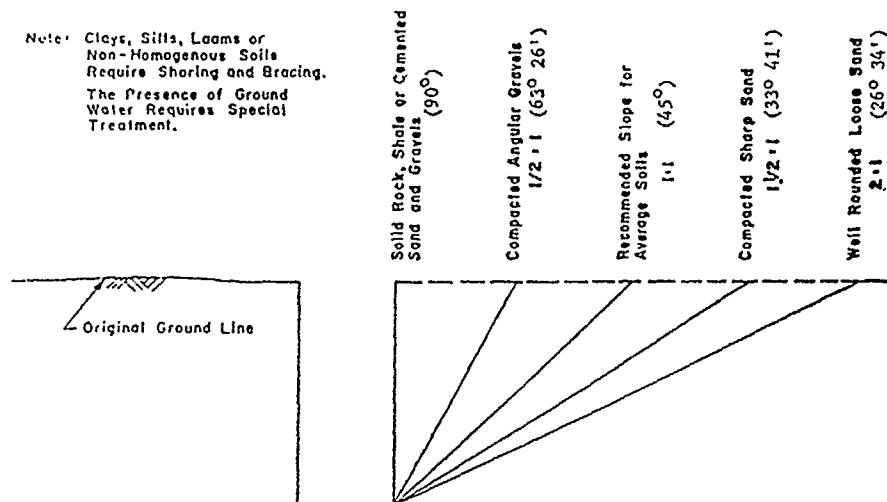


TABLE P-2

TRENCH SHORING—MINIMUM REQUIREMENTS

Depth of trench	Kind or condition of earth	Size and spacing of members									
		Uprights		Stringers		Cross braces*				Max. spacing	
		Min. dim.	Max. spec.	Min. dim.	Max. spec.	Width of trench					
Feet		Inches	Feet	Inches	Feet	Inches	Inches	Inches	Inches	Feet	Feet
4 to 10	Hard, compact.....	3 x 4 or 2 x 6	6			2 x 6	4 x 4	4 x 6	6 x 6	4	6
	Likely to crack.....	"	3	4 x 6	4	"	"	"	"	"	"
	Soft, sandy, or filled....	"	Close sheeting	4 x 6	"	4 x 4	4 x 6	6 x 6	8 x 8	"	"
	Hydrostatic pressure....	"	"	6 x 8	"	"	"	"	"	"	"
10 to 16	Hard.....	"	4	4 x 6	"	"	"	"	"	"	"
	Likely to crack.....	"	2	4 x 6	4	"	"	"	"	"	"
	Soft, sandy, or filled....	"	Close sheeting	4 x 6	"	4 x 6	6 x 6	8 x 8	8 x 8	"	"
	Hydrostatic pressure....	2 x 6	"	8 x 10	"	"	"	"	"	"	"
16 to 20	All kinds or conditions..	"	Close sheeting	4 x 12	"	4 x 12	8 x 8	8 x 8	8 x 10	"	"
	All kinds or conditions..	"	"	6 x 8	"	"	8 x 8	8 x 10	10 x 10	"	"
Over 20	All kinds or conditions..	"	"	"	"	"	"	"	"	"	"

*Trench jacks may be used in lieu of, or in combination with, cross braces.

Shoring is not required in solid rock, hard shale, or hard slag.

Where desirable, steel sheet piling and bracing of equal strength may be substituted for wood.

(i) Bracing or shoring of trenches shall be carried along with the excavation.

(j) Cross braces or trench jacks shall be placed in true horizontal position, be spaced vertically, and be secured to prevent sliding, falling, or kick-outs.

(k) Portable trench boxes or sliding trench shields may be used for the protection of employees only. Trench boxes or shields shall be designed, constructed, and maintained to meet acceptable engineering standards.

(l) Backfilling and removal of trench supports shall progress together from the bottom of the trench. Jacks or braces shall be released slowly and, in unstable soil, ropes shall be used to pull out the jacks or braces from above after employees have cleared the trench.

§ 1518.653 Definitions applicable to this subpart.

(a) "Accepted engineering requirements (or practices)"—Those requirements or practices which are compatible with standards required by a registered architect, a registered professional engineer, or other duly licensed or recognized authority.

(b) "Angle of repose"—The greatest angle above the horizontal plane at which a material will lie without sliding.

(c) "Bank"—A mass of soil rising above a digging level.

(d) "Belled excavation"—A part of a shaft or footing excavation, usually near the bottom and bell-shaped; i.e., an enlargement of the cross section above.

(e) "Braces (trench)"—The horizontal members of the shoring system whose ends bear against the uprights or stringers.

(f) "Excavation"—Any manmade cavity or depression in the earth's surface, including its sides, walls, or faces, formed by earth removal and producing unsupported earth conditions by reasons of the excavation. If installed forms or similar structures reduce the depth-to-width relationship, an excavation may become a trench.

(g) "Faces"—See paragraph (k) of this section.

(h) "Hard compact soil"—All earth materials not classified as running or unstable.

(i) "Kickouts"—Accidental release or failure of a shore or brace.

(j) "Sheet pile"—A pile, or sheeting, that may form one of a continuous interlocking line, or a row of timber, concrete, or steel piles, driven in close contact to provide a tight wall to resist the lateral pressure of water, adjacent earth, or other materials.

(k) "Sides" "Walls" or "Faces"—The vertical or inclined earth surfaces formed as a result of excavation work.

(l) "Slope"—The angle with the horizontal at which a particular earth material will stand indefinitely without movement.

(m) "Stringers" (wales)—The horizontal members of a shoring system whose sides bear against the uprights or earth.

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(n) "Trench"—A narrow excavation made below the surface of the ground. In general, the depth is greater than the width, but the width of a trench is not greater than 15 feet.

(o) "Trench jack"—Screw or hydraulic type jacks used as cross bracing in a trench shoring system.

(p) "Trench shield"—A shoring system composed of steel plates and bracing, welded or bolted together, which support the walls of a trench from the ground level to the trench bottom and which can be moved along as work progresses.

(q) "Unstable soil"—Earth material, other than running, that because of its nature or the influence of related conditions, cannot be depended upon to remain in place without extra support, such as would be furnished by a system of shoring.

(r) "Uprights"—The vertical members of a shoring system.

(s) "Wales"—See paragraph (m) of this section.

(t) "Walls"—See paragraph (k) of this section.

Subpart Q—Concrete, Concrete Forms and Shoring

§ 1518.700 General provisions.

(a) *General.* All equipment and materials used in concrete construction and masonry work shall meet the applicable requirements for design, construction, inspection, testing, maintenance and operations as prescribed in ANSI A10.9-1970, Safety Requirements for Concrete Construction and Masonry Work.

(b) *Reinforcing steel.* (1) Employees placing and tying reinforcing steel in walls, piers, columns, etc., shall be provided with, and directed to wear safety belts which are properly secured, as set forth in Subpart E of this part.

(2) Employees shall not be permitted to work above vertically protruding reinforcing steel unless it has been protected to eliminate the hazard of impalement.

(3) *Guying.* Reinforcing steel for walls, piers, columns, and similar vertical structures shall be guyed and supported to prevent collapse.

(4) *Wire mesh rolls.* Wire mesh rolls shall be secured at each end to prevent dangerous recoiling action.

(c) *Bulk concrete handling.* Bulk storage bins, containers, or silos shall have conical or tapered bottoms with mechanical or pneumatic means of starting the flow of material.

(d) *Concrete placement.*—(1) *Concrete mixers.* Concrete mixers equipped with 1-yard or larger loading skips shall be equipped with a mechanical device to clear the skip of material.

(2) *Guardrails.* Mixers of 1-yard capacity or greater shall be equipped with protective guardrails installed on each side of the skip.

(3) *Bull floats.* Handles on bull floats shall be constructed of nonconductive material.

(4) *Powered concrete trowels.* Powered and rotating-type concrete troweling machines that are manually guided shall be equipped with a control switch

that will automatically shut off the power whenever the operator removes his hands from the equipment handles.

(5) *Concrete buggies.* Handles of buggies shall not extend beyond the wheels on either side of the buggy. Installation of knuckle guards on buggy handles is recommended.

(6) *Pumpcrete systems.* Pumpcrete or similar systems using discharge pipes shall be provided with pipe supports designed for 100 percent overload. Compressed air hose in such systems shall be provided with positive fail-safe joint connectors to prevent separation of sections when pressurized.

(7) *Concrete buckets.* (i) Concrete buckets equipped with hydraulic or pneumatically operated gates shall have positive safety latches or similar safety devices installed to prevent aggregate and loose material from accumulating on the top and sides of the bucket.

(ii) Riding of concrete buckets for any purpose shall be prohibited, and vibrator crews shall be kept out from under concrete buckets suspended from cranes or cableways.

(8) When discharging on a slope, the wheels of ready-mix trucks shall be blocked and the brakes set to prevent movement.

(9) Nozzlemen applying a cement, sand, and water mixture through a pneumatic hose shall be required to wear protective head and face equipment, as prescribed in Subpart E of this part.

(e) *Vertical shoring.*—(1) *General requirements.* (i) When temporary storage of reinforcing rods, material, or equipment on top of formwork becomes necessary, these areas shall be strengthened to meet the intended loads.

(ii) The sills for shoring shall be sound, rigid, and capable of carrying the maximum intended load without settlement or displacement.

(iii) All shoring equipment shall be inspected prior to erection to determine that it is as specified in the shoring layout. Any equipment found to be damaged shall not be used for shoring.

(iv) Erected shoring equipment shall be inspected immediately prior to, during, and immediately after the placement of concrete. Any shoring equipment that is found to be damaged or weakened shall be immediately reinforced or reshored.

(v) Reshoring shall be provided when necessary to safely support slabs and beams after stripping, or where such members are subjected to superimposed loads due to construction work done.

(2) *Tubular welded frame shoring.* (i) Metal tubular frames used for shoring shall not be loaded beyond the safe working load recommended by the manufacturer.

(ii) All locking devices on frames and braces shall be in good working order; coupling pins shall align the frame or panel legs; pivoted cross braces shall have their center pivot in place; and all components shall be in a condition similar to that of original manufacture.

(iii) When checking the erected shoring frames with the shoring layout, the spacing between towers and cross brace

spacing shall not exceed that shown on the layout, and all locking devices shall be in the closed position.

(iv) Devices for attaching the external lateral stability bracing shall be securely fastened to the legs of the shoring frames.

(v) All baseplates, shore heads, extension devices, or adjustment screws shall be in firm contact with the footing sill and the form.

§ 1518.701 Forms and shoring.

(a) *General provisions.* (1) Formwork and shoring shall be designed, erected, supported, braced, and maintained so that it will safely support all vertical and lateral loads that may be imposed upon it during placement of concrete.

(2) Drawings or plans showing the jack layout, formwork, shoring, working decks, and scaffolding, shall be available at the jobsite.

(3) Stripped forms and shoring shall be removed and stockpiled promptly after stripping, in all areas in which persons are required to work or pass. Protruding nails, wire ties, and other form accessories not necessary to subsequent work shall be pulled, cut, or other means taken to eliminate the hazard.

(4) Imposition of any construction loads on the partially completed structure shall not be permitted unless such loading has been considered in the design and approved by the engineer-architect.

(b) *Vertical slip forms.* (1) The steel rods or pipe on which the jacks climb or by which the forms are lifted shall be specifically designed for the purpose. Such rods shall be adequately braced where not encased in concrete.

(2) Jacks and vertical supports shall be positioned in such a manner that the vertical loads are distributed equally and do not exceed the capacity of the jacks.

(3) The jacks or other lifting devices shall be provided with mechanical dogs or other automatic holding devices to provide protection in case of failure of the power supply or the lifting mechanism.

(4) Lifting shall proceed steadily and uniformly and shall not exceed the predetermined safe rate of lift.

(5) Lateral and diagonal bracing of the forms shall be provided to prevent excessive distortion of the structure during the jacking operation.

(6) During jacking operations, the form structure shall be maintained in line and plumb.

(7) All vertical lift forms shall be provided with scaffolding or work platforms completely encircling the area of placement.

(c) *Tube and coupler shoring.* (1) Couplers (clamps) shall not be used if they are deformed, broken, or have defective or missing threads on bolts, or other defects.

(2) The material used for the couplers (clamps) shall be of a structural type such as drop-forged steel, malleable iron, or structural grade aluminum. Gray cast iron shall not be used.

(3) When checking the erected shoring towers with the shoring layout, the spacing between posts shall not exceed

that shown on the layout, and all interlocking of tubular members and tightening of couples shall be checked.

(4) All baseplates, shore heads, extension devices, or adjustment screws shall be in firm contact with the footing sill and the form material and shall be snug against the posts.

(d) *Single post shores.* (1) For stability, single post shores shall be horizontally braced in both the longitudinal and transverse directions, and diagonal bracing shall also be installed. Such bracing shall be installed as the shores are being erected.

(2) All baseplates or shore heads of single post shores shall be in firm contact with the footing sill and the form materials.

(3) Whenever single post shores are used in more than one tier, the layout shall be designed and inspected by a structural engineer.

(4) When formwork is at an angle, or sloping, or when the surface shored from is sloping, the shoring shall be designed for such loading.

(5) Adjustment of single post shores to raise formwork shall not be made after concrete is in place.

(6) Fabricated single post shores shall not be used if heavily rusted, bent, dented, rewelded, or having broken weldments or other defects. If they contain timber, they shall not be used if timber is split, cut, has sections removed, is rotted, or otherwise structurally damaged.

(7) All timber and adjusting devices to be used for adjustable timber single post shores shall be inspected before erection.

(8) Timber shall not be used if it is split, cut, has sections removed, is rotted, or is otherwise structurally damaged.

(9) Adjusting devices shall not be used if heavily rusted, bent, dented, rewelded, or having broken weldments or other defects.

(10) All nails used to secure bracing or adjustable timber single post shores shall be driven home and the point of the nail bent over if possible.

§ 1518.702 Definitions applicable to this subpart.

(a) "Bull float"—A tool used to spread out and smooth the concrete.

(b) "Formwork" or "falsework"—The total system of support for freshly placed concrete, including the mold or sheathing which contacts the concrete as well as all supporting members, hardware, and necessary bracing.

(c) "Guy"—A line that steadies a high place or structure by pulling against an off-center load.

(d) "Shore"—A supporting member that resists a compressive force imposed by a load.

(e) "Vertical slip forms"—Forms which are jacked vertically and continuously during placing of the concrete.

Subpart R—Steel Erection

§ 1518.750 Flooring requirements.

(a) *Permanent flooring—skeleton steel construction in tiered buildings.* (1) The

permanent floors shall be installed as the erection of structural members progresses, and there shall be not more than eight stories between the erection floor and the uppermost permanent floor, except where the structural integrity is maintained as a result of the design.

(2) At no time shall there be more than four floors or 48 feet of unfinished bolting or welding above the foundation or uppermost permanently secured floor.

(b) *Temporary flooring—skeleton steel construction in tiered buildings.* (1) (i) The derrick or erection floor shall be solidly planked over its entire surface except for access openings. Planking shall be of proper thickness to carry the working load, but shall be not less than 2 inches thick full size undressed, and shall be laid tight and secured to prevent movement.

(ii) On buildings or structures not adaptable to temporary floors, and where scaffolds are not used, safety nets shall be installed and maintained whenever the potential fall distance exceeds two stories or 25 feet. The nets shall be hung with sufficient clearance to prevent contacts with the surface of structures below.

(iii) *Floor periphery—safety railing.* A safety railing of ½-inch wire rope or equal shall be installed, approximately 42 inches high, around the periphery of all temporary-planked or temporary metal-decked floors of tier buildings and other multifloored structures during structural steel assembly.

(2) Where erection is being done by means of a crane operating on the ground, a tight and substantial floor shall be maintained within two stories or 25 feet, whichever is less, below and directly under that portion of each tier of beams on which bolting, riveting, welding, or painting is being done.

(c) *Flooring—other construction.* (1) In the erection of a building having double wood floor construction, the rough flooring shall be completed as the building progresses, including the tier below the one on which floor joists are being installed.

(2) For single wood floor or other flooring systems, the floor immediately below the story where the floor joists are being installed shall be kept planked over.

§ 1518.751 Structural steel assembly.

(a) During the final placing of solid web structural members, the load shall not be released from the hoisting line until the members are secured with not less than two bolts, or the equivalent at each connection and drawn up wrench tight.

(b) Open web steel joists shall not be placed on any structural steel framework unless such framework is safely bolted or welded.

(c) In steel framing, where bar joists are utilized, and columns are not framed in at least two directions with structural steel members, a bar joist shall be field-bolted at columns to provide lateral stability during construction.

(i) Where long span joists or trusses, 40 feet or longer, are used, a center row

of bolted bridging shall be installed to provide lateral stability during construction prior to slacking of hoisting line.

(ii) No load shall be placed on open web steel joists until these security requirements are met.

(d) Tag lines shall be used for controlling loads.

§ 1518.752 Bolting, riveting, fitting-up, and plumbing-up.

(a) *General requirements.* (1) Containers shall be provided for storing or carrying rivets, bolts, and drift pins, and secured against accidental displacement when aloft.

(2) Pneumatic hand tools shall be disconnected from the power source, and pressure in hose lines shall be released, before any adjustments or repairs are made.

(3) Air line hose sections shall be tied together except when quick disconnect couplers are used to join sections.

(4) Eye protection shall be provided in accordance with Subpart E of this part.

(b) *Bolting.* (1) When bolts or drift pins are being knocked out, means shall be provided to keep them from falling.

(2) Impact wrenches shall be provided with a locking device for retaining the socket.

(c) *Riveting.* (1) Riveting shall not be done in the vicinity of combustible material unless precautions are taken to prevent fire.

(2) When rivet heads are knocked off, or backed out, means shall be provided to keep them from falling.

(3) A safety wire shall be properly installed on the snap and on the handle of the pneumatic riveting hammer and shall be used at all times. The wire size shall be not less than No. 9 (B&S gauge), leaving the handle and annealed No. 14 on the snap, or equivalent.

(d) *Plumbing-up.* (1) Connections of the equipment used in plumbing-up shall be properly secured.

(2) The turnbuckles shall be secured to prevent unwinding while under stress.

(3) Plumbing-up guys related equipment shall be placed so that employees can get at the connection points.

(4) Plumbing-up guys shall be removed only under the supervision of a competent person.

(e) Wood planking shall be of proper thickness to carry the working load, but shall be not less than 2 inches thick full size undressed, exterior grade plywood, at least ¾-inch thick, or equivalent material.

(f) Metal decking of sufficient strength shall be laid tight and secured to prevent movement.

(g) Planks shall overlap the bearing on each end by a minimum of 12 inches.

(h) Wire mesh, exterior plywood, or equivalent, shall be used around columns where planks do not fit tightly.

(i) Provisions shall be made to secure temporary flooring against displacement.

(j) All unused openings in floors, temporary or permanent, shall be completely planked over or guarded in accordance with Subpart M of this part.

(k) Employees shall be provided with safety belts in accordance with

§ 1518.104 when they are working on float scaffolds.

Subpart S—Tunnels and Shafts, Caissons, Cofferdams, and Compressed Air

§ 1518.800 Tunnels and shafts.

(a) *General.* (1) The specific requirements of this Subpart S, Tunnels, Shafts, Caissons, Cofferdams, and Compressed Air, shall be complied with as well as the applicable provisions of all other subparts of this part.

(2) Safe means of access shall be provided and maintained to all working places.

(3) When ladders and stairways are provided in shafts and steep inclines, they shall meet the requirements of Subparts L and M of this part.

(4) Access to unattended underground openings shall be restricted by gates or doors. Unused chutes, manways, or other openings shall be tightly covered, bulkheaded, or fenced off, and posted. Conduits, trenches, and manholes shall meet the requirements of Subpart M of this part.

(5) Subsidence areas that present hazards shall be fenced and posted.

(6) Each operation shall have a check-in and check-out system that will provide positive identification of every employee underground. An accurate record and location of the employees shall be kept on the surface.

(b) *Emergency provisions.* (1) Evacuation plans and procedures shall be developed and made known to the employees.

(2) Emergency hoisting facilities shall be readily available at shafts more than 50 feet in depth, unless hoisting facilities are provided that are independent of electrical power failures. A boatswain's chair shall meet the requirements of Subpart L of this part.

(3) Bureau of Mines approved self-rescuers shall be available near the advancing face to equip each face employee. Such equipment shall be on the haulage equipment and in other areas where employees might be trapped by smoke or gas, and shall be maintained in good condition.

(4) Telephone or other signal communication shall be provided between the work face and the tunnel portal, and such systems shall be independent of the tunnel power supply.

(c) *Air Quality and Ventilation.* (1) *Air quality and quantity.* (i) Instruments shall be provided to test the atmosphere quantitatively for carbon monoxide, nitrogen dioxide, flammable or toxic gases, dusts, mists, and fumes that occur in the tunnel or shaft. Tests shall be conducted as frequently as necessary to assure that the required quality and quantity of air is maintained. A record of all tests shall be maintained and be kept available.

(ii) Field-type oxygen analyzers, or other suitable devices, shall be used to test for oxygen deficiency.

(iii) Respirators shall not be substituted for environmental control mea-

sures. However, where environmental controls have not yet been developed, or when necessary by the nature of the work involved (for example, welding, sand blasting, lead burning), an employee may work for short periods of time in concentrations of airborne contaminants which exceed the limit of permissible excursions referred to in subdivisions (iv) and (v) of this subparagraph, if such employee wears a respiratory protective device approved by the Bureau of Mines as protection against the particular hazards involved.

(iv) The exposure to airborne contaminants of an employee working in a tunnel or shaft shall not exceed the threshold limit values adopted by the American Conference of Governmental Industrial Hygienists, as set forth and explained in the 1970 edition of "Threshold Limit Values of Airborne Contaminants."

(v) Employees shall be withdrawn from areas in which there is a concentration of an airborne contaminant which exceeds the threshold limit value listed for that contaminant.

(vi) Atmospheres in all active areas shall contain at least 20 percent oxygen.

(2) *Ventilation.* (i) Tunnels shall be provided with mechanically induced primary ventilation in all work areas. The direction of airflow shall be reversible.

(ii) Ventilation doors, not operated mechanically, shall be designed and installed so that they are self-closing and will remain closed regardless of the direction of the air movement.

(iii) When there has been a failure of ventilation, and ventilation has been restored in a reasonable time, all places where flammable gas may have accumulated shall be examined by a competent person and determined to be free of flammable gas before power is restored and work resumed.

(iv) When the main fan or fans have been shut down with all employees out of the adit, tunnel or shaft, no employee, other than those qualified to examine the adit, tunnel, or shaft, or other authorized employee, shall go underground until the fans have been started, the work areas examined for gas and other hazards, and declared safe.

(v) The supply of fresh air shall not be less than 200 cubic feet per minute for each employee underground. The linear velocity of the air flow in the tunnel bore shall not be less than 30 feet per minute in those tunnels where blasting or rock drilling is conducted or where there are other conditions that are likely to produce dusts, fumes, vapors, or gases in harmful quantities.

(vi) If 1.5 percent or higher concentration of flammable gas is detected in air returning from an underground working place or places, the employees shall be withdrawn and the power cut off to the portion of the area endangered by such flammable gas until the concentration of such gas is reduced to 1 percent or less.

(vii) Internal combustion engines other than mobile diesel shall not be used underground. Mobile diesel-powered

equipment used underground shall be certified by the Bureau of Mines, U.S. Department of the Interior according to the Interior according to the Bureau of Mines publication "Mechanical Equipment for mines—tests for permissibility and suitability, Part 32, Mobile Diesel Power Equipment for Non-Coal Mines, Schedule 24" of March 23, 1965.

(d) *Illumination.* (1) Sufficient lighting shall be provided, in accordance with the requirements of Table D-3 of Subpart D of this part, to permit safe operations at the face as well as in the general tunnel or shaft area and at the employees' workplace.

(e) *Fire prevention and control.* (1) *General.* (i) The requirements for fire prevention and protection specified in Subpart F of this part shall be complied with in all tunnel and shaft operations.

(ii) Signs warning against smoking and open flames shall be posted so that they can be readily seen in areas or places where fire or explosion hazards exist.

(iii) The carrying of matches, lighters, or other flame-producing smoking materials shall be prohibited in all underground operations where fire or explosion hazards exist.

(iv) Not more than a 1 day's supply of diesel fuel shall be stored underground.

(v) Gasoline or liquefied petroleum gases shall not be taken, stored, or used underground.

(vi) Oil, grease, or fuel stored underground shall be kept in tightly sealed containers in fire-resistant areas, at safe distances from explosives magazines, electrical installations, and shaft stations.

(vii) Air that has passed through underground oil or fuel-storage areas shall not be used to ventilate working areas.

(viii) Approved fire-resistant hydraulic fluids shall be used in hydraulically actuated underground machinery and equipment.

(ix) Fires shall not be built underground.

(x) Noncombustible barriers shall be installed below welding or burning operations in or over a shaft or raise.

(xi) Fire extinguishers or equivalent protection shall be provided at the head and tail pulleys or underground belt conveyors and at 300-foot intervals along the belt line.

(xii) At tunnel operations, employing 25 or more employees at one time underground at least two rescue crews (10 employees divided between shifts) shall be trained annually in rescue procedures, in the use, care, and limitations of oxygen breathing apparatus, and the use and maintenance of firefighting equipment. Not less than one crew (5 employees) shall be trained at smaller operations.

(f) *Personal protective equipment.* Protective clothing or equipment shall be worn as specified in Subparts D and E of this part.

(g) *Noise.* (1) Permissible noise exposures shall conform to those specified in Subpart D of this part.

(h) *Ground support*—(1) *Tunnel portal area*. Portals shall be protected and supported where loose soil or rock or fractured material is encountered.

(2) *Tunnel area*. (i) The employer shall examine and test the roof, face, and walls of the work area at the start of each shift and frequently thereafter.

(ii) Loose ground shall be taken down or supported. Ground conditions along haulage ways and travelways shall be examined periodically and scaled or supported as necessary.

(iii) Torque meters and torque wrenches shall be available at tunnels where rock bolts are used for ground support. Frequent tests shall be made to determine if bolts meet the required torque. The test frequency shall be determined by rock conditions and distance from vibration sources.

(iv) Damaged or dislodged tunnel supports, whether steel sets or timber, shall be repaired or replaced. New supports shall be installed whenever possible before removing the damaged supports.

(v) All sets, including horseshoe-shaped or arched rib steel sets, shall be designed and installed so that the bottoms will have required anchorage to prevent pressures from pushing them inward into the excavation. Lateral bracing shall be provided between sets to further stabilize the support.

(3) *Shafts*. (1) Small diameter shafts, which employees are required to enter, shall be provided with a steel casing, concrete pipe, timber, or other material of required strength to support the surrounding earth.

(ii) The casing and bracing shall be provided the full depth of the shaft, or at least 5 feet into solid rock if possible, and shall extend at least 1 foot above ground level.

(iii) All wells or shafts over 5 feet in depth shall be retained with lagging, spiling, or casing.

(iv) In shafts, the employer shall inspect the walls, ladders, timbers, blocking, and wedges of the last set to determine if they have loosened following blasting operations. Where found unsafe, corrections shall be made before shift operations are started.

(v) Safety belts shall be worn on skips and platforms used in shafts by crews when the skip or cage does not conclude the opening to within 1 foot of the sides of the shaft, unless guardrails or cages are provided.

(i) *Drilling*. (1) Equipment that is to be used during a shift shall be inspected each shift by a competent person. Equipment defects affecting safety shall be corrected before the equipment is used.

(2) The drilling area shall be inspected for hazards before starting the drilling operation.

(3) Employees shall not be allowed on a drill mast while the drill bit is in operation.

(4) When a drill is being moved from one drilling area to another, drill steel, tools, and other equipment shall be secured, and the mast placed in a safe position.

(5) Receptacles or racks shall be provided for drill steel stored on jumbos.

(6) Before drilling cycle is started, warning shall be given to men working below jumbo decks.

(7) Drills on columns shall be anchored firmly before drilling is started and shall be retightened frequently thereafter.

(8) The employer shall provide mechanical means for lifting drills, roof bolts, mine straps, and other unwieldy heavy material to the top decks of jumbos over 10 feet in height.

(9) The employer shall provide stair access to jumbo decks wide enough to accommodate two persons if the deck is over 10 feet in height.

(10) On jumbo decks over 10 feet in height, guardrails which are removable (pipe in sockets with chain handrail), or equal, shall be provided on all sides and back platforms.

(11) Scaling bars shall be in good condition at all times, and blunted and severely worn bars shall not be used.

(12) When jumbos are being moved, riders will not be allowed on the jumbo unless they are assisting the driver.

(13) Before commencing the drill cycle, the face and lifters shall be examined for misfires (residual explosives) and, if found, they shall be removed before drilling commences at the face. Lifters shall not be drilled through blasted rock (muck) or water.

(14) Air lines that are buried in the invert shall be identified by signs posted nearby, warning all personnel.

(j) *Blasting*. All blasting and explosives-handling operations shall be conducted in compliance with Subpart U of this part.

(k) *Haulage*. (1) Equipment that is to be used during a shift shall be inspected by a competent person each shift. Equipment defects affecting safety shall be corrected before the equipment is used.

(2) Powered mobile equipment shall be provided with adequate brakes.

(3) Powered mobile haulage equipment shall be provided with audible warning devices. Lights shall be provided at both ends.

(4) Cab windows shall be of safety glass, or equivalent, in good condition, and shall be kept clean.

(5) Adequate backstops or brakes shall be installed on inclined conveyor drive units to prevent conveyors from running in reverse and creating a hazard to employees.

(6) No employee shall be permitted to ride a power-driven chain, belt, or bucket conveyor, unless the conveyor is specifically designed for the transportation of employees.

(7) The employer shall not permit employees to ride in dippers, shovel buckets, forks, clamshells, or in the beds of dump trucks, or on haulage equipment not specifically designed or adapted for the transportation of employees.

(8) Electrically powered mobile equipment shall not be left unattended unless the master switch is in the off position, all operating controls are in the neutral position, and the brakes are set, or other equivalent precautions are taken against rolling.

(9) When dumping cars by hand, the car dumps shall be provided with tie-down chains or bumper blocks to prevent cars from overturning.

(10) Rocker-bottom or bottom-dump cars shall be equipped with positive locking devices.

(11) Equipment which is to be hauled shall be so loaded and protected as to prevent sliding or spillage.

(12) Parked railcars shall be blocked securely.

(13) Berms, bumper blocks, safety hooks, or similar means shall be provided to prevent overtravel and overturning at dumping locations.

(14) Where necessary, bumper blocks, or the equivalent, shall be provided at all track dead ends.

(15) Supplies, materials, and tools, other than small handtools, shall not be transported with employees in mantrip cars.

(l) *Electrical equipment*. (1) Electrical equipment shall conform to the requirements of Subpart K of this part.

(2) Powerlines shall be well separated or insulated from waterlines, telephone lines, and airlines.

(3) Oil-filled transformers shall not be used underground unless they are located in a fire-resistant enclosure and surrounded by a dike to contain the contents of the transformers in event of a rupture.

(m) *Hoisting*. (1) Hoisting machines, either powered or hand operated, shall be worm-gear or powered both ways. The design must be such that when the power is stopped, the load cannot move.

(2) Controls for powered hoists shall be of the deadman type with a nonlocking switch or control.

(3) A device to shut off the power shall be installed ahead of the operating control.

(4) Hand-operated release mechanisms, which can permit the load to descend faster than the speed rating, shall not be used.

(5) Hoist machines with cast metal parts shall not be used.

(6) Every hoist shall be tested with twice the maximum load before being put into operation, and annually thereafter.

(7) All anchorages of hoists shall be inspected at the beginning of each shift.

(8) An enclosed covered metal cage shall be used to raise and lower persons in the shaft. The cage shall be designed with a safety factor of 4 and shall be load-tested prior to use. The exterior of the cage shall be free of projections or sharp corners. Only closed shackles shall be used in the cage rigging.

(9) If the cage is equipped with a door, a positive locking device shall be installed to prevent the door from opening accidentally while the cage is being lowered or raised while hoisting or lowering employees.

§ 1518.801 Caissons.

(a) Wherever, in caisson work in which compressed air is used, and the working chamber is less than 11 feet in length, and when such caissons are at any time suspended or hung while work

is in progress so that the bottom of the excavation is more than 9 feet below the deck of the working chamber, a shield shall be erected therein for the protection of the employees.

(b) Shafts shall be subjected to a hydrostatic or air-pressure test, at which pressure they shall be tight. The shaft shall be stamped on the outside shell about 12 inches from each flange to show the pressure to which they have been subjected.

(c) Whenever a shaft is used, it shall be provided, where space permits, with a safe, proper, and suitable staircase for its entire length, including landing platforms, not more than 20 feet apart. Where this is impracticable, suitable ladders shall be installed with landing platforms located about 20 feet apart to break the climb.

(d) All caissons, having a diameter or side greater than 10 feet shall be provided with a man lock and shaft for the exclusive use of employees.

(e) In addition to the gauge in the locks, an accurate gauge shall be maintained on the outer and inner side of each bulkhead. These gauges shall be accessible at all times and kept in accurate working order.

(f) In caisson operations where employees are exposed to compressed air working environments, the requirements contained in § 1518.803 shall be complied with.

§ 1518.802 Cofferdams.

(a) If overtopping of the cofferdam by high waters is possible, means shall be provided for controlled flooding of the work area.

(b) Warning signals for evacuation of employees in case of emergency shall be developed and posted.

(c) Cofferdam walkways, bridges, or ramps with at least two means of rapid exit, shall be provided with guardrails as specified in Subpart M of this part.

(d) Cofferdams located close to navigable shipping channels shall be protected from vessels in transit, where possible.

§ 1518.803 Compressed air.

(a) *General provisions.* (1) There shall be present, at all times, at least one competent person designated by and representing the employer, who shall be familiar with this subpart in all respects, and responsible for full compliance with these and other applicable subparts.

(2) Every employee shall be instructed in the rules and regulations which concern his safety or the safety of others.

(b) *Medical attendance, examination, and regulations.* (1) There shall be retained one or more licensed physicians familiar with and experienced in the physical requirements and the medical aspects of compressed air work and the treatment of decompression illness. He shall be available at all times while work is in progress in order to provide medical supervision of employees employed in compressed air work. He shall himself be physically qualified and be willing to enter a pressurized environment.

(2) No employee shall be permitted to enter a compressed air environment until he has been examined by the physician and reported by him to be physically qualified to engage in such work.

(3) In the event an employee is absent from work for 10 days, or is absent due to sickness or injury, he shall not resume work until he is reexamined by the physician, and his physical condition reported, as provided in this paragraph, to be such as to permit him to work in compressed air.

(4) After an employee has been employed continuously in compressed air for a period designated by the physician, but not to exceed 1 year, he shall be reexamined by the physician to determine if he is still physically qualified to engage in compressed air work.

(5) Such physician shall at all times keep a complete and full record of examinations made by him. The physician shall also keep an accurate record of any decompression illness or other illness or injury incapacitating any employee for work, and of all loss of life that occurs in the operation of a tunnel, caisson, or other compartment in which compressed air is used.

(6) Records shall be available for the inspection of the Secretary or his representatives, and a copy thereof shall be forwarded to the Bureau of Labor Standards within 48 hours following the occurrence of the accident, death, injury, or decompression illness. It shall state as fully as possible the cause of said death or decompression illness, and the place where the injured or sick employee was taken, and such other relative information as may be required by the Secretary.

(7) A fully equipped first aid station shall be provided at each tunnel project regardless of the number of persons employed. An ambulance or transportation suitable for a litter case shall be at each project.

(8) Where tunnels are being excavated from portals more than 5 road miles apart, a first aid station and transportation facilities shall be provided at each portal.

(9) A medical lock shall be established and maintained in immediate working order whenever air pressure in the working chamber is increased above the normal atmosphere.

(10) The medical lock shall:

(i) Have at least 6 feet of clear headroom at the center, and be subdivided into not less than two compartments;

(ii) Be readily accessible to employees working under compressed air;

(iii) Be kept ready for immediate use for at least 5 hours subsequent to the emergence of any employee from the working chamber;

(iv) Be properly heated, lighted and ventilated;

(v) Be maintained in a sanitary condition;

(vi) Have a nonshatterable port through which the occupant(s) may be kept under constant observation;

(vii) Be designed for a working pressure of 75 p.s.i.g.

(viii) Be equipped with internal controls which may be overridden by external controls;

(ix) Be provided with air pressure gauges to show the air pressure within each compartment to observers inside and outside the medical lock.

(x) Be equipped with a manual type sprinkler system that can be activated inside the lock or by the outside lock tender.

(xi) Be provided with oxygen lines and fittings leading into external tanks. The lines shall be fitted with check valves to prevent reverse flow. The oxygen system inside the chamber shall be of a closed circuit design and be so designed as to automatically shut off the oxygen supply whenever the fire system is activated.

(xii) Be in constant charge of an attendant under the direct control of the retained physician. The attendant shall be trained in the use of the lock and suitably instructed regarding steps to be taken in the treatment of employee exhibiting symptoms compatible with a diagnosis of decompression illness;

(xiii) Be adjacent to an adequate emergency medical facility;

(xiv) The medical facility shall be equipped with demand-type oxygen inhalation equipment approved by the U.S. Bureau of Mines;

(xv) Be capable of being maintained at a temperature, in use, not to exceed 90° F. nor be less than 70° F.; and

(xvi) Be provided with sources of air, free of oil and carbon monoxide, for normal and emergency use, which are capable of raising the air pressure in the lock from 0 to 75 p.s.i.g. in 5 minutes.

(11) Identification badges shall be furnished to all employees, indicating that the wearer is a compressed air worker. A permanent record shall be kept of all identification badges issued. The badge shall give the employee's name, address of the medical lock, the telephone number of the licensed physician for the compressed air project, and contain instructions that in case of emergency of unknown or doubtful cause or illness, the wearer shall be rushed to the medical lock. The badge shall be worn at all times—off the job, as well as on the job.

(c) *Telephone and signal communication.* (1) Effective and reliable means of communication, such as bells, whistles, or telephones, shall be maintained at all times between all the following locations:

(i) The working chamber face;

(ii) The working chamber side of the man lock near the door;

(iii) The interior of the man lock;

(iv) Lock-attendant's station;

(v) The compressor plant;

(vi) The first-aid station;

(vii) The emergency lock (if one is required); and

(viii) The special decompression chamber (if one is required).

(d) *Signs and records.* (1) The time of decompression shall be posted in each man lock as follows:

TIME OF DECOMPRESSION FOR THIS LOCK

----- pounds to ----- pounds in -----
minutes.
----- pounds to ----- pounds in -----
minutes.

(Signed by) -----
(Superintendent)

This form shall be posted in the Man Lock at all times.

(2) Any code of signals used shall be conspicuously posted near workplace entrances and such other locations as may be necessary to bring them to the attention of all employees concerned.

(3) For each 8-hour shift, a record of employees employed under air pressure shall be kept by an employee who shall remain outside the lock near the entrance. This record shall show the period each employee spends in the air chamber and the time taken from decompression. A copy shall be submitted to the appointed physician after each shift.

(e) *Compression.* (1) Every employee going under air pressure for the first time shall be instructed on how to avoid excessive discomfort.

(2) During the compression of employees, the pressure shall not be increased to more than 3 p.s.i.g. within the first minute. The pressure shall be held at 3 p.s.i.g. and again at 7 p.s.i.g. sufficiently long to determine if any employees are experiencing discomfort.

(3) After the first minute the pressure shall be raised uniformly and at a rate not to exceed 10 p.s.i. per minute.

(4) If any employee complains of discomfort, the pressure shall be held to determine if the symptoms are relieved. If, after 5 minutes the discomfort does not disappear, the lock attendant shall gradually reduce the pressure until the employee signals that the discomfort has ceased. If he does not indicate that the discomfort has disappeared, the lock attendant shall reduce the pressure to atmospheric and the employee shall be released from the lock.

(5) No employee shall be subjected to pressure exceeding 50 pounds per square inch except in emergency.

(f) *Decompression.* (1) Decompression to normal condition shall be in accordance with the Decompression Tables in Appendix A of this subpart.

(2) In the event it is necessary for an employee to be in compressed air more than once in a 24-hour period, the appointed physician shall be responsible for the establishment of methods and procedures of decompression applicable to repetitive exposures.

(3) If decanting is necessary, the appointed physician shall establish procedures before any employee is permitted to be decompressed by decanting methods. The period of time that the employees spend at atmospheric pressure between the decompression following the shift and recompression shall not exceed 5 minutes.

(g) *Man locks and special decompression chambers.* (1) *Man locks.* (i) Except in emergency, no employees employed in compressed air shall be permitted to pass from the working chamber to atmospheric pressure until after de-

compression, in accordance with the procedures in this subpart.

(ii) The lock attendant in charge of a man lock shall be under the direct supervision of the appointed physician. He shall be stationed at the lock controls on the free air side during the period of compression and decompression and shall remain at the lock control station whenever there are men in the working chamber or in the man lock.

(iii) Except where air pressure in the working chamber is below 12 p.s.i.g., each man lock shall be equipped with automatic controls which, through taped programs, cams, or similar apparatus, shall automatically regulate decompressions. It shall also be equipped with manual controls to permit the lock attendant to override the automatic mechanism in the event of an emergency, as provided in subdivision (viii) of this subparagraph.

(iv) A manual control, which can be used in the event of an emergency, shall be placed inside the man lock.

(v) A clock, thermometer, and continuous recording pressure gauge with a 4-hour graph shall be installed outside of each man lock and shall be changed prior to each shift's decompression. The chart shall be of sufficient size to register a legible record of variations in pressure within the man lock and shall be visible to the lock attendant. A copy of each graph shall be submitted to the appointed physician after each shift. In addition, a pressure gauge, clock, and thermometer shall also be installed in each man lock. Additional fittings shall be provided so that test gauges may be attached whenever necessary.

(vi) Except where air pressure is below 12 p.s.i.g. and there is no danger of rapid flooding, all caissons having a working area greater than 150 square feet, and each bulkhead in tunnels of 14 feet or more in diameter, or equivalent area, shall have at least two locks in perfect working condition, one of which shall be used exclusively as a man lock, the other, as a materials lock.

(vii) Where only a combination man-and-materials lock is required, this single lock shall be of sufficient capacity to hold the employees constituting two successive shifts.

(viii) Emergency locks shall be large enough to hold an entire heading shift and a limit maintained of 12 p.s.i.g. There shall be a chamber available for oxygen-decompression therapy to 28 p.s.i.g.

(ix) The man lock shall be large enough so that those using it are not compelled to be in a cramped position, and shall not have less than 5 feet clear head room at the center and a minimum of 30 cubic feet of air space per occupant.

(x) Locks on caissons shall be so located that the bottom door shall be not less than 3 feet above the water level surrounding the caisson on the outside. (The water level, where it is affected by tides, is construed to mean high tide.)

(xi) In addition to the pressure gauge in the locks, an accurate pressure gauge shall be maintained on the outer and inner side of each bulkhead. These

gauges shall be accessible at all times and shall be kept in accurate working order.

(xii) Man locks shall have an observation port at least 4 inches in diameter located in such a position that all occupants of the man lock may be observed from the working chamber and from the free air side of the lock.

(xiii) Adequate ventilation in the lock shall be provided.

(xiv) Man locks shall be maintained at a minimum temperature of 70° F.

(xv) When locks are not in use and employees are in the working chamber, lock doors shall be kept open to the working chamber, where practicable.

(xvi) Provision shall be made to allow for rescue parties to enter the tunnel if the working force is disabled.

(xvii) A special decompression chamber of sufficient size to accommodate the entire force of employees being decompressed at the end of a shift shall be provided whenever the regularly established working period requires a total time of decompression exceeding 75 minutes.

(2) *Special decompression chamber.*

(i) The headroom in the special decompression chamber shall be not less than a minimum 7 feet and the cubical content shall provide at least 50 cubic feet of airspace for each employee. For each occupant, there shall be provided 4 square feet of free walking area and 3 square feet of seating space, exclusive of area required for lavatory and toilet facilities. The rated capacity shall be based on the stated minimum space per employee and shall be posted at the chamber entrance. The posted capacity shall not be exceeded, except in case of emergency.

(ii) Each special decompression chamber shall be equipped with the following:

(a) A clock or clocks suitably placed so that the attendant and the chamber occupants can readily ascertain the time;

(b) Pressure gauges which will indicate to the attendants and to the chamber occupants the pressure in the chamber;

(c) Valves to enable the attendant to control the supply and discharge of compressed air into and from the chamber;

(d) Valves and pipes, in connection with the air supply and exhaust, arranged so that the chamber pressure can be controlled from within and without;

(e) Effective means of oral intercommunication between the attendant, occupants of the chamber, and the air compressor plant; and

(f) An observation port at the entrance to permit observation of the chamber occupants.

(iii) Seating facilities in special decompression chambers shall be so arranged as to permit a normal sitting posture without cramping. Seating space, not less than 18 inches by 24 inches wide, shall be provided per occupant.

(iv) Adequate toilet and washing facilities, in a screened or enclosed recess,

shall be provided. Toilet bowls shall have a built-in protector on the rim so that an air space is created when the seat lid is closed.

(v) Fresh and pure drinking water shall be available. This may be accomplished by either piping water into the special decompression chamber and providing drinking fountains, or by providing individual canteens, or by some other sanitary means. Community drinking vessels are prohibited.

(vi) No refuse or discarded material of any kind shall be permitted to accumulate, and the chamber shall be kept clean.

(vii) Unless the special decompression chamber is serving as the man lock to atmospheric pressure, the special decompression chamber shall be situated, where practicable, adjacent to the man lock on the atmospheric pressure side of the bulkhead. A passageway shall be provided, connecting the special chamber with the man lock, to permit employees in the process of decompression to move from the man lock to the special chamber without a reduction in the ambient pressure from that designated for the next stage of decompression. The passageway shall be so arranged as to not interfere with the normal operation of the man lock, nor with the release of the occupants of the special chamber to atmospheric pressure upon the completion of the decompression procedure.

(h) *Compressor plant and air supply.*

(1) At all times there shall be a thoroughly experienced, competent, and reliable person on duty at the air control valves as a gauge tender who shall regulate the pressure in the working areas. During tunneling operations, one gauge tender may regulate the pressure in not more than two headings: *Provided*, That the gauge and controls are all in one location. In caisson work, there shall be a gauge tender for each caisson.

(2) The low air compressor plant shall be of sufficient capacity to not only permit the work to be done safely, but shall also provide a margin to meet emergencies and repairs.

(3) Low air compressor units shall have at least two independent and separate sources of power supply and each shall be capable of operating the entire low air plant and its accessory systems.

(4) The capacity, arrangement, and number of compressors shall be sufficient to maintain the necessary pressure without overloading the equipment and to assure maintenance of such pressure in the working chamber during periods of breakdown, repair, or emergency.

(5) Switching from one independent source of power supply to the other shall be done periodically to ensure the workability of the apparatus in an emergency.

(6) Duplicate low-pressure air feedlines and regulating valves shall be provided between the source of air supply and a point beyond the locks with one of the lines extending to within 100 feet of the working face.

(7) All high- and low-pressure air supply lines shall be equipped with check valves.

(8) Low-pressure air shall be regulated automatically. In addition, manually operated valves shall be provided for emergency conditions.

(9) The air intakes for all air compressors shall be located at a place where fumes, exhaust gases, and other air contaminants will be at a minimum.

(10) Gauges indicating the pressure in the working chamber shall be installed in the compressor building, the lock attendant's station, and at the employer's field office.

(i) *Ventilation and air quality.* (1) Exhaust valves and exhaust pipes shall be provided and operated so that the working chamber shall be well ventilated, and there shall be no pockets of dead air. Outlets may be required at intermediate points along the main low-pressure air supply line to the heading to eliminate such pockets of dead air. Ventilating air shall be not less than 30 cubic feet per minute.

(2) The air in the workplace shall be analyzed by the employer not less than once each shift, and records of such tests shall be kept on file at the place where the work is in progress. The test results shall be within the threshold limit values specified in Subpart D of this part, for hazardous gases, and within 10 percent of the lower explosive limit of flammable gases. If these limits are not met, immediate action to correct the situation shall be taken by the employer.

(3) The temperature of all working chambers which are subjected to air pressure shall, by means of after-coolers or other suitable devices, be maintained at a temperature not to exceed 85° F.

(4) Forced ventilation shall be provided during decompression. During the entire decompression period, forced ventilation through chemical or mechanical air purifying devices that will ensure a source of fresh air shall be provided.

(5) Whenever heat-producing machines (moles, shields) are used in compressed air tunnel operations, a positive means of removing the heat build-up at the heading shall be provided.

(j) *Electricity.* (1) All lighting in compressed-air chambers shall be by electricity exclusively, and two independent electric-lighting systems with independent sources of supply shall be used. The emergency source shall be arranged to become automatically operative in the event of failure of the regularly used source.

(2) The minimum intensity of light on any walkway, ladder, stairway, or working level shall be not less than 10 foot-candles, and in all workplaces the lighting shall at all times be such as to enable employees to see clearly.

(3) All electrical equipment, and wiring for light and power circuits, shall comply with requirements of the National Electrical Code for use in damp, hazardous, high temperature, and compressed air environments.

(4) External parts of lighting fixtures and all other electrical equipment, when within 8 feet of the floor, shall be constructed of noncombustible, nonabsorptive, insulating materials, except that

metal may be used if it is effectively grounded.

(5) Portable lamps shall be equipped with noncombustible, nonabsorptive, insulating sockets, approved handles, basket guards, and approved cords.

(6) The use of worn or defective portable and pendant conductors is prohibited.

(k) *Sanitation.* (1) Sanitary, heated, lighted, and ventilated dressing rooms and drying rooms shall be provided for all employees engaged in compressed air work. Such rooms shall contain suitable benches and lockers. Bathing accommodations (showers at the ratio of one to 10 employees per shift), equipped with running hot and cold water, and suitable and adequate toilet accommodations, shall be provided. One toilet for each 15 employees, or fractional part thereof, shall be provided.

(2) When the toilet bowl is shut by a cover, there should be an air space so that the bowl or bucket does not implode when pressure is increased.

(3) All parts of caissons and other working compartments shall be kept in a sanitary condition.

(l) *Fire prevention and protection.*

(1) Firefighting equipment shall be available at all times and shall be maintained in working condition.

(2) While welding or flame-cutting is being done in compressed air, a fire-watch with a fire hose or approved extinguisher shall stand by until such operation is completed.

(3) Shafts and caissons containing flammable material of any kind, either above or below ground, shall be provided with a waterline and a fire hose connected thereto, so arranged that all points of the shaft or caisson are within reach of the hose stream.

(4) Fire hose shall be at least 1½ inches in nominal diameter; the water pressure shall at all times be adequate for efficient operation of the type of nozzle used; and the water supply shall be such as to ensure an uninterrupted flow. Fire hose, when not in use, shall be located or guarded to prevent injury thereto.

(5) The power house, compressor house, and all buildings housing ventilating equipment, shall be provided with at least one hose connection in the waterline, with a fire hose connected thereto. A fire hose shall be maintained within reach of structures of wood over or near shafts.

(6) Tunnels shall be provided with a 2-inch minimum diameter waterline extending into the working chamber and to within 100 feet of the working face. Such line shall have hose outlets with 100 feet of fire hose attached and maintained as follows: One at the working face; one immediately inside of the bulkhead of the working chamber; and one immediately outside such bulkhead. In addition, hose outlets shall be provided at 200-foot intervals throughout the length of the tunnel, and 100 feet of fire hose shall be attached to the outlet nearest to any location where flammable material is being kept or stored or where any flame is being used.

(7) In addition to fire hose protection required by this subpart, on every floor of every building not under compressed air, but used in connection with the compressed air work, there shall be provided at least one approved fire extinguisher of the proper type for the hazard involved. At least two approved fire extinguishers shall be provided in the working chamber as follows: One at the working face and one immediately inside the bulkhead (pressure side). Extinguishers in the working chamber shall use water as the primary extinguishing agent and shall not use any extinguishing agent which could be harmful to the employees in the working chamber. The fire extinguisher shall be protected from damage.

(8) Highly combustible materials shall not be used or stored in the working chamber. Wood, paper, and similar combustible material shall not be used in the working chamber in quantities which could cause a fire hazard. The compressor building shall be constructed of noncombustible material.

(9) Man locks shall be equipped with a manual type fire extinguisher system that can be activated inside the man lock and also by the outside lock attendant. In addition, a fire hose and portable fire extinguisher shall be provided inside and outside the man lock. The portable fire extinguisher shall be the dry chemical type.

(10) Equipment, fixtures, and furniture in man locks and special decompression chambers shall be constructed of noncombustible materials. Bedding, etc., shall be chemically treated so as to be fire resistant.

(11) Head frames shall be constructed of structural steel or open frame-work fireproofed timber. Head houses and other temporary surface buildings or structures within 100 feet of the shaft, caisson, or tunnel opening shall be built of fire-resistant materials.

(12) No oil, gasoline, or other combustible material shall be stored within 100 feet of any shaft, caisson, or tunnel opening, except that oils may be stored in suitable tanks in isolated fireproof buildings, provided such buildings are not less than 50 feet from any shaft, caisson, or tunnel opening, or any building directly connected thereto.

(13) Positive means shall be taken to prevent leaking flammable liquids from flowing into the areas specifically mentioned in the preceding paragraph.

(14) All explosives used in connection with compressed air work shall be selected, stored, transported, and used as specified in Subpart U of this part.

(m) *Bulkheads and safety screens.* (1) Intermediate bulkheads with locks, or intermediate safety screens or both, are required where there is the danger of rapid flooding.

(2) In tunnels 16 feet or more in diameter, hanging walkways shall be provided from the face to the man lock as high in the tunnel as practicable, with at least 6 feet of head room. Walkways shall

be constructed of noncombustible material. Standard railings shall be securely installed throughout the length of all walkways on open sides in accordance with Subpart M of this part. Where walkways are ramped under safety screens, the walkway surface shall be skidproofed by cleats or by equivalent means.

