PLAINTIFF'S EXHIBIT
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NO. 31506

SHIRLEY HODGE, Individually and as Personal Representative of the and Estate of A. J. Hodge, Jr., Deceased; GREGG A HODGE and ANGELA R. McClain,	:	IN THE DISTRICT COURT OF
Plaintiffs,	:	
VS.	:	FANNIN COUNTY, T E X A S
TEXAS UTILITIES ELECTRIC COMPANY (d/b/a VALLEY POWER PLANT), et al	:	
Defendants.	:	6TH JUDICIAL DISTRICT

VIDEOTAPE

ORAL DEPOSITION OF RAYMOND A. HEIT

September 24th, 1996

Houston, Texas

COPY

depotist. B&R

Taxable Costs $______________

Paid by: Plaintiffs
Andrew Waters, Esq.
SBN 20911450

EXAMINATION INDEX

EXHIBIT INDEX

EXHIBITS MARKED FOR IDENTIFICATION

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REPORTED BY:

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APPEARANCES CONTINUED:

VIDEOGRAPHER:

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ALSO PRESENT:

Ms. Lynnette G. Adams

On the 24th day of September, 1996, in the offices of Brown & Root, 4100 Clinton Drive, Houston, Harris County, Texas, beginning at 1:10 p.m., RAYMOND A. HEIT appeared before me, Michelle Pfeiffer, a notary public in and for the State of Texas, and being by me first duly sworn, testified by his video oral deposition as hereinafter set out, pursuant to notice and the Texas Rules of Civil Procedure;

The deposition may be signed by the witness before any notary public or other officer authorized to administer oaths.

THE VIDEOGRAPHER: Okay. You're on the record. Go ahead. 1:10.

THE REPORTER: Stipulations?

MR. WATERS: Just by the Rules.

THE REPORTER: Signature?

MR. BROWN: He'll read and sign. I haven't even seen his notice. So if you're gonna ask him about the notice, could someone share it with me. I don't understand that he was asked to bring anything.

MR. WATERS: Well, the -- the notice pertained to all three of the depositions with respect to the --

MR. BROWN: He's not an industrial hygienist.

MR. WATERS: I appreciate that, but it would probably --

MR. BROWN: So if there's anything other than that --

MR. WATERS: There's nothing other than that, but if -- if you were -- I imagine you have those pulled together. If you could give them to us now, Todd can be looking at them while I'm deposing him.

MR. BROWN: Mr. Drysdale's gonna bring them.

MR. WATERS: Okay.

MR. BROWN: If they can be available any sooner than that, I'll -- I'll certainly at a break make that inquiry.

MR. WATERS: All right. Let's go ahead and mark the depo notice as Exhibit 1.

MR. FISHER: Additionally, Michelle, an objection by one would be good for both of the defendants so we don't have to both pipe up during the same --

MR. WATERS: That's fine.

MR. FISHER: Okay.

MR. KALE: Also, Michelle, that's the notice for -- for all three depositions.

THE REPORTER: Okay.

MR. WATERS: Okay.

THE REPORTER: Can we go off the record, please?

MR. WATERS: You most certainly may.

(At which time, a short recess was taken.)

(At this time, the instrument referred to was marked Heit Exhibit No. 1 for identification and is attached hereto.)

THE VIDEOGRAPHER: Back on the record at 1:12.

DIRECT EXAMINATION

BY MR. WATERS:
Q Would you tell us your full name, sir?
A Raymond A. Heit.
Q H-E-I-T?
A That is correct.
Q Mr. Heit, what is your date of birth?
A September the 12th, 1936.
Q That would make you 59 years of age?
A No.
Q 60 years of age?
A Correct.
Q Just had your birthday. Okay.
A Correct.
Q How long have you been employed with Brown & Root?
A Approximately 22 years.
Q All right, sir. Have you ever given a deposition before?
A Yes, sir, I have.
Q On how many occasions?

A Two.
Q Did either of those involve asbestos in any way?
A No, sir.
Q Okay. What did they involve?
A One was an election situation up in Ohio, and the other was a resolution of some contract expenses with respect to some work I had been involved with.
Q Were either -- Well, the one you spoke of first, I take it, was before you were employed with Brown & Root?
A That's correct.
Q The second one was a contract dispute?
A Contract involved some work I had done prior to coming with Brown & Root.
Q Oh, I see.
A Yes.
Q Okay. All right. So both of those cases were independent and totally separate from your work with Brown & Root?
A That is correct.
Q Have you -- So therefore, you've never given a deposition while a Brown & Root employee before today?
A That is correct.
Q All right, sir. Since you're somewhat familiar

with the process, I'll just briefly refresh the ground rules, if you will. If for any reason you don't understand my question, will you stop me and ask me to rephrase or repeat the question?

A Yes, sir, I will.

Q Okay. And you're doing fine so far. If you'll continue to be sure to let me finish my questions before you answer, and likewise, I will let you finish your answers before I start another question. Will that be all right?

A Great.

Q Okay. What is your present position with Brown & Root?

A I'm manager of engineering procedures and standards.

Q How long have you been in that position, approximately?

A On and off, essentially my entire career at Brown & Root.

Q Okay. From -- Would it be from 1974 to the present?

A That's correct, with some project assignments scattered in between.

Q Okay. How was it that you -- Well, strike that.

Let me ask you first, just very generally,

what are your duties -- what do you consider your duties and responsibilities to be at the present time?
A In a nutshell, to a laymen, the best I can describe it is that I recycle intellectual products. Specifically, engineering documents. Now, that covers just a multitude of areas.
Q When you say recycle, do you mean that you utilize engineering plans and documents that have previously been used for something and you use them again for some other purpose?
A Parts.
Q Okay. If I were to ask you what your job description was when you started with the company 22 years ago, what would you have said?
A Design engineer. As it turns out, I was under review for the job I'm in right now.
Q And as a design engineer, what were your duties and responsibilities?
A Work with project requirements on a specific task and bring those requirements to completion where they could be used in the actual procurement and construction of the plant or whatever to completion.
Q How was it that you came to be hired by

Brown & Root in 1974?
A I had just gotten back in from an assignment in Algeria and went back through the interview process here in late 1973, and Brown & Root gave me the best job offer of all the groups that I had talked to.
Q Now, how would you have been employed immediately prior to coming to work for Brown & Root?
A I was an independent consultant for the five years prior.
Q Approximately '69 to '74?
A That's correct.
Q And just again very generally, describe what sort of consulting services you provided in that time frame.
A Among other things, I was a private consultant to the design of the TransAlaska Pipeline. I was design consultant to a local engineering architectural firm on the design of the College of Minerals and Petroleum in Saudi Arabia. I did the safety, fire protection and security consulting work in Algeria in '73. I was the design consultant for a grass roots fiberglass plant, manufacturing plant. I was the owner's consultant for a manufacturing storage facility south of

downtown here where I was able to make use of an existing foundation and floor system. Then, at the same time, I was doing OSHA consulting for various groups around town on an intermittent consultant basis.

Q All right. The safety work that you did in Algeria, was that in connection with a particular project, construction project?

A No. This originated in Washington, D.C. One of the consultants in Washington was hired or directed by American insurance interests and, I believe, their international insurance interests, also, to review the status of safety, fire protection and security at all Algerian industrial facilities. So I was part of the team that went over to do that task.

Q And did you go to a variety of manufacturing or refining complexes?

A Yes, sir. Yes, sir. We looked at everything of any significance in Algeria.

Q Okay. And what -- The Algeria job was in '73?

A Yes, sir.

Q And I think you said that was the last thing you did before you came to Brown & Root?

A That's correct.

Q Okay. You indicated that you had been a design consultant at a fiberglass plant.
A Yes, sir.
Q Where was that located?
A Galveston, Texas.
Q What's the name of the plant, if you remember the owner, perhaps, or the --
A I believe it was Texas Fiberglass Products.
Q And when was that project?
A That would have been in early 1969.
Q All right, sir. Then you mentioned a Houston manufacturing facility. I think you may have said south of Houston.
A Yes, sir.
Q What is that called?
A I do not recall the name of that concern.
Q Do you recall what the plant was set up to manufacture?
A It was electrical goods.
Q Electrical goods?
A Yes, sir.
Q What was the time frame you were involved with that project?
A That was in mid to late 1969.
Q Okay. And you also mentioned that you had done

some OSHA consulting?

A That's correct. That's correct.

Q How is it that you got involved with OSHA consulting?

A OSHA was breaking on the scene. There was a significant amount of concern, frustration, and let me say confusion as to where OSHA was going to take the American construction industry and American business and industry in general.

Q All right.

A So I saw it as a good extension to things that I had been doing up to this point.

Q Okay. Had you previously been involved in occupational health and safety matters?

A Remotely.

Q Okay. We'll come back to that.

A Okay.

Q Maybe the better way to go is go back to -- start at the beginning and work our way forward to fill in the gap.

A Okay.

Q You were born in 1936. Where were you born?

A Norfolk, Virginia.

Q Okay. Well, I went to school at William and Mary, and I used --

A Okay.
Q -- to spend a lot of time down there.
A Okay.
Q How long did you take in Norfolk, Virginia?
A My family left there in 1946.
Q All right. And where did you move?
A To a city just outside of Cincinnati known as Hamilton, Ohio.
Q Okay. And how long did you reside in Hamilton, Ohio?
A Till I went away to college. In fact, I would stay at home with my parents until I graduated.
Q Where did you go to college?
A University of Cincinnati.
Q Okay. When did you graduate from the University of Cincinnati?
A 1959.
Q What was your degree in?
A It's the professional degree of civil engineer. It's a little known degree. It ranks between a bachelor's and a master's.
Q Okay.
A The University of Cincinnati is allowed to award that on the basis of a cooperative education program.

Q Okay. After you graduated in 1959, what did you do?
A I went with a group known as Factory Mutual Engineering Division.
Q What did they do?
A This was the technical arm of the Factory Mutual Insurance Companies.
Q And what sort of services did the technical arm of these insurance companies provide?
A Factory Mutual was, and is, one of the leaders in preferred risk industrial fire insurance. And accordingly, they backed up their marketplace with a full complement of fire protection related engineering services. So this included everything from review of policyholder plans for expansions, new construction in the words of -- Okay. Just to give you an idea of Factory Mutual's marketplace, at that point in time, they carried all your Blue Ribbon manufacturing facilities and other Blue Ribbon properties. For example -- Go ahead.
Q Well, I just want to be clear on one thing. Is the coverage that they provide pretty much limited to fire, or is it more broad than that?
A It was fire and what's called use and occupancy. In other words, if one of their insured facilities

was taken out of service as a result of fire or other disaster, such as wind storm or flood or what have you, then they also covered the operating expenses and salaries and profits that would not have been made during that period.
Q So it's sort of like a catastrophic loss coverage?
A No.
Q No?
A It depended on the client. For example, most of their policies were full coverage. However, at the other end of the spectrum, there were a few companies, like Union Carbide, that carried as much as a million-dollar deductible. But Union Carbide and other groups that had this kind of deductible wanted the benefit of the fire protection and related engineering services.
Q Okay. Did they provide any worker's compensation coverage?
A No.
Q Okay.
A No.
Q No general liability coverage?
A No.
Q Okay. And was that true throughout the entire time you worked with them?

A That is correct.
Q And if I understand your position in the position of the Factory Mutual engineering division, y'all would provide the expertise to assist the customers in taking the appropriate precautions that would help them avoid those types of losses?
A That is correct.
Q Was there a fair amount of travel involved with the job?
A Yes, sir. It just so happened that I was the only bachelor at that point in time in the Cleveland, Ohio office, so I got the majority of the road work.
Q Okay. Did you travel to Texas during that time frame?
A No, sir.
Q Okay. For how long a period did -- did you work for Factory Mutual engineering division?
A Approximately three and a half years.
Q And that was out of Cleveland?
A Correct. Correct.
Q Let me ask you if at -- during that time frame or at any point in time up to, say, 1964, had you ever learned anything about asbestos?
A Yes, sir. Are you familiar with asbestos cement

pipe?

Q Yes, sir.

A Okay. Asbestos cement pipe was very highly regarded --

Q From a fire --

A -- for underground water supply. In fact, I can vividly recall one plant up i. central Ohio that had had the misfortune of having a tremendous amount of cinders used as fill material around the plant site. The cinders, in turn, generated fair amounts of acid, which, in turn, attacked the cast-iron fire water mains. So on visits to insured facilities, when the weather permitted, people like myself would run hydraulic tests on the water system. And invariably, at this particular location, when the fire pumps would kick in, it was almost a sure bet you were gonna blow some of the cast-iron water main. So people like myself would stand by, stay on site until that fire main was back in service. So the asbestos cement pipe was the -- the, I guess, hands-down choice to replace the cast-iron pipe.

Q Is that your -- at that point in time, in that time frame -- your experience with that product? Was that your first experience or knowledge about any

asbestos-containing products?
A No. My parents used to make candy as an art form when I was a youngster, and I can vividly remember the asbestos gloves that my father used in moving the big copper candy pot. And he had other asbestos pads that he used to set things on. So I vividly remember asbestos from my days as -- as a youngster.
Q Okay. In the time frame up to 1964, did you ever have any understanding or knowledge about the health hazards of asbestos?
A No, sir.
Q Okay. Did you ever have any -- any courses, for example, in college that touched on biology or mineralogy that discussed at all asbestos?
A I had a basic geology course, and then I did some graduate work in sanitary engineering, and in neither of those programs do I recall anything in regard to asbestos.
Q Okay. Now, up to this point in time by 1964, had you received any training, either formal or informal, in industrial hygiene?
A No, sir.
Q Had you received any training in on-the-job safety?
A No, sir.

Q Okay. Why did you decide to -- to leave the Factory Mutual engineering division?
A I had the opportunity to take a very unique position with one of the suburbs of Cleveland, Ohio.
Q Okay. What was that position?
A That was village engineer for the Village of Cuyahoga Heights.
Q I need you to spell Cuyahoga for me.
A C-U-Y-A-H-O-G-A.
Q All right. And tell me again, it was called village engineer?
A Village engineer, yes.
Q What were the -- what was the nature and duty of your responsibilities in that job?
A Essentially, I was the technical expertise for the town. It's a very unique situation. At that point in time it had a bedroom population of approximately a thousand people and a working population of something in excess of 50,000 people. In other words, this little town had a lion's share of Cleveland's industry. So I essentially served as the technical arm for the Village.
Q And did that require you, for example, to spend time at manufacturing facilities that were operated

in the Village?
A That's correct.
Q Were you a consultant for the city -- Strike that.
Did your duties and responsibilities include inspecting on behalf of the Village the sites to -- to ensure that operations were safe and met specifications and things of that nature?
A That is correct. In addition to being village engineer, I was also the Village building commissioner and the Village zone commissioner.
Q How was it that you came across this opportunity or how did it -- how did you -- how were you given this job?
A I was approached by -- well, it was known in the industry as a headhunter.
Q Okay. Does the Village of Cuyahoga Heights have -- did it have a mayor, for example?
A That's correct.
Q Okay. Did you work directly for the mayor?
A I was directly employed by a civil engineering firm out of Cleveland, and I was positioned out at the Village.
Q Okay. So you were technically not employed by the Village; you were employed by the consulting firm, but your services --

A Yes.

Q Okay.

A Yes. My full work week was spent out at the Village.

Q And for how long a period did you maintain that position?

A That was approximately three years.

Q In those -- During that time frame, did you become familiar with whatever local or state ordinances or regulations may have applied to safety in the workplace?

A Yes, sir.

Q And in the course of your duties, did you advise facilities or the Village of Cuyahoga Heights if certain regulations or ordinances were not being followed or if there were violations of those requirements?

A Yes, sir, I did.

Q Was that a significant part of your -- of your job?

A It all depends on significant. Among other things, the Village was topographically suited for landfills. So as a result, the majority of Cleveland's industrial refuse was brought out there for dumping and I had to ride heard on the landfill contractors. So typically, once or twice a day the chief of police would come by and pick me up, and we would probably stop for coffee, and then we would just go visit the landfills. So it's a rather dubious distinction, but it was my responsibility to ensure that noxious materials were not being allowed into the landfills and that things were generally being kept in control.

Q Do you recall the specific regulations or requirements that had to be adhered to or had to be followed by the landfill operators, for example?

A Just the high points.

Q Well, let me -- let me ask the question this way.

A Sure. Go ahead.

Q Was it, for example, state law or was it local municipal ordinances that had to be followed? Do you recall?

A Yes, sir. It was contract requirements with the landfill operators. These -- these were contracts that were prepared by the Village solicitor.

Q Okay. So the Village had contracts with the landfill operators which required the landfill operators to follow certain safe practices?

A That's correct, yes.

Q Okay. Did either the city or the state, to your knowledge, at that time, have any regulations in

place that pertained to these types of operations?
A I do not recall anything of that nature.
Q Did the city or the state have any regulations in place at that time that pertained to safety and health generally in industrial operations?
A The Village had its own code. I do not recall anything in state regulations that I was required to follow in dealing with the industries in the town.
Q And the code that the Village had, that was mandatory for that to be followed by the industrial industry -- rather, by industries that were located in the Village?
A That's correct.
Q Okay. And all of the people -- all of the companies that operated facilities in the Village were essentially held to understand that they had to follow those codes?
A That is correct.
Q Okay. And for the most part did they follow those codes?
A Yes, sir.
Q Okay. Did you ever have any of the industrial operations out there respond to a violation of codes by merely saying, well, we didn't know about

it, we didn't know that that was a requirement or we didn't know that that was a restriction, something of that nature?
A I do not recall any situations like that.
Q As -- as a general rule, would you agree with me that companies are required and held to -- to know whatever laws or regulations may be applicable to their operations?

MR. BROWN: May he limit his answers to his perspective, which is engineering, or are you asking him broader than that?

MR. WATERS: Well, we -- he's been talking about regulations that pertain to safety and health.

MR. BROWN: Well, I understand that. But you understand his background, training and experience?

MR. WATERS: Yeah. I think he -- he's -- he's --

MR. BROWN: I think your question's

outside his area of expertise, and I want to go ahead and make that objection.

MR. WATERS: All right.

MR. FISHER: We also object that it calls for a legal conclusion on the part of this witness and it's outside of his scope.

BY MR. WATERS:

Q Okay. Having said all that, you can answer my question. From time to time there will be objections. Do you want the question read back to you, or do you recall it?

A I think it would be a good idea if we went back over it.

MR. WATERS: Okay. Do you mind reading that back?

MR. BROWN: Let me, before you do that, tell you, Mr. Heit, that when counsel says to you, "You now can answer the question," you need to understand that that means if you can.

THE WITNESS: Okay.

MR. WATERS: No. I certainly --

MR. BROWN: You're not under any obligation to do more than try to respond as completely and fully as you can to the question that's asked, not to speculate or do anything beyond that.

BY MR. WATERS:

Q Absolutely. Mr. Heit, if you don't know the answer to my question, all you need to tell me is you don't know and we'll move on to something else. I'm only interested in the knowledge that you've acquired in your years of experience and what you know. And if there's something that you don't understand or don't know, just tell me and we'll move on to something else.

MR. WATERS: Okay. Can you read that back to him?

THE REPORTER: Can we go off the record, please?

MR. WATERS: Sure.

(At which time, a short recess was taken.)

RAYMOND A. HEIT,

having now been duly sworn, testified as to the following:

(Whereupon the following was read by the reporter:

"QUESTION: As -- as a general rule, would you agree with me that companies are required and held to -- to know whatever laws or regulations may be applicable to their operations?")

THE VIDEOGRAPHER: You're on.

A That covers a lot of territory. Back in the 60s, from a technical point of view, life was a lot more simple. What it came down to is we didn't know as much then as we do now. By their very nature, laws and regulations are meant to apply to everybody. But sometimes there is a lag in disseminating this information through the community and through those that need to know.

BY MR. WATERS:

Q All right. I think that's a fair answer.

When you say life was more simple then, in fact, in that time frame -- and we're really talking about the early 60s right now, I think.

A Mid 60s.

Q Mid 60s. Okay.

A Uh-huh.

Q Okay. There were a lot less regulations concerning safety and health in the workplace than there are today?

A That is correct.

Q And the regulations that they had in those days tended to be simpler -- that is to say, they were less complex and easier to understand?

A That is correct.

Q Okay. And you would expect that in terms of the lag time for a company or an individual to recognize and address and follow a regulation, that the larger the -- and more sophisticated the company, the more able it would be to fairly quickly understand the regulation and follow it to the best of its abilities?

A Again, you're -- you're covering a lot of territory there. Today we look at all the regulations that are put out by EPA, NIOSH, OSHA, Internal Revenue. I've had the opportunity to try to keep up with the Federal Register, which -- at the federal level where so much of this is put out. Most businesses cannot afford to dedicate someone to stay right on top of this on a day-to-day basis. It's -- it's just the reality of the situation. Again, the variety of subjects that are under regulation and the variety of requirements. This is why OSHA is still maintaining such a strong inspection posture.

Q Okay. And I appreciate what you've said and -- and especially what you're talking about now --

A Uh-huh.

Q -- how we have a lot of regulation.

A Uh-huh.

Q But going back to the mid 1960s when there was significantly less regulation, am I correct that the companies that were better able to understand and comply with those regulations would tend to be the larger companies that had the financial

wherewithal to make themselves familiar and be on top of what the requirements were?
A I can't guarantee that that would be true.
Q Okay. Can you think of any reason why a large company in the early to mid 1960s would not be aware of regulations concerning safety and health in the workplace?
A I believe it's a matter of experience and exposure to the sources of these regulations. For example, again, looking at today's situation, the variety of subjects that are being flushed out as being problems.
Look at the tobacco industry today. Here we have the tobacco industry that claims that there's no hazard to cigarette smoking. So that you -- you have the -- this gap of credibility. In other words, what -- what -- what are we really seriously talking about here? And your corporate managers, of course, are committed to their stockholders and to the boards of directors.
Q Well, and I guess that presents -- can present a problem in the sense that the corporate managers, in their commitment to the stockholders, they have a direct concern in -- in enhancing the profitability of the enterprise, correct?

A I would believe so.
Q Okay. And oftentimes the -- the profit motivation, if you will, or incentive, can outweigh other considerations, such as health and safety, that might -- might be pushed a little bit aside?
A I would probably have to look at that as a broad generalization.
Q Yeah. I'm -- and I'm --
A Go -- go ahead. I'm sorry.
Q I -- I wasn't speaking in any specifics, just in general. Absolutely.
A There's no doubt that that does happen.
Q Okay. Do you believe that there's too much regulation at the present time?
A That's almost like asking me if -- if I quit beating my wife. It's -- it's a two-edged sword.
Q Okay. Do you think that there is adequate regulation in the workplace today so that if the regulations are followed, workers will generally be -- be protected from accidents and industrial exposures and things of that nature?
A I do believe that.
Q Okay. Do you believe that there was adequate -- that there were adequate regulations in place in the mid 1960s to properly protect workers from

injuries and exposures in the work place?

MR. BROWN: Again, is your question limited to his perspective -- that is, from an engineering standpoint? Or are you asking more than that?

MR. WATERS: I'm asking his perspective based on his world view, if you will. He has a lot of different experiences which we're still working our way through.

MR. BROWN: Are you asking him for his personal opinion?

MR. WATERS: Based on his experience and training and background.

MR. BROWN: Personal opinion?

MR. WATERS: Well, his opinion. I don't know how personal it is. He's sharing it with us.

MR. BROWN: Okay. Just as long as you understand it's outside his area of expertise, but he certainly can share with you any personal opinion he may have.

BY MR. WATERS:

Q All right, sir.

A Applying the knowledge and expertise that we have acquired up to this point in time, I have to say that in the mid 60s we probably did not have adequate regulation.

Q Okay.

A And a real quick example would the safety belt and the lumbar belt.

Q Okay. In that time frame, mid 1960s, you were personally involved with trying to ensure that companies followed regulatory or other requirements, correct?

A That is correct.

Q Okay. And at that time, in dealing with the industrial concerns in facilities that you addressed on a continuing basis, would you have been critical of a company that professed ignorance of applicable regulations?

A At that point in time it was my responsibility to ensure that the businesses and industries in that municipality were, in deed, following the regulations that had been enforced. In other words, I -- for lack of a better expression, I was a miniature OSHA.

Q All right.

A And, to a degree, a -- a miniature EPA.

Q All right. Well, and that -- that brings me back to my question. In that capacity in which you found yourself employed at that time, you expected, did you not, that the industrial concerns in facilities would know what the requirements were and would follow the requirements, correct?

A If I had expected them to know and follow everything, I would not have had to make rounds to ensure that they were.

Q When you made the rounds, the purpose was to -- to determine whether or not they were following the regulations and doing so correctly?

A That's correct.

Q All right. And before doing so, before you would make those rounds, you anticipated, did you not, that -- that these companies would take the necessary steps and would know about the regulations and at least they should have been following them?

A Would you go back over that?

Q Try that one again? Okay.
As you went out to make your rounds and make your inspections as a miniature OSHA or EPA, as you've described it, --
A Uh-huh.
Q -- these -- you anticipated that these companies would know about the regulations and that they should have been following them, correct?
A No. I -- I did not anticipate that they did know them. And, in fact, in some cases they did not know.
Q Okay. And --
A And -- Go ahead.
Q And so part of -- of your job description, then, was to educate them on what they didn't know --
A Yes.
Q -- concerning the requirements?
A Yes, that would be correct.
Q Okay.
A Uh-huh.
Q And then once they did know, you would certainly expect them to follow them thereafter?
A Yes.
Q Okay.
A Yes. Which they did not always do.

Q I'm sure that's true.

And some of those companies presumably didn't follow the regulations, which they knew about, at least in part because of their commitment to stockholders and to the -- the profit situation?

A I really can't answer that.

Q Okay.

A Again, that -- that's a -- that's a broad generalization.

Q All right. Where did you go when you left Cuyahoga Heights?

A I went to the position of assistant county engineer in Lake County, Ohio.

Q And what was the approximate time frame that you made that move?

A I'm gonna say early 1966 -- excuse me, early 1965.

Q All right. Did you continue to operate as a mini OSHA or a mini EPA in your new job as the assistant county engineer, Lake County?

A No. For the short time I stayed in that slot, I was looking after county road responsibilities.

Q All right. How long did you actually stay there?

A Just a matter of a couple of months.

Q Okay. And then where did you go after that?

A I went with a general contractor there in Lake

County.
Q Okay. Where is Lake County vis-a-vis Cleveland?
A Immediately east.
Q Okay.
A Cleveland's located in Cuyahoga County, and Lake County is the next county to the east.
Q And I'm sorry. What was the name of the engineering company?
A In Cleveland?
Q The one you went to. Right.
A Okay. I went to work for the county engineer, a gentleman by the name of Frank Riley.
Q All right. I've gotten myself confused. You left the Lake County assistant county engineer job --
A Okay. No. No -- okay. Yeah. Yeah. Go ahead.
Q All right. And -- and that -- and that would have been approximately mid 1965?
A Yeah, close to that.
Q And then you went -- What was the name of the company you went with then?
A I went to Osborne, Incorporated.
Q Osborne.
All right. And it was -- What was Osborne, Incorporated?
A General contractor.

Q What kind of work did they do?
A Highway construction, site development, concrete supply and building materials.
Q How long were you employed by Osborne?
A A little over a year and a half.
Q Till approximately the end of 1967?
A End of 1966.
Q Oh, I'm sorry. What were your duties and responsibilities while employed by Osborne for that year and a half?
A My primary responsibility was to keep the construction of about a five-mile stretch of freeway on track. In other words, I had to look after the layout work and the materials testing. Then there were some inconsistencies in the results of the Ohio Department of Highway testing program, so it was necessary to unravel that. So then along the way I was estimating and bidding projects -- and I was chief engineer for Osborne.
Q How -- how big a company was Osborne?
A Okay. With all the divisions, they probably had 10 million dollars worth of equipment, in the dollars at that time. He had -- I guess you'd call it a franchise where he used one of the lake mooring boats to go across Lake Erie to Canada and he would

bring -- the mooring boat would bring back a boat load of crushed limestone.
Q Huh.
A And this, of course, was the aggregate that was used in the concrete and it was a material that was used in a variety of ways. So that's probably one of the best money machines I've ever seen. But he had the ready mix concrete business --
Q When you say he --
A Jerry Osborne, the owner.
Q Okay.
A Yeah. Yeah.
Q Okay. Did Osborne have a safety department?
A Not as such. I -- I was the unofficial safety manager.
Q Okay.
A With that kind of work, the primary concern is cave-ins with your underground.
Q Did you familiarize yourself, to the extent you may not have already known them, with whatever requirements, regulations may have applied to digging trenches --
A Yes.
Q -- and that sort of thing?
A Yes.

Q Okay.
A There was not much in place at that point in time.
Q All right. Fair enough. To the extent there was, however, information and regulations in place, Osborne made a conscious effort to -- to address that and to follow those rules?
A Yes. Yes.
Q And was Osborne doing that before you arrived, to the best of your knowledge?
A From everything that I can recall, I maybe brought it up a notch.
Q Okay. Kind of tightened up the program?
A Yeah. Yeah. Yeah.
Q All right. And why was it that you left Osborne?
A Had the opportunity to come to Texas.
Q Okay.
A We had had two weeks of subzero weather in Cleveland and I came down here in January of '67 and had two of the most beautiful weeks I can ever recall. Nobody told me it was the mildest winter they had had in years. But I was able to interview and on the spot I decided, hey, I had had enough cold weather. So I was able to interview with half a dozen outfits at that point in time and was able to pick up employment. So I went back, packed and

moved south.
Q Were you interviewing with construction companies for the most part?
A No. I interviewed with Brown & Root.
Q Uh-huh.
A I interviewed with Exxon and Fluor and Union Carbide, and there were two others, and I don't recall who they were.
Q All right. And who did you wind up taking a job with?
A Union Carbide.
Q Do they have a plant in the Houston area?
A Texas City.
Q Texas City?
A Yeah. Yeah.
Q So you began work sometime -- was it in January '67?
A February of '67.
Q February of '67?
A Yeah.
Q And what was your position at Union Carbide?
A Essentially, I was project engineer responsible for civil, structural, architectural, fire protection and safety-related projects.
Q Wow. That's a big job description.

A It was a lot of fun.
Q Yeah. Now, when did -- when did that plant open, if you know?
A Yes, I do. Construction started in the late 30s, early 40s.
Q And how many employees did that plant have at the time frame you arrived, approximately?
A I would estimate maybe 2,000.
Q All right.
A It was around-the-clock operation.
Q Now, in your -- in terms of your safety-related responsibilities, did they have a -- sort of a safety hierarchy at the plant that you fit into or were you hired to -- to, in effect, oversee the safety department, or how did that fit together?
A As a project engineer, it was my job to pick up on a need or a problem and work with the unit management to arrive at a solution. Now, one of the surprises on arriving at Union Carbide at that point in time, early '67, was to find that they had an industrial hygienist. The first time I had ever -- ever come across that particular phrase. And they had a plant doctor, which apparently was pretty common at the larger refineries and chemical plants along the Gulf Coast at that point in time.

Q Let me just ask --
A Sure.
Q -- for a point of clarification. Do -- Are you saying it was common to have a plant doctor or it was common to have IH --
A It was common to have a plant doctor.
Q Okay.
A Again, the -- this plant hygienist -- industrial hygienist was the first time I -- I had come across that particular position.
Q Do you recall the name of the industrial hygienist working for Union Carbide in 1967?
A I do not. I do not.
Q Did you have an opportunity to spend time with -- with this gentleman and learn something of what his expertise was all about?
A Just very limited.
Q Okay.
A I -- I recall having conversations about ventilation problems, fume exposure. That particular plant was a petrochemical facility.
Q All right.
A And there were all kinds of noxious chemicals in the area.
Q Do you know if at that time Union Carbide had

developed some procedures that from an industrial hygiene standpoint would reduce or eliminate asbestos exposures?

A No, sir, I don't. In fact, I can vividly recall using cement asbestos siding and cement asbestos pipe with no knowledge of any concern.

