CASE 1369: Hearing upon motion of OCC, at request of Atlantic Refining Co., to amend Rule 107 of the Rules & Regulations.

Case No.

1369

Application, Transcript, Small Exhibits, Etc.

BEFORE THE
OIL CONSERVATION COMMISSION
Santa Fe, New Mexico
January 15, 1958

IN THE MATTER OF: Case No. 1369

TRANSCRIPT OF PROCEEDINGS

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IN THE MATTER OF:

The hearing upon the motion of the Oil Conservation Commission of New Mexico at the request of The Atlantic Refining Company to amend Rule 107 of the Commission Rules and Regulations pertaining to casing, tubing, and cementing requirements. — Case 1369

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BEFORE:

Mr. A. L. Porter, Jr.
Mr. Murray Morgan
Governor Edwin L. Mechem

TRANSCRIPT OF PROCEEDINGS

MR. PORTER: We will take up next Case 1369, and I would like to ask at this time all the interested parties who wish to make an appearance in this case, do so now.

MR. KELLAHIN: Jason Kellahin, Kellahin and Fox , representing The Atlantic Refining Company.

MR. PORTER: Anyone else?

MR. HUGHSTON: R. L. Hughston for Shell Oil Company. We are going to have to leave, Mr. Porter, and if the Commission will give us the permission to do so, we would like to make our statement before the Applicant puts on his case.

MR. KELLAHIN: We have no objection.

MR. PORTER: Any other appearances?

MR. `MPBELL: Jack M. Campbell, Roswell, New Mexico. I would like to enter an appearance on behalf of the Independent Producers and Royalty Owners Association of New Mexico.

MR. BUELL: Guy Buell for Pan American Petroleum Corporation.

MR. BRATTON: Howard Bratton, Hervey, Dow and Hinkle, Roswell, Humble Oil and Refining Company.

MR. PORTER: Anyone else desire to make an appearance in the case? Is there any objection to Mr. Hughston's motion or request to make a statement in order to be allowed time to make his plane connection? Mr. Hughston.

MR. HUGHSTON: I wish to thank the Commission and the others interested in this case for allowing me to do this; because of transportation arrangements, we will not be able to stay throughout the entire case. We wish to go on record, however, that our engineers have gone over the rules changes proposed in Case 1369, and they are in agreement therewith.

We understood in this connection that the Applicant will in putting on its case, change the figure in the fourth line of sub-paragraph (1) of paragraph (c) from 2500 to 1500, so that the maximum pressure required on the casing, so that the sentence will read: "Minimum casing test pressure shall be approximately one-third manufacturer's rated internal yield pressure except that the test pressure shall not be less than 600 pounds per square inch and need not be greater than 1500 pounds per square inch", instead of 2500 pounds as it now reads. That change will be agreeable to Shell, and we wish to urge the Commission, after it has heard the case, that it adopt the proposed rule.

MR. PORTER: Mr. Kellahin, will you proceed?

MR. KELLAHIN: If the Commission please, I would like to make a short preliminary statement. This application for amendment of Rule 107 proposes three basic changes in the rule. These changes would, first of all, reduce the minimum rating on cement intervals; second, establish a statewide casing test rule, a provision that does not now exist; third, allow completion with no restriction in the bottom of the tubing.

Changes one and three will make a considerable reduction in operating cost and use of approved completion equipment and procedures. Advances in technology and equipment within the last several years make these changes desirable and proper.

Change number two is proposed as a safety measure and represents an addition to the present existing Rule 107.

Just to discuss the proposed changes briefly, paragraph (a) of the present rule remains unchanged. The major change occurs in paragraph (b) where the present rule calls for a cement waiting time of 24 to 30 hours. The proposed revision would change it to either 18 hours or until a compressive strength of 500 pounds per square inch was reached, in what is defined within the rule as the "zone of interest". The zone of interest is defined as that part of the casing hole annulus where the cement should have sufficient strength to resist the stresses imposed by drilling out or completion operations. At the present time all waiting on cement operations are based on time. Some states cover one phase of the operation; some,others; for the most part this time interval is 12 to 24 hours. In reality time is important only in that it relates to the strength of the cement, and laboratory and field work have given an insight into what strength a cement should have to perform its function in an oil well. In that connection, we will attempt to show to the Commission the strengths which can be achieved with the various types of cements and the adequacy of the proposed rule for protection of the strata involved.

We will have three witnesses. I would like to have all of them sworn at this time. Mr. Davis, Mr. Ludwig, and Mr. Smith.

(Witnesses sworn.)

MR. PORTER: At this time the hearing will recess until 1:00 o'clock.

(Recess.)

AFTERNOON SESSION
January 15, 1958

MR. PORTER: The hearing will come to order, please. Mr. Kellahin.

MR. KELLAHIN: I would like to call Mr. Davis as the first witness, please.

S. H. DAVIS

a witness, of lawful age, having been first duly sworn on oath, testified as follows:

DIRECT EXAMINATION

By MR. KELLAHIN:

Q Would you state your name, please?

A S. H. Davis.

Q By whom are you employed?

A By The Atlantic Refining Company, Dallas, Texas.

Q What is your position?

A At the present time, I'm staff production engineer, in the Crude Oil Production Division.

Q You have never testified before this Commission in the past, have you?

A No, I have not.

Q What are your educational qualifications, Mr. Davis?

A I have a Bachelor of Mechanical Engineering degree, Ohio State University.

Q What date did you get your degree?

A I got my degree in June of 1949 and accepted employment immediately with Atlantic Refining Company.

Q What positions have you held with Atlantic Refining Company?

A For about four years I was in the Research Department working in the completion research end of the research work. In that capacity I worked on drilling fluid research, drilling rig research, and improvements in completion practices, cementing was one of the main parts of the completion work.

Q Are you presently engaged in that same type of work?

A That's right, and there was a period of time between the research work and the present work where I was engaged with the Drilling Department for about a half a year, where actually I was engaged actively in the running of casing and cementing of wells. At the present time I am actively engaged from the production engineering standpoint in well completions and remedial work, and the improvements in cementing and cementing techniques is one of the main features of my job at the time being.

MR. KELLAHIN: Are the witness's qualifications acceptable to the Commission?

MR. PORTER: Yes, they are.

Q Have you made any study in connection with your work on the strength required in oil cementing work?

A Yes, during the past year we have made quite an intensive study, started out initially to examine our own procedures and to see what improvements could be made in our own; and with Mr. Faulk I presented a paper before the A.P.I. that summed up what our findings were.

Q You say you and Mr. Faulk presented this paper?

A That's right, co-authored the paper.

Q What was the result of this research which you did?

A We found that actual cement waiting times could be lowered considerably over what the rules called for in various states, without adversely affecting the performance of the wells.

Q Now how much strength is required in oil well cementing, Mr. Davis?

A Well, I believe you read briefly there, many experts in the cementing field feel that, or believe that five hundred pounds per square inch is more than adequate for all cementing operations in an oil well, that this value probably is conservative and has a safety factor of from two to three within it. There is some evidence available that a compressive strength as low as two to three hundred pounds per square inch are adequate.

Q What is the required time, required to reach this strength?

A The factors that determine the time required for cement to gain strength is the composition of the cementing mixture, the temperature of the environment in which it sets or cures, and the pressure of the environment; and of these the composition and temperature are by far the most important from the standpoint of gaining strength.

Q You mentioned temperature as one of the factors involved. Have you made a study of the formation temperatures in New Mexico?

A Yes, we have, and I would like to point out some things about Exhibit 1 up here we wish to submit.

(Atlantic's Exhibit No. 1 marked for identification.)

A This Exhibit No. 1 is nothing more than a plot of subsurface static temperatures versus depth. The temperatures in degrees Fahrenheit are along this column, and depth along this column. This line on Exhibit 1 represents a plot of data taken primarily in southern New Mexico Counties of Eddy County, Lea County, I guess some in Chaves County, and one or two wells in Roosevelt County. The data were taken during bottom hole pressure tests where the wells would be shut in for a period of, oh, at least twenty-four hours, and sometimes as much as seventy-two hours with recording temperature bombs;and although, as specified on this particular curve as southern New Mexico because that was the area in which the data was taken, it should be fairly representative of the entire State of New Mexico. This upper line is the line that was prepared from sub-surface data in the Gulf Coast and is actually a line on which many of the A.P.I. cement test data are based. It is shown here for comparative purposes.

I want to come back to this Gulf Coast line, but right now I want to direct your attention to the New Mexico line where the temperatures ranged from about 60 degrees upward.

Q In your opinion is the temperature line for southern New Mexico representative of the sub-surface temperatures to be found in other areas in New Mexico?

A Yes, it is.

Q What relation do these formation temperatures have to this problem of cementing?

A The bottom hole formation temperature is considered to be the temperature at which the cement cures or sets. This value, this approach is somewhat conservative in that temperature surveys run after cementing actually indicate that because of the heat of hydration liberated by the cement, the temperature may be as much as twenty to forty degrees higher, so that the average setting and curing temperature of the cement in most cases will be somewhat above the line shown, but this line is shown as the static formation temperature, as being the lowest temperature which the cement could be considered as setting, for a given depth.

Q Have you made a study of the time that is required to gain a compressive strength of five hundred pounds?

(Atlantic's Exhibit No. 2 marked for identification.)

A Yes, we have accumulated considerable data along this line. I would like to introduce Exhibit 2, which shows the time required for a number of typical cementing mixtures to reach five hundred pounds at various formation temperatures. This particular exhibit, Exhibit 2, the time is shown along this column in hours, and the formation static temperature is shown along this horizontal line. There are several typical mixtures shown here; for instance, the first one being common cement with two percent calcium chloride added for an accelerator. The next is neat common cement; the third one is common cement with two percent gel added; and over to the right side of the exhibit is the line shown for 50-50 posolan mixture, typical slow set cement and 50-50 posolan material with six percent gel.

These curves shown in Exhibit 2 indicate, well, for instance, let's look at the common cement with two percent calcium chloride.

It shows at formation temperatures as low as fifty degrees Fahrenheit that five hundred pounds would be gained in approximately fifteen hours. Of course, as the temperature increases, this time falls off rapidly. Actually you can look at this Exhibit 2, and the slow setting cement over here will gain five hundred pounds per square inch at one hundred twenty degrees here in a period of about twelve hours.

Now from this Exhibit 2 you can see that the temperatures which we are talking about, in New Mexico the lowest temperature we have shown here is about sixty degrees. With the proper use and selection of cement and the use of calcium chloride at your low temperature, which would be a shallow well, we can get five hundred pounds in fifteen hours. The slow set cement when used at the temperatures in excess of one hundred degrees, those are the temperatures for which they are designed, and five hundred pounds per square inch can be gained there in a period of twelve hours; and this indicates that actually these typical cementing mixtures when used at the temperature range for which they're designed at, five hundred pounds compressive strength can be gained in considerably less time than twenty-four to thirty hours called for by Rule 107 in the present form.

Q Actually Exhibit 1 shows that the lowest temperature you would expect would be in the vicinity of sixty degrees. As a matter of practice, you would be working at higher temperatures most of the time?

A That's right. In nearly all we will be operating at temperatures in excess of this value of sixty degrees. I would like to point out that regardless of the weather conditions that within fifty feet below the surface, the temperature will remain, for practical purposes, constant all year round. This data will be practicable for year round.

Q Would it be practical to have one time requirement for all the different types of cement?

A No, there's a difference in cementing compositions, and as I have mentioned, there is different times required for the various compositions to reach a given strength.

(Atlantic's Exhibit No. 3 marked for identification.)

A We have Exhibit 3 here, which shows some extremes in cementing mixtures. This shows the compressive strength along this column in hundreds of pounds.

Q Which column are you referring to?

A Vertical column along the left side of Exhibit 3, and along the horizontal column, or line immediately at the bottom of the exhibit is the time in hours. The first three lines of Exhibit 3 here show neat common cement with a two percent calcium chloride added, it shows for one hundred degrees, eighty degrees, and fifty degrees. In looking at this we might pick the eighty degree line. We can take a look at five hundred pounds per square inch compressive strength, a period of approximately ten hours would be required to gain that strength. On the other hand, at the right and the lower portion of Exhibit 3, we have shown some examples of what we would refer to as filler-type cements, the top line being fifty percent posolan with six percent gel added, at one hundred degrees; the next line being the same cementing mixture at eighty degrees; and then the lower broken line is a typical filler cement that is marketed by one of the cementing companies, it is also at one hundred degrees.

From this you can see then, for instance, that five hundred pounds in compressive strength will not be gained by the fifty percent posolan and six percent gel until a period of roughly seventy hours. So here it may be necessary to wait seventy hours on this type of cement, the fifty percent posolan with six percent gel and at, say, one hundred degrees, whereas we can get five hundred pounds per square inch compressive strength at one hundred degrees and common cement, and two percent calcium chloride; this line is not actually continued down here, but it would be something less than ten hours required. So there is, because of the large difference, both the neat common cement with the two percent calcium chloride and these filler cements are excellent cementing materials, but still we would not feel that we should wait seventy hours on these mixtures of common cement, where it might be required on the filler-type cements.

Q Mr. Davis, you are familiar with the proposed rule changes which are under consideration here, are you not?

A Yes, I am.

Q Are you familiar with the proposal that a minimum waiting period of eighteen hours would be in effect?

A Yes.

Q How would you handle that, then, under the example that you have given of the mixture of fifty percent posolan with six percent gel at one hundred degrees, where you would say it would take seventy hours to set?

A We propose, we have proposed a zone of interest criterion to handle this sort of situation. In other words, we would use, if we had an application where we wanted to use a large amount of filler cement for most of the casing hole annulus, we will then finish out the operation with some common cement with two percent calcium chloride if necessary, if the temperature were down in the neighborhood of fifty or sixty degrees, to get the strength in the zone of interest.

Now as I have stated before, the zone of interest is that area in the well bore where some strength is required to resist the stresses of drilling out or perforating, fracturing. Under this proposition, if an operator instead of using the proper type cement in the zone of interest would elect to use one of these filler-type cements, then he should wait the additional time for his own protection, for the cement to gain strength.

We in our own operations, and most operators are familiar with these types of cements, would not normally use a cement of this type in what we have defined as a zone of interest. Actually we have no, we have no provisions in the proposed rule that would actually cover this situation; however, under the rule as it exists now, there is no provision for covering the situation of that kind. There's nothing in either rule, in other words, to guarantee that good cementing practices are used. That would have to be one of judgment on the operator. I would like to point out that those filler cements would be an exception in that over here in this Exhibit 2 that I already introduced, ordinary common cement at the temperatures that we'll normally be dealing with, somewhere in the neighborhood of at least seventy to eighty degrees, we will attain the five hundred pounds compressive strength in maybe twelve hours. Certainly considerably less than the eighteen hours called for, so we don't feel that there is any need for using any other types of cement, where there are many of the other available types of cement can be obtained.

Q Those other cements would meet the requirement of the eighteen-hour rule?

A Yes, the eighteen hour criterion was picked primarily for those that did not prefer to report cement strength and maybe didn't have the information readily available. The eighteen hours was selected because one of the most critical conditions in the well, of course, is one of low temperature, and by the use of an accelerator in the common cement, at temperatures as low as fifty degrees, five hundred pounds can be obtained in less than the eighteen hours, so the eighteen hours was selected on that basis.

Q Now, Mr. Davis, there are a great many different brands of cement. Are there variations in these brands as to the time required to reach the compressive strength that's needed?

A There is some variation in all cementing materials manufactured by different cement companies. However, in the common cements, common Portland cements which I have been discussing primarily here, the variation is not very great.

(Atlantic's Exhibit No. 4 marked for identification.)

A I have an exhibit, Exhibit 4, which shows the strength of three examples of accelerated cements. These cements were picked at random for cements that are available in New Mexico, and were sent to the Halliburton Oil Well Cementing Laboratories in Duncan to run tests on. Then I have shown in this example 4 the results of these tests. There are actually three distinct graphs on Exhibit 4. The graph A, for Portland cement A, the compressive strength in thousands of pounds is shown along the vertical column at the left of the graph, and along the bottom is the time in hours, and we have shown there the strength versus time for three different temperatures, and then the same type of data are reproduced then for Portland cement B and Portland cement C.

For example, let's look at the temperature of eighty degrees Fahrenheit on cement A, a thousand pounds per square inch compressive strength is obtained in a period of ten hours. On Portland cement

B it would appear that a thousand pounds per square inch compressive strength would be gained in somewhere between nine and ten hours; and on Portland cement C at eighty degrees, the thousand pounds would require approximately thirteen hours, so there may be a range of approximately four hours from the extreme in these examples shown.