(3) Bulkheads used to contain compressed air shall be tested, where practicable, to prove their ability to resist the highest air pressure which may be expected to be used.

§ 1518.304. Definitions applicable to this subpart.

(a) "Bulkhead"—An airtight structure separating the working chamber from free air or from another chamber under a lesser pressure than the working pressure.

(b) "Caisson"—A wood, steel, concrete or reinforced concrete, air- and water-tight chamber in which it is possible for men to work under air pressure greater than atmospheric pressure to excavate material below water level.

(c) "Decanting"—A method used for decompressing under emergency circumstances. In this procedure, the employees are brought to atmospheric pressure with a very high gas tension in the tissues and then immediately recompressed in a second and separate chamber or lock.

(d) "Emergency locks"—A lock designed to hold and permit the quick passage of an entire shift of employees.

(e) "High air"—Air pressure used to supply power to pneumatic tools and devices.

(f) "Low air"—Air supplied to pressurize working chambers and locks.

(g) "Man lock"—A chamber through which men pass from one air pressure environment into another.

(h) "Materials lock"—A chamber through which materials and equipment pass from one air pressure environment into another.

(i) "Medical lock"—A special chamber in which employees are treated for decompression illness. It may also be used in preemployment physical examinations to determine the adaptability of the prospective employee to changes in pressure.

(j) "Normal condition"—One during which exposure to compressed air is limited to a single continuous working period followed by a single decompression in any given 24-hour period; the total time of exposure to compressed air during the single continuous working period is not interrupted by exposure to normal atmospheric pressure, and a second exposure to compressed air does not occur until at least 12 consecutive hours of exposure to normal atmospheric pressure has elapsed since the employee has been under pressure.

(k) "Pressure"—A force acting on a unit area. Usually shown as pounds per square inch. (p.s.i.)

(l) "Absolute pressure" (p.s.i.a.)—The sum of the atmospheric pressure and gauge pressure (p.s.i.g.).

(m) "Atmospheric pressure"—The pressure of air at sea level, usually 14.7

p.s.i.a. (1 atmosphere), or 0 p.s.i.g.

(n) "Gauge pressure" (p.s.i.g.)—Pressure measured by a gauge and indicating the pressure exceeding atmospheric.

(o) "Safety screen"—An air- and water-tight diaphragm placed across the upper part of a compressed air tunnel between the face and bulkhead, in order to prevent flooding the crown of the tunnel between the safety screen and the bulkhead, thus providing a safe means of refuge and exit from a flooding or flooded tunnel.

(p) "Special decompression chamber"—A chamber to provide greater comfort for employees when the total decompression time exceeds 75 minutes.

(q) "Working chamber"—The space or compartment under air pressure in which the work is being done.

APPENDIX A

DECOMPRESSION TABLES

1. *Explanation.* The decompression tables are computed for working chamber pressures from 0 to 14 pounds, and from 14 to 50 pounds per square inch gauge inclusive by 2-pound increments and for exposure times for each pressure extending from one-half to over 8 hours inclusive. Decompressions will be conducted by two or more stages with a maximum of four stages, the latter for a working chamber pressure of 40 pounds per square inch gauge or over.

Stage 1 consists of a reduction in ambient pressure ranging from 10 to a maximum of 16 pounds per square inch, but in no instance will the pressure be reduced below 4 pounds at the end of stage 1. This reduction in pressure in stage 1 will always take place at a rate not greater than 5 pounds per minute.

Further reduction in pressure will take place during stage 2 and subsequent stages as required at a slower rate, but in no event at a rate greater than 1 pound per minute.

Decompression Table No. 1 indicates in the body of the table the total decompression time in minutes for various combinations of working chamber pressure and exposure time.

Decompression Table No. 2 indicates for the same various combinations of working chamber pressure and exposure time the following:

- The number of stages required;
- The reduction in pressure and the terminal pressure for each required stage;
- The time in minutes through which the reduction in pressure is accomplished for each required stage;
- The pressure reduction rate in minutes per pound for each required stage;

IMPORTANT NOTE: The Pressure Reduction in Each Stage is Accomplished at a Uniform Rate. Do Not Interpolate Between Values Shown on the Tables. Use the Next Higher Value of Working Chamber Pressure or Exposure Time Should the Actual Working Chamber Pressure or the Actual Exposure Time, Respectively, Fall Between Those for Which Calculated Values Are Shown in the Body of the Tables.

Examples:

Example No. 1:

4 hours working period at 20 pounds gauge.

Decompression Table No. 1:

20 pounds for 4 hours, total decompression time. 43 minutes.

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Decompression Table No. 2:

Stage 1: Reduce pressure from 20 pounds to 4 pounds at the uniform rate of 5 pounds per minute.

Elapsed time stage 1: $\frac{16}{5}$ 3 minutes.

Stage 2 (final stage): Reduce pressure at a uniform rate from 4 pounds to 0-pound gage over a period of 40 minutes.

Rate—0.10 pound per minute or 10 minutes per pound.

Stage 2 (final) elapsed time. 40 minutes.

Total time----- 43 minutes.

Example No. 2:

5-hour working period at 24 pounds gage.

Decompression Table No. 1:

24 pounds for 5 hours, total decompression time. 117 minutes.

Decompression Table No. 2:

Stage 1: Reduce pressure from 24 pounds to 8 pounds at the uniform rate of 5 pounds per minute.

Elapsed time stage 1: $\frac{16}{5}$ 3 minutes.

Stage 2: Reduce pressure at a uniform rate from 8 pounds to 4 pounds over a period of 4 minutes. Rate, 1 pound per minute elapsed time, stage 2----- 4 minutes.

Transfer men to special decompression chamber maintaining the 4-pound pressure during the transfer operation.

Stage 3 (final stage): In the special decompression chamber, reduce the pressure at a uniform rate from 4 pounds to 0-pound gage over a period of

110 minutes. Rate, 0.037 pound per minute or 27.5 minutes per pound. Stage 3 (final) elapsed time----- 110 minutes.

Total time----- 117 minutes.

DECOMPRESSION TABLE NO. 1—TOTAL DECOMPRESSION TIME

Work pressure p.s.i.g.	Working period hours										
	1/4	1	1 1/4	2	3	4	5	6	7	8	Over 8
0-12.....	3	3	3	3	3	3	3	3	3	3	3
14.....	6	6	6	6	6	6	6	6	16	16	33
16.....	7	7	7	7	7	7	7	17	33	48	62
18.....	7	7	7	8	11	17	48	63	63	73	87
20.....	7	7	8	15	15	43	63	73	83	103	113
22.....	9	9	16	24	38	68	93	103	112	128	133
24.....	11	12	23	27	52	92	117	122	127	137	151
26.....	13	14	29	34	69	104	126	141	142	142	163
28.....	15	23	31	41	98	127	143	163	183	168	183
30.....	17	28	38	62	105	143	165	168	178	188	204
32.....	19	35	43	85	128	163	178	193	203	213	226
34.....	21	39	58	98	151	178	195	218	223	233	248
36.....	24	44	63	113	170	198	223	233	243	253	273
38.....	28	49	73	128	178	203	223	238	253	263	278
40.....	31	49	84	143	183	213	233	248	258	278	288
42.....	37	56	102	144	189	216	245	260	263	268	293
44.....	43	64	118	164	199	234	254	264	266	269	293
46.....	44	74	139	171	214	244	269	274	289	299	318
48.....	51	89	144	189	229	269	299	309	319	319	-----
50.....	58	94	164	209	249	279	309	329	-----	-----	-----

DECOMPRESSION TABLE NO. 2

(Do not interpolate, use next higher value for conditions not computed.)

Working chamber pressure P.s.i.g.	Working period Hours	Stage No.	Decompression data				
			Pressure reduction P.s.i.g.		Time in stage Minutes	Pressure reduction rate Min/Pound	Total time decompress Minutes
			From	To			
14.....	1/4.....	1	14	4	2	0.20	6
		2	4	0	4	1.00	6
	1.....	1	14	4	2	0.20	6
		2	4	0	4	1.00	6
	1 1/4.....	1	14	4	2	0.20	6
		2	4	0	4	1.00	6
	2.....	1	14	4	2	0.20	6
		2	4	0	4	1.00	6
	3.....	1	14	4	2	0.20	6
		2	4	0	4	1.00	6
	4.....	1	14	0	2	0.20	6
		2	4	0	4	1.00	6
	5.....	1	14	4	2	0.20	6
		2	4	0	4	1.00	6

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Working chamber pressure P.s.i.g.	Working period Hours	Decompression data					Total time decompress Minutes		
		Stage No.	Pressure reduction P.s.i.g.		Time in stage Minutes	Pressure reduction rate Min/Pound			
			From	To					
14.....	6.....	1	14	4	2	0.20	0		
		2	4	0	4	1.00			
	7.....	1	14	4	2	0.20		16	
		2	4	0	14	3.50			
	8.....	1	14	4	2	0.20			
		2	4	0	14	3.50			
	Over 8.....	1	14	4	2	0.20		32	
		2	4	0	30	7.50			
	16.....	1/2.....	1	10	4	3		0.20	7
			2	4	0	4		1.00	
1.....		1	10	4	3	0.20	7		
		2	4	0	4	1.00			
1 1/2.....		1	16	4	3	0.20	7		
		2	4	0	4	1.00			
2.....		1	16	4	3	0.20	7		
		2	4	0	4	1.00			
3.....		1	16	4	3	0.20	7		
		2	4	0	4	1.00			
4.....		1	14	4	3	0.20	7		
		2	4	0	4	1.00			
5.....		1	14	4	3	0.20	17		
		2	4	0	4	3.50			
6.....		1	14	4	3	0.20	33		
		2	4	0	30	7.50			
7.....		1	14	4	3	0.20	48		
		2	4	0	46	11.25			
8.....		1	14	4	3	0.20	48		
		2	4	0	46	11.25			
Over 8.....	1	14	4	3	0.20	63			
	2	4	0	60	15.00				
18.....	1/2.....	1	18	4	3	0.20	7		
		2	4	0	4	1.00			
	1.....	1	18	4	3	0.20	7		
		2	4	0	4	1.00			
	1 1/2.....	1	18	4	3	0.20	7		
		2	4	0	4	1.00			
	2.....	1	18	4	5	1.25	8		
		2	4	0	3	0.20			
	3.....	1	18	4	8	2.00	11		
		2	4	0	3	0.20			
	4.....	1	15	4	14	3.50	17		
		2	4	0	3	0.20			
	5.....	1	18	4	46	11.25	48		
		2	4	0	3	0.20			
	6.....	1	18	4	60	15.00	63		
		2	4	0	3	0.20			
	7.....	1	18	4	60	15.00	63		
		2	4	0	3	0.20			
	8.....	1	18	4	70	17.50	73		
		2	4	0	3	0.20			
Over 8.....	1	18	4	84	21.00	87			
	2	4	0	3	0.20				
20.....	1/2.....	1	20	4	3	0.20	7		
		2	4	0	4	1.00			
	1.....	1	20	4	3	0.20	7		
		2	4	0	4	1.00			
	1 1/2.....	1	20	4	3	0.20	8		
		2	4	0	6	1.25			
	2.....	1	20	4	3	0.20	15		
		2	4	0	12	3.00			
	3.....	1	20	4	3	0.20	15		
		2	4	0	12	3.00			
	4.....	1	20	4	3	0.20	43		
		2	4	0	40	10.00			
	5.....	1	20	4	3	0.20	63		
		2	4	0	60	15.00			
	6.....	1	20	4	3	0.20	73		
		2	4	0	70	17.50			
	7.....	1	20	4	3	0.20	83		
		2	4	0	80	20.00			
	8.....	1	20	4	3	0.20	103		
		2	4	0	100	25.00			

RULES AND REGULATIONS

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Decompression data									
Working chamber pressure P.s.i.g.	Working period Hours	Stage No.	Pressure reduction P.s.i.g.		Time in stage Minutes	Pressure reduction rate Min/Pound	Total time decompress Minutes		
			From	To					
20	Over 8	1	20	4	3	0.20	113		
22	1/2	2	22	6	3	0.20	9		
	1	3	22	8	3	0.20	9		
	1 1/2	4	22	10	3	0.20	18		
	2	5	22	12	3	0.20	24		
	3	6	22	14	3	0.20	33		
	4	7	22	16	3	0.20	63		
	6	8	22	18	3	0.20	93		
	6	9	22	20	3	0.20	103		
	7	10	22	22	3	0.20	113		
	8	11	22	24	3	0.20	123		
	Over 8	12	22	26	3	0.20			
	1/2	13	22	28	3	0.20			
	1	14	22	30	3	0.20	11		
	1 1/2	15	22	32	3	0.20	12		
	2	16	22	34	3	0.20	23		
	3	17	22	36	3	0.20	27		
	4	18	22	38	3	0.20	32		
	6	19	22	40	3	0.20	32		
	8	20	22	42	3	0.20	117		
	6	21	22	44	3	0.20	122		
	7	22	22	46	3	0.20	127		
	8	23	22	48	3	0.20	137		
	Over 8	24	22	50	3	0.20	151		
	1/2	25	22	52	3	0.20	13		
	1	26	22	54	3	0.20	14		
	1 1/2	27	22	56	3	0.20	29		
	2	28	22	58	3	0.20	34		
	3	29	22	60	3	0.20	69		
	4	30	22	62	3	0.20			
	6	31	22	64	3	0.20			
	8	32	22	66	3	0.20			
	Over 8	33	22	68	3	0.20			
	1/2	34	22	70	3	0.20			
	1	35	22	72	3	0.20			
	1 1/2	36	22	74	3	0.20			
	2	37	22	76	3	0.20			
	3	38	22	78	3	0.20			
	4	39	22	80	3	0.20			
	6	40	22	82	3	0.20			
	8	41	22	84	3	0.20			
	Over 8	42	22	86	3	0.20			
	1/2	43	22	88	3	0.20			
	1	44	22	90	3	0.20			
	1 1/2	45	22	92	3	0.20			
	2	46	22	94	3	0.20			
	3	47	22	96	3	0.20			
	4	48	22	98	3	0.20			
	6	49	22	100	3	0.20			
	8	50	22	102	3	0.20			
	Over 8	51	22	104	3	0.20			
	1/2	52	22	106	3	0.20			
	1	53	22	108	3	0.20			
	1 1/2	54	22	110	3	0.20			
	2	55	22	112	3	0.20			
	3	56	22	114	3	0.20			
	4	57	22	116	3	0.20			
	6	58	22	118	3	0.20			
	8	59	22	120	3	0.20			
	Over 8	60	22	122	3	0.20			
	1/2	61	22	124	3	0.20			
	1	62	22	126	3	0.20			
	1 1/2	63	22	128	3	0.20			
	2	64	22	130	3	0.20			
	3	65	22	132	3	0.20			
	4	66	22	134	3	0.20			
	6	67	22	136	3	0.20			
	8	68	22	138	3	0.20			
	Over 8	69	22	140	3	0.20			
	1/2	70	22	142	3	0.20			
	1	71	22	144	3	0.20			
	1 1/2	72	22	146	3	0.20			
	2	73	22	148	3	0.20			
	3	74	22	150	3	0.20			
	4	75	22	152	3	0.20			
	6	76	22	154	3	0.20			
	8	77	22	156	3	0.20			
	Over 8	78	22	158	3	0.20			
	1/2	79	22	160	3	0.20			
	1	80	22	162	3	0.20			
	1 1/2	81	22	164	3	0.20			
	2	82	22	166	3	0.20			
	3	83	22	168	3	0.20			
	4	84	22	170	3	0.20			
	6	85	22	172	3	0.20			
	8	86	22	174	3	0.20			
	Over 8	87	22	176	3	0.20			
	1/2	88	22	178	3	0.20			
	1	89	22	180	3	0.20			
	1 1/2	90	22	182	3	0.20			
	2	91	22	184	3	0.20			
	3	92	22	186	3	0.20			
	4	93	22	188	3	0.20			
	6	94	22	190	3	0.20			
	8	95	22	192	3	0.20			
	Over 8	96	22	194	3	0.20			
	1/2	97	22	196	3	0.20			
	1	98	22	198	3	0.20			
	1 1/2	99	22	200	3	0.20			
	2	100	22	202	3	0.20			
	3	101	22	204	3	0.20			
	4	102	22	206	3	0.20			
	6	103	22	208	3	0.20			
	8	104	22	210	3	0.20			
	Over 8	105	22	212	3	0.20			
	1/2	106	22	214	3	0.20			
	1	107	22	216	3	0.20			
	1 1/2	108	22	218	3	0.20			
	2	109	22	220	3	0.20			
	3	110	22	222	3	0.20			
	4	111	22	224	3	0.20			
	6	112	22	226	3	0.20			
	8	113	22	228	3	0.20			
	Over 8	114	22	230	3	0.20			
	1/2	115	22	232	3	0.20			
	1	116	22	234	3	0.20			
	1 1/2	117	22	236	3	0.20			
	2	118	22	238	3	0.20			
	3	119	22	240	3	0.20			
	4	120	22	242	3	0.20			
	6	121	22	244	3	0.20			
	8	122	22	246	3	0.20			
	Over 8	123	22	248	3	0.20			
	1/2	124	22	250	3	0.20			
	1	125	22	252	3	0.20			
	1 1/2	126	22	254	3	0.20			
	2	127	22	256	3	0.20			
	3	128	22	258	3	0.20			
	4	129	22	260	3	0.20			
	6	130	22	262	3	0.20			
	8	131	22	264	3	0.20			
	Over 8	132	22	266	3	0.20			
	1/2	133	22	268	3	0.20			
	1	134	22	270	3	0.20			
	1 1/2	135	22	272	3	0.20			
	2	136	22	274	3	0.20			
	3	137	22	276	3	0.20			
	4	138	22	278	3	0.20			
	6	139	22	280	3	0.20			
	8	140	22	282	3	0.20			
	Over 8	141	22	284	3	0.20			
	1/2	142	22	286	3	0.20			
	1	143	22	288	3	0.20			
	1 1/2	144	22	290	3	0.20			
	2	145	22	292	3	0.20			
	3	146	22	294	3	0.20			
	4	147	22	296	3	0.20			
	6	148	22	298	3	0.20			
	8	149	22	300	3	0.20			
	Over 8	150	22	302	3	0.20			
	1/2	151	22	304	3	0.20			
	1	152	22	306	3	0.20			
	1 1/2	153	22	308	3	0.20			
	2	154	22	310	3	0.20			
	3	155	22	312	3	0.20			
	4	156	22	314	3	0.20			
	6	157	22	316	3	0.20			
	8	158	22	318	3	0.20			
	Over 8	159	22	320	3	0.20			
	1/2	160	22	322	3	0.20			
	1	161	22	324	3	0.20			
	1 1/2	162	22	326	3	0.20			
	2	163	22	328	3	0.20			
	3	164	22	330	3	0.20			
	4	165	22	332	3	0.20			
	6	166	22	334	3	0.20			
	8	167	22	336	3	0.20			
	Over 8	168	22	338	3	0.20			
	1/2	169	22	340	3	0.20			
	1	170	22	342	3	0.20			
	1 1/2	171	22	344	3	0.20			
	2	172	22	346	3	0.20			
	3	173	22	348	3	0.20			
	4	174	22	350	3	0.20			
	6	175	22	352	3	0.20			
	8	176	22	354	3	0.20			
	Over 8	177	22	356	3	0.20			
	1/2	178	22	358	3	0			

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Working chamber pressure P.s.i.g.	Working period hours	Stage No.	Decompression data		Pressure reduction rate Min/Pound	Total time decompress Minutes
			From	To		
31.....	8.....	1	31	18	0.20	233
		2	18	4	7.15	
	Over 8.....	3	4	0	32.50	
		4	31	18	0.20	
		5	18	4	8.23	
		6	4	0	32.50	
32.....	1/4.....	1	36	20	0.20	216
		2	20	4	1.00	
		3	4	0	1.25	
	1.....	4	36	20	0.20	
		5	20	4	1.00	
		6	4	0	6.25	
	1 1/4.....	7	36	20	0.20	
		8	20	4	1.85	
		9	4	0	7.50	
	2.....	10	36	20	0.20	
		11	20	4	2.60	
		12	4	0	17.00	
	3.....	13	36	20	0.20	
		14	20	4	3.25	
		15	4	0	28.75	
	4.....	16	36	20	0.20	
		17	20	4	1.00	
		18	4	0	32.50	
	5.....	19	36	20	0.20	
		20	20	4	0.75	
		21	4	0	3.00	
	6.....	22	36	20	0.20	
		23	20	4	0.75	
		24	4	0	3.00	
	7.....	25	36	20	0.20	
		26	20	4	0.85	
		27	4	0	32.50	
	8.....	28	36	20	0.20	
		29	20	4	0.90	
		30	4	0	7.50	
	Over 8.....	31	36	20	0.20	
		32	20	4	3.25	
		33	4	0	28.75	
33.....	1/4.....	1	38	22	0.20	273
		2	22	6	1.00	
		3	6	0	1.50	
	1.....	4	38	22	0.20	
		5	22	6	1.00	
		6	6	0	1.50	
	1 1/4.....	7	38	22	0.20	
		8	22	6	1.00	
		9	6	0	6.00	
	2.....	10	38	22	0.20	
		11	22	6	1.25	
		12	6	0	8.34	
	3.....	13	38	22	0.20	
		14	22	6	1.85	
		15	6	0	15.53	
	4.....	16	38	22	0.20	
		17	22	6	2.19	
		18	6	0	23.55	
	5.....	19	38	22	0.20	
		20	22	6	3.12	
		21	6	0	26.00	
	6.....	22	38	22	0.20	
		23	22	6	3.44	
		24	6	0	27.60	
	7.....	25	38	22	0.20	
		26	22	6	4.35	
		27	6	0	27.40	
	8.....	28	38	22	0.20	
		29	22	6	5.32	
		30	6	0	27.87	
	Over 8.....	31	38	22	0.20	
		32	22	6	6.43	
		33	6	0	27.81	
		34	38	22	0.20	
		35	22	6	6.43	
		36	6	0	27.81	
		37	38	22	0.20	
		38	22	6	6.43	
		39	6	0	27.81	
		40	38	22	0.20	
		41	22	6	6.43	
		42	6	0	27.81	
		43	38	22	0.20	
		44	22	6	6.43	
		45	6	0	27.81	
		46	38	22	0.20	
		47	22	6	6.43	
		48	6	0	27.81	
		49	38	22	0.20	
		50	22	6	6.43	
		51	6	0	27.81	
		52	38	22	0.20	
		53	22	6	6.43	
		54	6	0	27.81	
		55	38	22	0.20	
		56	22	6	6.43	
		57	6	0	27.81	
		58	38	22	0.20	
		59	22	6	6.43	
		60	6	0	27.81	
		61	38	22	0.20	
		62	22	6	6.43	
		63	6	0	27.81	
		64	38	22	0.20	
		65	22	6	6.43	
		66	6	0	27.81	
		67	38	22	0.20	
		68	22	6	6.43	
		69	6	0	27.81	
		70	38	22	0.20	
		71	22	6	6.43	
		72	6	0	27.81	
		73	38	22	0.20	
		74	22	6	6.43	
		75	6	0	27.81	
		76	38	22	0.20	
		77	22	6	6.43	
		78	6	0	27.81	
		79	38	22	0.20	
		80	22	6	6.43	
		81	6	0	27.81	
		82	38	22	0.20	
		83	22	6	6.43	
		84	6	0	27.81	
		85	38	22	0.20	
		86	22	6	6.43	
		87	6	0	27.81	
		88	38	22	0.20	
		89	22	6	6.43	
		90	6	0	27.81	
		91	38	22	0.20	
		92	22	6	6.43	
		93	6	0	27.81	
		94	38	22	0.20	
		95	22	6	6.43	
		96	6	0	27.81	
		97	38	22	0.20	
		98	22	6	6.43	
		99	6	0	27.81	
		100	38	22	0.20	
		101	22	6	6.43	
		102	6	0	27.81	
		103	38	22	0.20	
		104	22	6	6.43	
		105	6	0	27.81	
		106	38	22	0.20	
		107	22	6	6.43	
		108	6	0	27.81	
		109	38	22	0.20	
		110	22	6	6.43	
		111	6	0	27.81	
		112	38	22	0.20	
		113	22	6	6.43	
		114	6	0	27.81	
		115	38	22	0.20	
		116	22	6	6.43	
		117	6	0	27.81	
		118	38	22	0.20	
		119	22	6	6.43	
		120	6	0	27.81	
		121	38	22	0.20	
		122	22	6	6.43	
		123	6	0	27.81	
		124	38	22	0.20	
		125	22	6	6.43	
		126	6	0	27.81	
		127	38	22	0.20	
		128	22	6	6.43	
		129	6	0	27.81	
		130	38	22	0.20	
		131	22	6	6.43	
		132	6	0	27.81	
		133	38	22	0.20	
		134	22	6	6.43	
		135	6	0	27.81	
		136	38	22	0.20	
		137	22	6	6.43	
		138	6	0	27.81	
		139	38	22	0.20	
		140	22	6	6.43	
		141	6	0	27.81	
		142	38	22	0.20	
		143	22	6	6.43	
		144	6	0	27.81	
		145	38	22	0.20	
		146	22	6	6.43	
		147	6	0	27.81	
		148	38	22	0.20	
		149	22	6	6.43	
		150	6	0	27.81	
		151	38	22	0.20	
		152	22	6	6.43	
		153	6	0	27.81	
		154	38	22	0.20	
		155	22	6	6.43	
		156	6	0	27.81	
		157	38	22	0.20	
		158	22	6	6.43	
		159	6	0	27.81	
		160	38	22	0.20	
		161	22	6	6.43	
		162	6	0	27.81	
		163	38	22	0.20	
		164	22	6	6.43	
		165	6	0	27.81	
		166	38	22	0.20	
		167	22	6	6.43	
		168	6	0	27.81	
		169	38	22	0.20	
		170	22	6	6.43	
		171	6	0	27.81	
		172	38	22	0.20	
		173	22	6	6.43	
		174	6	0	27.81	
		175	38	22	0.20	
		176	22	6	6.43	
		177	6	0	27.81	
		178	38	22	0.20	
		179	22	6	6.43	
		180	6	0	27.81	
		181	38	22	0.20	
		182	22	6	6.43	
		183	6	0	27.81	
		184	38	22	0.20	
		185	22	6	6.43	
		186	6	0	27.81	
		187	38	22	0.20	
		188	22	6	6.43	
		189	6	0	27.81	
		190	38	22	0.20	
		191	22	6	6.43	
		192	6	0	27.81	
		193	38	22	0.20	
		194	22	6	6.43	
		195	6	0	27.81	
		196	38	22	0.20	
		197	22	6	6.43	
		198	6	0	27.81	
		199	38	22	0.20	
		200	22	6	6.43	
		201	6	0	27.81	
		202	38	22	0.20	
		203	22	6	6.43	
		204	6	0	27.81	
		205	38	22	0.20	
		206	22	6	6.43	
		207	6	0	27.81	
		208	38	22	0.20	
		209	22	6	6.43	
		210	6	0	27.81	
		211	38	22	0.20	
		212	22	6	6.43	
		213	6			

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Decompression data						
Working chamber pressure P.s.i.g.	Working period hours	Stage No.	Pressure reduction P.s.i.g.		Time in stage Minutes	Total time decompress Minutes
			From	To		
42	6	1	42	28	3	0.20
		2	28	10	27	1.01
		3	10	4	100	18.67
	7	4	4	0	130	32.69
		1	42	28	3	0.20
		2	28	10	30	1.58
		3	10	4	100	18.67
		4	4	0	130	32.69
	8	1	42	28	3	0.20
		2	28	10	35	2.12
		3	10	4	100	18.67
		4	4	0	130	32.69
	Over 8	1	42	28	3	0.20
		2	28	10	60	3.75
		3	10	4	100	18.67
		4	4	0	130	32.69
44	1 1/2	1	44	28	3	0.20
		2	28	12	16	1.00
		3	12	4	8	1.00
		4	4	0	10	4.00
	1	1	44	28	3	0.20
		2	28	12	16	1.00
		3	12	4	25	2.50
		4	4	0	25	6.25
	1 1/2	1	44	28	3	0.20
		2	28	12	16	1.00
		3	12	4	27	3.33
		4	4	0	72	18.00
	2	1	41	28	3	0.20
		2	28	12	16	1.00
		3	12	4	40	5.00
		4	4	0	95	23.75
	3	1	41	28	3	0.20
		2	28	12	16	1.00
		3	12	4	60	7.50
		4	4	0	120	30.00
	4	1	41	28	3	0.20
		2	28	12	16	1.00
		3	12	4	85	10.62
		4	4	0	130	32.69
	5	1	41	28	3	0.20
		2	28	12	16	1.00
		3	12	4	105	13.13
		4	4	0	130	32.69
	6	1	41	28	3	0.20
		2	28	12	16	1.00
		3	12	4	115	14.38
		4	4	0	130	32.69
	7	1	41	28	3	0.20
		2	28	12	16	1.00
		3	12	4	120	15.00
		4	4	0	130	32.69
	8	1	41	28	3	0.20
		2	28	12	16	1.00
		3	12	4	130	16.00
		4	4	0	130	32.69
	Over 8	1	41	28	3	0.20
		2	28	12	16	1.00
		3	12	4	40	2.50
		4	4	0	130	32.69
46	1 1/2	1	46	30	3	0.20
		2	30	14	11	1.00
		3	14	4	10	1.00
		4	4	0	15	3.75
	1	1	46	30	3	0.20
		2	30	14	16	1.00
		3	14	4	25	2.50
		4	4	0	30	7.50
	1 1/2	1	46	30	3	0.20
		2	30	14	16	1.00
		3	14	4	35	3.50
		4	4	0	65	21.25

Decompression data						
Working chamber pressure P.s.i.g.	Working period hours	Stage No.	Pressure reduction P.s.i.g.		Time in stage Minutes	Total time decompress Minutes
			From	To		
40	1 1/2	1	40	24	3	0.20
		2	24	8	16	1.00
		3	8	4	4	1.00
	1	4	4	0	8	2.00
		1	40	24	3	0.20
		2	24	8	16	1.00
		3	8	4	5	1.00
		4	4	0	25	1.25
	1 1/2	1	40	24	3	0.20
		2	24	8	16	1.00
		3	8	4	25	6.25
		4	4	0	25	6.25
	2	1	40	24	3	0.20
		2	24	8	16	1.00
		3	8	4	20	2.00
		4	4	0	45	11.25
	2	1	40	24	3	0.20
		2	24	8	25	1.56
		3	8	4	20	3.00
		4	4	0	95	23.75
	3	1	40	24	3	0.20
		2	24	8	30	1.88
		3	8	4	20	7.00
		4	4	0	120	30.00
	4	1	40	24	3	0.20
		2	24	8	45	2.81
		3	8	4	35	8.75
		4	4	0	130	32.69
	5	1	40	24	3	0.20
		2	24	8	47	3.44
		3	8	4	53	12.25
		4	4	0	130	32.69
	6	1	40	24	3	0.20
		2	24	8	60	4.00
		3	8	4	55	15.00
		4	4	0	130	32.69
	7	1	40	24	3	0.20
		2	24	8	65	4.61
		3	8	4	73	15.00
		4	4	0	130	32.69
	8	1	40	24	3	0.20
		2	24	8	70	4.70
		3	8	4	80	15.00
		4	4	0	130	32.69
	Over 8	1	40	24	3	0.20
		2	24	8	85	5.43
		3	8	4	90	15.00
		4	4	0	130	32.69
	1 1/2	1	42	26	3	0.20
		2	26	10	16	1.00
		3	10	4	6	1.00
		4	4	0	12	3.00
	1	1	42	26	3	0.20
		2	26	10	16	1.00
		3	10	4	25	6.25
		4	4	0	25	6.25
	1 1/2	1	42	26	3	0.20
		2	26	10	16	1.00
		3	10	4	23	3.83
		4	4	0	60	15.00
	2	1	42	26	3	0.20
		2	26	10	16	1.00
		3	10	4	25	3.83
		4	4	0	95	23.75
	3	1	42	26	3	0.20
		2	26	10	16	1.00
		3	10	4	25	3.00
		4	4	0	95	23.75
	4	1	42	26	3	0.20
		2	26	10	16	1.00
		3	10	4	25	3.00
		4	4	0	130	32.69
	5	1	42	26	3	0.20
		2	26	10	16	1.00
		3	10	4	25	3.00
		4	4	0	130	32.69
	6	1	42	26	3	0.20
		2	26	10	16	1.00
		3	10	4	25	3.00
		4	4	0	130	32.69

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chutes, the area onto which the material is dropped shall be completely enclosed with barricades not less than 42 inches high and not less than 6 feet back from the projected edge of the opening above. Signs, warning of the hazard of falling materials, shall be posted at each level. Removal shall not be permitted in this lower area until debris handling ceases above.

(l) All floor openings, not used as material drops, shall be covered over with material substantial enough to support the weight of any load which may be imposed. Such material shall be properly secured to prevent its accidental movement.

(j) Except for the cutting of holes in floors for chutes, holes through which to drop materials, preparation of storage space, and similar necessary preparatory work, the demolition of exterior walls and floor construction shall begin at the top of the structure and proceed downward. Each story of exterior wall and floor construction shall be removed and dropped into the storage space before commencing the removal of exterior walls and floors in the story next below.

(k) Employee entrances to multi-story structures being demolished shall be completely protected by sidewalk sheds or canopies, or both, providing protection from the face of the building for a minimum of 8 feet. All such canopies shall be at least 2 feet wider than the building entrances or openings (1 foot wider on each side thereof), and shall be capable of sustaining a load of 150 pounds per square foot.

§ 1518.851 Stairs, passageways, and ladders.

(a) Only those stairways, passageways, and ladders, designated as means of access to the structure of building, shall be used. Other access ways shall be entirely closed off at all times.

(b) All stairs, passageways, ladders and incidental equipment thereto, which are covered by this section, shall be periodically inspected and maintained in a clean safe condition.

(c) In a multistory building, when a stairwell is being used, it shall be properly illuminated by either natural or artificial means, and completely and substantially covered over at a point not less than two floors below the floor on which work is being performed, and access to the floor where the work is in progress shall be through a properly lighted, protected, and separate passageway.

§ 1518.852 Chutes.

(a) No material shall be dropped to any point lying outside the exterior walls of the structure unless the area is effectively protected.

(b) All materials chutes, or sections thereof, at an angle of more than 45° from the horizontal, shall be entirely enclosed, except for openings equipped with closures at or about floor level for the insertion of materials. The openings shall not exceed 48 inches in height measured along the wall of the chute. At all stories

below the top floor, such openings shall be kept closed when not in use.

(c) A substantial gate shall be installed in each chute at or near the discharge end. A competent employee shall be assigned to control the operation of the gate, and the backing and loading of trucks.

(d) When operations are not in progress, the area surrounding the discharge end of a chute shall be securely closed off.

(e) Any chute opening, into which workmen dump debris, shall be protected by a substantial guardrail approximately 42 inches above the floor or other surface on which the men stand to dump the material. Any space between the chute and the edge of openings in the floors through which it passes shall be solidly covered over.

(f) Where the material is dumped from mechanical equipment or wheelbarrows, a securely attached toeboard or bumper, not less than 4 inches thick and 6 inches high, shall be provided at each chute opening.

(g) Chutes shall be designed and constructed of such strength as to eliminate failure due to impact of materials or debris loaded therein.

§ 1518.853 Removal of materials through floor openings.

Any openings cut in a floor for the disposal of materials shall be no larger in size than 25 percent of the aggregate of the total floor area, unless the lateral supports of the removed flooring remain in place. Floors weakened or otherwise made unsafe by demolition operations shall be shored to carry safely the intended imposed load from demolition operations.

§ 1518.854 Removal of walls, masonry sections, and chimneys.

(a) Masonry walls, or other sections of masonry, shall not be permitted to fall upon the floors of the building in such masses as to exceed the safe carrying capacities of the floors.

(b) No wall section, which is more than one story in height, shall be permitted to stand alone without lateral bracing, unless such wall was originally designed and constructed to stand without such lateral support, and is in a condition safe enough to be self-supporting. All walls shall be left in a stable condition at the end of each shift.

(c) Employees shall not be permitted to work on the top of a wall when weather conditions constitute a hazard.

(d) Structural or load-supporting members on any floor shall not be cut or removed until all stories above such a floor have been demolished and removed. This provision shall not prohibit the cutting of floor beams for the disposal of materials or for the installation of equipment, provided that the requirements of §§ 1518.853 and 1518.855 are met.

(e) Floor openings within 10 feet of any wall being demolished shall be planked solid, except when employees are kept out of the area below.

construction, the steel framing may be left in place during the demolition of masonry. Where this is done, all steel beams, girders, and similar structural supports shall be cleared of all loose material as the masonry demolition progresses downward.

(g) Walkways or ladders shall be provided to enable employees to safely reach or leave any scaffold or wall.

(h) Walls, which serve as retaining walls to support earth or adjoining structures, shall not be demolished until such earth has been properly braced or adjoining structures have been properly underpinned.

(i) Walls, which are to serve as retaining walls against which debris will be piled, shall not be so used unless capable of safely supporting the imposed load.

§ 1518.855 Manual removal of floors.

(a) Openings cut in a floor shall extend the full span of the arch between supports.

(b) Before demolishing any floor arch, debris and other material shall be removed from such arch and other adjacent floor area. Planks not less than 2 inches by 10 inches in cross section, full size undressed, shall be provided for, and shall be used by employees to stand on while breaking down floor arches between beams. Such planks shall be so located as to provide a safe support for the workmen should the arch between the beams collapse. The open space between planks shall not exceed 16 inches.

(c) Safe walkways, not less than 18 inches wide, formed of planks not less than 2 inches thick if wood, or of equivalent strength if metal, shall be provided and used by workmen when necessary to enable them to reach any point without walking upon exposed beams.

(d) Stringers of ample strength shall be installed to support the flooring planks, and the ends of such stringers shall be supported by floor beams or girders, and not by floor arches alone.

(e) Planks shall be laid together over solid bearings with the ends overlapping at least 1 foot.

(f) When floor arches are being removed, employees shall not be allowed in the area directly underneath, and such an area shall be barricaded to prevent access to it.

(g) Demolition of floor arches shall not be started until they, and the surrounding floor area for a distance of 20 feet, have been cleared of debris and any other unnecessary materials.

§ 1518.856 Removal of walls, floors, and material with equipment.

(a) Mechanical equipment shall not be used on floors or working surfaces unless such floors or surfaces are of sufficient strength to support the imposed load.

(b) Floor openings shall have curbs or stop-logs to prevent equipment from running over the edge.

(c) Mechanical equipment used shall meet the requirements specified in Subparts N and O of this part.

§ 1518.857 Storage.

(a) The storage of waste material and debris on any floor shall not exceed the allowable floor loads.

(b) In buildings having wooden floor construction, the flooring boards may be removed from not more than one floor above grade to provide storage space for debris, provided falling material is not permitted to endanger the stability of the structure.

(c) When wood floor beams serve to brace interior walls or free-standing exterior walls, such beams shall be left in place until other equivalent support can be installed to replace them.

(d) Floor arches, to an elevation of not more than 25 feet above grade, may be removed to provide storage area for debris: *Provided*, That such removal does not endanger the stability of the structure.

(e) Storage space into which material is dumped shall be blocked off, except for openings necessary for the removal of material. Such openings shall be kept closed at all times when material is not being removed.

§ 1518.858 Removal of steel construction.

(a) When floor arches have been removed, planking in accordance with § 1518.855(b) shall be provided for the workers engaged in razing the steel framing.

(b) Cranes, derricks, and other hoisting equipment used shall meet the requirements specified in Subpart N of this part.

(c) Steel construction shall be dismantled column length by column length, and tier by tier (columns may be in two-story lengths).

(d) Any structural member being dismembered shall not be overstressed.

§ 1518.859 Mechanical demolition.

(a) No workers shall be permitted in any area, which can be adversely affected by demolition operations, when balling or clamping is being performed. Only those workers necessary for the performance of the operations shall be permitted in this area at any other time.

(b) The weight of the demolition ball shall not exceed 50 percent of the crane's rated load, based on the length of the boom and the maximum angle of operation at which the demolition ball will be used, or it shall not exceed 25 percent of the nominal breaking strength of the line by which it is suspended, whichever results in a lesser value.

(c) The crane boom and loadline shall be as short as possible.

(d) The ball shall be attached to the loadline with a swivel-type connection to prevent twisting of the loadline, and shall be attached by positive means in such manner that the weight cannot become accidentally disconnected.

(e) When pulling over walls or portions thereof with a demolition ball or clamshell bucket, or by attachment of a rope, all steel members affected shall have been previously cut free.

(f) All roof cornices or other such ornamental stonework shall be removed prior to pulling walls over.

(g) During demolition, continuing inspections by a competent person shall be made as the work progresses to detect hazards resulting from weakened or deteriorated floors, or walls, or loosened material. No employee shall be permitted to work where such hazards exist until they are corrected by shoring, bracing, or other effective means.

§ 1518.860 Selective demolition by explosives.

Selective demolition by explosives shall be conducted in accordance with the applicable sections of Subpart U of this part.

Subpart U—Blasting and the Use of Explosives**§ 1518.900 General provisions.**

(a) The employer shall permit only authorized and qualified persons to handle and use explosives.

(b) Smoking, firearms, matches, open flame lamps, and other fires, flame or heat producing devices and sparks shall be prohibited in or near explosive magazines or while explosives are being handled, transported or used.

(c) No person shall be allowed to handle or use explosives while under the influence of intoxicating liquors, narcotics, or other dangerous drugs.

(d) All explosives shall be accounted for at all times. Explosives not being used shall be kept in a locked magazine, unavailable to persons not authorized to handle them. The employer shall maintain an inventory and use record of all explosives. Appropriate authorities shall be notified of any loss, theft, or unauthorized entry into a magazine.

(e) No explosives or blasting agents shall be abandoned.

(f) No fire shall be fought where the fire is in imminent danger of contact with explosives. All employees shall be removed to a safe area and the fire area guarded against intruders.

(g) Original containers, or Class II magazines, shall be used for taking detonators and other explosives from storage magazines to the blasting area.

(h) When blasting is done in congested areas or in proximity to a structure, railway, or highway, or any other installation that may be damaged, the blaster shall take special precautions in the loading, delaying, initiation, and confinement of each blast with mats or other methods so as to control the throw of fragments, and thus prevent bodily injury to employees.

(i) Employees authorized to prepare explosive charges or conduct blasting operations shall use every reasonable precaution including, but not limited to, visual and audible warning signals, flags, or barricades, to ensure employee safety.

(j) Insofar as possible, blasting operations above ground shall be conducted between sunup and sundown.

(k) Due precautions shall be taken to prevent accidental discharge of electric

blasting caps from current induced by radar, radio transmitters, lightning, adjacent powerlines, dust storms, or other sources of extraneous electricity. These precautions shall include:

(1) Detonators shall be short-circuited in holes which have been primed and shunted until wired into the blasting circuit.

(2) The suspension of all blasting operations and removal of persons from the blasting area during the approach and progress of an electric storm:

(3) The posting of signs warning against the use of mobile radio transmitters on all roads within 1,000 feet of the blasting operations. Signs shall have 4-inch white letters on a red background, with the words, "Blasting Area—Radio Transmitting Prohibited."

(4) Ensuring that mobile radio transmitters which are less than 100 feet away from electric blasting caps, in other than original containers, shall be de-energized and effectively locked;

(5) Compliance with the recommendations of The Institute of the Makers of Explosives with regard to blasting in the vicinity of radio transmitters as stipulated in Radio Frequency Energy—A Potential Hazard in the Use of Electric Blasting Caps, IME Publication No. 20, March 1968.

(l) Empty boxes and paper and fiber packing materials, which have previously contained high explosives, shall not be used again for any purpose, but shall be destroyed by burning at an approved location.

(m) Explosives, blasting agents, and blasting supplies that are obviously deteriorated or damaged shall not be used.

(n) Delivery and issue of explosives shall only be made by and to authorized persons and into authorized magazines or approved temporary storage or handling areas.

(o) Blasting operations in the proximity of overhead power lines, communication lines, utility services, or other services and structures shall not be carried on until the operators and/or owners have been notified and measures for safe control have been taken.

(p) The use of black powder shall be prohibited.

(q) All loading and firing shall be directed and supervised by competent persons thoroughly experienced in this field.

(r) All blasts shall be fired electrically with an electric blasting machine or properly designed electric power source, except as provided in § 1518.906 (a) and (r).

§ 1518.901 Blaster qualifications.

(a) A blaster shall be able to understand and give written and oral orders.

(b) A blaster shall be in good physical condition and not be addicted to narcotics, intoxicants, or similar types of drugs.

(c) A blaster shall be qualified, by reason of training, knowledge, or experience, in the field of transporting, storing, handling, and use of explosives, and have a working knowledge of State and local

laws and regulations which pertain to explosives.

(d) Blasters shall be required to furnish satisfactory evidence of competency in handling explosives and performing in a safe manner the type of blasting that will be required.

(e) The blaster shall be knowledgeable and competent in the use of each type of blasting method used.

§ 1518.902 Surface transportation of explosives.

(a) Transportation of explosives shall meet the provisions of Department of Transportation regulations contained in 14 CFR Part 603, Air Transportation; 46 CFR Parts 146-149, Water Carriers; 49 CFR Parts 171-179, Highways and Railways; 49 CFR Part 180, Pipelines; and 49 CFR Parts 290-297, Motor Carriers.

(b) Motor vehicles or conveyances transporting explosives shall only be driven by, and be in the charge of, a licensed driver who is physically fit. He shall be familiar with the local, State, and Federal regulation governing the transportation of explosives.

(c) No person shall smoke, or carry matches or any other flame-producing device, nor shall firearms or loaded cartridges be carried while in or near a motor vehicle or conveyance transporting explosives.

(d) Explosives, blasting agents, and blasting supplies shall not be transported with other materials or cargoes. Blasting caps (including electric) shall not be transported in the same vehicle with other explosives.

(e) Vehicles used for transporting explosives shall be strong enough to carry the load without difficulty, and shall be in good mechanical condition.

(f) When explosives are transported by a vehicle with an open body, a Class II magazine or original manufacturer's container shall be securely mounted on the bed to contain the cargo.

(g) All vehicles used for the transportation of explosives shall have tight floors and any exposed spark-producing metal on the inside of the body shall be covered with wood, or other nonsparking material, to prevent contact with containers of explosives.

(h) Every motor vehicle or conveyance used for transporting explosives shall be marked or placarded on both sides, the front, and the rear with the word "Explosives" in red letters, not less than 4 inches in height, on white background. In addition to such marking or placarding, the motor vehicle or conveyance may display, in such a manner that it will be readily visible from all directions, a red flag 18 inches by 30 inches, with the word "Explosives" painted, stamped, or sewed thereon, in white letters, at least 6 inches in height.

(i) Each vehicle used for transportation of explosives shall be equipped with a fully charged fire extinguisher, in good condition. An Underwriters Laboratory-approved extinguisher of not less than 10-ABC rating will meet the minimum requirement. The driver shall be trained

in the use of the extinguisher on his vehicle.

(j) Motor vehicles or conveyances carrying explosives, blasting agents, or blasting supplies, shall not be taken inside a garage or shop for repairs or servicing.

(k) No motor vehicle transporting explosives shall be left unattended.

§ 1518.903 Underground transportation of explosives.

(a) All explosives or blasting agents in transit underground shall be taken to the place of use or storage without delay.

(b) The quantity of explosives or blasting agents taken to an underground loading area shall not exceed the amount estimated to be necessary for the blast.

(c) Explosives in transit shall not be left unattended.

(d) The hoist operator shall be notified before explosives or blasting agents are transported in a shaft conveyance.

(e) Trucks used for the transportation of explosives underground shall have the electrical system checked weekly to detect any failures which may constitute an electrical hazard. A written record of such inspections shall be kept on file.

(f) The installation of auxiliary lights on truck beds, which are powered by the truck's electrical system, shall be prohibited.

(g) Explosives and blasting agents shall be hoisted, lowered, or conveyed in a powder car. No other materials, supplies, or equipment shall be transported in the same conveyance at the same time.

(h) No one, except the operator, his helper, and the powderman, shall be permitted to ride on a conveyance transporting explosives and blasting agents.

(i) No person shall ride in any shaft conveyance transporting explosives and blasting agents.

(j) No explosives or blasting agents shall be transported on any locomotive. At least two car lengths shall separate the locomotive from the powder car.

(k) No explosives or blasting agents shall be transported on a man haul trip.

(l) The car or conveyance containing explosives or blasting agents shall be pulled, not pushed, whenever possible.

(m) The powder car or conveyance especially built for the purpose of transporting explosives or blasting agents shall bear a reflectorized sign on each side with the word "Explosives" in letters, not less than 4 inches in height; upon a background of sharply contrasting color.

(n) Compartments for transporting detonators and explosives in the same car or conveyance shall be physically separated by a distance of 24 inches or by a solid partition at least 6 inches thick.

(o) Detonators and other explosives shall not be transported at the same time in any shaft conveyance.

(p) Explosives, blasting agents, or blasting supplies shall not be transported with other materials.

(q) Explosives or blasting agents, not in original containers, shall be placed in a suitable container when transported manually.

(r) Detonators, primers, and other explosives shall be carried in separate containers when transported manually.

§ 1518.904 Storage of explosives and blasting agents.

(a) Explosives and related materials shall be stored in approved facilities required under the applicable provisions of the Internal Revenue Service regulations contained in 26 CFR 181, Commerce in Explosives.

(b) Blasting caps, electric blasting caps, detonating primers, and primed cartridges shall not be stored in the same magazine with other explosives or blasting agents.

(c) Smoking and open flames shall not be permitted within 50 feet of explosives and detonator storage magazine.

(d) No explosives or blasting agents shall be permanently stored in any underground operation until the operation has been developed to the point where at least two modes of exit have been provided.

(e) Permanent underground storage magazines shall be at least 300 feet from any shaft, adit, or active underground working area.

(f) Permanent underground magazines containing detonators shall not be located closer than 50 feet to any magazine containing other explosives or blasting agents.

§ 1518.905 Loading of explosives or blasting agents.

(a) Procedures that permit safe and efficient loading shall be established before loading is started.

(b) All drill holes shall be sufficiently large to admit freely the insertion of the cartridges of explosives.

(c) Tamping shall be done only with wood rods or plastic tamping poles without exposed metal parts, but nonsparking metal connectors may be used for jointed poles. Violent tamping shall be avoided. The primer shall never be tamped.

(d) No holes shall be loaded except those to be fired in the next round of blasting. After loading, all remaining explosives and detonators shall be immediately returned to an authorized magazine.

(e) Drilling shall not be started until all remaining butts of old holes are examined for unexploded charges, and if any are found, they shall be refired before work proceeds.

(f) No person shall be allowed to deepen drill holes which have contained explosives or blasting agents.

(g) No explosives or blasting agents shall be left unattended at the blast site.

(h) Machines and all tools not used for loading explosives into bore holes shall be removed from the immediate location of holes before explosives are delivered. Equipment shall not be operated within 50 feet of loaded holes.

(i) No activity of any nature other than that which is required for loading

holes with explosives shall be permitted in a blast area.

(j) Powerlines and portable electric cables for equipment being used shall be kept a safe distance from explosives or blasting agents being loaded into drill holes. Cables in the proximity of the blast area shall be deenergized and locked out by the blaster.

(k) Holes shall be checked prior to loading to determine depth and conditions. Where a hole has been loaded with explosives but the explosives have failed to detonate, there shall be no drilling within 50 feet of the hole.

(l) When loading a long line of holes with more than one loading crew, the crews shall be separated by practical distance consistent with efficient operation and supervision of crews.

(m) No explosive shall be loaded or used underground in the presence of combustible gases or combustible dusts.

(n) No explosives other than those in Fume Class 1, as set forth by the Institute of Makers of Explosives, shall be used; however, explosives complying with the requirements of Fume Class 2 and Fume Class 3 may be used if adequate ventilation has been provided.

(o) All blast holes in open work shall be stemmed to the collar or to a point which will confine the charge.

(p) Warning signs, indicating a blast area, shall be maintained at all approaches to the blast area. The warning sign lettering shall not be less than 4 inches in height on a contrasting background.

(q) A bore hole shall never be sprung when it is adjacent to or near a hole that is loaded. Flashlight batteries shall not be used for springing holes.

(r) Drill holes which have been sprung or chambered, and which are not water-filled, shall be allowed to cool before explosives are loaded.

(s) No loaded holes shall be left unattended or unprotected.

(t) The blaster shall keep an accurate, up-to-date record of explosives, blasting agents, and blasting supplies used in a blast and shall keep an accurate running inventory of all explosives and blasting agents stored on the operation.

§ 1518.906 Initiation of explosive charges—electric blasting.

(a) Electric blasting caps shall not be used where sources of extraneous electricity make the use of electric blasting caps dangerous. Blasting cap leg wires shall be kept short-circuited (shunted) until they are connected into the circuit for firing.

(b) Before adopting any system of electrical firing, the blaster shall conduct a thorough survey for extraneous currents, and all dangerous currents shall be eliminated before any holes are loaded.

(c) In any single blast using electric blasting caps, all caps shall be of the same style or function, and of the same manufacture.

(d) Electric blasting shall be carried out by using blasting circuits or power circuits in accordance with the electric

blasting cap manufacturer's recommendations, or an approved contractor or his designated representative.

(e) When firing a circuit of electric blasting caps, care must be exercised to ensure that an adequate quantity of delivered current is available, in accordance with the manufacturer's recommendations.

(f) Connecting wires and lead wires shall be insulated single solid wires of sufficient current-carrying capacity.