Q Okay. And this was personally used on your part?

A No. No. This was --

Q This was -- the workers?

A -- with respect to the projects that I was responsible for.

Q All right. And I take it that at that point in time anyway you did not have any knowledge about the potential hazards that could result from dust, dusty operations or inhaling the dust?

A That is correct. There was -- there was no knowledge.

Q Had you had knowledge at that time that you subsequently developed in your position in -- in -- with respect to your safety-related responsibilities, would you have asked for a change in procedures to try to eliminate those exposures?

A Well, I believe that Union Carbide would have handcuffed me. In other words, they flat -- they'd have rode me out of the plant, if -- if, for

example, today I would go and try to use corrugated asbestos.
Q Uh-huh. Well, if you had -- if you had known about the hazards of asbestos in '67 and had gone to Union Carbide with your concerns, do you think that they would have responded by trying to adopt some safer practices?
A That -- that's a good question. I can't be real sure about the answer. Unfortunately, the Gilbert principle wasn't in effect back then. There were a couple of situations where I had put in what I thought were significant improvements -- not in the safety field, but in -- let me call it engineering economics, and the bureaucracy was able to make sure it didn't get implemented.
Q It was hard to make changes, in other words?
A That's correct.
Q Okay.
A That's correct.
Q Did you understand that the -- the gentleman -- and I -- I know you can't recall his name, but the gentleman that was employed there was a certified industrial hygienist, or do you know if he was certified?
A That, I don't recall.

Q Okay.

A I'm not sure that they -- they might have had a certification program that far back.

Q All right. Was Brown & Root involved with any of the projects at the Union Carbide facility while you worked there?

A At the time that I was on site, there were not any Brown & Root crews there. However, Brown & Root had been one of the major contractors in that plant.

Q How long a time frame were you there at Union Carbide?

A Approximately two years.

MR. BROWN: We've been going about an hour.

MR. WATERS: Yeah.

MR. BROWN: Do you want to take a break, Mr. Heit?

MR. WATERS: Sure. We can do that.

THE WITNESS: Okay. Sounds good.

THE VIDEOGRAPHER: Off the record at 2:10.

(At which time, a short recess was taken.)

THE VIDEOGRAPHER: Okay. Back on the record at 2:22.

BY MR. WATERS:

Q Mr. Heit, we were talking about your employment from, I guess, '67 to '69 -- early '69 at the Union Carbide facility.

A That's correct.

Q Okay. And where did you go after that?

A The next five years I essentially worked as an independent consultant.

Q All right. And that would be early '69 to '74?

A Late '73.

Q To late '73?

A Yes, sir.

Q All right. We've come full circle. Tell me, if you will, what -- I assume that it was during the time you were at Union Carbide that you decided you

were gonna go into business for yourself?
A That's correct.
Q All right. And what was it that you hoped to accomplish or what was -- what was your goal in setting up that business in terms of what sort of customers you wanted to have, what sort of work you intended to do, what sort of services -- services you intended to provide?
A I intended for my consulting practice to be primarily civil structural, but to -- to also offer the fire protection and safety consulting.
Q Did you anticipate that the safety consulting would generally be in the context of construction operations?
A No.
Q Okay.
A I figured that would be one part of it.
Q All right. What other --
A Go ahead.
Q What other parts did you anticipate at that time in addition to --
A The industrial -- primarily the industrial side.
Q And when you say industrial side, you're talking about manufacturing operations or refining?
A Primarily.

Q Okay.
A Yes. Yes.
Q During your time that -- the two years at Union Carbide, did you receive any additional training or instruction with respect to safety or industrial hygiene matters?
A Nothing that would be classed as formal training. I was interacting with a variety of disciplines. We had a full complement of technical disciplines on site there.
Q All right. Including the industrial hygienist you referenced earlier?
A Yes.
Q All right.
A Yes. Yes.
Q During the time frame you were at -- at Union Carbide, did you learn anything about the hazards or potential hazards of asbestos in the workplace?
A I did not.
Q Okay. When was it that you first learned or understood about the -- developed an understanding about the hazards of asbestos?
A To the best of my recollection, that started to come into the picture in 1974, after I had joined Brown & Root.

Q Okay.
A And the asbestos picture began to unfold at that point.
Q Okay. So is it a fair statement that prior to arriving at Brown & Root you were not yet aware that asbestos was hazardous?
A Yes, sir. Yes, sir.
Q And you mentioned that you -- one of the things that you did was OSHA consulting?
A Yes, sir.
Q In that time frame when you were an independent consultant?
A Yes, sir.
Q Okay. Did you understand at that time frame, in, let's say, 1970, that OSHA -- that the -- that the Act had been passed and signed by President Nixon in 1970?
A That would have been -- You're referring to the William Stigar?
Q Well, I -- I'm not -- What I'm referring to is the Occupational Safety and Health Act, which is what set up the OSHA administration and commenced the -- the preparation of regulations.
A Okay. I believe that's referred to as William Stigar Occupational Safety and Health Act.

Q I think that must be right.
A Yes.
Q And that was signed into law by President Nixon in 1970?
A That's correct. Yes.
Q Okay. And are you telling me that you did not become aware until 1974 that one of the regulated substances, materials in the implementing regula -- in the implementing regulations was asbestos?
A Okay. I knew that asbestos was in the -- the dust and breathing area, but it was not considered any more unusual than any of the other regulations that came out. You have to understand that when they put together the first two regulation packages -- okay. Part 1910 is what they called the general industry regulations, and Part 1926 was the construction regulations. Essentially, what they did with those two packages was to pull together a lot of loose consensus standards or voluntary standards that were in existence at that time.
Does the term ANSI mean anything to you?
Q Uh-huh.
A Okay. Most of the material published in 1910 and 1926 were existing ANSI regulations. So there were just innumerable loose ends that were included in

those two packages.

Q I take it that in the time frame '69 to '74, in your work as an independent consultant, you did not address or encounter the OSHA regulations pertaining to asbestos in the workplace?

A It was never an issue. Now, the -- the prime emphasis was on trenching, perimeter protection, hard hats, untidy job sites. At that point in time, there was so much in the elementary area of safety control that needed attention that the more sophisticated ends really did not get significant attention.

Q Okay. So just to kind of capsulize what you've just told me, the asbestos regulations that were passed in '70, as you say were more -- the more -- at the more sophisticated end?

A Yes.

Q And they tended to be overlooked, for lack of a better word, for a few years until implementation really began to kick in?

A Yes. At that point in time, you never saw anything in the way of air sampling on a job site. In other words, there were too many tripping hazards or too many working without hard hats. There were too many obvious shortcomings that needed immediate attention.

Q Okay. So you would not anticipate, for example, that at construction sites in the 1970s time frame Brown & Root, for example, would have completed air monitoring while working with asbestos?

A I would have been surprised if they had.

Q Okay.

A I really would.

Q Are you aware of the fact that the State of Texas, as of 1958, had passed regulations that required a minimum -- or excuse me, that required that asbestos exposures be limited to a certain level?

A I've learned that --

Q Okay.

A -- since that era.

Q Okay. I take it that's not something you knew in the 1960s, for example?

A No. No.

Q All right. How was it that you learned that Texas, in 1958, had adopted maximum concentrations -- allowable concentrations for workers working with asbestos?

A It's just come up in discussions over the years.

Q Okay.

A In talking with other engineers and -- Of course, after the cancer connection started coming to the front in the mid 70s, then more and more attention was focused on the finer points.

Q Okay. All right. Just -- Have you heard from other people at Brown & Root that you've worked with over the years -- is that how you learned about the 1958 standard?

A Yes. Yes.

Q Okay. And in the course of those conversations, while you never had any personal knowledge of that -- of those regulations, you came to und -- to understand from talking to older, I guess, or perhaps Brown & Root employees who had been with the company much longer that, in fact, those standards had been in place?

MR. BROWN: Let me object. That assumes facts not in evidence. He has not identified who he talked to. Could be that some young whipper snapper just joined the job and got out of college and knew a lot about it. Who knows. So I object to your question.

BY MR. WATERS:

Q All right. You can answer, sir.

MR. BROWN: If you can without speculating.

A Restate that question --

BY MR. WATERS:

Q Sure.

A -- because it's -- Go ahead.

Q What -- what you've told us already --

A Uh-huh.

Q -- and I think the record's pretty clear on this, but I just wanted to follow up, is that at some point in time since you started working for Brown & Root in 1974, you've had conversations with other Brown & Root personnel and as a result of those conversations have come to understand about the Texas threshold limits for asbestos that were put into place in 1958?

A Uh-huh.

Q Is that a fair statement?

A Yes, that is.

Q Okay.

A That is.

Q Can you recall the names of any of the individuals

at Brown & Root that you spoke with after 1974 that identified for you the fact that this previous regulation had been in place, starting in 1958?
A I recall conversations back in the mid 70s. I was working with some of the disciplines on development and various standards, and insulation was part of what I was involved with, and a big deal was made that, hey, we get rid of the asbestos --
Q Okay. And so --
A -- usage.
Q -- in that context, y'all were discussing presumably the new regulations, the OSHA regulations that y'all --
A Primarily, yes.
Q Okay.
A Yes.
Q And it would have come up that, in fact, these gentlemen would have told you -- I understand you can't recall who they were necessarily -- that, in fact, there had been some previous regulations as well that you had not personally been familiar with?
A Yes. That -- that did come up.
Q Okay. Did you understand from speaking to those gentlemen or just in general that the regulations

that had been in effect since 1958 had not been routinely followed by Brown & Root over the years?

A To the best of my recollection, the regulations were not that well known or understood up until the mid 70s. In other words, there was not an intimate knowledge of what was involved there.

MR. WATERS: Okay. Let me object. And I'm gonna make an objection that your answer was nonresponsive to my question. Don't take that in the wrong way.

A Okay. No. No. That's all right.

BY MR. WATERS:

Q My -- my specific question was -- and I think you sort of answered it, but my specific question was: As a result of those conversations, did you come to understand that Brown & Root had not routinely followed or had not been focused on the 1958 regulations that had been in place?

MR. BROWN: Excuse me. You've asked two questions.

MR. WATERS: I'll -- I'll break it down.

MR. BROWN: Followed or focused on.

MR. WATERS: I'll break it down.

MR. BROWN: I don't mind the --

MR. WATERS: I'll break it up.

MR. BROWN: -- focused on.

MR. WATERS: Withdraw the question.

BY MR. WATERS:

Q In the course of those conversations, Mr. Heit, did you come to understand that with respect to the 1960s, Brown & Root had not routinely followed the 1958 regulation, that there had not been a policy to do so?

A We're -- we're looking at two areas here. The -- My side of the house at that point in time was primarily engineering people. And the engineering people would not have had any direct input to site safety activities so that they would not have had

any direct interest in the monitoring functions at the job site.
Q Okay. And the people you had your discussions with in the mid 70s would have been engineering folks?
A That's correct, yes.
Q All right.
A Uh-huh.
Q And what you're telling us is that to the extent there may have been asbestos exposures in the 60s, or going back to 1958, that's something the engineering people would not necessarily be concerned or involved with?
A That's correct, yes.
Q Okay.
A Uh-huh.
Q And I think you've already told us that at least prior to the early 70s that prior -- you would be very surprised if there was any air monitoring with respect to --
A Yes.
Q -- asbestos levels done?
A Yes. Yes.
Q Okay. You talked about the -- I think you used the term the cancer connection.
A Uh-huh.

Q Do you remember using that term?
A Yes. Yes.
Q Okay. Have you been made aware over the course of your experience with Brown & Root that there were some studies completed in the early to mid 1960s that confirmed that asbestos exposure could cause cancer?
A I've heard bits and pieces on that. I have not heard or seen anything --
Q Okay.
A -- that I would use as definitive. In other words, I -- I've never read any -- any reports like that myself.
Q This morning in deposition -- I think the jury will hear this in trial -- Dr. Cagle, who is testifying on behalf of Brown & Root, testified that as early as the 1930s and on up to the 1960s there were hundreds or even thousands of articles that discussed the fact that asbestos -- people exposed to asbestos could get cancer as a result of that. Have you ever been made aware by Brown & Root of that cancer connection?
A I have not. I'm surprised to hear the numbers of articles that he's quoting.

MR. BROWN: In fairness to you, Mr. Heit, he didn't say that. Counsel had to remind him of some earlier testimony.

BY MR. WATERS:

Q In any event, the cancer connection was brought to your attention by Brown & Root the first time in the -- approximately the mid 1970s?

A I'm not gonna say specifically Brown & Root.

Q Okay.

A Because I do read a lot of technical journals. In the mid 70s it just all of a sudden came on the scene.

Q What you're basically telling us is that from the standpoint of the media and the public at large, there was a lot more information in the latter part of the 1970s about asbestos and cancer?

A Yes. Yes.

Q Let's talk about your -- Well, let me -- let me back up. I had a couple more questions.

A Sure.

Q When you interviewed with Brown & Root in January 1967, were you interviewing for the -- a job of project engineer?

A No. Primarily, job as specification engineer or

design engineer.
Q At that time was Brown & Root a large company?
A Large is relative.
Q That's right.
A Compared to the organization I had been with, yes, Brown & Root was a large organization.
Q Okay. Do you know when Brown & Root first had industrial hygienists on its staff?
A I have no idea.
Q Do you know if they have industrial hygienists on their staff today?
A I know they do today.
Q Okay.
A Uh-huh.
Q Just to clarify, the -- the OSHA consulting that you did up until 1974 when you went to work for Brown & Root --
A Uh-huh.
Q -- did not include work related to asbestos?
A That is correct.
Q Okay.
A I'd gone into an OSHA school in '72, and I do not recall anything specifically being brought up about asbestos at that program.

MR. WATERS: Okay. Let me object to the nonresponsive portion of that answer.

BY MR. WATERS:

Q Another one of the companies you interviewed with was Exxon?
A Uh-huh.
Q Did you come to understand after you began to work for Brown & Root, if you didn't already, that Brown & Root was the most significant contractor working for Exxon in this area?
A I've never heard that.
Q Okay.
A I would not be surprised.
Q All right. Have you personally been involved with projects undertaken on behalf of Exxon by Brown & Root at the Baytown facility?
A Not directly.
Q Okay. Indirectly have -- do you have some knowledge about that?
A At the present time, I've supplied a number of engineering standards out to work that's in progress at Baytown, and I -- I've put up material for other Baytown-related projects.
Q Is it your understanding, based on your experience

with Brown & Root, that the relationship between -- between Brown & Root and Exxon, and specifically pertaining to the Baytown facility, goes back all the way to the 1940s?

A I'm not familiar with that.

Q Okay. Do you know whether or not Brown & Root was involved with construction and maintenance projects at the Exxon facility in the 1950s, 1960s -- or 1960s?

A I do not have any knowledge of what Brown & Root might have been doing with Exxon at that point. In fact, Exxon did not exist in the 50s and 60s.

Q Was it -- What was it called, Standard?

A No. No.

Q ESSO?

MR. KALE: Humble.

A Yes, sir. The facilities that we know primarily down here today as Exxon were Humble Oil.

BY MR. WATERS:

Q Okay.

A But they were owned by what was then known as Standard of Jersey or Eastern State Standard Oil,

or more better known as ESSO.
Q Let me ask the question a different way because I'm glad you brought that up. In -- in the course of your work from '74 to the present, have you come to understand that Brown & Root did work at the Baytown facility, regardless of who -- who they -- what they called the owner at the time?
A Yeah. I knew that there had been work out there.
Q Okay. And did you understand that that work went all the way back to 19 -- to the 1940s?
A No, I did not know that.
Q Okay. How far back did you understand that that work had gone, or do you understand?
A To the best of my recall, I have not heard of any work with Exxon prior to the 60s.
Q Okay. All right. I'd like to ask you some questions about your work with Exxon from 1974 to the present. And I guess more particularly, let me just ask the question this way, in a general sense. Have you continued to have some involvement with health and safety issues from 1974 to the present?
A Health and safety issues have always been a companion part of basic engineering work. And with my work in standards and specifications, I have had to pay attention to health and safety issues

wherever they became evident.

Q All right, sir. Have you had any involvement with Brown & Root related to health and safety and specifically asbestos or the hazards of asbestos?

A Yes. I end up, more or less, being the final check point on the publishing of the -- the company engineering standards, so one of the things that I have kept an eye out for is anything that -- that would specify asbestos. And it's -- it's part of my duty to eliminate that from the standards, or at least control it.

Q Just to make sure I'm clear, are you speaking of circumstances where you'd received specifications from a potential customer?

A No. No. No.

Q Specifications from a supplier of machinery or equipment?

A No.

Q No?

A No.

Q All right. You better explain it.

A Okay. It's part of my program to take in specifications from our individual design disciplines. For example, right now I have a brief concrete specification that would be used for concrete work on small projects. That comes to me ready for final issue. I check it for overall format, general order and general technical accuracy so that if that specification would have called for asbestos fiber as a mineral fiber binder -- by comparison, there -- there are such things as plastic fiber binders -- that had that specification in reference to asbestos, I would have had to call a meeting with the civil people and essentially drawn the line and said no, you can't do that.

Q Okay. So you kind of, in that capacity, act as a watchdog to make sure that the specifications don't require the use of something as hazardous as asbestos?

A That -- that's one of the things.

Q Sure.

A That's one of the many. With all due respect to the young lady right here, I've been told that part of my mission is to catch any of the dumb ass mistakes that come across my desk.

Q And clearly in this day and time, and I guess, perhaps, any time after 1975, you would characterize specifying the use of asbestos as just one of those kind of mistakes, wouldn't you?

A Yes, but there's exceptions. I had talked about asbestos cement pipe. And in a perfect world, we would say, hey, no more asbestos pipe. So in our underground piping specs today, the national specification for asbestos pipe is listed, but there's a big note that says we do not use this under ordinary circumstances. If the customer or client is requesting this, there has to be coordination through with the Brown & Root legal department.

MR. WATERS: Okay. Let me just for the record object to everything after yes as --

A Oh, I'm sorry. I --

BY MR. WATERS:

Q No. No. You go right ahead and answer the questions as best you can. Don't worry about -- That's just a technical legal thing.

A Well, there was a -- an exception to the basic rule is what I was trying to indicate.

Q I appreciate that very much. One of the reasons that you, in that watchdog role, watch out for specifications that might require some kind of asbestos is because you don't want for some future -- for in the future some individual to be exposed to asbestos and run the risk of developing cancer and all that that might entail?

A That's correct. That's a good expression.

Q Okay. How large was Brown & Root when you arrived as an employee in 1974? And -- and perhaps the best way for me to ask you the question is in terms of number of employees. And I'm just really looking for --

A That's an illusive number. This is a ballpark guess. I'm gonna say maybe 20, 25,000 employees.

Q Wow. Okay. When you became aware after starting with Brown & Root that Brown & Root had known previously of the 1958 standard that we talked about, when you became aware of that, did you consider that given Brown & Root's size, given their significant involvement in the construction industry, that's precisely the kind of information they probably should have been aware of?

MR. BROWN: Excuse me. Let me object. There's no evidence that Brown & Root knew. What the man testified to was he may have had some discussions with some employees, but that's not to say that that ever was communicated to whomever --

MR. WATERS: Let -- let me --

MR. BROWN: -- speaks on behalf of the company.

MR. WATERS: I'll withdraw the question. Try this -- try this another way.

BY MR. WATERS:

Q Given the size of Brown & Root and the nature of their operations, sir, would you anticipate that a company like Brown & Root would have known about the 1958 asbestos standard?
A I'm gonna have to say no.
Q Okay. But what you have --
A Can I tell you why?
Q No. That's okay.
A Okay.
Q I might come back to that. What you do know is, from talking to these various individuals, that, in fact, Brown & Root did know about it. Can you tell us how Brown & Root learned about the 1958 standard?

A No, I can't. I cannot answer that.
Q Okay.
A I have no idea.
Q We'd have to talk to somebody who was with the company a long time ago in order to determine that, I presume?
A I would --

MR. BROWN: Excuse me. That calls for speculation. Object.

BY MR. WATERS:
Q You can answer.
A I -- I agree. That would be a logical assumption.
Q Are you aware of anyone today that you work with or know at Brown & Root who was employed by the company in the 1950s?
A At this point in time, no, I do not.
Q Other than your involvement and your concerns about specifications that may require the use of asbestos that you just described, --
A Uh-huh.
Q -- have you had any other involvement with the hazards of asbestos from 1974 to the present?
A Not that I can recall.

Q Okay. I'm sorry. I -- I think I asked you this question before, but I don't recall your answer. Did you say that you had been involved with some projects at Exxon Baytown since 1974?
A Yes. I have put up specifications and procedures that are used by our people.
Q Okay. Are you aware that -- that there's a long-standing policy that when Brown & Root employees, or for that matter other contractors' employees work at the Exxon Baytown facility, they are required to follow Exxon safety regulations?
A Yes. Yes.
Q Okay. And that's not particularly surprising, I suppose. Isn't that probably true with a lot of the big industrial premises owners when they have contractors come to their facilities, they -- they require them to follow their safety policies?
A This day and age, to the best of my knowledge, that is pretty typical.
Q Okay. In fact, the Brown & Root crews that worked at Exxon were required to not only follow the Exxon safety regulations, but to actually adopt them as their own?

MR. BROWN: Excuse me here. There's been

no foundation for this. You're asking the witness to speculate. I didn't understand that he did anything in Exxon other than to send out some engineering standards. And if those, in fact, encompass this, then I withdraw the objection. Other than that, I don't see how he's in a position to know what may have happened if he was not there.

BY MR. WATERS:

Q All right. Let me reask my question, in light of the objection.

Have you also understood that there has been a long-standing requirement that Brown & Root crews that work at Exxon -- Exxon Baytown not only are required to follow Exxon safety regulations, as you've testified, but are also required to actually adopt Exxon's safety requirements as their own?

A No. I'm not intimately familiar with any kind of relationship like that because I have visited the Baytown job site just maybe once or twice for a short-term visit and was never put through any of the site indoctrinations that typically occurs when a Brown & Root employee goes on a client property.

Q Well, you called the process site indoctrination?

A Yes.
Q And that's where the -- the premises owner fully instructs the contractor, superintendent and the contracting crews what rules and regulations they're to follow?
A Okay. I'm using it in terms of an individual like me going to that job site and I'm gonna go out to a work area. Then, in most cases, my company is required to indoctrinate me and familiarize me with what the site requirements will be.
Q Okay.
A That's how I'm using indoctrinated.
Q All right. Okay. I think I understand. So basically, the Brown & Root policy, in compliance with Exxon's policy, would be to acquaint you, before you go out there and before you get on site, with what the safety rules and requirements are?
A I can't answer that for sure because I'm not even remotely familiar with what relationship exists there.
Q Okay.
A I've never seen any of that.
Q Brown & Root has had a safety department for a -- a long time, correct, before you --
A To the best of my knowledge, yes.

Q In your experience, has the Brown & Root safety department made every effort to try to be aware of any hazards that its employees might encounter?

MR. BROWN: Excuse me here. There's no foundation for this, and unless he somehow knows what they've done, you're asking him to speculate.
You can answer it if you know.

A I cannot give you a hard and fast answer on that. I know from company publications that Brown & Root does emphasize workers' safety to a high degree. I do know that Brown & Root realized a long time ago that it's very worthwhile from a monetary point of view to take good care of your employees and promote a strong safety program. The monetary value, of course, is reflected in the lower insurance rates. So there's both an altruistic and a monetary driving force here.

BY MR. WATERS:
Q Did you become aware of that attitude or that policy, if you will, sometime after you came to the company in 1974?
A No. I knew a lot of Brown & Root people when I --

when I first got down here in the late 60s and I --
I picked up on that immediately.

Q Okay. Did you understand from that experience and from your experience actually as a Brown & Root employee that Brown & Root wanted to be aware of any hazards its employees might encounter so that it could warn those employees and assist them in avoiding injury?

MR. BROWN: Here again, there's no foundation, and I think you're asking him to speculate unless he has some involvement in that.

A That -- that's a very complex question. I can't give you any specifics that -- that I could detail out with respect to that question.

BY MR. WATERS:

Q Well, let me just ask in the context of 1974 to the present. Has it been your experience that Brown & Root has made efforts to understand and determine what hazards there are so they can warn their employees and their employees can avoid injury?

A Yes.

Q Okay.
A Yes.
Q And those efforts on the part of Brown & Root, for example, would include determining and understanding what types of exposures could be toxic or hazardous to workers' health?
A Yes, sir.
Q Do you have any knowledge about the membership of Brown & Root in the National Safety Council?
A I do not.
Q Okay. Did you know that they were a member of the National Safety Council?
A I do not.
Q Okay.
A Even today I -- I could not answer that question.
Q I guess you are aware from your involvement with -- with the company and your understanding of the nature of their -- that the work that they do, that at least up until the middle 1970s, Brown & Root was involved with numerous projects, either construction or maintenance, that utilized asbestos as a thermal insulating material?
A I do not know that for a fact.
Q And my question to you is if you are aware of that or do you have an understanding of that based on

what you've learned since 1974 in the context of the historical work that the company's done. Have you come to understand that up until that time frame, approximately when you joined the company, Brown & Root was involved with construction work that utilized asbestos thermal insulation as part of the construction process?
A I do know that asbestos was in some of our standards back in that era.
Q Okay.
A Now, as to what extent asbestos was used, I cannot give you an accurate picture at all.
Q Have you reviewed any of the documentation in this case that pertains to the contract for building Units 2 and 3 of the Valley Plant in Savoy, Texas?
A Yes. I've had an opportunity to review the cost reports, and cost reports only.
Q Okay. Have you not reviewed the contracts?
A No, sir, I have not seen the contracts.
Q They were not provided to you?
A No, sir.
Q Did Brown & Root retain or hire insulators on a routine basis to complete insulation work at the various facilities where they performed construction activities?

MR. BROWN: At what point in time, Counsel?

MR. WATERS: Any time that he's familiar with.

BY MR. WATERS:

Q Let's say -- let's say when you started with the company, 1974.

A Insulation is -- and I -- I can't guarantee this, but insulation is one of those necessary evils on a project that gets done, depending on the job circumstances. Specifically, you have two parts in the insulation. One is the procurement of the material, and two is the actual insulation or application. So depending on circumstances, as I understand it, one job Brown & Root might buy the insulation and hire the insulators and put it in as a Brown & Root part of the job. Another time they might subcontract out the purchase and the insulation. Another time they might buy the insulating material and then hire an insulation subcontractor to install the material purchased by Brown & Root. And to the best of my knowledge,

there's no direct policy as to how any one given project is going to administer that segment of the contract.
Q When Brown & Root did directly employ insulators, --
A Uh-huh.
Q -- would it employ them -- would they be union workers? I'm sorry. Would they be members of a union?
A In all probability, I believe the answer to that would be no.
Q In fact, did Brown & Root have a policy of trying to avoid hiring union members in this time frame?
A I cannot answer that because I'm not familiar with that end of the business.
Q Hiring?
A I -- I've never --
Q When you said in all probability, no that Brown & Root would hire union members to do insulating work, what was the basis of your statement, or why is it that you feel that way?
A Brown & Root has always promoted the merit shop philosophy. From the earliest days, Brown & Root has been a merit shop organization.
Q So they have essentially, to the extent possible,

avoided hiring union labor for a variety of -- of crafts?

A Okay. Maybe I'm not interpreting the question correctly. I don't know that Brown & Root would exclude an individual that put in an application because he was a union member. I don't know -- and again, I'm an innocent in this area. I don't know how Brown & Root could identify a union man if he showed up at the hiring office. Now, when you first started talking unions, I was thinking of union subcontractors. And I doubt that union subcontractors would want to come on a site, and I doubt that union men would want to come on site either.

Q Okay. Insulation work, I think you described it as a necessary evil?

A Yeah. Yeah.

Q Okay.

A Yeah.

Q It was a dirty job, but somebody had to do it? Fair statement?

A Yes.

Q Okay.

A Like several others on a typical construction job.

Q Okay. Since 1974, have you been involved with the construction of any power plant or power generating units?

A At the construction site, no. I have been involved with some of the design side.

Q Have you reviewed the documentation in this case that pertains to the change orders and the actual insulation work done at the Valley Unit No. 3?

A I'm totally unfamiliar with what you're talking about.

Q Okay.

A I didn't see any trace of that in the cost -- final cost reports.

Q What is the final cost report, by the way, that -- that you did review? What -- what is that document so I can understand?

A It's a summary of where the money was spent. It's a breakdown of labor and materials for the various parts of the plant.

Q At the end of the day?

A No -- Well, some of it was prorated by number of workers on a week-to-week basis. The other was -- was essentially a final summary of how many dollars were spent on insulation, how many dollars were spent on electrical. There were some percentages of over and under. Each one was only less than a

hundred pages each.
Q Okay. Have you ever observed construction activities at a power plant at any time?
A Yes, I have.
Q Where would that have been?
A The Parish generating station up here -- I believe it's Route 2 -- was Route 249. I believe it's 149 now.
Q Somewhere in the Houston vicinity?
A Yeah. Yeah. It's down south of the Willowbrook Mall.
Q Did Brown & Root build that facility?
A At the time I went out there, Brown & Root was doing some additional work. I don't know that we were the original contractor there.
Q When was it that you made that trip?
A I'm gonna say in '74 or '75.
Q Are you familiar with plans for the construction of other power generating units other than the one you just described?
A I did some work for the Florida Power & Light. This was early on when I joined Brown & Root in early '74. I was part of a three-man team that designed a huge cooling tower complex. Then I put up other various standard documents, standard

specifications that were used by other power plant projects. Then I was what you might say the point man in getting Brown & Root's first radioactive source license for doing on-site radiography. This was primarily for power plants. I was the point man in getting Brown & Root's initial quality control manual approved by the American Society of Mechanical Engineers. And this was a -- a new requirement that had been promulgated by ASME in '73, then I picked up on it in '74. And of course -- Are you familiar with ASME?

Q I think so. It's the American Society of Mechanical Engineers?

A Correct. Correct. Yes.

Q In reviewing the -- the documentation that you were provided concerning the construction at Valley 3, did you see anything that was of significance to you concerning this case?

A There was one mention of what was apparently a brand name for asbestos insulation, and I think it may have been J-M, or Johns-Manville. As I recall, their trade name was Thermobestos.

Q Okay.

A And that was in one of the little short descriptions on some of the insulating work.

Q And the document presumably priced out, for example, just how much money was spent on --
A Yes, sir.
Q -- Thermobestos, among other things?
A Yes. Yeah. Yeah.
Q Do you understand that the J-M Thermobestos that was identified was an asbestos product?
A I assume that it probably was.
Q Okay.
A I have no hard and fast information that would tell me yes, it was or no, it wasn't.
Q Do you have any opinions concerning the nature of the work that was done at the Valley Plant Unit No. 3 from 1969 to 1971?
A With regard to what?
Q With regard to the nature of the work, the way it may have been done, the materials that may have been used, anything of that nature.
A The best I can offer is that Brown & Root, by and large, has left a remarkable track record in the work that they have designed, the work that they have constructed and the work that they have designed and constructed. I believe there's very few people who really comprehend the extent of what this company has done over the years.

Q All right, sir. And if I understand you correctly, what you're saying is from the documentation that you've reviewed, from an engineering standpoint, it would appear that the construction was done the way that it should be done?

A Yes, sir.

Q Okay.

A Yes, sir. There's -- there's a lot of key things that I could spot in the -- just in the final cost report. I could see the exotic materials that were used in some of the piping and some of the valves. I recognize some of the premium subcontractors that were involved there, Babcock and Wilcox, and I believe there were some General Electric generators. When you see those kind of names in the order to the overall package, it fits with what I've worked with in other standard documents. In other words, this is where a standard document should end up. So just with a few minutes of review, I could see it was a typical project.

Q So your opinion would be that the project was well designed and apparently well constructed?

A Yes, sir. Yes, sir. Based on what I've had an opportunity to look at.

Q Sure. And you've told us a little bit about that.

Do you have any other opinions that you derived from reviewing any of the -- of the documents that were provided to you by Brown & Root or by Brown & Root attorneys?