I would like to point out that at five hundred pounds per square inch which we have proposed, all of these cements are well within the eighteen hour proposal. For instance, at sixty degrees, five hundred pounds would be right along here upon example cement A, a period of about eleven or twelve hours would be required for the cement to gain five hundred pounds per square inch. On example B, the same period of approximately eleven, about twelve hours would be required to gain five hundred pounds per square inch; and on the example Portland cement C, five hundred pounds would be obtained in, looks like fourteen or fifteen hours, all of which are below the eighteen hours proposal.

Q Now in preparing Exhibit 4 what was your source of information?

A It was the Halliburton Oil Well Cementing Company ran the tests on three separate brands of cement that were obtained in New Mexico and sent to their Duncan laboratories, and their data was then sent to me. I actually prepared the curves from the data sent.

Q Is this type of information available on other cements?

A Yes, this type of data is readily available from cement manufacturers and from cement service companies operating in the New Mexico area. Much of it is already published in booklet form and is available on request; however, all of these companies will upon request run tests on any cement which they are asked to do so.

Q So if the Commission is in need of this type of information in administering the proposed rule, would they have any difficulty in obtaining it?

A No, they would not. In fact, I have compiled over the past year a considerable volume of this type of information, and would be more than willing to make it available. I know that the cementing companies would do the same thing.

Q On Exhibit 4 you have shown an accelerated type of cement. Will the use of these cements,when you use these cements will the mixture remain fluid long enough to be pumped into position?

A I have shown the accelerated cements in these instances primarily because the cold temperature, or the low temperature condition is the most critical and I wanted to show that cements were readily available which would handle even temperatures as low as fifty degrees. However, but for most applications down the hole, the temperature may be eighty degrees, a common cement without an accelerator would be satisfactory. However, since we have discussed the accelerated cements for use, I have prepared an Exhibit 5 to show that these cements do remain fluid enough to be pumped to the bottom of the hole.

(Atlantic Exhibit No. 5 marked for identification.)

A Exhibit 5 is a chart which shows the pumpability time, that is, the time that cement will remain fluid under various conditions of depth and temperature. Now this temperature action is across the top of the Exhibit 5, is actually taken from Exhibit 1, as is the depth, so in other words, the temperature shown up here corresponds to the depth shown at the bottom of Exhibit 5, and they were taken from the southern New Mexico temperature gradient shown in Exhibit 1. I would like at this time to direct the attention to the difference between the Gulf Coast gradient and the New Mexico gradient in Exhibit 1. The examination will reveal that a temperature difference for a given depth will vary from approximately twenty to fifty degrees Fahrenheit, the southern New Mexico temperatures being the lowest.

Now the A.P.I. has set up a standard test procedure for determining the pumpability of cements under down hole conditions. These tests are all founded and based on the temperature gradient of the Gulf Coast. For that reason, pumpability times of cements measured at Gulf Coast conditions will be too short or be conservative for use in New Mexico, because of the difference in temperatures. Actually at this time the data avilable is all based on,as I understand, there has been a lot of data accumulated, but it is based on the Gulf Coast temperature gradient. For that reason we have prepared this Exhibit 5 which shows the actual pumpability at the time of common cement with calcium chloride and ordinary common cement. This data has been shifted slightly from its original form in order to make it adaptable to the temperatures found in New Mexico. In other words, the same data for the Gulf Coast would be slightly different. The important thing to be noticed from this is the depth to which either one of these, the common cement with calcium chloride added or the plain common cement, can be safely run in New Mexico.

This horizontal line intersecting both the pumpability lines in Exhibit 5 is the maximum time required to mix a thousand sacks of cement and pump it into position. That is based on A.P.I. specifications that have been developed during the past several years. Actually I have a safety factor of about thirty minutes to the time required, as an additional safety factor to take care of any breakdowns in cement equipment, so this maximum time then, as you see, the deeper that the well is, the greater the time required to place a thousand sacks of cement, because of the greater distance it has to be pumped.

Where this line intersects the two pumpability lines represents the maximum depth to which that slurry could be safely run so the important point from this is that actually the accelerated common cement could be run to this point of intersection or about fifty-five hundred feet in New Mexico. That would be a perfectly safe operation. Common cement without the accelerator can be run to a depth of about ninety-five hundred feet. Now at greater depths than this, the slow set cements would be required.

Q On these exhibits you have shown the time and temperature on accelerated cement. Do you advocate their use at all depths?

A No, we advocate the accelerated cement be used only at temperatures lower than, say, eighty degrees, where by their use we can take advantage of the shorter WOC time. At eighty degrees for instance, common cement, as we can see from Exhibit 2, at eighty degrees common cement will reach five hundred pounds per square inch compressive strength in a period of twelve hours. There is no need for the use of an accelerator at temperatures of eighty degrees and above.

Q That completes your testimony on the exhibits, does it not?

A Yes, that covers the exhibits.

Q I believe you have already stated that you are familiar with the proposed changes in Rule 107 which are under consideration here. Will these changes meet the requirements which have been discussed by you in connection with the five exhibits?

A Yes, I believe they will. In looking at the proposed rule in part, paragraph (b), we have, it is proposed that a waiting time of eighteen hours or until the compressive strength of at least five hundred pounds per square inch shall be gained in the zone of interest. The eighteen hour criterion, as we pointed out, even at temperatures as low as fifty degrees, common cement with an accelerator in it will reach the five hundred pounds in fifteen hours. So we feel that the eighteen hours does represent a saving in time over the present rule, yet it is more than adequate to get the strengths that we feel necessary. As already testified, the five hundred pounds we believe to be a conservative number, in that there is some evidence available that the compressive strengths as low as two to three hundred pounds are adequate. By defining the zone of interest, as pointed out, these filler types of cement which are excellent cost saving materials can be used in a large part of the casing hole annulus, and we can still take advantage of the low or the short waiting times afforded by common cement and accelerated common cement. Therefore we believe that the exhibits show that the proposed rule change is actually a little on the conservative side and that it represents what we would consider good practice in our own operations.

Q Do you consider a strength criterion as being superior to one in which time is the only factor?

A Yes, we believe that the strength is superior, in that time is of importance only in that it relates to the strength of the cement, and that we feel that strength is actually more direct, and since there are a number of compositions that are used, that is, of cementing compositions that are used and are excellent materials, we feel that a strength criterion fits all of these compositions, whereas a single time that we might arrive at may not fit all the cementing compositions in use today.

Q Do you consider five hundred pounds per square inch adequate for cementing operations?

A Yes, and I feel that it actually has some safety factor; I would say from two to three, that would allow us, that we will be doubly sure, is about the only way I can put it, there is evidence available that strengths as low as two hundred pounds are satisfactory for all operations in oil well cementing.

Q Is there sufficient technical data available at this time to predict the time required for a given cementing mixture to reach the necessary compressive strength?

A Yes, this data that I have presented here, must of it has been taken from, as I said,data that was already published. The others, at low temperatures particularly, we had special tests run to provide this data, and as I pointed out by Exhibit 4, the three different brands of cement that are available in New Mexico all fall within the proposed rule; and this data, as I pointed out before, can be obtained upon request from cementing companies or the cement -- that is, the cement manufacturers or the cement service companies and other operating companies,such as Atlantic will furnish that data where requested.

Q Can these compressive strengths needed be achieved in less than the twenty-four to thirty hours called for in Rule 107, in your opinion?

A In my opinion, they can be obtained in considerably less than twenty-four hours. I will say there needs to be some judgment used in selection of the cement, but it's of primary importance for the operator to use the cement which is suitable for an operation, and there are many cements available which will meet the requirements of Rule 107. Some of the filler cements, as I stated previously, will require a somewhat longer time, but they would require longer times, actually, than as specified under the present rule. I know of no occasion where the filler types of cement which require the longer times are used in that portion of the hole where strength is required before perforating or drilling out. Now by using the strength criterion, we would permit the use of these filler-type cements up the hole, for instance, to protect your casing against corrosion and to cover some zones that might be perforated some years later, but what we're interested in primarily is having the cement that will gain the strength within the proposed rule in the zone of interest where we are going to perforate immediately or where we are going to drill out immediately.

Q Now in the proposed rule there is a new provision calling for a statewide casing test. Will you discuss that, Mr. Davis?

A As you mentioned, this rule is an addition to the present rule, and it's proposed primarily as a safety factor or as a safety provision. An adequate casing test assures the operator that casing will hold pressure without leaking. Should casing leak, it could be responsible for the loss of hydrocarbon reserves to other underground formations, and in some instances could be responsible for serious blow-out. The proposed Rule 107 as it was initially presented called for a test pressure as high as 2500 pounds. At this time we would like to reduce that 2500 to 1500 pounds per square inch, so that the rule would then be as follows: The casing test rule when applied to rotary tools calls for a pressure test equal to "one-third of the manufacturer's rated internal yield pressure except that the test pressure shall not be less than 600 pounds per square inch and need not be greater than 1500 pounds per square inch." The 1500 was put in at the suggestion of several operators, who felt that many of the rigs, rotary rigs available would not have mud pumps capable of reaching 2500 pounds.

Q In that connection, Mr. Davis, would you mark that change on what has been marked as Exhibit No. 6?

(Atlantic's Exhibit No. 6 marked for identification.)

A Yes, I will. Now for the cable tool operations, we have provided a bailing test, in order that the cable tool operator wouldn't be forced to have an auxilliary pump to perform the pressure test at his casing. The cable tool operator is free to use the pressure test,in addition, the operator of rotary tools is free to use a test pressure of higher than 1500 if he felt it would be desirable.

Q There is a proposal to allow completions with no restrictions in the bottom of the tubing. What is the reason for that proposal?

A Paragraph (c) of the present Rule 107 states that the bottom of the tubing shall be restricted to an opening of less than one inch or be bull plugged. During the recent years, the development of permanent type of well completion equipment and procedures makes it desirable to have the bottom of the tubing full open. As a matter of interest, one of the main developments has been the development of the through tubing perforator, which enables us to run a perforating device through the tubing and out the casing and perforate a given zone. There are other tools that are run in conjunction with permanent type completions which also require full open tubing. There are also provisions available for putting a removable type plug in the bottom of the tubing if we want to block the bottom of the tubing to prevent the loss of instruments, the difference being, between the permanent type and this type, is that it can be retrieved by a wire line which will then permit us to run the tools out of the open end of the tubing, so we would like to propose that in order to allow the use of this equipment that we would leave off the last sentence of paragraph (c) in the current rule.

Q Mr. Davis, were Exhibits 1 through 5 inclusive prepared by you or under your direction and supervision?

A Yes, they were.

Q And Exhibit 6 is a copy of the proposed rule, as was circulated by the Commission, with the exception of the change made by you as to the pressure under the testing procedure, is that correct?

A That is correct.

MR. KELLAHIN: At this time we would like to offer in evidence Exhibits 1 through 6 inclusive.

MR. PORTER: Without objection Exhibits 1 through 6 will be admitted.

MR. KELLAHIN: That's all the questions we have.

MR. PORTER: Does anyone have a question of Mr. Davis? Mr. Buell.

CROSS EXAMINATION

By MR. BUELL:

Q Mr. Davis, my name is Guy Buell with Pan American Petroleum Corporation. I will hand you what I will ask to be marked as Pan American's Exhibit No. 1.

(Pan American's Exhibit No. 1 marked for identification.)

Q Are you generally familiar with what Exhibit 1 contains?

A Yes, I am.

Q You have seen that previous to this hearing, have you not?

A That's right.

Q That relates entirely to Section (d) of Rule 107, does it not?

A That's right.

Q I believe the changes that it makes over your proposed rule and the present Rule 107 is generally that gas wells that produce no liquids shall not require tubing, and also provides for administrative exception to where your tubing is bottomed and where your tubing has its perforation. Is that generally your understanding?

A That is generally my understanding.

Q Would you have any engineering objection to an amendment such as this being adopted?

A No, I can see cases that might come up where it may be desirable to raise the tubing to the point of getting it above a pay zone that we hadn't completed in initially. It would be very desirable.

Q In other words, administrative exceptions should encourage more permanent type completions?

A Yes.

Q Isn't that generally considered a conservation measure?

A Yes.

MR. BUELL: Thank you.

A I have a correction to add myself. I called the wrong paragraph when I was discussing the restrictions in the bottom. I called it paragraph (c) and it is paragraph (d). I would like to make that correction.

MR. COOLEY: The restrictions as provided by the present rules are in paragraph (c).

A Is that right? I don't have my copy of the original.

MR. COOLEY: I'm sure they are. There is no paragraph (d) in the existing Rule 107.

A No (d)?

Q No paragraph (d) at all.

A I thought I had made an error when I presented that. In the proposed rule it will be in paragraph (d).

MR. COOLEY: Are you through, Mr. Buell?

MR. BUELL: Yes. I would like to formally offer Pan American's Exhibit 1.

MR. PORTER: Without objection it will be admitted. Mr.

Campbell.

MR. CAMPBELL: Jack M. Campbell, Roswell, New Mexico.

By MR. CAMPBELL:

Q I'll ask this question on behalf of Texas Pacific Coal and Oil Company. Did I understand you to say that you saw no engineering objection to the proposed amendment of Pan American with regard to not requiring tubing in gas wells?

A No, it doesn't cover not requiring tubing in gas wells.

Q That was my understanding of it.

A It was my understanding --

Q That if there was no fluid that you did not need tubing in gas wells?

A No, that doesn't cover. It covers only the movement of the lower end of the tubing without calling a hearing, is my understanding.

Q "All flowing oil wells and gas wells that produce liquids shall be tubed, and the tubing shall be set as near the bottom as practical." I would assume from that if there is no liquids the gas well doesn't need to be tubed?

A That is in the present rule.

Q That is the present rule?

A Yes.

Q Do you consider you can determine accurately whether there are liquids and the extent of those liquids without tubing?

A I have no comment to make along that regard. That was in the present rule and we proposed to change only that portion which would, we were interested in having changed.

MR. PORTER: In order that there be no mistake here, I think possibly we should read the present rule.

MR. COOLEY: Would you like me to do so?

MR. PORTER: Yes.

MR. COOLEY: Paragraph (c) reads as follows: "All flowing wells shall be tubed, the tubing shall be set as near the bottom as practical, but tubing perforations shall not be more than 250 feet above the top of pay, unless authorized by the Commission. The bottom of the tubing shall be restricted to an opening of less than one inch or bull plugged in order to prevent loss of pressure bombs or other devices."

MR. CAMPBELL: That is a change at least in terminology. I am not familiar with whether the Commission considers a flowing well includes a gas well under their interpretation of it. This would quite definitely exclude it.

MR. COOLEY: The Commission has interpreted a gas well as being included in a flowing well.

MR. CAMPBELL: I have no further questions.

MR. PORTER: Anyone else have a question? Mr. Nutter.

By MR. NUTTER:

Q Mr. Davis, you were a co-author of a paper delivered to the A.P. I., or A.I.M.E.?

A A.P.I.

Q About a year ago?

A Yes.

Q In that paper, wasn't some mention made of the temperatures of the slurry?

A Yes.

Q And whether the setting time was affected by the slurry temperature?

A Yes.

Q What effect has the slurry temperature to do with this setting? I don't see it covered in any of the exhibits.

A Since writing that paper, we have taken a number of temperature surveys, some run in cold weather operations that would indicate that the slurry temperature, even though you may start out with cold slurry due to cold mixing water, has raised to the formation temperature in a very short period after the cement has reached bottom, particularly in the cases of shallow wells where the bottom hole temperature of the well hasn't been lowered a lot by a long period of circulation. We have investigated further this heat of hydration which I mentioned, and in examining these temperature surveys where there were temperatures taken at intervals of one to two hours after pumping, the plug indicated that the temperature of the slurry had actually come up to the formation temperature in a period of one or two hours after having reached bottom, and that it continued to rise up to as much as forty degrees above the static temperature, so thereby we now believe that the average curing temperature, so to speak, is somewhere between the peak temperature reached during setting and the formation temperature, the static formation temperature; and that the effect of cold water mixing temperature will have very little effect on the time required to gain five hundred pounds.

Q So for that reason you don't feel that the temperature of the water is material --

A No.

Q -- in the setting time of the cement?

A No, we have other factors such as heat of hydration and loss of water into the slurry that would hasten setting that we haven't counted on, and that are factors that would more than overcome the cold water problem.

Q Do you think that all waters that would be available throughout the State of New Mexico would be of such temperature that no effect, that no detrimental effect would be had in the slurry mixtures?

A That is my opinion.

Q Have you established any temperature gradient for areas except southeast New Mexico as depicted on Exhibit 1?

A No, I have not. We operate no wells in the area other than that covered. However, that temperature gradient will actually hold also for West Texas and I see no reason why it should be appreciably different in the northern part of New Mexico.

Q So you would recommend that temperature gradient for the entire State?

A That's right.

Q Mr. Davis, are casing test rules such as you have proposed here rather common practice throughout the industry, whether they be by regulatory bodies or by individual companies? Are they recognized things?