(g) Bus wires shall be solid single wires of sufficient current-carrying capacity.

(h) When firing electrically, the insulation on all firing lines shall be adequate and in good condition.

(i) A power circuit used for firing electric blasting caps shall not be grounded.

(j) In underground operations when firing from a power circuit, a safety switch shall be placed in the permanent firing line at intervals. This switch shall be made so it can be locked only in the "Off" position and shall be provided with a short-circuiting arrangement of the firing lines to the cap circuit.

(k) In underground operations there shall be a "lightning" gap of at least 5 feet in the firing system ahead of the main firing switch; that is, between this switch and the source of power. This gap shall be bridged by a flexible jumper cord just before firing the blast.

(l) When firing from a power circuit, the firing switch shall be locked in the open or "Off" position at all times, except when firing. It shall be so designed that the firing lines to the cap circuit are automatically short-circuited when the switch is in the "Off" position. Keys to this switch shall be entrusted only to the blaster.

(m) Blasting machines shall be in good condition and the efficiency of the machine shall be tested periodically to make certain that it can deliver power at its rated capacity.

(n) When firing with blasting machines, the connections shall be made as recommended by the manufacturer of the electric blasting caps used.

(o) The number of electric blasting caps connected to a blasting machine shall not be in excess of its rated capacity. Furthermore, in primary blasting, a series circuit shall contain no more caps than the limits recommended by the manufacturer of the electric blasting caps in use.

(p) The blaster shall be in charge of the blasting machines, and no other person shall connect the leading wires to the machine.

(q) Blasters, when testing circuits to charged holes, shall use only blasting galvanometers equipped with a silver chloride cell especially designed for this purpose.

(r) Whenever the possibility exists that a leading line or blasting wire might be thrown over a live powerline by the force of an explosion, care shall be taken to see that the total length of wires are kept too short to hit the lines, or that the wires are securely anchored to the

ground. If neither of these requirements can be satisfied, a nonelectric system shall be used.

(s) In electrical firing, only the man making leading wire connections shall fire the shot. All connections shall be made from the bore hole back to the source of firing current, and the leading wires shall remain shorted and not be connected to the blasting machine or other source of current until the charge is to be fired.

(t) After firing an electric blast from a blasting machine, the leading wires shall be immediately disconnected from the machine and short-circuited.

§ 1518.908 Use of detonating cord.

(a) Care shall be taken to select a detonating cord consistent with the type and physical condition of the bore hole and stemming and the type of explosives used.

(b) Detonating cord shall be handled and used with the same respect and care given other explosives.

(c) The line of detonating cord extending out of a bore hole or from a charge shall be cut from the supply spool before loading the remainder of the bore hole or placing additional charges.

(d) Detonating cord shall be handled and used with care to avoid damaging or severing the cord during and after loading and hooking-up.

(e) Detonating cord connections shall be competent and positive in accordance with approved and recommended methods. Knot-type or other cord-to-cord connections shall be made only with detonating cord in which the explosive core is dry.

(f) All detonating cord trunklines and branchlines shall be free of loops, sharp kinks, or angles that direct the cord back toward the oncoming line of detonation.

(g) All detonating cord connections shall be inspected before firing the blast.

(h) When detonating cord millisecond-delay connectors or short-interval-delay electric blasting caps are used with detonating cord, the practice shall conform strictly to the manufacturer's recommendations.

(i) When connecting a blasting cap of an electric blasting cap to detonating cord, the cap shall be taped or otherwise attached securely along the side or the end of the detonating cord, with the end of the cap containing the explosive charge pointed in the direction in which the detonation is to proceed.

(j) Detonators for firing the trunkline shall not be brought to the loading area nor attached to the detonating cord until everything else is in readiness for the blast.

§ 1518.909 Firing the blast.

(a) A code of blasting signals equivalent to Table U-1, shall be posted on one or more conspicuous places at the operation, and all employees shall be required to familiarize themselves with the code and conform to it. Danger signs shall be placed at suitable locations.

(b) Before a blast is fired, a loud warning signal shall be given by the

blaster in charge, who has made certain that all surplus explosives are in a safe place and all employees, vehicles, and equipment are at a safe distance, or under sufficient cover.

(c) Flagmen shall be safely stationed on highways which pass through the danger zone so as to stop traffic during blasting operations.

(d) It shall be the duty of the blaster to fix the time of blasting.

(e) Before firing an underground blast, warning shall be given, and all possible entries into the blasting area, and any entrances to any working place where a drift, raise, or other opening is about to hole through, shall be carefully guarded. The blaster shall make sure that all employees are out of the blast area before firing a blast.

§ 1518.910 Inspection after blasting.

(a) Immediately after the blast has been fired, the firing line shall be disconnected from the blasting machine, or where power switches are used, they shall be locked open or in the off position.

(b) Sufficient time shall be allowed, not less than 15 minutes in tunnels, for the smoke and fumes to leave the blasted area before returning to the shot. An inspection of the area and the surrounding rubble shall be made by the blaster to determine if all charges have been exploded before employees are allowed to return to the operation, and in tunnels, after the muck pile has been wetted down.

§ 1518.911 Misfires.

(a) If a misfire is found, the blaster shall provide proper safeguards for excluding all employees from the danger zone.

(b) No other work shall be done except that necessary to remove the hazard of the misfire and only those employees necessary to do the work shall remain in the danger zone.

(c) No attempt shall be made to extract explosives from any charged or misfired hole; a new primer shall be put in and the hole reblasted. If refiring of the misfired hole presents a hazard, the explosives may be removed by washing out with water or, where the misfire is under water, blown out with air.

(d) If there are any misfires while using cap and fuse, all employees shall remain away from the charge for at least 1 hour. Misfires shall be handled under the direction of the person in charge of the blasting. All wires shall be carefully traced and a search made for unexploded charges.

(e) No drilling, digging, or picking shall be permitted until all missed holes have been detonated or the authorized representative has approved that work can proceed.

§ 1518.912 Underwater blasting.

(a) A blaster shall conduct all blasting operations, and no shot shall be fired without his approval.

(b) Loading tubes and casings of dissimilar metals shall not be used because of possible electric transient currents from galvanic action of the metals and water.

(c) Only water-resistant blasting caps and detonating cords shall be used for all marine blasting. Loading shall be done through a nonsparking metal loading tube when tube is necessary.

(d) No blast shall be fired while any vessel under way is closer than 1,500 feet to the blasting area. Those on board vessels or craft moored or anchored within 1,500 feet shall be notified before a blast is fired.

(e) No blast shall be fired while any swimming or diving operations are in progress in the vicinity of the blasting area. If such operations are in progress, signals and arrangements shall be agreed upon to assure that no blast shall be fired while any person is in the water.

(f) Blasting flags shall be displayed.

(g) The storage and handling of explosives aboard vessels used in underwater blasting operations shall be according to provisions outlined herein on handling and storing explosives.

(h) When more than one charge is placed under water, a float device shall be attached to an element of each charge in such manner that it will be released by the firing. Misfires shall be handled in accordance with the requirements of § 1518.911.

§ 1518.913 Blasting in excavation work under compressed air.

(a) Detonators and explosives shall not be stored or kept in tunnels, shafts, or caissons. Detonators and explosives for each round shall be taken directly from the magazines to the blasting zone and immediately loaded. Detonators and explosives left over after loading a round shall be removed from the working chamber before the connecting wires are connected up.

(b) When detonators or explosives are brought into an air lock, no employee except the powderman, blaster, lock tender and the employees necessary for carrying, shall be permitted to enter the air lock. No other material, supplies, or equipment shall be locked through with the explosives.

(c) Detonators and explosives shall be taken separately into pressure working chambers.

(d) The blaster or powderman shall be responsible for the receipt, unloading, storage, and on-site transportation of explosives and detonators.

(e) All metal pipes, rails, air locks, and steel tunnel lining shall be electrically bonded together and grounded at or near the portal or shaft, and such pipes and rails shall be cross-bonded together at not less than 1,000-foot intervals throughout the length of the tunnel. In addition, each low air supply pipe shall be grounded at its delivery end.

(f) The explosives suitable for use in wet holes shall be water-resistant and shall be Fume Class 1.

(g) When tunnel excavation in rock face is approaching mixed face, and when tunnel excavation is in mixed face, blasting shall be performed with light charges and with light burden on each hole. Advance drilling shall be performed as tunnel excavation in rock face approaches mixed face, to determine the general nature and extent of rock cover and the remaining distance ahead to soft ground as excavation advances.

§ 1518.914 Definitions applicable to this subpart.

(a) "American Table of Distances" (also known as Quantity Distance Tables) means American Table of Distances for Storage of Explosives as revised and approved by the Institute of the Makers of Explosives, June 5, 1964.

(b) "Approved storage facility"—A facility for the storage of explosive materials conforming to the requirements of this part and covered by a license or permit issued under authority of the Internal Revenue Service. (See 26 CFR Part 181).

(c) "Blast area"—The area in which explosives loading and blasting operations are being conducted.

(d) "Blaster"—The person or persons authorized to use explosives for blasting purposes and meeting the qualifications contained in § 1518.901.

(e) "Blasting agent"—A blasting agent is any material or mixture consisting of a fuel and oxidizer used for blasting, but not classified an explosive and in which none of the ingredients is classified as an explosive provided the furnished (mixed) product cannot be detonated with a No. 8 test blasting cap when confined. A common blasting agent presently in use is a mixture of ammonium nitrate (NH₄NO₃) and carbonaceous combustibles, such as fuel oil or coal, and may either be procured, premixed and packaged from explosives companies or mixed in the field.

(f) "Blasting cap"—A metallic tube closed at one end, containing a charge of one or more detonating compounds, and designed for and capable of detonation from the sparks or flame from a safety fuse inserted and crimped into the open end.

(g) "Block holing"—The breaking of boulders by firing a charge of explosives that has been loaded in a drill hole.

(h) "Conveyance"—Any unit for transporting explosives or blasting agents, including but not limited to trucks, trailers, rail cars, barges, and vessels.

(i) "Detonating cord"—A flexible cord containing a center core of high explosives which when detonated, will have sufficient strength to detonate other cap-sensitive explosives with which it is in contact.

(j) "Detonator"—Blasting caps, electric blasting caps, delay electric blasting caps, and nonelectric delay blasting caps.

(k) "Electric blasting cap"—A blasting cap designed for and capable of detonation by means of an electric current.

(l) "Electric blasting circuitry"—

(1) Bus wire. An expendable wire, used in parallel or series, in parallel circuits, to which are connected the leg wires of electric blasting caps.

(2) Connecting wire. An insulated expendable wire used between electric blasting caps and the leading wires or between the bus wire and the leading wires.

(3) Leading wire. An insulated wire used between the electric power source and the electric blasting cap circuit.

(4) Permanent blasting wire. A permanently mounted insulated wire used between the electric power source and the electric blasting cap circuit.

(m) "Electric delay blasting caps"—Caps designed to detonate at a predetermined period of time after energy is applied to the ignition system.

(n) "Explosives"—(1) Any chemical compound, mixture, or device, the primary or common purpose of which is to function by explosion; that is, with substantially instantaneous release of gas and heat, unless such compound, mixture or device is otherwise specifically classified by the U.S. Department of Transportation.

(2) All material which is classified as Class A, Class B, and Class C explosives by the U.S. Department of Transportation.

(3) Classification of explosives by the U.S. Department of Transportation is as follows:

Class A Explosives. Possessing detonating hazard, such as dynamite, nitroglycerin, picric acid, lead azide, fulminate of mercury, black powder, blasting caps, and detonating primers.

Class B Explosives. Possessing flammable hazard, such as propellant explosives, including some smokeless propellants.

Class C Explosives. Include certain types of manufactured articles which contain Class A or Class B explosives, or both, as components, but in restricted quantities.

(o) "Fuse lighters"—Special devices for the purpose of igniting safety fuse.

(p) "Magazine"—Any building or structure, other than an explosives

manufacturing building, used for the storage of explosives.

(q) "Misfire"—An explosive charge which failed to detonate.

(r) "Mud-capping" (sometimes known as bulldozing, adobe blasting, or dobying). The blasting of boulders by placing a quantity of explosives against a rock, boulder, or other object without confining the explosives in a drill hole.

(s) "Nonelectric delay blasting cap"—A blasting cap with an integral delay element in conjunction with and capable of being detonated by a detonation impulse or signal from miniaturized detonating cord.

(t) "Primary blasting"—The blasting operation by which the original rock formation is dislodged from its natural location.

(u) "Primer"—A cartridge or container of explosives into which a detonator or detonating cord is inserted or attached.

(v) "Safety fuse"—A flexible cord containing an internal burning medium by which fire is conveyed at a continuous and uniform rate for the purpose of firing blasting caps.

(w) "Secondary blasting"—The reduction of oversize material by the use of explosives to the dimension required for handling, including mudcapping and blockholing.

(x) "Stemming"—A suitable inert incombustible material or device used to confine or separate explosives in a drill hole, or to cover explosives in mud-capping.

(y) "Springing"—The creation of a pocket in the bottom of a drill hole by the use of a moderate quantity of explosives in order that larger quantities or explosives may be inserted therein.

(z) "Water gels, or slurry explosives"—A wide variety of materials used for blasting. They all contain substantial proportions of water and high proportions of ammonium nitrate, some of which is in solution in the water. Two broad classes of water gels are: (1) Those which are sensitized by a material classed as an explosive, such as TNT or smokeless powder, and (2) those which contain no ingredient classified as an explosive; these are sensitized with metals such as aluminum or with other fuels. Water gels may be premixed at an explosives plant or mixed at the site immediately before delivery into the bore hole.

Subpart V—Power Distribution and Transmission Lines [Reserved]

Subpart W—Recording and Reporting Work Injury Frequency and Severity Data and Accident Costs [Reserved]

Subpart X—Effective Dates

§ 1518.1050 Effective dates (general).

Except where different effective dates are specifically provided in § 1518.1051, the safety and health standards published in Subparts C through U of this part shall become effective on April 24, 1971, for all Federal and federally assisted advertised contracts subject thereto which are advertised after that date and on April 27, 1971, for all such negotiated contracts for which negotiations begin after that date.

§ 1518.1051 Effective dates (specific).

(a) With respect to standards concerning brakes and fenders prescribed in § 1518.602, the rules contained therein specify the applicable effective dates.

(b) (1) To the extent that the standards in Subpart C of this part apply to light residential construction, their application is delayed until August 15, 1971, which is 120 days following the publication of the standards in the FEDERAL REGISTER.

(2) For the purpose of this paragraph, the term "light residential construction" is limited to the construction of homes and apartments which do not exceed three stories in height, and which do not have an elevator.

(3) Interested persons are encouraged to petition within the 60-day period following publication of this part, for the issuance, amendment, or repeal of particular safety or health standards as they relate to light residential construction which would facilitate adjustments to the safety or health standards as a whole in such construction, or which would offer alternative standards that would not prejudice the safety or health of laborers or mechanics employed therein.

Signed at Washington, D.C., this 13th day of April 1971.

J. D. HONGSON,
Secretary of Labor.

[FR Doc.71-5317 Filed 4-16-71; 8:45 am]

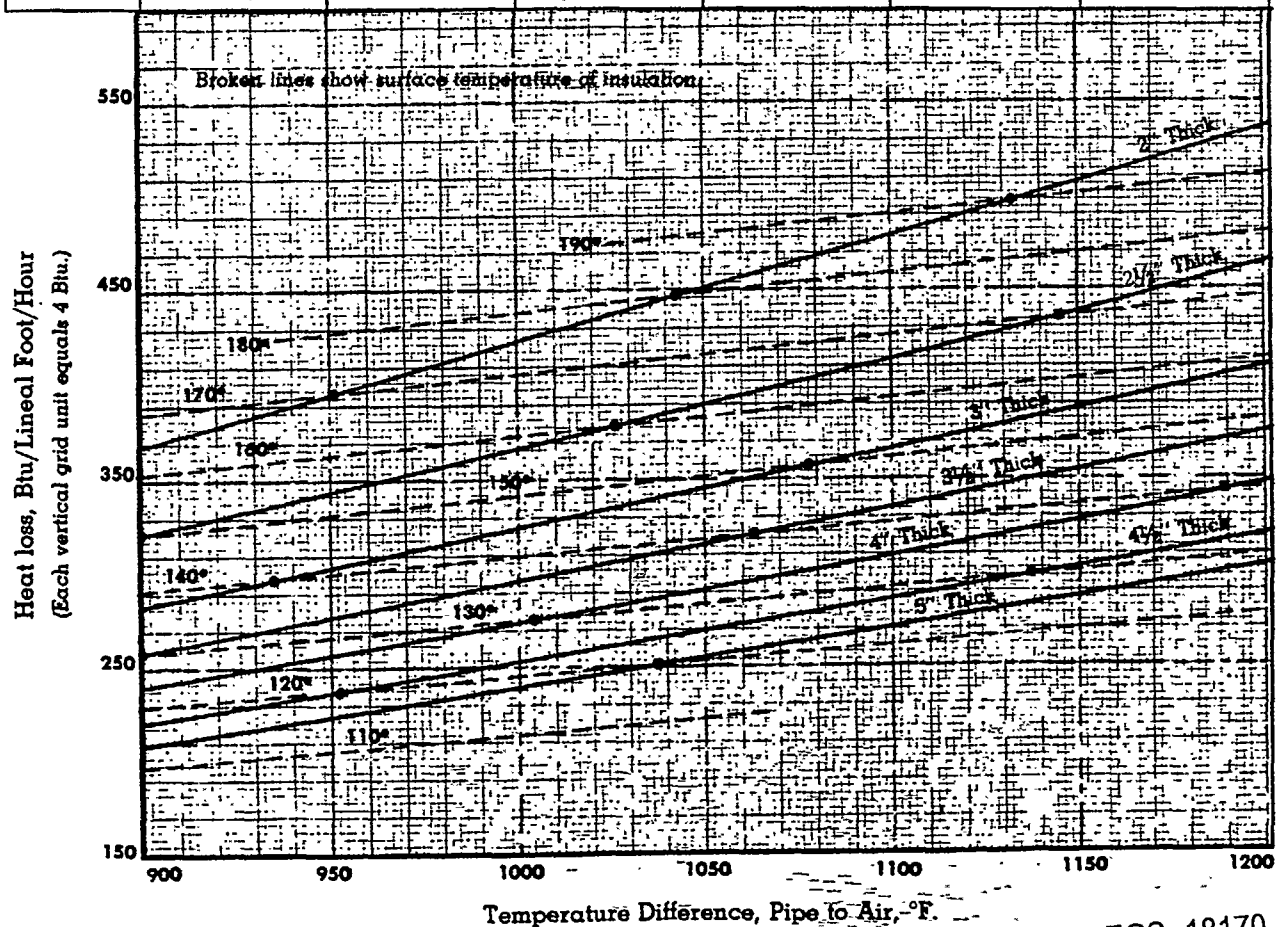
KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

4-Inch Pipe

Ambient still air 80°F.

Pipe Temp. °F.	1030°			1080°			1130°			1180°			1230°			1280°		
Temp. Diff. Pipe to Air °F.	950°			1000°			1050°			1100°			1150°			1200°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	11123	1030		12599	1080		14218	1130		15988	1180		17920	1230		20022	1280	
1																		
1 1/2	395	170	96.4	423	175	96.6	450	180	96.8	478	185	97.0	506	190	97.2	537	195	97.3
2	343	154	96.9	366	158	97.1	390	162	97.3	418	166	97.4	441	172	97.5	464	175	97.7
2 1/2	303	141	97.3	323	144	97.4	345	148	97.6	366	152	97.7	388	155	97.8	410	159	98.0
3	277	133	97.5	298	136	97.7	314	139	97.8	335	142	97.9	354	145	98.0	375	148	98.1
3 1/2	256	127	97.7	274	130	97.8	291	132	98.0	309	134	98.1	328	137	98.2	347	141	98.3
4	236	120	97.9	252	123	98.0	269	125	98.1	288	127	98.2	303	130	98.3	320	132	98.4
4 1/2	224	116	98.0	239	118	98.1	254	121	98.2	270	123	98.3	287	125	98.4	303	127	98.5
5																		



KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

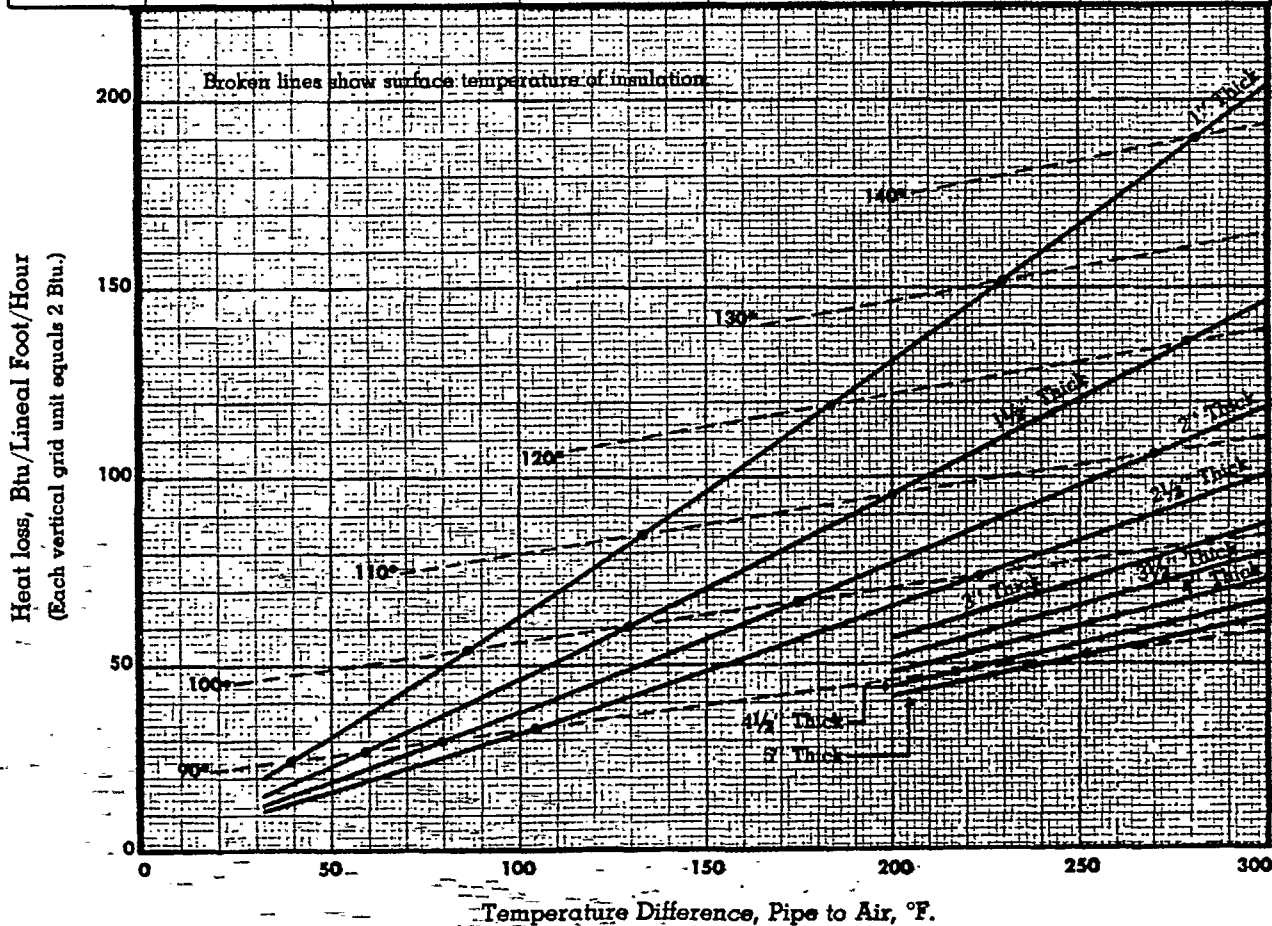
4½-Inch Pipe

OWENS-ILLINOIS
 GLASS COMPANY

KAYLO
 HEAT INSULATING
 PRODUCTS

Ambient still air 80°F.

Pipe Temp. °F.	130°			180°			230°			280°			330°			380°		
Temp. Diff. Pipe to Air °F.	50°			100°			150°			200°			250°			300°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	121	130		281	180		476	230		708	280		977	330		1298	380	
1	29.5	92	75.6	61.2	103	78.2	94.1	113	80.2	129	124	81.8	166	134	83.0	203	144	84.4
1½	21.6	88	82.1	44.5	95	84.2	68.3	102	85.7	93.3	109	86.8	119	116	87.8	146	123	88.8
2	17.5	86	85.5	35.9	91	87.2	55.2	97	88.4	75.0	102	89.4	96.0	107	90.2	118	113	90.9
2½	15.0	85	87.6	30.7	89	89.1	47.1	93	90.1	64.0	97	91.0	81.6	102	91.6	100	106	92.3
3										55.8	94	92.1	70.9	97	92.7	86.8	101	93.3
3½										50.5	92	92.9	64.3	95	93.4	78.9	98	93.9
4										46.4	90	93.4	59.2	93	93.9	72.2	95	94.4
4½										42.6	89	94.0	54.2	91	94.5	66.2	93	94.9
5										40.1	88	94.3	51.0	90	94.8	62.0	92	95.2

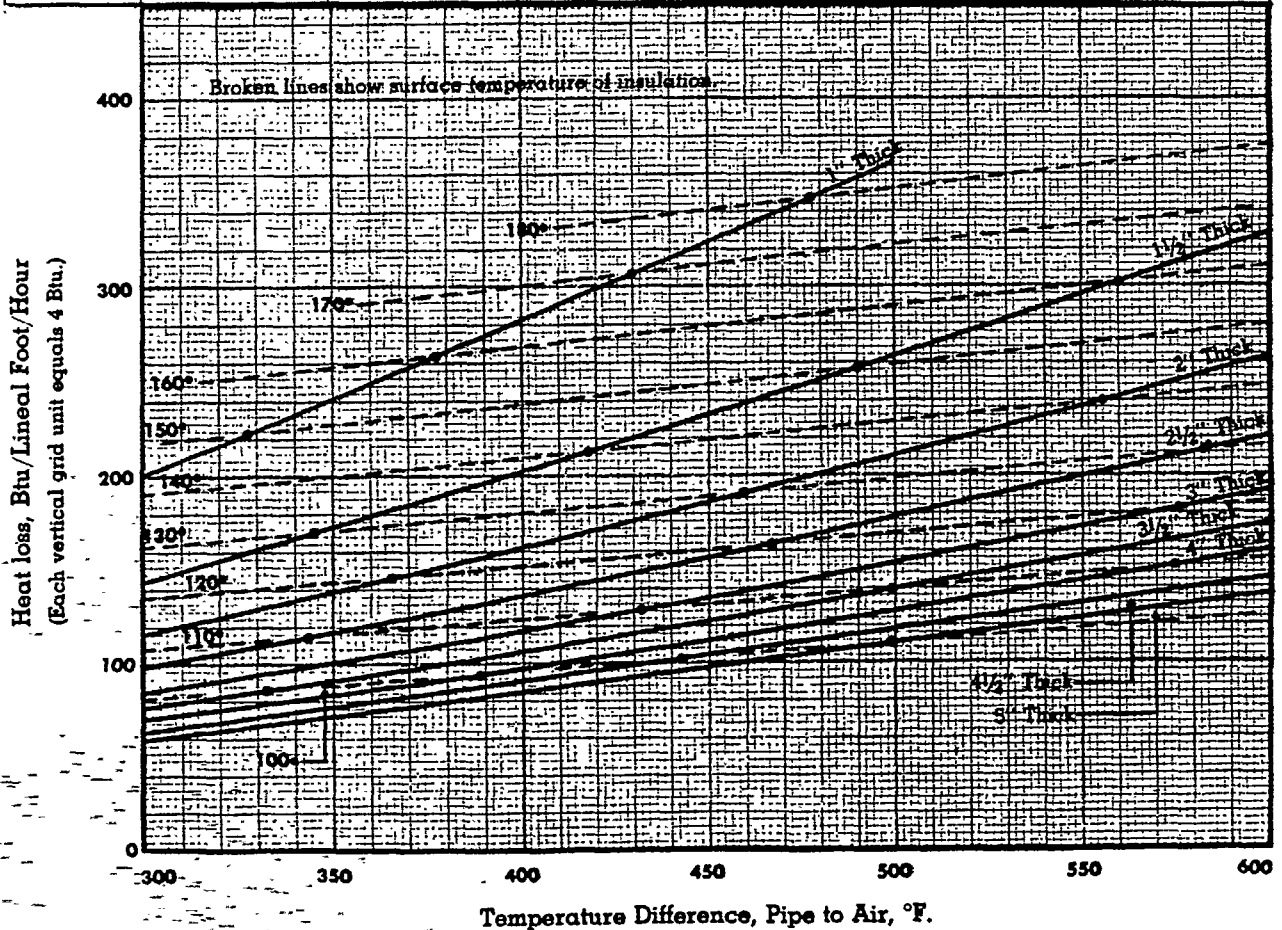


EGS 18171

KAYLO PIPE INSULATION **Heat Loss — Surface Temperature — Efficiency** **4½-Inch Pipe**

Ambient still air 80°F.

Pipe Temp. °F.	430°			480°			530°			580°			630°			680°		
Temp. Diff. Pipe to Air °F.	350°			400°			450°			500°			550°			600°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	1666	430		2090	480		2577	530		3137	580		3766	630		4481	680	
1	243	154	85.4	283	164	86.5	326	174	87.3	369	184	88.2	412	194	89.1	458	204	90.0
1½	174	130	89.6	203	137	90.3	233	144	91.0	264	151	91.6	296	158	92.1	328	165	92.7
2	140	118	91.6	163	123	92.2	187	128	92.7	212	134	93.2	237	139	93.7	263	145	94.1
2½	119	110	92.9	138	114	93.4	158	119	93.9	179	123	94.3	201	127	94.7	222	131	95.1
3	103	104	93.8	120	108	94.3	138	111	94.6	156	115	95.0	174	118	95.4	193	122	95.7
3½	93.5	101	94.4	109	104	94.8	125	107	95.1	141	110	95.5	158	113	95.8	175	116	96.1
4	85.8	98	94.8	100	100	95.2	115	103	95.5	129	106	95.9	145	108	96.1	161	111	96.4
4½	78.6	95	95.3	91.6	97	95.6	105	100	95.9	119	102	96.2	133	104	96.5	147	107	96.7
5	74.0	94	95.6	85.9	96	95.9	98.0	98	96.2	112	100	96.4	124	102	96.7	138	104	96.9



KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

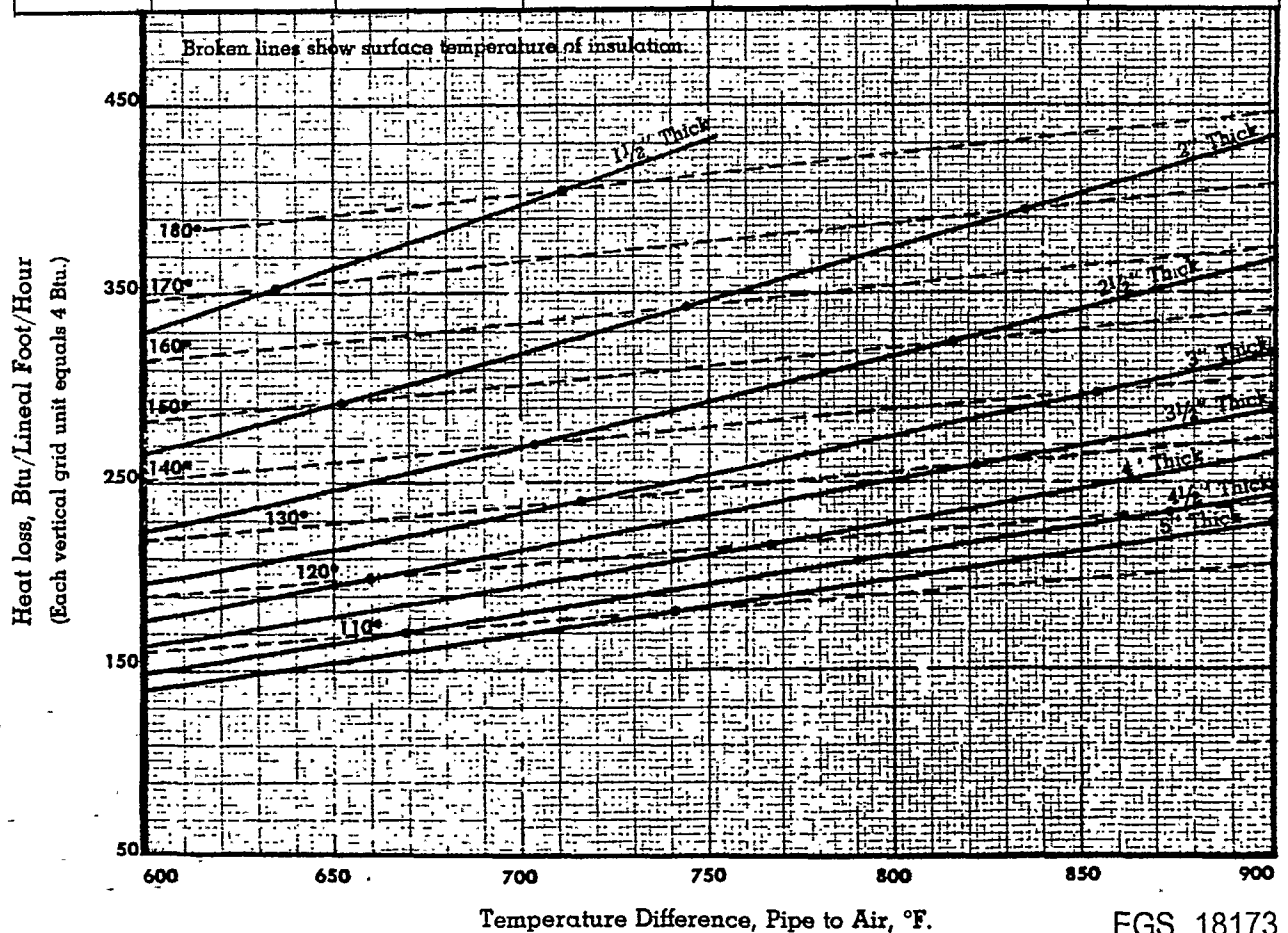
4½-Inch Pipe

OWENS-ILLINOIS
 GLASS COMPANY

KAYLO
 HEAT INSULATING
 PRODUCTS

Ambient still air 80°F.

Pipe Temp. °F.	730°			780°			830°			880°			930°			980°		
Temp. Diff. Pipe to Air °F.	650°			700°			750°			800°			850°			900°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	5277	730		6164	780		7157	830		8258	880		9482	930		10834	980	
1																		
1½	361	172	93.2	396	179	93.6	431	186	94.0									
2	290	150	94.5	317	155	94.9	345	161	95.2	374	166	95.5	404	172	95.7	434	177	96.0
2½	245	136	95.4	269	140	95.6	292	145	95.9	317	149	96.2	342	154	96.4	368	158	96.6
3	213	125	96.0	233	129	96.2	254	133	96.5	275	137	96.7	297	140	96.9	319	144	97.1
3½	193	119	96.3	211	122	96.6	230	125	96.8	248	128	97.0	269	132	97.2	288	135	97.3
4	177	114	96.6	194	117	96.9	211	119	97.1	228	122	97.2	247	125	97.4	265	128	97.6
4½	162	109	96.9	177	113	97.1	193	114	97.3	209	116	97.5	226	119	97.6	243	121	97.8
5	152	106	97.1	167	108	97.4	181	110	97.5	197	112	97.6	212	115	97.8	228	117	97.9

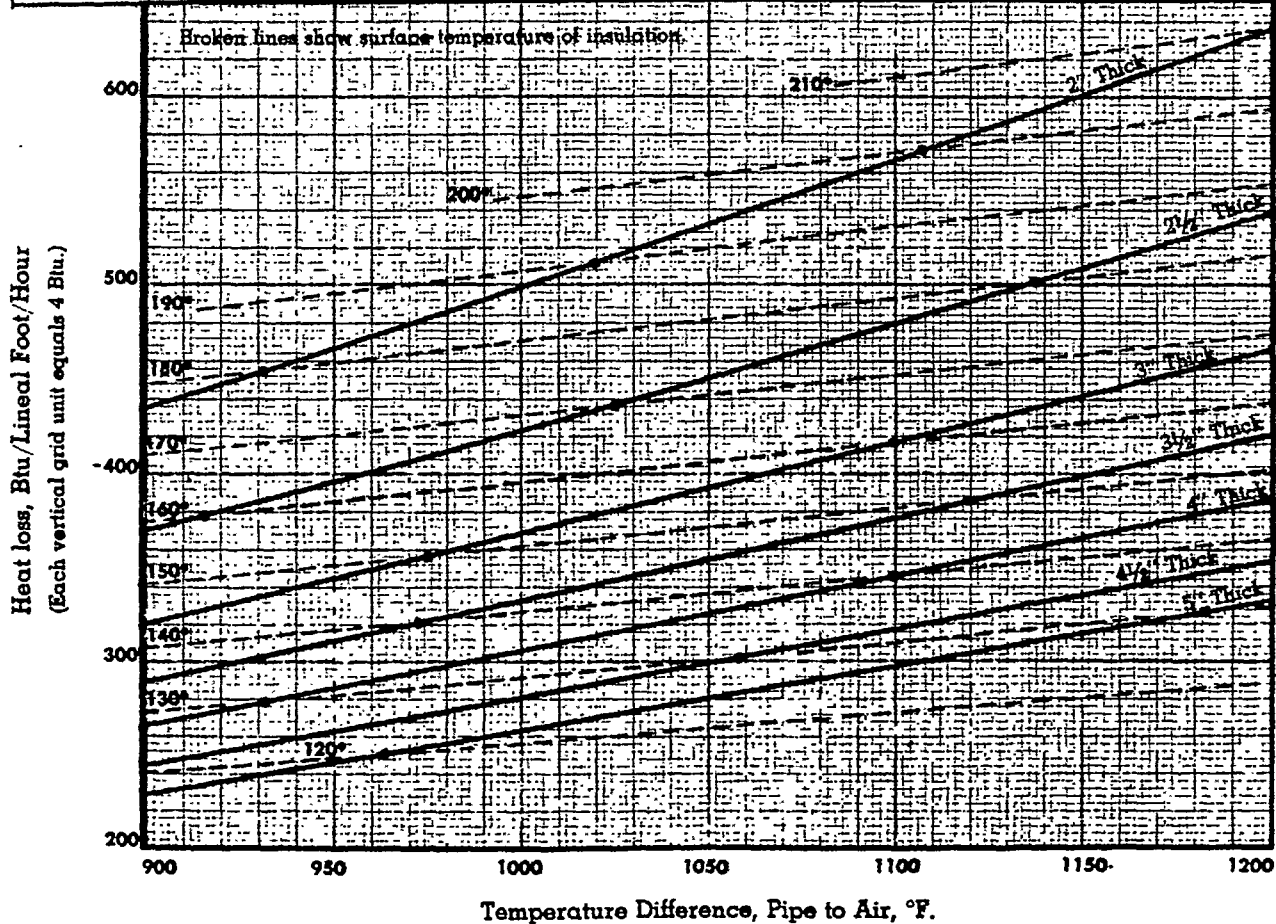


KAYLO PIPE INSULATION Heat Loss — Surface Temperature — Efficiency

4½-Inch Pipe

Ambient still air 80°F.

Pipe Temp. °F.	1030°			1080°			1130°			1180°			1230°			1280°		
Temp. Diff. Pipe to Air °F.	950°			1000°			1050°			1100°			1150°			1200°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	12324	1030		13962	1080		15759	1130		17724	1180		19868	1230		22201	1280	
1																		
1½	466	183	96.2	498	188	96.4	531	194	96.6	564	199	96.8	599	205	97.0	634	210	97.1
2	394	163	96.8	422	168	97.0	450	172	97.1	479	177	97.3	507	181	97.4	537	186	97.6
2½	343	148	97.2	366	152	97.4	390	156	97.5	415	160	97.7	440	163	97.8	465	167	97.9
3	310	138	97.5	330	141	97.6	352	145	97.8	374	148	97.9	396	151	98.0	419	155	98.1
3½	284	131	97.7	304	134	97.8	323	137	98.0	344	140	98.1	365	143	98.2	385	146	98.3
4	260	124	97.9	278	126	98.0	296	129	98.1	314	131	98.2	333	134	98.3	352	137	98.4
4½	244	119	98.0	262	122	98.1	278	124	98.2	295	126	98.3	313	128	98.4	331	131	98.5



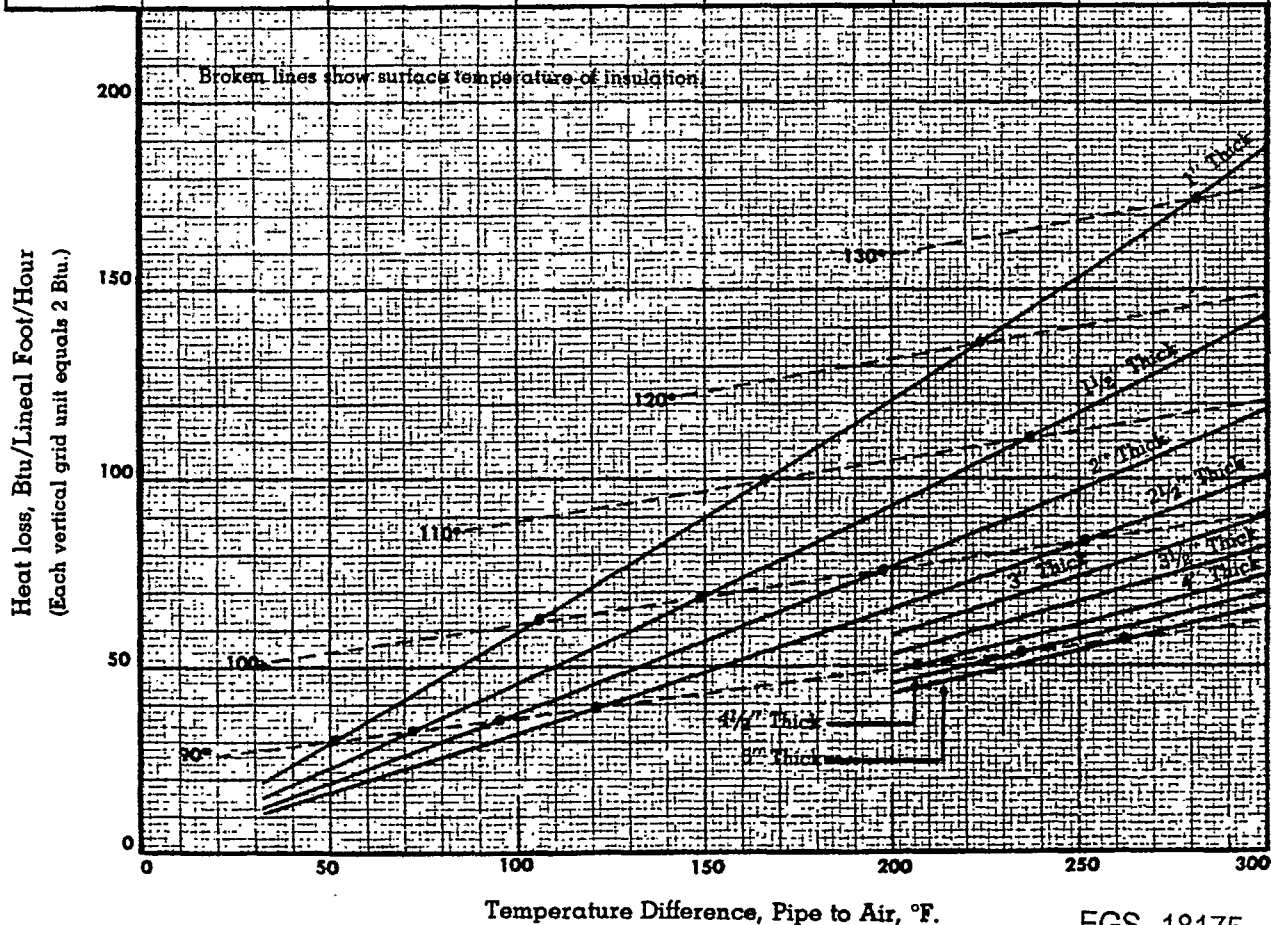
KAYLO PIPE INSULATION **Heat Loss — Surface Temperature — Efficiency** **5-Inch Pipe**

OWENS-ILLINOIS
 GLASS COMPANY

KAYLO
 HEAT INSULATING
 PRODUCTS

Ambient still air 80°F.

Pipe Temp. °F.	130°			180°			230°			280°			330°			380°		
Temp. Diff. Pipe to Air °F.	50°			100°			150°			200°			250°			300°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	133	130		310	180		525	230		782	280		1083	330		1435	380	
1	27.8	90	79.1	56.9	99	81.6	87.3	103	83.4	120	116	84.7	153	125	85.9	188	134	86.9
1½	21.4	87	83.9	43.7	93	85.9	67.2	100	87.2	91.4	106	88.3	117	112	89.2	143	119	90.0
2	17.6	85	86.8	36.2	90	88.3	55.5	95	89.4	75.4	100	90.4	96.4	105	91.1	118	110	91.8
2½	15.0	84	88.7	30.8	88	90.0	47.0	92	91.0	64.3	96	91.8	82.0	100	92.4	100	103	93.0
3										57.2	93	92.7	73.1	96	93.3	89.5	100	93.8
3½										52.2	91	93.3	66.5	94	93.9	81.5	97	94.3
4										47.5	90	93.9	60.4	92	94.4	73.7	94	94.9
4½										42.2	89	94.6	56.3	91	94.8	68.8	93	95.2
5										41.7	88	94.7	53.0	89	95.1	64.8	91	95.5



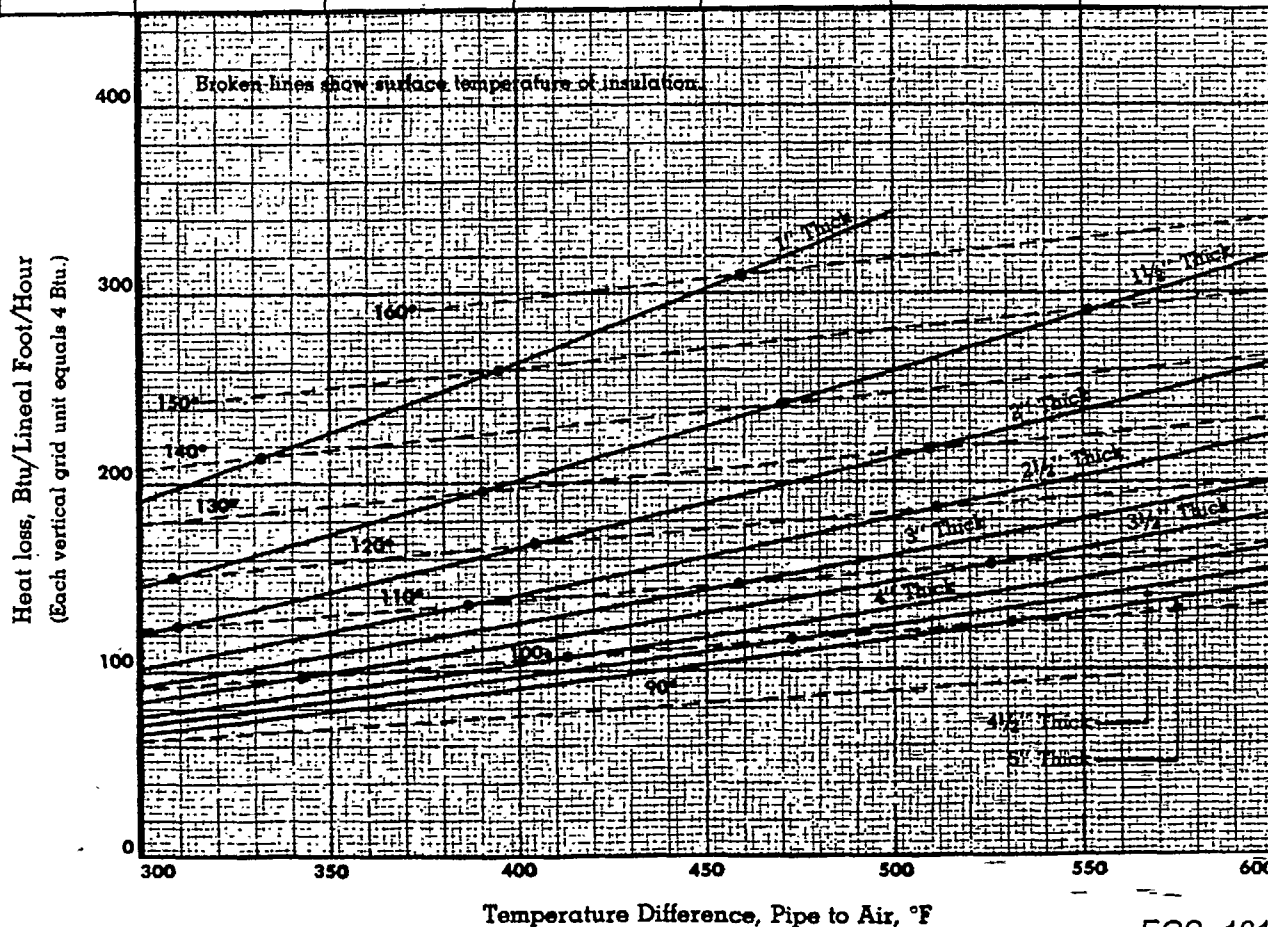
KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

5-Inch Pipe

Ambient still air 80°F.

Pipe Temp. °F.	430°			480°			530°			580°			630°			680°		
Temp. Diff. Pipe to Air °F.	350°			400°			450°			500°			550°			600°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	1842	430		2312	480		2853	530		3472	580		4172	630		4965	680	
1	224	142	87.8	262	151	88.7	297	158	89.6	342	168	90.2	288	150	93.1	320	156	93.6
1½	170	125	90.8	199	131	91.4	228	137	92.0	258	143	92.6	288	150	93.1	320	156	93.6
2	140	115	92.4	164	119	92.9	187	124	93.4	212	129	93.9	238	134	94.3	262	139	94.7
2½	119	108	93.5	139	111	94.0	159	116	94.4	180	119	94.8	202	123	95.2	224	127	95.5
3	106	103	94.2	124	106	94.6	142	110	95.0	160	113	95.4	179	116	95.7	199	120	96.0
3½	96.6	100	94.8	113	103	95.1	129	106	95.5	145	108	95.8	163	111	96.1	181	114	96.4
4	87.6	97	95.2	102	99	95.6	117	102	95.9	132	104	96.2	148	107	96.5	164	109	96.7
4½	81.6	95	95.6	95.0	97	95.9	109	99	96.2	123	101	96.5	138	104	96.7	153	106	96.9
5	77.0	93	95.8	89.4	95	96.1	102	97	96.4	116	99	96.7	130	101	96.9	144	103	97.1



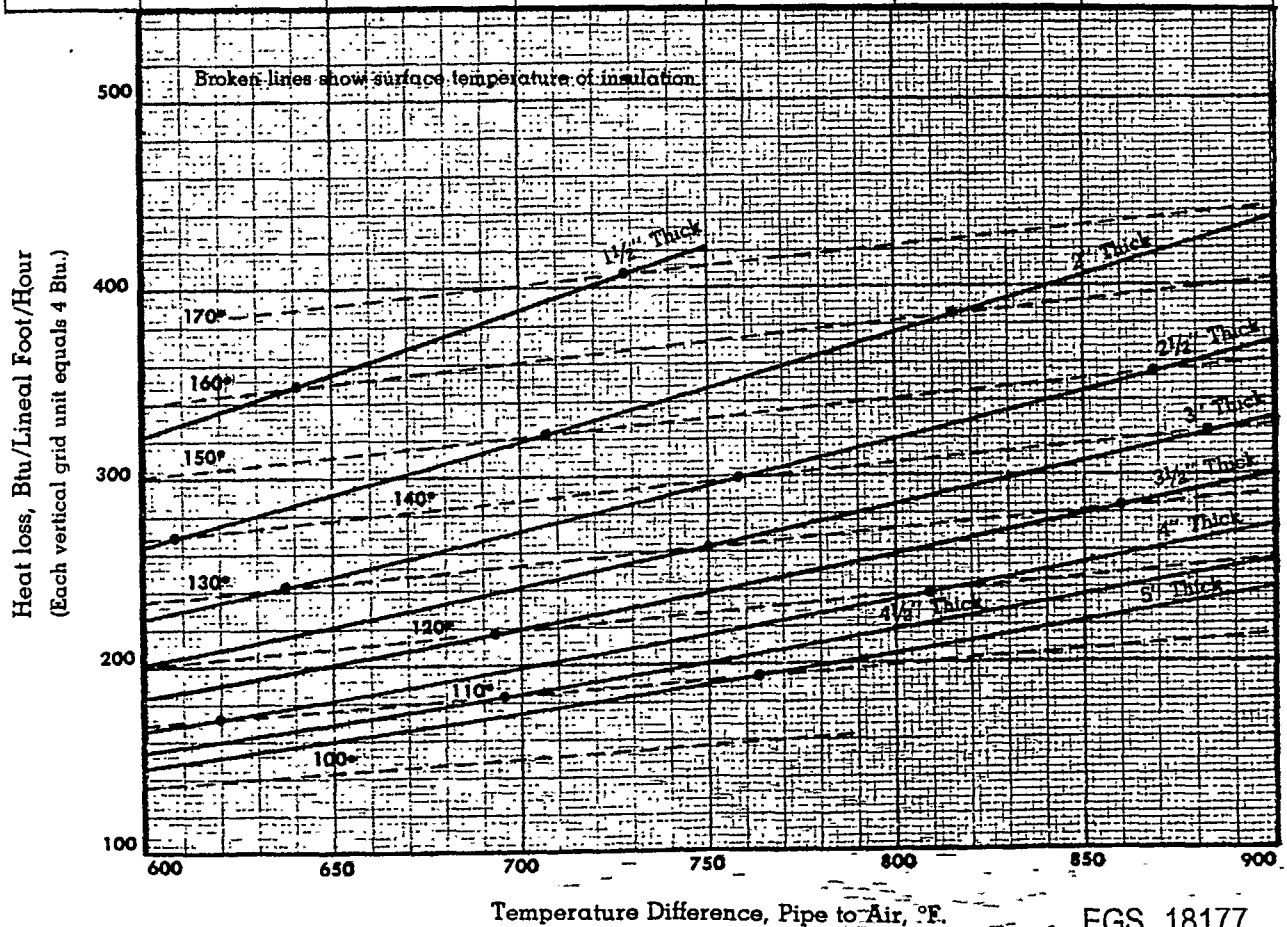
KAYLO PIPE INSULATION Heat Loss — Surface Temperature — Efficiency 5-Inch Pipe

OWENS-ILLINOIS
 GLASS COMPANY

KAYLO
 HEAT INSULATING
 PRODUCTS

Ambient still air 80°F.