A With regard to anything special or --

Q Anything else you may have seen in that documentation or been asked to look for or look at?

A Other than that the job was done the way I believe it should have been done.

Q Okay.

A I'm not sure what else I might need to be looking for.

Q Let's take one break. He's got to switch the tape and then I'll --

A Okay. Okay.

(At which time, a short recess was taken.)

THE VIDEOGRAPHER: We'll go back on the record at 3:44.

BY MR. WATERS:

Q Mr. Heit, let me ask you a few more questions about the job, the work at the Valley Plant. Am I

correct that your only knowledge about that plant, that project, that work was what you gleaned from reviewing the cost breakdown?
A Correct. Yes.
Q Okay. Have you had any interviews -- excuse me. Have you had any conversations with anybody else at Brown & Root concerning that job?
A Just the superficial conversations that I've had with Mr. Brown and the Brown & Root paralegals.
Q Okay. Have you learned anything about the job that's of significance to you other than what you learned from that documentation?
A No, sir.
Q Okay.
A No.
Q Am I correct that when Brown & Root contracts to build a facility such as a power plant, they typically contract to do all of the work that's involved or at least to be responsible for all of the work that's done?
A That tends to vary all over the map. We talk about EPC prices -- EPC, and that's engineering procurement and construction. Now, in a lot of cases we do all -- we do the whole shooting match. But then in a -- again, I'm gonna say a significant

number of cases, the client may pick selected parts of the project that they take care of themselves.

Q All right. EPC. "E" is engineering. That's the design, correct?

A Correct.

Q "P" is procurement. That's the acquiring of necessary materials to do the work?

A Procurement covers both purchasing and subcontracts.

Q Okay.

A Then there's a lot of subservices with that.

Q All right. And I forgot what the "C" stood for.

A Construction.

Q Actual construction?

A Yes. Yes.

Q All right. From your review of the documentation that was provided to you by the Brown & Root attorneys, did you determine or did it appear to you that the Valley Unit 3 job was an EPC job?

A It was not readily clear.

Q Okay. At this point in time are you unclear as to whether or not that was an EPC job?

A I would have to say I'm unclear.

Q Okay. There have been some contracts produced in this case, contracts between Brown & Root and TPL, Texas Power & Light --

A Uh-huh.

Q -- for the construction of Unit 2 and then later Unit 3. The contracts appear to require Brown & Root to put together the engineering designs and specifications for the construction projects. Is that a typical arrangement that you have seen Brown & Root have in the past?

A No. Most often you have a starting point of your design criteria document and your flow diagrams. Now, your design criteria -- in fact, I have an obsolete design criteria form that was used in the power division up until we pulled it here a couple of years ago, because it needs upgrading. But this walks through all the bits and pieces that go into the design of a power plant. So then that is typed up with a -- a flow diagram. This essentially is a pictorial representation of what you're doing. For example, back in the late 60s, early 70s, it was real common to have a boiler where you heated water to get steam. The steam went over to what's known as a steam turbine. The steam turned the -- the wheels on the turbine. The steam is then pulled through a cooling system, which is why you need these huge cooling towers. Today, you'll most

often hear about cogeneration plants. Are y'all familiar with that?
Q I think so, but go ahead. Explain it, if you will.
A Okay. A cogeneration plant typically is the equivalent of a jet engine like you'd have on an airliner. In fact, there's one aircraft class of, I guess, turbine that is used in this situation. But anyway, this is a gas-fired turbine. Instead of steam, you're firing natural gas in there. So the -- the combustion turns the wheels. The turbine itself is direct connected to a generator which is generating electricity. Then you have what's called a heat recovery unit on the jet engine or the gas turbine. The heat is drawn off the exhaust from that turbine. It's like the exhaust coming off a jet airplane. That heat is used to heat water, which in turn becomes steam and drives a -- a steam turbine connected to a -- another generator. That's where they come up with the co --
Q Co --
A -- generation. So in either case, you start out with this pictorial picture. Okay. This is gonna be the heat source, here's the size of the generator we want. Okay. Here in this part of the

country lignite coal is our best fuel. So then you set up your pictorial layout. You'll have a coal unloader, you'll have a coal storage, et cetera, and all the other pieces. So there's enough definition between the design criteria document and the flow diagrams that the engineer constructor and the client can arrive at a reasonable cost and then they have categories of estimates. They get refined as the work progresses. Does that --

Q I think that's very helpful to me. Have you -- have you had -- other than this case, obviously, have you had an opportunity at any point in time since 1974 to review cost analyses or other documents that relate to the specification and what's to be used in the construction process?

A From a cost point of view, I don't recall any direct cost analyses that I've been involved with in any real detail.

Q Okay. When you looked at the -- the cost document with respect to the Valley No. 3 unit, --

A Uh-huh. Uh-huh.

Q -- did it appear to you that the -- the -- the component parts and materials that were used were typical for a Brown & Root project of that time frame?

A I cannot give you a definitive answer to that because I have not looked at cost details of any other power plants from that era. Just in -- in broad terms, I do not see any numbers that seem out of the ordinary.
Q Okay. You mentioned, for example, that the Johns-Manville Thermobestos --
A Uh-huh.
Q -- product had been used. Was that a product that had been used on other occasions by Brown & Root, standard insulating material that they used for high temperature applications?
A I can't answer that. I do have some of our standard specifications that go back to that era and they are based on national standards and there were -- I don't recall the Thermobestos being noted in any of those.
Q Okay. Now, do you recall a product called Unibestos?
A No.
Q Okay.
A No.
Q Do you recall a product called Kaylo?
A No.
Q No. Okay.

A No.
Q Since you've come to work at Brown & Root, have you -- have you learned that asbestos exposure can cause the -- a disease called asbestosis?
A Yes. Yes.
Q Have you learned that asbestos exposure can cause lung cancer?
A Yes.
Q Have you learned that asbestos can cause the disease that is -- that is at issue in this case, mesothelioma?
A I have to say that I've never heard that term before.
Q Okay.
A That's brand new to me.
Q All right. So at least in the context of your work at Brown & Root from 1974 here to 1996, you do not recall ever being told or learning in training sessions or anything of that nature that mesothelioma is a cancer that can be caused by asbestos?
A I have not -- never heard that before. It's totally new to me.
Q What you have learned, however, sir, is -- I think you'll agree with me that asbestos is an extremely

hazardous substance?
A There's much evidence to that effect.
Q All right, sir.
A And -- Okay. Go ahead.

MR. BROWN: No. You finish your answer. What else were you gonna say?

A I marvel at the exposure that automobile mechanics have been subjected to in dealing with brakes. And it's just been a couple years now that asbestos has been taken out of brake linings. And I vividly remember time and time again seeing a mechanic blow out a brake lining, either when there was brake work being done or when I had mentioned squeaking in my brakes. And this is typically an accumulation of dust. And I can vividly remember many times seeing these people blow that stuff out and a big puff of what had to be heavily contaminated air. Yet, I'm sure they exist, but I have not heard -- and now, I do not follow the cancer patients, but I have not come across any lung cancer cases occurring from that brake lining exposure. So in my mind, that's a question mark.
Q As to whether brake lining exposure can cause

cancer?
A Yes. Specifically, the asbestos that would be -- would probably be in that dust.
Q The -- the situation you described with -- with the clouds of dust coming from brake work, is that something you observed at Brown & Root?
A No. No. This is in -- in having my own personal automobiles serviced.
Q Based on what you've learned since you joined Brown & Root in 1974, do you consider asbestos to be dangerous?
A I do. I do. I personally at this point in time would not make use of any asbestos product unless a client insisted on it and, of course, took the -- the liability on it. This is at the same time that the technical community continues to publish national consensus standards for asbestos products.
Q And, in fact, if you had a customer come to you and specifically ask and request that a certain project be completed asbestos free -- that is to say asbestos not be used in the construction -- you would make every effort possible to avoid using asbestos in that project?
A Yeah. That's correct. Yes. Yes. I believe it would be foolhardy to -- to take any other tact but

that.

Q All right. And if that tacc -- if, in fact, despite a customer's request asbestos was used in the construction of a certain facility, that would be very poor corporate practice, would it not?

MR. BROWN: Excuse me here. You're -- you're assuming that it's possible for a customer to make that statement and -- and not be aware of what actually is going on there and I think that's -- that's an incorrect assumption. I want to object to it.

BY MR. WATERS:

Q Let me ask the question again since I kind of broke it up.

A Okay.

Q If, in fact, a customer specifically requested and anticipated that their project would be completed asbestos free, --

A Yes.

Q -- but despite that, asbestos -- extensive amounts of asbestos were used in the project and the customer was not informed of that, under those circumstances would you believe that the contractor should be responsible for any problems that result from that?

A That's a complex question. You got a lot of parts there. Let me get this straight. The customer has come to me and asked for an asbestos free plant or project?

Q Sure.

A I, in turn, have turned around and loaded the project with asbestos? Sir, I find that is a non-real situation.

Q You've never encountered that situation yourself that you're aware of?

A No, sir. In all my years, I don't ever recall working with an engineer that would fly into a client's face in that manner. Every so often there is a charlatan will come along that will parade as a registered P.E. who will pull a stunt like what you're talking about. Sometimes the engineering community gets painted with the paint brush that comes out of that. But in my 42 years of experience in construction and engineering work, I have not ever seen an engineer that would pull anything close to that.

Q If that -- if that were to happen, that would just indicate that engineer or the contractor just really didn't care about the safety and welfare of the people that were gonna have to work in that plant in the future?

A I can imagine there would be all kinds of motivations for a move like that and they would all be out of the norm of what I have seen over the years. Again, I -- I cannot conceive of a scenario like that. Engineers are pretty conservative animals. Typically, they want to play their work close to the vest. They know the -- the hazards of going out on a limb.

MR. WATERS: Let me -- let me just object --

A Sure.

MR. WATERS: -- to the nonresponsive portion.

A Sure.

BY MR. WATERS:

Q Let me ask you if you can envision this scenario where a customer makes an informal request,

informal, not in writing.
A Uh-huh.
Q Informal request that a product -- project be asbestos free.
A Uh-huh.
Q For whatever reason, the project is built using asbestos. And it may be that the information didn't get passed along or no one knows why or perhaps it was one of those other motivations you were describing earlier, I don't know. If that were to happen, would you agree with me that the contractor would be responsible for any resulting injuries that might occur?

MR. BROWN: Well, I need to object to that because you've -- you've assumed that the information wasn't even passed along to the contractor.

MR. WATERS: No. No. No. No. No. I did not assume that. I said --

MR. BROWN: I heard you say that.

MR. WATERS: I said it didn't get

followed.

MR. BROWN: Well --

MR. WATERS: I said the request was made and not --

MR. BROWN: Well, you're assuming facts not in evidence.

MR. WATERS: That's fine.

MR. BROWN: And this witness has an opinion quite to the contrary about that.

MR. WATERS: Well, he can -- I've asked him the question.

MR. BROWN: Well, before we get through, so you don't get sandbagged, we will state for you what that is, if I have to ask the question rather than you.

BY MR. WATERS:

Q Can you answer my question, Mr. Heit?

A Okay. Let's get this straight. We've got a client --
Q Who's made an informal request.
A Who's made an informal request.
Q Orally, not in writing.
A Okay. Who -- who has he made it to?
Q To a representative of the contractor.
A Okay. Who's the representative of the contractor?
Q An engineer, perhaps. I don't know the answer to that. Someone who has been told that they would like the plant to be asbestos free.
A Okay. This -- this is a common problem, especially on EPC jobs, because typically they are in the realm of what's called cost plus. Client people -- client reps are notorious for requesting something on the site and, hey, we don't want it in writing. It -- it's a real whipsaw.
Q Especially if it costs more, I imagine?
A Especially, yes. Yes. So the basic rule is that you get it in writing. We have an elaborate procedure for this. It starts out as a project deviation notice, and it's spelled out what the client has requested or one of our people has identified as a problem. So a preliminary cost comparison is made, the Brown & Root project

manager decides is this worthy of reviewing with the client in the client hierarchy. If he says yes, then it is upgraded to the status of a project variance notice. So at this point we sit down and review the details with the client. If the client agrees to the change and the cost differences, then that becomes a contract change order, and that's the formal route that such a change should be accomplished.

Q Okay.

A Now, we've had jobs where verbal requests have been honored and they always come back to haunt you at the end of the job when the accountants come in and want to know why we've had all these overrides.

Q So it's not uncommon for a customer to come to Brown & Root, or a contractor, like I said, orally, and say, well, we'd like you to do it a little bit different way this time? That is something that happens from time to time, I take it?

A It does happen. It's a dangerous situation.

Q And the proper procedure, if that does happen, is for the contractor to issue a project deviation notice which may become a project variance --

A Variance.

Q -- notice?

A Yes. Yes. Which --
Q And that then becomes a change order?
A Contract change order, yes.
Q All right. And that's the proper way to deal with a -- an oral request of that nature?
A Yes.
Q Okay.
A Yes.
Q And that's -- that's been the policy at Brown & Root since at least '74?
A That's correct.
Q Okay.
A No. No. Let me back up. That probably came into effect maybe in the late 70s --
Q Okay.
A -- as we started to refine our project management approach.
Q And in the late 70s, you established that new approach, if you will, I guess in large part because you were having problems with not having a formal structure to deal with these informal or oral requests from customers?
A Yes. Not only customers, but in managing our own people.
Q Okay. And I guess that was a problem that you

became aware of shortly after you joined in '74?
A No.
Q Not till later?
A Actually, it was maybe about the later 70s.
Q That you became aware of the problem?
A Where I became involved in the problem.
Q Oh, I'm sorry.
A I was assigned to some design work and there were a lot of changes being implemented that were not being properly controlled so that -- I recall procedures being implemented there to pick up on changes.
Q It strikes me that there could be two results of the old policy, both of them bad. One of them you mentioned was that you follow the oral requests and you wind up with cost overrides. Correct?
A Uh-huh. Uh-huh.
Q And the second possibility is that you don't follow the customer's oral request and you maybe wind up getting the customer upset with you for not following the oral request. Is that the other possibility that you've encountered?
A Not necessarily. The fact that you upset a client rep, but keep his home office happy, may be a credit.

Q Okay.
A The idea of following an individual's -- a client rep's oral request may end up disturbing relations with his home office. If he's asked for something that they really don't want, okay, that's gonna be a source of conflict, too.
Q Okay. I appreciate that. When you --
A Let -- let me mention this.
Q Sure.
A There's no carbon copy for all of this. It's amazing the variations that will pop up on a project.
Q Just to switch gears, when you arrived in 1974, were they still using asbestos at Brown & Root for insulation purposes?
A I don't think so.
Q Okay.
A From what I recall, I do not think so.
Q Okay. Your best recollection is sometime before you got there in 1974, Brown & Root had decided to stop using asbestos for insulation purposes?
A Yes. Yes.
Q Okay.
A And the discussions were in progress there in '74.
Q Okay. And, in fact, you may have become aware that

asbestos thermal insulation, such as pipe covering and block and cement, became unavailable after 1972 and 1973. It was no longer on the market. Did you know that?

A No, I did not know that.

Q Okay. Well, I -- There's a whole bunch of questions I don't have to ask you because you weren't at the job site, so we can skip through those.

I think you told me earlier that you would -- given the time frame of this work, that you would not anticipate that safety precautions concerning the asbestos dust would have been taken by Brown & Root -- been taken by Brown & Root in the 1969 to 1971 time frame?

A In my opinion, there -- there probably would not have been any attention directed towards that.

Q All right. So, for example, they wouldn't have used a wetting method or masks or ventilation or barriers or warning signs, protective clothing, nor would they have probably taken measurements, dust measurements in that time frame?

A Okay. My honest opinion is I would have been surprised as hell to have seen any of that taken place out there --

Q Okay.
A -- at that particular time frame.
Q Tell me this, because this is something that I -- from a technical standpoint, I've been unable to fully understand. When a job like that is -- is worked on over the course of a couple of years, --
A Uh-huh.
Q -- do they do insulation work intermittently throughout the time frame, or is insulation work done all at once in a given time frame, or how does that generally work?
A Okay. With respect to a power plant, you have essentially two major work areas for insulation. One is to insulate the steam turbine and its appurtenances. And the other task is to insulate the pipe, okay, and -- and insulate the boiler.
Q Okay. So the boiler, the steam pipe and the turbine?
A That's correct. So typically, you would wait until each of these items is in place. And one of the last things you would do would be to apply the insulation. For example, on your piping, it has to be flushed and then hydrostatically tested. And it's a mandatory requirement that all the joints be visible. So just by the nature of the beast,

insulation comes down towards the later stage of the project.

Q All right. Given the nature of the project and what you know about it from the documentation you were provided by Brown & Root attorneys --

A Uh-huh.

Q -- and given what you've told us about what safety precautions might have been taken or were not taken, do you believe, sir, that Brown & Root workers would have been exposed to asbestos during that project?

MR. BROWN: And here there's no foundation for this. The gentleman was not there, so you're asking him to speculate.

MR. WATERS: No. I'm asking him based on the documentation reviewed and all of his experience.

MR. BROWN: You're asking him about a specific job site and a specific time frame, if not mistaken, Counsel.

MR. WATERS: That's right.

MR. BROWN: Did I miss something?

MR. WATERS: I don't -- Perhaps you did, but I can't speak for your missing or not missing --

MR. BROWN: Well, if he wasn't there, I think you're asking him to speculate.

MR. WATERS: Well, I don't think I am.

BY MR. WATERS:

Q But you can answer, sir, if you can.

MR. BROWN: If you can answer that without speculating, please do so.

A Okay. One of the things that surprise me in those cost reports and a little blurb on insulation, apparently there was some fiberglass insulation, and I believe it was mineral rock.

BY MR. WATERS:

Q Mineral wool?

A Mineral wool insulation. And there was one other non -- I believe it may have been cellular glass, but I was surprised -- okay, and calcium silicate was used, and this -- this is out of the cost reports, so I cannot give you any indication as to what extent asbestos-containing insulation was used because there are these other products and there's no clue there as to how much of each one was used.

MR. WATERS: All right. Let me object to the nonresponsive portion.

BY MR. WATERS:

Q You have told us that asbestos -- Thermobestos was used on the job. Correct, sir?

A Yes, I have. That was in the report.

Q Right. And you know about the use, and I think you used the word application or fabrication of that type of product to know that it will produce dust when it's sawed or cut?

A Okay. Now -- now, Thermobestos, I indicated was a trade name and, I believe, of Johns-Manville. I have no knowledge of what percent asbestos might have been in that product, if there was any asbestos in there.

Q Okay.
A Now -- now, had that product been described by an ASTM requirement, I could go back to the -- Are you familiar with ASTM?
Q Uh-huh.
A I could go back to the ASTM from that era and tell you the percent of asbestos that would have been in those materials.

MR. WATERS: All right. Let me -- let me object to the nonresponsiveness.

BY MR. WATERS:
Q Let's go back a second.
A No, sir. No, sir. I would like to state I am trying my level best to answer directly the question you've laid on me.
Q Oh, that's fine, but I didn't get to finish my question because you interrupted me in the middle.
A I'm sorry.
Q Let me -- let me go back and ask it again. My question to you is, sir: You've told us that asbestos was used on this job, correct? You do not recall testifying to that effect?
A I testified that I saw the reference to

Thermobestos.
Q Let's do this. Are you telling us now at this point in time, sir, that you do not believe asbestos was used on that job?
A No, I didn't say that.
Q Okay.
A No. No, I'm not saying that.
Q All right.
A That -- that's your statement.
Q All right. Let's do this. Assume with me for a moment that asbestos thermal insulation was used on that job. Can you?
A No. No, I -- I refuse to make an assumption like that.
Q Okay. Do you have any reason to think that asbestos was not used on that job?
A No.
Q Okay.
A Again, I don't have anything to put my thinking on it.

MR. BROWN: It's 4:15. I've got another witness that's out in the hall.

MR. WATERS: I'm almost there.

MR. BROWN: Can you give me some idea how much longer we might be?

MR. WATERS: Oh, probably five or ten.

MR. BROWN: Otherwise, I'm gonna send him home.

MR. WATERS: Well, we'll be almost done. We won't have to -- we can start right on him.

MR. BROWN: All right.

BY MR. WATERS:

Q All right. Fair statement that you don't have an opinion as to whether or not people would have been exposed during the operation?

A Yes. Yes. That's correct.

Q All right. Okay. Likewise, you don't have an opinion as to whether or not subcontractors' employees may have been exposed during the project?

A No, sir, I do not.

Q All right. And similarly, you don't have an opinion one way or another as to whether or not employees of the Texas Power & Light Company may have been exposed to asbestos during the course of the project operations?

A No, sir.

Q Okay. You will agree with me, sir, that OSHA, which we've talked about before, you consider them to be a reliable authority with respect to asbestos and the hazards of asbestos?

A At what point in time?

Q At the present point in time.

A Today, yes.

Q Okay. Did you consider OSHA to be a reliable authority on asbestos when you first became cognizant of the OSHA asbestos regulations in the early 1970s?

A I -- I think the record's pretty clear they were not -- they were not an authority.

Q Okay. What criticisms do you have of OSHA and their work with asbestos or concerning asbestos in the early 1970s?

A It's not my opinion. It's out of the -- I don't have them here. If you go back to the Federal Register from that era -- okay. Let me back up. Are you familiar with Walsh-Healy?

Q Uh-huh.

A Okay. First the Federal Register states that the Walsh-Healy monitoring requirements were apparently inadequate, and then there's similar wording for OSHA requirements. It is clearly stated that OSHA was in confusion about the subject at the time.
Q About which -- which standard should apply?
A That's correct.
Q Okay.
A And there was not any regulation against asbestos itself. The regulation dealt with the employee protection.
Q The actual exposure?
A The actual exposure, yes.
Q Okay.
A So it's on up into the 80s. In fact, I believe that it's 1986 before OSHA came out with that huge -- let me call it the Bible, and that remained under attack. And I believe that was under attack on up into the early 90s. So again, it's not my opinion, but I'm simply looking at the Federal Register --
Q All right.
A -- and reading the government's statements.

MR. WATERS: Okay. And let me object, to

the extent you may have exceeded my question, as nonresponsive.

BY MR. WATERS:

Q You mentioned the Walsh-Healy Act. Did Brown & Root do work -- contracting work for the United States Government in the 1960s, to your knowledge?

A Yes, sir, I believe they did.

Q Okay. And as a result of that, they would have been aware of the application of the Walsh-Healy Act to health and safety practices on those federal contract jobs in that time frame?

A I can't say definitively because I wasn't there. I've never had conversations with any of the Brown & Root people with regard to Walsh-Healy. I do know that Walsh-Healy was not that well published or disseminated in the community and it was really the William Stigar Act that brought Walsh-Healy to the forefront.

Q Were you aware that contracts with the United States Government for construction projects specifically stated that the Walsh-Healy Act would apply to the work that was done?

A Yes. Yes, I know that.

Q Okay.
A Yes. Yes.
Q And to the extent that Brown & Root had contracts with the United States Government in the 1950s and 1960s, the Walsh-Healy Act would have been part of those contracts, wouldn't it?
A I can't say for sure. I don't recall that Walsh-Healy goes that far back.
Q All right. In any event, I guess you --
A And I --
Q Go ahead.
A If you -- if you know the date of initiation on Walsh-Healy --
Q I think it's '52, but I don't recall specifically.
A Okay. Okay. Now, I do know that, again, Walsh-Healy did not prohibit the use of asbestos.
Q Right.
A It merely set the exposure limit.
Q The Walsh-Healy Act, as you've just stated, just to repeat it, merely set a standard or a maximum level of exposure --
A Yes.
Q -- that workers working on contracts with the U.S. Government were supposed to be limited to?
A Yes.

Q Okay.
A Yes. Yes.
Q Do you have any familiarity with Thorpe Products Company?
A I do not.
Q Okay.
A I saw their name in the final cost report, I believe, on Valley No. 3.
Q Okay.
A And I'm -- I'm attempting an educated guess there. I believe it was 3.
Q All right. Did you look at some other plans other than 3?
A I looked at the final cost report from 2.
Q Okay. What other documents have you looked at in regards to this case or in preparation for your deposition?
A Valley 2 or 3 documents?
Q Yes, sir.
A That's it.
Q Have you looked at any other documents? I noticed you picked up a document and were looking for a reference here a few moments ago. Have you looked at any other documents in preparation for your deposition that may not have been related to Valley

2 and 3?

A Yes.

Q And what were those?

A Okay. The one I found was just sort of indicative of the times, and this is from the 1965 edition of the American Educator Encyclopedia and they have a discussion here on asbestos. Do you want me to read the whole thing?

Q No. Let me -- Actually, I -- I may shortcut this and just attach it to your deposition.

A Okay.

Q Is this something that you had at home?

A No. I -- I was able to acquire it. But essentially, it describes asbestos as a harmless, very utilitarian material. It goes back to the days of Marco Polo and it gives all the household uses that asbestos has been subjected to or utilized for.

Q Okay.

A And I'd have -- I'd have to say that this is a good representation of my outlook on asbestos at that point in time.

MR. WATERS: All right. Let me object to it as nonresponsive.

BY MR. WATERS:
Q The -- what is the American Educator Encyclopedia?
A It's one of the encyclopedia sets that has been published.
Q Are you familiar with the Encyclopedia Britannica?
A Yes, I am.
Q And will you agree with me that of the various encyclopedias that are published, Encyclopedia Britannica is more well-respected, certainly, than the American Educator Encyclopedia?
A I can't say that.
Q Okay. Are you familiar with the fact that Encyclopedia Britannica, in the 1940s, identified a number of diseases, including cancer, as being caused by asbestos, if you were to happen to look up asbestos in that encyclopedia?
A I have not had the opportunity to look that one up.
Q Okay.
A I have no idea of what you're commenting on here.
Q What other documents have you -- have you looked at in preparation for your deposition or for testifying today?
A Okay. These are some odds and ends. This is a

reference book that goes back to the 60s put out by -- okay. This one was issued in '71. It's a key word index to the various national standards, and you can see there's many, many asbestos products that were described by National Voluntary Consensus Standards.
Q And it doesn't anywhere in this document, for example, indicate how those products may be used safely or how to avoid injury with those products?
A No, sir. This is merely a listing of titles that have been simplified to allow quick access.
Q All right, sir. And what else have you got?
A This is a listing of the asbestos products that are described by National Standards, products and other related activities. I have to admit I was surprised to see how much there is published in asbestos products even today. A few of those have been updated within just the last year or so. This is -- These are shots out of one of the reference catalogs I use.
Q All right, sir.
A Then this is a -- These are a couple of indexes from the 1970 ASTM books, parts 12 and 14, and there's some asbestos products identified there. In other words, these are standards that are

produced by these voluntary committees and represent essentially state-of-the-art thinking.

Q All right. What these documents are not, however, is a reflection of or discussion or presentation of any of the hazards of asbestos or cancer or anything of that nature?

A No, sir. They're -- there's no reference that I've ever come across in any of the material in that era that -- that denoted any hazards of the material.

MR. WATERS: All right. Let me object --

A And --

BY MR. WATERS:

Q Go ahead.

A Okay. Now, you're throwing me with your comment about not answering properly or --

Q Nonresponsive.

A Nonresponsive. Well, would you explain to me what you mean by nonresponsive?

MR. WATERS: As soon as I finish making the same objection one more time that you've been nonresponsive.

THE WITNESS: Okay.

BY MR. WATERS:

Q My specific question to you, Mr. Heit, was only that these documents did not appear to make any reference with respect to the hazards of asbestos, including asbestos. The answer to that was no, they do not.

A Okay.

Q And then you went on to say some additional information, which I appreciated, but I had to make that objection.

A Okay. Okay.

Q All right. It looks to me like you've done -- as part of your involvement with this case, you've taken it upon yourself to do a little bit of independent research.

A That's --

Q Okay.

A -- correct.

Q All right.

A Do you want this last one?

Q I have one more question.

A Sure.

Q I take it, however, that you did not go look in the library and find any of the literally thousands of articles and the medical and scientific literature that discuss people dying by the hundreds of asbestos-related diseases and cancers in this country since the 1930s?

MR. BROWN: That assumes facts not in evidence.

BY MR. WATERS:

Q That's not --

MR. BROWN: I object. It calls for speculation.

BY MR. WATERS:

Q That was not the type of information you were looking for when you did your research, was it, sir?

MR. BROWN: Counsel, the purpose for these documents is in support of his opinion that the use of asbestos in the power plants, such as Valley, in 1967 to 1971 is proper, meets with good construction engineering standards, which is one of the opinions he's going to have. That's why he has that. Also to show you some evidence of the knowledge as it existed under the same or similar circumstances under which this project was designed and built, or one like it. That's why he brought you these.

MR. WATERS: I appreciate that. Thank you, Phil, for telling us why he brought it.

A Now --

BY MR. WATERS:

Q But -- but I need an answer to my question, which is that you did not do that type of research when you went -- research, you weren't looking for information in the literature, scientific and medical literature about those hazards?

MR. BROWN: And -- and you're assuming that such information existed --

MR. WATERS: Dr. Cagel testified it existed.

MR. BROWN: -- at a particular time. I don't remember any particular time frame being mentioned this morning, Andy.

MR. WATERS: Well, whatever.

A Let me say that I believe Brown & Root has one of the most complete engineering libraries of any of the engineering companies in town, and I'm not aware of any medical documents that we keep out there. So that -- the medical area is not something that I -- I would have been attempting to research.

BY MR. WATERS:

Q Okay. I think you've answered it.

A In other words, I've -- I've approached it from an engineer's point of view.

Q What's your last document there, sir?

A These are some shots out of a book published or copyrighted in 1969 and the title of the book is "Thermal Insulation." And this is part of the Von Nostrand Reinhold Environmental Engineering Series and they talk about their environmental engineering series as dedicated to the presentation of current and vital information relative to the engineering aspects of controlling man's physical environment, et cetera, et cetera.

But anyway, they cover all your various kinds of insulations, and I've gone ahead and xeroxed sheets that have reference to asbestos and a lot of related material. This book was co-authored by a number of insulation people. I thought that was in here.

Q Let me take a look at it. Maybe we can just short circuit this.

A Sure. Sure. Oh, okay. On Page 204, they talk about safety requirements and it's all with respect to the operating requirements for insulation, but there's no mention of any -- any hazards whatsoever in relation to asbestos, and this -- this particular book was probably the primary insulation textbook at the time. And like I say, it was copyrighted in 1969.

MR. WATERS: All right. Let me object to the portion that was nonresponsive.

BY MR. WATERS:

Q This is essentially a textbook for engineers. Correct, sir?

A Yes, sir. Yeah. That's a good description.

Q It's for people that are involved with drawing and -- the drawings and the practical applications necessary to construct power plants or refineries?

A This is more basic. This would be used by the people who were selecting the materials --

Q Okay.

A -- to be used in the particular project.

Q All right. If it's all right with you and your lawyer, what we'll do is attach these documents as exhibits to the deposition.

MR. BROWN: That's fine.

MR. WATERS: Okay.

MR. BROWN: And it's 4:30. I'm just gonna release this other witness unless we're finished here pretty quick.

MR. WATERS: Let me think. I think I may be finished.

MR. BROWN: Have you got anything?

MR. FISHER: (Shaking head).

MR. BROWN: We'll reserve our questions.

MR. WATERS: I'm sorry. I -- I was just looking over my notes. I have one more -- one or two more questions.

BY MR. WATERS:

Q I went through a list with you sometime earlier of some precautions and -- that might have been taken, and you indicated they probably were not taken in that time frame.

A Uh-huh.

Q Do you recall that?

A Yes, sir, I do.

Q Are you aware that all of those precautions -- precautionary measures that I read off to you were suggested in the medical and scientific literature back in the 1930s to avoid asbestos disease?

MR. BROWN: Again, I -- Excuse me. That

assumes facts not in evidence.

MR. WATERS: Okay.

MR. BROWN: And you're asking him to speculate. He's told you he hasn't made that kind of analysis, so how could he be in a position to respond to that?