A Yes, they are very much recognized in many pool rules and in some additional State rules. The test is made before drilling out, and as such is an actual test of whether the casing itself is leaking, and from that standpoint we feel that at the present day operations, for instance, the surface pipe is one of the important casing strings in the well and that we should be assured that the casing is not leaking before we continue operations.

Q What does the rule,as far as New Mexico is concerned, require in the line of casing tests?

A There is no statewide test rule. There are several pool rules. These pool rules in most instances call for a test to be -- a pressure test to be applied when rotary tools are used, to be applied after drilling out a portion of the casing shoe and approximately five feet into the formation. Actually we feel that this type of practice is not in the best interest of safety in the operation of drilling an oil well, since all we have done when we pressure test a condition of that kind is to determine how much is required to break the formation down, and that we have created a zone of weakness that may be there to bother us at some later date as we drill on later.

Q Is this cable tool optional test standard practice through the industry?

A Some form of a bailing test is standard through the industry. There is some slight difference in wording in various states; however, this rule as we proposed it appears to be about what is being done in New Mexico and in parts of Texas. The specific wording is not quite the same.

Q Will this amended pressure test from 2500 to 1500 pounds provide an adequate test on the casing in a thirty-minute period?

A I believe it will provide an adequate test of whether the casing will leak if it doesn't leak under fifteen hundred pounds, it's very unlikely that it would leak at twenty-five hundred.

Q Is the ten percent pressure drop that's permitted usually construed to be an acceptable pressure drop?

A Yes, that is in a number of rules of regulatory bodies.

Q What is the meaning of "satisfactorily" drying in the bailing test with the cable tool operations?

A That is a wording that was made to approximate what was being done. Actually if you will look, there are some pool rules in the State of New Mexico, for instance in Eddy County that say "will remain approximately dry", so I guess "satisfactorily" is "approximately". Actually there can be, I might point out, in some other states the rule calls for the casing to be bailed down to a point mid-way between the top of the cement and the bottom of the cement, and that there shall be no greater, the fill shall be no greater than two percent of the bailed distance in a period of two to six hours. To me it is very unlikely that with bailing equipment available, that when you get down to such fine numbers that might represent on a shallow well that you would actually be able to determine two percent of the bailed distance with a bailer. So the wording "satisfactory to dry" was left that way, and it would be at the discretion of the Commission to interpret it.

Q You feel that the operator of a cable tool rig that has run a test should report how dry it remained or how satisfactorily?

A Yes, I think that if there is any leakage at all he should report it.

Q Mr. Davis, you testified that you couldn't see anything engineeringly wrong with this amendment to Rule 107 (d) as proposed by Pan American on their Exhibit No. 1?

A Yes.

Q If that were rephrased to read something similar to this: That all flowing oil wells and gas wells shall be tubed, provided however that administrative exception could be granted to gas wells that did not make liquids -- would you see anything engineeringly wrong with such an amendment as that?

A Well, speaking from our own operations, if a gas well could be considered as non-corrosive, I feel there would be nothing particularly wrong in not having tubing. However, that is something that should be, you have to consider the pressure at which that gas was at. There are such things as,gas, of course, is more likely to find its way through couplings, or it's harder to hold, confine, than is a liquid,such that if you have high pressure gas and you were to have a leak and not have tubing to immediately kill it, you might have some serious difficulties.

Q In other words, you bring up things besides just the liquids that may make it desirable or undesirable?

A That's right. In other words, we would not in our operations complete a gas well without tubing in it.

MR. NUTTER: Thank you.

MR. PORTER: Mr. Utz, did you have a question?

By MR. UTZ:

Q Mr. Davis, referring to your Exhibit No. 4, as I understand that exhibit, your Portland cement A, B, and C are different brand names?

A Different brand names.

Q Who accomplishes the test that you show on the graph there on the exhibit?

A You want to know the one specifically that made those tests?

A Yes, did the companies give you that information?

A Some operating companies are in position to make those tests themselves. We do make tests of that nature in our laboratory. Those specific tests were made by Halliburton at our request. They would make them at any operator's request or Commission's request.

Q Would there be a neutral agency that could accomplish those tests, supply us with information, other than --

A (Interrupting) There are neutral testing laboratories, yes.

It would be a matter of the expense of having the test run. Somebody would have to provide the expense of running the tests if an independent laboratory were to do them. However, I would consider any one of the cement service companies as independent, as far as that goes, of any of the operators.

Q You would consider their tests then as being accurate?

A That's right, because you see those tests are all, the pumpability tests and actual curing tests are all conducted under recommended practice bulletins published by the A.P.I.. RP-10-B and RP-10-A are two of the bulletins that specify the testing of oil well cements, and all of these laboratories that are conducting these tests are equipped with that type of identical equipment for running these tests. The tests of one laboratory have been correlated with tests of another laboratory, and in most instances where the same conditions were used, there was very little variation detected.

Q Would they test all brands of cement and make that information available to the Commission?

A I'm sure they would run tests of any brands that were available in a given state. For instance, in New Mexico they would make the test -- I would like to point out to you that the common cements that I have shown there, Portland common cement doesn't vary a whole lot from one brand to the other, and that you could accumulate some data but you would find that various brands of common cement would all fall within the specifications called for in the proposed rule. The slow set cements are something different;

various cement manufacturers use different retarding agents in their cements, and as such their pumpabilities will be different and the times to require setting will be different. However, slow set cements are used and are designed to be used at temperatures in excess of forty degrees. At those temperatures you will find that even though there is some variation between various brands of slow set cements, that they would still meet the specifications called for in Rule 107.

Q You feel that any brand of cement that the Commission would like data on would be reliable information, tested by a well service company such as Halliburton?

A I do.

MR. PORTER: Anyone else have a question of Mr. Davis? You may be excused.

(Witness excused.)

MR. KELLAHIN: I would like to call as our next witness Mr. Dwight K. Smith.

DWIGHT K. SMITH

a witness, of lawful age, having been first duly sworn on oath, testified as follows:

DIRECT EXAMINATION

By MR. KELLAHIN:

Q Would you state your name, please?

A Dwight K. Smith.

Q By whom are you employed, Mr. Smith?

A Halliburton Oil Well Cementing Company, Duncan, Oklahoma.

Q What is your position?

A Section leader of the Cement Section of our Research Testing Laboratory.

Q What is your education, Mr. Smith?

A I hold a B. S. degree in Chemistry.

Q From what school?

A Oklahoma Baptist University, 1943.

Q What has been your experience since that date?

A I have been employed by Halliburton for approximately twelve years. Ten of that has been working with testing, using additives in cement in oil wells.

Q How long have you been section leader at the lab in Duncan?

A Approximately four years.

MR. KELLAHIN: Are the witness's qualifications acceptable?

MR. PORTER: Yes.

Q Have you had occasion in connection with your work to observe the cementing practices in states other than New Mexico?

A Yes, sir, I have.

Q Is that observation in states where temperature is comparable to those in New Mexico?

A Yes, sir.

Q What states would those be?

A I am actually more familiar with the practices in Oklahoma and Kansas than I would be here in New Mexico. I think the temperature changes would be somewhat comparable in those states.

Q How do the practices in those states compare with the changes being considered in Rule 107 under consideration here?

A Actually I think the regulations in Oklahoma, there are no regulations except on surface pipe, and that is twelve hours. Kansas follows a similar trend. The regulations are fairly close. I know of some instances recently where wells have been cemented and drilled out on surface pipe within a four to twelve hour period. We have had some instances this past summer when we have been doing some work with accelerators where a shallow well has been cemented in the morning, perforated in the afternoon, and fractured the next morning.

Q Do you consider that a safe procedure?

A Yes, sir, I do.

Q In connection with your work, do you run tests on cement?

A Yes, sir, we did. We probably test cements from all areas of the United States, different manufacturers as well as foreign cements.

Q Now on the basis of work done in the laboratory, do the results of that work generally agree with the test that has been presented here by Mr. Davis?

A Yes, I think so. Most of your common cements as designated by the A.P.I. as Class A cements will have strengths at one hundred degrees in twenty-four hours of two thousand pounds or better. Some will run as high as three thousand, which is probably higher than some of the values Mr. Davis has shown here. Actually they are designed so they are compatible with additives and still have desirable strengths.

Q Is this test data available to the operators and to the Commission from your company?

A Yes, it is.

Q In the event that the New Mexico Oil Conservation Commission needed such information, would you be willing to supply it to them?

A Yes, sir, we would. Actually here in New Mexico I doubt if you have over about three brands or four brands maybe, at the most, different brands of common cement available, and you have only one retarded type at the present time; but we would furnish such information, either existing information or new information, that might be desired.

Q On the basis of the cements which are in use here in New Mexico to which you have just referred, do those cements, both the common cement and the retarded cements, meet the requirements outlined by Mr. Davis?

A I would say yes.

Q Both as to time and as to strength?

A Yes.

Q On the basis of the information which has been given here, do you consider that the proposed Rule 107 would be a conservative approach?

A I think so, yes.

MR. KELLAHIN: That's all the questions we have.

MR. PORTER: Does anyone have a question of Mr. Smith? Mr. Nutter.

CROSS EXAMINATION

By MR. NUTTER:

Q Mr. Smith, are you acquainted with temperature gradients encountered in the wells in southeast New Mexico?

A To some extent, yes, sir.

Q Does that graph, Exhibit 1, pretty well depict the temperature gradient per thousand foot depth?

A I would say it does, yes, sir.

Q What about northwest New Mexico?

A I'm not too familiar with that area, but I would say from our experience with temperature and logs that it would. I think it would cover the area,as Mr. Davis pointed out, across the West Texas and into southeastern and northwestern New Mexico.

Q So you think that one temperature gradient chart, as this one is, would cover the entire state?

A I believe it would, yes, sir.

MR. NUTTER: Thank you.

MR. PORTER: Anyone else have a question? The witness may be excused. (Witness excused.)

MR. KELLAHIN: I would like to call Mr. Ludwig.

NORMAN C. LUDWIG

a witness, of lawful age, having been first duly sworn on oath, testified as follows:

DIRECT EXAMINATION

By MR. KELLAHIN:

Q Would you state your name, please?

A Norman C. Ludwig.

Q By whom are you employed?

A Universal Atlas Cement Company.

Q What is your position with that company?

A Associate director of research.

Q What is the business of the Universal Atlas Cement Company?

A Manufacturer of cement.

Q Now, in connection with your work as research associate, what educational qualifications do you have?

A I have a B. S. degree in Engineering from Illinois Tech and a Master's Degree in Physics from the University of Chicago.

Q What has been your experience, Mr. Ludwig?

A It has been more or less concentrated on oil well cements since 1939.

Q Has all of that time been with the Universal Atlas Cement Company?

A That's right.

MR. KELLAHIN: Are the witness's qualifications acceptable?

MR. PORTER: They are.

Q Mr. Ludwig, have you had any experience in oil well cementing and problems in connection with that type of work?

A That is, with the type of work that has been described here?

Q Yes.

A To preface my remarks, our company does not market cement in New Mexico because it's an out of area location. Referring to Figure 2 and Figure 3, our common cement, neat and with calcium chloride, as a rule gives a little greater strength than those curves show. On that basis I believe that the proposal as presented is conservative. The crux of the situation, of course,is the development of earlier strength.

Q Are you in agreement with Mr. Davis' testimony as to temperature being the prime factor in connection with that?

A Temperature is the prime factor in shallow depths,and at low temperatures,as has been discussed, pressure does not have a great effect.

Q To what extent, then, should time be considered in connection with achieving the strength required in oil well cementing?

A Would you state that question again?

Q Well, then, to what extent would you consider time is a factor in achieving strength?

A Well, time is the important factor.

Q But time and temperature together?

A Yes, time and temperature are the two important factors. Of course, as has been brought out by Mr. Davis, the things that affect the initial strength is the temperature and the time and the composition; those are the three things. Pressure is an added factor which becomes important as pressure becomes greater, and especially at higher temperatures.

Q Are you in general agreement, then, with Mr. Davis' presentation as to the change in the time rule in the New Mexico rule?

A Yes, I am. I feel that, as I have said, that eighteen hours is an ample time.

MR. KELLAHIN: That's all we have.

MR. PORTER: Anyone have a question of the witness? Mr. Nutter.

CROSS EXAMINATION

By MR. NUTTER:

Q Mr. Ludwig, do you believe that the curves with the various cement mixtures that are depicted on the charts are typical of most mixtures of that type, regardless of the manufacturer of the cement?

A By "mixtures", do you mean --

Q Well, I mean the mixture of two percent gel.

A I believe that the common cement with two percent gel and with calcium chloride are typical, and as I said, our cements with those mixtures develop a little more strength than what is shown. We do not, as a cement manufacturer, have experience with the 50-50 posolan so I am not qualified to give an opinion on that. Our slow set cement in the temperature range shown on the curve would be somewhat under the curve that is shown in Figure 2, especially when we bring in the factor of temperature which is important when you get into the well depths as you would use that cement in.

Q In other words, there is a variation, and sometimes a marked variation in the strength of one cement mixture as compared with the same cement mixture made by another manufacturer?

A Not the common cements, there is not too much; but in the slow set cements, as explained by Mr. Davis, there is a -- I wouldn't say marked difference, but there is an appreciable difference. I'm not qualified, as I mentioned a minute ago, to discuss the posolan mixtures; there are a number of different posolans, of course, as everybody knows, different types of posolans. To amplify the situation on slow set cements, you may be interested in some cooperative A.P.I. work that has been done within the past year, in which eight slow set cements were tested by eleven laboratories, to determine the strength of the cements and to determine the reproducibility of test procedures. It was rather remarkable how the application of pressure tended to bring those slow set cements down to pretty much the same common basis insofar as early strength goes. That work is available, too.

Q Do you think that by use of a chart such as these charts, when you know the brand of the cement and the mixture of the cement and the temperature of the hole, that an accurate appraisal can be made of the strength of the cement, with a given time period?

A Yes, I think it's possible.

Q You are from Indiana?

A Gary, Indiana.

Q You wouldn't know about the temperature gradient in the San Juan Basin, I don't suppose?

A No, I don't.

MR. NUTTER: Thank you.

MR. PORTER: Anyone else have a question of the witness? The witness may be excused.

(Witness excused.)

MR. PORTER: Anyone have any more testimony to present in the case? Any statements?

MR. KELLAHIN: That's all the testimony we have at this time.

MR. PORTER: Mr. Buell.

MR. BUELL: May it please the Commission, Guy Buell, Pan American Petroleum Corporation. Let me state at the outset, we certainly would have no objection to the proposal by Mr. Nutter to our proposed amendment of section (d), and we would recommend the adoption of the proposed Rule 107 as amended by our amendment and as amended by Mr. Nutter's amendment.

MR. PORTER: Mr. Campbell.

MR. CAMPBELL: With regard to the statement of Mr. Buell, I think that is a rather consequential change, and one that perhaps requires some study by operators and the Commission. I would like to inquire whether it is possible that a period of time could be given to submit comments on this proposed rule, or that the case be continued until the next monthly hearing. Most people did not receive it until the docket was sent out. So far as the Association is concerned, we are certainly in agreement generally with all of the provisions. However, there are two or three provisions dealing with shallow cable tool pools which we would like to have an opportunity to study a little further, and perhaps make some suggestions to the Commission, either at another hearing or if, rather than slow the matter down, if there is a hurry about it, have a period of time in which to submit written comments on that.

I would like to request the Commission to allow us to do that either in that manner, or allow a continuance of the case until the next hearing.

MR. PORTER: Mr. Campbell, we will defer action on your motion for a moment. We will see if anybody else has a statement to make at this time.

MR. KELLAHIN: We would like to say there seems to be some concern expressed by the Commission staff with regard to the temperature gradient in the northwestern part of the State, and we will make every possible effort to supply the Commission with temperature gradients in that area as soon as possible. We will be able to produce it and according to the information available at the present time, it seems to be indicated that they would run higher than in southeastern New Mexico. Also in connection with the case, we have a letter from Phillips Petroleum Company expressing support of the proposed change, which I would like to submit to the Commission for their information.

I believe that we have nothing further to add to what has already been said. We urge the adoption of the rule.

MR. PORTER: Does anyone else have a statement to make at this time in the case?

MR. BRATTON: Howard Bratton, Hervey, Dow and Hinkle, Roswell, New Mexico, representing Humble Oil and Refining Company. We have a statement which we will make at this time; however, if the Commission is going to take further statements or continue the case for the possibility of further testimony, I believe we prefer to wait to introduce our statement until such time.

MR. COOLEY: Mr. Commissioner, I have some communications here.

MR. PORTER: In other words, you would like a ruling on the motion before you decide which way you would go? Is there any objection to Mr. Campbell's motion to continue this case until the next regular hearing?

MR. KELLAHIN: We have no objection, and then, as I understand it, the statements would be made at that time?