Pipe Temp. °F.	730°			780°			830°			880°			930°			980°		
Temp. Diff. Pipe to Air °F.	650°			700°			750°			800°			850°			900°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	5848	730		6834	780		7937	830		9161	880		10519	930		12022	980	
1																		
1½	354	162	93.9	387	168	94.3	420	175	94.7									
2	290	144	95.0	318	149	95.3	346	154	95.6	374	160	95.9	405	165	96.1	435	170	96.4
2½	246	131	95.8	269	135	96.1	293	139	96.3	318	144	96.5	343	148	96.7	368	155	97.0
3	218	123	96.3	240	127	96.5	260	130	96.7	282	134	96.9	307	138	97.1	328	141	97.3
3½	199	117	96.6	218	120	96.8	237	123	97.0	256	127	97.2	278	130	97.4	298	133	97.5
4	181	112	96.9	197	114	97.1	215	117	97.3	233	120	97.5	252	123	97.6	271	125	97.7
4½	168	108	97.1	184	111	97.3	200	113	97.5	217	115	97.6	234	118	97.8	252	120	97.9
5	158	105	97.3	174	108	97.5	189	110	97.6	205	112	97.8	221	114	97.9	237	116	98.0



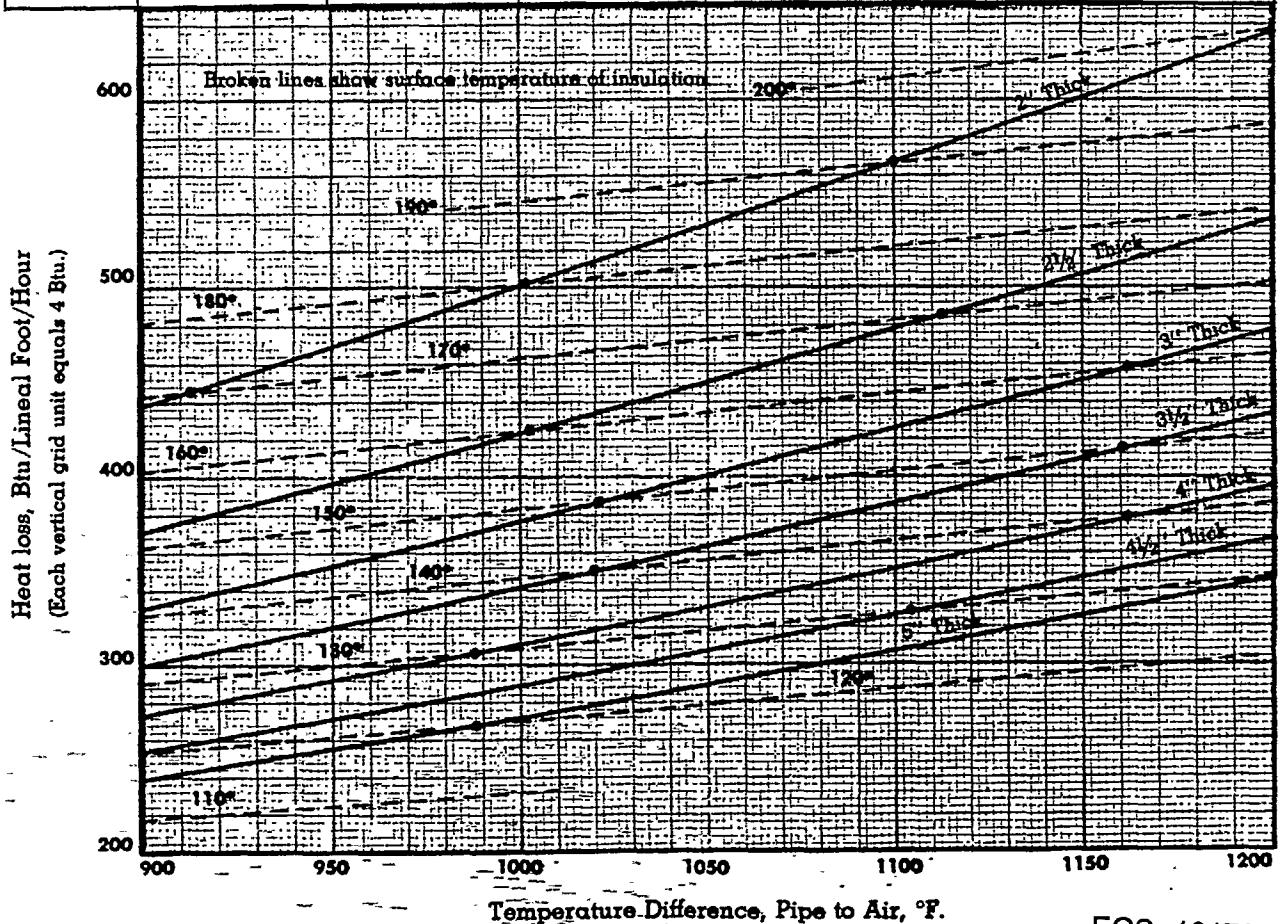
KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

5-Inch Pipe

Ambient still air 80°F.

Pipe Temp. °F.	1030°			1080°			1130°			1180°			1230°			1280°		
Temp. Diff. Pipe to Air °F.	950°			1000°			1050°			1100°			1150°			1200°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	13679	1030		15500	1080		17497	1130		19680	1180		22065	1230		24659	1280	
1																		
1½	469	175	96.6	500	180	96.8	533	185	97.0	565	190	97.1	600	196	97.3	635	200	97.4
2	394	156	97.1	422	160	97.3	450	165	97.4	476	169	97.6	506	173	97.7	536	178	97.8
2½	352	145	97.4	375	148	97.6	400	152	97.7	425	156	97.8	451	159	98.0	477	163	98.1
3	320	136	97.7	341	139	97.8	362	142	97.9	386	146	98.0	409	149	98.1	433	152	98.2
3½	290	128	97.9	310	131	98.0	330	134	98.1	350	136	98.2	372	139	98.3	393	142	98.4
4	270	123	98.0	288	125	98.1	307	128	98.2	326	130	98.3	346	133	98.4	366	135	98.5
4½	255	119	98.1	272	121	98.2	289	123	98.3	308	125	98.4	326	128	98.5	345	130	98.6
5																		



KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

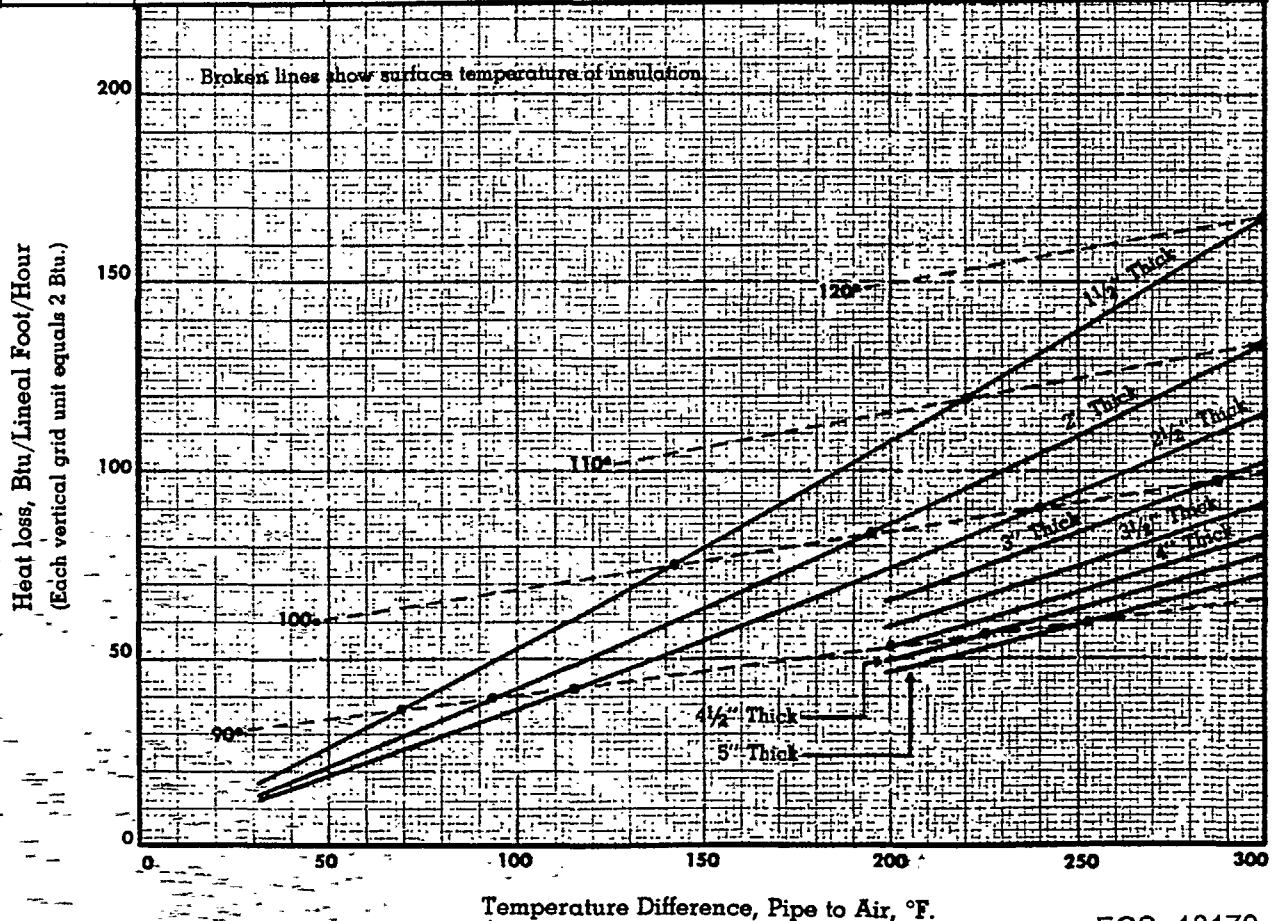
6-Inch Pipe

OWENS-ILLINOIS
 GLASS COMPANY

KAYLO
 HEAT INSULATING
 PRODUCTS

Ambient still air 80°F.

Pipe Temp. °F.	130°			180°			230°			280°			330°			380°		
Temp. Diff. Pipe to Air °F.	50°			100°			150°			200°			250°			300°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	157	130		364	180		618	230		920	280		1275	330		1691	380	
1	24.8	87	84.2	51.0	94	86.0	78.3	101	87.3	107	107	88.4	136	114	89.3	167	120	90.1
1½	19.9	85	87.3	40.7	90	88.8	62.9	96	89.8	85.3	100	90.7	109	105	91.5	134	110	92.1
2	17.2	84	89.0	35.2	88	90.3	54.0	93	91.3	73.6	97	92.0	94.0	101	92.6	115	105	93.2
2½										65.3	94	92.9	83.1	97	93.5	102	101	94.0
3										58.2	92	93.7	74.0	94	94.2	90.6	97	94.6
3½										53.3	90	94.2	67.8	93	94.7	82.9	95	95.1
4										49.7	89	94.6	63.2	91	95.0	77.3	93	95.4
4½										46.5	88	95.0	59.3	90	95.3	72.5	92	95.7
5																		



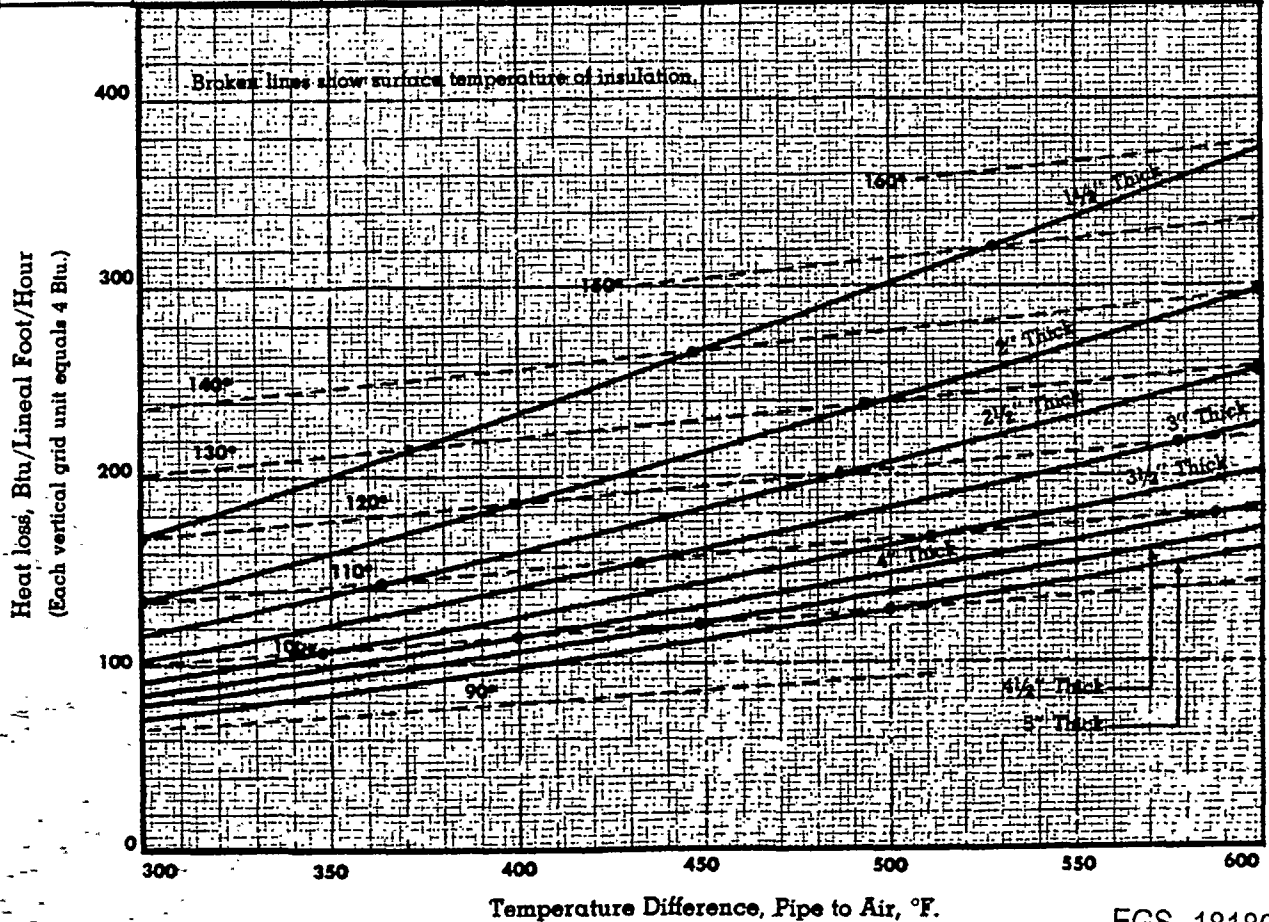
KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

6-Inch Pipe

Ambient still air 80°F.

Pipe Temp. °F.	430°			480°			530°			580°			630°			680°		
Temp. Diff. Pipe to Air °F.	350°			400°			450°			500°			550°			600°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	2172	430		2728	480		3368	530		4100	580		4930	630		5870	680	
1	199	127	90.8	232	133	91.8	266	140	92.1	301	146	92.7	336	153	93.2	374	159	93.6
1½	158	115	92.7	185	120	93.2	212	125	93.7	240	130	94.1	268	135	94.6	297	140	94.9
2	137	109	93.7	159	113	94.2	183	117	94.6	206	121	95.0	231	125	95.3	256	130	95.6
2½	121	104	94.4	141	108	94.8	162	111	95.2	182	115	95.6	204	118	95.9	227	122	96.1
3	108	100	95.0	126	103	95.4	144	106	95.7	162	109	96.0	182	112	96.3	202	115	96.6
3½	98.4	98	95.5	115	100	95.8	131	103	96.1	148	105	96.4	166	108	96.6	184	111	96.9
4	91.8	96	95.8	107	98	96.1	122	100	96.4	138	103	96.6	155	105	96.9	172	107	97.1
4½	86.1	94	96.0	100	96	96.3	115	98	96.6	130	100	96.8	145	102	97.1	161	105	97.3
5																		



KAYLO PIPE INSULATION

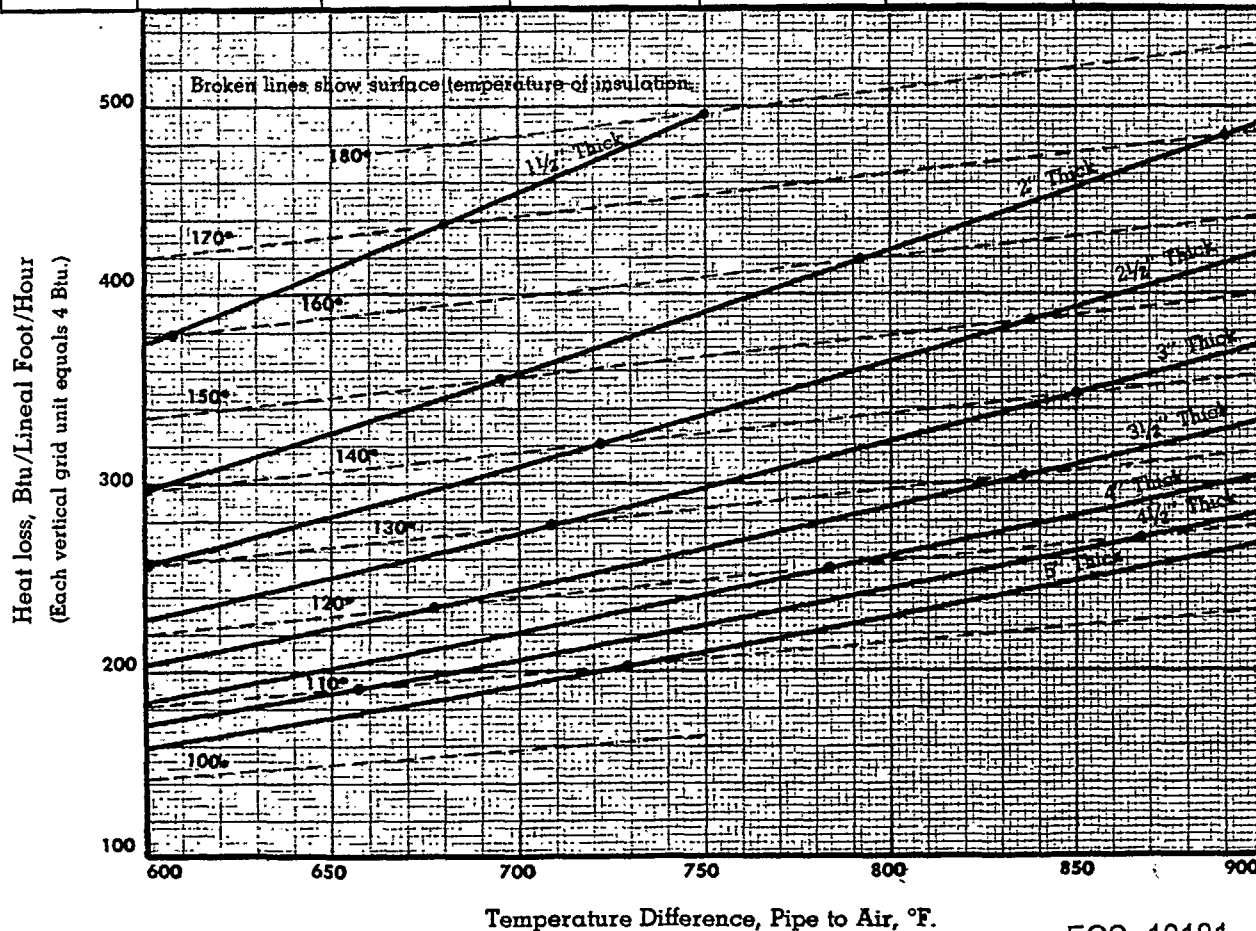
Heat Loss – Surface Temperature – Efficiency

6-Inch Pipe

OWENS-ILLINOIS
 GLASS COMPANY
KAYLO
 HEAT INSULATING
 PRODUCTS

Ambient still air 80°F.

Pipe Temp. °F.	730°			780°			830°			880°			930°			980°		
Temp. Diff. Pipe to Air °F.	650°			700°			750°			800°			850°			900°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	6920	730		8075	780		9395	830		10848	880		12461	930		14248	980	
1																		
1 1/2	412	166	94.0	452	172	94.4	494	179	94.7									
2	328	146	95.3	359	150	95.6	392	156	95.8	424	161	96.1	459	166	96.3	491	171	96.6
2 1/2																		
3	287	134	95.9	308	138	96.2	336	142	96.4	364	147	96.6	392	151	96.9	424	155	97.0
3 1/2	249	125	96.4	272	129	96.6	298	133	96.8	322	136	97.0	348	140	97.2	374	144	97.4
4	222	118	96.8	243	121	97.0	264	124	97.2	286	127	97.4	310	131	97.5	332	134	97.7
4 1/2																		
5	202	113	97.1	222	116	97.2	242	119	97.4	262	122	97.6	283	124	97.7	304	127	97.9
	189	110	97.3	207	112	97.4	225	114	97.6	244	117	97.8	263	119	97.9	283	122	98.0
	178	107	97.4	194	109	97.6	210	111	97.8	229	113	97.9	247	116	98.0	266	118	98.1



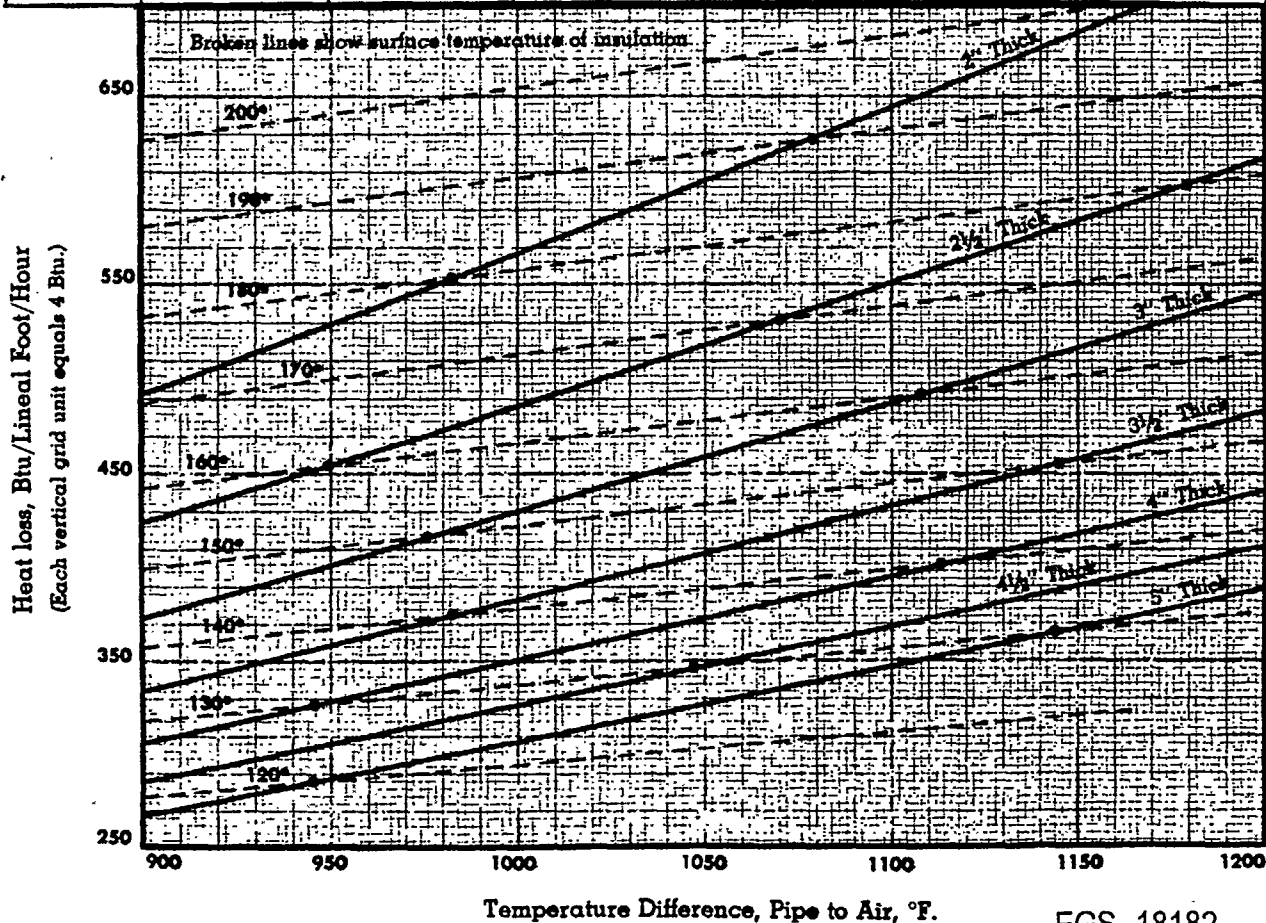
KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

6-Inch Pipe

Ambient still air 80°F.

Pipe Temp. °F.	1030°			1080°			1130°			1180°			1230°			1280°		
Temp. Diff. Pipe to Air °F.	950°			1000°			1050°			1100°			1150°			1200°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	16215	1030		19763	1080		20751	1130		23347	1180		26181	1230		29267	1280	
1																		
1 1/2																		
2	528	176	96.7	565	182	97.1	604	187	97.1	640	192	97.3	680	197	97.4	718	202	97.5
2 1/2	453	160	97.2	484	164	97.6	515	168	97.5	550	173	97.6	580	177	97.8	615	182	97.9
3	401	148	97.3	427	151	97.8	456	155	97.8	485	159	97.9	515	163	98.0	544	167	98.1
3 1/2	357	137	97.8	380	140	98.1	405	143	98.0	430	147	98.2	455	150	98.3	483	153	98.4
4	326	130	98.0	348	133	98.2	370	136	98.2	394	139	98.3	418	142	98.4	441	145	98.5
4 1/2	303	125	98.1	323	127	98.4	345	130	98.3	367	133	98.4	389	135	98.5	411	138	98.6
5	284	120	98.2	305	123	98.5	324	125	98.4	344	128	98.5	366	130	98.6	386	132	98.7



KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

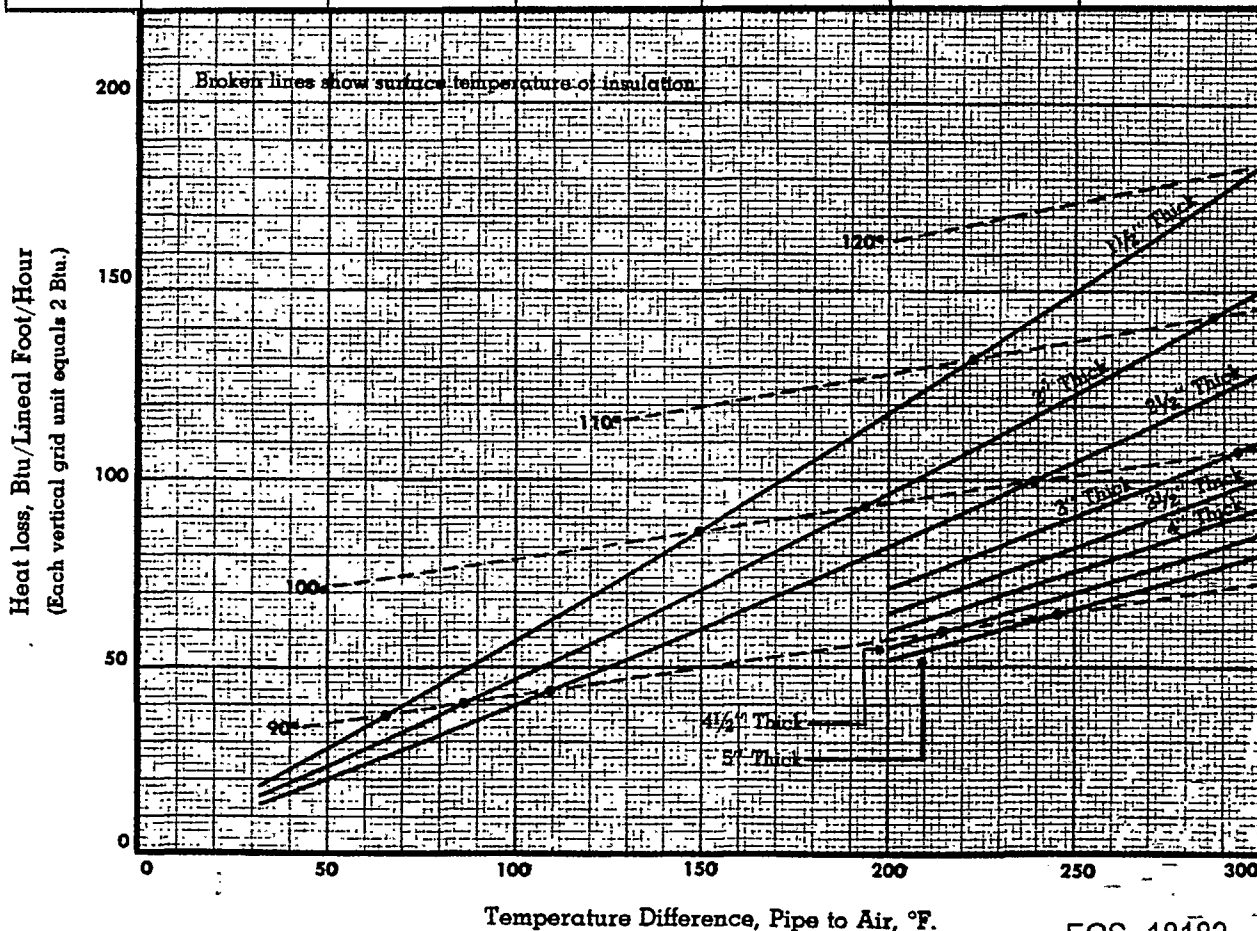
7-Inch Pipe

OWENS-ILLINOIS
 GLASS COMPANY

KAYLO
 HEAT INSULATING
 PRODUCTS

Ambient still air 80°F.

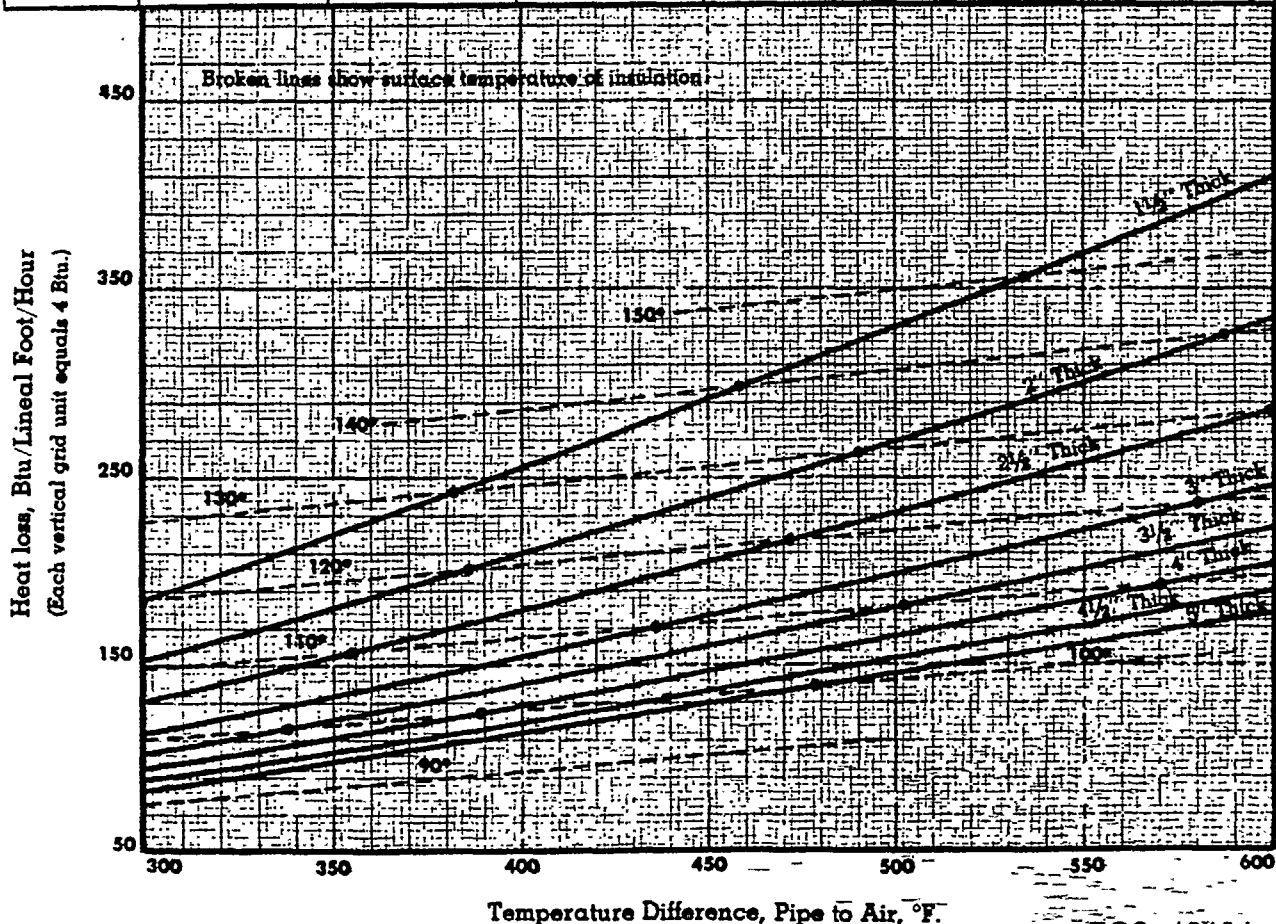
Pipe Temp. °F.	130°			180°			230°			280°			330°			380°		
Temp. Diff. Pipe to Air °F.	50°			100°			150°			200°			250°			300°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	179	130		416	180		705	230		1050	280		1457	330		1931	380	
1																		
1½	27.1	87	84.9	55.5	94	86.7	85.3	100	87.9	116	107	88.9	149	113	89.8	183	120	90.5
2	22.2	86	87.6	45.6	91	89.0	70.0	96	90.1	95.3	101	90.9	122	106	91.6	149	111	92.3
2½	19.1	84	89.4	39.2	89	90.6	60.0	93	91.5	81.5	97	92.2	104	101	92.9	128	105	93.4
3										70.4	94	93.3	89.6	97	93.8	110	100	94.3
3½										63.8	92	93.9	81.3	95	94.4	99.6	98	94.8
4										58.6	90	94.4	74.6	93	94.9	91.1	96	95.3
4½										54.5	89	94.8	69.4	92	95.2	84.8	94	95.6
5										51.1	88	95.1	65.0	90	95.5	79.5	92	95.9



KAYLO PIPE INSULATION **Heat Loss — Surface Temperature — Efficiency** **7-Inch Pipe**

Ambient still air 80°F.

Pipe Temp. °F.	430°			480°			530°			580°			630°			680°		
Temp. Diff. Pipe to Air °F.	350°			400°			450°			500°			550°			600°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	2482	430		3120	480		3853	530		4694	580		5646	630		6726	680	
1	217	126	91.3	252	132	91.9	290	139	92.5	328	145	93.0	366	152	93.5	406	158	93.9
1½	177	116	92.9	206	121	93.4	236	126	93.9	266	131	94.3	300	137	94.7	332	142	95.1
2	152	110	93.9	177	114	94.3	202	118	94.8	229	122	95.1	256	127	95.5	284	131	95.8
2½	130	104	94.8	152	107	95.1	174	111	95.5	196	114	95.8	220	118	96.1	244	121	96.4
3	118	101	95.2	138	104	95.6	157	107	95.9	178	110	96.2	199	113	96.5	222	116	96.7
3½	106	98	95.6	126	101	96.0	144	103	96.3	164	106	96.5	183	109	96.8	203	112	97.0
4	101	96	95.9	117	98	96.2	134	101	96.5	152	103	96.8	170	106	97.0	188	108	97.2
4½	94.5	95	96.2	110	97	96.5	126	99	96.7	142	101	97.0	159	103	97.2	177	105	97.4
5																		



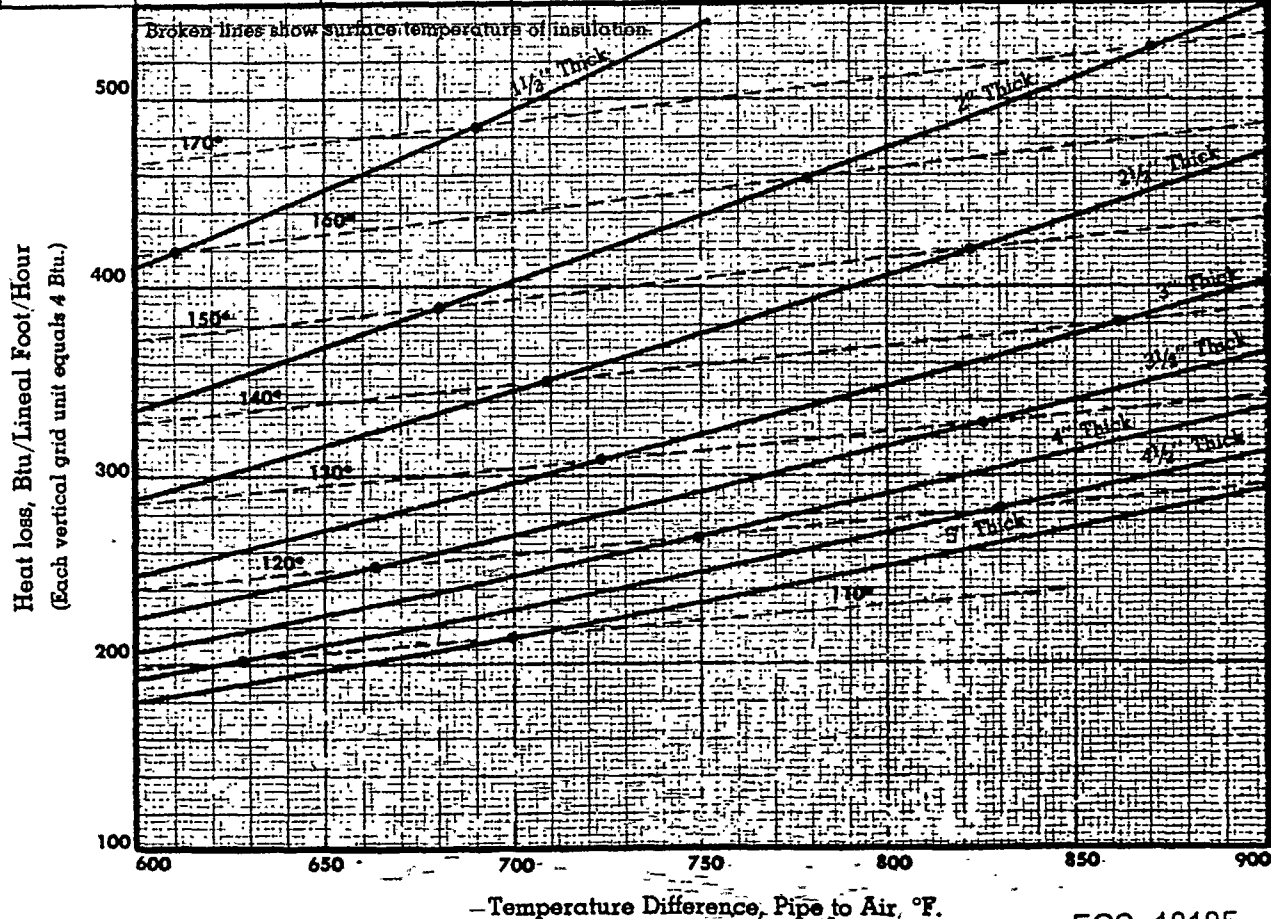
KAYLO PIPE INSULATION **Heat Loss — Surface Temperature — Efficiency** **7-Inch Pipe**

OWENS-ILLINOIS
 GLASS COMPANY

KAYLO
 HEAT INSULATING
 PRODUCTS

Ambient still air 80°F.

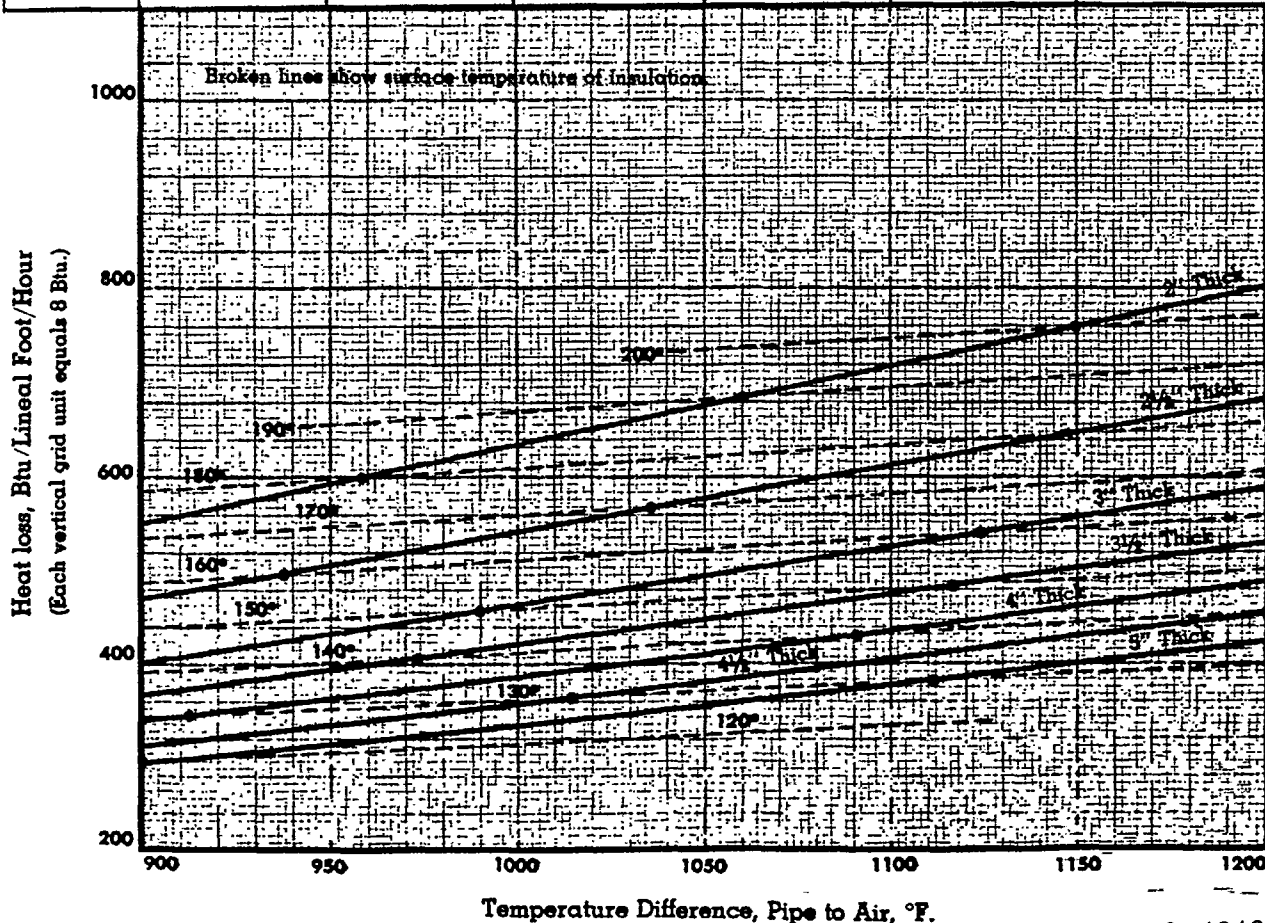
Pipe Temp. °F.	730°			780°			830°			880°			930°			980°		
Temp. Diff. Pipe to Air °F.	650°			700°			750°			800°			850°			900°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	7927	730		9272	780		10775	830		12445	880		14299	930		16353	980	
1																		
1½	449	165	94.3	492	171	94.7	538	178	95.0									
2	366	147	95.4	401	152	95.7	437	158	95.9	473	163	96.2	511	168	96.4	549	173	96.6
2½	314	135	96.0	343	139	96.3	373	144	96.5	405	148	96.7	435	153	97.0	470	157	97.1
3	268	125	96.6	294	129	96.8	320	132	97.0	348	136	97.2	374	140	97.4	401	143	97.5
3½	244	119	96.9	266	122	97.1	290	125	97.3	314	128	97.5	340	132	97.6	364	135	97.8
4	224	114	97.2	244	117	97.4	266	120	97.5	288	123	97.7	312	126	97.8	335	129	97.9
4½	207	111	97.4	227	113	97.6	247	116	97.7	268	118	97.8	289	121	98.0	311	124	98.1
5	194	108	97.6	213	110	97.7	231	112	97.9	251	115	98.0	270	117	98.1	291	119	98.2



KAYLO PIPE INSULATION Heat Loss — Surface Temperature — Efficiency 7-Inch Pipe

Ambient still air 80°F.

Pipe Temp. °F.	1030°			1080°			1130°			1180°			1230°			1280°		
Temp. Diff. Pipe to Air °F.	950°			1000°			1050°			1100°			1150°			1200°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	18616	1030		22698	1080		23833	1130		26820	1180		30082	1230		33631	1280	
1																		
1½	591	179	96.8	630	184	97.2	674	189	97.2	714	194	97.3	759	200	97.5	802	205	97.6
2	903	162	97.3	938	166	97.6	973	171	97.6	1010	175	97.7	1046	180	97.9	1084	184	98.0
2½	432	147	97.7	461	151	98.0	492	155	97.9	521	158	98.1	555	162	98.2	586	166	98.3
3	392	138	97.9	417	142	98.2	445	145	98.1	471	148	98.2	500	152	98.3	529	155	98.4
3½	359	132	98.1	383	135	98.3	408	138	98.3	435	141	98.4	462	144	98.5	486	147	98.6
4	333	126	98.2	355	129	98.4	378	132	98.4	402	134	98.5	427	137	98.6	451	140	98.7
4½	311	122	98.3	333	124	98.5	355	127	98.5	377	129	98.6	400	132	98.7	423	134	98.8
5																		



KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

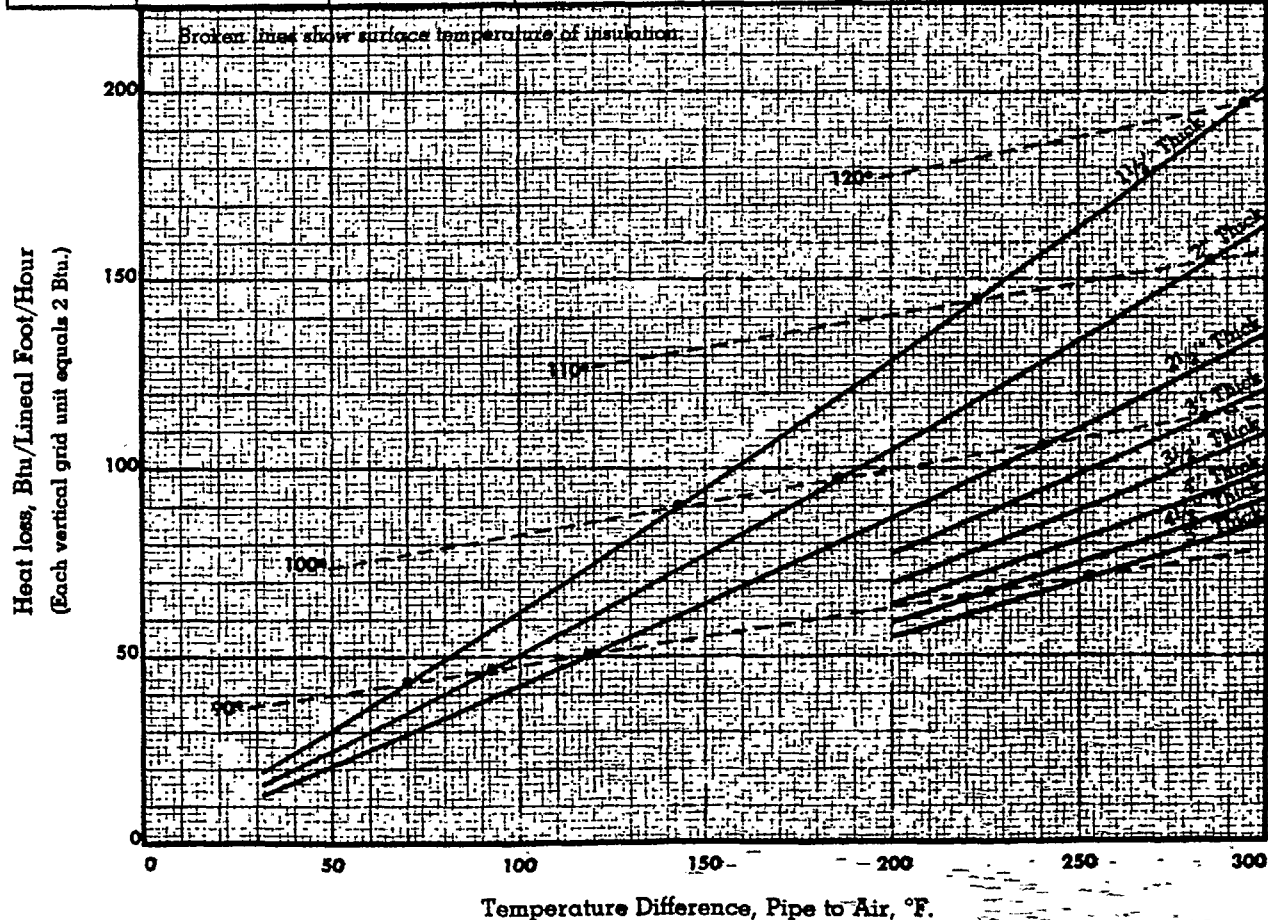
8-Inch Pipe

OWENS-ILLINOIS
 GLASS COMPANY

KAYLO
 HEAT INSULATING
 PRODUCTS

Ambient still air 80°F.

Pipe Temp. °F.	130°			180°			230°			280°			330°			380°		
Temp. Diff. Pipe to Air °F.	50°			100°			150°			200°			250°			300°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	200	130		464	180		791	230		1178	280		1634	330		2169	380	
1	30.0	87	85.0	61.5	94	86.7	94.4	101	88.1	129	107	89.0	165	114	89.9	202	121	90.7
1½	24.4	86	87.8	50.5	91	89.1	77.3	96	90.2	105	101	91.1	134	106	91.8	164	112	92.4
2																		
2½	20.4	84	89.8	41.8	89	91.0	64.0	93	91.9	87.0	97	92.6	111	101	93.2	136	105	93.7
3										77.1	94	93.5	98.4	98	94.0	121	101	94.4
3½										69.7	92	94.1	88.8	95	94.6	109	98	95.0
4																		
4½										63.9	91	94.6	81.2	93	95.0	99.7	96	95.4
5										59.3	89	95.0	75.5	92	95.4	92.2	94	95.7
										55.7	89	95.3	70.6	90	95.7	86.4	93	96.0



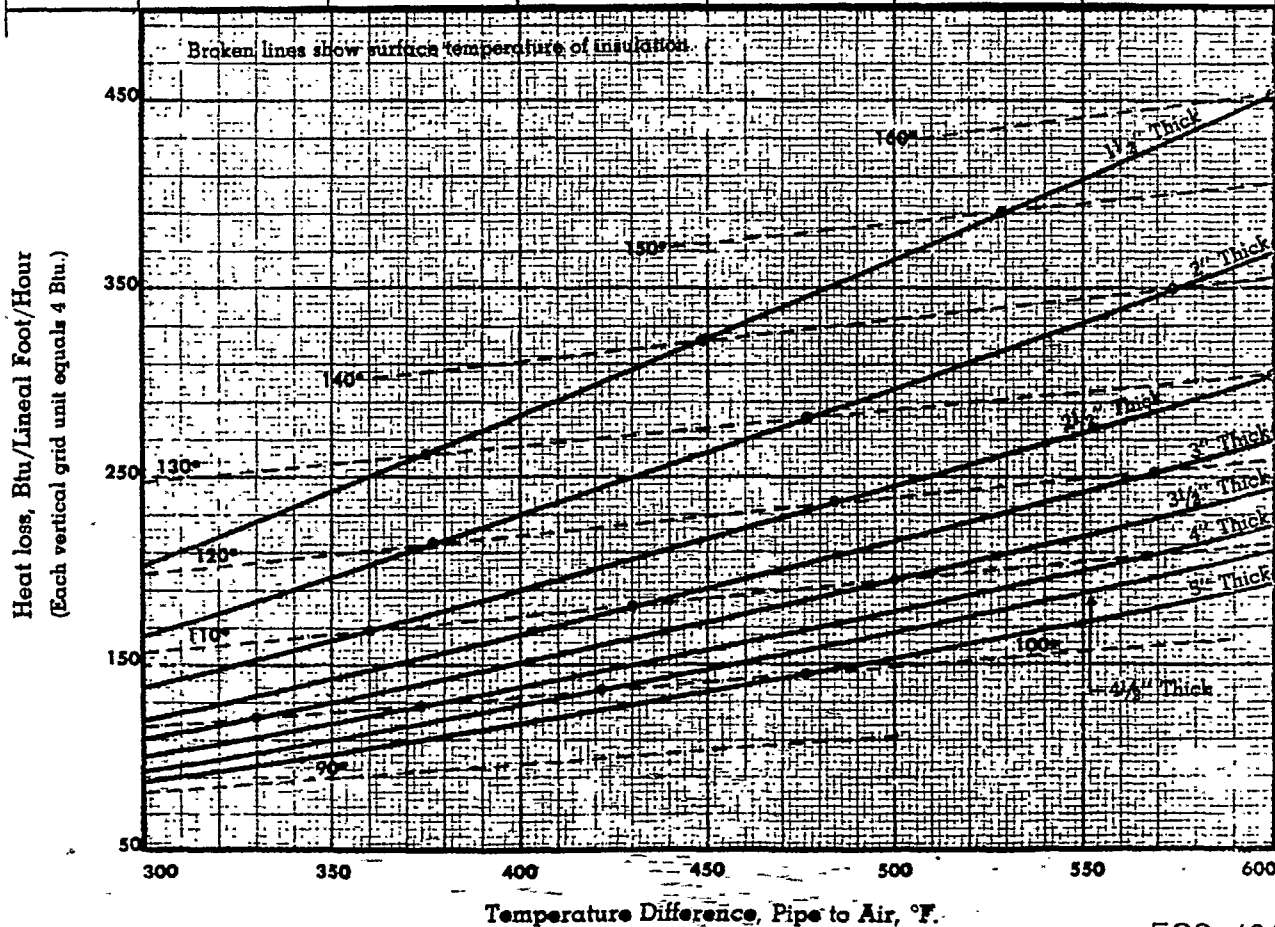
KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

8-Inch Pipe

Ambient still air 80°F.