MR. WATERS: Well, if he's not aware of it, he can so answer.

A I'm not aware of that.

BY MR. WATERS:

Q Knowing what you know today, sir, will you agree with me that asbestos products are defective -- were defective and dangerous?

MR. BROWN: Wait a minute. Wait a minute. Wait a minute. That's -- You don't define defective. You certainly don't limit it to the time frame at issue in this case.

MR. WATERS: I said knowing --

MR. BROWN: It's a highly improper question. You're asking for a legal conclusion, and this witness, I don't believe, is qualified to answer that, even if he understood the question.

BY MR. WATERS:

Q All right. Let me take it in pieces.

MR. BROWN: He's not gonna respond to that question, Andy.

MR. WATERS: Well, then you can instruct him not to answer the question.

MR. BROWN: I'll instruct you not to answer.

THE WITNESS: Okay.

MR. WATERS: I haven't asked it yet.

MR. BROWN: Are you gonna ask him that?

MR. WATERS: Did you hear me? I said let

me do it in pieces. And you said no, he's not gonna answer it. I haven't even put the question forth yet.

BY MR. WATERS:

Q Will you agree with me --

MR. BROWN: Well, I'm gonna let the next witness go unless you hurry up.

BY MR. WATERS:

Q Will you agree with me, sir, that knowing what you know today, that asbestos thermal insulation products that were used in the early 70s were dangerous?

MR. BROWN: I'm gonna object. Asks for a legal conclusion. You haven't framed it within the area of his expertise and you haven't tied it down to any specific time frame or made it relevant to any of the issues at trial in this case. Nor have you defined the term defective or dangerous.

MR. WATERS: I think dangerous was. I was --

MR. BROWN: You certainly haven't cited any circumstances or description of what the particular products are. So without any of these basic elemental things, how can this witness do anything but speculate?

BY MR. WATERS:

Q Mr. Heit, can you answer my question, sir?

MR. BROWN: And I object.

A Only if I qualify it.

BY MR. WATERS:

Q All right.

A Okay. I believe probably everyone of us in here uses gasoline on a regular basis.

Q Probably.

A Okay. Would you consider gasoline to be dangerous?

MR. BROWN: It's not his deposition, Mr. Heit.

THE WITNESS: Oh, I'm sorry.

MR. BROWN: It's your deposition.

THE WITNESS: I'm sorry. I'm sorry.

MR. BROWN: If you can answer the question without speculating, please do so. We haven't -- One of your colleagues has been cooling his heels out there for 35 minutes.

MR. WATERS: Well, let's just get one answer to this final question and see if we can --

MR. BROWN: If he can answer it. And I think he cannot answer it. It calls for speculation.

A It -- it's too broad-based a question. I can't answer it.

BY MR. WATERS:

Q Okay. You have told us previously that you considered asbestos to be dangerous, correct, sir?

MR. BROWN: Well, again, he -- you've

misstated his prior testimony.

MR. WATERS: No, I'm not.

MR. BROWN: He said earlier about what you think today -- some opinion, blah, blah, blah. Here your question's not tied to any particular time frame or any circumstances under which the product may be used. And therefore, it's not relevant to any issue.

BY MR. WATERS:

Q All right. Let me see if I can clear up Mr. Brown's objections.

Knowing what you know today, sir, will you agree with me that asbestos thermal insulation products that were used in the early 1970s and when their use created asbestos-containing dust, that those products were dangerous?

A I would have to qualify that kind of an answer. If the worker were wearing a -- a face protector or if the material was damp, then it probably wouldn't be dangerous, same as the gasoline.

Q All right. Fair enough. And if those two things were not taking place, if the worker was not using a respirator, if wetting had not taken place, under those circumstances you would consider it to be dangerous?

MR. BROWN: And again, I need to object. It's -- You're just -- you're asking this question without tying it down to any specific issue in this case. You haven't described what the products are or the circumstances. You haven't -- you haven't put the worker in any proximity to the product. You're asking this witness to speculate.

BY MR. WATERS:

Q Can you answer?

MR. BROWN: And he's not been put up as a witness on the question of industrial hygiene and matters such that -- such as that. He is here to give you his opinions from an engineering standpoint about the design, construction and use of asbestos and that at the times relevant to this issue. And it's outside his designation and you're asking him to speculate and it's something he's already told you he doesn't have expertise about. Now, if you want to ask him for his personal opinion --

MR. WATERS: I want an answer to my question, Phil. Are you finished with your objection?

MR. BROWN: If you want to ask him a personal opinion, that's different.

BY MR. WATERS:

Q Well, can you tell me the answer to my question, sir, so we can get this over with?
A I don't feel it would be an accurate answer or a reasonable answer.
Q All right. Let's -- let's go back over this. You've told us that you would not consider asbestos producing dust to be hazardous in the early 70s if the person was using protection, respiratory protection or if the material was wetted down. Do you recall that testimony?
A Yes.
Q All right.
A Yes. Yes.
Q I want you to assume now that neither of those two protections were being taken. Under those

circumstances, would you consider it to be dangerous?
A I still can't give a reasonable answer because I don't know how much of the asbestos has been disturbed. I don't know how close the employee is.
Q Okay. But you do know one thing, and that is that in the time frame 1969 to 1971, those precautions were not being taken. Correct, sir?

MR. BROWN: Well, again -- again, if you're trying to tie it to this case, there's no foundation for that. You're asking him to speculate.

BY MR. WATERS:
Q Can you answer, Mr. Heit?

MR. BROWN: He didn't even start with the company until 1974.

A I do not have any hard and fast information or knowledge of what occurred at that job site.

BY MR. WATERS:
Q All right. What you have --

A I really don't.
Q What you have told us earlier, Mr. Heit, is that under the circumstances, you don't believe probably that those precautions would have been taken in that time frame. Correct, sir? Do you recall that?

MR. BROWN: He didn't say that.

BY MR. WATERS:
Q Do you recall that testimony?

MR. BROWN: That's an incorrect statement of his earlier testimony.

MR. WATERS: Well, then he can tell me that.

BY MR. WATERS:
Q But do you recall that testimony, sir?
A Okay. Now, I'm -- I'm afraid some words are getting shifted around here.
Q Do you recall testifying earlier, sir, that based on your experience and understanding of the work that was done and the precautions that may have

been taken, that this laundry list of precautions probably were not taken in the 1969 to 1971 time frame? Do you recall testifying --
A Yes.
Q All right.
A Okay.

MR. BROWN: And he explained to you why, too, Counsel.

MR. WATERS: Thank you, Mr. Brown. And no further questions, Mr. Heit. Thank you, very much.

THE WITNESS: Thank you.

MR. BROWN: Do you have any questions?

MR. FISHER: (Shakes head).

MR. BROWN: We reserve our questions.

MR. KALE: Thank you, Mr. Heit.

THE WITNESS: Thank you.

THE VIDEOGRAPHER: Okay. Off the record at 4:45.

(At this time, the instruments referred to were marked Heit Exhibit Nos. 2 through 7 for identification and are attached hereto.)

(Signature required.)

THE STATE OF TEXAS :

I, Michelle Pfeiffer, a Certified Shorthand Reporter and the undersigned notary public in and of the State of Texas, certify that the caption to this video deposition correctly states the facts set forth therein; that the examination of the witness named in said caption was correctly reported in shorthand by me at the time and place and under the agreement set forth in said caption.

I further certify that this transcription has been transcribed from shorthand into typewriting through stenographically computer-aided transcription and under my supervision in the foregoing transcript; and that said transcript contains a correct record of the proceedings had at said time and place.

Given under my hand and seal of office this the 2nd day of September, 1996.

MICHELLE PFEIFFER
NOTARY PUBLIC
State of Texas
Comm. Exp. 07-18-98

Michelle Pfeiffer
Notary Public in and for
The State of Texas

My Commission Expires: 7-18-98

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I, RAYMOND A. HEIT, have read the foregoing deposition and hereby affix my signature that same is true and correct, except as noted herein.

____
RAYMOND A. HEIT

THE STATE OF TEXAS :

SUBSCRIBED AND SWORN to before me this the ________ day of ______________________, 1996.

____
Notary Public in and for
The State of Texas

My Commission Expires: ________________________

NO. 31506

SHIRLEY HODGE, Individually and as Personal Representative of the and Estate of A. J. Hodge, Jr., Deceased; GREGG A HODGE and ANGELA R. McClain,	:	IN THE DISTRICT COURT OF
Plaintiffs,	:	
VS.	:	FANNIN COUNTY, T E X A S
TEXAS UTILITIES ELECTRIC COMPANY (d/b/a VALLEY POWER PLANT), et al	:	
Defendants.	:	6TH JUDICIAL DISTRICT

CERTIFICATE FOR THE VIDEOTAPE ORAL DEPOSITION OF
RAYMOND A. HEIT
September 24th, 1996

Taxable Costs: ________________
Charged to: Andrew Waters, Esq.
Bar Number: 20911450
For: Plaintiffs

I, Michelle Pfeiffer, a Certified Shorthand Reporter for the State of Texas, hereby certify, pursuant to the Rules and/or agreement of the parties present, to the following:

That this deposition transcript is a true record of the testimony given by the witness named herein, after said witness was duly sworn by me;

_____ That signature was waived by the witness.

_____ That signature is in process of being obtained, but filing was requested before time allowable for signature.

_____ That the deposition transcript by way of_________ ______________ was submitted on __________________ to ____________________________ for examination, signature and return to Q & A Reporting, Inc.

_____ That attached is the signature page and Change/Correction Sheet containing changes, if any, and the reasons therefor, made by the witness.

_____ That the deposition transcript and/or signature page was not returned to the deposition officer by the witness.

_____ That the witness failed to appear to read and sign the deposition.

_____ That the original deposition transcript, or a copy thereof, together with copies of all exhibits provided to the reporter, was delivered on __________________ to the attorney or party who asked the first question appearing in the transcript.

_____ That a copy of this certificate is being sent to: the following includes all parties of record:

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THE STATE OF TEXAS:
COUNTY OF HARRIS:

SUBSCRIBED and SWORN TO on this the ______ day of __________________________, 1996.

MICHELLE PFEIFFER
NOTARY PUBLIC
State of Texas
Comm. Exp. 07-18-98

____
Michelle Pfeiffer
Certification No. 3212
Cert. Expires: 12-31-96
Commission Expires: 7-18-98

Q & A Reporting, Inc.
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NO. 31506

SHIRLEY HODGE, Individually and as Personal Representative of the and Estate of A. J. Hodge, Jr., Deceased; GREGG A HODGE and ANGELA R. McClain,	:	IN THE DISTRICT COURT OF
Plaintiffs,	:	
VS.	:	FANNIN COUNTY, T E X A S
TEXAS UTILITIES ELECTRIC COMPANY (d/b/a VALLEY POWER PLANT), et al	:	
Defendants.	:	6TH JUDICIAL DISTRICT

EXHIBITS TO THE

VIDEOTAPE

ORAL DEPOSITION OF RAYMOND A. HEIT

September 24th, 1996

COPY

NO. 31506

SHIRLEY HODGE, Individually and as Personal Representative of the and Estate of A J HODGE, JR., Deceased; GREGG A. HODGE and ANGELA R. McCLAIN,	§	IN THE DISTRICT COURT OF
Plaintiffs,	§	
vs.	§	
TEXAS UTILITIES ELECTRIC COMPANY (d/b/a VALLEY POWER PLANT); CSR, LTD.; BROWN & ROOT USA, INC.; BROWN & ROOT, INC. (A DELAWARE CORPORATION)and as successor to BROWN & ROOT, INC. (A TEXAS CORPORATION), individually and as successor to BROWN & ROOT, INC.; THORPE PRODUCTS COMPANY; THORPE CORPORATION; J. T. THORPE COMPANY (Individually and as successor-in-interest to THORPE INSULATION COMPANY) and THORPE INSULATION SERVICES COMPANY,	§	FANNIN COUNTY, TEXAS
Defendants.	§	6TH JUDICIAL DISTRICT

AMENDED NOTICE OF INTENTION TO TAKE
VIDEOTAPED DEPOSITION DUCES TECUM

Heit
EXHIBIT NO. 1
9/24/96
M PFEIFFER

TO ALL DEFENDANTS AND THEIR COUNSEL OF RECORD:

PLEASE TAKE NOTICE that, pursuant to the Texas Rules of Civil Procedure, Plaintiff, Shirley Hodge, Individually and as Personal Representative of the Heirs and Estate of A. J. Hodge, Jr., Deceased, will take the following **rescheduled** videotaped depositions at the offices of Brown & Root, 4100 Clinton Dr., Houston, Texas before a certified court reporter and videotape technician:

NAME	DATE	TIME
Raymond Heit	September 24, 1996	1:00 p.m.
Dale Drysdale	September 24, 1996	Immediately following Mr Heit's deposition
Delbert Gaines	September 24, 1996	Immediately following Mr. Drysdale's deposition

The depositions will continue from day to day until completed. All counsel of record are invited to attend and cross-examine. The previously noticed depositions of Francis Weir for September 23, 1996 at 10:00 a.m. and Jimmy Kubeck for September 27, 1996 at 10:00 a.m. are **cancelled**.

Each Deponent will produce at the time of this deposition the items listed on Exhibit "A" attached hereto and incorporated herein.

Respectfully submitted,

SILBER • PEARLMAN, P C.

By J Todd Kale /SB
J. Todd Kale
State Bar No. 11079960

3110 Webb Avenue
Dallas, Texas 75205
(214) 528-2000
(214) 522-7400 FAX

CERTIFICATE OF SERVICE

The undersigned certifies that a true and correct copy of the foregoing instrument has been served on all known counsel of record for the Defendants by telecopy on the 20th day of September, 1996

J. Todd Kale /SB

J. Todd Kale

EXHIBIT "A"

The following items from Brown & Root's Industrial Hygiene Library are to be produced at each witness' deposition. Please bring the following reference books or materials:

TITLE OF PUBLICATION	PUBLISHER	AUTHOR/ EDITOR	DATE	B/F/O	PGS	OWNER	LOCA-TION(S)
Air Contaminants - Perm. Exposure Limits	OSHA	OSHA	1989	B	78	CSH	03-117B
Asbestos Alternatives				F		DTD	03-120/ File #1
Asbestos Analyses				F		DTD	03-120/ File #1
Asbestos Controls				F		DTD	03-120/ File #1
Asbestos Federal Reg. & Guid. Doc.	UTHCat Tyler	UTHC at Tyler	1986	O	483	CSH	03-120
Asbestos Information				F		DTD	03-120/ File #1
Asbestos Information				F		DTD	03-120/ File #1
Benzene				F		DTD	03-120/ File #1
Carcinogens	Tech. Resources	DHHS	1991	B	481	CSH	03-1188
Dust/Dust Controls				F		DTD	03-120/ File #1
Epidemiology Man and Disease	Macmillian Company	Fox, Hall, Elveback	1970		339	DTD	03-120
Health Effects of Exp. To Diesel Exhaust	NAP	NRC	1981	B	169	CSH	03-120
Industrial Hygiene and Toxicology, Vol. 1-2	Wiley & Sons	Patty, F. A.	48-58	B	830	CSH	03-117A
MMMF - TOX & EPI				F		DTD	03-120/ File #2
Occupational Diseases	NIOSH	NIOSH	1977	B	606	CSH	03-120
Recordkeeping Guide-lines for Occ. Injur.	OSHA	OSHA	1970	B	82	DTD	03-120
Toxicological Profile for Asbestos	Clement Int. Corp.	Henriques/ Kiman	1993	B	200	CSH	03-117B

Thermal Insulation

JOHN F. MALLOY

VAN NOSTRAND REINHOLD COMPANY
New York Toronto London Melbourne

LIBRARY OF CONGRESS CATALOG CARD NUMBER: 70-80096

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MALVERN F. OBRECHT, PH.D., P.E.
Consulting Editor

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Malloy Thermal Insulation

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4 Properties of Thermal Insulation

Basic Types of Thermal Insulation

The characteristics of a thermal insulation are mainly determined by its composition. For that reason thermal insulations are divided into five major types, although in many instances particular insulations are hybrids of these types.

The five major types are

1. Flake
2. Fibrous
3. Granular
4. Cellular
5. Reflective

Flake insulation is composed of small particles or flakes which finely divide the air space. These flakes may or may not be bonded together. Vermiculite, or expanded mica, is commonly used for flake insulation.

Fibrous insulation is composed of small diameter fibers which finely divide the air space. These fibers may be organic or inorganic and may or may not be bonded together. Organic fibers may be of hair, wood or cane, or synthetic. The inorganic fibers may be of glass, rock wool, slag wool, alumina silica, asbestos, or carbon.

Granular insulation is composed of small nodules which contain voids or hollow spaces. It is not considered a true cellular material since gas can be transferred between the individual spaces. The material may be magnesia, calcium silicate, diatomaceous earth, and vegetable cork.

Cellular insulation is composed of small individual cells sealed from each other. It is produced of glass, rubber, and plastics.

Reflective insulation is composed of parallel thin sheets, or foil, of high thermal reflectance and spaced to reflect radiant heat back toward its source. The spacing also is designed to provide restricted air (or gas) spaces. The restricted air space reduces heat transfer which would be caused by convection and conduction. In most instances the thin reflective sheets are made of aluminum or stainless steel.

Reflective insulation obtains its results from its design and construction, it is a system rather than a single homogeneous material For this reason its properties will be discussed separately from those of the mass insulations

Forms of Mass Insulation

Many mass insulations are produced using two or more of the types listed above. For example, fibers are added to granular material to increase the tensile strength of the product.

To obtain desired properties, frequently one type of insulation is used in combination with others, such as systems using lightweight fibers to separate reflective sheets. Another method used to reduce heat transfer is to install various types of insulation in a system by which the amount of air is reduced to small quantities. These *systems* of insulation will be discussed further on in the Manual.

The numerous mass insulations produced have varied characteristics and are intended for many uses. For this reason insulations are produced in many forms. Some of these are:

1. Rigid boards, blocks, sheets, and preformed shapes such as pipe covering, curved segments, etc.
2. Semi-rigid boards, sheets, and preformed shapes
3. Flexible boards, sheets and preformed shapes
4. Blankets
5. Batts
6. Felts
7. Tapes
8. Ropes
9. Cements
10. Loose
11. Fill
12. Mastics

Eventually each of these forms of insulation is installed and becomes a part of an insulation *system*. Its properties then become important to ensure that it will function properly in the system. Thus the insulation's properties become of utmost importance to its economic installation, service life, and thermal efficiency

The large number of types of insulation and forms in which it is produced almost ensures that their comparative properties will vary widely This is to be expected and desired, as the uses of the material also vary widely

Properties of mass insulations

Knowledge of the properties of insulations is necessary for selection of the proper insulation for specific uses. Many times, in a given installation, a certain property may be of little importance, whereas that same property may be of utmost importance in a different application One of the problems in the insulation industry is that some of the manufacturers resist providing information as to their material's properties. They feel that this information may limit the use of their material; this is an error Without this information their materials may be misused, resulting in failures and a loss of money to the manufacturer, the contractor and the user

Many of the following listed properties are not freely available from the manufacturers or in their published literature: therefore they have not been included in the Tables of Properties 30–38, which follow later in this chapter Upon occasion, however, some of the omitted properties may assume extreme importance In this case effort should be made to obtain them on an individual basis from the appropriate manufacturers

Properties (and Their Significance) of Rigid and Semi-Rigid Insulations

The basic properties of mass insulations and the significance of these properties in choosing an insulation are as follows:

Abrasion resistance The property of a material measuring its ability to withstand abrasion without wearing away. Abrasion is caused by the rubbing together of two abutting objects or by an external force or object rubbing against the surface of one of the objects.

Alkalinity (pH) or acidity The tendency of a material to have a basic (alkaline) or acidic reaction. It is measured on the pH scale, with all readings above 7.0 alkaline and below 7.0 acidic. A reading of 7.0 indicates *neutral*. This indicates to which metals the material may be applied without causing corrosion.

Breaking load The property of a material which indicates its strength in flexure when loaded as a simply supported beam with a constantly increasing concentrated load at its center.

This property is of significance in installations where the material must "bridge" over a discontinuity in its support.

Capillarity The property of a material which enables it to suck liquid up into or through itself.

Should a water leak occur in installed insulation, high capillarity will spread the damage.

Chemical reaction The property of a material which measures its tendency to chemically combine (or react) with other materials which may come into contact with or be absorbed by it.

This information is very important as such reaction may cause a fire hazard. In addition to holding the combustible liquids, the intermixing may change the combustibility of the chemicals by lowering their flash, fire, and self-ignition points.

Coefficient of expansion (Contraction) The property of a material which measures its dimensional change corresponding to temperature change.

This is necessary information in solving problems related to spacing and design of expansion and contraction joints in the insulation system.

Combustibility The property of a material which measures (on an arbitrary scale referred to some common material) its tendency to burn.

This information is vital in determining any possible fire hazard. If a material is combustible its potential contribution to a fire hazard is determined by the combination of the following.

1. Flash point
2. Fire point
3. Self-ignition point (if any)
4. Burning rate
5. Rate of flame travel
6. Heat contribution
7. Explosion index
8. Self-internal heating
9. Toxicity of products of combustion
10. Smoke index
11. Melting point

Compressive strength The property of a material which measures its ability to resist a load tending to squeeze or shorten it.

It is one of the properties of insulation which determines its performance in service. The desirable compressive strength may be high or low. Where the insulation should support a load without crushing, high compression strength is needed. Conversely when insulation is used to take up dimensional change, a low compressive strength may be needed. In the latter case the *percentage of recovery* to original size upon the relief of stress becomes important.

Corrosion to substrates The property of a material which indicates its chemical effect on various metals upon which it may be installed. (See "*Corrosion Effect*," Chapter 15.)

This is of upmost importance. If an insulation may cause corrosion to a substrate metal, either another insulation should be selected or the substrate metal should be protected by a proper coating. The fact that certain combinations of insulations and metals may cause a corrosion of the metal makes it necessary to determine the corrosive effect of each insulation on, for example, carbon steel, stainless steel, monel, copper, and aluminum. Of particular importance is the stress-corrosion effect on austenitic stainless steels.

Density The weight of a unit volume of insulation, such as lb cu ft.

It is necessary to know the density to calculate loadings and the heating rate when mass is one of the functions.

Dimensional stability The property of a material which indicates its ability to retain its size or shape after aging, cutting, or being subjected to temperature or moisture.

As every insulation must be installed to given dimensions, this property affects the ease of installation and also its service life

Flexural strength The property of a material which measures its ability to resist bending (flexing) without breaking.

It is one of the mechanical properties which determines the suitability of an insulation during application and in service.

Hardness The property of a material which measures its ability to resist penetration.

In some applications a hard surface is needed, while in others a soft surface is desired. It is, again, one of the mechanical properties to be considered in the selection of a material for a given application.

Hygroscopicity The property of a material which measures its ability to absorb and retain water, in either the liquid or vapor state from the ambient air, with said retained moisture being in a state of equilibrium with the moisture in the surrounding air.

This property points up the fact that water in insulation, however it got there, must be allowed to escape without damage to the outer insulation protection. In other words, the higher the hygroscopicity, the more water the insulation will initially absorb and eventually have to reject when subjected to heat. This emphasizes the need for near-perfect moisture protection in the first place. If moisture does get in, however, then the outer barrier must be of the "breathing" type to let it back out when heated.

Incidence of cracking The property of a material which indicates its tendency to crack when applied to a hot surface at its recommended maximum temperature.

This cracking affects the strength of the insulation and its thermal conductivity.

Resistance to acids The property of a material which indicates its ability to resist decomposition by various acids to which it may be subjected.

As insulation is used in all kinds of atmospheres and conditions of chemical contamination, its resistance to the acids to which it may be subjected affects its service life.

Resistance to caustics The definition and significance of resistance to caustics is the same as that given for "resistance to acids," but it is paraphrased to read "caustics" instead of "acids."

Resistance to solvents The definition and significance of resistance to solvents is the same as that given for "resistance to acids" but it is paraphrased to read "solvents" instead of "acids."

Shear strength The property of a material which indicates its ability to resist cleavage

It is another of the mechanical properties which indicates the suitability of an insulation during application and in service.

Shrinkage The property of a material which indicates its proportionate loss in dimensions or volume when its temperature is changed

It is a major cause of cracks in high-temperature applications. It will occur both as linear (length and width) and volumetric loss. Insulation's shrinkage in relation to temperature should be determined in order to properly design insulation expansion-contraction joints for vessels and piping.

Specific gravity—apparent The ratio of the specific weight of a material, including all its voids, to the weight of an equal volume of water. This can be obtained by the simple device of dividing the weight/cu ft of the material (density) by the weight of a cubic foot of water.

Specific gravity—real The ratio of the specific weight of the mass of solids making up a material to the weight of an equal volume of water.

To illustrate the difference between these two specific gravities, glass fiber insulation will have an approximate *apparent specific gravity of 0.05* and a *real specific gravity of 2.5*

Specific heat The ratio of the amount of heat required to raise a unit mass of material 1 F to that required to raise a unit mass of water 1 F at some specified temperature. It is essential to know this property for solution of problems related to heat storage and temperature-time lag.

Temperature limits The maximum temperatures, as determined by its properties, up to and down to which a material will experience no essential change in its properties.

Within its limits a material should not fail mechanically, chemically, or thermally. These limits are determined by the effect of the temperature on the properties listed in this chapter. Time exposure to temperature and the number of changes in temperature have an effect on some materials. For this reason, in most instances, it is necessary to determine the following:

Max. temp.—continuous operation
Max. temp.—intermittent operation
Max. temp.—cycle operation
Min. temp. —cycle operation
Min. temp.—continuous cycle operation

Temperature rise—self-internal heating A property of some materials indicating that when heated above a certain temperature an internal reaction will occur, causing an internal temperature rise far in excess of the temperatures to which they are subjected.

This internal temperature not only causes damage to the material itself, but can be very hazardous, as serious fires can result.

Tensile strength The property of a material which measures its ability to resist a stress tending to pull it apart.

It is another of the mechanical properties which evaluate the service performance of the insulation.

Thermal conductivity The property of a material which indicates the relative ease or difficulty by which heat is transmitted through the material due to a temperature difference existing between its two surfaces. (See Chapter 15)

As the property varies with mean temperature it is essential to know the conductivity curve of an insulation to calculate heat transfer. However, the prime value of insulation is its *resistance* to heat transfer. The "thermal resistivity" of a material is the reciprocal of thermal conductivity and as it is more meaningful should be the fundamental property listed for insulations. For example: An insulation with a conductivity of 0.25 as compared to another of 0.45 appears to be not too much different. Whereas if the thermal resistivity was stated it would be 4.00 for the first material and 2.22 for the second.

Thermal diffusivity The property of a material which measures the time rate of temperature movement through it. It is *not* a measure of amount of heat or heat transfer.

In many cases this is an important factor. For example, in cycle operations where rapid dissipation of temperature is desired a high rate of thermal diffusivity is important. Conversely, when insulation is used as fire protection a slow rate of thermal diffusivity is most important. This little understood factor is of utmost importance in engineering these types of applications.

Thermal shock resistance The property of a material which indicates its ability to be subjected to rapid temperature changes without physical failure.

This property is important when insulations are used on cycle operations, fast heat ups, and for fire protection.

Vapor migration The property of a material which measures the rate at which water vapor will penetrate it due to vapor pressure differences between its surfaces.

The water vapor which enters insulation has serious effects on its thermal conductivity and on some of its physical and chemical properties. It is well known that water vapor entering low temperature insulation will at some point condense into liquid or freeze into ice and will eventually destroy the thermal efficiency of the insulation. However, vapor migration into insulation on ambient and hot service may cause swelling of the insulation and contribute to rusting of steel or stress corrosion of stainless steel.

Vibration resistance The property of a material which indicates its ability to resist mechanical vibration, without wearing away, settling, or dusting off.

Almost any insulation used in an industrial application will be subjected to some vibration, such as compressor vibration, fan pulsations, or vibrations caused by the fluids or gases passing through the lines or vessels.

Warpage The change in dimension of one surface of insulation as compared to that of another surface due to difference in temperature of the two surfaces.

Warpage will cause cracks in the finished insulation and damage to the weather and vapor barriers.

Water absorption The property of a material which measures the amount of water it will soak up when submerged in water.

It is a measure of the amount of water which may be taken into an insulation due to water leaks in weather barrier or during construction.

It is also important as an indicator of the amount of combustible or toxic liquids which an insulation could absorb in case of spillage. However, a material may be water repellent and still be quite absorptive when subjected to hydrocarbons, solvents, or other penetrating liquids. In special cases like these, the absorptivity of insulations must be tested with the chemical to which it may be subjected.

Properties of Insulating Cements, Foams, and Insulating Mastics

After they are applied and dried, insulating cements, insulating mastics, foamed in place insulations, sprayed foam, and sprayed inorganic insulations all become rigid or semi-rigid and their properties are the same as those listed for the rigid or semi-rigid material. However, from the wet state to dried (or cured) state additional properties must be considered as follows:

Adhesion—wet The property of a material which indicates its ability to stick to the surface to which it has been applied without sliding or falling off.

As the temperature at the time of application and the temperature of the surface to which the material is applied affect the adhesion, either the limits of these two temperatures must be established or the adhesion for various temperatures determined. This property has direct bearing on the capability and cost of an installation.

Adhesion—dry The property of a material which indicates its ability to bond to the surface to which it is applied and remain in place in service.

Temperature may alsoaffect this surface adhesion so limits must be set, or adhesion must be determined at various temperatures.

Shrinkage—wet to dry The property of a material which measures the difference in volumetric and linear change which occurs in the drying of insulating cements and mastics.

This change affects not only the quantities of material required, but it can also affect the finished, dried material if cracks or breaks develop because of excessive shrinkage.

Expansion—wet state to cured state The property of a material which measures the difference in volumetric change in poured or sprayed, foamed-in-place organics.

This information is necessary in the calculation of quantities of material necessary to obtain a given amount of mass insulation.

Coverage—wet The property of a material which measures the amount of material necessary to cover a given area to obtain a specific dried or cured thickness.

Of course this information is necessary for calculation of quantities necessary for a particular application.

Properties of Blanket and Batt Insulation

Since blankets and batt insulations are essentially non-rigid, such physical properties as flexural strength and shear, listed as properties of rigid materials, are not applicable. However, other properties given for rigid materials are also properties of the non-rigid materials. These include:

- Alkalinity (pH)
- Capillarity
- Combustibility (or non-combustibility)
- Chemical reaction
- Compressive strength (although generally of relatively low value as compared to rigid material)
- Corrosion to substrates
- Density
- Hygroscopicity
- Resistance to acids
- Resistance to caustics
- Resistance to solvents
- Specific gravity—apparent
- Specific gravity—real
- Specific heat
- Tensile strength
- Thermal conductivity
- Thermal diffusivity
- Temperture limits
- Temperature rise (self internal heating)
- Vapor migration
- Vibration resistance
- Water absorption

In addition, properties other than those listed for rigid materials do become important in this form of insulation, namely:

Compaction or settling The property of the blankets or batts which measures their change in density and thickness resulting from loading or vibration thus producing change of thermal efficiency.

Some materials tend to fluff up when subjected to vibration whereas others tend to compact. This factor has a definite relation to suitability of the insulation for certain installations.

Recovery of thickness after compression of blankets or batts after having been compressed is a vital factor in the use of material as cushion blankets, or in expansion joints.

Resistance to air movement The property which indicates the ability of a blanket-type material to resist erosion by air currents over its surface.

The importance of a blanket being able to resist air velocities across its surface is demonstrated most frequently when blankets are used to line the inside of ducts.