MR. PORTER: Yes.

MR. KELLAHIN: We have no objection to that.

MR. PORTER: The case will be continued until the regular February hearing, which I believe is February 13th.

* * * * * * *

C E R T I F I C A T E

STATE OF NEW MEXICO)
) ss
COUNTY OF BERNALILLO)

I, ADA DEARNLEY, Notary Public in and for the County of Bernalillo, State of New Mexico, do hereby certify that the foregoing and attached Transcript of Proceedings before the New Mexico Oil Conservation Commission was reported by me in stenotype and reduced to typewritten transcript under my personal supervision, and that the same is a true and correct record to the best of my knowledge, skill and ability.

WITNESS my Hand and Seal this 25th day of January, 1958, in the City of Albuquerque, County of Bernalillo, State of New Mexico.

Ada Dearnley
NOTARY PUBLIC

My commission expires:
June 19, 1959.

The
FRONTIER REFINING CO.
4040 EAST LOUISIANA AVENUE • DENVER 22, COLORADO

FRONTIER

DENVER, COLORADO
General Office

CHEYENNE, WYOMING
Manufacturing

4040 East Louisiana Avenue
Denver 22, Colorado
January 10, 1958

New Mexico Oil Conservation Commission
Santa Fe, New Mexico

Gentlemen:

Re: Case 1369
Hearing January 15, 1958

We wish to enter an appearance in this case by letter as follows:

We object to paragraph (c)(1) with regard to testing production casing strings. When the top plug is bumped with approximately 500 PSI greater than the pump pressure during final stage of the cementing operation, this in effect is a test of the casing. When rotary rig is released and the well completed with cable tools, the proposed order would impose on the operator an additional pump truck charge of from about $200 to $300, plus approximately 75¢ per mile one way over 25 miles.

We also object to (c)(2): When completing a well with cable tools, we have found that a dry test of 2 hours has always been sufficient.

We believe adoption of the proposed rule change would for the most part cause unwarranted additional expense to the operator. In general we believe the existing Rule 107 is entirely adequate and would urge that the proposed rule change be denied in entirety with one exception: we agree that 18 hours WOC on surface casing would be sufficient.

Yours very truly,

E. B. Granville

E. B. Granville
Drilling and Production
Superintendent

EBG:pb

PHILLIPS PETROLEUM COMPANY

BARTLESVILLE, OKLAHOMA

October 14, 1957

PRODUCTION DEPARTMENT
L. E. FITZJARRALD
MANAGER

EARL GRIFFIN
GENERAL SUPERINTENDENT
JACK TARNER
TECHNICAL ADVISER TO MGR.
H. S. KELLY
CHIEF ENGINEER

In re: Completion Practices - Cementing - Proposal for Amendment of New Mexico Oil Conservation Commission Statewide Rule 107.

Atlantic Refining Company
Midland, Texas

Attention of Mr. J. H. Faulk

Gentlemen:

This is to advise that Phillips Petroleum Company is in support of your proposal to amend the subject rule to reduce WOC time and to eliminate the requirement of an opening of less than 1" at the bottom of the tubing on flowing wells. The proposal to change the WOC time was expressed in your memorandum of September 24, 1957.

You may advise the New Mexico Oil Conservation Commission of our concurrence.

Very truly yours,

L. E. Fitzjarrald

L. E. Fitzjarrald

LEF:OPN:HD

OIL CONSERVATION COMMISSION
P. O. BOX 871
SANTA FE, NEW MEXICO

May 5, 1958

COPY

Mr. Jason Kellahin
Kellahin & Fox
P.O. Box 1713
Santa Fe, New Mexico

Dear Mr. Kellahin:

On behalf of your client, Atlantic Refining Company, we enclose two copies of Order R-1173 issued May 5, 1958, by the Oil Conservation Commission in Case 1369, which was heard on January 15th and February 13th at Santa Fe.

Very truly yours,

A. L. Porter, Jr.
Secretary - Director

bp
Encls.

Campbell's Amendments

PROPOSED RULE CHANGE PROPOSED RULE CHANGE PROPOSED RULE CHANGE

Rule 107 - Casing and Tubing Requirements

(a) All wells drilled for oil or natural gas shall be completed with a string of casing which shall be properly cemented at a sufficient depth to protect adequately the oil or natural gas bearing strata to be produced. In addition thereto such other casing and cement shall be used as necessary in order to seal off all oil, gas, and water strata which may be encountered in the well except the one or ones to be produced. ~~Sufficient cement shall be used on surface casing to fill the annular space back of the casing to the top of the hole.~~ All cementing shall be by pump and plug method, or such other method approved by the Commission. All casing strings shall be tested and proved satisfactory as provided in paragraph (c) below.

(b) Before initiating tests (as in (c) below), all casing strings shall stand cemented a minimum of

(1) eighteen (18) hours, or

(2) until the compressive strength is at least 500 pounds per square inch in the "zone of interest," as determined from typical performance data furnished for the particular cement mix used in the well, by the cement manufacturer or other testing agency in accordance with API RP 10 B, Recommended Practice for Testing Oil-Well Cements, Latest Edition, and at a curing temperature not exceeding the lowest temperature existing in the "zone of interest" provided, however, that no tests shall be commenced until the cement has been in place for at least eight (8) hours.

Regardless of whether option (1) or (2) above is taken, the casing shall remain under pressure and stationary ~~as to tension~~ for the first eight (8) hours after the cement has been placed.

"Under pressure" is complied with if one or more float valves are employed and are shown to be holding the cement in place, or when other means of holding pressure is used.

The "zone of interest" for surface, intermediate, and protection casing strings shall be the bottom 20 percent of the casing string, but shall be no greater than 1000 feet nor less than 300 feet of the bottom part of the casing unless the casing is set at a depth less than 300 feet. In the case of the production casing string the "zone of interest" shall include the interval or intervals where immediate completion is contemplated. Operators using the minimum 18-hour criterion of cement strength shall report on Form C-103 the actual time the cement was in place before initiating tests. Operators using compressive strength criterion shall report the following information on Form C-103:

(1) Volume of cement slurry (cubic feet).
(2) Brand name of cement together with additives showing sequence of placement if more than one type cement slurry is used.
(3) Approximate temperature of cement slurry when mixed.
(4) Estimated native bottom hole formation temperature.
(5) Estimate of cement strength at time of testing.
(6) Time interval between plug down and starting of casing test.

(c) All casing strings except conductor pipe shall be tested after cementing and before commencing any other operations on the well.

(1) Wells drilled with rotary tools shall be pressure tested. Minimum casing test pressure shall be approximately one-third manufacturer's rated internal yield pressure except that the test pressure shall not be less than 600 pounds per square

inch and need not be greater than 2500 pounds per square inch. In cases where combination strings are involved, the above test pressures shall apply to the lowest pressure rated casing used. Test pressures shall be applied for a period of 30 minutes. If a drop of more than 10 percent of the test pressure shall occur, the casing shall be considered defective and corrective measures shall be applied.

(2) Wells drilled with cable tools may be tested as outlined in sub-paragraph (c) (1) above, or by bailing the well dry in which case the hole must satisfactorily remain dry for a period of at least six hours (6) before commencing any further operations on the well.

The results of casing tests on each string shall be reported on Form C-103.

(d) All flowing wells shall be tubed, and the tubing shall be set as near the bottom as practical; tubing perforations shall not be more than 250 feet above the top of the pay, unless authorized by the Commission.

ATLANTIC

THE ATLANTIC REFINING COMPANY
INCORPORATED 1870
PETROLEUM PRODUCTS
ATLANTIC BUILDING
DALLAS, TEXAS

March 5, 1958

DOMESTIC PRODUCING DEPARTMENT
PRODUCTION DIVISION

T. C. FRICK, MANAGER
V. E. STEPP, CHIEF PET. ENGR.
R. O. CHILDERS, GEN'L. DRILLING SUPT.
W. L. BOWSER, SUPT. OF NATURAL GAS
R. A. HAMILTON, SUPT. OF MATERIALS
H. C. RENZ, SUPV. OF CLERICAL AND RECORDS

MAILING ADDRESS
P. O. BOX 2819
DALLAS 21, TEXAS

Mr. Daniel S. Nutter
New Mexico Oil Conservation Commission
P. O. Box 871
Santa Fe, New Mexico

Dear Mr. Nutter:

Enclosed is the temperature and cement strength data which you requested. The separate temperature graphs and the curves showing the time required for bentonite-cements to gain 500 psi are new. The remaining curves are those which were presented as exhibits at the hearing.

I hope these graphs will provide the information which you will need. Please call on us, however, if we can be of any further assistance to you.

Very truly yours,

Sidney H. Davis

Sidney H. Davis

/at
Enc.

TENTATIVELY PROPOSED NEW MEXICO OIL CONSERVATION COMMISSION STATE WIDE

RULE 107. CASING AND TUBING REQUIREMENTS

(a) No change.

(b) Cementing shall be by pump and plug method, or other method approved by the Commission. Sufficient cement shall be used on surface casing to fill the annular space back of the casing to the bottom of the collar or to the surface of the ground. Before initiating tests, all casing strings shall stand cemented a minimum of either (1) 18 hours, or (2) until compressive strength of the cement is at least 500 pounds per square inch in the "zone of interest". In the case of surface, intermediate or protection casing strings the "zone of interest" shall be the bottom 20% of the casing string, but shall be no greater than 1,000' nor less than 300' from the bottom of the string unless the casing is set at a depth less than 300'. In the case of the production casing string the "zone of interest" shall include all known hydrocarbon producing formations. Operators using compressive strength criterion shall report the following information on Form C-103:

(1) Volume of cement slurry (cubic feet)
(2) Brand name of cement together with additives showing sequence of placement if more than one type cement slurry is used.
(3) Approximate temperature of cement slurry when mixed.
(4) Estimate of cement strength at time of testing.

(c) All casing strings, except conductor pipe, shall be tested satisfactorily after cementing and before starting operations such as drilling plug or perforating. Minimum casing test pressure shall be approximately one-third casing interval yield pressure except that the test pressure shall not be less than 600 psi nor more than 2500 psi. Test pressure shall be applied for a period of 30 minutes. If a drop of more than ten percent of the test pressure should occur, the casing shall be considered defective and corrective measures shall be applied.

(d) All flowing wells shall be tubed, and tubing shall be set as near the bottom as practical, but tubing perforations shall not be more than 250 feet above the top of pay, unless authorized by the Commission.

Case 1347

LAW OFFICES
HERVEY, DOW & HINKLE
FIRST NATIONAL BANK BUILDING
ROSWELL, NEW MEXICO

J. M. HERVEY 1874-1953
HIRAM M. DOW
CLARENCE E. HINKLE
W. E. BONDURANT, JR.
GEORGE H. HUNKER, JR.
HOWARD C. BRATTON
S. B. CHRISTY IV
J. PENROD TOLES
LEWIS C. COX, JR.
PAUL W. EATON, JR.

TELEPHONE MAIN 2-6510
POST OFFICE BOX 547

December 31, 1957

New Mexico Oil Conservation Commission
Mabry Hall, State Capitol
Santa Fe, New Mexico

Attention: Mr. Dan Nutter

Gentlemen:

This will refer to the writer's conversation with Mr. Nutter last week in regard to the proposed amendment of Rule 107 of the Rules of the New Mexico Oil Conservation Commission.

It is our understanding that this matter will go on the docket for the regular January hearing on the motion of the Commission at the request of The Atlantic Refining Company. As you know, The Atlantic Refining Company has been in touch with us in regard to the matter and this is agreeable to The Atlantic and they will be prepared to submit evidence in support of the proposed amendment.

Yours very truly,

HERVEY, DOW & HINKLE

By [signature]

CEH/bp

BEFORE THE
OIL CONSERVATION COMMISSION
Santa Fe, New Mexico
February 13, 1958

IN THE MATTER OF: Case No. 1369

TRANSCRIPT OF PROCEEDINGS

DEARNLEY - MEIER & ASSOCIATES
INCORPORATED
GENERAL LAW REPORTERS
ALBUQUERQUE, NEW MEXICO
3-6691 5-9546

BEFORE THE
OIL CONSERVATION COMMISSION
Santa Fe, New Mexico
February 13, 1958

IN THE MATTER OF:

The hearing upon the motion of the Oil Conservation Commission of New Mexico at the request of The Atlantic Refining Company to amend Rule 107 of the Commission Rules and Regulations pertaining to casing, tubing, and cementing requirements.

Case 1369

BEFORE:

Mr. A. L. Porter, Jr.
Mr. Murray Morgan
Governor Edwin L. Mechem

TRANSCRIPT OF PROCEEDINGS

MR. PORTER: We'll take up next Case 1369.

MR. COOLEY: Case 1369: In the matter of the hearing upon the motion of the Oil Conservation Commission of New Mexico at the request of The Atlantic Refining Company to amend Rule 107 of the Commission Rules and Regulations pertaining to casing, tubing, and cementing requirements.

Is the Atlantic witness prepared to proceed?

MR. KELLAHIN: At the conclusion of the hearing in the case last month, the case was continued at the request of some of the operators and the New Mexico Producers and Royalty Owners Association. We had completed our testimony.

There was a question, however, in regard to a temperature survey in the northwestern part of the State. We assured the Commission we would make every effort to obtain that information. We are prepared to go ahead on that phase of the hearing. I would like to ask if there are others going to put on testimony. We would like to close our witness and it would be awkward to put him on and take him off and put him back on again. If there are others, we would like for them to go ahead.

MR. PORTER: Anyone else have testimony to present in this case? It looks as though Mr. Davis may be the only witness.

MR. KELLAHIN: I would like to call Mr. Davis, then.

(Witness sworn.)

S. H. DAVIS

called as a witness, having been first duly sworn on oath, testified as follows:

DIRECT EXAMINATION

By MR. KELLAHIN:

A At the close of the hearing, we promised to provide this temperature data for the Northwestern part of New Mexico. We obtained temperature data from three or four different operators and several service companies during this interim period, and I have plotted a curve on the graph before you here which we have entered as Exhibit 7. The Exhibit 7 is identical to Exhibit 1, except that a temperature gradient line for northwestern New Mexico has been added. The line is an average line drawn through the central portion of a group of points from approximately fifty-five wells. I would like to submit that as Exhibit 7 for the hearing.

Q Mr. Davis, was your curve on northwestern New Mexico prepared on the same basis as that for southern New Mexico and the Gulf Coast?

A Yes. It is, as you will notice, somewhat higher, as we had mentioned during the last hearing.

Q Do you have with you the temperature spotted on another exhibit showing the specific temperatures used in connection with that curve?

A I do. I have a graph, a small graph, which I will be glad to leave with the Commission, which actually shows the spread of points from which the northwestern New Mexico temperature gradient was drawn. I have no other comments to make, other than to mention that the line, the temperature being higher in northwestern New Mexico, the cement curing is actually less critical than it would be in southern New Mexico, and we have based our entire testimony on the temperature gradient in the southern part of New Mexico. There is no conflict between the two temperatures shown.

Q That curve is shown on what has been marked as Atlantic's Exhibit No. 7?

A That's right.

MR. KELLAHIN: We would like to offer in evidence Exhibit No. 7.

MR. PORTER: Is there objection to the admission of the exhibit? It will be admitted. Anyone have a question of Mr. Davis?

MR. KASTLER: Bill Kastler representing Gulf Oil Corporation.

CROSS EXAMINATION

By MR. KASTLER:

Q Mr. Davis, I hand you herewith a duplicated copy which has been prepared by Gulf Oil Corporation, and it has been deleted as to sub-paragrphs (a) and (c) of the proposed rule change, for the reason that Gulf Oil Corporation is in agreement or substantial agreement with Atlantic on those. In sub-paragraph (b) of your proposed rule change, this paper I have handed you contains certain underlining of additional language, which would accomplish two results: namely, to define the 500 pound compressor strength by A.P.I. standards, and to provide that the casing shall remain under pressure and stationary as to tension for the first eight hours, and thereafter it purports to define what is under pressure.

Mr. Davis, does this prepared statement appear to accomplish the two results that I have outlined?

A Yes. It covers those points.

MR. KASTLER: If the Commission please, I would like to submit this as Gulf's Exhibit No. 1 for the Commission's consideration of a proposed rule change containing these particular additions.

MR. PORTER: Is there objection to the admission of this exhibit? It will be admitted.

MR. KASTLER: Thank you, Mr. Davis.

MR. PORTER: Anyone else have a question of Mr. Davis?

MR. PORTER: Mr. Nutter.

By MR. NUTTER:

Q Do you feel that this temperature gradient that you have established for northwest New Mexico represents the temperatures to be encountered at various depths throughout the San Juan Basin?

A Yes.

Q You think that this provides an accurate enough measurement of temperature in order to use the minimum strength criterion--

A Yes.

Q -- to judge that the strength that a cement has attained in a certain period of time?