Pipe Temp. °F.	430°			480°			530°			580°			630°			680°		
Temp. Diff. Pipe to Air °F.	350°			400°			450°			500°			550°			600°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	2789	430		3506	480		4332	530		5280	580		6352	630		7570	680	
1																		
1½	240	127	91.4	280	133	92.0	321	140	92.6	364	146	93.1	406	153	93.6	451	160	94.0
2	195	117	93.0	228	122	93.5	261	127	94.0	294	132	94.4	330	138	94.8	366	143	95.2
2½	161	109	94.2	188	113	94.6	216	118	95.0	244	121	95.4	272	126	95.7	302	130	96.0
3	143	105	94.9	167	108	95.2	191	112	95.6	215	115	95.9	241	119	96.2	268	122	96.5
3½	129	101	95.4	151	104	95.7	172	107	96.0	195	110	96.3	218	114	96.6	242	117	96.8
4	118	99	95.8	138	101	96.1	158	104	96.4	178	107	96.6	199	110	96.9	221	112	97.1
4½	110	97	96.1	128	99	96.3	146	101	96.6	165	104	96.9	185	106	97.1	206	109	97.3
5	103	95	96.3	119	97	96.6	136	99	96.9	155	102	97.1	173	104	97.3	192	106	97.5



KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

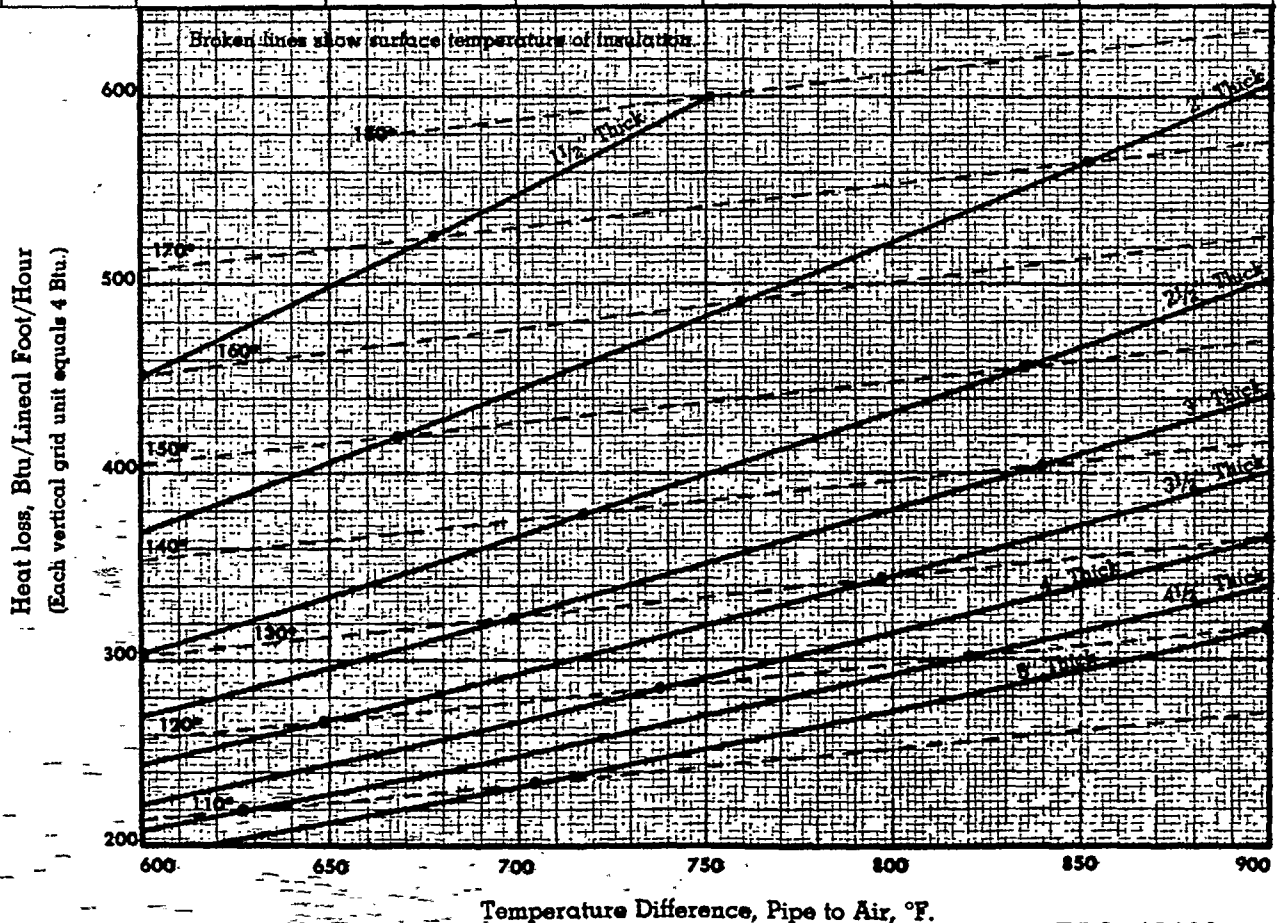
8-Inch Pipe

OWENS-ILLINOIS
GLASS COMPANY

KAYLO
HEAT INSULATING
PRODUCTS

Ambient still air 80°F.

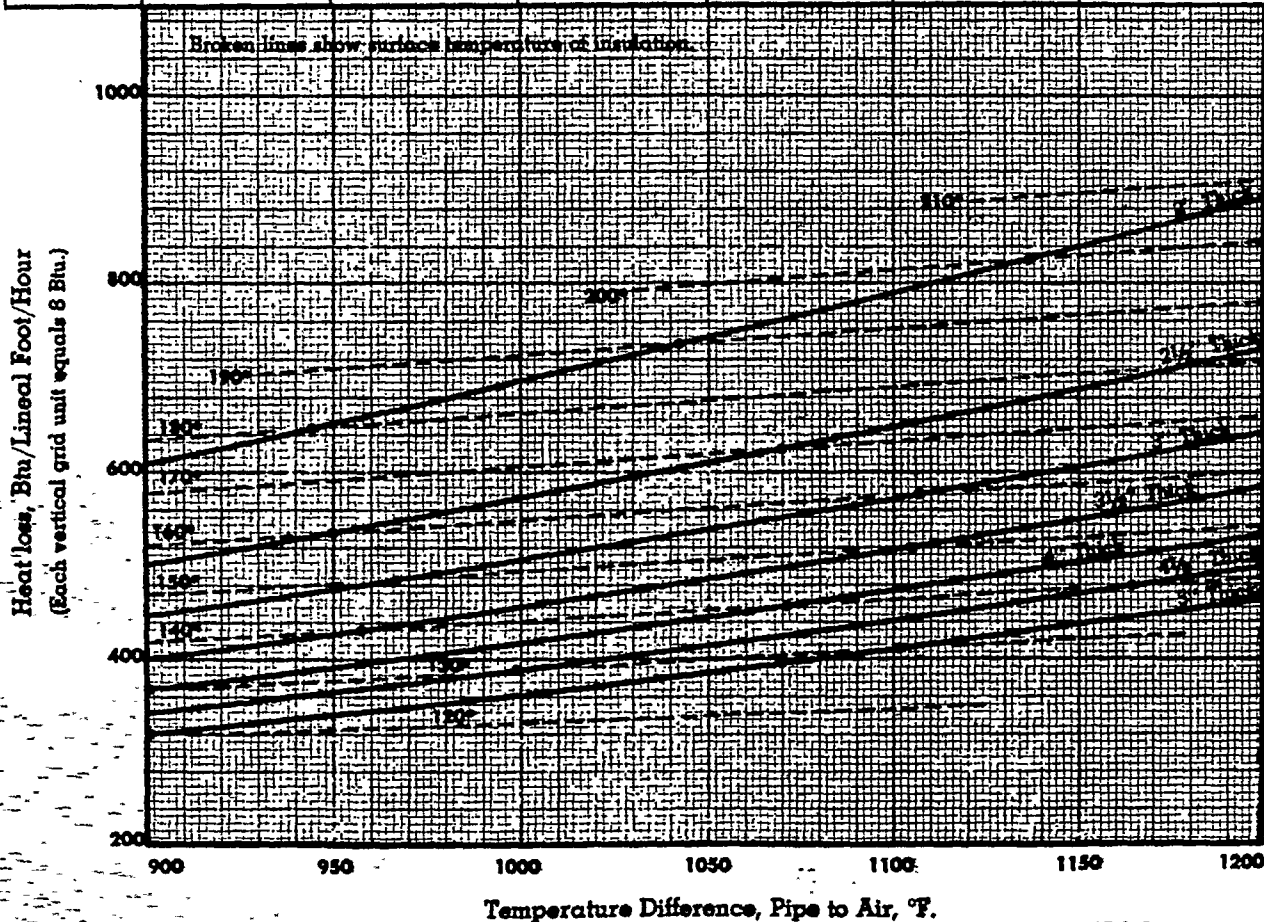
Pipe Temp. °F.	730°			780°			830°			880°			930°			980°		
Temp. Diff. Pipe to Air °F.	650°			700°			750°			800°			850°			900°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	8926	730		10443	780		12138	830		14024	880		16118	930		18436	980	
1	499	166	94.4	546	173	94.7	596	179	95.1									
1½	405	148	95.5	443	154	95.8	482	159	96.0	521	164	96.3	565	170	96.5	605	175	96.7
2																		
2½	334	134	96.3	364	138	96.5	396	142	96.7	431	147	96.9	465	151	97.1	500	156	97.3
3	294	126	96.7	323	130	96.9	350	133	97.1	380	137	97.3	410	141	97.5	441	145	97.6
3½	266	120	97.0	291	123	97.2	317	126	97.4	343	130	97.6	371	133	97.7	398	137	97.8
4																		
4½	244	115	97.3	266	118	97.5	290	121	97.6	315	124	97.8	340	127	97.9	365	130	98.0
5	226	111	97.5	247	114	97.6	269	117	97.8	292	119	97.9	315	122	98.0	338	125	98.2
	211	106	97.6	231	111	97.8	251	113	97.9	272	115	98.1	294	118	98.2	316	120	98.3



KAYLO PIPE INSULATION Heat Loss — Surface Temperature — Efficiency 8-Inch Pipe

Ambient still air 80°F.

Pipe Temp. °F.	1030°			1080°			1130°			1180°			1230°			1280°		
Temp. Diff. Pipe to Air °F.	950°			1000°			1050°			1100°			1150°			1200°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	20990	1030		23801	1080		26886	1130		30261	1180		33944	1230		37955	1280	
1																		
1½	651	181	96.9	695	186	97.1	744	191	97.2	788	197	97.4	838	202	97.5	886	208	97.7
2	535	160	97.4	572	164	97.6	610	169	97.7	650	173	97.9	689	178	98.0	727	182	98.1
2½	474	149	97.7	505	152	97.9	539	156	98.0	571	160	98.1	606	164	98.2	642	168	98.3
3	428	140	98.0	456	143	98.1	486	147	98.2	517	150	98.3	546	154	98.4	579	157	98.5
3½	392	133	98.1	419	136	98.2	445	139	98.3	474	142	98.4	503	145	98.5	532	148	98.6
4	362	128	98.3	387	130	98.4	412	133	98.5	438	136	98.5	465	139	98.6	491	141	98.7
4½	339	123	98.4	362	125	98.5	386	128	98.6	409	130	98.6	435	133	98.7	459	136	98.8
5																		



KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

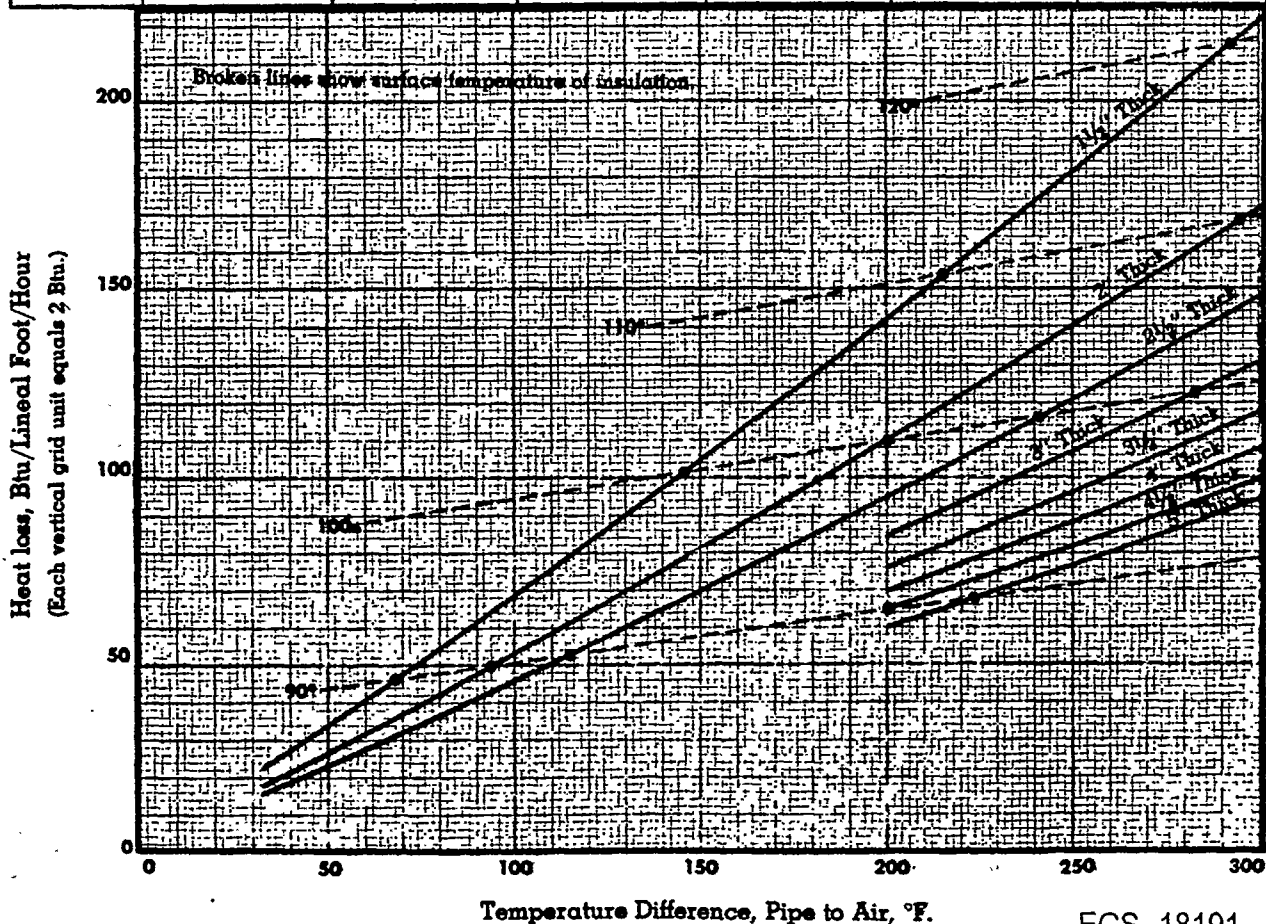
9-Inch Pipe

OWENS-ILLINOIS
GLASS COMPANY

KAYLO
HEAT INSULATING
PRODUCTS

Ambient still air 80°F.

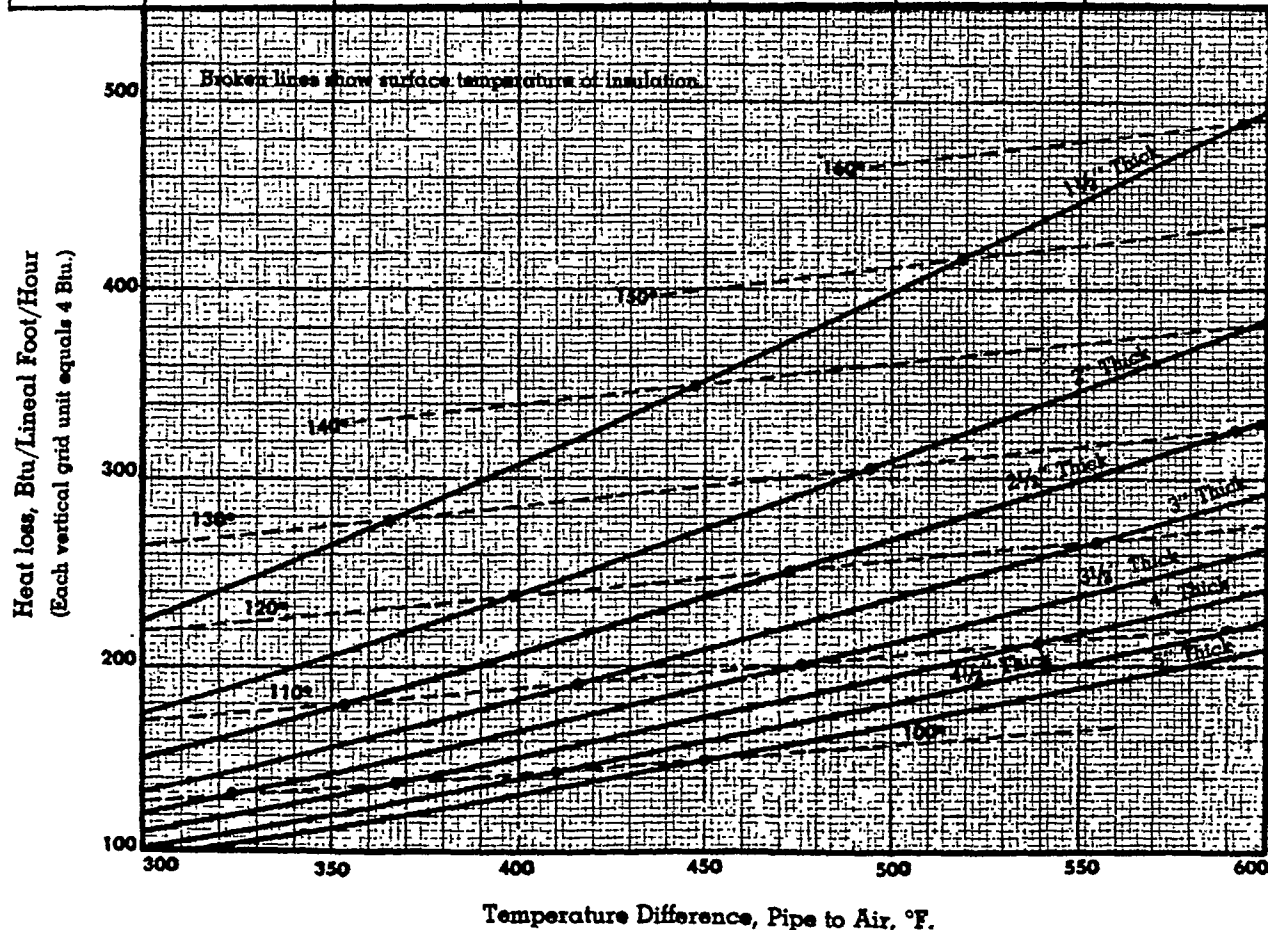
Pipe Temp. °F.	130°			180°			230°			280°			330°			380°		
Temp. Diff. Pipe to Air °F.	50°			100°			150°			200°			250°			300°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	222	130		516	180		876	230		1306	280		1812	330		2406	380	
1	32.9	87	85.2	67.4	94	86.9	104	102	88.1	142	108	89.1	181	114	90.0	222	121	90.8
1½	25.7	85	88.4	52.9	91	89.7	81.0	96	90.8	110	100	91.6	141	106	92.2	172	111	92.9
2	22.2	84	90.0	45.5	89	91.2	69.8	93	92.0	94.9	97	92.7	121	101	93.3	148	105	93.8
2½										83.8	94	93.6	107	98	94.1	131	101	94.6
3										75.6	92	94.2	96.0	95	94.7	118	98	95.1
3½										69.1	91	94.7	88.0	94	95.1	108	96	95.5
4										64.1	90	95.1	81.4	92	95.5	99.8	95	95.9
4½										59.9	89	95.4	76.3	91	95.8	94.3	93	96.1
5																		



KAYLO PIPE INSULATION Heat Loss — Surface Temperature — Efficiency 9-Inch Pipe

Ambient still air 80°F.

Pipe Temp. °F.	430°			480°			530°			580°			630°			680°		
Temp. Diff. Pipe to Air °F.	350°			400°			450°			500°			550°			600°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	3095	430		3893	480		4811	530		5864	580		7060	630		8462	680	
1	264	128	91.3	307	134	92.1	354	141	92.6	398	147	93.2	447	155	93.7	495	161	94.2
1½	204	115	93.4	238	120	93.9	273	125	94.3	308	130	94.7	346	136	95.1	384	141	95.5
2	176	109	94.3	206	114	94.7	236	118	95.1	266	122	95.5	298	126	95.8	330	131	96.1
2½	156	105	95.0	181	109	95.4	208	112	95.7	234	116	96.0	262	119	96.3	291	123	96.6
3	140	102	95.5	163	105	95.8	186	108	96.1	211	111	96.4	236	114	96.7	262	118	96.9
3½	128	99	95.9	149	102	96.2	171	105	96.4	193	108	96.7	216	110	96.9	240	113	97.2
4	118	97	96.2	138	99	96.5	158	102	96.7	179	105	96.9	200	107	97.2	222	110	97.4
4½	111	95	96.4	129	98	96.7	148	100	96.9	167	102	97.2	187	104	97.4	207	107	97.6



KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

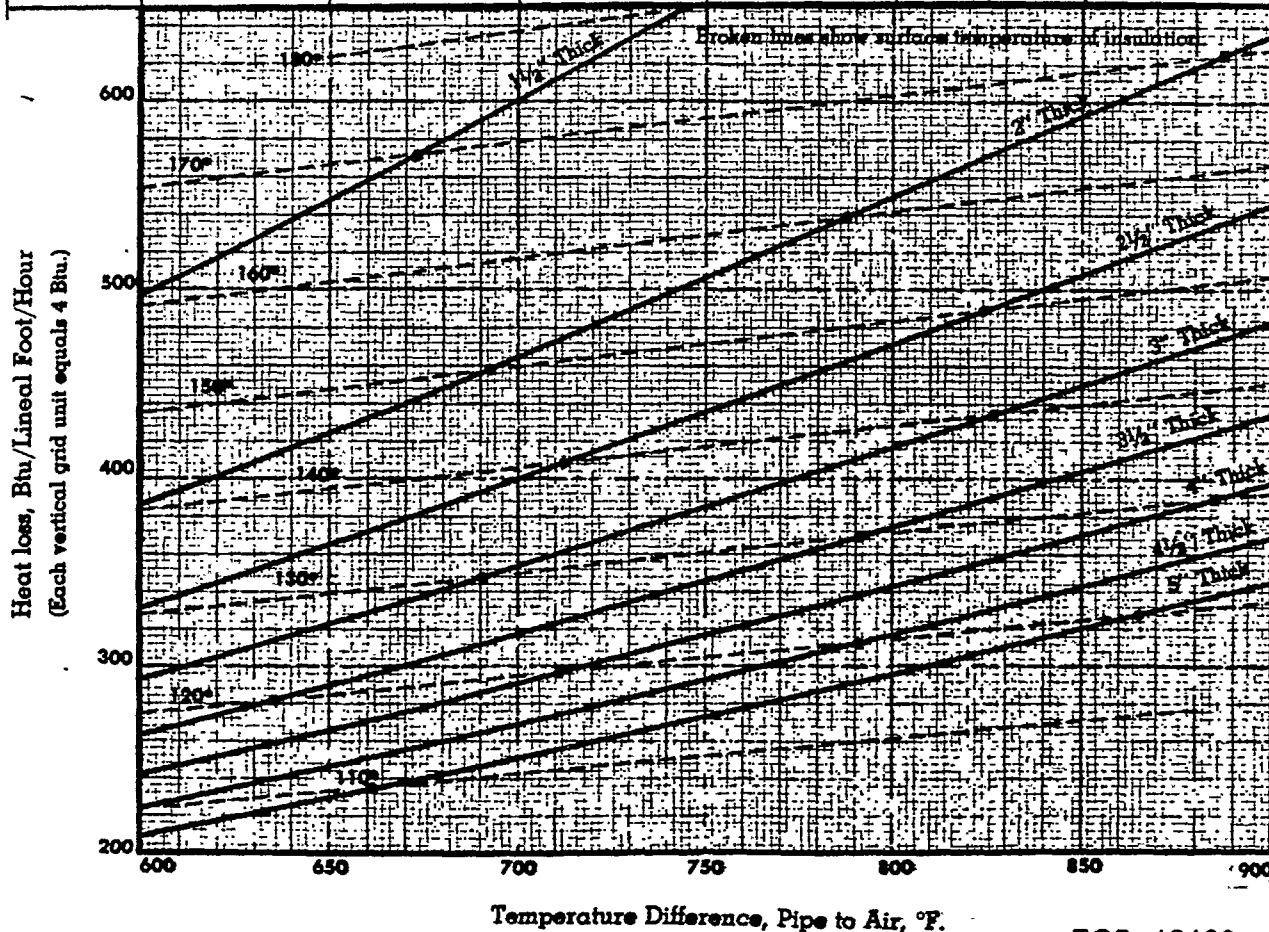
9-Inch Pipe

OWENS-ILLINOIS
GLASS COMPANY

KAYLO
HEAT INSULATING
PRODUCTS

Ambient still air 80°F.

Pipe Temp. °F.	730°			780°			830°			880°			930°			980°		
Temp. Diff. Pipe to Air °F.	650°			700°			750°			800°			850°			900°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	9926	730		11614	780		13504	830		15604	880		17938	930		20522	980	
1																		
1½	546	167	94.5	599	174	94.8	654	181	95.2									
2	424	146	95.7	463	151	96.0	505	156	96.3	547	161	96.5	591	167	96.7	635	172	96.9
2½	364	138	96.3	397	139	96.6	434	144	96.8	470	148	97.0	506	153	97.2	545	157	97.3
3	320	127	96.8	351	131	97.0	382	134	97.2	415	138	97.3	446	142	97.5	480	146	97.7
3½	288	121	97.1	316	124	97.3	344	128	97.5	372	131	97.6	402	134	97.8	431	138	97.9
4	264	116	97.3	289	119	97.5	315	122	97.7	340	125	97.7	368	128	97.9	395	131	98.1
4½	244	112	97.5	267	115	97.7	291	118	97.8	315	120	98.0	340	123	98.1	366	126	98.2
5	228	109	97.7	249	112	97.9	273	114	98.0	293	116	98.1	318	119	98.3	342	122	98.3



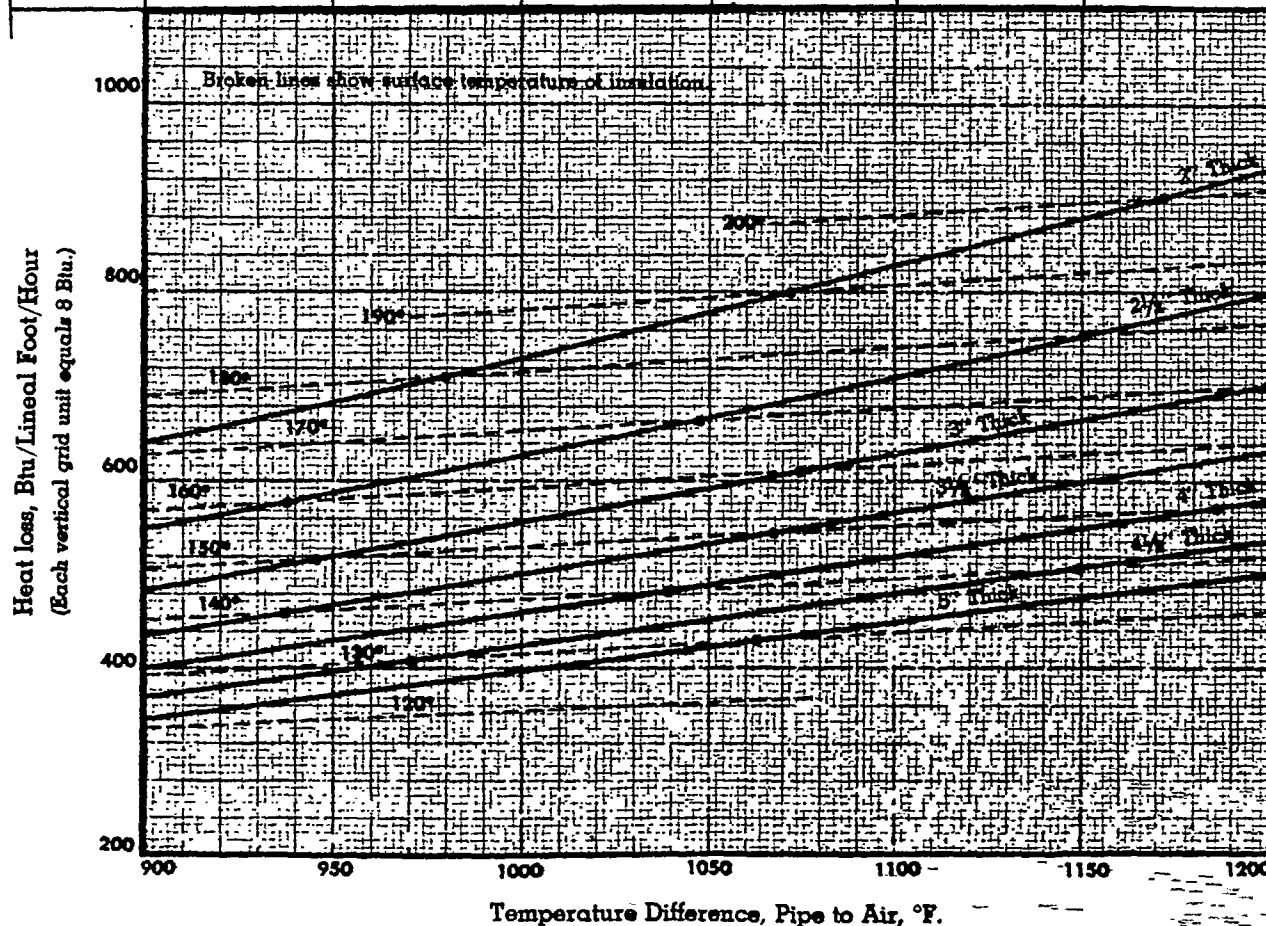
KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

9-Inch Pipe

Ambient still air 80°F.

Pipe Temp. °F.	1030°			1080°			1130°			1180°			1230°			1280°		
Temp. Diff. Pipe to Air °F.	950°			1000°			1050°			1100°			1150°			1200°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	23371	1030		26505	1080		29943	1130		33705	1180		37816	1230		42287	1280	
1																		
1½																		
2	683	177	97.1	727	182	97.3	776	188	97.4	825	193	97.6	876	198	97.7	927	203	97.8
2½	585	161	97.5	624	166	97.6	665	170	97.8	709	175	97.9	750	180	98.0	793	184	98.1
3	515	150	97.8	550	154	97.9	588	158	98.0	623	162	98.2	662	166	98.2	698	170	98.3
3½	464	141	98.0	493	145	98.1	529	148	98.2	560	152	98.3	593	155	98.4	628	159	98.5
4	423	134	98.2	453	137	98.3	482	140	98.4	513	144	98.5	544	147	98.6	576	150	98.6
4½	392	129	98.3	410	131	98.4	446	134	98.5	474	137	98.6	503	139	98.7	531	143	98.7
5	366	124	98.4	390	126	98.5	417	129	98.6	443	132	98.7	470	134	98.8	496	137	98.8



KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

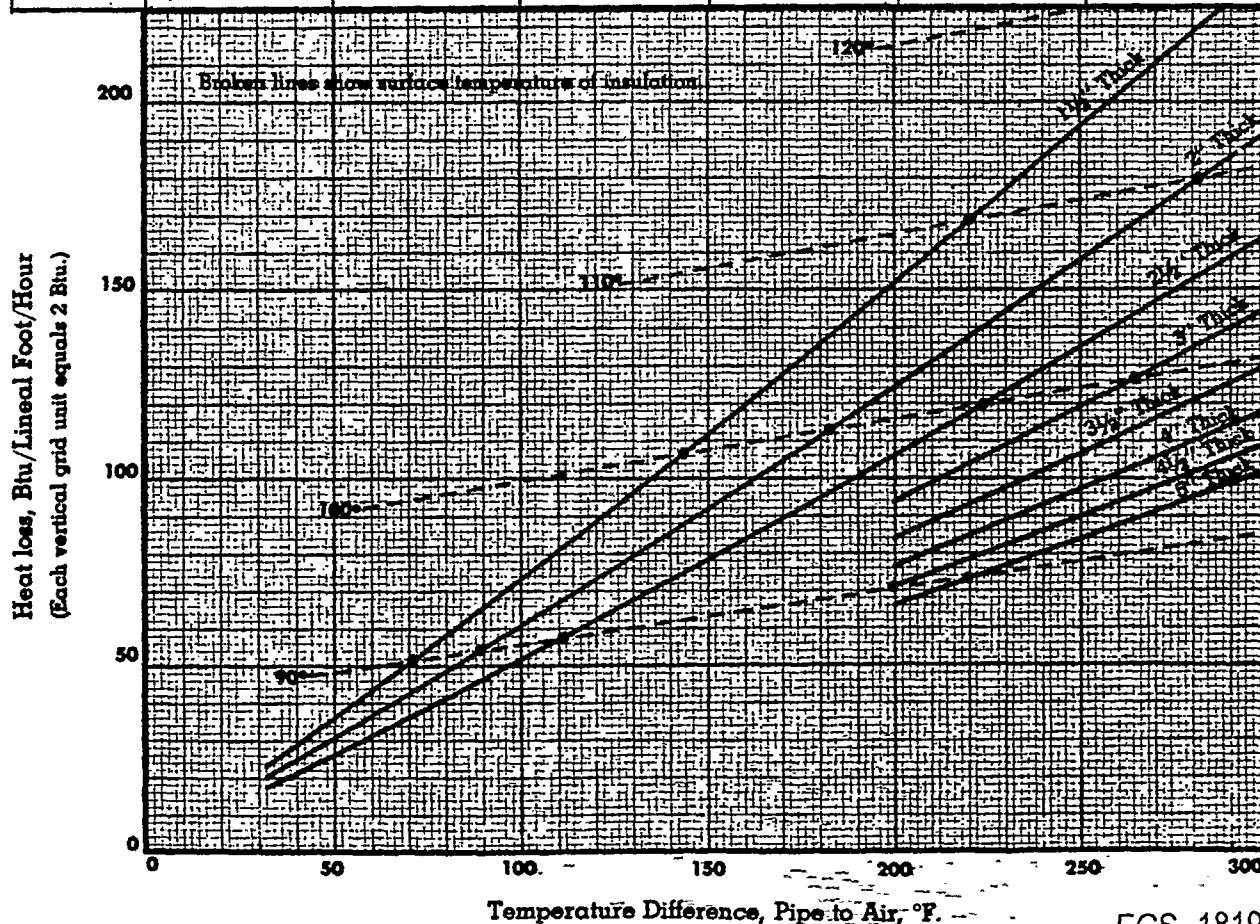
10-Inch Pipe

OWENS ILLINOIS
GLASS COMPANY

KAYLO
HEAT INSULATING
PRODUCTS

Ambient still air 80°F.

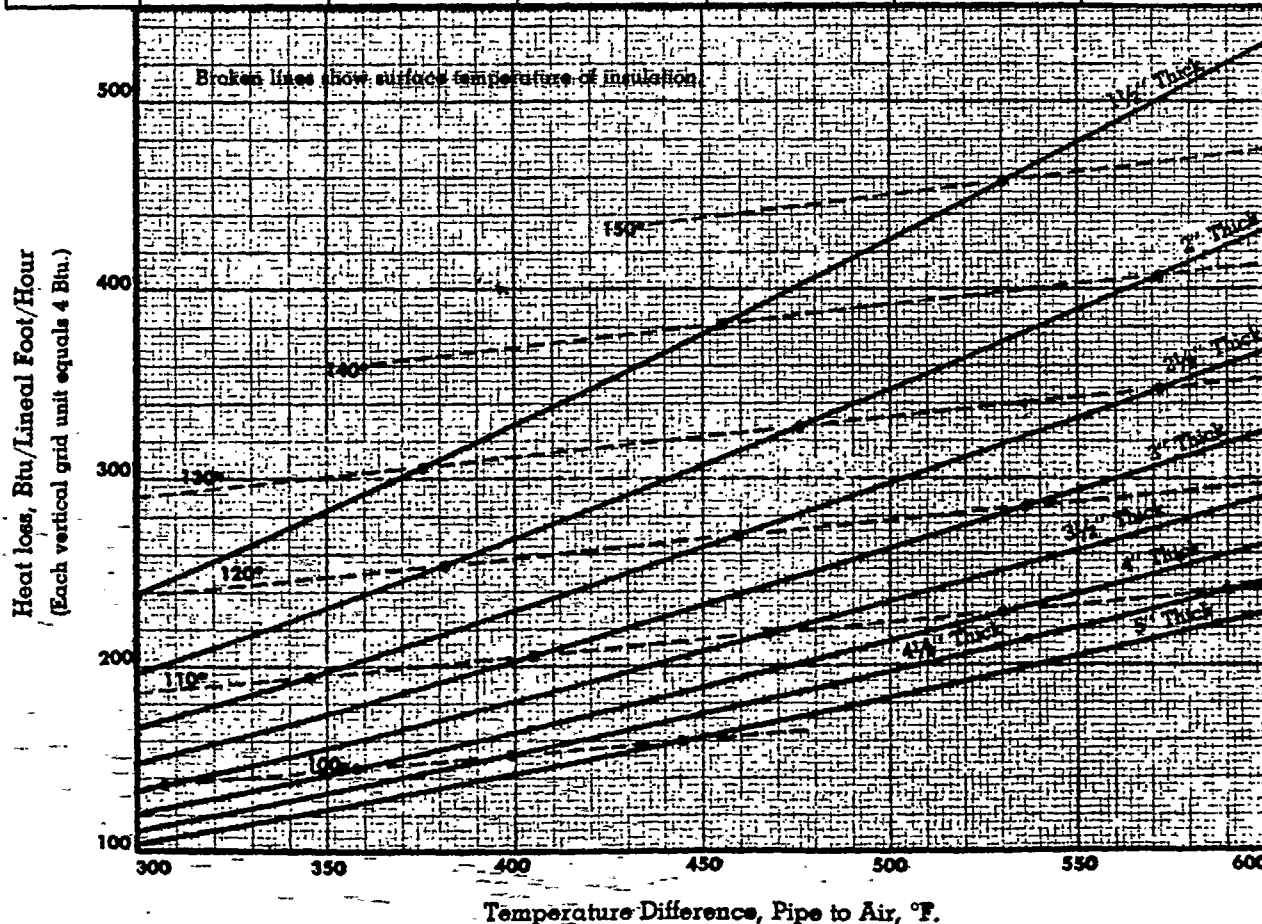
Pipe Temp. °F.	130°			180°			230°			280°			330°			380°		
Temp. Diff. Pipe to Air °F.	50°			100°			150°			200°			250°			300°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	246	130		572	180		971	230		1447	280		2009	330		2668	380	
1	35.1	87	85.7	72.1	94	87.4	111	101	88.6	151	107	89.6	193	114	90.4	236	120	91.2
1½	28.8	86	88.3	59.0	91	89.7	90.8	96	90.6	123	101	91.5	157	107	92.2	193	112	92.8
2	24.7	85	90.0	50.5	89	91.2	77.4	93	92.0	105	98	92.7	135	102	93.3	164	106	93.9
2½										92.7	95	93.6	119	99	94.1	145	102	94.6
3										83.3	93	94.2	106	96	94.7	130	99	95.1
3½										75.9	91	94.7	96.6	94	95.2	118	97	95.6
4										70.1	90	95.2	89.2	93	95.6	109	95	95.9
4½										65.3	89	95.5	83.2	91	95.9	102	94	96.2
5																		



KAYLO PIPE INSULATION Heat Loss — Surface Temperature — Efficiency 10-Inch Pipe

Ambient still air 80°F.

Pipe Temp. °F.	430°			480°			530°			580°			630°			680°		
Temp. Diff. Pipe to Air °F.	350°			400°			450°			500°			550°			600°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	3433	430		4318	480		5241	530		6512	580		7841	630		9350	680	
1																		
1½	281	127	91.8	328	133	92.4	376	139	92.8	425	146	93.5	475	152	93.9	530	159	94.3
2	229	117	93.3	267	122	93.8	306	128	94.2	346	133	94.7	388	138	95.1	430	143	95.4
2½	196	111	94.3	228	115	94.7	261	119	95.0	294	124	95.5	330	128	95.8	366	133	96.1
3	173	106	95.0	200	110	95.4	230	114	95.6	259	117	96.0	291	121	96.3	322	125	96.6
3½	154	102	95.5	179	106	95.9	206	109	96.1	232	112	96.4	260	116	96.7	288	119	96.9
4	140	100	95.9	163	103	96.2	187	106	96.4	212	109	96.7	237	111	97.0	263	114	97.2
4½	130	98	96.2	151	100	96.5	173	103	96.7	195	105	97.0	219	108	97.2	243	111	97.4
5	121	96	96.5	141	98	96.7	161	101	96.9	182	103	97.2	203	105	97.4	228	108	97.6



KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

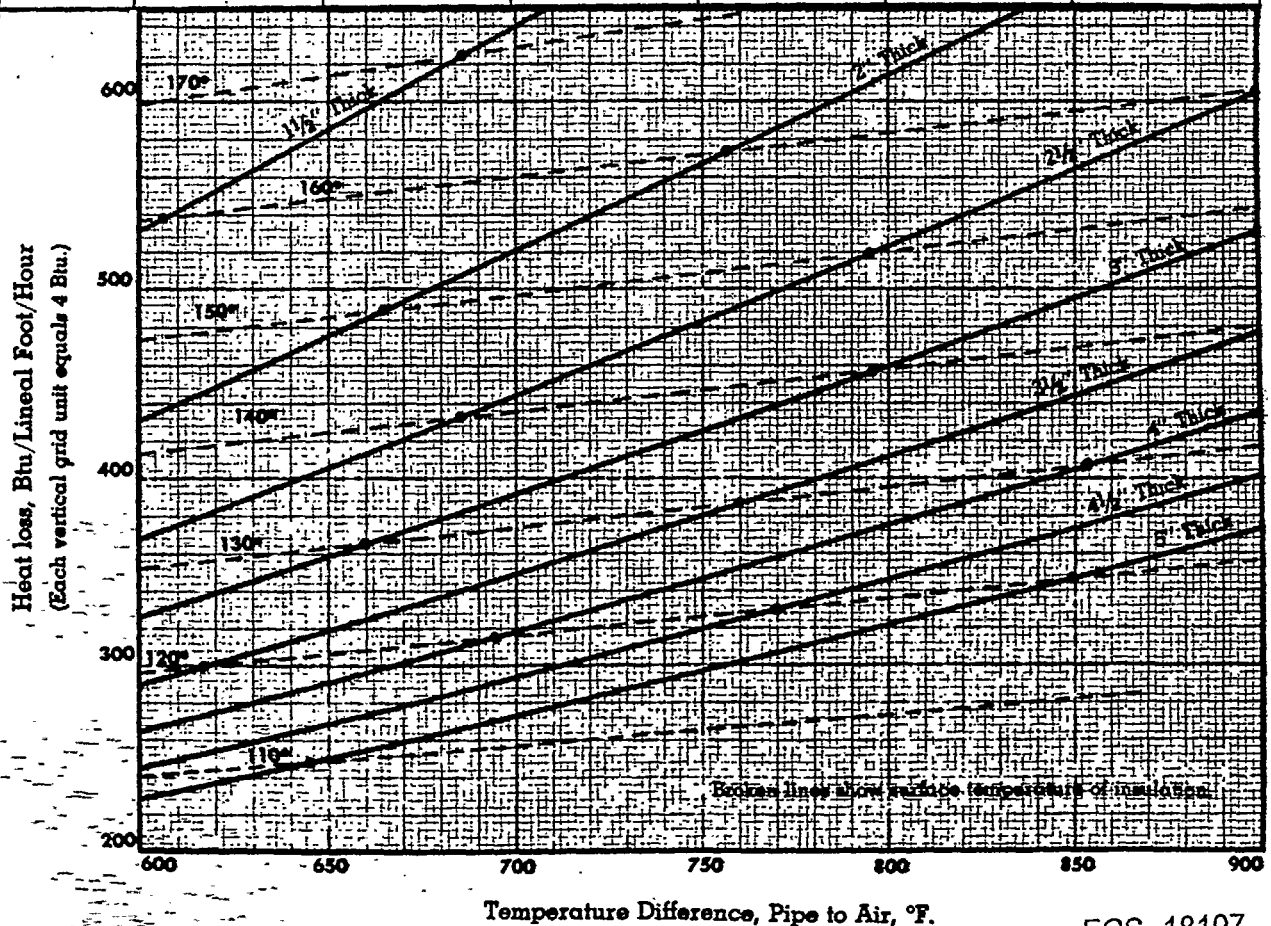
10-Inch Pipe

OWENS ILLINOIS
GLASS COMPANY

KAYLO
HEAT INSULATING
PRODUCTS

Ambient still air 80°F.

Pipe Temp. °F.	730°			780°			830°			880°			930°			980°		
Temp. Diff. Pipe to Air °F.	650°			700°			750°			800°			850°			900°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	11031	730		12912	780		15015	830		17355	880		19955	930		22833	980	
1																		
1½	583	166	94.7	639	172	95.0	698	179	95.4									
2	475	149	95.7	520	154	96.0	566	159	96.2	612	165	96.5	664	170	96.7	711	175	96.9
2½	404	137	96.3	442	141	96.6	481	146	96.8	521	151	97.0	562	155	97.2	605	160	97.4
3	354	129	96.8	388	133	97.0	422	136	97.2	458	141	97.4	493	144	97.5	531	148	97.7
3½	318	122	97.1	348	126	97.3	378	129	97.5	410	133	97.6	443	136	97.8	476	140	97.9
4	289	117	97.4	317	120	97.5	344	123	97.7	373	127	97.9	404	130	98.0	435	133	98.1
4½	267	114	97.6	292	116	97.7	318	119	97.9	344	122	98.0	372	125	98.1	400	128	98.2
5	249	110	97.7	272	113	97.9	296	115	98.0	321	118	98.2	346	120	98.3	372	123	98.4



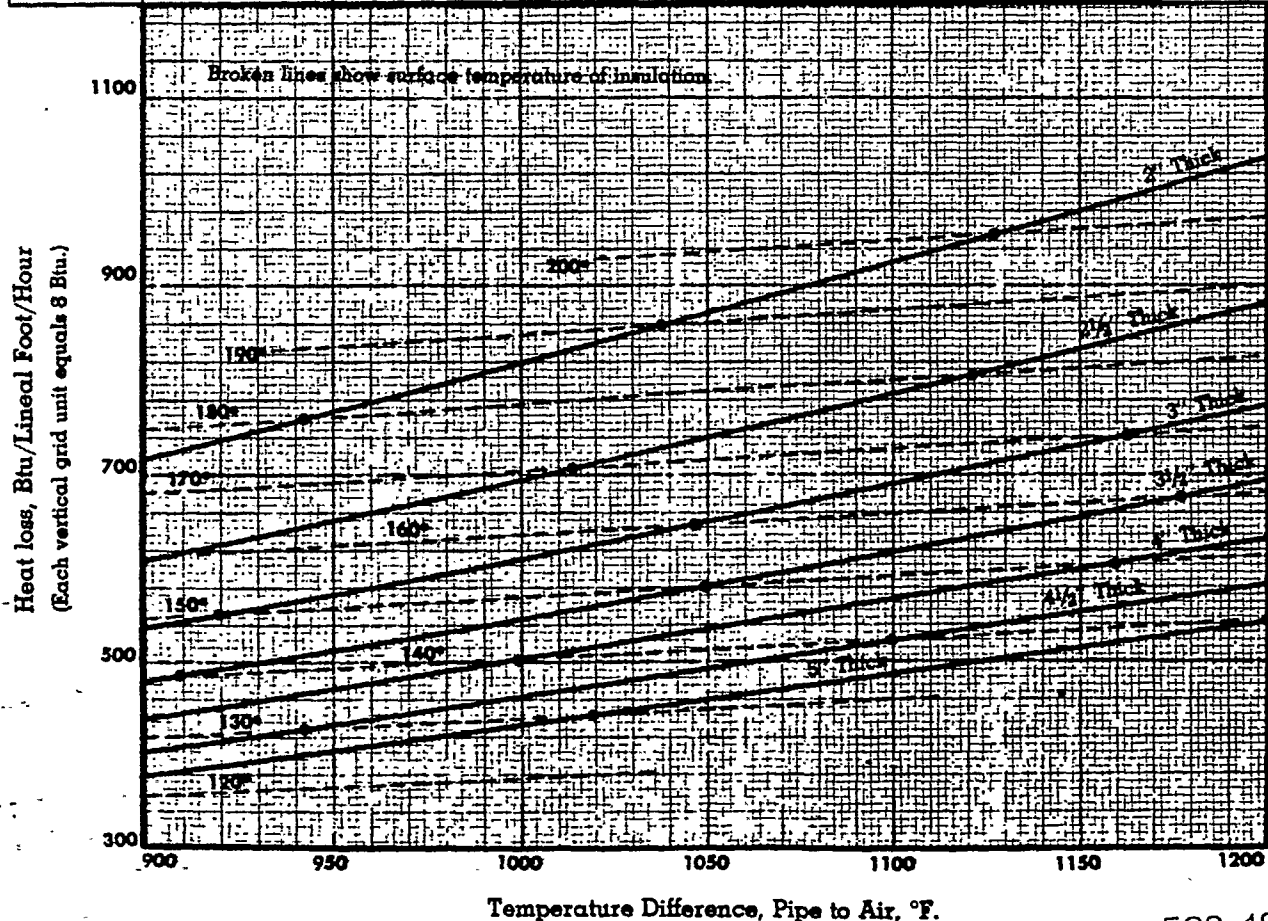
KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

10-Inch Pipe

Ambient still air 80°F.