Properties of Fill Insulations

Although the particular set of properties which is important to fill material is slightly different from the forms of insulation previously discussed, each of the individual properties have already been mentioned. The important properties of fill insulations follows:

- Adsorptivity
- Alkalinity
- Capillarity
- Combustibility (or non-combustibility)
- Chemical reaction
- Compaction or settling
- Corrosion to substrates
- Hygroscopicity
- Resistance to acids
- Resistance to caustics
- Resistance to solvents
- Specific gravity—apparent
- Specific gravity—real
- Specific heat
- Thermal conductivity
- Thermal diffusivity
- Temperature limits
- Temperature rise—self internal heating
- Vapor migration

Measurement of Properties of Thermal Insulation

Determining what insulation properties are important only indicates the information needed and provides the basis of investigation. The next question then becomes, how can these properties be measured and under what conditions should they be measured? Another question which follows is whether or not measurements made by laboratory test are truly indicative of the properties of the material in service. Does aging affect the properties? If so, how much and at what rate? What effect does temperature have on test results? What effect does moisture content have on the properties?

Unfortunately, testing methods and studies of properties of material are not yet able to answer all these questions. Nor is there a laboratory available which is accepted as *the* authority on testing of properties of insulation materials. This statement does not imply that there are no standard test methods and laboratories to perform these standard test methods, but it does mean that the insulation industry lacks even the minimum requirements to provide reliable information. In many instances the manufacturers of insulation have developed their own test methods and can furnish some information regarding their materials. However, the test method used by one manufacturer is not always identical with that of another, so that the values of one cannot be compared with the results obtained by another. This makes direct comparison of material properties quite difficult. Another problem is that most of the mechanical properties are measured at atmospheric conditions and not at the temperatures to which the material is subjected in service. Inadequate information leads to poor design, the use of improper materials, and the installation failures to which the insulation industry has become accustomed.

In recent years progress has been made in correcting this confusion and presently there exists a number of American Society of Testing and Materials Standard Test Methods. However, even with standard test methods, sometimes it is necessary, because of the wide range in characteristics, to perform more than one test for a single property, as one test may be incapable of measuring all the characteristics for the wide variety of insulation materials. Thus, duplication of test methods for a single property of insulations does exist and the proper selection must be made for the insulation being tested. Following is a list of American Society of Testing and Materials Test Methods for various properties.

Breaking Load—Calculated Flexural Strength
- Block Insulation—C-203
- Pipe Insulation—C-446
- Organic Foam—D-790

Closed Cell Content
- Organic Foam Insulations—D-1940

Coefficient of Expansion
- Organic Foam Insulation—D-696

Combustibility
- Test for Flash Point by Tag Closed Tester—D-56
- Test for Flash and Fire Point by Open Cup—D-92
- Test for Flash Point by Pensky (Martens Closed Tester)—D-1310
- Ignition Properties of Plastics—D-1929
- Determining Noncombustibility of Elementary Materials—E-136
- Burning Extent of Plastic Foams—D-1692
- Flame Spread—C-209 part 32

Compressive Strength
- Compressive Strength of Insulation Material—C-165, C-354
- Compressive Strength of Foam Insulation—D-1692

Deflection Strength
- Deflection Strength—C-209 (parts 14 thru 16)

Density
- Block Insulation—C-303
- Pipe Insulation—C-302
- Blanket Insulation—C-167
- Organic Foam Insulation—D-1622

Hardness—C-569

Hot Surface Performance—C-411

Maximum Use Temperature—C-447

Resistance to Abrasion—C-421

Resistance to Dropping—C-487

Shear Strength—C-273

Shrinkage after Heat Soaking—C-356

Specific Heat—C-351

Tensile Strength C-446
Tensile Strength C-209 (parts 18 thru 24)
Thermal Conductivity C-177
Thermal Conductivity C-335
Thermal Conductivity C-420
Thermal Conductivity C-518
Water Absorption—C-209 (parts 26 thru 28)
Water Vapor Transmission C-355

As can be seen from the above, standard test methods do not exist for all the properties of insulation listed previously. One reason is that some of these properties are difficult to determine. In other cases test equipment is quite expensive, few manufacturers or laboratories have the required equipment, and an industry standard has never been devised.

It should be remembered that any laboratory test is a measure of a small sample. For certain characteristics, a small sample will provide an accurate appraisal, whereas for other materials the answer may only *indicate* the characteristics of that insulation. Other tests may attempt to predict the service life of insulation. Such service life tests are quite difficult to devise and evaluate. Yet this type of test is essential, and as the demand for it increases, eventually such tests will be devised by the industry.

Service records also assist in evaluating materials. Unfortunately, an early failure is costly and a successful installation requires many years to prove its success. There is no one method of engineering all insulation installations, and the really difficult applications still depend upon engineering judgment. An engineer with an extensive knowledge of the properties of *many* insulations is in a position to make the best decision, *based on available knowledge at the time of the decision.*

Reflective Insulation

Reflective insulation, which consists of metallic sheets spaced to direct the heat back to its source, must be constructed to provide space between each of the reflective sheets. As its efficiency depends upon the arrangement of the sheets and their means of support, a *system* of construction is necessary. Its effectiveness and properties are those of the system and not the properties of any single material used in its construction.

Reflective insulation systems have been employed in the side walls and ceilings of building, and when proper spacing of layers and methods of construction are used they have proven to be extremely efficient.

Another use of reflective insulations has been in the construction of cold storage rooms. This type of construction is similar to that used for insulation of buildings, the only difference being that tight vapor seals must be constructed on the warm side for cold service.

Reflective insulation used to insulate pipes and vessels, is a factory made product, and more closely approaches a form which can be evaluated by a list of properties. This type of reflective insulation is formed into sectional pipe insulation, fitting covers, and shaped segments to fit equipment. These shapes consist of reflective sheets of aluminum, or stainless steel, so formed as to have little direct contact between the sheets, or with spacers of a low conductive metal or other material to form isolated air chambers between the sheets and end closures.

As a finished product these formed reflective insulation structures can be evaluated to have certain characteristics as follows:

Aklalinity (pH)
Capillarity
Coefficient of expansion
Combustibility (or non-combustibility)
Corrosion to substrates
Cracking (in service)
Hygroscopicity
Leachable material content
Resistance to acids
Resistance to caustics
Resistance to solvents
Resistance to nuclear radiation effects
1. Damage to material
2. Loss in thermal efficienty
3. "Half life"

Strength
1. Crushing
a. Perpendicular to longitudinal axis
b. Parallel to longitudinal axis
2. Flexural—beam across supports
3. Impact resistance
Specific gravity—apparent
Specific gravity—real
Temperature limits
1. Maximum—continuous
2. Maximum—cyclic
3. Maximum—intermittemt
4. Minimum—continuous
5. Minimum—cyclic
Thermal emittance
1. Inner surfaces
2. Outer surfaces
Thermal conductance
1. Across total thickness
2. Per inch displacement
Thermal shock resistance
Vibration resistance
Water vapor transmission

The reflective insulation systems are fabricated insulation structures and do not lend themselves as easily to testing as do homogeneous materials. Thus there does not exist a series of standard test methods for their evaluation, as exists for other materials. Since these are designed systems, the physical properties and strength required for any given installation can be engineered into the finished product, whereas with homogeneous materials a product naturally having the properties must be selected to fulfill the installation requirements.

Although each of the individual materials used in the construction may be tested by standard test methods, there presently exist few ASTM test methods which are suitable for the testing of reflective insulation *systems*. However as these and other cryogenic insulation systems increase in importance tests will be developed.

Cryogenic Insulation

When the term *cryogenic insulation* is used it does not designate a specific type or system of insulation, but refers to the use of insulation in controlling heat gains to cryogenic liquids. There is no established temperature below which insulation is termed cryogenic. However, it is generally understood to be in the range of −150°F down to absolute zero (−459.6°F).

Although homogeneous mass insulations are used for applications at the upper part of the cryogenic temperature range, to obtain the efficiency necessary for proper control of very low temperatures, a system of insulation using more than one material is generally employed. Maximum efficiency to retard the flow of heat by the combined action of all heat transfer mechanisms (radiation, conduction and convection) is the aim of the cryogenic insulation *systems*.

Combining the principles of the control of heat transfer by mass, by reflective substances, and by vacuum, systems have been designed to obtain thermal resistances unobtainable with ordinary mass insulations. Development of these efficient insulations essentially started with the discovery of the Dewar Flask by James Dewar in 1898. Further contributions to the development of these systems were made by I. A. Black, A. A. Fowle and P. E. Glaser of Arthur D. Little Company; and by P. E. Riede, D. Wang, L. C. Matsch, C. R. Lindquist and L. R. Niendorf of the Linde Company.

The systems of cryogenic insulations made possible by these developments are basically of two types—one type is composed of powders in a partial vacuum and the other multilayered, spaced reflective sheets in a partial vacuum.

Powders such as perlite and "Santocel" used in vacuum have a conductivity of approximately 0.012 Btu/sq ft, hr, in., °F at temperatures from 70°F to −300°F. Powders used with reflective and absorptive opacifiers of the proper formula can improve the performance. Such a formula, developed by Linde, using "Santocel" and copper powder in a vacuum has a conductivity of 0.0026 Btu/sq ft, hr, in., °F in a vacuum of 0.05 to 5.0 microns of mercury, absolute pressure.

RIGID AND SEMI-RIGID INSULATIONS

Material identification number	Insulation material, generic type	Description and general characteristics
1	Alumina-silica fibers, combined with binders.	Block insulation for exceptionally high temperature service, resists thermal shock.
2	Alumina-silica fibers, combined with binders.	Block insulation—stronger than (1) above. For exceptionally high temperature services. Resists thermal shock.
3	Refractory-fiber molded, predominantly alumina and silica.	High temperature lightweight board.
4	Amosite fibers and silica binders.	Formed rigid pipe covering. Resists fracture. Good cutting characteristics. Water absorbent.
5	Asbestos sponge felts laminated together.	Formed semi-rigid block and pipe covering. Soft. Water absorbent.
6	Asbestos paper, plain and corrugated, cemented together.	Formed semi-rigid pipe covering. Soft. Water absorbent.
7	Calcium-silicate, hydrous, reinforced with small amounts of asbestos fiber.	Molded into rigid block and pipe covering. Strong, for its weight. Good cutting characteristics. Water absorbent, but retains most of its strength when wet.
8	Calcium-silicate, hydrous, reinforced with small amounts of asbestos fiber, extra high temperatures.	Molded into rigid block and pipe covering. Strong, for its weight. Good cutting characteristics. Water absorbent.
9	Cork, vegetable, compressed.	Molded into rigid blocks or sheets. Strong, for its weight. Good cutting characteristics. Will resist liquid water, but has relatively high rate of vapor transmission.
10	Diatomaceous silica, blended and bonded. Class I.	Formed into rigid block and pipe covering. Good for high temperatures. Excellent thermal shock resistance.
11	Diatomaceous silica, blended and bonded. Extra high temperature. Class II.	Formed into rigid block and pipe covering. Good for higher temperatures than material (10). Higher density. Excellent thermal shock resistance.
12	Diatomaceous silica, asbestos fibers and inorganic binder.	Light density rigid sheet. Good cutting characteristics.
13	Diatomaceous silica, asbestos fibers and inorganic binder.	Moderate density rigid sheet, excellent strength for its weight. Excellent cutting characteristics. Good for panels where needed in high temperatures. Also serves as fire protective material.

Material identification number	Insulation material generic type	Description and general characteristics
14	Diatomaceous silica, asbestos fibers and inorganic binder	Heavy density rigid sheet. Similar to (12) and (13) except harder and stronger
15	Glass, cellular	Rigid block and pipe covering. Good strength characteristics. Poor abrasion resistance. Can be formed and fabricated rapidly. Water resistant. Has almost perfect resistance to the migration of moisture vapor
16	Glass, cellular, between layers of felt.	Same as material (15) except it is fabricated into sheets between layers of felt for roof insulation.
17	Glass, fiber, with organic binder.	Semi-rigid formed pipe covering. Light density pipe insulation. Available with various types of factory attached jacketing.
18	Glass, fiber, with organic binder.	Formed into rigid pipe covering. Heavy density pipe insulation. Available with various types of factory attached jacketing.
19	Glass, fiber, with organic binder—higher temperature limit	Semi-rigid formed pipe covering, moderate density with slightly higher temperature limit than (17) and (18). Available with various types of factory attached jacketing.
20 21 22	Glass, fiber, with organic binder.	Semi-rigid formed board or sheets of various densities. The higher the density the stronger the material. The higher densities also provide a lesser conductivity. Available with various types of factory attached outer facings.
23	Glass, fiber, with high temperature binder.	Formed semi-rigid board and sheets. Suitable for higher temperatures than (20), (21), (22).
24	Glass, fiber, with organic binders with asphalt attached facings on both sides.	Formed into rigid sheets, for roof deck insulation.
25	Glass, fiber, with organic binder with one surface coated or treated.	Semi-rigid formed sheets for use in insulating interiors of air conditioning or heating ducts. One side, facing the air stream, coated to resist air erosion.
26 27	Glass, fiber, with inorganic binder, faced one side with vapor resistant facing.	Formed into rigid sheets for constructing air conditioning and heating ducts. No. 27 is a higher density material than (26), for use where additional strength is required

Material identification number	Insulation material, generic type	Description and general characteristics
28	Glass, fiber, with inorganic binder faced with aluminum sheet metal-factory attached.	Formed into semi-rigid panels for application to large diameter or flat surfaces. Aluminum facing provides basic weather-barrier.
29	Magnesium carbonate, with asbestos fibers and binders (80% Magnesia)	Formed into rigid block and pipe covering Relatively soft.
30	Mineral fiber, with inorganic binders.	Formed rigid block.
31	Mineral fiber, with inorganic binders.	Formed semi-rigid block. Made in various densities.
32	Perlite, expanded, blended and bonded with binders. Water repellent.	Rigid board and pipe covering. Low shrinkage at high temperatures. Water repellent.
33	Polystyrene, expanded beads, molded to shape.	Formed into rigid block, board and pipe covering. Light weight, excellent cutting characteristics.
34	Polystyrene, cellular foam, molded.	Molded rigid board and pipe covering. Light weight.
35	Polystyrene, cellular foam.	Rigid board, sheets and pipe covering cut from slab stock. Light weight. Good cutting characteristics. Combustible.
36	Polystyrene, cellular foam, self-extinguishing.	Rigid boards, sheets and pipe covering. Light weight. Good cutting characteristics. Will not continue burning after removal of fire.
37	Polyurethane, cellular foam.	Formed into rigid boards, sheets, and pipe covering. Light weight. Good cutting characteristics.
38	Polyurethane, cellular foam, self-extinguishing	Formed into rigid boards, sheets and pipe covering. Light weight. Good cutting characteristics. Will not continue burning after fire is removed.
39	Rubber resin, cellular foam—self-extinguishing.	Rigid board and pipe covering. Good cutting characteristics. Will not continue burning after fire is removed.
40	Siliceous fibers and binders with factory attached sheet aluminum facing.	4'x8' (approx.) semi-rigid panels for insulation of large diameter and flat surfaces.
41	Vinyl chloride cellular foam.	Formed into rigid block and pipe covering. Easily cut. Light weight. Will not continue to burn when fire is removed.
42	Wood fiber and binder.	Formed into rigid panels for roof deck insulation.

FLEXIBLE INSULATION

Material identification number	Insulation material, generic type	Description and general characteristics
43	Asbestos braid inner and outer tubing, filled with glass fiber.	Seamless flexible tubular insulation.
44 45 46 47	Glass fiber and inorganic binder, available with various facings.	Flexible rolls or sheets. All are of similar material except for density. As the density affects both strength and flexibility and also conductivity, divisions in density were provided to establish the relationships.
48	Polystyrene foam.	Roll foam, flexible. Light weight
49	Rubber resin, cellular foam, self-extinguishing.	Molded into flexible sheets and pipe covering. Resilient. Will not continue to burn when fire is removed.

BLANKET, FELT AND BATT INSULATION

Material identification number	Insulation material, generic type	Description and general characteristics
50	Alumina-silica fiber.	Formed into blanket for high temperature service.
51	Alumina-silica fiber.	Formed into felt for high temperature service.
52	Alumina-silica fiber and asbestos fiber with binder.	Formed into blanket for high temperature service.
53	Asbestos fiber.	Formed into blanket.
54	Asbestos woven fibers.	Formed into felts.
55	Glass fiber, batts with various facings.	Formed into batts and encased in various facings. Mainly used for building ceiling and wall cavity insulation.
56	Glass fiber, bonded with thermosetting organic binders. Available in various facings.	Formed into blankets. Numerous densities available. General purpose blanket.
57	Glass fiber, faced on one or both sides with metal mesh.	Formed into blankets. Expanded metal lath or 1" hexagonal wire facings on one or both sides. General purpose high temperature blankets.
58	Glass fiber, blanket, coated one side.	Blanket specially coated on one side to resist air erosion. For lining heating or air conditioning ducts.
59	Glass fiber, woven felt.	Formed into woven felt for high temperature installations.

Material identification number	Insulation material, generic type	Description and general characteristics
60	Glass fiber (high temperature glass), needled glass matt.	Specially needled matt of high temperature glass fibers—without binders. Soft and resilient.
61	Mineral fibers, faced on one or both sides with metal mesh.	Formed into blankets. Expanded metal lath or 1" hexagonal wire facings on one or both sides. General purpose high temperature blanket.
62	Mineral fibers, with various binders.	Formed into blankets.
63	Mineral fibers, secured by 1" hexagonal wire netting precut and edged for various pipe sizes.	Formed into blankets to be wrapped around pipe. Facing precut and edged and equipped with fasteners to secure around pipe.
64	Refractory fibers predominantly alumina and silica.	Felts available in various densities from 3 to 24 lbs/cu ft and thicknesses 1/8 in. to 2 in.
65	Silica fibers.	Formed into felts or blankets.

INSULATING AND FINISHING CEMENTS

Material identification number	Insulation material, generic type	Description and general characteristics
66	Alumina-silica, semi-rigid, hydraulic setting cement.	Semi-refractory and insulating cement. Water mix—hydraulic setting.
67	Alumina-silica, asbestos fibers and binder.	High temperature—water mix—cement.
68	Asbestos fibers, and bonding clays.	Water mix, insulating and finishing cement.
69	Asbestots fibers, and binders.	Water mix, finishing cement.
70	Asbestos fibers, bonding clays and binders.	Water mix, hard surface finishing cement.
71	Asbestos fibers, with special binders for adhesion to water repellent insulation.	Water mix, finishing cement.
72	Calcium silicate with binders.	Water mix, insulating and finishing cement.
73	Diatomaceous silica powder with binder.	High temperature—water mix—insulating cement.
74	Magnesium carbonate and asbestos fibers.	Water mix insulating cement. High shrinkage.

Material identification number	Insulation material, generic type	Description and general characteristics
75	Mineral fiber with hydraulic setting binder	Water mix, insulating cement. Hydraulic setting. General purpose insulating cement.
76	Mineral fiber with hydraulic setting binder-high adhesion.	Water mix, insulating cement Hydraulic setting. Similar to (75) with special binders to increase initial wet adhesion
77	Mineral fibers, asbestos fibers and hydraulic setting binder	Water mix, insulating cement. Formulated for use as a fire protection insulation
78	Vermiculite and binder	Water mix, insulating cement.

FORMED OR FOAMED SPRAYED-IN-PLACE INSULATIONS

Material identification number	Insulation material, generic type	Description and general characteristics
79	Asbestos fibers, Amosite, and inorganic binders.	Sprayable insulation cement mix. Water added by spray gun. Compressed after being applied to surface.
80	Asbestos fibers, Crocidolite, and inorganic binders.	Sprayable insulation cement mix. Water added by spray gun. Compressed after being applied to surface. Similar to (79) except will withstand higher service temperatures.
81	Bituminous material, cork or mica filled mastic.	Premixed mastic. Available in consistencies suitable for application by spray or trowel. Used to control condensate.
82	Ceramic fiber and inorganic fibers.	Sprayable mix. Semi-refractory insulation
83	Mineral wool granules, asbestos and inorganic binders.	Sprayable insulation cement mix. Water added by spray gun. Formulated to be used as a fire protection and high temperature insulation.
84	Polyvinyl acetate cork filled mastic.	Premixed mastic. Can be applied by spray, trowel or palm. Used to control condensation.
85	Urethane, two part liquid mix, rigid foam. Self-extinguishing.	Liquids mixed by spray gun. Liquid on surface foams to form rigid insulation. Formulas obtainable for insulation will not continue burning after fire is removed.

FILL AND LOOSE INSULATION

Material identification number	Insulation material, generic type	Description and general characteristics
86	Alumina-silica fibers, bulk.	For fill applications such as packing furnace joints.
87	Alumina-silica, chopped and milled.	Same as (86)
88	Alumina-silica, long fibers	Same as (86).
89	Asbestos fibers.	Available in various grades and densities.
90	Cork, granulated.	Available in various grades and particle sizes.
91	Diatomaceous silica, coarse powder.	Milled to a coarse powder, for filling cavities.
92	Diatomaceous silica, fine powder.	Milled to a fine powder, for filling cavities.
93	Diatomaceous silica, calcined.	Calcined to withstand higher temperatures. Used as fill, or with concrete to form insulating concrete.
94	Diatomaceous silica and asbestos fibers.	Mixture for fill installations.
95	Gilsonite granules.	Available in various grades for various service temperatures. Used as fill around underground hot piping.
96	Glass fibers, loose or shredded.	Various grades available.
97	Glass fibers, wool.	For pouring or blowing into cavity spaces.
98	Glass, cellular, pellets.	Available in various sized pellets. Each pellet formed with hermetically sealed cells.
99	Gypsum pellets.	For pouring into cavity spaces.
100	Lampblack	Powder for pouring into cavity spaces.
101	Mineral fibers, with small amount of oil lubricant.	Fibers in loose form for filling cavity spaces.
102	Mineral fibers, oil free.	Loose fiber for filling cavity spaces.
103	Mineral fiber, granulated.	For pouring or blowing in cavity spaces.
104	Perlite, expanded, loose.	Loose for filling cavity spaces. Available in various size spheres.
105	Silica fibers.	Soft fibers for high temperature service.
106	Silica-aerogel spheres.	Small spheres. Very low conductivity. Will flow through a very small opening.
107	Vermiculite flakes.	Expanded mica. Available in various sizes. For filling cavity spaces.

REFLECTIVE INSULATION/FOILS AND SHEETS

Material identification number	Insulation material, generic type	Description and general characteristics
108	Aluminum Sheet.	Polished sheet, thickness as required for strength. Installed to enclose and separate air spaces.
109	Aluminum Foil.	Thickness as required for strength. Installed to enclose or separate air spaces.
110	Aluminum Foil on membrane paper, or other reinforcements such as glass fiber.	Foil with various reinforcements. Installed to enclose or separate air spaces.
111	Preformed aluminum with kraft paper, accordian formed. Wall and ceiling insulation.	Preformed into strips or rolls, then when opened and installed, layers of foil will form enclosed spaces in cavity installation.

REFLECTIVE INSULATION/PREFORMED PIPE AND EQUIPMENT INSULATION

Material identification number	Insulation material, generic type	Description and general characteristics
112	Preformed stainless steel case with stainless steel reflective sheets.	Custom formed to fit piping or equipment Non absorbent. Can be removed and replaced rapidly. Light weight.
113a	Preformed stainless steel case with aluminum reflective sheets.	Same as above. Slightly more efficient, but limited to lesser service temperatures
113b	Preformed aluminum case with aluminum reflective sheets.	Same as 113a above.

REFLECTIVE INSULATION/PREFORMED PIPE AND EQUIPMENT INSULATION

Material identification number	Insulation material, generic type	Description and general characteristics
114	Aluminum foil, spaced with glass mat—In vacuum.	Multilayers of aluminum reflective foil in vacuum cavity. Very low thermal conductivity.
115	Aluminum foil, spaced with glass paper. In vacuum.	Same as above.
116	Carbon-silica in vacuum.	Powder in vacuum cavity.
117	Perlite in vacuum.	Same as above.
118	"Santocel" in vacuum.	Same as above.
119	"Santocel" and aluminum powder in vacuum.	"Santocel" opacified with aluminum powder in vacuum cavity
120	"Santocel" and copper powder in vacuum.	"Santocel" opacified with copper powder in vacuum cavity

Multilayered reflective sheets consist of layers of reflective sheets such as aluminum foil or metal-coated plastics film, separated by micro glass-fiber mats in a vacuum space, can attain even lower thermal conductivity than opacified powders. However, their effectiveness is much more dependent upon the almost complete absence of pressure than the powders. Depending upon the layers per inch, conductivities of 0.00108 to 0.00012 Btu/sq ft, hr, in., °F can be attained when in spaces under a vacuum of 0.5, or less, microns of mercury, absolute pressure.

Of course, the problem is to provide the vacuumized space for these insulations to function. This is done by utilizing double-shell vessels, with the insulation installed between the two shells and the vacuum generated in the insulated space. "Permanent vacuum" vessels of such extremely low leak rate that they do not require any re-evacuation for many years have been developed.

As with reflective insulations, the cryogenic vacuum insulated vessels are designed and constructed to withstand any mechanical and chemical abuses to which they may be subjected. Thus the properties are those of a design rather than that of a material. A chart of thermal conductivities of the cryogenics will be given later in this chapter.

Underground Insulation Systems

Pipe or equipment located underground, which must be insulated, in most instances uses the more conventional mass insulations in some system which not only insulates, but also protects the insulation from water.

As these systems use many combinations of conduit and thermal insulations, they are not a "class" of insulation in themselves. The properties of the insulation used in their construction can be obtained from the properties of that insulation as listed. These systems will be discussed in a later chapter.

Property Tables—Not Including Conductivity

The properties in Tables 30 through 38 are not all of the relevant properties of the materials listed previously in this Chapter. The tables do list, however, the most important properties and those most commonly needed to make an intelligent selection of an insulation for a specific purpose.

Note that many of the materials have only a few properties listed and that none of them are complete. The properties were compiled from information obtained from many sources, but most were secured directly from the manufacturers of the insulations, or from their published literature. As can easily be understood, further testing and checking by the author of each individual value obtained, involved a task much beyond the scope of this book. However, based upon the author's knowledge of insulation materials, the values presented were reviewed to establish that each one was apparently reasonable for that particular insulation and that particular property.

All properties listed are not significant for all materials. For example, the water vapor transmission rate of an insulation used for high temperature service is unimportant because the high temperature pipe or vessel causes a high vapor pressure which drives moisture outward and the insulation remains dry and effective. For this reason, the vapor transmission rate on high temperature materials is seldom measured.

For certain properties, such as alkalinity, there has been no test method agreed upon by the insulation industry. Some manufacturers provide the information in terms of pH and others in respect to percentage of Na_2O. Again because of these limitations, despite the fact that this may cause confusion, the only recourse was to list the values obtainable.

Another factor which should be remembered in the use of these tables is that a particular generic material may be made by several

(Text continued on p. 192)

TABLE 30 Rigid and semi-rigid insulations

Material identification number	Generic type and class or description of insulation material	Form	Maximum temp limits °F		Density lbs/cu ft	Abrasion resistance % weight loss by tumbling/		Alkalinity pH	Capillarity
			Continuous	Short		1st 10 min run	2nd 10 min run		
1	Alumina-silica fibers combined with binders	Block	2200	2300	13 to 14				
2	Alumina-silica fibers combined with binders	Block	2000	2000	21				
3	Refractory fiber-molded Light Weight	Board	2300	2300	11				will wick
4	Amosite asbestos fibers with silicate binders	Pipe Covering	1200	1200	10 to 16			8 to 10.5	will wick
5	Asbestos sponge felts laminated together	Block and PC	550 to 700	550 to 700	26 to 33			9 to 10	will wick
6	Asbestos paper, plain and corrugated. Cemented together.	Pipe Covering	300	300	9 to 13			10 to 11	will wick
7	Calcium silicate, hydrous. Reinforced with asbestos fiber.	Block and PC	1200	1200	10 to 13	20 to 50	40 to 80	8 to 12.5	will wick
8	Calcium silicate, hydrous. (Same as 7)	Block and PC	1800	1800	10 to 14	7.5 to 20	16 to 40	8 to 12.5	will wick
9	Cork, vegetable compressed	Block	200	200	6 to 9			6.5 to 7.5	Neg.
10	Diatomaceous silica, blended and bonded Class I	Block and PC	1600	1600	21 to 24	30 to 55	50 to 80	7 to 9	will wick
11	Diatomaceous silica, blended and bonded Class II	Block and PC	1900	1900	24 to 26	30 to 55	50 to 80	7 to 9	will wick
12	Diatomaceous silica, asbestos fibers and inorganic binders.	Board	1200	1200	23			9 to 11	will wick
13	Diatomaceous silica, asbestos fibers and inorganic binders.	Board	1200	1200	36			9 to 11	will wick
14	Diatomaceous silica, asbestos fibers and inorganic binders	Board	1200	1200	65			9 to 11	will wick
15	Glass, cellular, Hermetically sealed cells.	Block and PC	800	800	7 to 9.5			7 to 8	Neg.
16	Glass, cellular, Hermetically sealed cells. Between layers of felt	Board	200	200	7 to 9.5			7 to 8	Neg.
*17	Glass, fiber, with organic binder	PC	370	370	3 to 4			7.5 to 9	Neg.
*18	Glass, fiber, with organic binder	PC	450	450	7.0			7.5 to 9	Neg.
*19	Glass, fiber, bonded, with organic binder.	PC	500	500	3.0 to 5			7.5 to 9	Neg.