A Yes, I do.

Q I think last month you probably testified that you felt the same about the southern New Mexico temperature gradient?

A That is correct.

Q You feel that we have temperature gradient curves here that would reliably determine the strength of the cement?

A Yes.

MR. PORTER: Anyone else have a question of the witness? Mr. Davis may be excused.

(Witness excused.)

MR. KELLAHIN: If the Commission please, that's all we have at this time.

MR. PORTER: Anyone else have a statement to make in the case? Mr. Campbell.

MR. [illegible]: I would like to offer, for what consideration the Commission may desire to give it, a statement presenting the views of certain members of the Independent Producers and Royalty Owners Association, operating in the Artesia area with cable tool operations. The statement affects only a portion of paragraph (a) and paragraph (c)-2. We have no objection whatsoever to any other portions of the proposed rule change nor so far as I know to the amendments suggested in this Gulf exhibit. The statement was actually prepared by Mr. V. P. Sheldon after discussion of the matter with other operators in that area.

Independent Producers and Royalty Owners Association of New Mexico recommends that Rule 107 as proposed be amended in the following two ways:

1. In paragraph (a), the sentence, "Sufficient cement shall be used on surface casing to fill the annular space back of the casing to the top of the hole," that sentence be completely deleted.

This is the basis for that suggestion. The interest of the Oil Conservation Commission is to see that the various oil pays and water bearing strata are protected from contamination and moving of the fluids from one formation to the other. The cementing of the surface casing to ground level does not necessarily accomplish that end, nor is it always necessary to so cement to accomplish the goal and interest of the Commission. It is believed by this Association that the main objective of cementing surface casing to ground level or to the bottom of the cellar is to provide a rigid anchor for the installation of a blowout preventer in rotary drilling. In cable tool drilling, gravel formations, either dry or water bearing, are often encountered which take cement or other fluids introduced, making it impossible to fill the annulus with cement without expensive hole conditioning. Even in cases where the cement actually reaches the surface during cementing operations, the cement often breaks down and enters the gravels after the cement is pumped and before it sets. There are a good many known cases where all of the cement pumped in enters the gravel, even leaving the casing shoe uncemented. This phenomenon is caused by an overbalanced condition, the fluid inside of the casing forcing the cement upwards away from the shoe. In cable tool drilling, a rigid anchor is not needed and it thus becomes necessary to cement to the surface or to the cellar.

We would like to further point out that the rules do not specifically define what surface casing is, and there may be several possible interpretations of that, which further complicates the picture.

We are aware of the vital importance in protecting the usable waters; we do not offer this amendment to avoid that responsibility, but we feel that by making this rule elastic in relying upon the approval by the Commission representatives in the area of the cementing program and examination of the cementing program after it is completed is sufficient to accomplish that purpose in individual cases.

The second suggestion that we make, the waiting or test time as referred to in (c)2, to check water shut-off in cable tool drilling, be reduced from six hours to one hour.

In actual field practice, by the time the water inside the casing has been bailed out, it is quite obvious as to whether or not a satisfactory water shut-off has been achieved. A one-hour test period after the hole has been bailed down is quite conclusive and a further wait serves no useful purpose. In fact, we would be willing to go further, in that should water break in around the shoe even after the prescribed test period indicated a satisfactory shut-off and drilling was resumed, the casing should be then re-cemented. Again, we make the point that a somewhat elastic rule better serves the goal of protecting the formations penetrated. They feel that the Commission has ample authority under the general powers in this order or this rule to set up satisfactory cementing requirements on cable tool holes in the area where these wells are drilled. The adoption of the one-hour test period will amply serve the Commission's needs and will make the operators more willing to cooperate. The Commission will still have ample powers to achieve its goals by virtue of the basic rule contained in the first paragraph of this order.

MR. PORTER: Mr. Hinkle.

MR. HINKLE: Clarence Hinkle. I have a brief statement on behalf of Humble.

Humble Oil and Refining Company would prefer a simple rule which does not involve reporting detailed information on the type of cement used, temperatures, and so forth. However, if a rule of the type proposed is to be adopted, we believe that the 500 psi compressive strength requirement is unnecessarily high. There are a number of engineering and research reports indicating that a cement tensile strength of 8 psi or compressive strength of 50 psi should be adequate. Field rules in several West Texas Fields permit drilling the plug in 12 hours and a number of wells have been cemented without failures under conditions where the theoretical cement strength before initiating tests approach 100 psi. It is our belief that if cement has reached final set, its strength is adequate to support the casing, and therefore we recommend that a rule be adopted to permit an operator to resume operations after waiting 12 hours on cement, provided the composition of the cement is such that it will have reached final set in this time.

We recommend adoption of the 1500 psi maximum casing test pressure as proposed by Atlantic.

We concur with Pan American that provision be made in Rule 107 (c) to provide for administrative exception to where tubing is bottomed. This should facilitate making permanent type completions and dual completions.

MR. PORTER: Anyone else have a statement in this case? We'll take the case under advisement.

* * * * * * * *

C E R T I F I C A T E

STATE OF NEW MEXICO)
) ss
COUNTY OF BERNALILLO)

I, ADA DEARNLEY, Notary Public in and for the County of Bernalillo, State of New Mexico, do hereby certify that the foregoing and attached Transcript of Proceedings before the New Mexico Oil Conservation Commission was reported by me in stenotype and reduced to typewritten transcript under my personal supervision, and that the same is a true and correct record to the best of my knowledge, skill and ability.

WITNESS my Hand and Seal this 6th day of March, 1958, in the City of Albuquerque, County of Bernalillo, State of New Mexico.

Ada Dearnley
NOTARY PUBLIC

My commission expires:
June 19, 1959.

API RP 10B
Seventh Edition
January 1958

API RECOMMENDED PRACTICE for TESTING OIL-WELL CEMENTS

AMERICAN PETROLEUM INSTITUTE
New York, N. Y.

Issued by
API DIVISION OF PRODUCTION
300 Corrigan Tower Bldg.
Dallas 1, Texas

Price: 75 Cents

TABLE OF CONTENTS

Note

This edition of RP 10B supersedes the 6th edition dated May 1957. It includes changes adopted at the June 1957 meeting, which were reported in detail in Circ. PS 1109.

This recommended practice was originally published in February 1948, as Code 32, and reissued as the 2nd edition in June 1952. In June 1952, this code was transferred to the jurisdiction of the Committee on Standardization of Oil-Well Cements, and redesignated RP 10B. The 3rd edition was issued in May 1954, and the 4th edition in May 1955. It was advanced to "standard" in June 1955. Further revised editions were issued in 1956 and May 1957.

API RECOMMENDED PRACTICE FOR TESTING OIL-WELL CEMENTS

Foreword

a. This recommended practice is under the jurisdiction of the API Committee on Standardization of Oil-Well Cements.

b. This recommended practice describes test procedures for the evaluation and definition of those physical properties of cements of special importance to the oil and gas industry. Certain of these procedures are required methods of test under API Std 10A: Specification for Oil-Well Cements.

c. These procedures are applicable to the following classes and types of oil-well cement (see API Std 10A for specification requirements).

Class A: Intended for use from surface to 6,000-ft depth,* when special properties are not required. Available in regular type only (similar to ASTM C 150, type I).

Class B: Intended for use from surface to 6,000-ft depth.* Available in the regular type (similar to ASTM C 150, type II) for conditions requiring moderate sulfate resistance, and in the high sulfate-resistant type.

*These depth limits are based on the conditions imposed by the casing cementing well-simulation tests (Schedules 1-9, incl.), and should be considered as approximate values.

Class C: Intended for use from surface to 6,000-ft depth,* for conditions requiring high early strength. Available in the regular type (similar to ASTM C 150, type III) and in the high sulfate-resistant type.

Class N: Intended for use from 6,000 to 9,000-ft depth,* for conditions of moderate temperature and pressure. Available in the regular type (having moderate sulfate resistance) and in the high sulfate-resistant type.

Class D: Intended for use from 6,000 to 12,000-ft depth,* for conditions of moderately high temperature and moderately high pressure. Available in the regular type (having moderate sulfate resistance) and in the high sulfate-resistant type.

Class E: Intended for use from 6,000 to 14,000-ft depth,* for conditions of high temperature and high pressure. Available in the regular type (having moderate sulfate resistance) and in the high sulfate-resistant type.

Class F: Intended for use from 10,000 to 16,000-ft depth,* for conditions of extremely high temperature and extremely high pressure. Available in the regular type (having moderate sulfate resistance) and in the high sulfate-resistant type.

SECTION I
SAMPLING

1. In order to secure a sample of cement which is truly representative of the lot in question, it is recommended that the following cement-sampling equipment and methods be employed whenever possible.

2. Apparatus. The following apparatus for sampling cement should be used:

a. **Sacked Cement.** A tube sampler, as shown in Fig. 1, should be used, if possible, for sampling sacked cement.

b. **Bulk Cement.** For sampling bulk cement, either of the following samplers should be used:

I. A tube sampler similar to that shown in Fig. 2 consisting of two polished brass telescopic tubes with registering slots which are opened or closed by rotation of the inner tube, the outer tube being provided with a sharp point to facilitate penetration. The length should be appropriate to the vessel from which the sample is being collected.

II. A small grocers scoop, for sampling during loading or unloading operations.

3. Procedure. The following procedure for sampling cement should be used:

a. **Sacked Cement.** When using the sampler shown in Fig. 1, the Bates valve in the upper right-hand corner of the sack should be opened, the sampler inserted diagonally, and the thumb placed over the air hole. The sampler should then be carefully withdrawn. When it is impossible or not feasible to sample cement with the tube sampler, every effort should be made to secure a representative sample from the lot of cement in question, be it large or small. A minimum of one sample from each 50 sacks (or less) is desirable. The sample should then be placed in an air-tight container, preferably metal, and kept there until immediately before testing is started.

b. **Bulk Cement.** The various procedures given in the latest edition of ASTM C 183*: Method of Testing Hydraulic Cement, should be used for the sampling of bulk cement.

4. Size of Sample. The minimum weights of cement required for test purposes are given in Table 1. The total weight of sample collected should not be less than 25 per cent in excess of the amount required for the tests to be conducted.

*ASTM standards referred to herein are available from American Society for Testing Materials, 1916 Race St., Philadelphia, Pa.

TABLE 1
WEIGHT OF TEST SAMPLES

Method of Test	Quantity for Single Test, min., lb.	Quantity for Complete Tests, min., lb.
Soundness	1	1
Fineness	1	1
Thickening Time		
Atmospheric Pressure Test A	3	12
Atmospheric Pressure Test B	6	24
Pressure Temperature	2	12
Tensile strength	2 (per gang mold)	32
Compressive strength	3 (per gang mold)	48

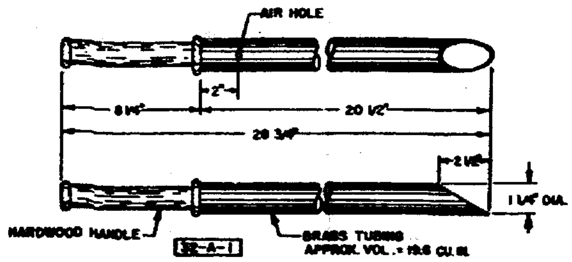

FIG. 1
TUBE SAMPLER FOR SACKED CEMENT

FIG. 2
TUBE SAMPLER FOR BULK CEMENT

SECTION II

PREPARATION OF SLURRY

Apparatus

5. Scales. The indicated load on scales should be accurate within a tolerance of 2 g for loads of 2000 g or more, and within 0.1 per cent of the indicated load for loads smaller than 2000 g, except that for new scales the tolerances on accuracy should be one-half of these values. The sensibility reciprocal should not be greater than twice the permissible tolerance on scale accuracy.

6. Weights. Weights should be accurate within the tolerances shown in Table 2, except that new weights should be accurate within one-half of such tolerances. On beam-type scales where the weights are on the beam, the indicated weights should conform to the requirements given in Par. 5

TABLE 2
PERMISSIBLE VARIATION IN WEIGHTS

Weight, g.	Variation, Plus or Minus, g.
1000	0.50
500	0.35
300	0.30
200	0.20
100	0.15
50	0.10

7. Graduated Glass Cylinders. Graduated glass cylinders should be large enough to measure and deliver, in a single operation, the required volume of mixing water, at 20 C (68 F). The variation in volume should not exceed ±0.2 per cent. The graduations should be subdivided to at least 5 ml. The main graduation lines should be complete circles, and should be numbered. The intermediate graduations should extend around a minimum of one-fifth of the circumference, and the smallest graduations should extend around a minimum of one-seventh of the circumference of the cylinder.

8. Mixing Device. The mixing device for preparation of cement slurries shall be a 1-qt size, two-speed Waring Blendor. This is a propeller-type high-speed mixer capable of rotating at 4,000 rpm or greater at no load on "slow" speed, and 10,000 rpm or greater at no load on "high" speed. The propeller blade and mixing container (1-qt) shall be constructed of corrosion resistant metal.

Procedure

9. Screening. The sample of cement to be tested should be passed through an 840 micron (No. 20) sieve meeting the requirements given in the latest edition of ASTM E 11: Sieves for Testing Purposes, in order to break up lumps and remove foreign materials. The materials retained on the screen should be weighed, the weight recorded as a per cent of the total cement sieved, and a notation made as to its characteristics, after which it should be discarded.

10. Mixing Water. For reference tests, freshly distilled water or distilled water essentially free of CO_2 should be used. For routine tests, any normal potable water may be employed. The mixing water should be measured in a graduated glass cylinder (see Par. 7) or weighed by means of scales and weights (see Par. 5 and 6).

11. Temperature of Water and Cement. The temperature of the water prior to mixing should be 80 ±5 F and that of the cement should be 80 ±10 F.

12. Water Percentage. The water percentage by weight to be added for each class of cement should conform to the values given in Table 3. No water shall be added to compensate for evaporation, wetting, etc.

TABLE 3
CEMENT SLURRY COMPOSITION

1	2	3	4	5
	Water		Required Quantity to Yield 750 ml of Slurry	
API Class of Cement	Percentage by Wt. of Cement	Gal. per Sack	g. water	g. cement
A and B	46	5.19	444	965
C	56	6.32	479	855
N, D, E, and F	40	4.51	420	1050

NOTE: *The addition of bentonite to cement requires that the amount of water be increased. It is recommended, for testing purposes, that 4.5 per cent water be added for each 1 per cent bentonite in classes A, and B, and C, and 3.8 per cent water for each per cent bentonite in classes N, D, E, and F cement. For example, a class A cement slurry having a normal water-cement ratio of 46 per cent, to which is added 3 per cent bentonite, will require an increase in water-cement ratio to 59.5 per cent.*

13. Mixing of Cement and Water. Mixing of the cement and the requisite percentage of water at the given temperature shall conform to the following mixing procedure:

> The required quantity of water shall be placed in the mixing container, the mixer turned on "slow" speed, and the cement sample added in not more than 5 sec. After all of the cement has been added to the water, the cover shall be placed on the mixing container and stirring shall be continued at "high" speed for 35 sec.

14. Volume of Slurry. The volume of slurry in the mixing container shall be 750 ml.

SECTION III

DETERMINATION OF DENSITY OF SLURRY

15. **Apparatus and Calibration.** Cement slurry density should be determined by the use of any accurate instrument, such as a hydrometer or mud balance as described in API RP 29: Recommended Practice for Standard Field Procedure for Testing Drilling Fluids.

16. **Procedure.** The procedure for using a hydrometer or mud balance should be as recommended in the latest edition of API RP 29 except that the slurry, after being poured into the hydrometer or mud-balance cup, should be puddled 25 times to eliminate any air that may be entrapped in the slurry.

SECTION IV

FILTER-LOSS TEST

(Tentative)

17. **Apparatus.** The following apparatus should be used.

a. **Filter Press.** The filter press should consist of a frame and cylinder assembly similar to that shown in Fig. 3. The cylinder should have an internal diameter of 3 ± .07 in. and a height of at least 2½ in. The cylinder assembly should be constructed of materials not affected by alkaline solutions and so fitted that a pressure medium can be conveniently admitted into and bled from the top. The bottom of the cell should be closed by a bottom cap with a drain tube and necessary gaskets to provide an effective seal. The filtration area should be 7.1 sq in. The entire assembly should be supported in a convenient stand.

b. **Pressure Medium.** Pressure should be supplied by compressed air, nitrogen, or any other safe and adequate means of maintaining constant gas pressure.

c. **Filter Medium.** The filter medium should be 28 x 500 Dutch Twill Weave stainless steel metallic filter cloth with a stainless steel binder or a 325-mesh U S Standard Sieve Series screen (ASTM E 11-39) supported by a 14-mesh Sieve Series screen, both fabricated from stainless steel into an integral unit.

d. **Graduated Glass Cylinders.** The graduated glass cylinders should be large enough to contain and measure the expected volume of filtrate.