Pipe Temp. °F.	1030°			1080°			1130°			1180°			1230°			1280°		
Temp. Diff. Pipe to Air °F.	950°			1000°			1050°			1100°			1150°			1200°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	26007	1030		29500	1080		33329	1130		37525	1180		42104	1230		47089	1280	
1																		
1½																		
2	765	181	97.1	815	186	97.2	873	192	97.4	924	197	97.5	984	203	97.7	1039	208	97.8
2½	646	164	97.5	694	169	97.6	739	174	97.8	785	178	97.9	831	183	98.0	882	188	98.1
3	569	153	97.8	608	157	97.9	650	161	98.0	687	165	98.2	731	169	98.3	773	173	98.4
3½	510	143	98.0	545	147	98.2	581	151	98.3	616	154	98.4	654	158	98.4	692	161	98.5
4	465	136	98.2	497	139	98.3	530	143	98.4	563	146	98.5	597	149	98.6	630	152	98.7
4½	429	131	98.4	457	133	98.5	488	136	98.5	519	139	98.6	550	142	98.7	581	145	98.8
5	398	126	98.5	426	128	98.6	453	131	98.6	483	134	98.7	512	136	98.8	541	139	98.9



KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

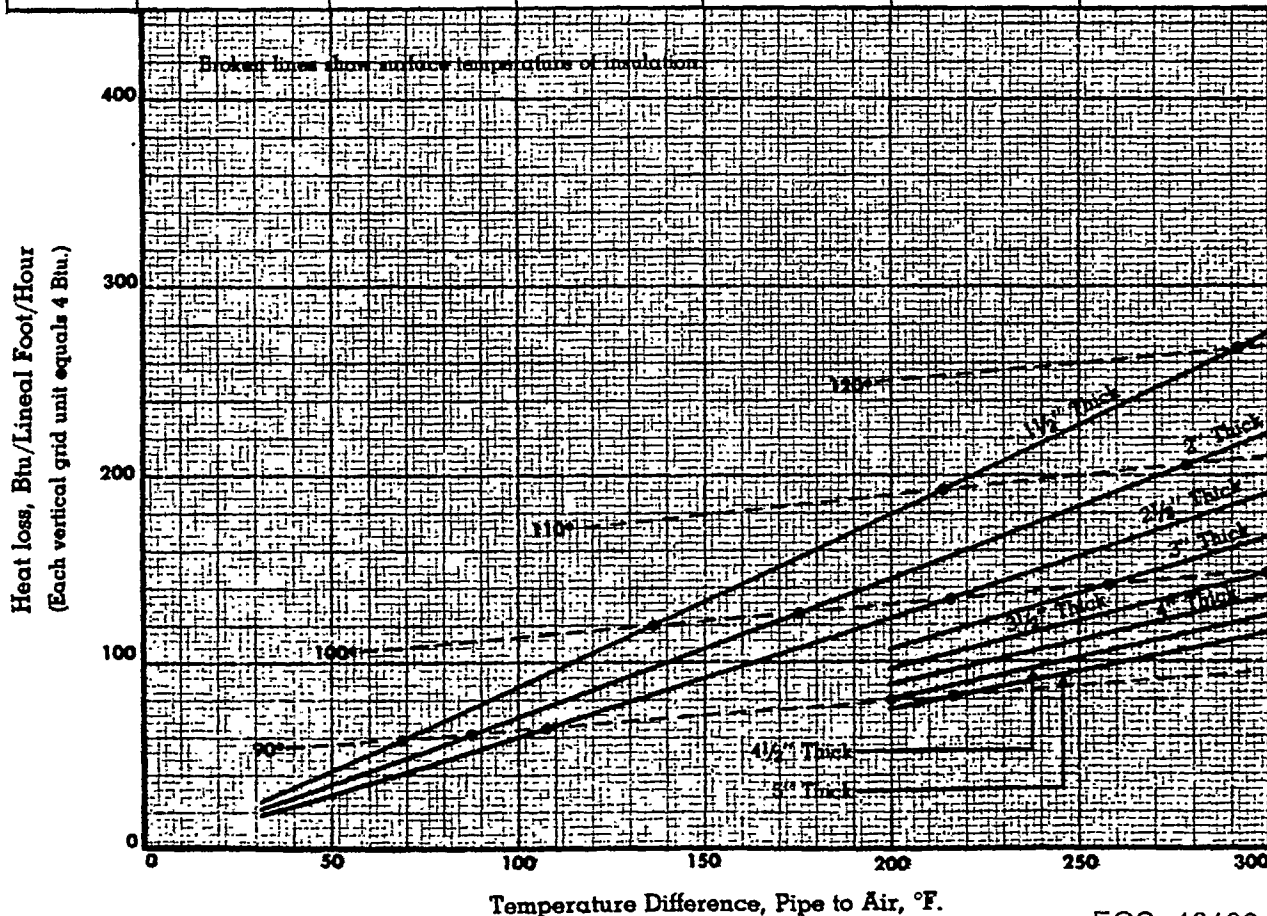
12-Inch Pipe

OWENS ILLINOIS
 GLASS COMPANY

KAYLO
 HEAT INSULATING
 PRODUCTS

Ambient still air 80°F.

Pipe Temp. °F.	130°			180°			230°			280°			330°			380°		
Temp. Diff. Pipe to Air °F.	50°			100°			150°			200°			250°			300°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	239	130		671	180		1134	230		1699	280		2361	330		3137	380	
1																		
1½	40.8	87	85.9	83.4	94	87.6	128	101	88.7	174	108	89.8	224	114	90.5	274	121	91.3
2	33.2	86	88.5	68.1	91	89.8	103	97	90.7	142	102	91.6	182	107	92.3	222	112	92.9
2½	28.4	85	90.2	58.1	89	91.3	89.1	94	92.1	121	98	92.9	153	103	93.4	189	107	94.0
3										106	95	93.8	135	99	94.3	166	103	94.7
3½										93.1	93	94.4	121	97	94.9	148	100	95.3
4										86.4	92	94.9	110	95	95.3	135	98	95.7
4½										79.7	90	95.3	101	93	95.7	124	96	96.0
5										74.0	89	95.6	94.2	92	96.0	115	94	96.3



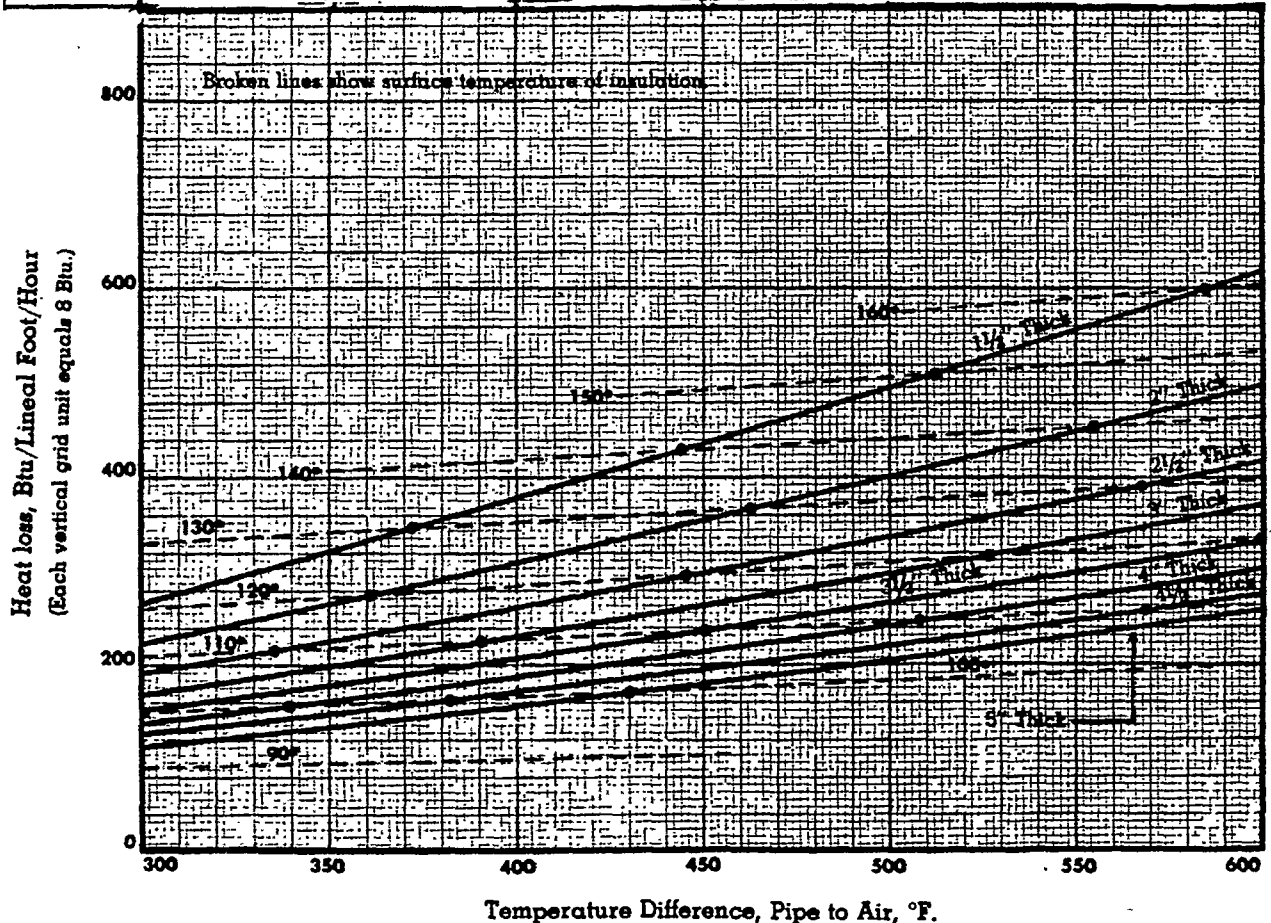
KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

12-Inch Pipe

Ambient still air 80°F.

Pipe Temp. °F.	430°			480°			530°			580°			630°			680°		
Temp. Diff. Pipe to Air °F.	350°			400°			450°			500°			550°			600°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	4038	430		5086	480		6290	530		7675	580		9246	630		11031	680	
1	326	128	91.9	380	134	92.5	435	141	93.1	494	148	93.6	554	154	94.0	615	161	94.4
1½	264	118	93.5	308	123	93.9	354	129	94.4	400	134	94.8	447	139	95.2	496	145	95.8
2	225	111	94.4	262	116	94.8	301	120	95.2	339	125	95.6	380	129	95.9	420	134	96.2
2½	197	107	95.1	230	111	95.5	263	114	95.8	297	118	96.1	334	122	96.4	369	126	96.7
3	176	103	95.6	206	107	95.9	235	110	96.3	266	113	96.5	297	117	96.8	330	120	97.0
3½	160	100	96.0	186	103	96.3	213	106	96.6	242	109	96.8	270	112	97.1	300	116	97.3
4	147	98	96.4	171	101	96.6	196	104	96.9	222	106	97.1	243	109	97.3	275	112	97.5
4½	137	96	96.6	159	99	96.9	183	101	97.1	206	104	97.3	231	106	97.5	256	109	97.7
5																		



KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

12-Inch Pipe

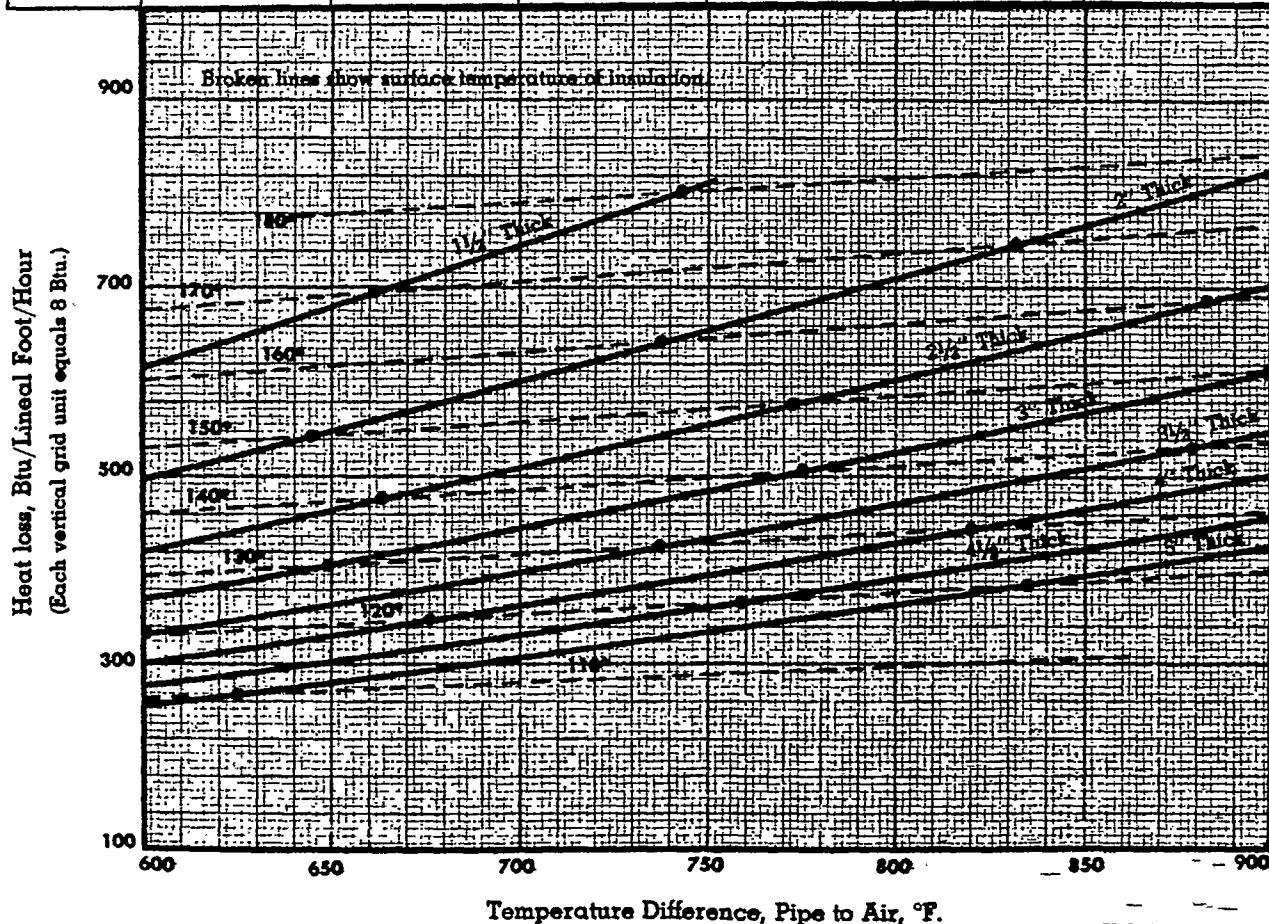
OWENS-ILLINOIS
GLASS COMPANY

KAYLO

HEAT INSULATING
PRODUCTS

Ambient still air 80°F.

Pipe Temp. °F.	730°			780°			830°			880°			930°			980°		
Temp. Diff. Pipe to Air °F.	650°			700°			750°			800°			850°			900°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	13020	730		15243	780		17734	830		20505	880		23583	930		26993	980	
1																		
1½	676	168	94.8	742	174	95.1	810	181	95.4									
2	548	150	95.8	600	156	96.1	655	161	96.3	708	167	96.5	765	172	96.8	821	178	97.0
2½	465	139	96.4	509	143	96.7	555	148	96.9	600	153	97.1	648	157	97.3	698	162	97.4
3	406	130	96.9	444	134	97.1	484	138	97.3	526	142	97.4	566	146	97.6	610	150	97.7
3½	363	124	97.2	398	127	97.4	433	131	97.6	470	134	97.7	506	138	97.9	544	142	98.0
4	330	119	97.5	362	122	97.6	394	125	97.8	426	128	97.9	460	131	98.0	495	135	98.2
4½	303	115	97.7	332	117	97.8	361	120	98.0	391	123	98.1	423	126	98.2	455	129	98.3
5	282	111	97.8	308	114	98.0	336	117	98.1	364	119	98.2	394	122	98.3	423	125	98.4



EGS 18201

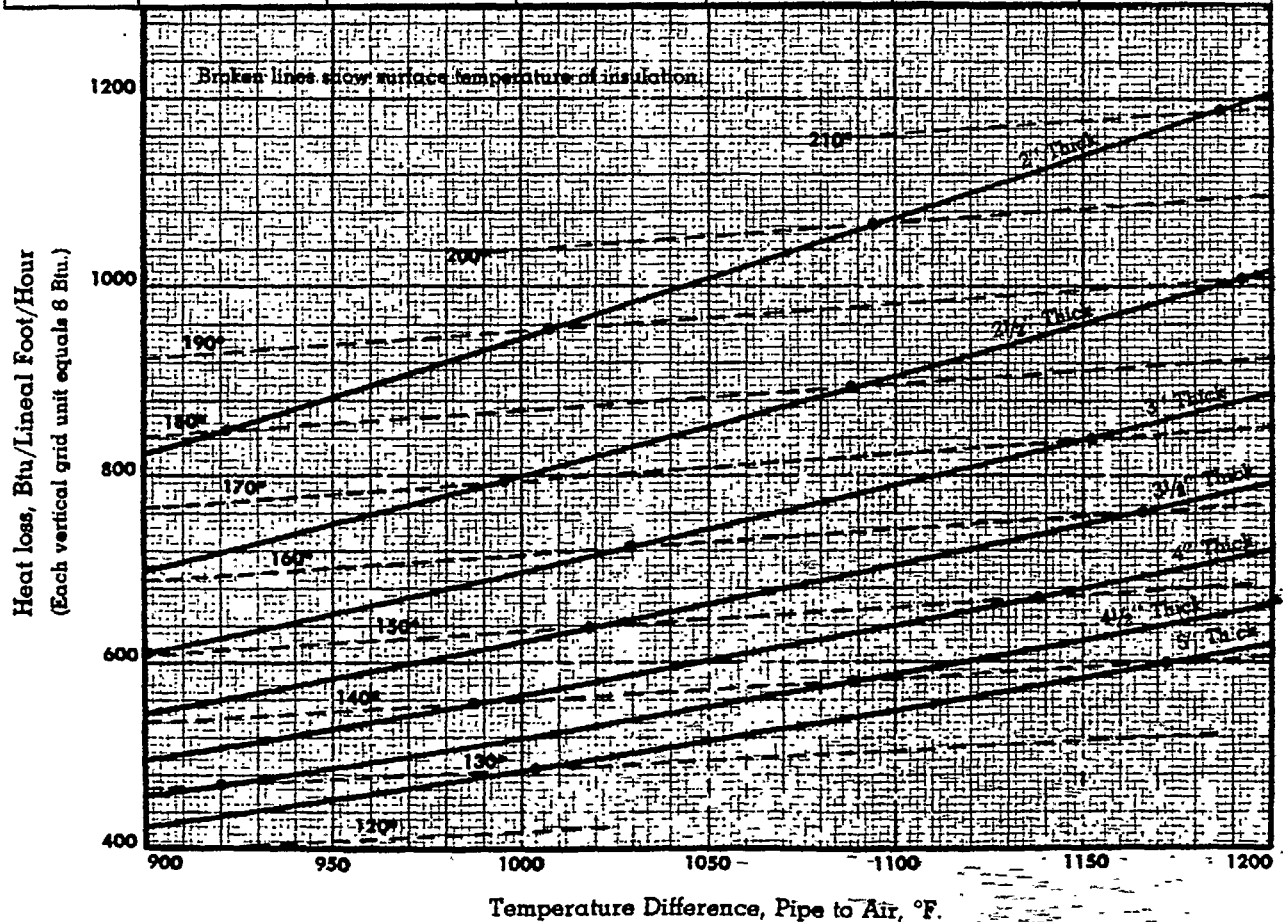
KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

12-Inch Pipe

Ambient still air 80°F.

Pipe Temp. °F.	1030°			1080°			1130°			1180°			1230°			1280°		
Temp. Diff. Pipe to Air °F.	950°			1000°			1050°			1100°			1150°			1200°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	30755	1030		34891	1080		39431	1130		44402	1180		49831	1230		55742	1280	
1																		
1½	884	183	97.1	944	189	97.3	1009	194	97.4	1067	200	97.6	1137	205	97.7	1201	211	97.8
2	749	167	97.6	799	171	97.7	851	176	97.8	907	181	98.0	961	186	98.1	1016	191	98.2
2½	653	154	97.9	697	159	98.0	744	163	98.1	790	167	98.2	840	171	98.3	887	175	98.4
3	584	145	98.1	623	149	98.2	665	153	98.3	703	156	98.4	748	160	98.5	792	164	98.6
3½	530	138	98.3	567	141	98.4	604	145	98.5	642	148	98.5	681	151	98.6	720	155	98.7
4	487	132	98.4	520	135	98.5	554	138	98.6	589	141	98.7	625	144	98.7	660	147	98.8
4½	453	127	98.5	483	130	98.6	515	133	98.7	548	135	98.8	580	138	98.8	613	141	98.9



KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

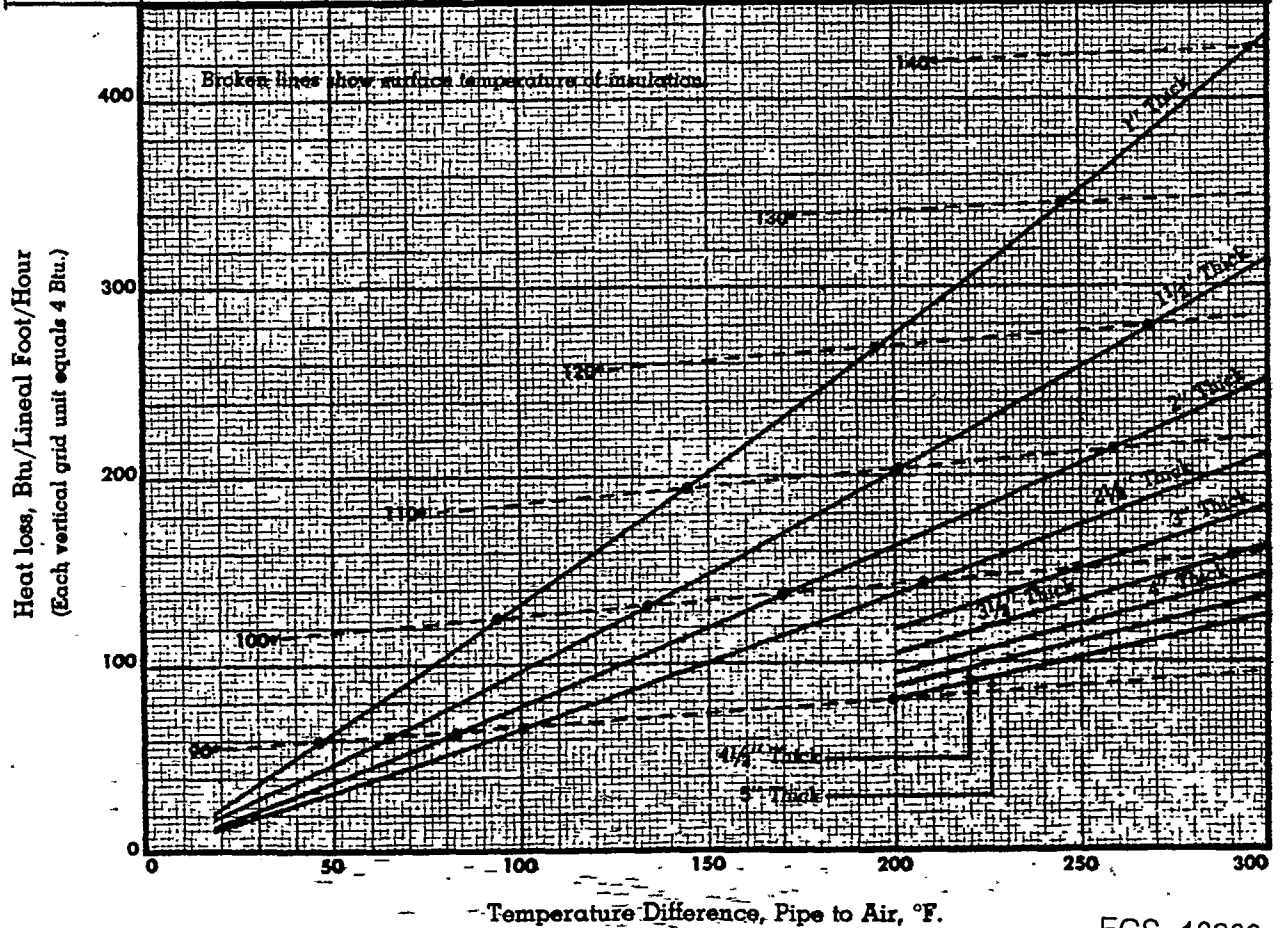
14-Inch Pipe

OWENS ILLINOIS
 GLASS COMPANY

KAYLO
 HEAT INSULATING
 PRODUCTS

Ambient still air 80°F.

Pipe Temp. °F.	130°			180°			230°			280°			330°			380°		
Temp. Diff. Pipe to Air °F.	50°			100°			150°			200°			250°			300°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	314	130		731	180		1241	230		1851	280		2572	330		3419	380	
1	63.0	91	79.9	131	101	82.1	201	111	83.8	276	121	85.1	353	131	86.3	435	141	87.3
1½	46.9	88	83.1	95.0	98	87.0	148	103	88.1	202	110	89.1	258	117	90.0	317	125	90.7
2	37.6	86	88.0	77.3	92	89.4	119	98	90.4	162	103	91.2	206	109	92.0	253	115	92.6
2½	31.8	85	89.9	65.1	90	91.1	100	95	91.9	136	99	92.7	174	104	93.2	213	109	93.8
3										118	96	93.6	151	100	94.1	185	104	94.6
3½										105	94	94.3	134	97	94.8	164	101	95.2
4										95.2	92	94.9	121	95	95.3	148	98	95.7
4½										87.4	91	95.3	111	94	95.7	136	96	96.0
5										80.9	90	95.6	103	92	96.0	126	95	96.3



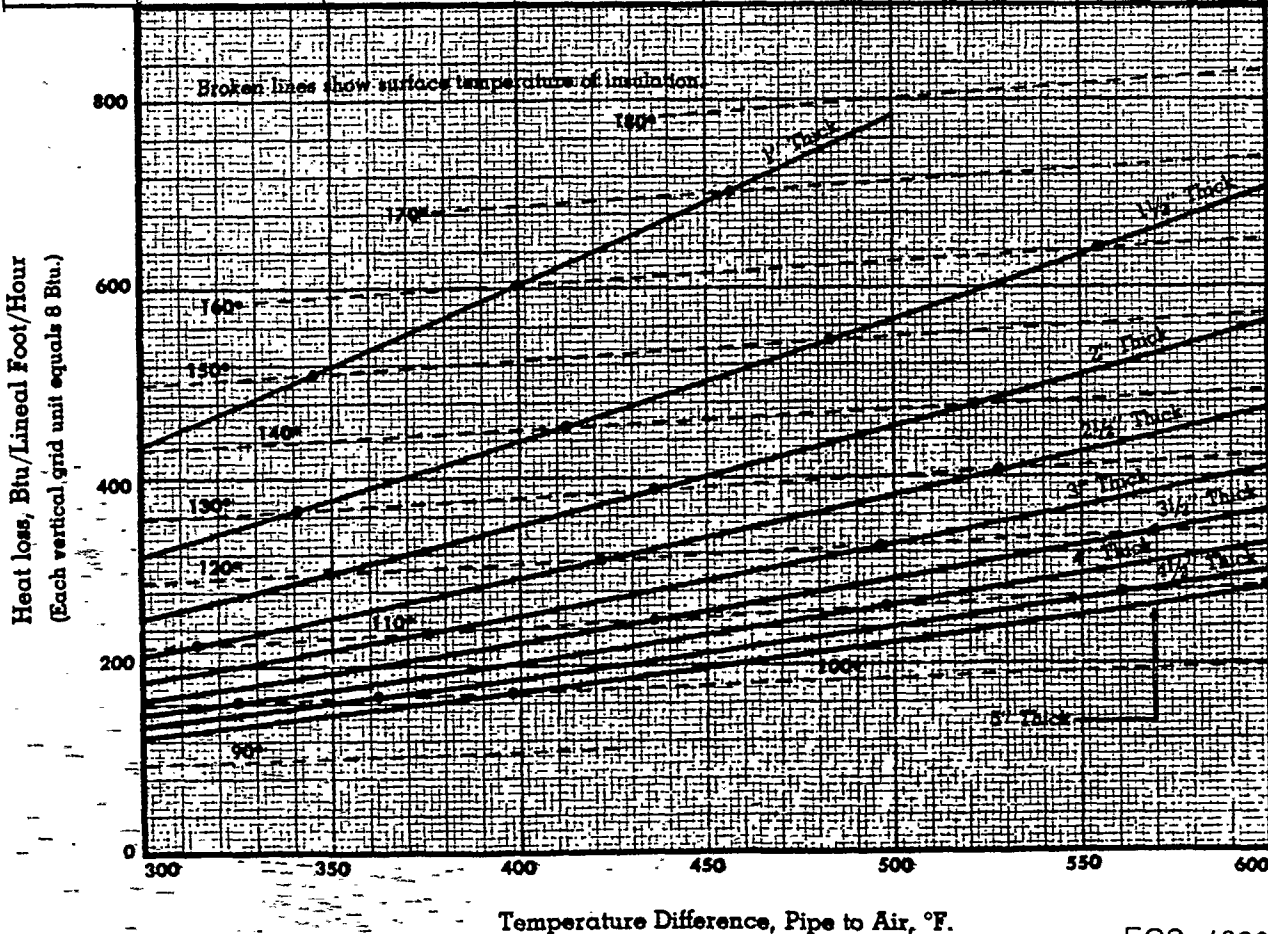
KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

14-Inch Pipe

Ambient still air 80°F.

Pipe Temp. °F.	430°			480°			530°			580°			630°			680°		
Temp. Diff. Pipe to Air °F.	350°			400°			450°			500°			550°			600°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	4404	430		5544	480		6862	530		8374	580		10091	630		12042	680	
1	517	150	88.3	607	160	89.0	693	169	89.9	786	177	90.6						
1½	378	131	91.4	439	138	92.1	505	146	92.6	571	153	93.2	640	160	93.7	711	167	94.1
2	301	120	93.2	351	126	93.7	401	132	94.2	456	138	94.6	510	143	94.9	566	149	95.3
2½	250	113	94.3	294	118	94.7	338	123	95.1	381	127	95.5	428	132	95.8	474	137	96.1
3	220	108	95.0	256	112	95.4	294	116	95.7	331	120	96.0	372	125	96.3	411	129	96.6
3½	195	104	95.6	227	108	95.9	260	111	96.2	294	115	96.5	328	119	96.7	366	122	97.0
4	176	101	96.0	206	105	96.3	235	108	96.6	266	111	96.8	297	114	97.1	330	117	97.3
4½	161	99	96.3	188	102	96.6	215	105	96.9	243	108	97.1	272	110	97.3	302	113	97.5
5	149	97	96.6	174	100	96.9	199	102	97.1	225	105	97.3	252	107	97.5	280	110	97.7



KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

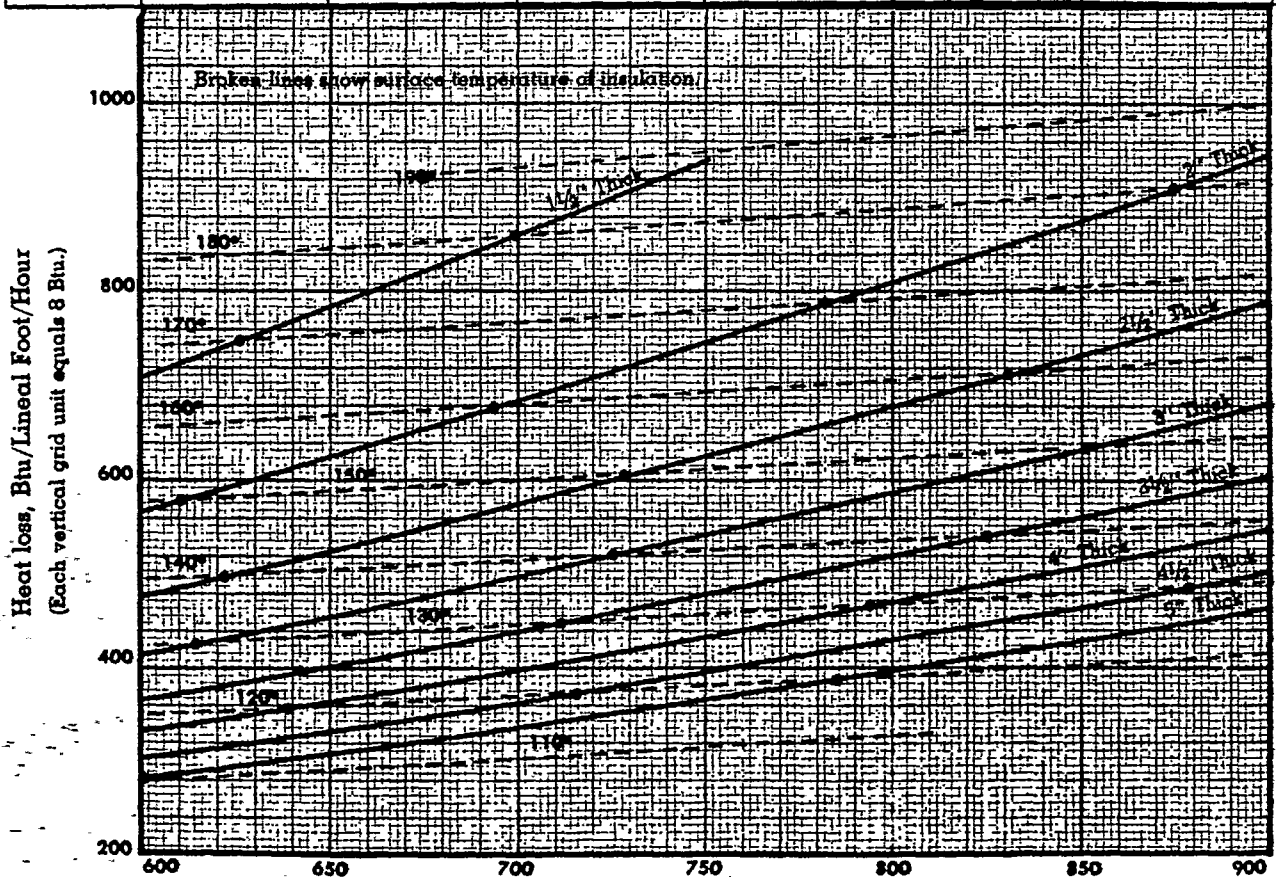
14-Inch Pipe

OWENS ILLINOIS
 GLASS COMPANY

KAYLO
 HEAT INSULATING
 PRODUCTS

Ambient still air 80°F.

Pipe Temp. °F.	730°			780°			830°			880°			930°			980°		
Temp. Diff. Pipe to Air °F.	650°			700°			750°			800°			850°			900°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	14174	730		16649	780		19374	830		22403	880		25740	930		29502	980	
1	785	174	94.5	859	181	94.8	938	188	95.2									
1½	625	155	95.6	683	161	95.9	745	166	96.2	810	172	96.4	873	178	96.6	944	184	96.8
2																		
2½	524	142	96.3	572	147	96.6	625	152	96.8	675	157	97.0	731	162	97.2	785	167	97.3
3	455	133	96.8	496	137	97.0	540	141	97.2	585	145	97.4	631	150	97.5	680	154	97.7
3½	402	126	97.2	440	130	97.4	478	133	97.5	519	137	97.7	560	141	97.8	600	145	98.0
4																		
4½	364	120	97.4	398	124	97.6	434	127	97.8	470	130	97.9	506	134	98.0	544	137	98.2
5	333	116	97.7	364	119	97.8	396	122	98.0	429	125	98.1	464	128	98.2	499	131	98.3
5	308	113	97.8	337	115	98.0	367	118	98.1	397	121	98.2	429	124	98.3	461	126	98.4



Temperature Difference, Pipe to Air, °F.

EGS 18205

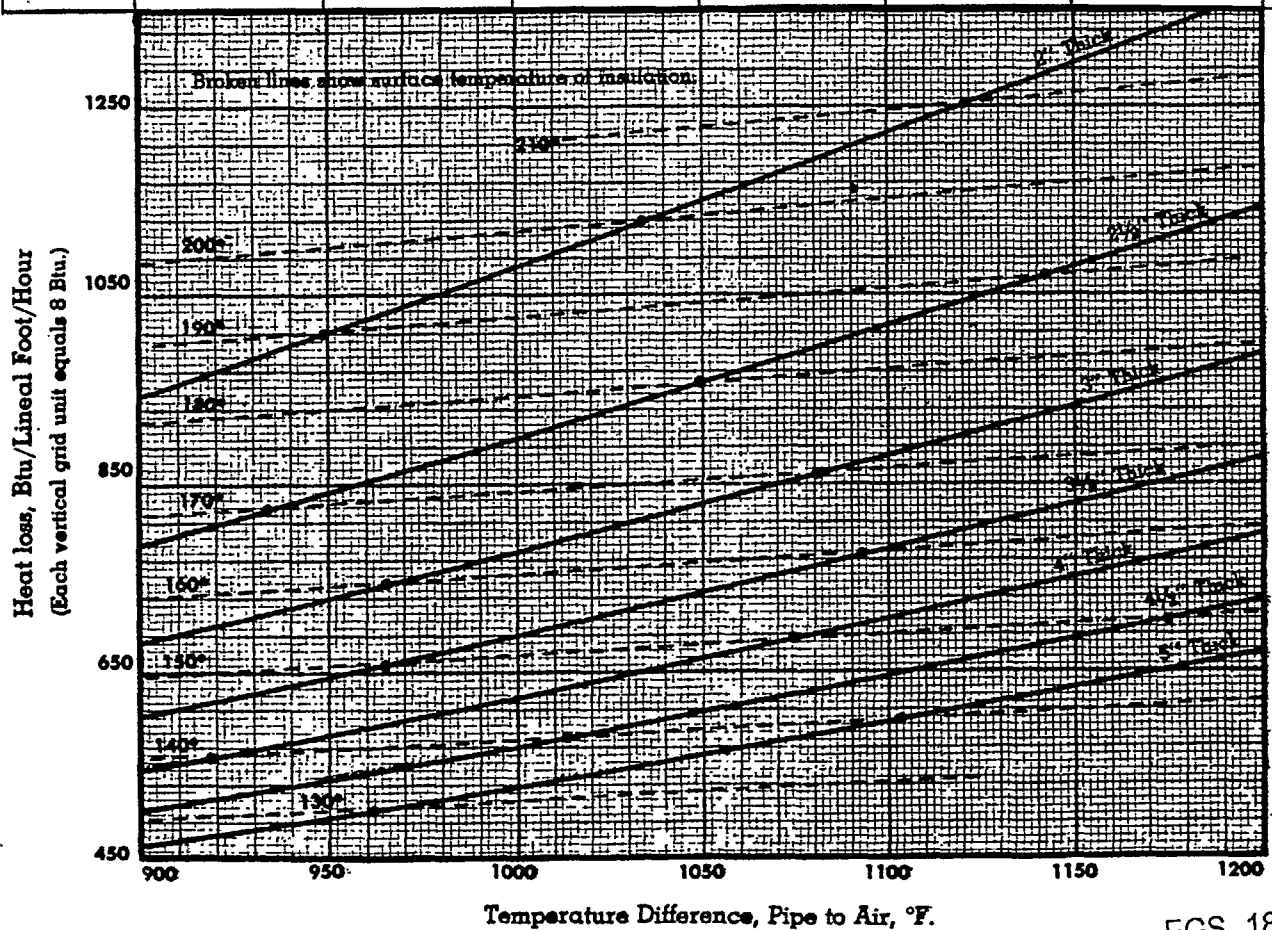
KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

14-Inch Pipe

Ambient still air 80°F.

Pipe Temp. °F.	1030°			1080°			1130°			1180°			1230°			1280°		
Temp. Diff. Pipe to Air °F.	950°			1000°			1050°			1100°			1150°			1200°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	33619	1030		38143	1080		43115	1130		48557	1180		54496	1230		60967	1280	
1																		
1½	1009	190	97.0	1076	195	97.2	1148	201	97.4	1220	207	97.5	1295	213	97.6	1368	219	97.8
2																		
2½	841	172	97.5	898	176	97.6	959	181	97.8	1020	186	97.9	1078	191	98.0	1142	196	98.1
3	726	158	97.8	777	163	98.0	829	167	98.1	881	171	98.2	935	176	98.3	989	180	98.4
3½	645	148	98.1	690	152	98.2	735	156	98.3	780	159	98.4	830	164	98.5	877	168	98.6
4	584	141	98.3	624	144	98.4	665	148	98.5	707	151	98.5	749	154	98.6	793	158	98.7
4½	535	134	98.4	570	137	98.5	609	141	98.6	647	144	98.7	685	147	98.7	725	150	98.8
5	494	129	98.5	527	132	98.6	563	135	98.7	596	138	98.8	634	141	98.8	669	144	98.9



KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

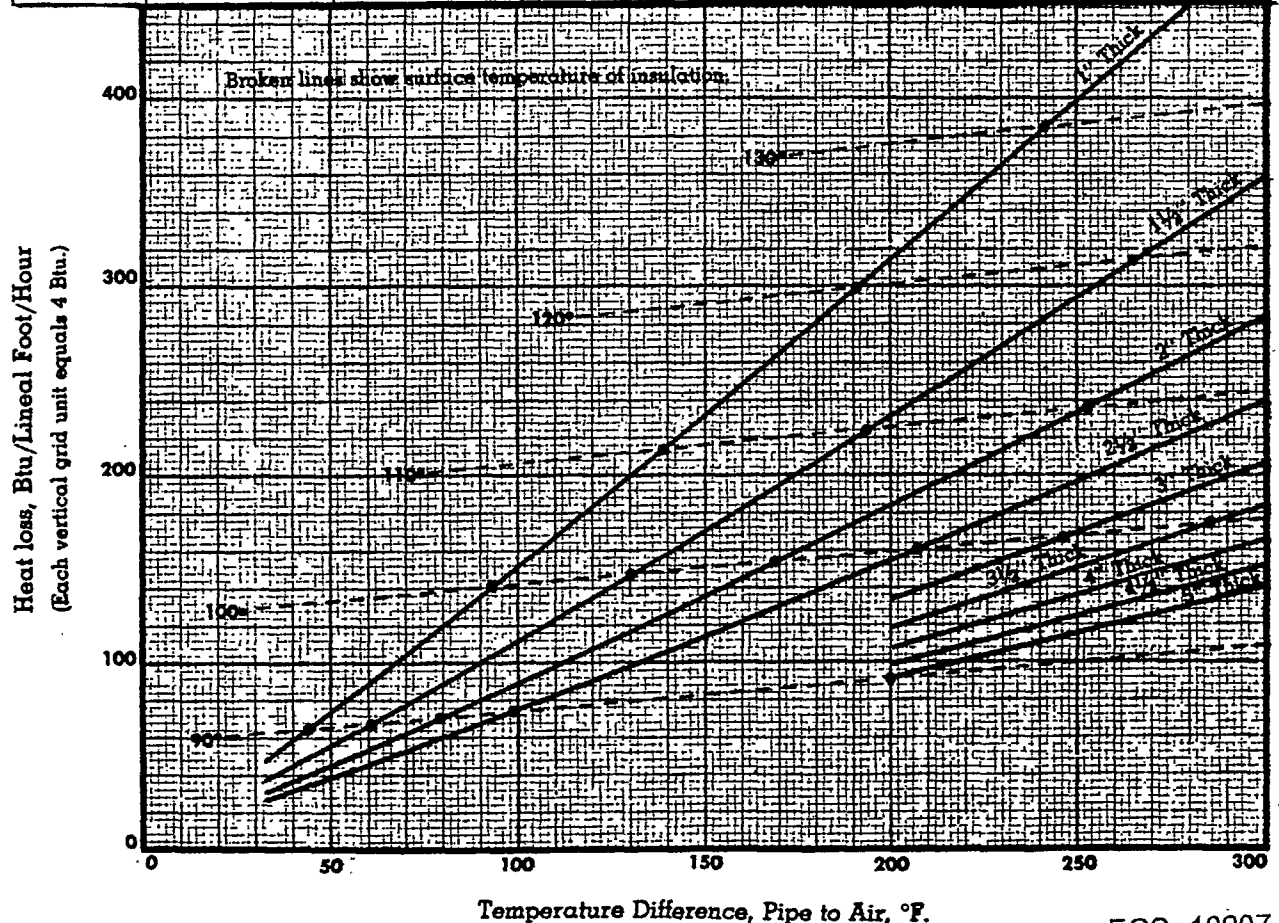
16-Inch Pipe

OWENS-ILLINOIS
 GLASS COMPANY

KAYLO
 HEAT INSULATING
 PRODUCTS

Ambient still air 80°F.

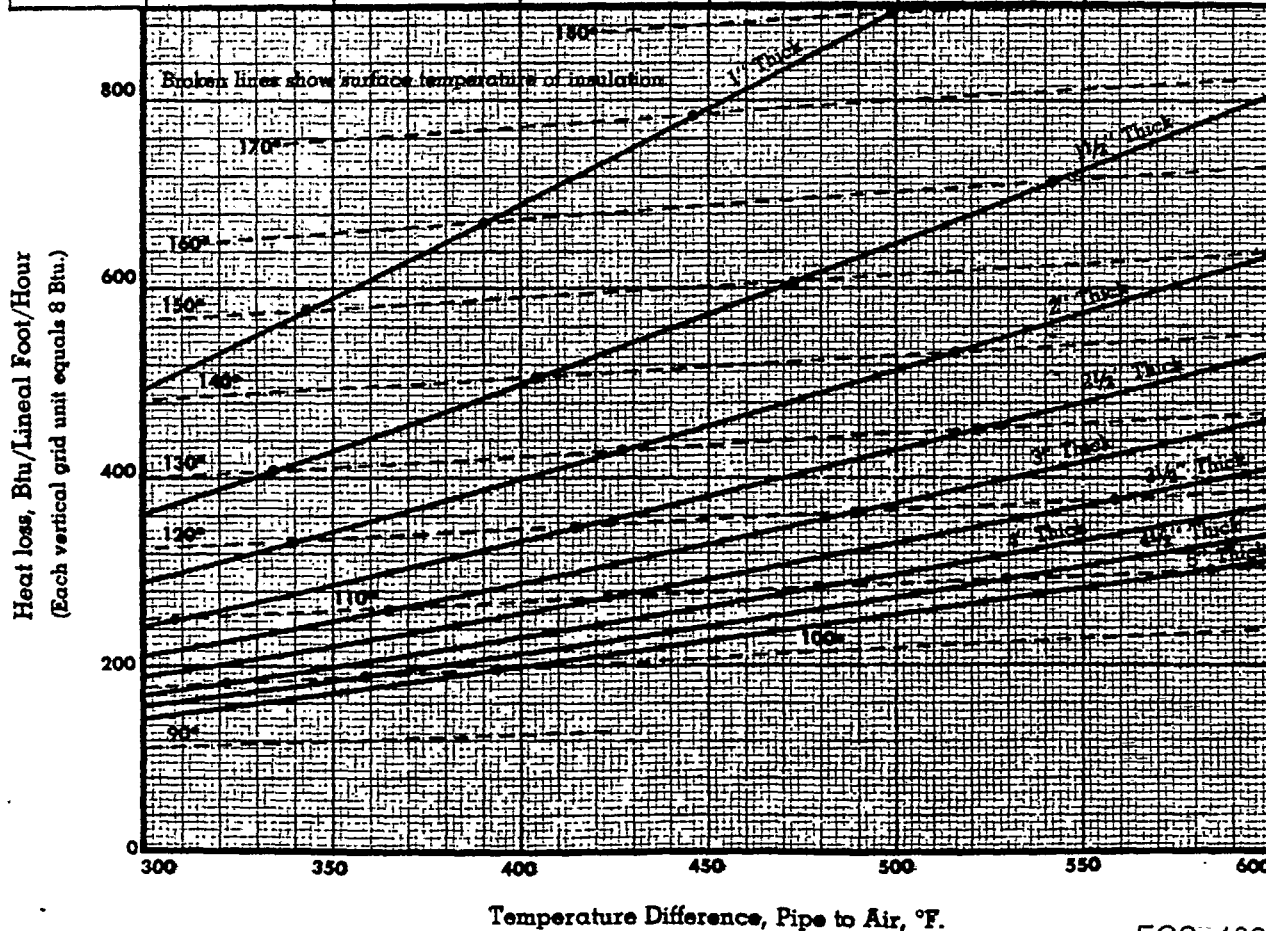
Pipe Temp. °F.	130°			180°			230°			280°			330°			380°		
Temp. Diff. Pipe to Air °F.	50°			100°			150°			200°			250°			300°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	356	130		828	180		1405	230		2098	280		2916	330		3877	380	
1	71.7	91	79.9	148	102	82.1	228	112	83.8	312	122	85.1	398	131	86.3	492	141	87.3
1½	52.8	88	85.2	109	96	86.8	169	102	88.0	228	111	89.1	291	118	90.0	358	125	90.8
2	42.4	86	88.1	87.0	92	89.5	134	98	90.5	182	104	91.3	232	110	92.0	284	115	92.7
2½	35.7	85	90.0	73.4	90	91.1	112	95	92.0	153	100	92.7	198	104	93.3	238	109	93.9
3										132	97	93.7	169	101	94.2	206	105	94.7
3½										117	94	94.4	150	98	94.9	183	101	95.3
4										106	93	94.9	138	96	95.4	165	99	95.7
4½										97.0	91	95.4	123	94	95.8	151	97	96.1
5										89.7	90	95.7	114	93	96.1	139	95	96.4



KAYLO PIPE INSULATION Heat Loss — Surface Temperature — Efficiency 16-Inch Pipe

Ambient still air 80°F.

Pipe Temp. °F.	430°			480°			530°			580°			630°			680°		
Temp. Diff. Pipe to Air °F.	350°			400°			450°			500°			550°			600°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	4997	430		6294	480		7793	530		9514	580		11469	630		13692	680	
1	585	151	88.3	686	161	89.1	785	169	89.9	890	179	90.6						
1½	426	132	91.5	496	139	92.1	569	147	92.7	645	154	93.2	723	161	93.7	804	168	94.1
2	338	121	93.2	394	127	93.7	451	133	94.2	511	139	94.6	571	144	95.0	636	150	95.4
2½	283	114	94.3	330	119	94.8	379	124	95.1	426	128	95.5	480	133	95.8	530	138	96.1
3	246	109	95.1	286	113	95.5	328	117	95.8	370	121	96.1	415	125	96.4	460	129	96.6
3½	218	105	95.6	253	108	96.0	290	112	96.3	328	116	96.6	367	119	96.8	407	123	97.0
4	196	102	96.1	229	105	96.4	262	108	96.6	296	112	96.9	331	115	97.1	368	118	97.3
4½	179	100	96.4	209	102	96.7	239	105	96.9	271	108	97.2	302	111	97.4	336	114	97.5
5	166	98	96.7	193	100	96.9	221	103	97.2	250	105	97.4	279	108	97.6	310	111	97.7



KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

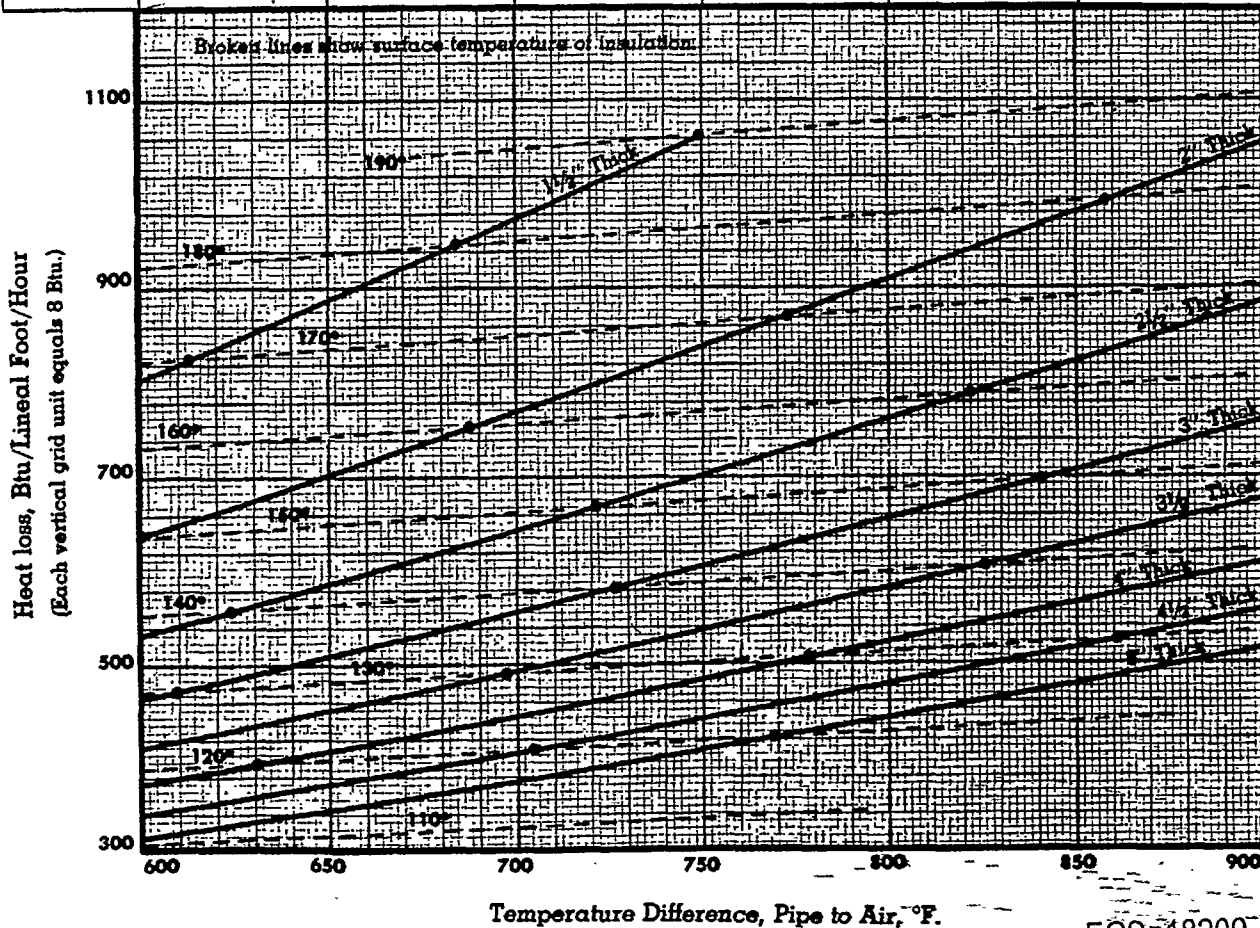
16-Inch Pipe

OWENS ILLINOIS
GLASS COMPANY

KAYLO
HEAT INSULATING
PRODUCTS

Ambient still air 80°F.