Combustibility: Flame spread/ flame spread index	Combustibility: Smoke density/ smoke density index	Non-combustible	Compressive strength/lbs/ sq in. at % deformation	Hygroscopicity/ % volume after test	Linear shrinkage/ max % at max temp °F	Specific heat/ btu per lb per °F	Tensile strength/ lbs/sq in.	Thermal diffusivity/ ft²/hr (calculated)	Water absorption/ % vol. 24 hr submersion	Water vapor transmission perm inch
		NC			1.0				91	
		NC			5.4				90	
		NC			2.2					
		NC	12.5 at 5%	2 to 5 at 70 F 90 RH	.25	.22 to .25	67	009	84	
		NC			4 to 5.5	.25		.005	85	
		NC			3 to 7				85	
		NC	75 to 165 at 5%	10% by Wgt.	1.5 to 2	.20 to .21	10 to 30	16	90	
		NC	110 to 130 at 5%	1.5	1.6 to 2.5	.25 to .28		016	90	
			5 to 10 at 5%	1.0		.43		006		2 to 7
		NC	50 to 120 at 5%	2 to 8 by Wgt.	2.0	.22 to 28	10 to 20	.008 to 01	85	
		NC	65 to 120 at 5%	2 to 8 by Wgt.	2.7 to 3.5	.22 to .28	15 to 20	009 to .012	83	
		NC	800 at 10%	9	1 to 2	.25 to .34	18	.006 to 01		16
		NC	1500 at 10%	9	1 to 2	.25 to .34	460	006 to .01		8
		NC	2500 at 10%	9	1 to 2	.25 to 34	750	.006 to .01		
		NC	100	0	.0000046 Exp. Co.	.20	50	.18		
			100	0	0000046 Exp. Co.	.20	50	.18		
25 or less	50 or less			.2	Neg.	.20		.02	93	
25 or less	50 or less			.2	Neg.	.20		015	92	
25 or less	50 or less			.2	Neg.	.20		.018	93	

TABLE 30 Rigid and semi-rigid insulations (continued)

Material identification number	Generic type and class or description of insulation material	Form	Maximum temp limits °F Continuous	Maximum temp limits °F Short	Density lbs/cu ft	Abrasion resistance % weight loss by tumbling/ 1st 10 min run	Abrasion resistance % weight loss by tumbling/ 2nd 10 min run	Alkalinity pH	Capillarity
*20	Glass, fiber, with organic binder. Available with various facings.	Board	450	450	4 to 5			7.5 to 9	Neg.
*21	Glass, fiber, with organic binder. Available with various facings.	Board	450	450	5 to 7			7.5 to 9	Neg.
*22	Glass, fiber, with organic binder. Available with various facings.	Board	450	450	7 to 9			7.5 to 9	Neg.
23	Glass, fiber, bonded with high temperature binder.	Board	1000	1000	3¼			8.5 to 9	Neg.
24	Glass, fiber, with organic binder. Asphalt attached foil facing. (Roof board)	Board	100	100	6			8.5 to 9.5	Neg.
25	Glass, fiber, coated one side to resist air erosion	Board (Duct Lining)	250	250	1.5 to 6			8.5 to 9.5	Neg.
26	Glass, fiber, bonded with organic resin, with vapor resistant facing. (Ducts)	Board & Round	250	250	3			8.5 to 9.5	Neg.
27	Glass, fiber, bonded with organic resin, with vapor resistant facing. (Ducts)	Board & Round	250	250	5			8.5 to 9.5	Neg.
28	Glass, fiber, bonded with organic binder, with factory applied aluminum facing.	4' x 8' Panels	450	450	Insul. only 3 to 5				
29	Magnesium carbonate, with asbestos fibers and binders	Block and PC	600	600	11 to 13	25 to 50	50 to 80	7 to 10.5	will wick
30	Mineral fiber with inorganic binder.	Block	1800	1800	15 to 18			7 to 9	will wick
31	Mineral fiber, with inorganic binder. Semi-rigid	Block	850 to 1000	850 to 1000	4 to 12			7 to 9	will wick
32	Perlite, expanded. Blended and bonded by binders. Water repellent	Block and PC	1500	1500	9.5 to 11.5	35 to 40	64 to 70	7 to 8	Neg.
33	Polystyrene, expanded beads. Molded to shape	Block, Board, PC	180	180	1			6.5 to 7.5	None
34	Polystyrene, cellular foam. Molded to shape.	Block, Board, PC	165 to 175	165 to 175	1.5 to 3.3			6.5 to 7.5	None
35	Polystyrene, cellular foam	Block, Board, PC	165	165	1.5 to 2.5			6.5 to 7.5	None
36	Polystyrene, cellular foam. Self-extinguishing	Block, Board, PC	165	165	1.0 to 2.2			6.5 to 7.5	None

Combustibility										
Flame spread/ flame spread index	Smoke density/ smoke density index	Non-com-bustible	Compressive strength/lbs/ sq in at % deformation	Hygro-scopicity/ % volume after test	Linear shrinkage/ max % at max temp °F	Specific heat/ btu per lb per °F	Tensile strength/ lbs/sq in.	Thermal diffusivity/ sq ft/hr (calculated)	Water absorption/ % vol. 24 hr sub-mersion	Water vapor trans-mission perm inch
25 or less	50 or less		1.2 at 10%	2	Neg.	.20		018	93	
25 or less	50 or less		2.7 at 10%	.2	Neg.	.20		.02	92	
25 or less	50 or less		3.5 at 10%	.2	Neg.	.20		.03	91	
25 or less	50 or less			.2	Neg.	.20		.03	93	
25 or less	50 or less			.2	0	.20		.009	93	.01 to 05
25 or less	50 or less			.2	0	.20		.018	93	
25 or less	50 or less			.2	0	.20		018	93	.01 to .10
25 or less	50 or less			.2	0	.20		.017	93	01 to .10

		NC	50 at 10%	10 by Wgt.	2	.30		.008 to .012	90	
		NC	2 to 18 at 10%	.2	1.6	.22		.005 to .010	85	
			1 to 1.5 at 10%	.2	4	.22		.01 to 02	85 to 93	
		NC	80 at 5%	.5	1.25	.216	32	.014	3.5 to 4	18
less than 25	less than 350		6 to 8 at 5%		.000035 Exp. Co.	.27		.063	2.5	3.0
less than 25	less than 350		14 at 5%		.000035 Exp. Co.	.27	225	.017	0.1 to 1.25	1.0 to 2.0
Comb.	Comb.	Comb.	10 to 30 at 5%		.000035 Exp. Co.	.27	70	.017	0.1 to 1.25	1.0
less than 25	less than 400		8 to 30 at 5%		.000035 Exp. Co.	.27	70	.017	0.1 to 1.25	1.0

TABLE 30 Rigid and semi-rigid insulations (continued)

Material identification number	Generic type and class or description of insulation material	Form	Maximum temp limits °F		Density lbs/cu ft	Abrasion resistance % weight loss by tumbling/		Alkalinity pH	Capillarity
			Continuous	Short		1st 10 min run	2nd 10 min run		
37	Polyurethane foam	Block, Board, PC	250	250	1.5 to 2.5	3 to 15		6.5 to 7.5	None
38	Polyurethane foam self-extinguishing	Block, Board, PC	200 to 250	300	1.0 to 4.0	6 to 20		6.5 to 7.5	None
39	Rubber resin, cellular foam.	Block and PC	220	220	5 to 8				None
40	Siliceous fibers and binder, with factory applied aluminum facing.	4' x 8' Panels	450	450	4%				will wick
41	Vinyl chloride, cellular foam. Self-extinguishing.	Block and PC	212 to 275	212 to 275	1.5 to 3				None
42	Wood fiber and binder	Board	175	175	15 to 18				will wick

TABLE 31 Flexible insulations

Material identification number	Generic type and class or description of insulation material	Form	Continuous	Short	Density lbs/cu ft	1st 10 min run	2nd 10 min run	Alkalinity pH	Capillarity
43	Asbestos braided. Inner and outer tubing filled with glass fiber.	Seamless flexible tube	500	500	10 to 14			7 to 8	will wick
44	Glass, fibrous, with organic binder. Available with various facings.	Flexible Roll or sheets	400	400	.6 to 1.5			[a]8.5 to 9	Neg.
45	Glass, fibrous, with organic binder. Available with various facings.	Flexible sheets	400	400	1.5 to 2.0			[a]8.5 to 9	Neg.
46	Glass, fibrous, with organic binder. Available with various facings.	Flexible sheets	400	400	2 to 3			[a]8.5 to 9.0	Neg.
47	Glass, fibrous, with organic binder. Available with various facings.	Flexible sheets	400	400	3 to 4			[a]8.5 to 9.0	Neg.
48	Polystyrene, cellular foam. Flexible	Roll form	165	165	0.9 to 1.2			6.5 to 7.5	None
49	Rubber resin, cellular foam. Flexible	Sheet and PC	220	220	5 to 11				None

[a] Also less than 0.6% of Na_2O

Combustibility										
Flame spread/ flame spread index	Smoke density/ smoke density index	Non-com-bustible	Compressive strength/lbs/ sq in. at % deformation	Hygro-scopicity/ % volume after test	Linear shrinkage/ max % at max temp °F	Specific heat/ btu per lb per °F	Tensile strength/ lbs/sq in.	Thermal diffusivity/ sq ft/hr (calculated)	Water absorption/ % vol. 24 hr sub-mersion	Water vapor trans-mission perm inch
Comb.	Comb.	Comb.	40 to 85			.25	38 to 42	011 to 027	1.5 to 3	1.5 to 2
Appr. 25 and up	less than 500		16 to 100		2% Exp. at 250 F	.23	20 to 125	.011 to 027	2 to 3	1.2 to 2.7
less than 50	Approx. 500		40 at 10%		2 to 10 at 220	.19 to .27	82		1	0.1
		NC			0	.2				
less than 20	less than 100		28 to 50 at 5%		.00005 Exp. Co.		60		4.5	1.1 to 1.0
				14	5.4		500 paral. to grain		2.8 to 5.4	

*Note. All glass with organic binders has an alkalinity expressed in terms of Na_2O of less than 0.6%.

		NC		5 90 F 90 RH	0	.24		21		
25 or less	50 or less		Up to .02 at 10%	2 125 F 95 RH	0	.20				
25 or less	50 or less		Up to 03 at 10 %	.2 125 F 95 RH	0	.20				
25 or less	50 or less		Up to .07 at 10 %	2 125 F 95 RH	0	.20				
25 or less	50 or less		Up to 5 at 10%	2 125 F 95 RH	0	20				
			7 at 5%	1					1	1.0 to 2.4
			2 to 6 at 25 %	3.5 to 10	3.6				.9 to 1.2	05 to 28

Note: Material Numbers 43 through 49 are all sufficiently flexible to bend 180 degrees around a ½ inch O.D. mandrel.

TABLE 32. Blanket, felt, or batt insulations

Material identification number	Generic type and class or description of insulation material	Form	Facing	Maximum temp. limits °F Continuous	Maximum temp. limits °F Short	Density lbs/cu ft	Alkalinity pH	Capillarity
50	Alumina-silica fiber	Blanket		2300	2300	3 to 24		will wick
51	Alumina-silica fiber	Felt		2300	2300	4 to 6		will wick
52	Alumina-silica, long fiber and binder	Blanket		2300	2300	6		will wick
53	Asbestos fibers	Blanket		750	750	9 to 12		will wick
54	Asbestos woven felt	Felt		750	750	10		will wick
55	Glass, fibrous-batts, with various facings	Batt	Foil or other facings	200	200	.65 to 2.0	7 to 9	Neg.
56	Glass, fibrous, bonded with thermosetting resin. Available with various facings.	Blanket	Foil-Kraft Aluminum foil	250 to 450	450	6 to 3.0	7 to 9	Neg.
57	Glass, fibrous, Faced one or both sides with metal mesh	Blanket	Metal lath or 1" Hex. wire netting	1000	1000	2.4 to 6	7 to 9	Neg.
58	Glass, fiber. Coated one side. (Duct liner)	Blanket	One side treated to resist air erosion.	180 to 250	180 to 250	1.5 to 3	8 to 9	Neg.
59	Glass, fiber, woven felt	Felt	None	1100	1100	9	6 to 8.	Neg.
60	Glass fiber, needled. High temp. (No binder)	Matt	None	1200	1200	6 to 11	7 to 9	
61	Mineral fibers Blanket between various types of metal fabric.	Blanket	1" hex. wire netting or metal lath	1200	1200	6 to 8	7 to 9	
62	Mineral fibers with binders.	Blanket	None	450 to 600	450 to 600	3 to 9	7 to 9	
63	Mineral fiber, secured by 1" hex. wire netting, precut and edged for various pipe sizes.	PC	1" hex. wire	1200	1200	6 to 12	7 to 9	
64	Refractory fibers, predominantly of Alumina and Silica	Felt	None	2300	2300	3 to 24		
65	Silica, fibers	Felt and Blanket	None	1800	1800	8 to 9.5		

Combustibility: Flame spread/flame spread index	Combustibility: Smoke density/smoke density index	Noncombustible	Compressive strength/lbs/sq in. at % deformation	Flexibility ability to bend 90°	Hygroscopicity/% volume after test	Linear shrinkage/max % at max temp °F	Specific heat Btu per lb per °F	Tensile strength/lbs/sq in. Parallel	Tensile strength/lbs/sq in. Perpendicular	Thermal diffusivity sq ft/hr (calculated)	Water absorption %vol, 24 hr submersion
		NC					.20				
		NC					.20				
		NC					.20				
		NC					.28				
		NC	5 at 3%		3	0	.28				
less than 25	less than 50			Yes	.2	0	.20			.016	98
less than 25	less than 50			Yes	.2 125 F 95 RH	0	.20				99
				No	2	0	.20			035	96
less than 25	less than 50			Yes	.2 125 F 95 RH	0	.20			.018	99
		NC	20 at 63%	Yes	2	0	.20			.02	
				Yes				14.7			
					2.0	0	.22			.012	96
					2.0		.24			.01 to .026	98
					1 to 5	0	.22				
		NC									
		NC	10 at 50%		5	5	.2				98

TABLE 33 Insulating and finishing cements

Material identification number	Generic type and class or description of insulation material	Maximum temp. limits °F Continuous	Maximum temp. limits °F Short	Density dried lbs/cu ft	Abrasion resistance % weight loss by tumbling 1st 10 min run	Abrasion resistance % weight loss by tumbling 2nd 10 min run	Adhesion wet sliding lbs/sq ft	Adhesion dried lbs/sq ft	Alkalinity pH
66	Alumina-silica, semi-refractory, hydraulic setting cement	2000	2000	48 to 70					
67	Alumina-silica, and asbestos fibers and binder	1900	1900	54 to 56					
68	Asbestos fibers and bonding clays	1000	1000	25 to 60					
69	Asbestos long fibers and binders. Finishing cement	1000	1000	40 to 70					7 to 11
70	Asbestos fibers and bonding clays. Finishing cement	1000	1000	40 to 55			1.8		7 to 11
71	Asbestos fibers with special binders for adhesion to water repellent surfaces	1000	1000	50 to 60					
72	Calcium silicate cement	1200	1200	19 to 22	10 to 20	30 to 40			
73	Diatomaceous silica, powdered, with binders	1900	1900	18 to 30					8.5 to 9.5
74	Magnesium carbonate and asbestos fibers	600	600	15 to 20					10 to 11
75	Mineral fiber, with inorganic binder	1500	1500	18 to 24			5.0 to 10.5	5	8.5 to 11
76	Mineral fiber, with hydraulic setting binder. High adhesion	1200	1200	40			8 to 9	.3	8.5 to 11
77	Mineral fiber, asbestos fibers and hydraulic setting binder.	1400	1400	30 to 42			5 to 7	.3	8 to 11.5
78	Vermiculite and binders	1800	1800	15 to 20	25 to 35	55 to 65			

Combustibility									
Flame spread/ flame spread index	Smoke density/ smoke density index	Non-com-bustible	Compressive strength/lbs/ sq in at % deformation	Dry covering capacity/lbs/ 100 sq ft 1 inch thick	Shrinkage wet to dry % volume change	Linear shrinkage max % at max temp °F	Specific heat Btu per lb per °F	Thermal diffusivity/ sq ft/hr (calculated)	Water absorption % vol., 24 hr sub-mersion
				400 to 550	1				
				600	1				
		NC		210 to 500					
		NC		330 to 580					
		NC	100 to 150 at 5%	370 to 525	1 to 5	.25			
				240 to 250	2				
		NC	100 at 5%	155 to 190	1		.28	0055	
		NC		150 to 240	1 to 5	2	.25	01	
		NC	50 at 10%	125 to 165	22		.28	.0055	
		NC		160 to 200	22	2	.22 to .23	008 to .012	
		NC	150 at 10%	330	10	2	.23	.007	
		NC	150 at 10%	240 to 350	10	2	.22	011	
		NC		150 to 165				015	

TABLE 34 Sprayed, formed, or foamed-in-place insulations

Material identification number	Generic type and class or description of insulation material	Maximum temp limits °F		Density dried/ lbs/cu ft	Adhesion		Alkalinity pH	Combustibility		
		Continuous	Short		Wet sliding lbs/sq ft	Dried lbs/sq ft		Flame spread/ flame spread index	Smoke density/ smoke density index	Non-combustible
79	Asbestos fibers, amosite, and inorganic binders. Spray mix.	750	750	8 to 13			9 to 10			NC
80	Asbestos fibers, crocidolite, and inorganic binders. Spray mix.	1350	1350	8 to 15			9 to 10			NC
81	Bituminous materials, cork or mica filled. Mastic.	200	200	40 to 50				Comb.	Comb.	—
82	Ceramic fiber and inorganic binders. Spray mix.	2200	2200	12 to 13			-			NC
83	Mineral fiber granules, asbestos fibers and inorganic binders.	1800	1800	11 to 15						NC
84	Polyvinyl acetate, cork filled. Mastic	170	170				7 to 7.5	less than 25		
85	Urethane, 2 part mix, rigid foam. Self-extinguishing.	250	250	1.8 to 3				less than 50		

TABLE 35 Loose and fill insulations

Material identification number	Generic type and class or description of insulation material	Form	Max and min % volume on different size sieves	Maximum temperature limits °F		Density lbs per cu ft	
			Aggregate or fiber size	Continuous	Short	As received	Packed
86	Alumina-silica fibers	Bulk fibers	Short to ½" long. Submicron to 10 microns.	2300	2300	3 to 4	6
87	Alumina-silica fibers	Chopped and milled	50-1000 microns long. Submicron to 10 microns.	2300	2300	7.5	7.5
88	Alumina-silica long fibers	Bulk fibers	½" to 10" long. 1 to 25 microns.	2300	2300	3	6
89	Asbestos fibers	Bulk fibers	Various types and grades available.	1000	1000	20	20 to 50
90	Cork, vegetable, Granulated	Granulated. Suitable to be poured in place.	Various grades available	200	200		8 to 12
91	Diatomaceous silica	Coarse powder		1600	1600	25 to 27	20 to 31

Compressive strength/lbs/sq in. at % deformation	Dry covering capacity/lbs/100 sq ft 1 inch thick	Shrinkage Wet to dry/% volume change	Linear shrinkage/max % at max temp °F	Specific heat/Btu per lb per °F	Thermal diffusivity/sq ft/hr (calculated)	Water absorption/% vol. 24 hr submersion	Water vapor transmission/perm inch
5 at 5%	67 to 120			.23 to .27	.01 to 017		
1.5 to 5 at 5%	67 to 120			.23 to .27	01 to .017		
	15-20 gal. /100 sf ¼" thk.						
0.6 at 5%	100 to 110		1.5 to 2 at 2000				
			.65 at 1200				
	15-20 gal. /100 sf ¼" thk.	30					
15 at yield	20 to 30	Expands approx. 30 times	0	.25			

Alkalinity pH	Combustibility			Hygroscopicity/% volume after test	Specific heat/Btu per lb per °F	Thermal diffusivity/sq. ft/hr (calculated)	Water absorption % vol, 24 hr submersion
	Flame spread/flame spread index	Smoke density/smoke density index	Non-combustible				
			NC		.20		
			NC		.20		
			NC		.20		
9 to 11			NC	3	.27		
8.5 to 7.5		-					
5 to 7			NC		.25	.0009	

TABLE 35 Loose and fill insulations (continued)

Material identification number	Generic type and class or description of insulation material	Form	Max and min % volume on different size sieves / Aggregate or fiber size	Maximum temperature limits °F: Continuous	Maximum temperature limits °F: Short	Density lbs per cu ft: As received	Density lbs per cu ft: Packed
92	Diatomaceous silica. Fine powder.	Fine powder		1600	1600	10 to 13	12 to 17
93	Diatomaceous silica. Calcined.	Powder		2000	2000	28	[illegible]
94	Diatomaceous silica and asbestos fibers.	Loose		1800	1800		18
95	Gilsonite granules. Various grades for various temperature.	Granules, for packing around underground pipe.	Various sizes.	300 to 460	300 to 460		44 to 50
96	Glass fiber, unbonded.	Shredded, or loose fibers.		1000	1000		2 to 12
97	Glass fiber. Pouring wool	Pouring or blowing wool		250	250		0.5 to 1.5
98	Glass, cellular.	Pellets	Various sizes available	800	800	6	6
99	Gypsum, in pellets.	Bulk		800	800	12 to 20	
100	Lampblack	Powder	.01 to 4 microns	1200	1200	4.7 to 18	
101	Mineral fibers, with small amount of oil lubricant	Loose		1000 to 1200	1000 to 1200	4 to 11	4 to 12
102	Mineral fibers. Oil free.	Loose		1000 to 1200	1000 to 1200	4 to 11	10 to 15
103	Mineral fibers	Granulated.		1000 to 1200	1000 to 1200	6	7
104	Perlite, expanded. Spheres.	Loose powder.	Available in various grain sizes.	1400	1400		3
105	Silica, fibers.	Loose fibers.		1800	1800	3 to 9	6 to 12
106	Silica aerogel. Granules	Granules	8 mesh 1% 40 mesh 35%	1300	1300	3.5 to 5.5	4 to 5.5
107	Vermiculite	Flakes		2000	2000	4 to 10	5 to 10

Alkalinity pH	Combustibility			Hygroscopicity/ % volume after test	Specific heat/ Btu per lb per °F	Thermal diffusivity/ sq ft/hr (calculated)	Water absorption % vol 24 hr submersion
	Flame spread/ flame spread index	Smoke density/ smoke density index	Non-com-bustible				
5 to 7			NC		.25	01	
6 to 7			NC		24		
6 to 7			NC		.25		
							Low
8 to 10			NC	.2 at 125 F 95 RH	.20	.17 to .24	
8 to 10			NC		.20		
7 to 8			NC	0	.20	.18	
			NC				
			NC				
7 to 9					.22		
7 to 9					.22		
7 to 9					.22		
			NC				
5 to 7			NC	10 at 70 F 90 RH	.2	.054	98
3.5 to 4			NC	10-15 at 71 F 90 RH	.21	.02	
6 to 8			NC	2 at 70 F 90 RH	.20 to .24	.025	

TABLE 36 Reflective insulation/foils and sheets

Material identification number	Generic type and class or description of insulation	Form	Maximum temp. limits °F Continuous	Maximum temp. limits °F Short	Density lbs/cu ft	Capillarity
108	Aluminum Sheet	Sheet. Any thickness.	1100	1100	169 (metal)	Neg
109	Aluminum foil Various thicknesses	Rolls.	600	600		Neg
110	Aluminum foil, on membrane paper or other reinforcement.	Kraft or asbestos paper with foil attached.	200	200		Neg
111	Aluminum-kraft. Accordian formed. Roll insulation	Reflective sheet, separated to form air spaces	200	200		Neg.

TABLE 37 Reflective insulation-preformed to fit piping and equipme

Material Identification number	Generic type and class or description of insulation material	Form	Maximum temp Limits °F Continuous	Maximum temp Limits °F Short	Density (Apparent) lbs/cu ft	Alkalinity pH	Capillarity
112	Stainless steel casing and SS reflective sheets	Factory fabricated to fit dimensions of equipment or piping systems.	1500	1500	8 to 10	7	0
113 A	Stainless steel casing and aluminum reflective sheets		1000	1000	6 to 8	7	0
113 B	Aluminum casing and aluminum reflective sheets.		1000	1000	5 to 7	7	0

TABLE 38 Cryogenic insulations

Material Identification number	Generic Type and Class or Description of Insulation Material	Construction		Number of Layers	Recommended Vacuum – Absolute Pressure in Microns of Hg	Density lbs/cu ft.
114	Aluminum foil, glass mat	Fluffy glass mats separating foil sheets		10 to 20	0.1	2.5
114	Aluminum foil, glass mat	Same as above		15 to 30	0.1	2.0
114	Aluminum foil, glass mat	Same as above		35 to 70	0.1	4.7
115	Aluminum foil, glass paper	Glass paper separating aluminum foil sheets		50 to 100	0.1	5.5
115	Aluminum foil, glass paper	Same as above		75 to 150	0.1	7.5
116	Carbon-silica	Carbon-silica powder mixture		–	2.0	8.0
117	Perlite	Perlite powder		–	2.0	8.0
118	Santocel®	Santocel powder		–	2.0	6.0
119	Santocel,® aluminum	Santocel and aluminum powder	Opacified Powder	–	2.0	10.0
120	Santocel,® copper	Santocel and copper powder	Opacified Powder	–	2.0	11.0

Combustibility					
Flame density/ flame spread index	Smoke density/ smoke density index	Noncombustible	Heat emissivity	Heat reflectance	Construction
		NC	.05	.95	Installed to form air spaces which are enclosed and/or seperated by sheets of aluminum, or aluminum surfaced paper.
		NC	.06	.95	
less than 25		NC	.06	.95	
less than 25			.06 each reflec.	.95 each reflec.	To be installed into cavity spaces.

Combustibility								
Flame Spread/ Flame Spread Index	Smoke Density/ Smoke Density Index	Noncombustible	Expansion in./in./°F	Hygroscopicity % Volume after Test	Linear Shrinkage Max % at Max Temp °F	Specific Heat Btu per lb per °F	Thermal Diffusivity sq ft/hr (calculated)	Water Absorption % vol., 24 hr submersion
		NC	.000001	0	0	.12		0
		NC	.000001	0	0	.16		0
		NC	.000001	0	0	.17		0

Table 39 Thermal conductivities of insulation (Btu/sq ft, hr, inch, °F) (continued)

Identification number	Generic type, class or description of insulation material	Form	Max temp °F	Density lbs/cu ft	Mean Temperature °F -200	-100	0	100	200	300	400	500	600	700	800	900	1000	1100	1200
1	Alumina silica fibers, combined with binders	Block	2000	16							0.39	0.43	0.48	0.53	[illegible]	0.63	0.69	0.74	0.80
2	Alumina silica fibers combined with binders	Block	2000	21								0.60	0.65	0.70	0.75	0.80	0.85	0.93	1.11
3	Refractory fiber molded Light weight	Board	2300	11					0.36	0.40	0.46	0.60	0.56	0.62	0.68	0.74	0.81	0.88	0.96
4	Amosite asbestos fibers and silicate binder.	PC	1200	14 to 16				0.32	0.37	0.42	0.47	0.52	0.57						
5	Amosite sponge felts, laminated together	Block and PC	660 to 700	26 to 33				0.36	0.42	0.48									
6	Asbestos paper, plain and corrugated. Cemented together.	PC	300	9 to 13				0.50	0.68										
7	Calcium silicate, reinforced with asbestos fibers.	Block and PC	1200	10 to 13				0.33	0.37	0.41	0.46	0.51	0.57	0.60					
8	Calcium silicate, reinforced with asbestos fibers (Extra high temperature)	Block and PC	1800	10 to 14				0.45	0.51	0.55	0.60	0.64	0.69	0.74	0.80				
9	Cork, vegetable	Block	200	6 to 9			0.24	0.28											
10	Diatomaceous silica, blended and bonded Class I	Block and PC	1600	24						0.61	0.62	0.64	0.66	0.68	0.69	0.71	0.74		
11	Diatomaceous silica, blended and bonded Class II (Extra high temperature)	Block and PC	1900	26						0.67	0.69	0.71	0.73	0.75	0.77	0.79	0.82		
12	Diatomaceous silica, asbestos fibers and inorganic binder	Board	1200	23						0.59	0.60	0.61	0.62	0.63	0.65	0.66	0.67		
13	Diatomaceous silica asbestos fibers and inorganic binder	Board	1200	36						0.78	0.79	0.80	0.81	0.82	0.84	0.85	0.86		

14	Diatomaceous silica, asbestos fibers and inorganic binder.	Board	1200	66				1.70	1.76	1.80				
15	Glass, cellular. Hermetically sealed cells	Block and PC	800	9 to 10	0.20	0.26	0.32	0.39	0.47	0.55	0.64	0.74	0.86	0.94
16	Glass, cellular. Hermetically sealed cells Between layers of felt	Board	200	9 to 10				0.39	0.47	0.55				
17	Glass, fibrous, with organic binders.	PC	370	3 to 4				0.23	0.27	0.32				
18	Glass, fibrous, with organic binder.	PC	450	7.0				0.26	0.30	0.34				
19	Glass, fibrous, with organic binder.	PC	600	3 to 5				0.23	0.27	0.32				
20	Glass, fibrous, with organic binder. Available with various facings	Semi-rigid Board	450	4 to 5				0.24	0.30	0.37				
21	Glass, fibrous, with organic binder. Available with various facings	Semi rigid Board	450	5 to 7				0.24	0.28	0.34	0.41			
22	Glass, fibrous, with organic binder. Available with various facings.	Semi-rigid Board	450	7 to 9				0.23	0.27	0.33	0.39			
23	Glass, fibrous, with high temperature binder.	Board	1000	3½				0.25	0.32	0.39	0.46	0.63		
24	Glass, fibrous, with organic binder. Asphalt attached facings. (roof board)	Board	100	6				0.30						
25	Glass, fibrous Coated one side to resist air erosion	Board Duct Liner	250	1.5 to 6				0.25	0.30					
26	Glass, fibrous, organic binder. With vapor resistant facing (Ducts)	Cylindrical and Board	250	3				0.24						
27	Glass, fibrous, organic binder With vapor resistant facing. (Ducts)	Cylindrical and Board	250	5				0.23						

TABLE 39 Thermal conductivities of insulations (Btu/sq ft, hr, inch, °F)

Identification number	Generic type, class or description of insulation material	Form	Max temp °F	Density lbs/cu ft	Mean temperature °F -200	-100	0	100	200	300	400	500	600	700	800	900	1000	1100	1200
28	Glass, fibrous, bonded to sheet aluminum.	4' x 8' Panels	450	Insul only 3 to 5				0.26	0.32	0.38									
29	Magnesium carbonate, with asbestos fibers and binders.	Block and PC	600	11 to 13				0.36	0.39	0.43	0.46								
30	Mineral fiber and inorganic binder.	Block	1800	15 to 18					0.36	0.39	0.42	0.47	0.51						
31	Mineral fiber and inorganic binder.	Block	1200	4 to 8		8 lb density			0.29	0.34	0.40	0.48	0.56	0.65					
						4 lb density			0.32	0.41	0.50	0.60							
32	Perlite, expanded and bonded. Treated to be water repellent.	Block and PC	1600	9.5 to 11.5				0.34	0.40	0.46	0.50	0.54	0.60	0.64	0.70	0.75	0.80		
33	Polystyrene, expanded beads. Molded to shape	Block, Board, PC	180	1			0.22	0.27											
34	Polystyrene, cellular foam Molded to shape.	Block, Board, PC	175	9 to 1.2			0.22	0.26											
35	Polystyrene, cellular foam.	Block, Board, PC	165	1.5 to 3.3			0.22	0.26											
36	Polystyrene, cellular foam, self-extinguishing	Block Board, PC	165	1.0 to 2.2			0.22	0.27											
37	Polyurethane foam	Block, Board, PC	250	1.5 to 2.5			0.16	0.16	0.19										
38	Polyruthene foam. Self-extinguishing	Block, Board, PC	250	1.9 to 4			0.17	0.16	0.19										
39	Rubber resin, foamed	Block, PC	220	4 to 6				0.29											
40	Siliceous fibers, with factory applied aluminum facing	4' x 8' Panels	450	4.5 to 5				0.26	0.32										

41	Vinyl chloride, cellular foam. Self-extinguishing	Block, PC	212 to 275	1.6 to 2		0.15	0.16	0.18											
42	Wood fiber insulating board (Roofs)	Board	175	15 to 18				0.36											
43	Asbestos, braided, inner and outer tubing. Filled with glass fibers.	Flexible PC						0.57	0.69	0.82									
44	Glass, fibers, with organic binder. Available with various facings.	Flexible Roll & Board	400	0.6 to 1.5	0.6 lb. density			0.32	0.42										
					1.5 lb density			0.26	0.32										
45	Same as 44	Flexible Board	400	1.5 to 2	1.5 lb. density			0.26	0.32										
					2 lb. density			0.25	0.30										
46	Same as 44	Flexible Board	400	2 to 3	2 lb. density			0.25	0.30										
					3 lb. density			0.24	0.29										
47	Same as 44	Flexible Board	400	3 to 4	3 lb. density			0.24	0.29										
					4 lb. density			0.23	0.28										
48	Polystyrene, cellular foam, Flexible	Roll	165	0.9 to 1.2			0.22	0.27											
49	Rubber resin, foamed. Flexible.	Sheet, PC	220	5 to 6				0.27											
50	Alumina silica fiber	Blanket	2300	3 to 8	3 lb Density						0.38	0.49	0.60	0.73	0.88	1.03	1.20	1.38	1.57
					4 lb "						0.33	0.41	0.50	0.60	0.73	0.85	0.97	1.13	1.28
					6 lb "						0.30	0.36	0.44	0.53	0.62	0.72	0.83	0.94	1.06
					8 lb.						0.28	0.34	0.40	0.47	0.55	0.63	0.70	0.80	0.90
51	Alumina silica fiber	Felt	2300	4 to 6										0.55	0.66	0.76	0.85	0.95	1.15
52	Alumina silica, long fiber and binder	Blanket	2300	6							0.36	0.41	0.47	0.54	0.62	0.70	0.78	0.87	0.97
53	Asbestos fiber.	Blanket	750	9 to 12					0.50	0.56	0.61	0.67	0.74						
54	Asbestos woven felt	Felt	750	10					0.50	0.56	0.62	0.67	0.72						

Table 39 Thermal conductivities of insulation (Btu/sq ft, hr, inch, °F) (continued)