18. **Preparation of Filter Press and Slurry.** Prior to placing the slurry in the press the filter press and cement slurry should be prepared as follows:

a. **Filter Press.** The cell of the filter press should be assembled dry.

b. **Slurry.** When the cement slurry is prepared in accordance with Sect. II, it is placed in the press as quickly as convenient handling will allow. The time between cessation of stirring and application of pressure shall not exceed 2 min. The temperature of slurry should be determined in degrees Fahrenheit.

c. **Special Slurry.** When the test is used on field prepared slurries or on pressure and/or temperature treated slurries, the method of preparation and handling shall be stated.

Procedure

19. **Placing of Slurry in Press and Commencing of Test.** The cell should be filled with at least 2 in. of cement slurry, capped, and secured in the frame. A dry graduated cylinder should be placed under the drain tube to receive the filtrate, the relief valve closed, and a gas pressure of 100 ±5 psi applied within 5 sec after the relief valve is closed.

20. **Test Period.** The test period should be timed from the instant of initial pressure application. Filtrate readings should be taken at ¼, ½, 1, 2, and 5 min, and thereafter at 5-min intervals, until 30 min have elapsed. If dehydration occurs before the end of the 30-min test period, the elapsed time required to dehydrate the sample should be observed. At the completion of the test, the gas pressure should be shut off and the relief valve opened.

21. **Recording of Results.** Record the initial temperature of the slurry in degrees Fahrenheit. The volume of the filtrate should be recorded as follows:

a. **For 30-Min Test Period.** Report the volume of filtrate as the fluid loss at 100 psi.

b. **For Short Test Periods.** For slurries which dehydrate in less than 30 min, and tests of shorter duration than 30 min, a hypothetical 30-min fluid-loss value may be obtained for comparative purposes by multiplying the quantity of filtrate at that time by 5.477 divided by the square root of that time in minutes. This relationship is shown by the following equation:

$$Q_{30} = Q_t \times \frac{5.477}{\sqrt{t}}$$

Wherein:

Q_{30} = the quantity of filtrate in 30 min.

Q_t = the quantity of filtrate at time t.

All computed 30-min fluid-loss values should be so noted and should not be construed as true fluid-loss values.

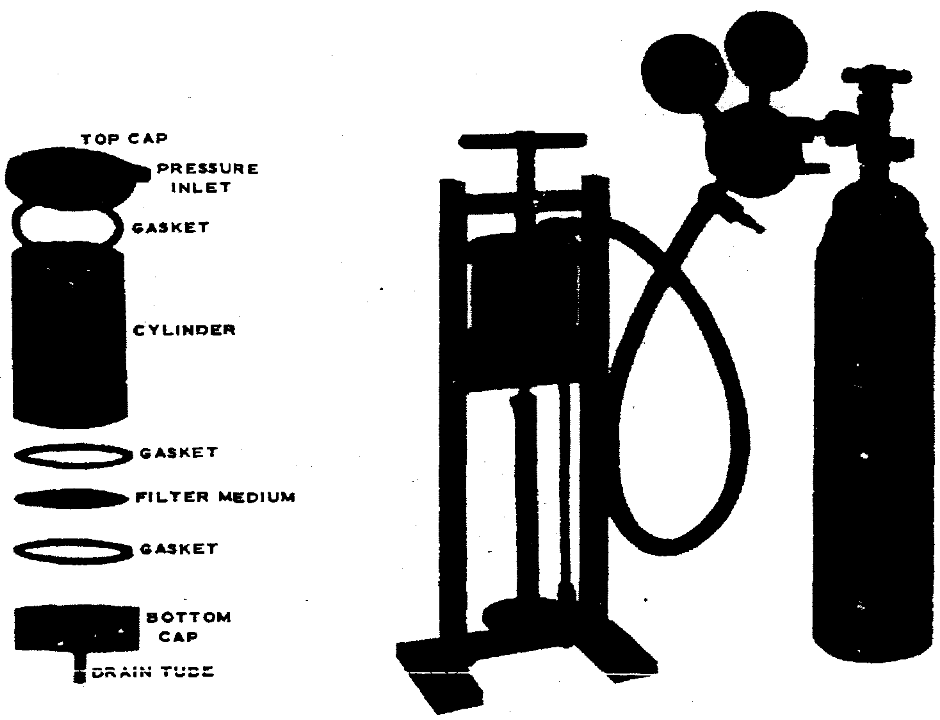

FIG. 3

TYPICAL FILTRATION TESTER

SECTION V

STRENGTH TESTS

NOTE: *Procedures are given for both compressive- and tensile-strength testing. However, comparative tests indicate that the results of tensile-strength tests do not reflect the effect of variation in age of specimens and in temperature of curing as well as do the results of compressive-strength tests.*

22. Apparatus. The following apparatus shall be used:

a. **Sieve:** 840 micron (No. 20) woven-wire cloth sieve, meeting requirements given in the latest edition of ASTM E 11: Specification for Sieves for Testing Purposes.

b. **Specimen Molds and Strength-Testing Machine:** Molds and testing machine for the tensile-strength test conforming to requirements in the latest edition of ASTM C 190: Method of Test for Tensile Strength of Hydraulic-Cement Mortars. Molds and testing machine for the compressive-strength test conforming to the requirements in the latest edition of ASTM C 109: Method of Test for Compressive Strength of Hydraulic-Cement Mortars.

c. **Base and Cover Plates:** Plate glass or non-corroding metal plates ¼-in. thick, approximately 4 in. wide, and 12 in. long.

d. **Water Curing Bath:** A curing bath or tank having dimensions suitable for the complete immersion in water of ASTM tensile or compressive molds and operable within ±3F of the prescribed test temperatures. The bath shall have a suitable agitator or circulating system to insure a uniform bath temperature. The two types of water curing bath are as follows:

   I. A non-pressure vessel suitable for curing specimens at temperatures of 180 F or less.

   II. A pressure vessel suitable for curing specimens at temperatures up to and including 350 F, and at pressures that can be controlled between 0 and 3,000 psi. The vessel shall have sufficient heating capacity to raise the temperature uniformly from 80 to 300 F in 100 min.

e. **Cooling Bath:** A bath in which the specimen to be cooled from the curing temperature, can be completely submerged in water maintained at 80 F, ±5 F.

f. **Thermometers:**

   I. Thermometer, range 0-220 F, with minimum scale divisions not exceeding 2 F, for use in non-pressure type vessels.

   II. Pyrometer or thermometer, range 0-400 F, with minimum scale divisions not exceeding 5 F, for use in pressure type vessels.

g. **Puddling Rod:** A glass puddling rod approximately 8 in. in length and ¼ in. in diameter.

h. **Cup Grease:** Cup grease, grade No. 2.

i. **Asphalt:** Asphalt for use in sealing specimen molds, having a softening point above 180 F.

Procedure

23. Preparation of Slurry and Molds. The cement slurry and molds used for strength-test specimens shall be prepared prior to placing the slurry in the mold as follows:

a. Slurry. The cement slurry shall be prepared in accordance with Sect. II.

b. **Molds.** The interior faces of the molds and the contact surface of the plates shall be thinly covered with cup grease. The contact surfaces of the halves of each mold shall also be coated with cup grease to make the joint water tight when assembled. Excess grease shall be removed from the interior faces of the assembled molds, and the molds placed on a thinly greased plate or sealed to the base plate with asphalt heated to a pouring consistency and applied to the exterior contact lines of the molds and base plates. In the event that cup grease is used, it is necessary that it be applied to the exterior contact line of the mold and the base plate.

24. Placing of Slurry in Molds. The slurry shall be placed in the prepared molds in a layer equal to one half of the mold depth, and the layer puddled 25 times per specimen with a puddling rod. The slurry shall be placed in all the specimen compartments before commencing the puddling operation. On completion of the puddling of the layer, the remaining slurry shall be stirred to eliminate segregation, after which the molds shall be filled to overflowing and puddled as for the first layer. After puddling, the excess slurry shall be struck off even with the top of the mold, using a straightedge. Specimens in molds which show evidence of leaking shall be discarded. A greased cover plate shall be placed on top of the mold.

25. Curing Periods. The curing period is the elapsed time from that of subjecting the specimen to temperature in the curing vessel to that of testing the specimen for strength.

a. For specimens cured at atmospheric pressure, the curing period starts when specimens are initially placed in the curing bath, immediately after slurry has been placed in the molds. The curing period ends when specimens are tested for strength.

b. For specimens cured at pressures above atmospheric, the curing period starts with the initial application of pressure and temperature, to be applied immediately after specimens are sealed in the curing vessel. The curing period ends when specimens are tested for strength.

c. The recommended curing periods for test specimens are 8, 12, 18, 24, 36, 48, and 72 hr. Tests at 8, 24, 48, and 72 hr are usually sufficient, but in some cases where "waiting on cement" time and further information are wanted, additional tests may be necessary.

Curing Temperatures and Pressures

26. For curing at atmospheric pressure at temperatures of 180 F or less, one or more of the following temperatures are recommended: 80, 100, 120, 140, 160, 180. For curing at pressures above atmospheric, at temperatures of 170 F, or less, one or more of the following schedules are recommended (see Table 4): 1S, 2S, 3S, 4S.

27. For curing at temperatures above 180 F one or more of the following schedules (see Table 4) are recommended: 5S, 5AS, 6S, 7S, 8S, 9S, 10S.

Curing Procedures

28. Curing at Atmospheric Pressure. For curing at atmospheric pressure the test specimens, immedi-

ately after being placed in molds and covered, shall be immersed in a water bath maintained at the curing temperature.

a. Where specimens are to be tested at ages of less than 24 hr, they shall be removed from the curing bath approximately 45 min before the age at which they are to be tested, immediately removed from their molds, and placed in a water bath maintained at 80 F ±5 F for approximately 35 min.

b. Where specimens are to be tested at ages of 24 hr or more, they shall be removed from the curing bath 20 to 23 hr after the cement slurry is initially mixed, immediately removed from their molds, and returned to the curing bath. They shall remain in the curing bath until approximately 45 min prior to the age at which they are to be tested, at which time they shall be transferred to a water bath and maintained at 80 F ±5 F for approximately 35 min.

29. **Curing at Pressures Above Atmospheric.** For curing pressures greater than atmospheric, the test specimens, immediately after molding and covering, shall be immersed in water at 80 F ±5 F in the pressure vessel. Heat and pressure shall be applied in accordance with the appropriate schedule as recommended in Par. 26 and 27 and in Table 2 of API Std 10A. The maximum scheduled temperature and pressure shall be maintained as shown in footnotes 1 and 2 of Table 4 until 1 hr and 45 min prior to the age at which the specimens are to be tested, at which time heating shall be discontinued. During the next 60 min the temperature shall be decreased to 200 F or less without release of the pressure other than that caused by thermal contraction. At 45 min prior to the age at which specimens are to be tested, the pressure then remaining shall be released gradually (to avoid damaging specimens) and the specimens then removed from molds, transferred to a water bath and maintained at 80 F for approximately 35 min.

30. **Testing of Specimens.** The testing of the specimens shall be carried out immediately after their removal from the cooling-bath water, the testing procedure to conform with the proper ASTM standard method as follows:

a. Cube specimens shall be tested in accordance with the latest edition of ASTM C 109: Method of Test for Compressive Strength of Hydraulic-Cement Mortars, Sect. 12 (b), 12 (c), 13, and 14, except that in the calculation of compressive strengths, variations from the specified cross-sectional area (4.00 sq in.) may be disregarded, provided deviations of $\frac{1}{16}$ in. or more from the specified nominal (cross-sectional) dimensions (2.00 in.) are reported.

b. Briquet specimens shall be tested in accordance with the latest edition of ASTM C 190: Method of Test for Tensile Strength of Hydraulic-Cement Mortars, Sect. 9 (b) and 10, except that in the calculation of tensile strength, variations from the specified cross-sectional area (1.00 sq in.) at the waistline may be disregarded, provided deviations of $\frac{1}{32}$ in. or more from the specified nominal dimensions (1.00 in.) are reported.

TABLE 4
WELL-SIMULATION TEST SCHEDULES FOR CURING STRENGTH SPECIMENS

1	2	3	4	5	6	7	8	9	10	11	12	13
			TEMPERATURE, deg. F.									
			Elapsed Time from First Application of Heat and Pressure, hr-min.									
Schedule Number	Depth, ft.	Pressure,[1] psi	0:30	0:45	1:00	1:15	1:30	2:00	2:30	3:00	3:30	[2]4:00
1S	1,000	800	80	81	82	83	84	86	88	90	92	95
2S	2,000	1,600	90	91	92	93	94	96	99	102	106	110
3S	4,000	3,000	100	105	109	113	117	121	125	130	135	140
4S	6,000	3,000	100	115	120	124	128	136	144	152	160	170
5S	8,000	3,000	105	115	125	135	140	150	165	175	190	200
5AS	9,000	3,000	105	120	130	140	145	160	175	185	200	215
6S	10,000	3,000	110	125	140	150	155	170	185	200	215	230
7S	12,000	3,000	115	135	155	175	185	200	215	230	245	260
8S	14,000	3,000	125	150	170	195	215	230	245	260	275	290
9S	16,000	3,000	135	165	190	220	245	260	275	290	305	320
10S	18,000	3,000	145	180	210	245	280	305	315	325	335	350

[1]The test pressure shall be applied as soon as specimens are placed in the pressure vessel and maintained at the given pressure within the following limits for the duration of the curing period:

Schedule 1S .... 800 psi ± 100 psi
Schedule 2S ....1600 psi ± 200 psi
Schedules 3S through 10S ....3000 psi ± 500 psi

[2]Final temperature (Col. 13) shall be maintained ± 3 F throughout the remainder of the curing period.

SECTION VI
SOUNDNESS AND FINENESS TESTS

31. Soundness Tests. Tests for soundness of oil-well cement should be made in accordance with the provisions of the testing procedure provided by the American Society for Testing Materials in the latest edition of ASTM C 151: Method of Test for Autoclave Expansion of Portland Cement.

32. Fineness Tests. Tests for fineness of oil-well cement should be made in accordance with the testing procedure provided by the American Society for Testing Materials in the latest edition of ASTM C 115: Method of Testing Fineness of Portland Cement by the Turbidimeter.

SECTION VII
THICKENING-TIME TESTS

NOTE: *Thickening-time tests are designed to determine the length of time a given cement slurry remains in a fluid state under given laboratory conditions, and thus serve as a method of comparing various cements. Following is a description of three recommended methods of test.*

PRESSURE-TEMPERATURE THICKENING-TIME TEST

33. Apparatus. The following apparatus should be used:

a. Thickening-time tester unit as developed by Pan American Petroleum Corp., formerly Stanolind Oil & Gas Co.* This apparatus consists essentially of a rotating cylindrical slurry container equipped with a stationary paddle assembly, all enclosed in a pressure chamber capable of withstanding the pressures and temperatures described herein. The space between the slurry container and the walls of the pressure container should be completely filled with white mineral oil, grade 95NF (National Formulary). A heating element capable of raising the temperature of this oil bath at the rate of at least 5 F per min is provided. Thermocouples are provided for determining the temperature of the oil bath and also that of the cement slurry. The slurry container is rotated at a speed of 50 rpm. The consistency of the cement slurry is indicated by the amount of deformation of a standardized coil spring connecting the stirring paddle and a stationary head. The stirring paddle and all metal parts of the slurry container exposed to the slurry are made of corrosion-resistant alloys.

b. Interval counter (stopwatch).

34. Calibration. The apparatus should be calibrated with Paratone calibration oil,** the viscosity of which is known over a range of 5 to 100 poises. The apparatus should be recalibrated at least once each year, also whenever wear of any metallic part in contact with the cement slurry becomes noticeable or when such part is replaced, and when the coil spring of the indicating mechanism is replaced. (Paratone should be discarded after use, because of possible contamination during the calibration test.) The thermocouples should be calibrated at frequent intervals to insure the accuracy of temperature measurements.

Procedure

35. Operating Instructions. Detailed operating instructions, as furnished by the manufacturer, are applicable under this method and should be followed. The apparatus should be at room temperature at the start of each test.

36. Filling of Apparatus. The slurry (prepared according to Sect. II) should be quickly poured into the slurry container. During this filling operation, the slurry should be lightly stirred to prevent segregation. When the slurry container is completely filled, the bottom should be screwed in, care being taken to insure that all air is excluded. The center plug should then be screwed in tightly, the container placed in the pressure chamber, and the chamber filled with the bath oil. Next, the head assembly of the pressure chamber should be screwed in place, the slurry container set to rotating, and the oil-pressure pump started. With the pump in operation, any air in the top of the chamber should be vented through the top vent. The operation of filling and sealing the slurry container, placing the container in the pressure chamber, sealing and venting the pressure chamber, and placing the apparatus in operation should be completed within 5 min after completion of the mixing period.