Pipe Temp. °F.	730°			780°			830°			880°			930°			980°		
Temp. Diff. Pipe to Air °F.	650°			700°			750°			800°			850°			900°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	16168	730		18941	780		22044	830		25499	880		29340	930		33597	980	
1	885	175	94.5	969	182	94.9	1059	190	95.2	1066	190	95.2	1179	199	96.7	1254	205	97.1
1½	700	156	95.7	768	162	95.9	835	168	96.2	906	174	96.4	979	179	96.7	1054	185	96.9
2	586	143	96.4	641	148	96.6	700	153	96.8	756	158	97.0	820	163	97.2	880	168	97.4
2½	507	134	96.9	555	138	97.1	604	142	97.3	655	147	97.4	705	151	97.6	761	155	97.7
3	449	127	97.2	491	131	97.4	535	134	97.6	580	138	97.7	625	142	97.9	672	146	98.0
3½	405	121	97.5	443	125	97.7	483	128	97.8	523	132	97.9	564	136	98.1	606	139	98.2
4	370	117	97.7	405	120	97.9	441	123	98.0	477	126	98.1	515	129	98.2	554	133	98.4
4½	342	113	97.9	374	116	98.0	406	119	98.2	441	122	98.3	475	125	98.4	512	128	98.5
5																		



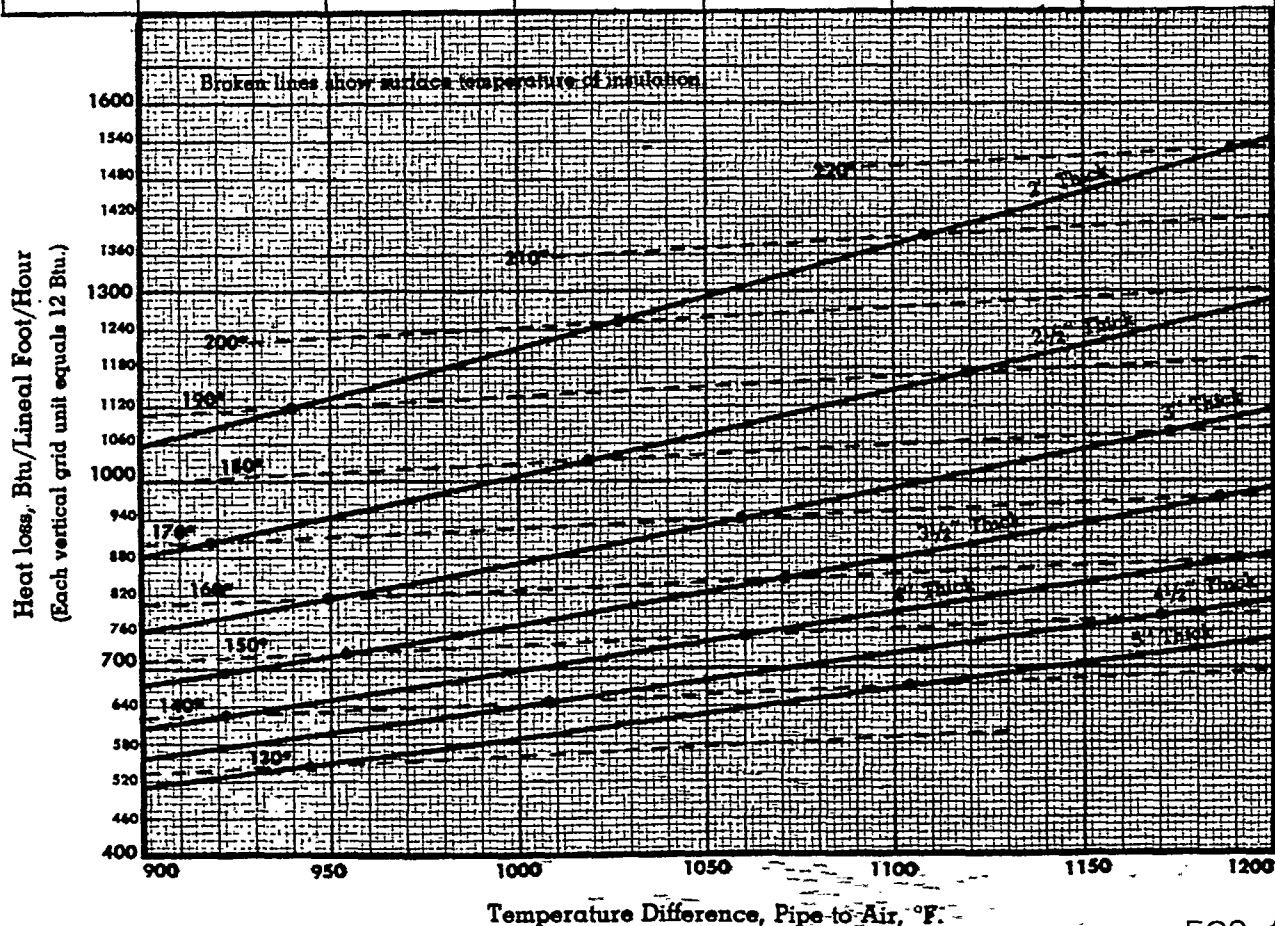
KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

16-Inch Pipe

Ambient still air 80°F.

Pipe Temp. °F.	1030°			1080°			1130°			1180°			1230°			1280°		
Temp. Diff. Pipe to Air °F.	950°			1000°			1050°			1100°			1150°			1200°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	38289	1030		43451	1080		49120	1130		55330	1180		62108	1230		69493	1280	
1																		
1½																		
2	1130	191	97.0	1209	197	97.2	1288	203	97.4	1370	209	97.5	1452	215	97.7	1538	221	97.8
2½	945	173	97.5	1007	178	97.7	1076	183	97.8	1143	188	97.9	1211	193	98.1	1281	198	98.2
3	815	160	97.9	870	164	98.0	929	169	98.1	989	173	98.2	1048	178	98.3	1106	182	98.4
3½	720	150	98.1	770	154	98.2	820	157	98.3	871	162	98.4	924	165	98.5	978	169	98.6
4	650	142	98.3	694	145	98.4	742	149	98.5	789	153	98.6	836	156	98.6	881	160	98.7
4½	594	136	98.4	633	139	98.5	676	142	98.6	719	145	98.7	762	148	98.8	804	152	98.8
5	548	130	98.6	585	133	98.7	624	136	98.7	664	139	98.8	704	142	98.9	742	145	98.9



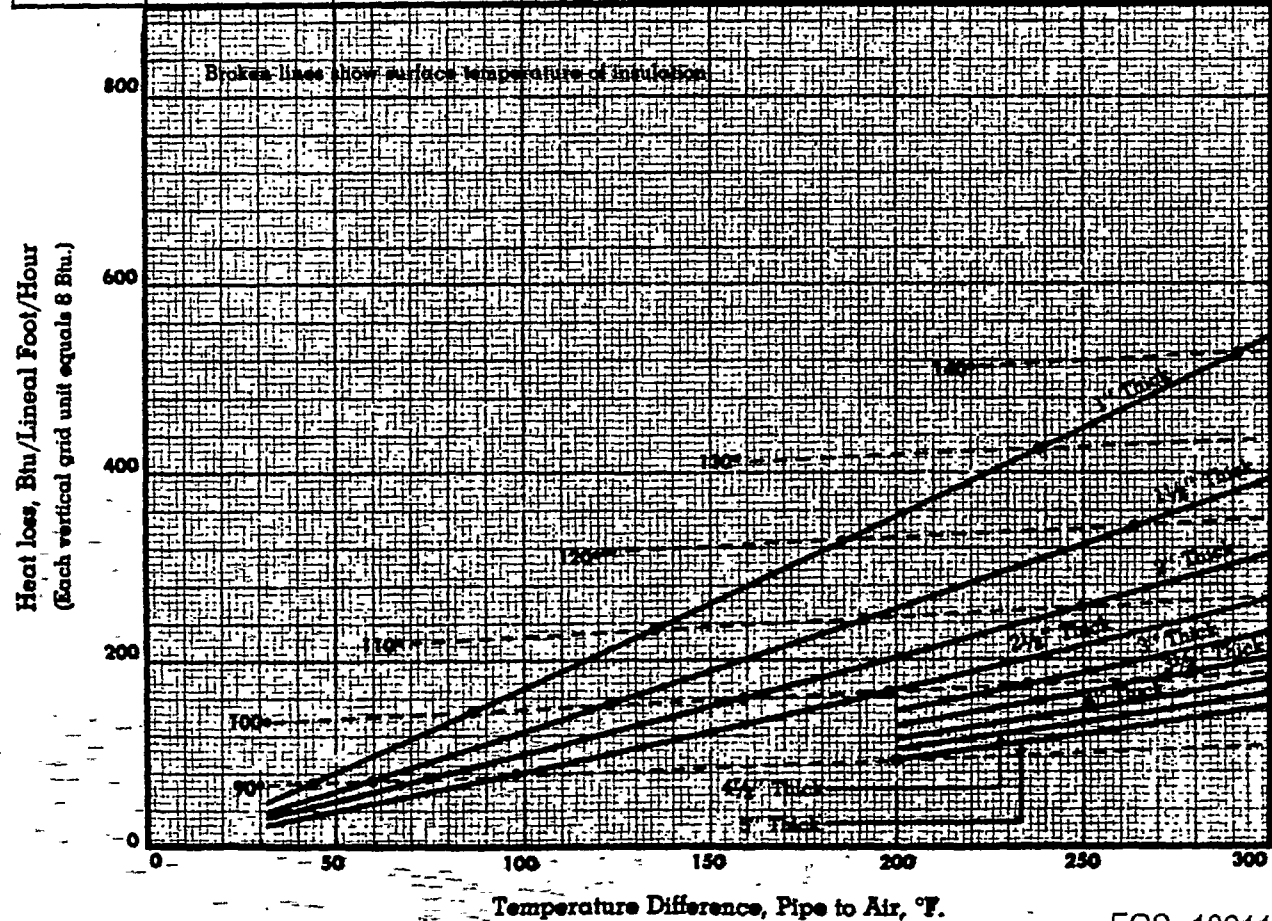
KAYLO PIPE INSULATION **Heat Loss — Surface Temperature — Efficiency** **18-Inch Pipe**

OWENS-ILLINOIS
 GLASS COMPANY

KAYLO
 HEAT INSULATING
 PRODUCTS

Ambient still air 80°F.

Pipe Temp. °F.	130°			180°			230°			280°			330°			380°		
Temp. Diff. Pipe to Air °F.	50°			100°			150°			200°			250°			300°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	399	130		926	180		1573	230		2348	280		3265	330		4344	380	
1	79.9	91	80.1	165	102	82.2	254	112	83.9	348	122	85.2	444	132	86.4	548	142	87.4
1½	58.9	88	85.2	121	96	86.9	186	103	88.2	253	111	89.2	324	118	90.1	398	125	90.8
2	47.0	86	88.2	96.4	92	89.6	148	98	90.6	202	104	91.4	258	110	92.1	316	116	92.7
2½	39.5	85	90.1	80.9	90	91.3	124	95	92.1	169	100	92.8	216	105	93.4	264	110	93.9
3										146	97	93.8	187	101	94.3	228	105	94.8
3½										130	95	94.5	166	98	94.9	202	101	95.3
4										117	93	95.0	149	96	95.4	182	99	95.8
4½										107	91	95.4	136	94	95.8	166	97	96.2
5										98.4	90	95.8	125	93	96.2	153	95	96.5



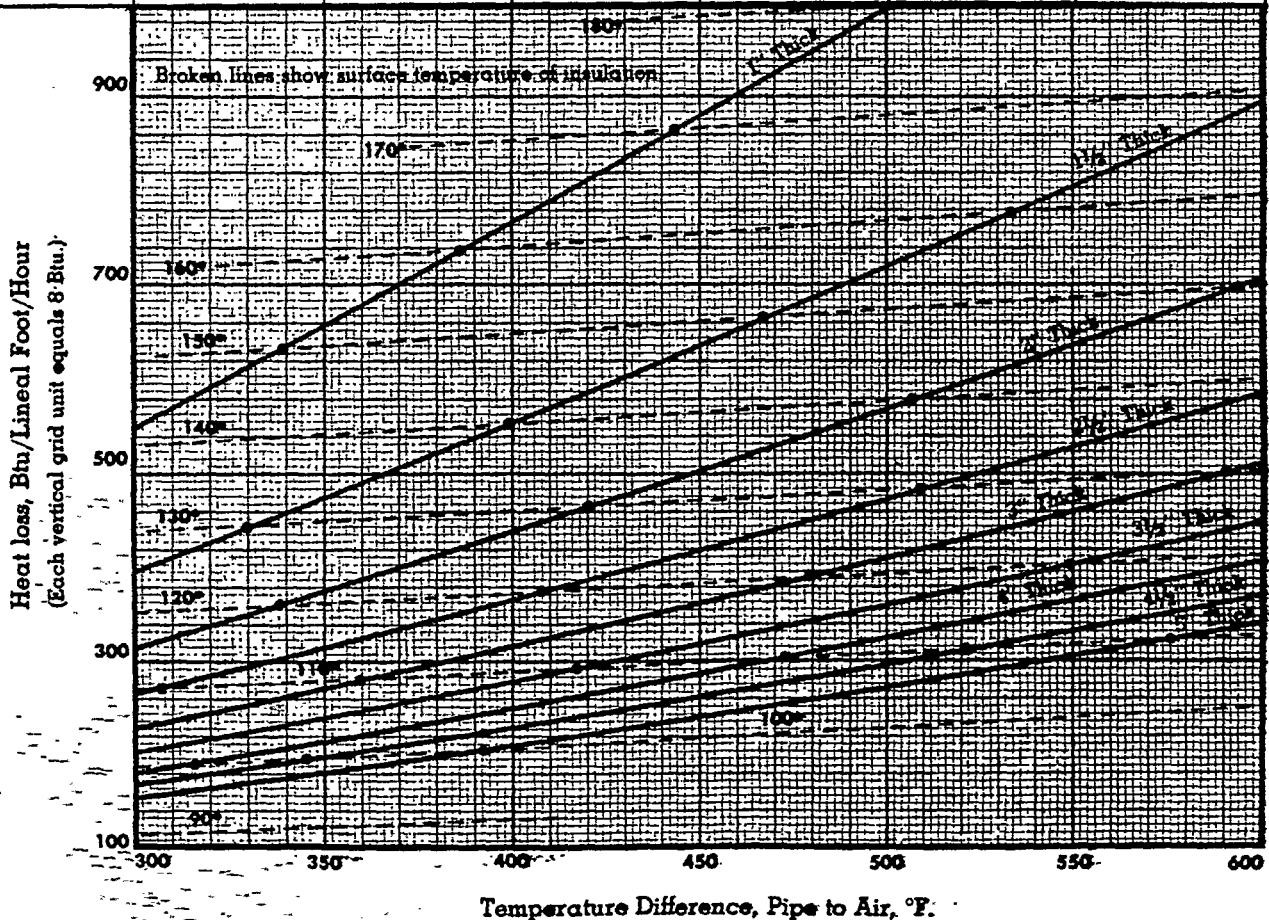
KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

18-Inch Pipe

Ambient still air 80°F.

Pipe Temp. °F.	430°			480°			530°			580°			630°			680°		
Temp. Diff. Pipe to Air °F.	350°			400°			450°			500°			550°			600°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	5600	430		7059	480		8741	530		10672	580		12876	630		15374	680	
1	652	151	88.3	765	162	89.2	875	170	90.0	993	180	90.7				895	169	94.2
1½	473	133	91.6	553	140	92.2	633	147	92.8	717	155	93.3	805	163	93.7			
2	376	122	93.3	436	127	93.8	503	133	94.3	570	139	94.7	635	145	95.1	709	151	95.4
2½																		
3	314	114	94.4	366	119	94.8	420	124	95.2	474	129	95.6	531	134	95.9	589	139	96.2
3½	272	109	95.1	316	113	95.5	364	118	95.8	410	122	96.2	460	126	96.4	509	130	96.7
4	240	105	95.7	280	109	96.0	320	113	96.3	362	116	96.6	405	120	96.9	450	124	97.1
4½	216	102	96.1	251	106	96.4	288	109	96.7	326	112	96.9	365	115	97.2	404	119	97.4
5	197	100	96.5	230	103	96.7	263	106	97.0	299	109	97.2	333	112	97.4	369	115	97.6
	182	98	96.8	212	101	97.0	242	103	97.2	274	106	97.4	306	109	97.6	340	111	97.8



KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

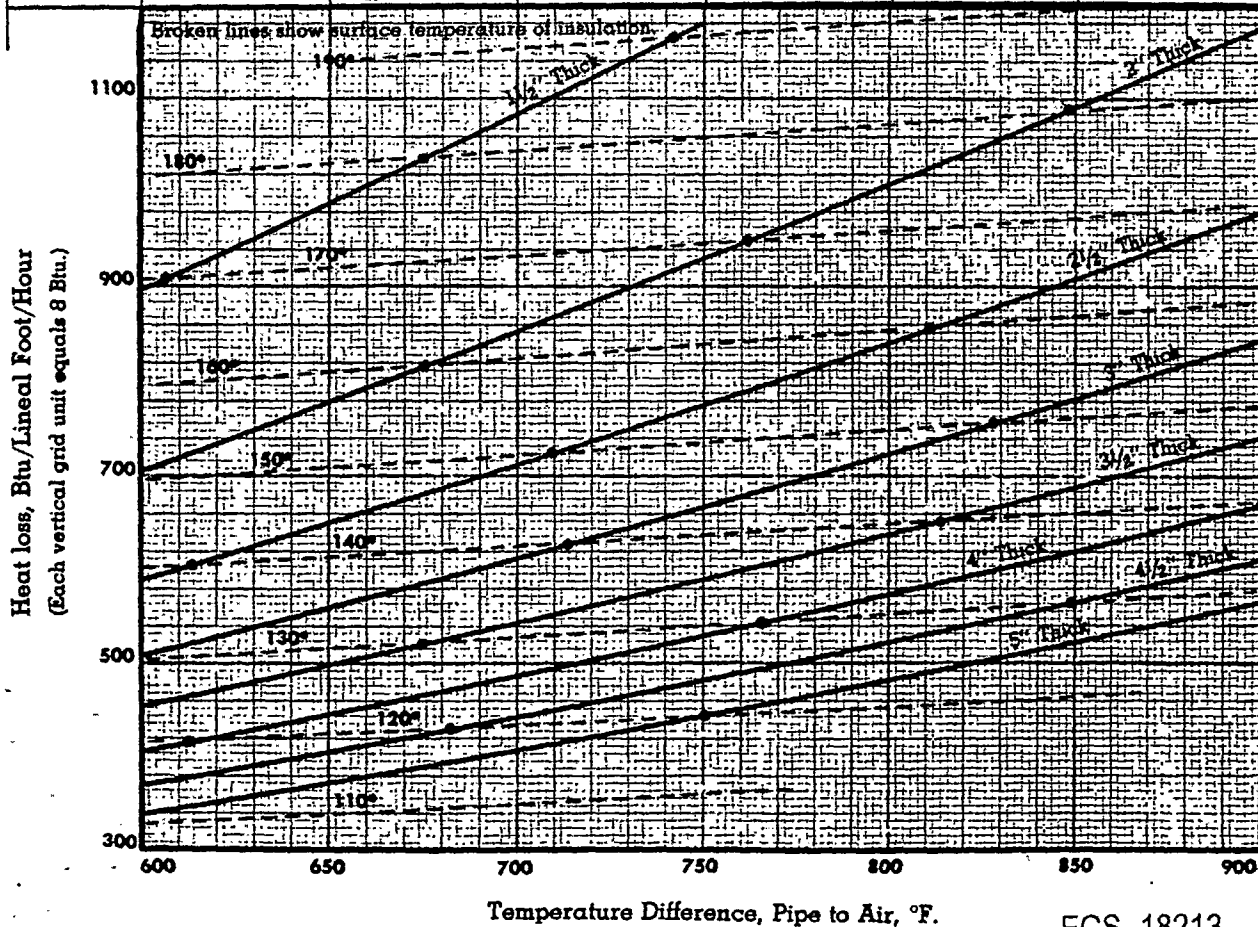
18-Inch Pipe

OWENS ILLINOIS
 GLASS COMPANY

KAYLO
 HEAT INSULATING
 PRODUCTS

Ambient still air 80°F.

Pipe Temp. °F.	730°			780°			830°			880°			930°			980°		
Temp. Diff. Pipe to Air °F.	650°			700°			750°			800°			850°			900°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	18160	730		21277	780		24771	830		28660	880		32982	930		37775	980	
1																		
1½	986	176	94.6	1082	184	94.9	1178	191	95.2									
2	779	157	95.7	853	163	96.0	930	169	96.2	1011	175	96.5	1089	181	96.7	1175	187	96.9
2½	650	144	96.4	711	149	96.7	776	154	96.9	840	159	97.1	910	164	97.2	976	169	97.4
3	561	135	96.9	613	139	97.1	668	143	97.3	725	148	97.5	780	152	97.6	844	157	97.8
3½	495	128	97.3	542	131	97.4	590	135	97.6	640	139	97.8	690	143	97.9	742	147	98.0
4	446	122	97.5	489	126	97.7	530	129	97.9	576	133	98.0	621	136	98.1	666	139	98.2
4½	406	118	97.8	445	121	97.9	485	124	98.0	525	127	98.2	566	130	98.3	609	133	98.4
5	374	114	97.9	410	117	98.1	446	120	98.2	484	123	98.3	522	125	98.4	566	128	98.5



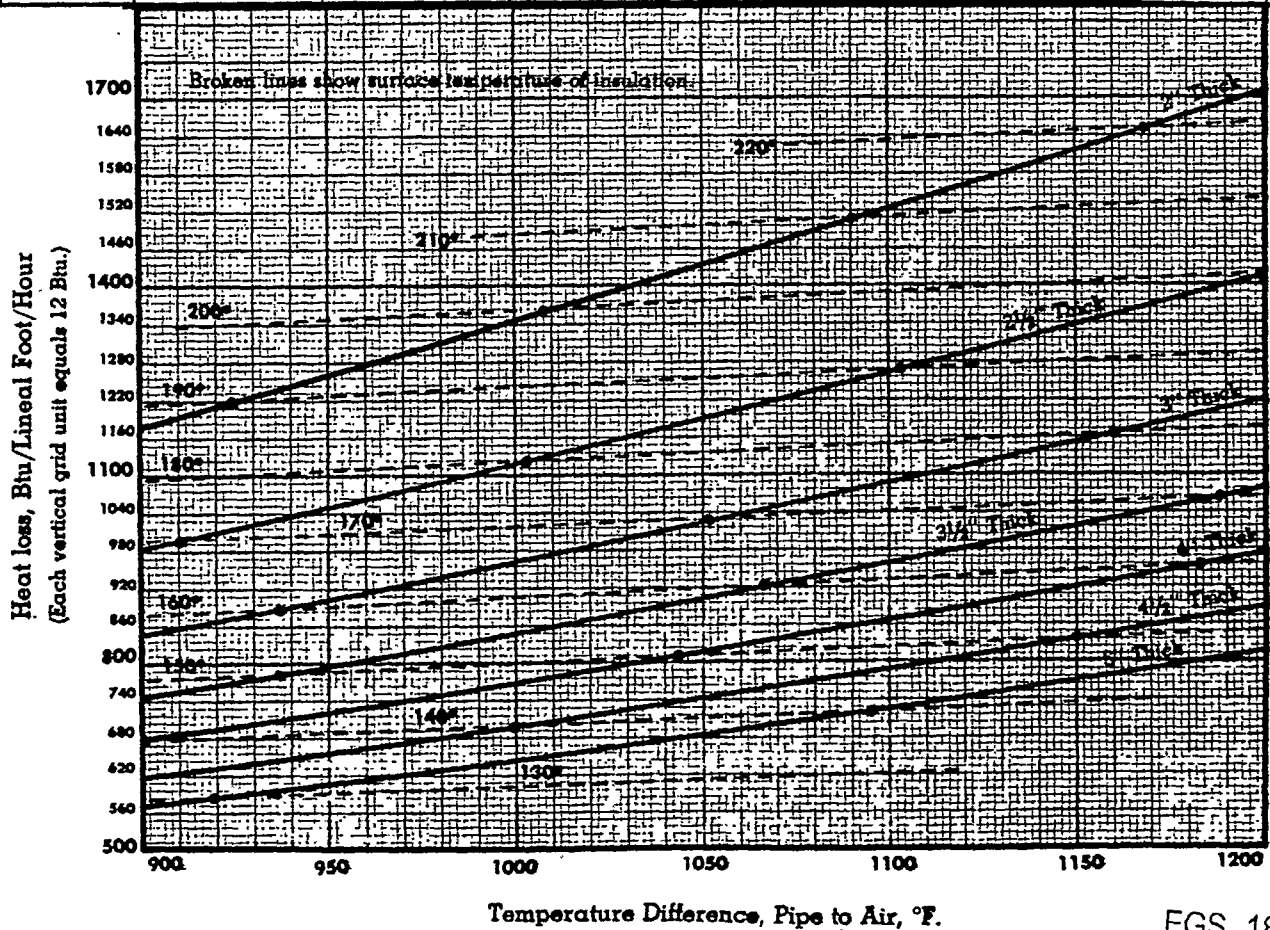
KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

18-Inch Pipe

Ambient still air 80°F.

Pipe Temp. °F.	1030°			1080°			1130°			1180°			1230°			1280°		
Temp. Diff. Pipe to Air °F.	950°			1000°			1050°			1100°			1150°			1200°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	43059	1030		48873	1080		55259	1130		62249	1180		69884	1230		78204	1280	
1																		
1½																		
2	1259	193	97.1	1347	199	97.2	1432	205	97.4	1524	210	97.5	1618	217	97.7	1709	223	97.8
2½	1047	174	97.6	1116	179	97.7	1190	184	97.8	1268	190	98.0	1342	195	98.1	1419	200	98.2
3	900	161	97.9	962	165	98.0	1022	170	98.1	1090	175	98.2	1155	179	98.3	1223	184	98.4
3½	795	151	98.1	850	155	98.3	906	159	98.4	963	163	98.4	1020	167	98.5	1079	171	98.6
4	717	143	98.3	764	147	98.4	816	150	98.5	867	154	98.6	920	158	98.7	971	161	98.8
4½	654	137	98.5	697	140	98.6	744	143	98.6	791	146	98.7	839	150	98.8	885	153	98.9
5	601	131	98.6	642	134	98.7	684	137	98.8	728	140	98.8	773	143	98.9	815	146	99.0



KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

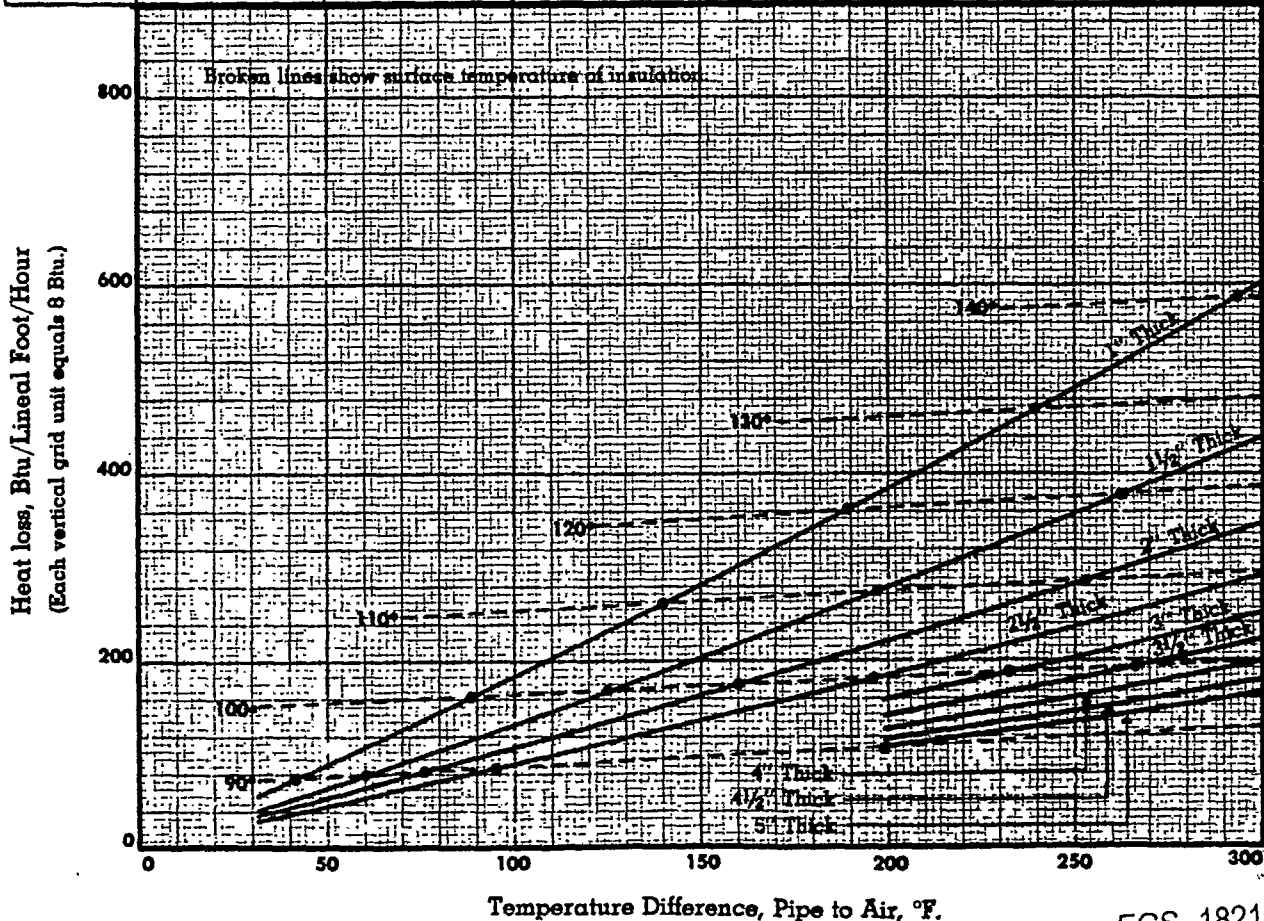
20-Inch Pipe

OWENS ILLINOIS
 GLASS COMPANY

KAYLO
 HEAT INSULATING
 PRODUCTS

Ambient still air 80°F.

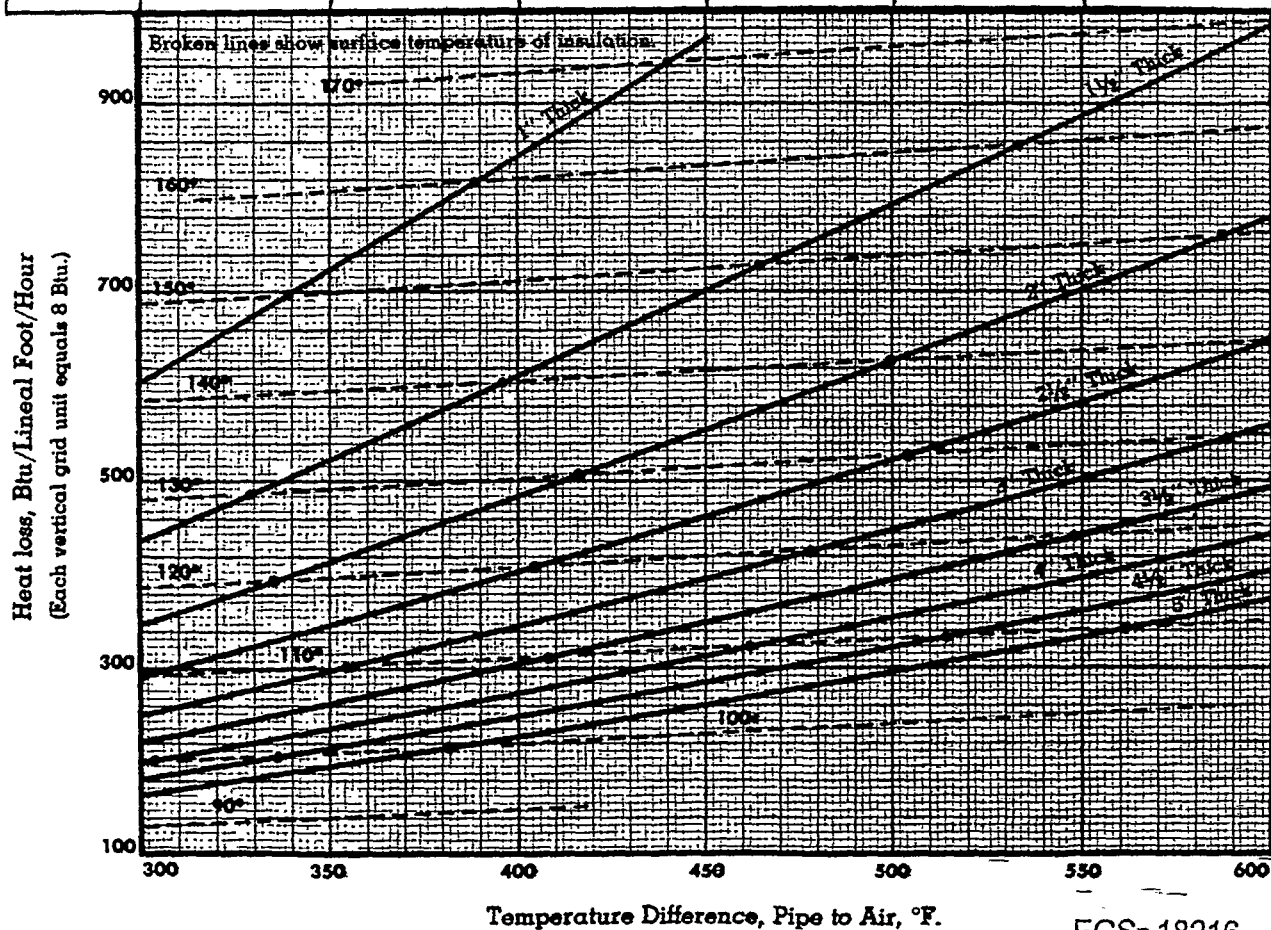
Pipe Temp. °F.	130°			180°			230°			280°			330°			380°		
Temp. Diff. Pipe to Air °F.	50°			100°			150°			200°			250°			300°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	440	130		1022	180		1736	230		2592	280		3606	330		4797	380	
1	86.8	91	80.3	182	102	82.2	280	112	83.9	383	122	85.2	489	132	86.4	604	142	87.4
1½	64.7	88	85.3	133	96	87.0	205	103	88.2	279	111	89.2	357	118	90.0	438	126	90.9
2	51.6	86	88.3	106	93	89.6	163	99	90.6	222	104	91.4	283	110	92.2	348	116	92.7
2½	43.3	85	90.2	88.6	90	91.3	136	95	92.2	186	100	92.8	237	108	93.4	290	110	93.9
3										160	97	93.8	204	101	94.3	250	105	94.8
3½										142	95	94.5	181	98	95.0	222	102	95.4
4										128	93	95.1	162	96	95.5	198	99	95.9
4½										116	92	95.5	148	94	95.9	181	97	96.2
5										107	90	95.9	136	93	96.2	168	96	96.5



KAYLO PIPE INSULATION **Heat Loss — Surface Temperature — Efficiency** **20-Inch Pipe**

Ambient still air 80°F.

Pipe Temp. °F.	430°			480°			530°			580°			630°			680°		
Temp. Diff. Pipe to Air °F.	350°			400°			450°			500°			550°			600°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	6187	430		7800	480		9664	530		11806	580		14243	630		17009	680	
1	719	152	88.4	845	162	89.2	968	170	90.0	1095	181	90.7						
1½	521	133	91.6	608	141	92.2	697	148	92.8	790	155	93.3	885	163	93.8	983	170	94.2
2	412	122	93.3	481	128	93.8	551	134	94.3	625	140	94.7	699	146	95.1	779	152	95.4
2½	344	115	94.4	401	120	94.9	461	125	95.2	520	130	95.6	585	135	95.9	646	140	96.2
3	298	110	95.2	346	114	95.6	397	118	95.9	448	122	96.2	504	127	96.5	556	131	96.7
3½	264	106	95.7	305	109	96.1	349	113	96.4	396	117	96.6	443	121	96.9	494	125	97.1
4	236	103	96.2	274	106	96.5	314	109	96.8	355	113	97.0	398	116	97.2	442	119	97.4
4½	214	100	96.6	250	103	96.8	286	106	97.0	324	109	97.3	362	112	97.5	402	115	97.6
5	198	98	96.8	230	101	97.1	264	104	97.3	299	106	97.5	334	109	97.7	370	112	97.8



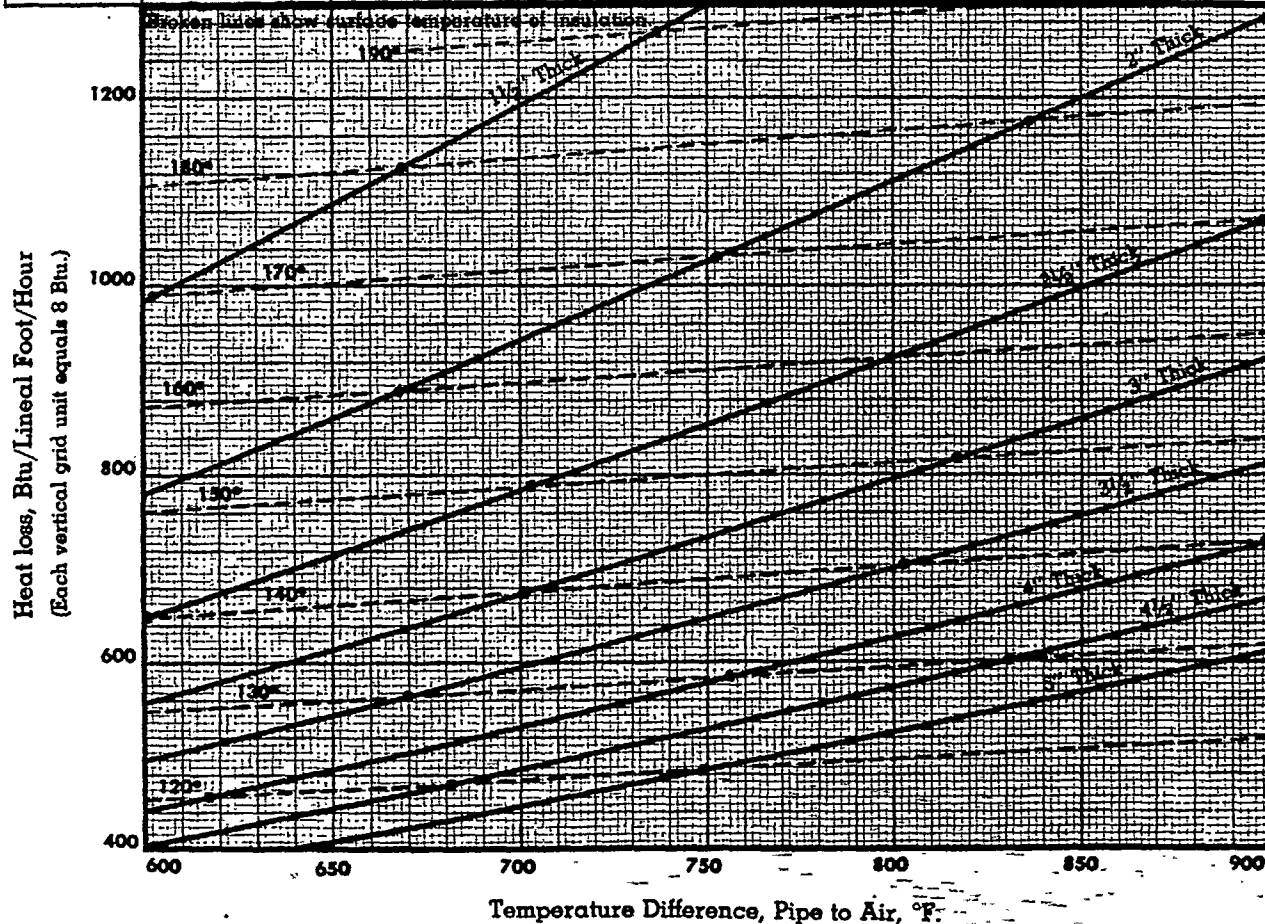
KAYLO PIPE INSULATION **Heat Loss — Surface Temperature — Efficiency** **20-Inch Pipe**

OWENS-ILLINOIS
 GLASS COMPANY

KAYLO
 HEAT INSULATING
 PRODUCTS

Ambient still air 80°F.

Pipe Temp. °F.	730°			780°			830°			880°			930°			980°		
Temp. Diff. Pipe to Air °F.	650°			700°			750°			800°			850°			900°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	20097	730		23554	780		27429	830		31742	880		36536	930		41848	980	
1																		
1½	1083	177	94.6	1191	184	94.9	1295	192	95.3									
2	854	158	95.7	938	164	96.0	1020	170	96.3	1110	176	96.5	1193	182	96.7	1289	188	96.9
2½	714	145	96.4	780	150	96.7	853	155	96.9	921	160	97.1	998	165	97.3	1070	170	97.4
3	610	135	97.0	672	140	97.1	730	144	97.3	794	149	97.5	855	153	97.7	923	158	97.8
3½	543	128	97.3	593	132	97.5	645	136	97.6	700	140	97.8	755	144	97.9	812	148	98.1
4	486	123	97.6	532	126	97.7	579	130	97.9	629	133	98.0	679	137	98.1	729	140	98.3
4½	443	118	97.8	485	122	97.9	528	125	98.1	578	128	98.2	617	131	98.3	664	134	98.4
5	408	115	98.0	447	118	98.1	485	120	98.2	526	123	98.3	568	126	98.4	610	129	98.5



EGS 18217

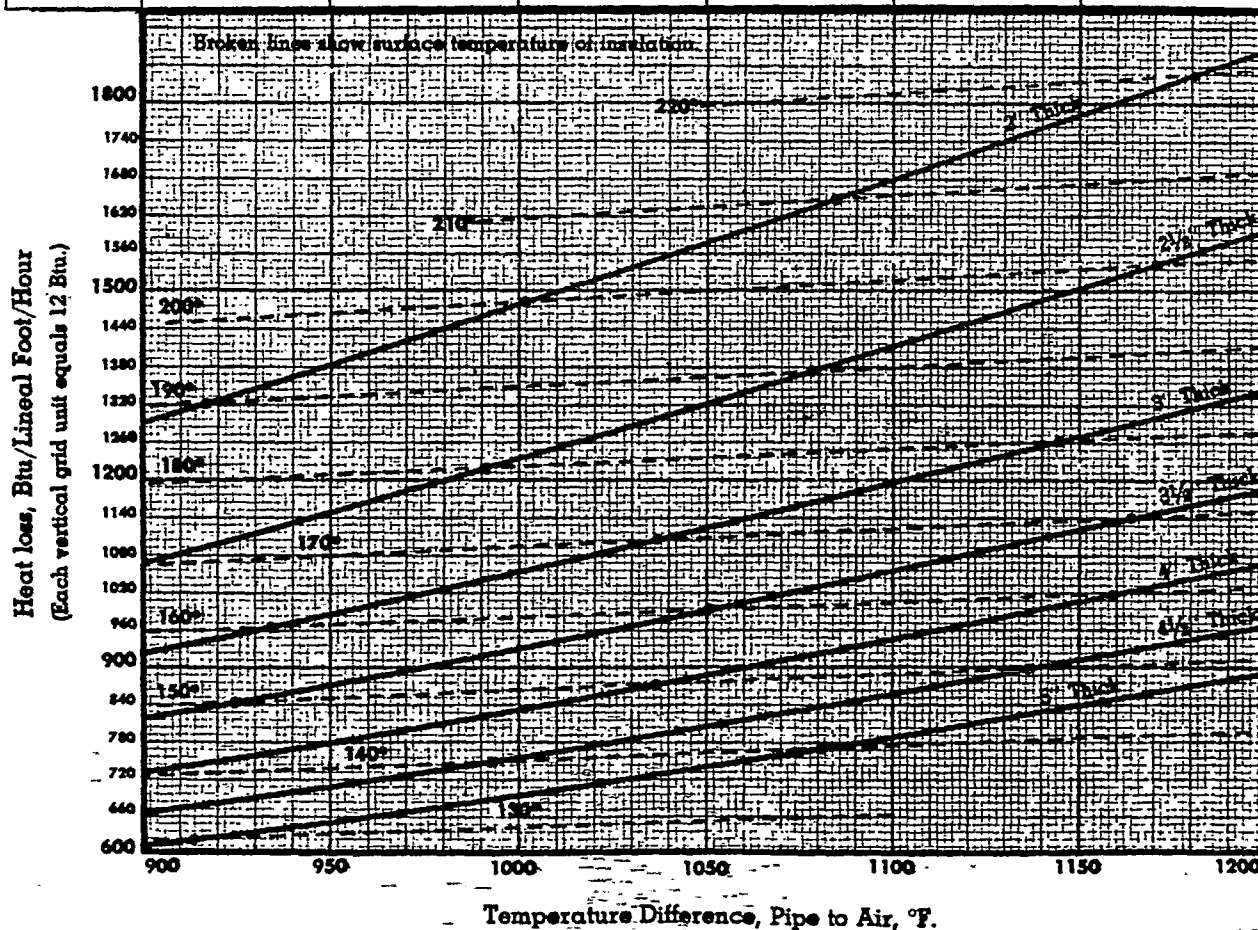
KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

20-Inch Pipe

Ambient still air 80°F.

Pipe Temp. °F.	1030°			1080°			1130°			1180°			1230°			1280°		
Temp. Diff. Pipe to Air °F.	950°			1000°			1050°			1100°			1150°			1200°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	47711	1030		54161	1080		61241	1130		69003	1180		77477	1230		86704	1280	
1																		
1½	1379	194	97.1	1480	200	97.3	1571	206	97.4	1675	212	97.6	1775	218	97.7	1879	224	97.8
2	1148	175	97.6	1225	181	97.7	1310	186	97.9	1389	191	97.9	1474	196	98.1	1594	201	98.2
2½	985	162	97.9	1053	167	98.1	1123	171	98.2	1198	176	98.3	1268	180	98.4	1340	185	98.5
3	870	152	98.2	929	156	98.3	990	160	98.4	1052	164	98.5	1116	168	98.6	1181	172	98.6
3½	783	144	98.4	835	147	98.5	890	151	98.5	946	155	98.6	1003	159	98.7	1060	162	98.8
4	712	138	98.5	760	141	98.6	810	144	98.7	861	147	98.7	914	151	98.8	965	154	98.9
4½	655	132	98.6	699	135	98.7	745	138	98.8	792	141	98.8	840	144	98.9	888	147	99.0
5																		



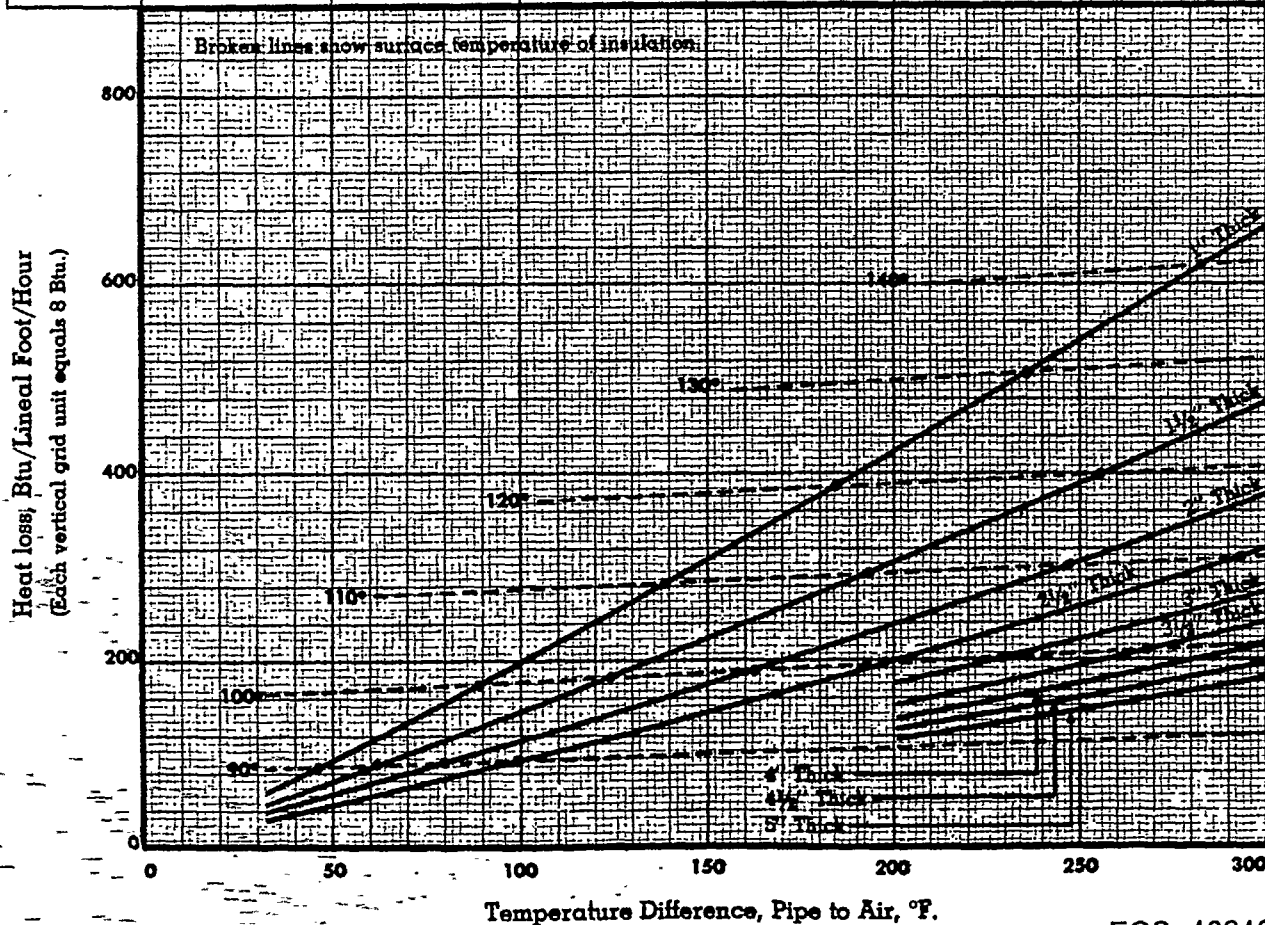
KAYLO PIPE INSULATION **Heat Loss — Surface Temperature — Efficiency** **22-Inch Pipe**

OWENS-ILLINOIS
 GLASS COMPANY

KAYLO
 HEAT INSULATING
 PRODUCTS

Ambient still air 80°F.

Pipe Temp. °F.	130°			180°			230°			280°			330°			380°		
Temp. Diff. Pipe to Air °F.	50°			100°			150°			200°			250°			300°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	481	130		1117	180		1898	230		2835	280		3943	330		5250	380	
1	95.4	92	80.2	198	102	82.3	306	112	83.9	419	123	85.2	536	132	86.4	661	143	87.4
1½	70.7	88	85.3	145	96	87.0	224	104	88.2	305	111	89.2	389	119	90.1	478	126	90.9
2	56.3	86	88.3	116	93	89.6	178	99	90.6	242	105	91.5	308	110	92.2	378	117	92.8
2½	47.2	85	90.2	96.5	90	91.4	148	95	92.2	202	100	92.9	258	105	93.5	315	110	94.0
3										174	97	93.9	222	101	94.4	272	106	94.8
3½										154	95	94.6	196	99	95.0	240	102	95.4
4										138	93	95.1	176	96	95.5	215	100	95.9
4½										126	92	95.6	160	95	95.9	196	98	96.3
5										116	91	95.9	147	93	96.3	181	96	96.5



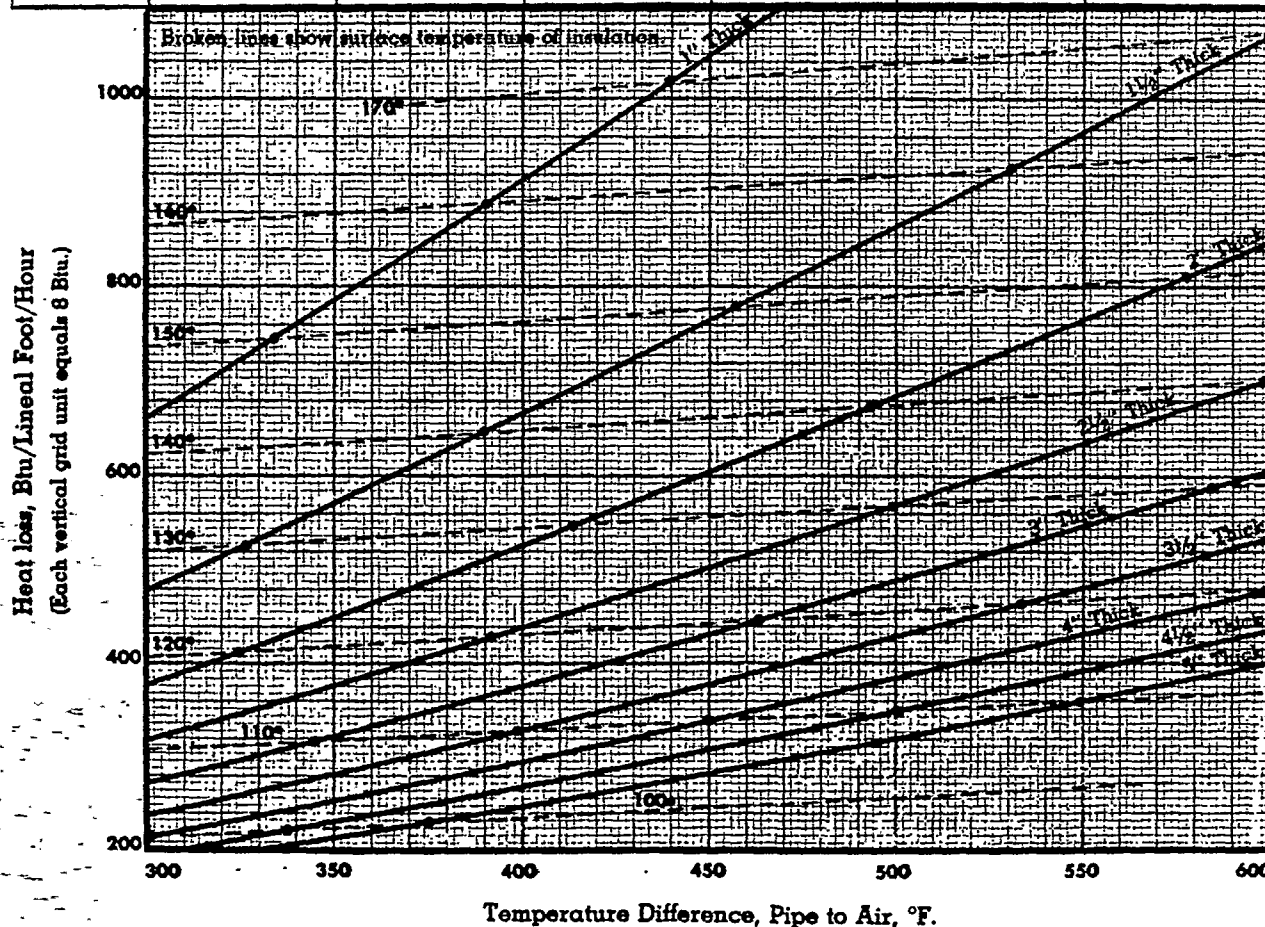
KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

22-Inch Pipe

Ambient still air 80°F.