Identification number	Generic type, class or description of insulation material	Form	Max temp °F	Density lbs/cu ft	Mean temperature °F -200	-100	0	100	200	300	400	500	600	700	800	900	1000	1100	1200
55	Glass, fibrous Batts in roll form.	Batts						0.31											
56	Glass, fibrous blankets Available with various facings	Blankets	250 to 450	0.6 to 3				0.32 0.26 0.24	0.42 0.32 0.29		0.6 to 1.5 density 1.5 to 2 lb " 2 to 3 lb "								
57	Glass, fibrous, faced on one or both sides with metal mesh.	Metal mesh Blanket	1000	2.4 to 6				0.24	0.32	0.40	0.50	0.61							
58	Glass fibrous blanket. Treated on one side (Duct liner)	One side treated to resist erosion	180 to 250	1.5 to 3				0.28											
59	Glass, woven felt	Felt	1200	8					0.28	0.32	0.36	0.41	0.48	0.50	0.55				
60	Glass, fiber, needled, no binder. (High Temperature)	Mat	1200	6 to 11						0.27	0.34	0.41	0.46	0.52					
61	Mineral fiber blankets between various types of metal fabric.	Blanket	1000	2.5 to 12				0.26	0.32	0.39	0.47	0.64							
62	Mineral fiber, felted, with binders.	Roll felt	460 to 600	3 to 8	3 lb density 8 lb. density			0.28 0.24	0.38 0.29	0.50 0.34									
63	Mineral fiber, secured by expanded metal mesh Precut for pipe covering	Sections for PC	1200	6 to 12	6 lb density			0.28	0.31	0.37	0.43	0.49							
64	Refractory fibers predominently Alumina and Silica	Felt	2300	3 to 24	3 lb density 12 lb. density 24 lb density					0.40 0.33 0.31	0.48 0.37 0.35	0.57 0.42 0.39	0.68 0.47 0.44	0.80 0.53 0.48	0.93 0.59 0.53	1.08 0.65 0.58	1.25 0.72 0.62		
65	Silica fibers	Felt and Blanket	1800	4.6 to 6									0.40	0.45	0.52	0.60	0.70		
66	Alumina silica, semi refractory, hydraulic setting cement.	Cement	2000	48 to 70									1.42	1.47	1.52	1.58	1.64	1.70	1.76
67	Alumina silica and asbestos fibers and binder.	Cement	1900	64 to 68					1.6										

68	Asbestos fibers and bonding clays. Finishing cement.	Cement	1000	40 to 60		2.1								
69	Asbestos, long fibers and binders	Cement	1000	40 to 70		1.5								
70	Asbestos fibers and bonding clays. Finishing cement	Cement	1000	45 to 65		2.1								
71	Asbestos fibers with special binders. For adhesion to water repellent surface	Cement	1000	60 to 60		1.20	1.30	1.40						
72	Calcium silicate cement	Cement	1200	19 to 22	0.40	0.43	0.48	0.62	0.67	0.82	0.68	0.74		
73	Diatomaceous silica, powder, with binders	Cement	1900	18 to 30		0.76	0.77	0.79	0.82	0.84	0.86	0.89	0.91	0.94
74	Magnesium carbonate and asbestos fibers	Cement	600	16 to 20	0.48	0.61	0.64							
75	Mineral fiber, with binders	Cement	1500	22 to 24	0.49	0.67	0.72	0.76	0.81	0.86	0.91	1.06		
76	Mineral fiber, with hydraulic setting binder. High adhesion.	Cement	1200	38 to 43		0.70	0.76	0.81	0.86	0.92				
77	Mineral fiber, asbestos fibers, with hydraulic setting binder.	Cement	1400	30 to 42	0.75	0.80	0.85	0.90	0.95					
78	Vermiculite and binders	Cement	1800	16 to 20		0.74	0.79	0.83	0.88	0.92	0.97	1.02	1.06	1.11
79	Asbestos, fibers, Amosite and inorganic binders	Spray mix	750	8 to 12	0.34	0.39	0.43	0.48	0.62	0.56	0.71			
80	Asbestos, fibers, Crocidolite and inorganic binders.	Spray mix	1350	8 to 12	0.34	0.39	0.43	0.48	0.52	0.56	0.71			

Table 39 Thermal conductivities of insulation (Btu/sq ft, hr, [illegible]

Identification number	Generic type, class or description of insulation material	Form	Max temp °F	Density lbs/cu ft	Mean temperature °F -200	-100	0	100	200	300	400	600	600	700	800	900	1000	1100	1200
81	Bituminous materials, cork or mica filled. Mastic.	Spray or trowel consistency mastic	200	40 to 60				0.90											
82	Ceramic fiber and inorganic binder.	Spray mix	2300	12 to 13								0.46	0.49	0.62	0.66	0.60	0.64		
83	Mineral fiber, granules, asbestos fibers and inorganic binder.	Spray mix	1800	11 to 13				0.32	0.36	0.40	0.44	0.61	0.69	0.68	0.74				
84	Polyvinyl acetate, cork filled. Mastic.	Spray or trowel consistency mastic	180					0.69											
85	Urethane 2 part mix. Self-extinguishing	2 part gun mix	250	2 to 3			0.17	0.18											
86	Alumina-silica fibers	Bulk fibers	2300	8										0.80	0.90	1.10	1.22	1.35	1.55
87	Alumina-silica fibers	Chopped and milled	2300	7.6										0.65	0.66	0.76	0.85	0.96	1.16
88	Alumina-silica long fibers	Long select fibers	2300	8								0.48	0.60	0.70	0.80	1.05	1.20	1.36	1.60
89	Asbestos fibers	Bulk fibers	1000	20 to 50				0.60 to 1.62											
90	Cork, vegetable, granulated	Granul for pouring	200	8 to 12	Average			0.31											
91	Diatomaceous silica	Coarse powder	1600	20 to 30	22 lb density				0.48		0.58		0.63		0.70		0.77		0.92
					25 lb density				0.63		0.77		0.92		1.13		1.27		1.47
92	Diatomaceous silica, fine	Fine powder	1600	12 to 17	12.6 lb density				0.36		0.44		0.53		0.64				
					17 lb density				0.42		0.48		0.55		0.62		0.69		0.84

93	Diatomaceous silica, calcined.	Loose	2000	26 to 31	26 lb. density	0.69	0.76	0.83	0.91	1.00	1.11	1.23	1.35				
					31 lb. density		0.92	0.97	1.03	1.08	1.14	1.18	1.28	1.31	1.37	1.42	1.48
94	Diatomaceous silica and asbestos fibers.	Loose	1800	18			0.59	0.61	0.62	0.63	0.65	0.66	0.68	0.69	0.71		
95	Gilsonite, granules. Various grades for various temperatures.	Granulated	300 to 460	44 to 60		0.65 to 0.80											
96	Glass, fibers, unbonded	Shredded or loose fibers	1000	2 to 12	4 lb. density	0.24	0.32	0.40	0.51								
					8 lb. density	0.24	0.31	0.36	0.46								
97	Glass, fibers. Pouring wool.	Pouring or blowing type	250	0.6 to 1.6		0.30											
98	*Glass, cellular, pellets*	Various size pellets	800			0.40											
99	Gypsum, cellular pellets		800			0.44 to 1.00											
100	Lampblack	Various grades	1200	4.7 to 18		0.20 to 0.26											
101	Mineral fibers, with small amount of oil lubricant.	Loose	1200	4 to 11	10 lb. density	0.28	0.34	0.42	0.51	0.61	0.72	0.83	0.94				
102	Mineral fibers Oil free	Loose	1200	10 to 15	10 lb. density		0.53	0.58	0.64	0.70	0.76	0.83	0.91				
103	Mineral fibers	Granulated	1000 to 1200	6 to 15	10 lb. density	0.28	0.34	0.42	0.51	0.61	0.72	0.83	0.94				
104	Perlite, expanded. Spheres	Loose	1400	3		0.27	0.36										
105	Silica fibers	Loose fibers	1800	3 to 9	3 lb. density						0.66	0.78	0.90	1.05	1.20	1.38	1.67
					9 lb. density						0.40	0.47	0.55	0.65	0.75	0.82	0.90
106	*Silica aerogel granules*	Various size granules	1300	4 to 5.5	5.3 lb. density 0.12	0.16	0.18	0.21									
107	Vermiculite	Flakes	2000	5 to 10	5 lb. density	0.47	0.58										
					10 lb. density	0.44	0.54	0.62	0.71	0.80	0.89	0.99	1.10	1.21	1.32		

TABLE 40 Thermal conductances of reflective insulations (Btu/sq. ft., hr., inch, °F)

Material identification number	Generic type and class or description of insulation material	Form	
108	Aluminum Sheet	Various thicknesses	all
109	Aluminum Foil	Various thicknesses	all
110	Aluminum foil (both sides) on membrane paper or other reinforcement.	Laminate	all
111	Aluminum foil, accordian formed roll insulation	Expendable roll for cavities	all

Position	Direction of heat flow	Conductance at 75°F Mean temperature, Air spaces ¾" ε = 0.05 (Aluminum), Air spaces enclosed and seperated by reflective shield — Number of spaces: 1	2	3	4	6	6	7	8	9	10
Vertical	Across	0.35	0.18	0.12	0.09	0.07	0.06	0.05	0.045	0.04	0.035
Horizontal	Upward	0.48	0.25	0.17	0.12	0.10	0.08	0.07	0.06	0.065	0.05
Horizontal	Downward	0.35	0.18	0.12	0.09	0.08	0.07	0.055	0.046	0.04	0.035

Note: Heat transfer is given in CONDUCTANCE, not Conductivity

TABLE 41 Thermal conductivities of insulations (Btu/sq. ft., hr., inch, °F)

Identification number	Generic type, class or description of insulation material	Form	Max. temp. °F	Density lbs/cu ft	Mean temperature °F: -200	-100	0	100	200	300	400	600	600	700	800	900	1000	1100	1200
112	Stainless steel casing and SS reflective sheets	Custom built	1600	8 to 10	Varied to suit need														
113 A	Stainless steel casing and aluminum reflective sheets	Custom built	1000	6 to 8				0.286	0.328	0.400	0.466	0.637	0.600						
113 B	Aluminum casing and aluminum reflective sheets	Custom built	1000	6 to 7				0.260	0.307	0.378	0.444	0.607	0.670						

Conductivities are giver. in "apparent" k values.
"Apparent" k value is the equivalent average thermal conductivity of this non homogeneous insulation, for comparison with the k value of homogeneous materials as determined by ASTM Test Method C 335.

TABLE 42 Thermal conductivities of insulations (Btu/sq. ft., hr., inch, °F)

Identification number	Generic type, class or description of insulation material	Form	Max. temp. °F	Density lbs/cu ft	Mean temperature °F														
					-200	-100	0	100	200	300	400	500	600	700	800	900	1000	1100	1200
114	Aluminum foil, glass mat	laminate 10 to 12 layers		2.6	0.00108														
114	Aluminum foil, glass mat	laminate 15 to 30 layers		2.0	0.00078														
114	Aluminum foil, glass mat	laminate 35 to 70 layers		4.7	0.00024														
115	Aluminum foil, glass paper	laminate 50 to 100 layers		5.5	0.00022														
115	Aluminum foil, glass paper	laminate 75 to 150 layers		7.6	0.00012														
116	Carbon-silica	powder mixture		8.0	0.00480														
117	Perlite	Powder		8.0	0.00866														
118	Santocel®	Powder		6.0	0.01150														
119	Santocel,® aluminum	Opacified powder		10.0	0.00264														
120	Santocel,® copper	Opacified powder		11.0	0.00270														

manufacturers. As there are differences in the properties of a generic material produced by different manufacturers, the properties are a mean of the values listed for the products of the various manufacturers. Thus, for those products made by several manufacturers, no single manufacturer's product will have exactly the values as listed. It follows then, that these tables are presented to serve as a *guide* for selection of the correct *generic material* for an installation. However, the final choice of the particular manufactured product must be made by the individual by comparing competitive products.

The property "Maximum Temperature Limits" is given first as this is the first requirement that must be fulfilled. "Density" is second, as it frequently identifies or classifies a particular material as being in a given generic class, and within a generic class it affects the thermal conductivity.

All other properties are listed in alphabetical order.

Property Tables—Conductivity

The thermal conductivities given in Tables 39 through 42 have been gathered from various sources and while deemed accurate, are not the result of tests by the author. In most cases, they are the results of tests performed upon laboratory-dried samples by the manufacturers. They are based upon representative values for generic material within their ranges of densities and are neither the highest nor the lowest of a particular listing of competitive materials. They represent mean averages which we expect will provide relatively accurate information for use in heat transfer calculations.

As all values listed are taken as representative of the means of generic materials available and are provided for engineering calculation only, they are not deemed suitable for use as material specification limits. Any one particular manufacturer's product is not likely to have the mean values of all the materials manufactured in that particular generic classification.

For a particular installation, the material specification must be written by deciding what property values are essential and, with knowledge of materials available, the specification must be written to obtain those essential properties within the ranges of the materials available.

Hopefully, this book will indicate the need for more complete information on properties of materials and that any missing information will be made available by the manufacturers. When insulation consumers understand the need for designing insulation systems on a scientific basis the manufacturers will quickly respond by providing the necessary technical information.

The abbreviations in the Tables have the following meanings:

amts.	amounts
Exp. Co.	Coefficient of expansion
Comb.	Combustible
hex.	hexagon
Insul.	Insulation
Neg.	Negligible
NC	Noncombustible
PC	Pipe Covering
RH	Relative Humidity
Temp.	Temperature
thk.	thickness
SS	stainless steel

Installation Requirements

"Installation Requirements" per se may be misunderstood to mean only the requirements during the application or service life of an "installation." What is intended, however, is a discussion of the requirements that an insulation must fulfill from the time it is manufactured until it is in service. After insulation is produced, it passes through several phases; i.e., it is shipped, stored, possibly fabricated, reshipped to the job, installed, and finally used in the service for which it was originally specified.

For lack of a more descriptive term, these various operations that the insulation must pass through from the time of its production until its ultimate discard will be called "phases." They may differ, depending upon the method of manufacture, type of material, and use, but in general they may be listed as follows:

Shipping
Storage
Fabrication
Application
Service

Each of these phases imposes a set of requirements upon the insulating material. It must meet these requirements in order to fulfill successfully its economic function. Evaluation of these requirements and the selection of the insulating material which will best perform the specified function is an engineering design problem. This problem is complicated, not only by the large number of requirements, but also by the lack of reliable data on the requirements themselves. Because of this lack of data, it is impossible to provide both an exact list of the requirements and of the properties whereby a precise selection of material can be determined. Therefore, this discussion must be kept general, for the final selection will be determined by engineering judgment. This chapter will be helpful in determining the factors affecting that judgment. It must be understood that an error in judgment here may make the difference between a successful or an unsuccessful installation—a profitable or unprofitable operation.

Other than the purely technical aspects, there are reasons of business and procurement (such as availability) which influence the selecsation and drip. A general rule to remember: the lower the emittance, the closer the outer surface temperature will be to the temperature of the surface under the insulation. Conversely, the higher the emittance, the closer the outer surface temperature will be to the temperature of the ambient air.

Moisture requirements

Insulation, to be efficient, must be kept dry. Moisture in two forms, the liquid or the vapor state, can saturate the insulation. It can enter by various means, water pressure, vapor pressure, in-gassing, and simple leaks. The protection required will be determined by the installation conditions.

When insulated piping or equipment is submerged in water, a completely water-tight outer shell is required around the insulation. Such systems must be encased in metal, fabricated by welded sections, and/or flanged with jacketed flanges, so that the outer jacket is sufficiently tight and strong to withstand the water pressure.

Underground installations where insulation systems may not be directly subjected to definite water pressure must still be protected to prevent the entry of water. Such protection must not only prevent the said entry, but it must also resist corrosion to remain water-tight. The corrosion may be ordinary rust, chemical corrosion, or galvanic corrosion.

If the function of the two previously mentioned examples is the insulation of hot surfaces, vapor migration will be of no concern. However, if the installation is for low temperature service, water vapor migration will be an additional problem. Many conduit systems may be water-tight and *not* be vapor-tight. Practically, it is relatively easy to construct water-tight systems, but *almost impossible* to construct vapor-tight ones. For this reason, it is suggested that, wherever possible, the cold equipment and piping be installed above grade.

The moisture protection necessary on equipment and piping located above grade is determined by whether the location is indoors or outdoors, and the operating temperature above or below ambient.

High temperature insulated equipment and piping located indoors and not subjected to rain, snow, or sleet does not require water or moisture protection. A word of caution—the insulation must be adequately protected from moisture due to possible spillage or the washing down of vessels.

Low temperature insulated equipment and piping located indoors must be protected against moisture vapor. The necessity for such protection was explained in Chapter 3, and illustrated in Figure 33.

High temperature insulated equipment and piping located outdoors must be protected from liquid moisture in the form of rain, sleet, or snow.

Low temperature insulated equipment and piping located outdoors must be protected both from liquid water, and also moisture in the vapor phase.

These moisture requirements are summarized below:

Service		Moisture Protection Required		
Temperature	Location	Water pressure	Water	Vapor
High temp.	Underwater	Required	Required	Not required
Cyclic temp.	Underwater	Required	Required	Required
Low temp.	Underwater	Required	Required	Required
High temp.	Below grade	Depends	Required	Not required
Cyclic temp	Below grade	Depends	Required	Required
Low temp.	Below grade	Depends	Required	Required
High temp.	Above grade indoors	Not required	Depends	Not required
Cyclic temp.	Above grade indoors	Not required	Depends	Required
Low temp.	Above grade indoors	Not required	Depends	Required
High temp	Above grade outdoors	Not required	Required	Not required
Cyclic temp	Above grade outdoors	Not required	Required	Required
Low temp.	Above grade outdoors	Not required	Required	Required

Safety requirements

The major safety requirements may be separated into the following divisions:

Safe surface temperature for personnel protection or ignition.

Safety from radioactivity or chemical reaction.

Safety from toxic conditions.

Fire protection.

When hot equipment or piping is located where its insulation may be touched by personnel, the insulation should be so designed that its thermal resistance, surface emittance, and jacket conductivity together create a condition which will not produce skin burns when its outer surface is accidentally touched. In general, metallic surfaces at a temperature over 145°F can cause skin burns. A specific figure is not possible as this depends upon the individual, the roughness of the surface, the cleanness of the surface, and the conductivity and mass of the metal. The higher the conductivity of the metal, the smoother the surface, the cleaner the surface, and the greater the mass of metal, the more likely a person is to be burned at a particular temperature.

Where combustible materials are present and chances of leakage or spillage prevail, a suitable low surface temperature of insulated vessels and piping may be very important in preventing the ignition of these materials. When this condition prevails, it becomes necessary that all hot surfaces, such as valves, flanges, and metal projections, be insulated so as to maintain all exposed surfaces below the maximum allowable surface temperature. Some areas which cannot be insulated, such as valve bonnets and stuffing boxes, may require shielding to prevent contact with the chemical.

As previously mentioned, non-combustible but *absorptive* insulation may be a fire hazard in two ways. First, in the case of combustible material leaks, the insulation's tremendous internal surface area can assist in causing rapid oxidation which will result in spontaneous combustion. Second, also in the case of leaks, any absorbent can *hold* large quantities of combustibles and, if an accidental fire occurs, the saturated insulation will feed and spread it. To illustrate the potential hazard—a cubic foot of saturated insulation can hold approximately six gallons of combustible material. In case of ignition, the insulation then acts like the wick of a lantern. Even though it does not itself burn, it conveys the vaporizing combustible to the surface where it can burn. For these reasons, it is evident that the process, the materials being processed, the potential of leaks, and the degree of hazard of the location, all must be considered in the selection and design of an insulation system.

The potential fire hazard of an insulation, as related to an installation, has been shown. However, properly used insulation can be used as fire protection. An installation on equipment and piping must be considered from two basically different viewpoints. First, the combustibility of the insulation must be considered, including the speed at which the insulation will spread fire, or the amount of heat and smoke it will contribute. Second, the time rate at which temperature will pass through the insulation from the fire side to the vessel or pipe must be thought of.

Where fire *spread* is hazardous, the system should be of non-combustible insulations which do not contribute fuel to the fire. In many instances light weight insulations and thin metallic jackets will meet these requirements.

If vessels and piping are to be protected for a period of time from accidental fire, then the time required for the high temperature of the fire to pass through the insulation to the pipe or vessel is of utmost importance. Where this is a requirement, light weight materials of high diffusivity are of little advantage even though they are incombustible. To illustrate: a piece of wood will provide much greater time-temperature protection to a vessel than any insulation of 2 to 3 lbs. density, even while burning on its outer surface. Of course, the use of wood is not recommended for fire protection as it can add considerable fuel to a fire. It was mentioned only to show that, for temperature retardation, the rate of diffusivity and mass are the deciding factors, not conductivity (by itself) or combustibility.

Economic requirements

The economic value of the insulation depends upon the installation requirements, and, as this

1970
ANNUAL BOOK OF ASTM STANDARDS

PART 14

Thermal and Cryogenic Insulating Materials; ... l Materials; Building Joint Sealants; ... Tests; Building Constructions

Includes Standards of:

Committee
- C-16 on Thermal and Cryogenic Insulating Materials
- C-20 on Acoustical Materials
- C-24 on Building Joint Sealants
- E-5 on Fire Tests of Materials and Construction
- E-6 on Performance of Building Constructions

Price $19.00

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LIST BY SUBJECTS, PART 14

THERMAL AND CRYOGENIC INSULATING MATERIALS, ACOUSTICAL MATERIALS, BUILDING JOINT SEALANTS, FIRE TESTS, BUILDING CONSTRUCTIONS

Since the standards in this book are arranged in alphanumerical sequence, no page numbers are given in this list.

THERMAL AND CRYOGENIC INSULATING MATERIALS

Specifications for:

*C 391 – 64	Amosite Asbestos Thermal Insulation for Pipes
C 194 – 64	Asbestos Thermal Insulating and Finishing Cement
C 533 – 67	Calcium Silicate Block and Pipe Thermal Insulation
C 298 – 56 (1965)	Cellular Asbestos Paper Thermal Insulation for Pipes
C 552 – 66	Cellular Glass Block and Pipe Thermal Insulation
C 640 – 69	Corkboard and Cork Pipe Insulation for Low Temperature Thermal Insulation
C 517 – 64	Diatomaceous Earth Block and Pipe Thermal Insulation
C 197 – 61 (1967)	Diatomaceous Silica Thermal Insulating Cement
C 489 – 64	85 Per Cent Magnesia Block and Pipe Thermal Insulation
C 196 – 61 (1967)	Expanded or Exfoliated Vermiculite Thermal Insulating Cement
C 610 – 67	Expanded Perlite Block and Pipe Thermal Insulation
C 299 – 56 (1965)	Laminated Asbestos Thermal Insulation for Pipes
C 193 – 64	Magnesia Thermal Insulating Cement
C 262 – 64	Mineral Fiber Batt Insulation (Industrial Type)
C 553 – 70	Mineral Fiber Blanket and Felt Insulation (Industrial Type)
C 592 – 70	Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type)
C 665 – 70	Mineral Fiber Blanket Thermal Insulation for Wood Frame and Light Construction Buildings
C 612 – 70	Mineral Fiber Block and Board Thermal Insulation
C 449 – 64	Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement
C 547 – 67	Mineral Fiber Preformed Pipe Insulation
C 195 – 64	Mineral Fiber Thermal Insulating Cement
C 549 – 67	Perlite Loose Fill Insulation
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C 591 – 69	Rigid Preformed Cellular Urethane Thermal Insulation
C 656 – 70	Structural Insulating Board, Calcium Silicate
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C 532 – 66	Structural Insulating Formboard Made from Vegetable Fibers
C 516 – 67	Vermiculite Loose Fill Insulation
*E 11 – 70	Wire-Cloth Sieves for Testing Purposes

* Approved as **American National Standard** by American National Standards Institute.

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C 590 – 69 Action on Substrates by Coatings, Adhesives, and Joint Sealants Used on or with Thermal Insulations
*C 353 – 56 (1965) Adhesion of Dried Thermal Insulating Cement
*C 383 – 58 (1967) Adhesion, Wet, of Thermal Insulating Cements to Metal
C 589 – 68 Apparent Impact Strength of Preformed Block-Type Insulating Materials
*C 203 – 58 (1965) Breaking Load and Calculated Flexural Strength of Preformed Block-Type Thermal Insulation
*C 446 – 64 Breaking Load and Calculated Modulus of Rupture of Preformed Insulation for Pipes
C 240 – 61 Cellular Glass Insulating Block (see Part 13)
*C 165 – 54 (1970) Compressive Strength of Preformed Block-Type Thermal Insulation
*C 354 – 56 (1965) Compressive Strength of Thermal Insulating Cement
*C 405 – 60 (1967) Consistency of Wet-Mixed Thermal Insulating Cement
*C 464 – 64 Corrosion Effect of Thermal Insulating Cements on Base Metal
*C 166 – 61 (1967) Covering Capacity and Volume Change Upon Drying of Thermal Insulating Cement
C 519 – 65 Density of Fibrous Loose Fill Building Insulation
C 520 – 65 Density of Granular Loose Fill Insulations
*C 303 – 56 (1965) Density of Preformed Block-Type Thermal Insulation
*C 302 – 56 (1965) Density of Preformed Pipe-Covering-Type Thermal Insulation
C 548 – 69 Dimensional Stability of Low-Temperature Thermal Block and Pipe Insulation
*C 487 – 64 Dropping of Preformed Block-Type Thermal Insulation, Resistance to
*C 445 – 61 (1967) Emmittance, Normal Total, of Surfaces of Materials 0.01 in. or Less in Thickness at Approximately Room Temperature
*C 488 – 64 (1970) Exposure Tests of Finishes for Thermal Insulation, Conducting Exterior
*C 411 – 61 (1967) Hot-Surface Performance of High-Temperature Thermal Insulations
C 569 – 68 Indentation Hardness of Preformed Thermal Insulations
*C 461 – 64 Mastic Coatings Used in Conjunction with Thermal Insulation
*C 447 – 64 Maximum Use Temperature of Preformed High-Temperature Insulation, Determining
*C 421 – 61 (1967) Mechanical Stability of Preformed Thermal Insulation by Tumbling
*C 163 – 64 Mixing Thermal Insulating Cement Samples
*C 390 – 60 (1967) Sampling Preformed Thermal Insulation
*C 356 – 60 (1967) Shrinkage, Linear, of Preformed High-Temperature Thermal Insulation Subjected to Soaking Heat
*C 351 – 61 (1967) Specific Heat, Mean, of Thermal Insulation
*C 209 – 60 (1966) Structural Insulating Board Made from Vegetable Fibers
*C 419 – 65 Test Specimens of Mastic Thermal Insulation Coatings, Making and Curing
*C 236 – 66 Thermal Conductance and Transmittance of Built-Up Sections by Means of the Guarded Hot Box
*C 177 – 63 (1968) Thermal Conductivity of Materials by Means of the Guarded Hot Plate
C 518 – 70 Thermal Conductivity of Materials by Means of the Heat Flow Meter
*C 335 – 69 Thermal Conductivity of Pipe Insulation
*C 167 – 64 (1970) Thickness and Density of Blanket- or Batt-Type Thermal Insulating Materials
C 550 – 68 Trueness and Squareness of Block Thermal Insulation
E 96 – 66 Water Vapor Transmission of Materials in Sheet Form
*C 355 – 64 Water Vapor Transmission of Thick Materials

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C 585 – 68 Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipes and Tubing (NPS System)
C 450 – 68 Prefabrication and Field Fabrication of Thermal Insulating Fitting Covers for NPS Piping, Vessel Lagging, and Dished Head Segments
C 653 – 70 Thermal Resistance of Low-Density Mineral-Fiber Blanket-Type Building Insulation, Determination of

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C 647 - 69	Properties and Tests of Mastic Coatings for Thermal Insulation

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C 635 - 69	Metal Suspension Systems for Acoustical Tile and Lay-In Panel Ceilings

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C 522 - 69	Airflow Resistance of Acoustical Materials
C 384 - 58	Impedance and Absorption of Acoustical Materials by the Tube Method
C 523 - 68	Light Reflectance of Acoustical Materials by the Integrating Sphere Reflectometer
C 643 - 69	Painting Ceiling Materials for Acoustical Absorption Tests
•C 423 - 66	Sound Absorption of Acoustical Materials in Reverberation Rooms
C 367 - 57	Strength Properties of Prefabricated Architectural Acoustical Materials

Recommended Practices for:

E 90 - 70	Airborne Sound Transmission Loss of Building Partitions, Laboratory Measurement of
C 636 - 69	Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-In Panels
E 336 - 67 T	Measurement of Airborne Sound Insulation in Buildings

Definition of Terms Relating to:

C 634 - 69	Acoustical Tests of Building Constructions and Materials

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C 509 - 70	Cellular Elastomeric Preformed Gasket and Sealing Material
C 542 - 69	Elastomeric Structural Glazing and Panel Gaskets
C 564 - 70	Rubber Gaskets for Cast Iron Soil Pipe and Fittings
C 510 - 66	Staining and Color Change of One- or Two-Part Joint Sealants

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D 2451 - 69	Degree of Set for Glazing Compounds on Sash
D 2452 - 69	Extrudability of Oil and Resin-Base Caulking Compounds
C 603 - 69	Extrusion Rate of One- and Two-Part Joint Sealants and Application Life of Two-Part Joints Sealants
C 661 - 70	Indentation Hardness of Elastomeric Type Sealants by Means of a Durometer
D 2249 - 67	Predicting the Effect of Weathering on Face Glazing and Bedding Compounds on Metal Sash
C 639 - 69	Rheological (Flow) Properties of One- and Two-Part Joint Sealants to Be Used in Building Construction
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D 2376 - 67	Slump of Face Glazing and Bedding Compounds on Metal Sash
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D 2377 - 67	Tack-Free Time of Oil and Resin-Base Caulking Compounds

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•E 119 - 69	Building Construction and Materials, Fire Tests of
•*D 1230 - 61*	*Clothing Textiles, Flammability of (see Part 24)*

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•E 152 – 66	Door Assemblies, Fire Tests of
D 1433 – 58 (1966)	*Flexible Thin Plastic Sheeting, Flammability of (see Part 27)*
E 136 – 65	Noncombustibility of Elementary Materials
D 1360 – 58 (1965)	*Paints, Fire Retardancy of (Cabinet Method) (see Part 21)*
D 1361 – 58 (1965)	*Paints, Fire Retardancy of (Stick and Wick Method) (see Part 21)*
D 777 – 46 (1965)	*Paper and Paperboard, Treated, Flammability of (see Part 15)*
D 1692 – 68	*Plastic Sheeting and Cellular Plastics, Flammability of (see Part 27)*
D 568 – 68	*Plastics, Flexible, Flammability of (see Part 27)*
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•E 84 – 68	Surface Burning Characteristics of Building Materials
E 286 – 69	Surface Flammability of Building Materials Using an 8-ft (2.44-m) Tunnel Furnace
E 162 – 67	Surface Flammability of Materials Using a Radiant Heat Energy Source
•E 160 – 50 (1969)	Treated Wood, Combustible Properties of, by the Crib Test
•E 69 – 50 (1969)	Treated Wood, Combustible Properties of, by the Fire-Tube Apparatus
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•E 72 – 68	Panels for Building Construction, Conducting Strength Tests of
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E 330 – 70	Structural Performance of Exterior Windows, Curtain Walls, and Doors Under the Influence of Wind Loads
E 154 – 68	Vapor Barriers, Materials for Use as, Under Concrete Slabs and as Ground Cover in Crawl Spaces
E 331 – 70	Water Penetration of Exterior Windows, Curtain Walls, and Doors by Uniform Static Air Pressure Differential
•C 355 – 64	Water Vapor Transmission of Thick Materials
E 405 – 70	Wear Testing Rotary Operators for Windows

Recommended Practices for:

E 241 – 68	Increasing Durability of Building Constructions Against Water Damage
E 90 – 70	Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions
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Classification for:

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METRIC PRACTICE GUIDE

E 380 – 70	*Metric Practice Guide (Excerpts) (see Related Materials section)*

NEW AND REVISED STANDARDS RECEIVED TOO LATE FOR PUBLICATION

(Available as Separate Reprints)

New Standards:

C 667 – 70, Recommended Practice for Prefabricated Reflective Insulation Systems for Equipment and Pipe Operating at Temperatures Above Ambient Air

C 669 – 70, Specifications for Glazing Compounds for Back Bedding and Face Glazing of Metal Sash

Revision of Standards:

C 517 - 70
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C 163 - 64 (1970)
C 193 - 64 (1970)
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ANNUAL BOOK OF ASTM STANDARDS

ASTM

PART 12

Chemical-Resistant Nonmetallic Materials; Clay and Concrete Pipe and Tile; Masonry Mortars and Units; Asbestos-Cement Products; Natural Building Stones

Includes standards of:

Committee

C-3 on Chemical-Resistant Nonmetallic Materials
C-4 on Clay Pipe
C-12 on Mortars for Unit Masonry
C-13 on Concrete Pipe
C-15 on Manufactured Masonry Units
C-17 on Asbestos-Cement Products
C-18 on Natural Building Stones

Price $16.00

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A complete Subject Index appears on p. 479.