37. Temperature and Pressure Control. During the test period, the temperature of the cement slurry, determined with the thermocouple in position in the center of the slurry container, and the pressure in the slurry container, should be increased in accordance with the well-simulation schedules given herein.

38. Casing-Cementing Schedules. Well-simulation test procedures for casing cementing are given in Schedules 1 through 10. These schedules are designed to represent field practices in cementing wells having depths ranging from 1,000 to 18,000 ft, based on assumed conditions shown in Table 5, and on the mud-circulating pressures and bottom-hole temperatures shown in Fig. 6 and 7.

39. Squeeze-Cementing Schedules. Well-simulation test procedures for squeeze cementing are given in Schedules 12 through 20. These schedules are designed to represent field practices in squeeze cementing of wells having depths ranging from 1,000 to 16,000 ft. These schedules are based on the data shown in Table 6 and Fig. 6 and 7.

40. Temperature and Pressure Ranges. The thickening time for classes A, B, and C cement should be determined in accordance with Schedules 1 through 4 for casing-cementing simulation tests, and in accordance with Schedules 12 through 15 for squeeze-cementing simulation tests. The thickening time for classes N, D, E, and F cement should be determined in accordance with Schedules 4 through 9 for casing-cementing simulation tests, and in accordance with Schedules 15 through 20 for squeeze-cementing simulation tests. If only limited data are required it is not necessary to conduct tests in accordance with all of the above mentioned schedules.

41. Thickening Time. The elapsed time between the starting of the apparatus and the occurrence of a consistency of 100 poises should be reported as the thickening time for the cement under test for the particular schedule followed in the test. For the schedules involving the higher temperatures, it is permissible to stop the test at a consistency of approximately 70 poises; and, by plotting the results, to extrapolate to the 100-poise value.

42. Recording of Results. The results of the thickening-time tests should be recorded on forms similar to that shown on Fig. 4. The results should be reported in poises.

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*As illustrated in Fig. 8, 9, and 10 herein. Further information pertaining to the Pan American thickening-time tester may be obtained from Refinery Supply Co., Tulsa, Okla.

**Paratone calibration oil is obtainable in gallon lots from Refinery Supply Co., Tulsa, Okla. A certification will be furnished with each lot showing the viscosity-temperature relations (four points between 5-30 poises and four between 30-100 poises) as determined in a Precision Interchemical Rotational Viscometer at a constant shear rate of 60 rpm, by the Armour Research Foundation of Illinois Institute of Technology. It is recommended that any lot of oil not be used after two years from its date of certification.

API CEMENT EVALUATION TESTS

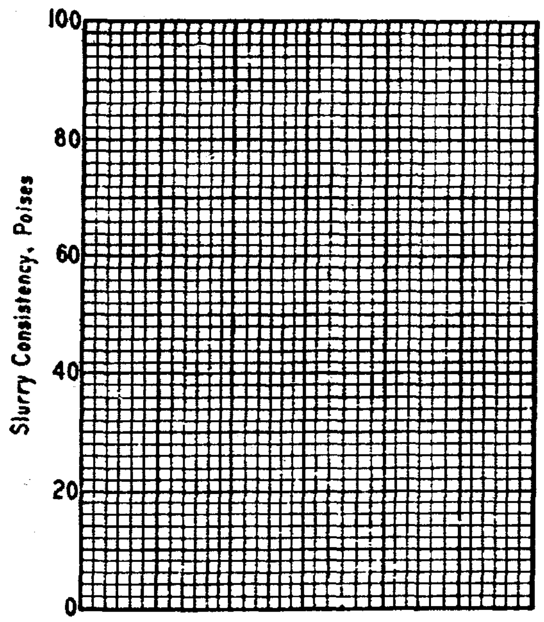
PAN AMERICAN[1] THICKENING-TIME TESTER

Brand..Source..

Class.................. Mixing Water, per cent.................................. Slurry Weight, lb. per gal. lb. per cu. ft. ....

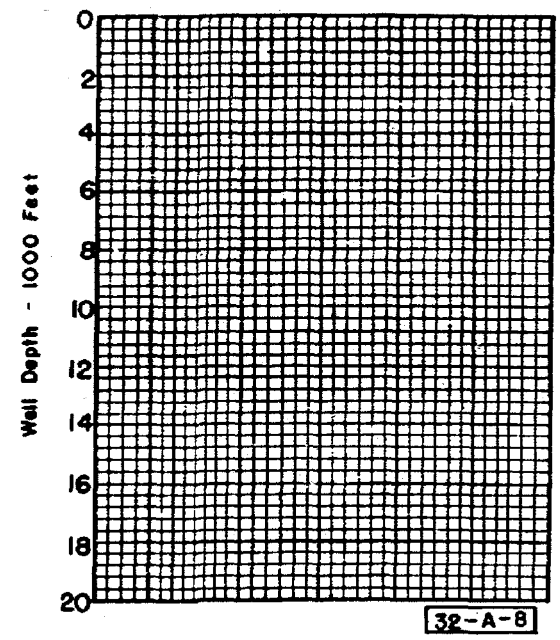
Tested by..Date Tested..

THICKENING TIME DATA



Time in Hours

SUMMARY OF THICKENING TIME DATA



Time in Hours

Bath Temp., deg. F., or Test Schedule	Compressive (1) and/or Tensile Strength (2), psi. Time cured under water, hr. 8		12		18		24		36		48		72	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)

Remarks:..

FIG. 4

FORM FOR REPORTING STRENGTH TESTS AND RESULTS OBTAINED FROM THICKENING-TIME TESTS ON THE PAN AMERICAN[1] THICKENING-TIME TESTER.

[1]Formerly Stanolind.

ATMOSPHERIC PRESSURE THICKENING-TIME TEST—A

43. **Apparatus.** The following apparatus should be used:

a. Thickening-time tester unit as developed by the Halliburton Oil Well Cementing Co.* This unit is furnished complete with motor, switches, thermo-regulator, base board, and carrying case.

b. Interval counter (stopwatch).

44. **Calibration.** The apparatus should be calibrated with Paratone calibration oil,** the viscosity of which is known over a range of 5 to 100 poises. The apparatus should be recalibrated at least once each year, also whenever wear of any metallic part in contact with cement slurry becomes noticeable or when such part is replaced. (Paratone should be discarded after use, because of possible contamination during the calibration test.)

Preparation of Apparatus

45. **Cleaning and Lubricating.** Care should be taken to insure that all surfaces which come in contact with the cement slurry are clean. After each test such surfaces (particularly the outside edges of the paddles) should be cleaned and brushed with a brass cement-mold brush. Surfaces which come in contact with the slurry should be given a thin coating of water-proof grease or light oil before each test. The ball bearings in the top of the cylinder and those in the torque-indicating mechanism should be kept clean by frequent washings in kerosine and should be oiled with a light grade of lubricating oil.

46. **Water Bath.** Water should always be used as the bath liquid. For this reason, all exposed steel parts should be kept clean and lightly oiled or greased. The water bath should always be filled with water before turning on the heater.

47. **Assembly.** The slurry container mechanism should be assembled and the paddle rotated by hand to insure that none of the parts scrape. The index of the torque-indicating mechanism should point to zero when the pendulum hangs free. If it does not, the quadrant scale should be adjusted.

Procedure

48. **Filling of Apparatus.** The slurry (prepared according to Sect. II) should be quickly poured into the slurry container to the proper fill level, which is indicated by the groove around the inside of the container. The paddle should then be inserted, the lid placed in position, and the slotted shaft engaged with the pin in the torque shaft in the lid. The assembly should then be placed in the bath, the gears engaged, and the torque-indicator cord passed around the torque drum and looped over the pin. Care should be taken to insure that the cord is properly aligned on the 1¾-in. drums of both the torque-indicator ring and the torque drum in order to preserve a constant radius of pull. The motor should then be started. The interval between the completion of mixing and the starting of the apparatus should not exceed 1 min.

49. **Temperature Ranges.** The thickening time for classes A, B, and C cement should be determined for temperature ranges of 80-100 F, 80-120 F, and 80-140 F; and the thickening time for classes N, D, E, and F cement for ranges of 80-140 F, 80-160 F, 80-180 F, and 80-200 F. If only limited data are required, it is not necessary to conduct tests at all of these temperature ranges.

50. **Temperature Control.** When testing slurries within the ranges of 80-100 F, 80-120 F, and 80-140 F, the rate of temperature increase should be 1 F per min. When testing within the ranges of 80-160 F, 80-180 F, and 80-200 F, the rate of increase should be 2 F per min. When the final temperature of the range is reached, that temperature should be maintained within ±1 F.

51. **Test Readings.** Readings of the torque-indicator scale should be taken at 10-min intervals for the first hour and at 30-min intervals thereafter, until the slurry starts to stiffen, when readings should be taken at 10-min intervals or at increments of 10 poises.

52. **Thickening Time.** The elapsed time between the initial starting of the apparatus and the occurrence of a consistency of 100 poises should be reported as the thickening time of the cement under test, for the particular temperature range. Under some test conditions, the slurry stiffens very rapidly; and in order to avoid difficulty in removing the thickened cement slurry, it may be advisable to stop the test when a consistency of approximately 70 poises is reached. In such cases, the data should be plotted and the curve extrapolated to the 100-poise value. If the slurry stiffens very slowly, the test may be stopped at the end of an 8-hr test period, and the results reported as "8+ hr."

53. **Recording of Results.** The results of the thickening-time tests should be recorded on a form similar to that shown in Fig. 5. The results should be reported in poises.

> NOTE: *In the operation of the apparatus, a moment is created which pulls the pendulum from the vertical position. This moment is a maximum when the pendulum is in a horizontal position. The quadrant scale behind the pendulum is graduated in ten equal increments of torque, and readings taken on this scale must be converted to poises, on the basis of the calibration chart.*

*As illustrated in Fig. 11, 12, 13 and 14 herein. Further information pertaining to the Halliburton thickening-time tester may be obtained from Halliburton Oil Well Cementing Co., Duncan, Okla.

**Paratone calibration oil is obtainable in gallon lots from Refinery Supply Co., Tulsa, Okla. A certification will be furnished with each lot showing the viscosity-temperature relation (four points between 5-30 poises and four between 30-100 poises) as determined in a Precision Interchemical Rotational Viscometer at a constant shear rate of 50 rpm, by the Armour Research Foundation of Illinois Institute of Technology. It is recommended that any lot of oil not be used after two years from its date of certification.

ATMOSPHERIC PRESSURE THICKENING-TIME TEST—B

54. Apparatus. The following apparatus should be used:

a. Thickening-time tester unit as developed by the Standard Oil Company of California*. The apparatus is mounted on a base and is furnished complete with motor, immersion heater, thermostat, pulleys, two V-belts, and two spring scales.

b. Interval counter (stopwatch).

55. **Calibration.** The torque-measuring spring scales (0 to 8 oz and 0 to 64 oz) should be calibrated frequently with dead weights.

Preparation of Apparatus

56. Accuracy. The apparatus should first be checked carefully to make certain that the paddles and slurry container are dimensionally accurate, that the outer paddles rotate freely about the stationary ones without play or wobble, that the torque measuring arm is $2\frac{13}{16}$ in. in length, and that the two spring scales are accurate.

57. **Cleaning and Lubricating.** Care should be taken to insure that all surfaces which come in contact with the cement slurry are clean. After each test such surfaces should be cleaned and brushed with a brass cement-mold brush. The following places should be well lubricated with water-proof grease before the start of each test: a, the bearing surface on the bottom of the slurry container which supports the container in the water bath; b, the inside of the bottom of the stationary paddle and the brass ring between this paddle and the movable paddle (sufficient grease should be used to prevent the slurry from entering the bearing); c, the top of the stationary paddle which is inserted into the revolving frame; and d, the threads between the container and the container bottom, in order to prevent loss of water to or from the cement slurry and to facilitate disassembly of the apparatus for cleaning after the test.

58. **Assembly.** After lubrication, the apparatus should be assembled in the water bath and rotated at the higher speed (60 rpm) to determine that none of the parts scrape. The spring scale may indicate a small torque at this speed. If so, this value should be recorded and subtracted from subsequent test readings. Care should be exercised that the water in the water bath covers the immersion heaters and is slightly above the height to which the slurry will fill the shell. Also, care should be taken to insure that the flexible chain which attaches to the spring scale does not touch the sides of the water bath, and that the direction of pull of the chain is tangential to the segment of the shell to which the chain is attached.

*As illustrated in Fig. 15 and 16 herein. Further information pertaining to the Standard of California thickening-time tester may be obtained from Cook Laboratories, Menlo Park, Calif.

Procedure

59. **Pretest Temperature.** Prior to testing, the apparatus should be heated to the desired pretest temperature (usually 80 F).

60. **Spring Scale.** The spring scale with the range of 0 to 8 oz should be used at the start of the test and until the pull reaches 8 oz, at which time it should be replaced with the scale with the range of 0 to 64 oz.

61. **Filling of Apparatus.** The slurry (prepared according to Sect. II) should be quickly poured into the slurry container of the apparatus. A funnel may be used to facilitate this transfer. The cement should fill the slurry container to the proper height which is indicated by a mark 1¼ in. from the top of the container. The time for filling the slurry container and placing the apparatus in operation should not exceed 1 min.

62. **Testing Speeds.** The apparatus should then be started at the higher speed (approximately 60 rpm), and the test continued at this speed for 15 min, after which the speed should be reduced to 14.5 rpm by placing the V-belt on the larger pulley. It is important that this speed be held within ±0.2 rpm since variations in speed affect the thickening time considerably.

63. **Temperature Ranges.** The thickening time for classes A, B, and C cement should be determined for temperature ranges of 80-100 F, 80-120 F, and 80-140 F; and the thickening time for classes N, D, E, and F cement for ranges of 80-140 F, 80-160 F, 80-180 F, and 80-200 F. If only limited data are required, it is not necessary to conduct tests at all of these temperature ranges.

64. **Temperature Control.** When testing slurries within the ranges of 80-100 F, 80-120 F, and 80-140 F the rate of temperature increase should be 1 F per min. When testing within the ranges of 80-160 F, 80-180 F, and 80-200 F, the rate of increase should be 2 F per min. When the final temperature of the range is reached, that temperature should be maintained within ±1 F.

65. **Test Readings.** Minimum readings of the pull exerted by the slurry should be taken at 10-min intervals, starting when the test apparatus is started at the higher speed. Also, readings should be taken immediately before and after the speed is changed.

66. **Thickening Time.** The elapsed time between the initial starting of the apparatus and the occurrence of a consistency of 40 oz should be reported as the thickening time of the cement under test.

67. **Recording of Results.** The results of the thickening-time tests should be recorded on a form simiiar to that shown in Fig. 5. The results should be reported in ounces.

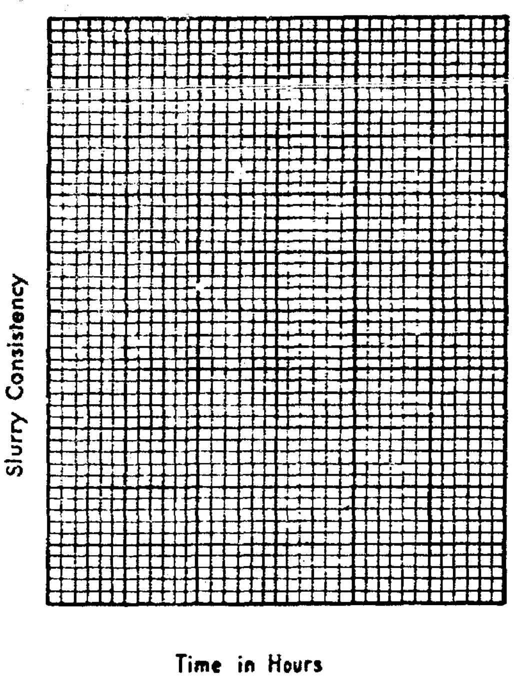
API CEMENT EVALUATION TESTS
........................THICKENING-TIME TESTER

Brand..Source..

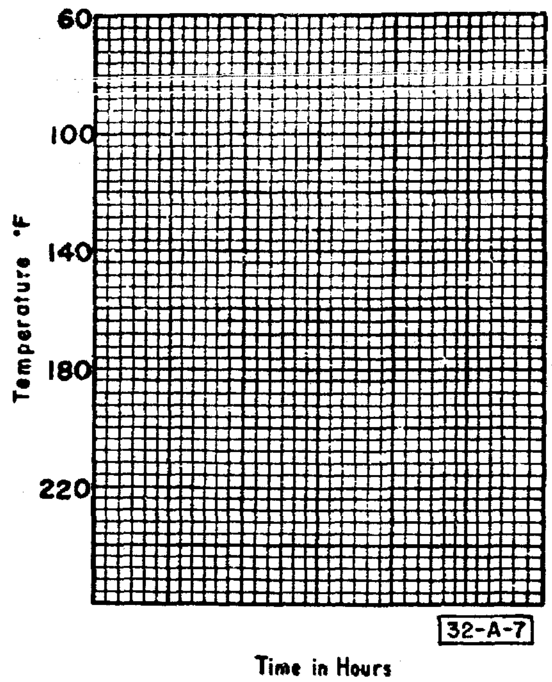
Class..........................Mixing Water, per cent.......................Slurry Weight, lb. per gal......................... lb. per cu. ft.