Pipe Temp. °F.	430°			480°			530°			580°			630°			680°		
Temp. Diff. Pipe to Air °F.	350°			400°			450°			500°			550°			600°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	6773	430		8539	480		10584	530		12935	580		15606	630		18642	680	
1	786	153	88.4	924	162	89.2	1043	171	90.1	1196	182	90.7						
1½	570	134	91.6	664	141	92.2	761	148	92.8	862	156	93.3	965	163	93.8	1073	171	94.2
2	450	123	93.4	525	129	93.9	601	134	94.3	682	141	94.7	761	146	95.1	849	153	95.4
2½																		
3	375	115	94.5	436	120	94.9	501	125	95.3	566	130	95.6	635	135	95.9	703	140	96.2
3½	324	110	95.2	378	114	95.6	434	119	95.9	487	123	96.2	548	127	96.5	606	132	96.7
4	285	106	95.8	332	110	96.1	381	114	96.4	430	117	96.7	481	121	96.9	533	125	97.1
4½																		
5	256	103	96.2	298	106	96.5	341	110	96.8	386	113	97.0	431	116	97.2	479	120	97.4
	232	100	96.6	270	103	96.8	310	107	97.1	351	110	97.3	392	113	97.5	435	116	97.7
	214	99	96.8	249	101	97.1	286	104	97.3	323	107	97.5	361	110	97.7	401	112	97.8



KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

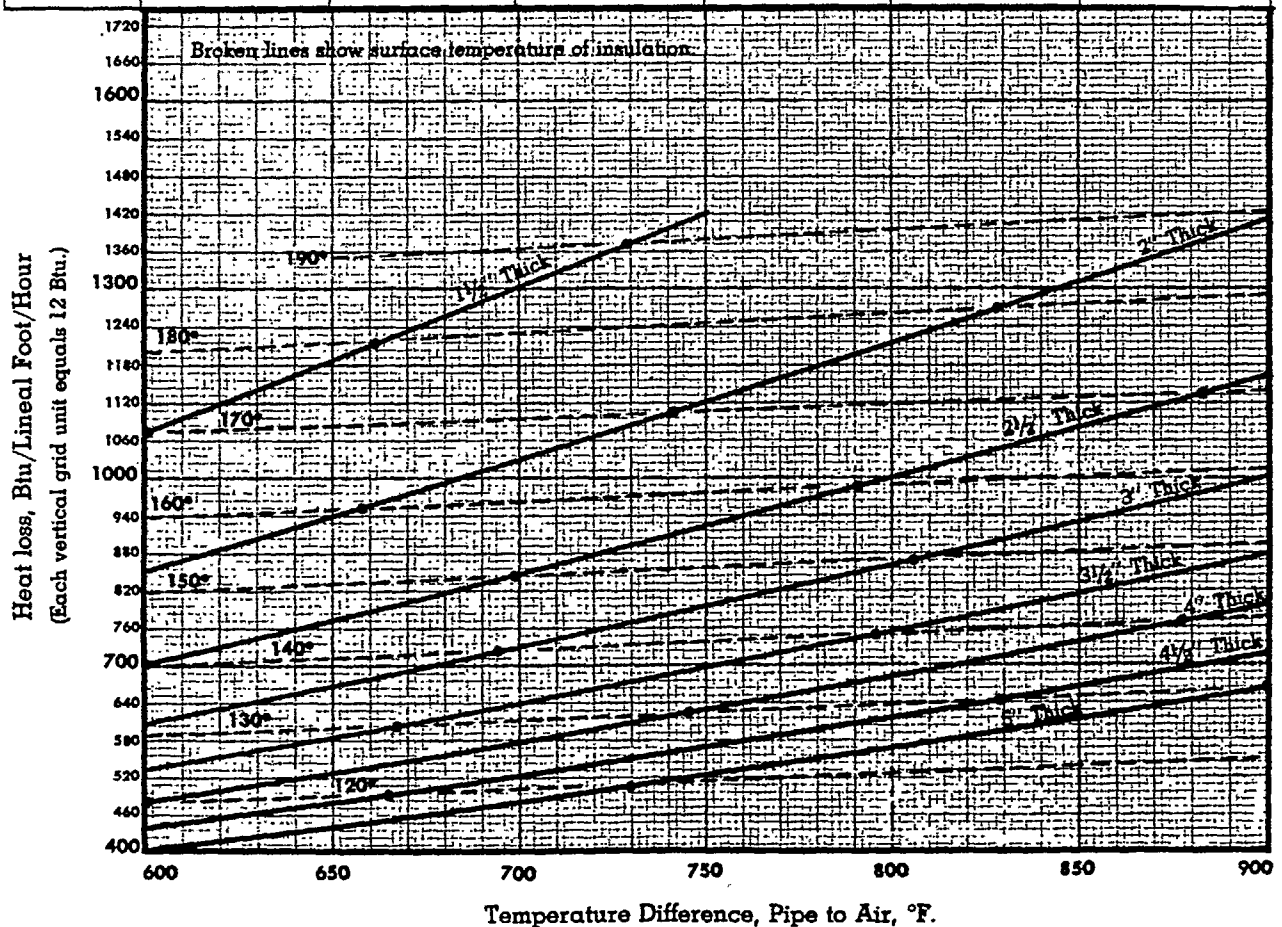
22-Inch Pipe

OWENS-ILLINOIS
GLASS COMPANY

KAYLO
HEAT INSULATING
PRODUCTS

Ambient still air 80°F.

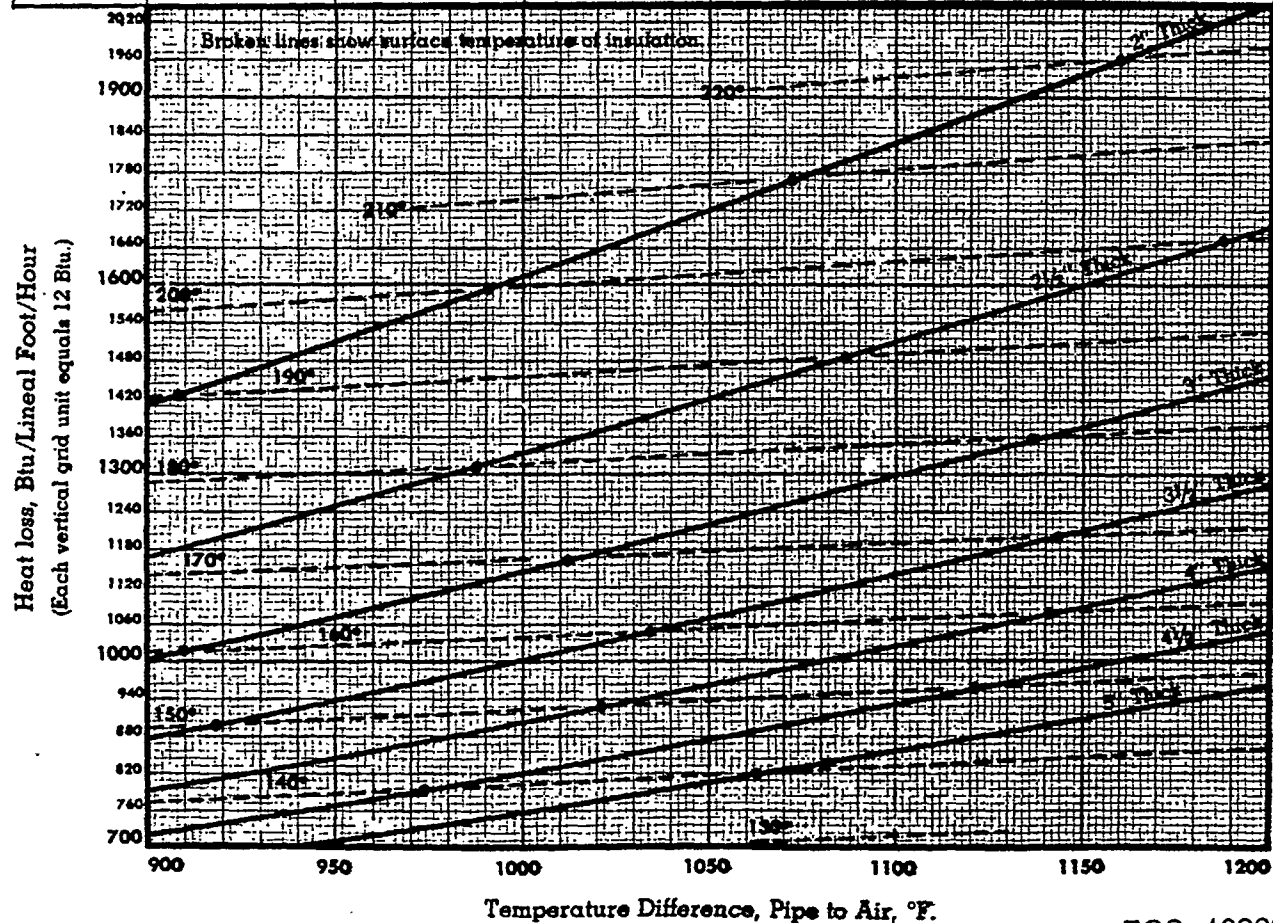
Pipe Temp. °F.	730°			780°			830°			880°			930°			980°		
Temp. Diff. Pipe to Air °F.	650°			700°			750°			800°			850°			900°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	22033	730		25829	780		30079	830		34817	880		40077	930		45917	980	
1	1184	178	94.6	1299	185	95.0	1415	193	95.3									
1½	933	158	95.8	1022	164	96.1	1112	170	96.3	1211	177	96.5	1302	182	96.7	1409	189	96.9
2																		
2½	776	146	96.5	849	151	96.7	929	156	96.9	1002	161	97.1	1087	166	97.3	1164	171	97.5
3	670	136	97.0	730	140	97.2	797	145	97.3	862	149	97.5	930	154	97.7	1002	159	97.8
3½	587	129	97.3	643	133	97.5	700	137	97.7	760	141	97.8	820	145	97.9	882	149	98.1
4	526	123	97.6	578	127	97.8	628	130	97.9	680	134	98.0	735	138	98.2	792	141	98.3
4½	480	119	97.8	525	122	98.0	572	125	98.1	620	128	98.2	669	132	98.3	719	135	98.4
5	441	115	98.0	483	118	98.1	526	121	98.2	570	124	98.4	615	127	98.5	662	130	98.6



KAYLO PIPE INSULATION **Heat Loss — Surface Temperature — Efficiency** **22-Inch Pipe**

Ambient still air 80°F.

Pipe Temp. °F.	1030°			1080°			1130°			1180°			1230°			1280°		
Temp. Diff. Pipe to Air °F.	950°			1000°			1050°			1100°			1150°			1200°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	52353	1030		59439	1080		67224	1130		75746	1180		85051	1230		95196	1280	
1																		
1½	1503	195	97.1	1615	201	97.3	1712	207	97.4	1828	213	97.6	1935	219	97.7	2048	225	97.8
2	1252	177	97.6	1334	182	97.8	1428	187	97.9	1514	192	98.0	1608	197	98.1	1697	203	98.2
2½	1072	163	97.9	1146	168	98.1	1222	172	98.2	1300	177	98.3	1378	181	98.4	1457	186	98.5
3	945	153	98.2	1010	157	98.3	1076	161	98.4	1142	165	98.5	1211	169	98.6	1281	173	98.7
3½																		
4	847	145	98.4	905	149	98.5	965	152	98.6	1025	156	98.6	1085	159	98.7	1150	163	98.8
4½	771	138	98.5	822	142	98.6	877	145	98.7	933	148	98.8	990	152	98.8	1045	155	98.9
5	709	133	98.6	756	136	98.7	807	139	98.8	858	142	98.9	910	145	98.9	960	148	99.0



KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

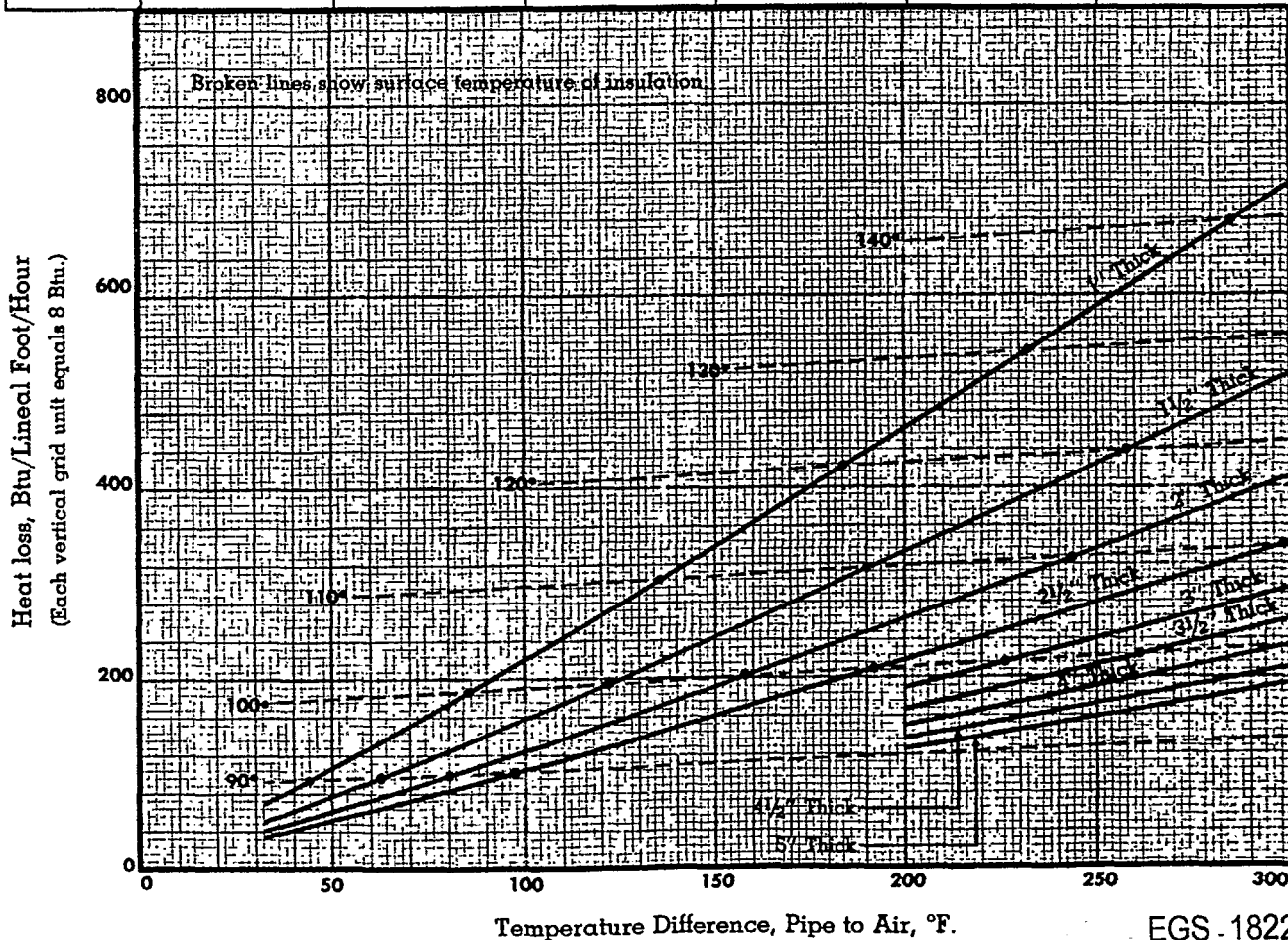
24-Inch Pipe

OWENS-ILLINOIS
 GLASS COMPANY

KAYLO
 HEAT INSULATING
 PRODUCTS

Ambient still air 80°F.

Pipe Temp. °F.	130°			180°			230°			280°			330°			380°		
Temp. Diff. Pipe to Air °F.	50°			100°			150°			200°			250°			300°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	522	130		1213	180		2060	230		3078	280		4285	330		5706	380	
1	105	92	79.9	215	103	82.3	335	113	83.7	455	123	85.2	582	133	86.4	718	143	87.4
1½	76.6	88	85.3	158	96	87.0	243	104	88.2	331	111	89.2	423	119	90.1	519	127	90.9
2	61.0	87	88.3	125	93	89.7	192	99	90.7	262	105	91.5	334	111	92.2	410	117	92.8
2½	51.0	85	90.2	104	90	91.4	160	95	92.2	218	100	92.9	278	105	93.5	341	110	94.0
3										188	97	93.9	240	102	94.4	294	106	94.8
3½										166	95	94.6	212	99	95.0	259	103	95.5
4										149	93	95.2	189	97	95.6	231	100	96.0
4½										136	92	95.6	172	95	96.0	211	98	96.3
5										125	91	95.9	158	93	96.3	194	96	96.6



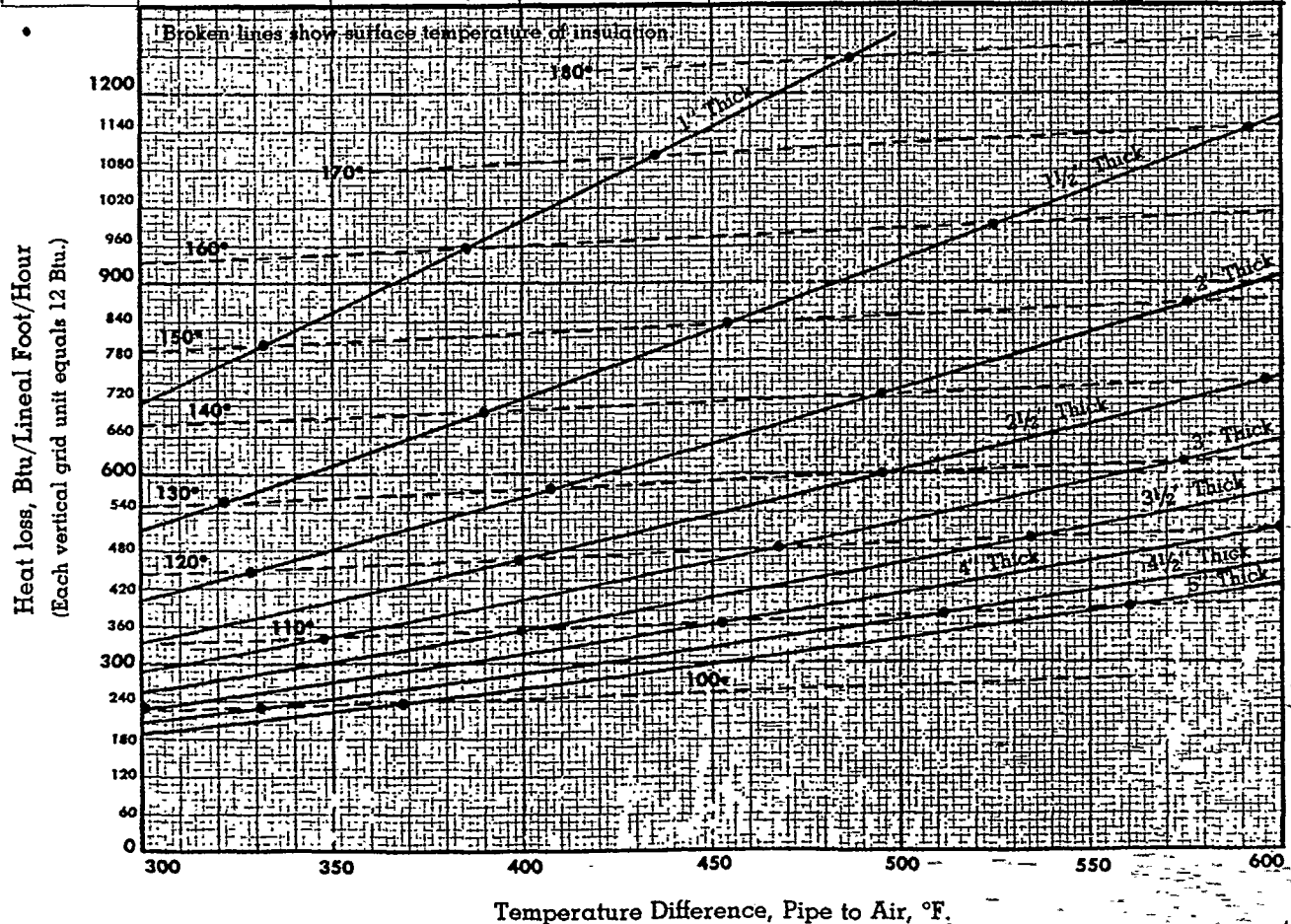
KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

24-Inch Pipe

Ambient still air 80°F.

Pipe Temp. °F.	430°			480°			530°			580°			630°			680°		
Temp. Diff. Pipe to Air °F.	350°			400°			450°			500°			550°			600°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	7362	430		9286	480		11513	530		14071	580		16982	630		20291	680	
1	855	153	88.4	1002	163	89.2	1133	172	90.2	1304	182	90.7						
1½	618	134	91.6	721	141	92.2	826	149	92.8	935	156	93.4	1050	164	93.8	1165	171	94.3
2	488	123	93.4	569	129	93.9	651	135	94.3	739	141	94.7	825	147	95.1	917	153	95.5
2½	405	116	94.5	472	121	94.9	540	126	95.3	610	131	95.7	685	136	96.0	759	141	96.3
3	350	110	95.2	407	115	95.6	466	119	96.0	526	123	96.3	590	128	96.5	654	132	96.8
3½	308	106	95.8	358	110	96.1	410	114	96.4	464	118	96.7	520	122	96.9	576	126	97.2
4	275	103	96.3	320	107	96.6	366	110	96.8	415	113	97.0	464	117	97.3	517	120	97.5
4½	250	101	96.6	292	104	96.9	334	107	97.1	378	110	97.3	422	113	97.5	469	116	97.7
5	230	99	96.9	268	102	97.1	307	104	97.3	347	107	97.5	388	110	97.7	431	113	97.8



KAYLO PIPE INSULATION

Heat Loss — Surface Temperature — Efficiency

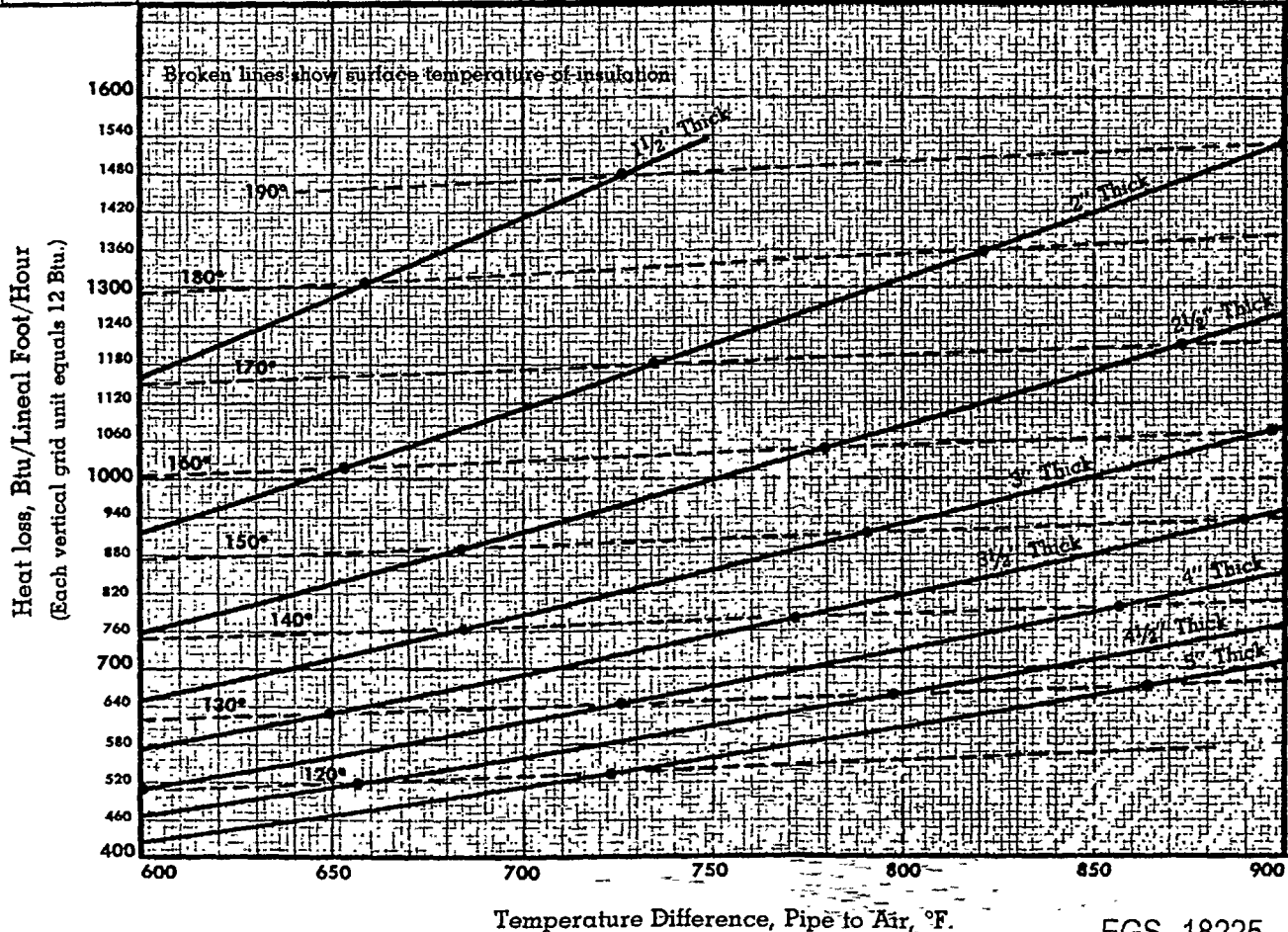
24-Inch Pipe

OWENS-ILLINOIS
 GLASS COMPANY

KAYLO
 HEAT INSULATING
 PRODUCTS

Ambient still air 80°F.

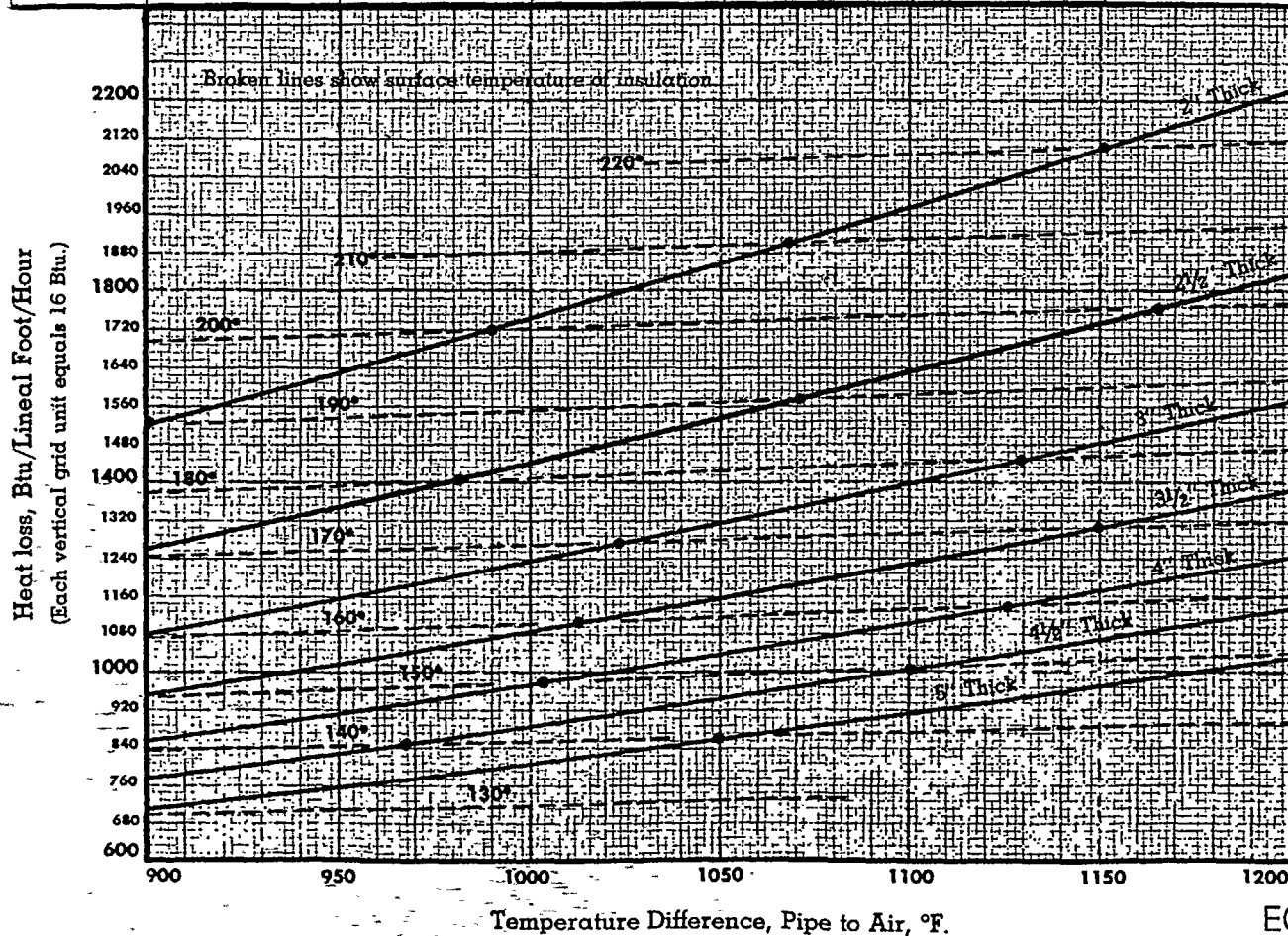
Pipe Temp. °F.	730°			780°			830°			880°			930°			980°		
Temp. Diff. Pipe to Air °F.	650°			700°			750°			800°			850°			900°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	23984	730		28122	780		32756	830		37917	880		43658	930		50023	980	
1																		
1½	1287	179	94.6	1411	186	95.0	1540	194	95.3									
2	1011	159	95.8	1107	165	96.1	1203	171	96.3	1311	177	96.5	1410	183	96.8	1525	190	97.0
2½	840	146	96.5	918	151	96.7	1001	156	96.9	1082	162	97.1	1171	167	97.3	1257	172	97.5
3	721	136	97.0	789	141	97.2	859	145	97.4	930	150	97.5	1001	155	97.7	1081	159	97.8
3½	634	130	97.4	694	133	97.5	755	138	97.7	819	141	97.8	885	146	98.0	951	150	98.1
4	568	124	97.6	620	127	97.8	676	131	97.9	734	135	98.1	792	138	98.2	852	142	98.3
4½	517	119	97.8	565	123	98.0	615	126	98.1	666	129	98.2	720	132	98.4	774	136	98.5
5	475	116	98.0	520	119	98.2	565	122	98.3	613	125	98.4	662	128	98.5	711	131	98.6



KAYLO PIPE INSULATION Heat Loss — Surface Temperature — Efficiency 24-Inch Pipe

Ambient still air 80°F.

Pipe Temp. °F.	1030°			1080°			1130°			1180°			1230°			1280°		
Temp. Diff. Pipe to Air °F.	950°			1000°			1050°			1100°			1150°			1200°		
Thickness KAYLO Insul. Inches	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %	Heat Loss Btu. per Lin. Ft.	Surf. Temp. °F.	Eff. %
Bare	57042	1030		64771	1080		73263	1130		82564	1180		92722	1230		103784	1280	
1																		
1½																		
2	1628	196	97.2	1745	202	97.3	1858	208	97.5	1979	214	97.6	2097	220	97.7	2219	226	97.9
2½	1350	177	97.6	1442	182	97.8	1539	188	97.9	1632	193	98.0	1737	198	98.1	1835	204	98.2
3	1156	164	98.0	1237	168	98.1	1319	173	98.2	1402	178	98.3	1484	182	98.4	1573	187	98.5
3½	1019	154	98.2	1089	158	98.3	1159	162	98.4	1232	166	98.5	1306	170	98.6	1383	174	98.7
4	915	146	98.4	976	149	98.5	1037	153	98.6	1105	157	98.7	1170	161	98.7	1240	164	98.8
4½	830	139	98.5	885	142	98.6	944	146	98.7	1004	149	98.8	1064	153	98.9	1127	156	98.9
5	762	134	98.7	813	137	98.7	866	140	98.8	922	143	98.9	978	146	98.9	1032	149	99.0



AREAS OF FLANGED FITTINGS*



TABLE I. Areas Expressed in Equivalent Lineal Feet of Pipe.

Pipe Size in Inches	FLANGED COUPLING		90° ELL		LONG RADIUS ELL		TEE		CROSS	
	Equivalent Lineal Feet		Equivalent Lineal Feet		Equivalent Lineal Feet		Equivalent Lineal Feet		Equivalent Lineal Feet	
	125#	250#	125#	250#	125#	250#	125#	250#	125#	250#
1"	.93	1.27	2.31	2.95	2.59	3.15	3.59	4.58	4.72	6.02
1 1/4"	.88	1.17	2.20	2.52	2.49	3.08	3.40	4.43	4.47	5.82
1 1/2"	.95	1.46	2.35	2.67	2.68	3.76	3.64	5.38	4.78	7.11
2"	1.08	1.36	2.65	3.23	2.96	3.47	4.08	4.97	5.34	6.53
2 1/2"	1.12	1.46	2.78	3.41	3.08	3.67	4.26	5.38	5.56	6.87
3"	1.03	1.62	2.60	3.81	2.93	4.08	3.99	5.82	5.70	7.58
3 1/2"	1.07	1.57	2.85	3.78	3.13	4.09	4.28	5.77	5.56	7.54
4"	1.14	1.62	2.90	3.94	3.36	4.24	4.59	6.00	5.97	7.84
4 1/2"	1.13	1.56	3.01	3.83	3.38	4.17	4.63	5.90	6.01	7.69
5"	1.11	1.50	3.05	3.76	3.43	4.13	4.67	5.85	6.06	7.53
6"	1.05	1.60	2.95	4.03	3.45	4.48	4.53	6.14	5.81	7.93
7"	1.05	1.73	3.09	4.32	3.70	4.87	4.60	6.18	6.01	8.43
8"	1.07	1.67	3.09	4.32	3.79	4.91	4.67	6.53	5.96	8.41
9"	1.19	1.76	3.46	4.54	4.20	5.23	5.23	6.84	6.66	8.77
10"	1.22	1.85	3.61	4.82	4.38	5.54	5.47	7.25	6.95	9.32
12"	1.32	2.01	3.92	5.31	4.90	5.62	5.89	7.99	7.45	10.22
14"	1.47	2.26	4.47	6.08	5.47	7.02	6.78	9.18	8.60	11.75
16"	1.60	2.40	4.82	6.48	6.07	7.58	7.23	9.78	9.15	12.50

TABLE II. Areas Expressed in Square Feet.

Pipe Size in Inches	FLANGED COUPLING		90° ELL		LONG RADIUS ELL		TEE		CROSS	
	Square Feet		Square Feet		Square Feet		Square Feet		Square Feet	
	125#	250#	125#	250#	125#	250#	125#	250#	125#	250#
1"	.32	.44	.79	1.02	.89	1.08	1.24	1.58	1.62	2.07
1 1/4"	.38	.51	.96	1.10	1.08	1.34	1.48	1.93	1.94	2.53
1 1/2"	.48	.73	1.17	1.33	1.34	1.87	1.82	2.68	2.38	3.54
2"	.67	.85	1.65	2.01	1.84	2.16	2.54	3.09	3.32	4.06
2 1/2"	.84	1.11	2.09	2.57	2.32	2.76	3.21	4.05	4.19	5.17
3"	.95	1.48	2.38	3.49	2.68	3.74	3.66	5.33	4.77	6.95
3 1/2"	1.12	1.64	2.98	3.96	3.28	4.28	4.48	6.04	5.83	7.89
4"	1.34	1.91	3.53	4.64	3.96	4.99	5.41	7.07	7.03	9.24
4 1/2"	1.47	2.04	3.95	5.02	4.43	5.46	6.07	7.72	7.87	10.07
5"	1.62	2.18	4.44	5.47	5.00	6.02	6.81	8.52	8.82	10.97
6"	1.82	2.78	5.13	6.99	5.99	7.76	7.84	10.64	10.08	13.75
7"	2.17	3.46	6.17	8.62	7.38	9.73	9.37	12.33	12.00	16.83
8"	2.41	3.77	6.98	9.76	8.56	11.09	10.55	14.74	13.44	18.97
9"	3.00	4.44	8.71	11.44	10.57	13.17	13.18	17.23	16.78	22.10
10"	3.43	5.20	10.18	13.58	12.35	15.60	15.41	20.41	19.58	26.26
12"	4.41	6.71	13.08	17.73	16.35	18.76	19.67	26.65	24.87	34.11
14"	5.39	8.30	16.38	22.31	20.17	25.70	24.81	33.63	31.48	43.15
16"	6.69	10.05	20.17	27.18	25.41	31.73	30.32	40.94	38.34	52.35

*Values shown are for cast iron fittings.
125# cast iron fittings equal 150# steel fittings.
250# cast iron fittings equal 300# steel fittings.

PROPERTIES OF SATURATED STEAM



Absolute Pressure (Lbs./Sq. In.)	Temp. °F	Specific Volume of Sat. Vapor (Cu. Ft./Lb.)	Total Heat Content of Sat. Vapor (Btu/Lb.)	Total Latent Heat of Vaporization (Btu/Lb.)	Absolute Pressure (Lbs./Sq. In.)	Temp. °F	Specific Volume of Sat. Vapor (Cu. Ft./Lb.)	Total Heat Content of Sat. Vapor (Btu/Lb.)	Total Latent Heat of Vaporization (Btu/Lb.)
<i>p</i>	<i>t sat.</i>	<i>v sat.</i>	<i>h sat.</i>	<i>r</i>	<i>p</i>	<i>t sat.</i>	<i>v sat.</i>	<i>h sat.</i>	<i>r</i>
1	101.8	333.9	1105.0	1035.3	102	329.3	4.344	1186.9	887.1
2	126.1	173.96	1115.6	1021.6	104	330.7	4.265	1187.3	886.0
3	141.5	118.86	1122.0	1012.7	106	332.1	4.189	1187.6	884.9
4	153.0	90.74	1126.8	1005.9	108	333.4	4.115	1188.0	883.8
5	162.2	73.61	1130.6	1000.4	110	334.8	4.044	1188.3	882.7
6	170.1	62.05	1133.7	995.8	115	338.1	3.878	1189.1	880.0
7	176.8	53.70	1136.4	991.7	120	341.3	3.725	1189.8	877.4
8	182.9	47.39	1138.9	988.1	125	344.3	3.587	1190.5	874.9
9	188.3	42.44	1141.0	984.8	130	347.3	3.451	1191.2	872.4
10	193.2	38.45	1143.0	981.8	135	350.2	3.329	1191.8	870.0
11	197.7	35.17	1144.8	979.1	140	353.0	3.216	1192.4	867.7
12	202.0	32.42	1146.4	976.5	145	355.8	3.110	1193.0	865.3
13	205.9	30.08	1147.9	974.1	150	358.4	3.010	1193.5	863.1
14	209.6	28.06	1149.3	971.8	155	361.0	2.917	1194.0	860.8
14.696	212.0	26.82	1150.2	970.2	160	363.5	2.830	1194.5	858.7
15	213.0	26.31	1150.6	969.6	165	366.0	2.748	1195.0	856.5
16	216.3	24.76	1151.8	967.4	170	368.4	2.671	1195.4	854.4
17	219.4	23.40	1152.9	965.4	175	370.8	2.598	1195.9	852.3
18	222.4	22.18	1154.0	963.5	180	373.1	2.529	1196.3	850.3
19	225.2	21.08	1155.0	961.7	185	375.3	2.463	1196.7	848.2
20	228.0	20.095	1156.0	959.9	190	377.5	2.401	1197.0	846.3
21	230.6	19.197	1156.9	958.2	195	379.7	2.342	1197.4	844.3
22	233.1	18.380	1157.8	956.6	200	381.8	2.285	1197.8	842.4
23	235.5	17.630	1158.6	955.0	210	385.9	2.180	1198.4	838.6
24	237.8	16.941	1159.5	953.4	220	389.9	2.084	1199.0	835.0
25	240.1	16.306	1160.2	951.9	230	393.7	1.9964	1199.6	831.4
26	242.2	15.718	1161.0	950.4	240	397.4	1.9156	1200.1	827.9
27	244.4	15.172	1161.7	949.0	250	401.0	1.8410	1200.5	824.5
28	246.4	14.664	1162.4	947.7	260	404.4	1.7723	1201.0	821.2
29	248.4	14.190	1163.1	946.3	270	407.8	1.7083	1201.4	818.0
30	250.3	13.745	1163.7	945.0	280	411.1	1.6490	1201.8	814.7
32	254.0	12.940	1165.0	942.5	290	414.2	1.5934	1202.1	811.6
34	257.6	12.226	1166.1	940.0	300	417.3	1.5414	1202.4	808.5
36	260.9	11.587	1167.2	937.7	320	423.3	1.4469	1203.0	802.5
38	264.2	11.015	1168.3	935.5	340	429.0	1.3630	1203.4	796.6
40	267.2	10.497	1169.2	933.3	350	431.7	1.3245	1203.6	793.7
42	270.2	10.027	1170.2	931.2	360	434.4	1.2881	1203.7	790.9
44	273.1	9.599	1171.1	929.2	380	439.6	1.2208	1203.9	785.3
46	275.8	9.207	1171.9	927.2	400	444.6	1.1601	1204.1	779.8
48	278.4	8.846	1172.7	925.4	420	449.4	1.1047	1204.1	774.5
50	281.0	8.514	1173.5	923.5	440	454.0	1.0540	1204.1	769.3
52	283.5	8.206	1174.3	921.7	450	456.3	1.0303	1204.1	766.7
54	285.9	7.919	1175.0	920.0	460	458.5	1.0077	1204.0	764.1
56	288.2	7.653	1175.7	918.3	480	462.8	0.9653	1203.9	759.0
58	290.5	7.405	1176.4	916.6	500	467.0	0.9261	1203.7	754.0
60	292.7	7.172	1177.0	915.0	550	476.9	0.8405	1203.1	741.7
62	294.8	6.955	1177.6	913.4	600	486.2	0.7677	1202.1	729.8
64	296.9	6.749	1178.2	911.9	700	503.0	0.6527	1199.7	706.8
66	299.0	6.556	1178.8	910.4	800	518.2	0.5653	1196.7	684.9
68	301.0	6.375	1179.4	908.9	900	531.9	0.4969	1193.3	663.8
70	302.9	6.203	1179.9	907.4	1000	544.6	0.4419	1189.6	643.5
72	304.8	6.041	1180.5	906.0	1100	556.3	0.3960	1185.6	623.9
74	306.7	5.887	1181.0	904.6	1200	567.1	0.3582	1181.4	604.9
76	308.5	5.741	1181.5	903.2	1300	577.3	0.3259	1177.0	586.3
78	310.3	5.602	1182.0	901.9	1400	587.0	0.2983	1172.4	568.1
80	312.0	5.470	1182.4	900.5	1500	596.1	0.2741	1167.6	550.2
82	313.7	5.343	1182.9	899.2	1600	604.7	0.2528	1162.7	532.6
84	315.4	5.222	1183.4	897.9	1800	620.9	0.2167	1151.8	497.2
86	317.1	5.107	1183.8	896.7	2000	635.6	0.1875	1139.0	460.0
88	318.7	4.997	1184.2	895.4	2200	649.2	0.1623	1123.8	420.0
90	320.3	4.892	1184.6	894.2	2400	661.9	0.1404	1105.8	376.4
92	321.8	4.791	1185.0	893.0	2600	673.8	0.1205	1084.5	327.8
94	323.4	4.694	1185.4	891.8	2800	684.9	0.1021	1058.9	272.3
96	324.9	4.602	1185.8	890.6	3000	695.2	0.0844	1025.6	202.5
98	326.4	4.512	1186.2	889.4	3200	704.9	0.0601	962.9	75.9
100	327.8	4.426	1186.6	888.2	3226*	706.1	0.0522	925.0	0.0

*The last line gives the critical values.

PROPERTIES OF SUPERHEATED STEAM

v = Volume of Superheated Vapor, Cu. Ft./Lb.
 h = Total Heat Content of Superheated Vapor, Btu/Lb.

Abs. Press. Lbs./ Sq. In. (Sat. Temp.)	Sat. Water	Sat. Steam	Temperature—Degrees Fahrenheit									
			350°	400°	450°	500°	550°	600°	700°	800°	900°	1000°
14.696 v (212.00) h	0.02 180.0	26.82 1150.2	32.59 1215.6	34.65 1239.0	36.70 1262.4	38.75 1286.0	40.79 1309.7	42.83 1333.7	46.91 1392.4	50.97 1432.1	55.03 1482.9	59.09 1534.9
20 v (227.96) h	0.02 196.1	20.10 1156.0	23.90 1214.8	25.43 1238.3	26.94 1261.9	28.45 1285.5	29.95 1309.3	31.46 1333.4	34.46 1382.1	37.44 1432.0	40.43 1482.8	43.42 1534.8
40 v (267.24) h	0.017 235.9	10.497 1169.2	11.843 1211.3	12.623 1235.6	13.392 1259.7	14.161 1283.7	14.922 1307.8	15.682 1332.0	17.190 1381.2	18.686 1431.3	20.18 1482.3	21.68 1534.4
60 v (292.71) h	0.017 262.0	7.172 1177.0	7.821 1207.7	8.353 1232.8	8.878 1257.4	9.398 1281.9	9.911 1306.2	10.423 1330.7	11.435 1380.2	12.436 1430.6	13.439 1481.8	14.440 1533.9
80 v (312.03) h	0.018 281.9	5.470 1182.4	5.806 1203.8	6.217 1229.9	6.618 1255.2	7.015 1280.0	7.406 1304.7	7.793 1329.3	8.558 1379.2	9.313 1429.9	10.067 1481.3	10.817 1533.5
100 v (327.83) h	0.018 298.3	4.426 1186.6	4.594 1199.7	4.934 1226.9	5.263 1252.8	5.585 1278.0	5.903 1303.0	6.215 1327.9	6.831 1378.2	7.439 1429.2	8.044 1480.7	8.644 1533.1
120 v (341.26) h	0.018 312.4	3.725 1189.8	3.781 1195.2	4.077 1223.8	4.359 1250.4	4.632 1276.1	4.899 1301.4	5.162 1326.5	5.680 1377.2	6.189 1428.5	6.693 1480.2	7.196 1532.7
140 v (353.03) h	0.018 324.7	3.216 1192.4		3.465 1220.5	3.713 1247.9	3.951 1274.1	4.182 1299.7	4.410 1325.1	4.857 1376.2	5.297 1427.8	5.728 1479.7	6.161 1532.2
160 v (363.55) h	0.018 335.9	2.830 1194.5		3.005 1217.1	3.227 1245.4	3.440 1272.1	3.645 1298.0	3.846 1323.7	4.240 1375.2	4.627 1427.1	5.006 1479.1	5.385 1531.8
180 v (373.08) h	0.018 346.0	2.529 1196.3		2.646 1213.5	2.849 1242.7	3.041 1270.0	3.226 1296.3	3.407 1322.2	3.760 1374.2	4.105 1426.3	4.444 1478.5	4.782 1531.4
200 v (381.82) h	0.018 355.3	2.285 1197.8		2.358 1209.8	2.547 1240.0	2.722 1267.9	2.892 1294.6	3.056 1320.8	3.376 1373.1	3.688 1425.6	3.995 1478.0	4.299 1531.0
220 v (389.89) h	0.019 364.0	2.084 1199.0		2.122 1205.9	2.299 1237.3	2.462 1265.7	2.617 1292.9	2.769 1319.3	3.062 1372.1	3.347 1424.8	3.628 1477.4	3.903 1530.6
240 v (397.40) h	0.0186 372.1	1.9156 1200.1		1.9250 1201.9	2.092 1234.4	2.244 1263.5	2.389 1291.1	2.529 1317.8	2.800 1371.0	3.063 1424.1	3.321 1476.8	3.574 1530.2
260 v (404.43) h	0.0187 379.8	1.7723 1201.0			1.9165 1231.5	2.060 1261.3	2.195 1289.3	2.327 1316.3	2.579 1370.0	2.823 1423.3	3.062 1476.3	3.295 1529.7
280 v (411.06) h	0.0188 387.0	1.6490 1201.8			1.7655 1228.4	1.9019 1259.0	2.030 1287.5	2.153 1314.8	2.389 1368.9	2.617 1422.5	2.839 1475.7	3.056 1529.3
300 v (417.33) h	0.0189 393.9	1.5414 1202.4			1.6347 1225.3	1.7648 1256.7	1.8863 1285.6	2.002 1313.3	2.224 1367.8	2.438 1421.7	2.646 1475.1	2.849 1528.9
350 v (431.71) h	0.0191 409.8	1.3245 1203.6			1.3712 1217.1	1.4899 1250.7	1.5981 1280.9	1.7003 1309.4	1.8945 1365.1	2.080 1419.8	2.260 1473.6	2.435 1527.9
400 v (444.58) h	0.0194 424.2	1.1601 1204.1			1.1726 1208.3	1.2828 1244.3	1.3817 1276.0	1.4740 1305.5	1.6472 1362.3	1.8119 1417.7	1.9704 1472.1	2.125 1526.8
450 v (456.27) h	0.0196 437.4	1.0303 1204.1				1.1204 1237.6	1.2127 1271.0	1.2972 1301.5	1.4548 1359.4	1.6032 1418.7	1.7455 1470.6	1.8834 1525.8
500 v (466.99) h	0.0198 449.7	0.9261 1203.7				0.9905 1230.5	1.0775 1265.8	1.1558 1297.3	1.3009 1356.6	1.4365 1413.6	1.5655 1469.1	1.6903 1524.8
550 v (476.92) h	0.0200 461.3	0.8402 1203.0				0.8823 1222.8	0.9658 1260.3	1.0398 1293.1	1.1746 1353.6	1.2996 1411.5	1.4191 1467.6	1.5321 1523.8
600 v (486.17) h	0.0202 472.3	0.7677 1202.1				0.7922 1214.7	0.8728 1254.6	0.9431 1288.7	1.0694 1350.6	1.1855 1409.3	1.2953 1466.1	1.4003 1522.8
700 v (503.04) h	0.0206 492.9	0.6527 1199.7					0.7251 1242.4	0.7905 1279.7	0.9038 1344.5	1.0063 1404.9	1.1029 1463.0	1.1929 1520.8
800 v (518.18) h	0.0209 511.8	0.5653 1196.7					0.6128 1228.8	0.6750 1270.1	0.7791 1338.2	0.8723 1400.4	0.9577 1459.9	1.0374 1518.8
900 v (531.95) h	0.0213 529.5	0.4969 1193.3					0.5234 1213.6	0.5844 1259.8	0.6821 1331.7	0.7675 1395.8	0.8451 1456.8	0.9166 1516.8
1000 v (544.58) h	0.0217 546.0	0.4419 1189.6					0.4495 1196.5	0.5111 1248.7	0.6040 1324.9	0.6837 1391.0	0.7547 1453.6	0.8199 1514.8
1100 v (556.28) h	0.0222 561.7	0.3960 1185.6						0.4500 1236.6	0.5401 1317.9	0.6152 1386.1	0.6810 1450.4	0.7408 1512.8
1200 v (567.14) h	0.0226 576.5	0.3582 1181.4						0.3985 1223.4	0.4865 1310.6	0.5578 1381.1	0.6195 1447.2	0.6750 1510.8
1400 v (586.96) h	0.0235 604.3	0.2983 1172.4						0.3144 1192.4	0.4021 1295.2	0.4678 1370.8	0.5229 1440.8	0.5712 1506.9
1600 v (604.74) h	0.0244 630.2	0.2528 1162.7							0.3384 1278.6	0.4002 1360.0	0.4503 1434.3	0.4935 1502.9
1800 v (620.86) h	0.0254 654.7	0.2167 1151.8							0.2880 1260.6	0.3472 1348.7	0.3938 1427.8	0.4330 1498.8
2000 v (635.61) h	0.0265 679.0	0.1875 1139.0							0.2468 1240.7	0.3047 1337.0	0.3486 1421.1	0.3847 1494.7