This contents includes only those standards and tentatives in this book and those standards in the area covered by Part 12 that have been superseded or discontinued during the past five years. Since the standards in this book are arranged in numeric sequence, no page numbers are given in this contents.

In the serial designations prefixed to the following titles, the initial letter, indicative of the general classification, and the first number are permanent. The number following the dash indicates the year of original issue as tentative or of adoption as standard or, in the case of revision, the year of last revision. Thus, standards adopted or revised during the year 1969 have as their final number, 69. A letter following this number indicates more than one revision during that year, that is 69a indicates the second revision in 1969, 69b the third revision, etc. Tentatives are identified by the letter T. Standards that have been reapproved without change are indicated by the year of last approval in parentheses as part of the designation number, for example, (1969).

* Approved as American National Standard by the American National Standards Institute.

C 120 - 52 (1970) Flexure Testing of Slate (Modulus of Rupture, Modulus of Elasticity)
C 121 - 48 (1970) Test for Water Absorption of Slate
•C 126 - 69 Spec. for Ceramic Glazed Structural Clay Facing Tile, Facing Brick, and Solid Masonry Units
C 129 - 64 T Spec. for Hollow Non-Load-Bearing Concrete Masonry Units
•C 139 - 65 Spec. for Concrete Masonry Units for Construction of Catch Basins and Manholes
•C 140 - 65 T Sampling and Testing Concrete Masonry Units
C 144 - 69 Spec. for Aggregate for Masonry Mortar
•C 145 - 66 T Spec. for Solid Load-Bearing Concrete Masonry Units
•C 159 - 63 Spec. for Vitrified Clay Filter Block for Trickling Filters
C 170 - 50 (1970) Test for Compressive Strength of Natural Building Stone
C 200 - 69 Spec. for Extra Strength Clay Pipe
•C 211 - 68 Spec. for Standard and Extra Strength Perforated Clay Pipe
C 212 - 60 Spec. for Structural Clay Facing Tile
•C 216 - 69 Spec. for Facing Brick (Solid Masonry Units Made from Clay or Shale)
C 217 - 58 (1970) Test for Weather Resistance of Natural Slate
C 218 *(Test for Effect of Combined Temperature Cycles and Weak Salt Solutions on Natural Building Stone) Discontinued 1965*
•C 220 - 67 Spec. for Flat Asbestos-Cement Sheets
•C 221 - 61 (1968) Spec. and Methods of Test for Corrugated Asbestos-Cement Sheets
•C 222 - 66 Spec. for Asbestos-Cement Roofing Shingles
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C 361 - 70 Spec. for Reinforced Concrete Low-Head Pressure Pipe
C 386 - 60 Rec. Practice for Use of Chemical-Resistant Sulfur Mortars
C 395 - 64 Spec. for Chemical-Resistant Resin Mortars
C 396 *(Test for Compressive Strength of Chemically Setting, Silicate and Silica Chemical-Resistant Mortars) Discontinued 1968—Replaced by Method C 579*
C 397 - 67 Rec. Practice for Use of Chemically Setting Chemical-Resistant Silicate and Silica Mortars
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C 404 - 61 (1969) Spec. for Aggregates for Masonry Grout
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C 425 - 66 T Spec. for Compression Joints for Vitrified Clay Bell and Spigot Pipe
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C 427 - 64 Test for Moisture Condition of Hardened Concrete by the Relative Humidity Method
C 428 - 69a Spec. for Asbestos-Cement Nonpressure Sewer Pipe
C 443 - 70 Spec. for Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets
C 444 - 68 Spec. for Perforated Concrete Pipe

RELATED MATERIAL

TENTATIVE REVISIONS

Under the standardization procedure of the Society, Tentative Revisions of ASTM Standards are published for one or more years with a view of eliciting criticisms of which the committee concerned will take due cognizance before recommending final action.

The Tentative Revisions pending of standards in this part are listed below.

Manufactured Masonry Units

*C 126 – 69	Specifications for Ceramic Glazed Structural Clay Facing Tile, Facing Brick, and Solid Masonry Units
*C 56 – 62	Specifications for Structural Clay Non-Load-Bearing Tile

Pipe and Drain Tile

C 14 – 68	Specifications for Concrete Sewer, Storm Drain, and Culvert Pipe

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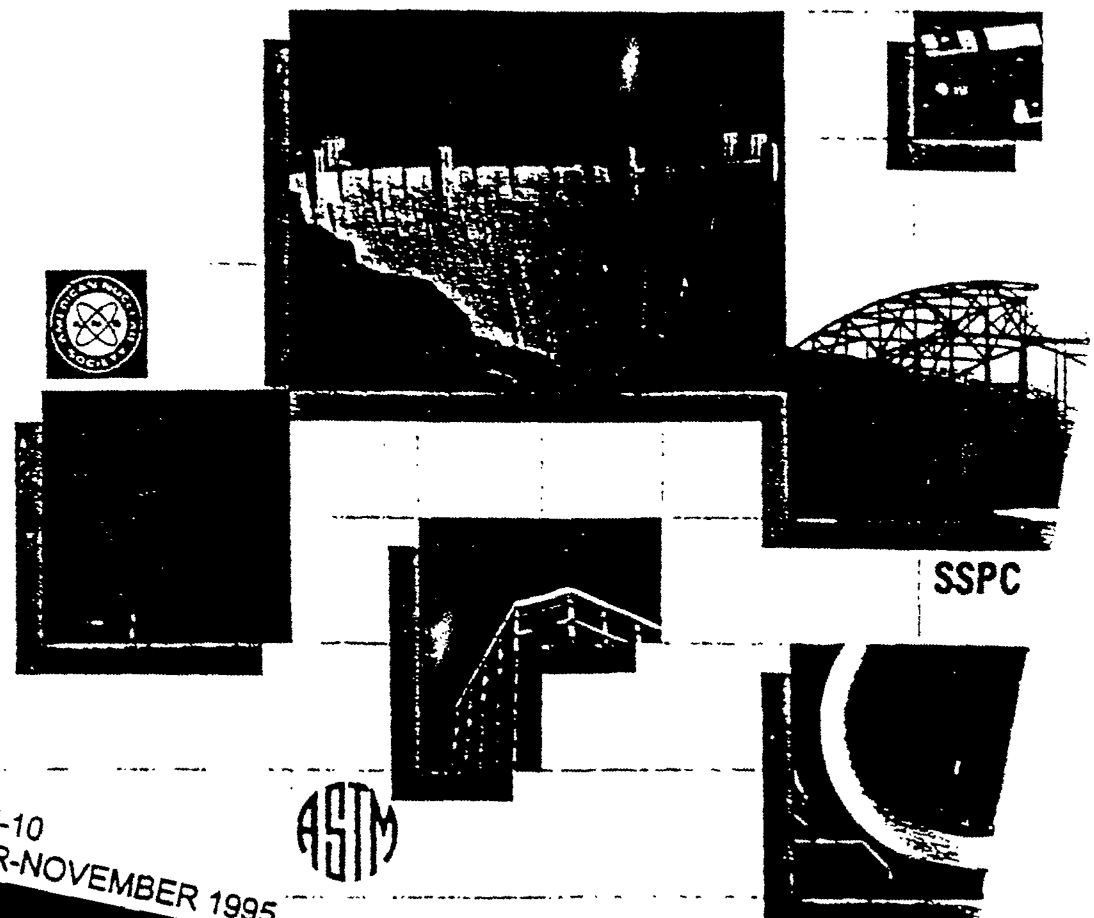

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INDUSTRY STANDARDS

AA-The Aluminum Association

AASHTO-American Association of State Highway and Transportation Officials

AATCC-American Association of Textile Chemists and Colorists

ABMA-American Bearing Manufacturers Association

ABS-American Bureau of Shipping

ACI-American Concrete Institute

A.G.A.-American Gas Association

AGMA-American Gear Manufacturers Association

AIA/NAS-Aerospace Industries Association of America

AI-Asphalt Institute

AIA®-The American Institute of Architects

AIChE-American Institute of Chemical Engineers

AIIM-Association for Information and Image Management

AISC-American Institute of Steel Construction

AISI-American Iron and Steel Institute

ANS-American Nuclear Society

ANSI-American National Standards Institute

API-American Petroleum Institute

AREA-American Railway Engineering Association

ARI-Air-Conditioning and Refrigeration Institute

ARINC-Aeronautical Radio

ASA-Acoustical Society of America

ASAE-The American Society of Agricultural Engineers

ASCE-American Society of Civil Engineers

ASHRAE-American Society of Heating, Refrigerating and Air-Conditioning Engineers

ASME-American Society of Mechanical Engineers

ASNT-American Society for Nondestructive Testing

ASQC-American Society for Quality Control

ASSE-American Society of Sanitary Engineering

ASTM-American Society for Testing and Materials

AWS-American Welding Society

AWWA-American Water Works Association

A2LA-American Association for Laboratory Accreditation

BHMA-Builders Hardware Manufacturers Association

CGA-Compressed Gas Association

CTI-Cooling Tower Institute

EIA-Electronic Industries Association

GPA-Gas Processors Association

IEEE-Institute of Electrical and Electronics Engineers

IESNA-Illuminating Engineering Society of North America

IFI-Industrial Fasteners Institute

IPC-The Institute for Interconnecting and Packaging Electronic Circuits

ISA-Instrument Society of America

ISHM-International Society for Hybrid Microelectronics

MSS-Manufacturers Standardization Society of the Valve and Fittings Industry

NACE-National Association of Corrosion Engineers

NEBB-National Environmental Balancing Bureau

NEMA-National Electrical Manufacturers Association

NFPA-National Fire Protection Association

NFP(A)-National Fluid Power Association

NISO-National Information Standards Organization

NSF-National Sanitation Foundation

PFI-Pipe Fabrication Institute

PPI-Plastics Pipe Institute

RTCA-Radio Technical Commission for Aeronautics

RWMA-Resistance Welder Manufacturers Association

SAE-Society of Automotive Engineers

SEMI-Semiconductor Equipment and Materials International

SJI-Steel Joist Institute

SMACNA-Sheet Metal and Air Conditioning Contractors' National Association

SSPC-Steel Structures Painting Council

TAPPI

UL-Underwriting Laboratories Inc

ENGINEERING DATA

CED-Civil Engineering Data

MCIC-Metal and Ceramics Information Center

NTIAC-Nondestructive Testing Information Analysis Center

PLASTEC-Plastics Technical Evaluation Center

RAC-Reliability Analysis Center

All the Standards You Need

Information Handling Services continues to expand the number and variety of standards services available. Review the list below and make sure you have all the standards you need. Your IHS representative will be happy to work with you.

Historical Industry Standards

A.G.A.-American Gas Association

ANS-American Nuclear Society

ANSI-American National Standards Institute

API-American Petroleum Institute

ASME-American Society of Mechanical Engineers

ASTM-American Society for Testing and Materials

AWS-American Welding Society

IEEE-Institute of Electrical and Electronics Engineers

NEMA-National Electrical Manufacturers Association

NFPA-National Fire Protection Association

International and Non-U.S. National Standards

AECMA-Association of European Aircraft and Components Manufacturers

AFNOR-French Standards

BSI-British Standards Institution

CAA-British Civil Aviation Authority

CCIR-International Radio Consultative Committee

CCITT-International Consultative Committee on Telegraph and Telephone

CECC-Cenelec Electronic Components Committee

CEN-European Committee for Standardization

CENELEC-European Committee for Electrotechnical Standardization

CEPT-Conference of European Postal and Telecommunications Administration

CGSB-Canadian General Standards Board

CNS-Chinese (ROC) National Standards

CPPA-Canadian Paper and Pulp Association

CSA-Canadian Standards Association

DIN-German Standards

ECMA-European Computer Manufacturers Association

EC-European Council/Commission Legislative Documents

ETSI-European Telecommunications Standards Institute

EUROCAE-European Organization for Civil Aviation Electronics

ICAO-International Civil Aviation Organization

IEC-International Electrotechnical Commission

ISO-International Organization for Standardization

JIS-Japanese Industrial Standards

OSI-Open Systems Interconnection

SAA-Standards Association of Australia

SASO-Saudi Arabian Standards Organization

SBAC-Society of British Aerospace Companies

VDE-Association of German Electrical Engineers

+ NEW, REVISED OR WITHDRAWN IN THIS ISSUE

Cart-Frame
Card Row-Col

Asbestos Cloths

Use: Asbestos Fabrics

Asbestos Content Analysis

See Also: Asbestos

—Asbestos Fabrics

† ASTM D1918-95. Standard Test Method for Asbestos Content of Asbestos Textiles. — 2001-0882 1522 D-12

Asbestos Fabrics

See Also: Asbestos; Fabrics

† ASTM D1571-95. Standard Specification for Woven Asbestos Cloth. — 2001-0866 1522 C-10

—Aging Testing

† ASTM D1573-95. Standard Test Method for Heat Aging of Asbestos Textiles. — 2001-0871 1522 C-01

—Asbestos Content

† ASTM D1918-95. Standard Test Method for Asbestos Content of Asbestos Textiles. — 2001-0882 1522 D-12

—Electrical Insulation

† ASTM D2100-95. Standard Specification for Asbestos Textiles Used for Electrical Insulating Purposes. — 2001-0893 1522 E-06

—Impregnated—Aerospace

SAE AMS 3456D-85. Asbestos Felting, "B" Stage Phenolic Resin Impregnated Low Pressure Molding NONCURRENT April 1991; — 1503-0897 1286 B-09

—Lap

† ASTM D1061-95. Standard Specification for Asbestos Lap. — 2001-0847 1522 B-05

—Magnetic Measurement

† ASTM D1118-95. Standard Test Method for Magnetic Rating of Asbestos Fiber and Asbestos Textiles. — 2001-0852 1522 B-10

Asbestos Filled Asphalt Coatings

Use: Asphalt Coatings (Made From Asphalt)

Asbestos Tapes

See Also: Asbestos; Tapes

† ASTM D315-95. Standard Specification for Woven Asbestos Tape. — 2001-0798 1521 E-11

Asbestos Yarns

See Also: Asbestos; Yarns

† ASTM D299-95. Standard Specification for Asbestos Yarns. — 2001-0791 1521 E-04

ASCII

Use For: American Standard Code for Information Interchange *See Also:* Coded Character Sets; Codes; Data Transmission; Graphic Characters; Information Interchange

ANSI X3.15-76. Bit Sequencing of the American National Standard Code for Information Interchange in Serial-By-Bit Data Transmission (R 1990). — 0808-1577 F210 E-13

ANSI X3.16-76. Character Structure and Character Parity Sense for Serial-By-Bit Data Communication in the American National Standard Code for Information Interchange (R 1990). — 0808-1587 F210 F-09

ANSI X3.28-76. Procedures for the Use of the Communication Control Characters of American National Standard Code for Information Interchange in Specified Data Communication Links (R 1992). — 0808-2639 F221 E-08 F222 A-01

ANSI X3.57-77. Structure for Formatting Message Headings for Information Interchange Using the American National Standard Code for Information Interchange for Data Communication System Control (R 1991). — 0808-3434 F229 F-03

FIPS FIPS PUB 16-1-77. Bit Sequencing of the Code for Information Interchange in Serial-By-Bit Data Transmission (ANSI X3.15-1976/R1983). — F008-0331 F003 C-07

FIPS FIPS P 17-1-77. Character Structure and Character Parity Sense for Serial-By-Bit Data Communication in the Code for Information Interchange (ANSI X3.16-1976/R1983). — F008-0337 F003 C-13

— 7-Bit—Graphic Characters

X3 X3.134.2-19XX. 7-Bit and 8-Bit ASCII Supplemental Multilingual Graphics Character Set Comment Deadline 07/14/85. — 1019 A-01

— 8-Bit

X3 X3.134.1-19XX. 8-Bit ASCII Structure and Rules Comment Deadline 07/14/85. — 1018 A-01

ASCII *(Cont.)*

— 8-Bit—Graphic Characters

X3 X3.134.2-19XX. 7-Bit and 8-Bit ASCII Supplemental Multilingual Graphics Character Set Comment Deadline 07/14/85. — 1019 A-01

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See Also: Residue Content Analysis; Residue-on-Ignition Determination; Sulfated Ash Content Analysis

—Activated Carbon

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—Adhesives

ASTM D5040-90. Standard Test Methods for Ash Content of Adhesives; — 2004-1551 1431 D-14

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ASTM D1119-85. Standard Test Method for Ash Content of Engine Coolants and Antirusts (R 1990); — 2160-0490 2617 A-01

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AASHTO T111-83. Standard Method of Test for Inorganic Matter or Ash in Bituminous Materials (R 1993). — 0023-1715 1917 D-03

—Carbon Black

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ASTM D3516-89. Standard Test Methods for Ashing Cellulose. — 2115-1422 2703 A-07

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A2LA. EMS— Sumter, SC

A2LA. Genera National La CA.

† A2LA. Honey Materials C

A2LA. IC

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A2LA. Mus Laboratory

† A2LA. Ohio and Materia Stow, OH

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† A2LA. Porve Clair, MI

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An Index of
U.S. Voluntary Engineering Standards

Covering those
Standards, Specifications, Test Methods, and Recommended Practices
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William J. Slattery, Editor

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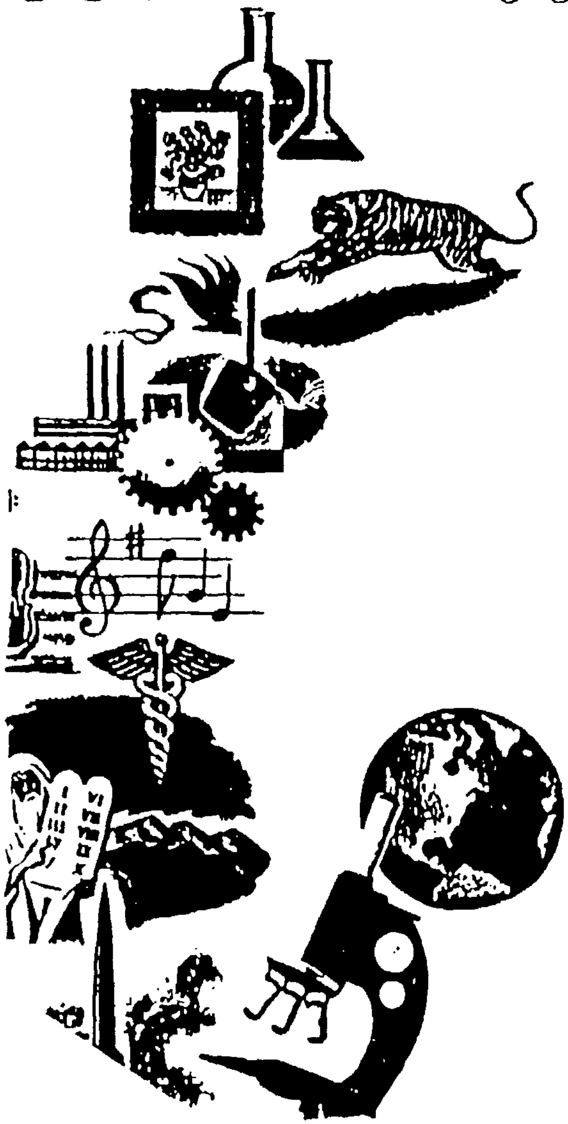

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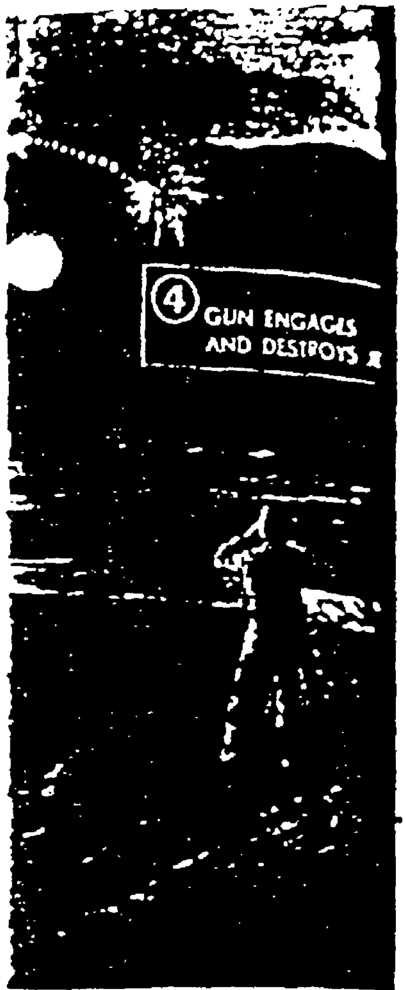

accurate antiaircraft gun.
...tes its speed, altitude, and
...d shoots it down.

...y by blasting the enemy's
... during attacks, disrupt-
... and transportation
... troops, destroying his
... and laying down smoke
...s, which are highly mo-
...ed on trucks, drawn by
... or be self-propelled. The
...he United States Field
...-mm. howitzer, which can
...nds during its first hour
...an pour out shells at a
...r brief periods (overheat-
...; too rapidly for too long
...stroys artillery). Other
...ons include the 75-mm.
...ty 76-mm. gun, 155-mm.
...8-in. howitzers and guns,
... and the 280-mm. atom

... The task of the coast
...ect seaports. It does not
...t like the field artillery,
...eavier guns. Its largest piece, the 16-in. rifle, is permanently emplaced. Other heavy pieces, such as 10-, 12-, and 14-in. guns and the 16-in. howitzer, may be either emplaced or mounted as railway guns. Smaller artillery also is used in coastal defenses, but large-caliber, high-velocity pieces that throw huge shells for great distances are more typical of coast artillery.

Antiaircraft Artillery, of vital importance in the air age, has reached a high state of development. See ANTIAIRCRAFT DEFENSE.

Naval Artillery. Naval vessels use guns of many kinds, ranging from 40-mm. antiaircraft guns to mighty 16-in. rifles. A battleship may carry as many as ten 14- or 16-in. guns, besides a large number of smaller pieces. The larger guns are mounted in heavily armored turrets, which are mechanically turned in the desired direction. Naval vessels may also carry equipment for launching torpedoes or depth charges. See DEPTH CHARGE; NAVY; TORPEDO.

History. The use of artillery began early in the fourteenth century. By the fifteenth century the typical gun was a huge, unwieldly weapon suited only to sieges. An extreme was reached in the guns Mohammed II used in the siege of Constantinople in 1453. Made of brass, seventeen feet long, and weighing almost nineteen tons, they fired a stone ball 25 inches in diameter and weighing 600 pounds. Smaller, lighter guns appeared in the sixteenth century, and the gun carriage, on which the gun could be fired as well as drawn, was invented. The cannon ball of solid iron also came into common use. With the iron cannon ball came the system of classifying guns as 6-pounders, 12-pounders, and so on, according to the weight of the shot.

In the seventeenth century, Sweden's military genius, Gustavus Adolphus, established a true field artillery — one capable of maintaining pace with the infantry and acting in its support. To attain the necessary mobility, he used light guns mounted on horse-drawn carriages. He also speeded up the rate of fire by using cloth cartridges of powder instead of the old method of measuring out each charge of powder with a ladle.

The outstanding artillerist of the eighteenth century was the French general Jean Baptiste Gribeauval. He established separate field, siege, and coast artillery organizations and provided different types of weapons for each. He standardized guns and carriages, making the parts of each type interchangeable.

Stronger guns, lighter for their caliber, came with the development of steel alloys and improved methods of manufacture in the nineteenth century. Soon after the middle of the century the rifled gun, spirally grooved within its barrel, and the cylindrical projectile came into use. The cylindrical projectile, presenting less surface to the air, could attain a greater range than the cannon ball. The rifling in the barrel caused the projectile to spin, preventing it from tumbling end over end in flight.

A problem that had vexed artillerists since the fourteenth century, that of preventing the propellant gases from escaping through an openable breech (rear of the barrel), was finally solved, and breech-loading guns became practicable. Near the end of the century, gunmakers began to equip gun carriages with mechanisms consisting of hydraulic braking devices and springs to absorb the shock of recoil and return the gun to its firing position. Previously recoil had driven the gun carriage backward, and it was necessary for the gunners to replace the gun in position after every shot. Smokeless powder also was invented. The improved guns and ammunition made possible ranges formerly believed to be unattainable. Longer ranges created a demand for more efficient aiming devices. To meet the need, telescopic range finders were invented.

Urged on by two world wars, artillery has made further great advances during the present century. Radar and other electronic aiming devices have greatly increased the speed and accuracy of artillery and have made it effectively usable in fog and darkness. The motorization of artillery has enabled it to maintain pace with the swiftest-moving forces (in aircraft and tanks, indeed, it has become part of the swiftest forces). It has made it possible also to regard such gigantic weapons as the 85-ton atom gun as field artillery. The development of easily portable light mortars, rocket launchers, and recoilless rifles has placed artillery in the hands of the infantry. See also AMMUNITION; BALLISTICS; DIRECTION FINDER; GUNCOTTON; GUNPOWDER; RADAR; SHRAPNEL; TANK, MILITARY; TNT.

ARTIODACTYLA, *ahr tih oh dak'tih luh*, the order of cloven-hoofed mammals to which many of our common wild and domesticated animals belong. Included in this large group are swine, cattle, sheep, goats, deer, antelope, camels, giraffes, hippopotamuses, and related forms.

ARYAN, *air'ih an*. See RACES OF MAN.

ASBESTOS, the common name of a number of kinds of remarkable rocks composed of fibers that will not burn, invaluable for their uses in fireproofing and as insulation. The kind of asbestos most widely used, *chrysotile*, is found in cracks in a rock called *serpentine*, where it has been formed by the action of underground water or steam on the rock. Chrysotile occurs as silky fibers extending across the cracks; they range from a fraction of an inch to several inches in length. The longer fibers may be separated, LONG, SILKY ASBESTOS FIBERS may be spun and woven into materials that will resist fire, water, chemical action, and decay.

spun, and made into cloth, straps, cords, ropes, and tubes. Several other kinds of asbestos may be similarly processed, but the fibers of some are too brittle, weak, or stiff to be spun.

Uses. When Marco Polo, back from his travels in Asia, spoke of seeing handkerchiefs that could be cleaned in a fire without burning, people listened in disbelief. But asbestos fabrics had been known in Europe long before the thirteenth century. They were known to the ancient Romans, who used asbestos lamp wicks, napkins, and a cloth in which bodies were wrapped before cremation so as to keep their ashes separate from those of the fire. Charlemagne is said to have had an asbestos tablecloth that was cleaned in fire.

Asbestos is now put to many uses. It is made into suits for fire fighters and into gloves, aprons, and other clothing to protect workers in mills and foundries. It is used in the safety curtains of theaters, and, often mixed with other fibers, in fire-resistant draperies, upholstery fabrics, and rugs. Asbestos is used also to make stove and lamp wicks, gaskets, and packing for steam engines, and it is employed to insulate and fireproof electric wires. Combined with strands of metal, it is used in the brake linings and clutch facings of automobiles.

Asbestos fibers unsuited to spinning are used in a variety of ways. They are felted, similarly to paper, for use as heatproof mats and pads such as those used in kitchens and dining rooms. They are mixed with other substances to make fireproof plasterboard, fiberboard, roofing felt, shingles, and floor tiles. Finely ground, they are used in fireproof paints. Huge quantities of asbestos are used as insulation to prevent the loss of heat from boilers, water heaters, and steam and hot-water pipes. Proof against all acids, asbestos is used in acid filters and in the walls and floors of laboratories.

Sources. About 75 per cent of the world's annual supply of asbestos is quarried in Canada, chiefly in Quebec. Other leading producers of asbestos are Africa (Southern Rhodesia, the Republic of South Africa, Swaziland), the Soviet Union, and the United States (Vermont and Arizona). See also SERPENTINE. EARL M. WEINER

AS'BURY, FRANCIS (1745-1816), known as the first bishop of the Methodist Episcopal Church in America, was born near Birmingham, England. In 1771 John Wesley sent Asbury to America as a missionary; the next year he made him general superintendent of the American organization, a post which a few months later Wesley assigned to Thomas Rankin. When the Revolutionary War began, Asbury's colleagues, some of whom were suspected of Loyalist sympathies, returned to England, but he remained in the colonies. Within a few years Asbury became the virtual head of American Methodism, and in 1784, at a conference in Baltimore, he was consecrated as superintendent. Thereafter he called himself bishop. Although not a great preacher, Asbury was a forceful leader and a master of organization. He advocated a strong central church government and instituted the circuit-rider system, which enabled him to reach the frontier regions. Traveling on horseback, he covered some five thousand miles a year for five years and went as far as the Mississippi River. See also METHODISTS; WESLEY, *John Wesley*.

ASCEN'SION DAY, one of the great festivals in most Christian churches, commemorates the ascension of Christ into heaven, forty days after His resurrection. It falls on the Thursday after the fifth Sunday after Easter. In the Anglican churches it is called Holy Thursday.

ASCETIC, *a set' ik*, one who turns away from worldly pleasures in favor of those of the spirit, for the purpose of attaining moral or religious perfection. Various religious orders require their members to lead lives of rigid self-denial, and many individual ascetics have spent years in fasting and solitary contemplation. Asceticism was widespread in medieval Europe and has always been prominent among the Hindus of India. In the New World the Puritans followed ascetic principles in banning all ornamentation of their clothes, their homes, and their churches and in forbidding all idle pleasures. Today not only those who practice extreme austerity for religious reasons but also those who choose lives of extraordinary simplicity are called ascetics. The ascetic way of life may be chosen for intellectual as well as spiritual rewards, for sheer love of simple living, and for the power of self-mastery. See also FRANCIS OF ASSISI, SAINT; HERMIT; MONASTICISM.

ASCH, SHOLEM or SHALO
Yiddish author whose works h
read in English translations.
village near Warsaw, Poland.
his education in the Hebrew
began to write after moving
1899, and within a few years
familiar to readers of Yiddish
of the Atlantic. After the outb
War I he went to the United
1920 became a citizen. He m
shortly before his death. Asch
short stories, most of which
with European Jews, are drama
and impressive in their authentic
arene (1939) is a story of Jesu
other works available in Englis
the Thief, *The God of Vengeance*
Three Cities, *Children of Abraha*
tle, and *A Passage in the Night*.

ASCORBIC, *a skawr' bik*,
VITAMINS.

ASGARD, *ahs' gahrd*, in Nors
the abode of the gods, corre
Olympus, home of the gods of an
Here Odin, god of war, was ch
also was Valhalla, hall of her
battle. See also ODIN; VALHALL

ASH, the common name of
trees of the olive family. The
pinnate (featherlike) compound
small, pointed leaflets, and they
ters of tiny flowers before their
pear. Their fruits are dry, one-w
or *samaras*. About twenty of the
sixty species of ashes are nativ
America. Largest and finest is the
which grows best in the Ohio Va
grow 120 feet tall and six feet i
but specimens of this size are rar
brown, close-grained wood is ex
tough and springy. It is used f
bats, skis, oars, tennis rackets
handles, and also for interior tr
cabinetmaking. The wood of the g
and *red* ashes is similarly used