Tested by..Date Tested..

THICKENING TIME DATA



SUMMARY OF THICKENING TIME DATA



Bath Temp., deg. F., or Test Schedule	Compressive (1) and/or Tensile Strenth (2), psi. — Time cured under water, hr.													
	8		12		18		24		36		48		72	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

Remarks:..

....

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FIG. 5

FORM FOR REPORTING STRENGTH TESTS AND RESULTS OBTAINED FROM THICKENING-TIME TESTS ON THE HALLIBURTON OR STANDARD OF CALIFORNIA THICKENING-TIME TESTER.

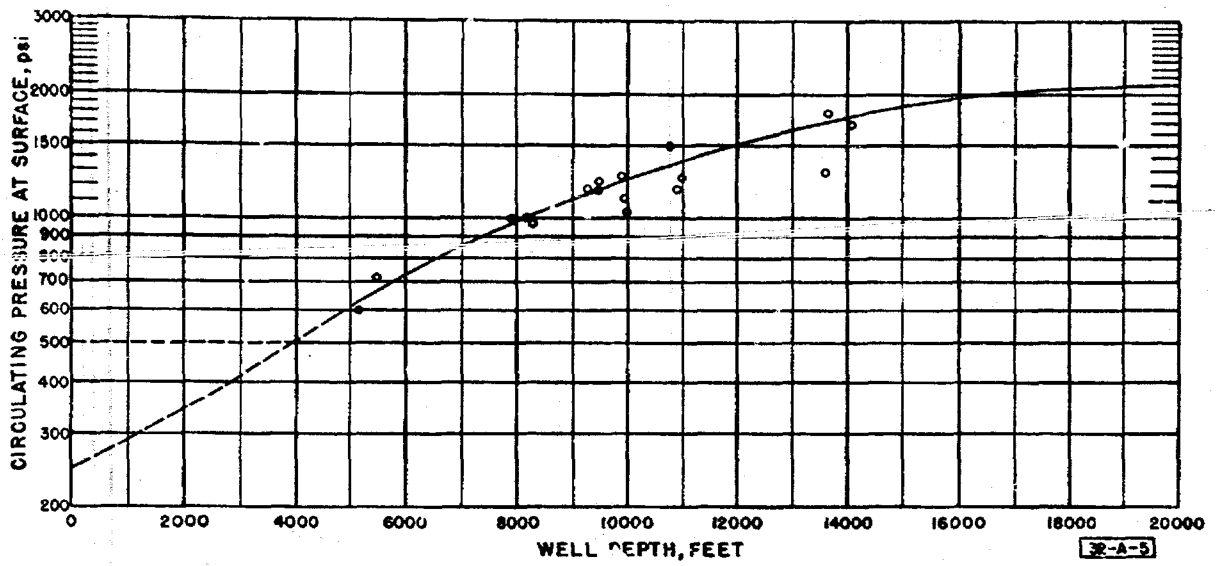


FIG. 6

AVERAGE MUD-CIRCULATING PRESSURES

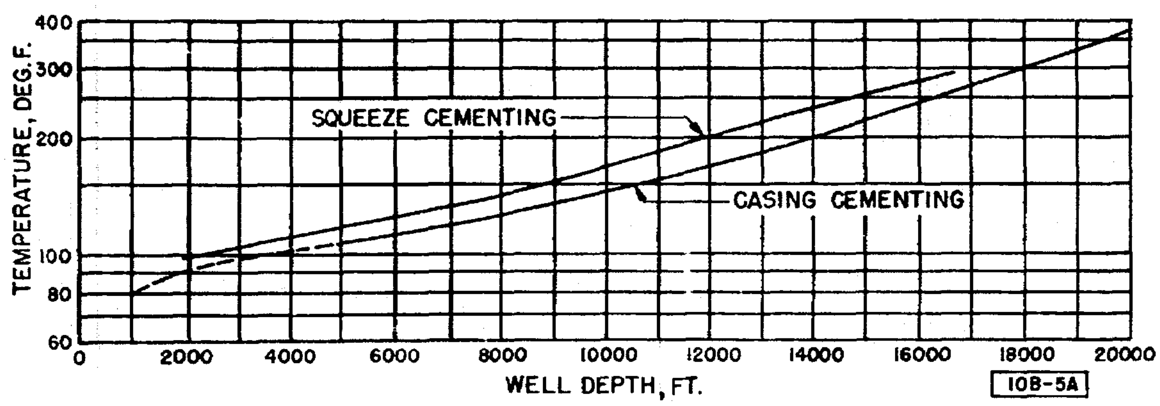


FIG. 7

BOTTOM-HOLE CASING-CEMENTING AND SQUEEZE-CEMENTING TEMPERATURES

TABLE 5
BASIS FOR CASING-CEMENTING WELL-SIMULATION TEST SCHEDULES

1	2	3		4	5	6	7
		Mud-Weight,					
Schedule No.	Depth, ft.	lb. per gal.	lb. per cu. ft.[1]	Surface Pressure, psi[2]	Bottom-Hole Circulating Temperature, deg. F.[3]	Bottom-Hole Pressure, psi[4]	Total Cementing Time, min.[5]
	......	....	......	....	....	......	....
1	1,000	10	74.8	500	80	1,020	23
2	2,000	10	74.8	500	91	1,540	27
3	4,000	10	74.8	500	103	2,580	37
4	6,000	10	74.8	750	113	3,870	46
5	8,000	10	74.8	1,000	125	5,160	55
5A	9,000	11	82.3	1,120	135	6,270	60
6	10,000	12	89.8	1,250	144	7,480	65
7	12,000	14	104.7	1,500	172	10,230	74
8	14,000	16	119.7	1,750	206	13,390	84
9	16,000	17	127.2	2,000	248	16,140	91
10	18,000	18	134.6	2,000	300	18,800	100

[1]Mud weights obtained from a review of field data.

[2]Surface pressure obtained from a review of field data.

[3]Bottom-hole circulating temperatures averaged from actual field tests run at various depths.

[4]Bottom-hole pressures calculated from surface pressures and mud weights.

[5]Total cementing time calculated from the following assumed conditions:

Casing size: 7-in. outside diameter

Size of job: 300 sacks of cement

Pumping rate: 50 cu ft per min

TABLE 6
BASIS FOR SQUEEZE-CEMENTING WELL-SIMULATION TEST SCHEDULES

1	2	3		4	5	6	7
		Mud-Weight,					
Schedule No.	Depth, ft.	lb. per gal.	lb. per cu. ft.[1]	Surface Pressure, psi[2]	Bottom-Hole Circulating Temperature, deg. F.[3]	Bottom-Hole Pressure, psi[4]	Total Cementing Time, min.[5]
12	1,000	10	74.8	500	89	3,300	29
13	2,000	10	74.8	500	98	4,200	31
14	4,000	10	74.8	500	116	4,600	35
15	6,000	10	74.8	800	136	6,700	40
16	8,000	10	74.8	1,000	159	7,800	45
16A	9,000	11	82.3	1,200	171	8,500	47
17	10,000	12	89.8	1,300	186	9,400	49
18	12,000	14	104.7	1,500	213	11,800	50
19	14,000	16	119.7	1,800	242	14,000	55
20	16,000	17	127.2	2,000	271	16,500	60

[1]Mud weights obtained from a review of field data.

[2]Surface pressure obtained from a review of field data.

[3]Bottom-hole circulating temperatures averaged from actual field tests run at various depths.

[4]Bottom-hole pressures calculated from surface pressures and mud weights.

[5]Total cementing time calculated from the following assumed conditions:

Tubing size: 2½ in.

Size of job: 100 sacks of cement

Pumping rate: 14.0 cu ft per min displacing; 14.0 cu ft to 1.4 cu ft per min squeezing

SCHEDULE 1

1000-ft CASING-CEMENTING WELL-SIMULATION TEST

Field Conditions Assumed

Surface temperature:	80 F
Surface pressure:	500 psi
Size of job:	300 sacks
Mud weight:	10 lb per gal
	74.8 lb per cu ft
Bottom-hole temperature:	80 F
Bottom-hole pressure:	1020 psi
Mixing time:	18 min
Total cementing time:	23 min

Time, min.	Pressure, psi	Temperature, deg. F.
0	500	80
2	550	80
4	590	80
6	640	80
8	680	80
10	730	80
12	780	80
14	820	80
16	870	80
18	910	80
20	960	80
22	1010	80
23	1020	80

Final temperature and pressure should be held constant to completion of test, within ±2 F and ±10 psi respectively.

SCHEDULE 2

2000-ft CASING-CEMENTING WELL-SIMULATION TEST

Field Conditions Assumed

Surface temperature:	80 F
Surface pressure:	500 psi
Size of job:	300 sacks
Mud weight:	10 lb per gal
	74.8 lb per cu ft
Bottom-hole temperature:	81 F
Bottom-hole pressure:	1540 psi
Mixing time:	18 min
Total cementing time:	27 min

Time, min.	Pressure, psi	Temperature, deg. F.
0	500	80
2	580	81
4	650	82
6	730	82
8	810	83
10	890	84
12	960	85
14	1040	86
16	1120	86
18	1190	87
20	1270	88
22	1350	89
24	1420	90
26	1500	90
27	1540	91

Final temperature and pressure should be held constant to completion of test, within ±2 F and ±10 psi respectively.

SCHEDULE 3

4000-ft. CASING-CEMENTING WELL-SIMULATION TEST

Field Conditions Assumed

Surface temperature:	80 F
Surface pressure:	500 psi
Size of job:	300 sacks
Mud weight:	10 lb per gal
	74.8 lb per cu ft
Bottom-hole temperature:	103 F
Bottom-hole pressure:	2580 psi
Mixing time:	18 min
Total cementing time:	37 min

Time, min.	Pressure, psi	Temperature, deg. F.
0	500	80
2	610	81
4	730	82
6	840	84
8	960	85
10	1070	86
12	1180	88
14	1300	89
16	1410	90
18	1530	91
20	1640	92
22	1750	94
24	1870	95
26	1980	96
28	2100	98
30	2210	99
32	2320	100
34	2440	101
36	2550	102
37	2580	103

Final temperature and pressure should be held constant to completion of test, within ±2 F and ±10 psi respectively.

SCHEDULE 4
6000-ft CASING-CEMENTING
WELL-SIMULATION TEST

Field Conditions Assumed

Surface temperature:	80 F
Surface pressure:	750 psi
Size of job:	300 sacks
Mud weight:	10 lb per gal
	74.8 lb per cu ft
Bottom-hole temperature:	113 F
Bottom-hole pressure:	3870 psi
Mixing time:	18 min
Total cementing time:	46 min

Time min.	Pressure, psi	Temperature, deg. F.
0	750	80
2	890	81
4	1020	83
6	1160	84
8	1290	86
10	1420	87
12	1560	89
14	1700	90
16	1830	91
18	1970	93
20	2100	94
22	2230	96
24	2370	97
26	2500	99
28	2640	100
30	2780	101
32	2910	103
34	3040	104
36	3180	106
38	3310	107
40	3450	109
42	3590	110
44	3720	111
46	3870	113

Final temperature and pressure should be held constant to completion of test, within ±2 F and ±10 psi respectively.

SCHEDULE 5
8000-ft CASING-CEMENTING
WELL-SIMULATION TEST

Field Conditions Assumed

Surface temperature:	80 F
Surface pressure:	1000 psi
Size of job:	300 sacks
Mud weight:	10 lb per gal
	74.8 lb per cu ft
Bottom-hole temperature:	125 F
Bottom-hole pressure:	5160 psi
Mixing time:	18 min
Total cementing time:	55 min

Time min.	Pressure, psi	Temperature, deg. F.
0	1000	80
2	1150	82
4	1300	83
6	1450	85
8	1600	87
10	1750	88
12	1900	90
14	2050	91
16	2200	93
18	2350	95
20	2500	96
22	2650	98
24	2800	100
26	2950	101
28	3100	103
30	3250	104
32	3400	106
34	3550	108
36	3700	109
38	3850	111
40	4000	112
42	4150	114
44	4300	116
46	4450	117
48	4600	119
50	4750	121
52	4900	122
54	5050	124
55	5160	125

Final temperature and pressure should be held constant to completion of test, within ±2 F and ±10 psi respectively.

SCHEDULE 5A

9,000-ft CASING-CEMENTING WELL-SIMULATION TEST

Field Conditions Assumed

Surface temperature:	80 F
Surface pressure:	1120 psi
Size of job:	300 sacks
Mud weight:	11 lb per gal
	82.3 lb per cu ft
Bottom-hole temperature:	135 F
Bottom-hole pressure:	6270 psi
Mixing time:	18 min
Total cementing time:	60 min

Time, min.	Pressure, psi	Temperature, deg. F.
0	1120	80
2	1290	82
4	1460	84
6	1640	85
8	1810	87
10	1980	89
12	2150	91
14	2320	93
16	2500	95
18	2670	96
20	2840	98
22	3010	100
24	3180	102
26	3350	104
28	3520	106
30	3700	107
32	3870	109
34	4030	111
36	4210	113
38	4380	115
40	4550	117
42	4730	118
44	4900	120
46	5070	122
48	5240	124
50	5410	126
52	5580	128
54	5760	129
56	5930	131
58	6100	133
60	6270	135

Final temperature and pressure should be held constant to completion of test, within ±2 F and ±10 psi respectively.

SCHEDULE 6

10,000-ft CASING-CEMENTING WELL-SIMULATION TEST

Field Conditions Assumed

Surface temperature:	80 F
Surface pressure:	1250 psi
Size of job:	300 sacks
Mud weight:	12 lb per gal
	89.8 lb per cu ft
Bottom-hole temperature:	144 F
Bottom-hole pressure:	7480 psi
Mixing time:	18 min
Total cementing time:	65 min

Time, min.	Pressure, psi	Temperature, deg. F.
0	1250	80
2	1440	82
4	1630	84
6	1830	86
8	2020	88
10	2210	90
12	2400	92
14	2590	94
16	2790	96
18	2980	98
20	3170	100
22	3360	102
24	3550	104
26	3750	106
28	3940	108
30	4130	110
32	4320	111
34	4510	113
36	4710	115
38	4900	117
40	5090	119
42	5280	121
44	5470	123
46	5670	125
48	5860	127
50	6050	129
52	6250	131
54	6440	133
56	6630	135
58	6930	137
60	7020	139
62	7210	141
64	7400	143
65	7480	144

Final temperature and pressure should be held constant to completion of test, within ±2 F and ±10 psi respectively.

SCHEDULE 7
12,000-ft CASING-CEMENTING WELL-SIMULATION TEST

Field Conditions Assumed

Surface temperature:	80 F
Surface pressure:	1500 psi
Size of job:	300 sacks
Mud weight:	14 lb per gal 104.7 lb per cu ft
Bottom-hole temperature:	172 F
Bottom-hole pressure:	10,230 psi
Mixing time:	18 min
Total cementing time:	74 min

Time, min.	Pressure, psi	Temperature, deg. F.
0	1,500	80
2	1,740	82
4	1,970	85
6	2,210	87
8	2,440	90
10	2,680	92
12	2,910	95
14	3,140	97
16	3,380	100
18	3,610	102
20	3,850	105
22	4,080	107
24	4,320	110
26	4,560	112
28	4,790	115
30	5,020	117
32	5,260	120
34	5,490	122
36	5,730	125
38	5,970	127
40	6,200	130
42	6,430	132
44	6,670	135
46	6,910	137
48	7,140	140
50	7,380	142
52	7,610	144
54	7,850	147
56	8,090	149
58	8,320	152
60	8,560	154
62	8,790	157
64	9,030	159
66	9,270	162
68	9,500	164
70	9,740	167
72	9,970	169
74	10,230	172

Final temperature and pressure should be held constant to completion of test, within ±2 F and ±10 psi respectively.

SCHEDULE 8
14,000-ft CASING-CEMENTING WELL-SIMULATION TEST

Field Conditions Assumed

Surface temperature:	80 F
Surface pressure:	1750 psi
Size of job:	300 sacks
Mud weight:	16 lb per gal 119.7 lb per cu ft
Bottom-hole temperature:	206 F
Bottom-hole pressure:	13,390 psi
Mixing time:	18 min
Total cementing time:	84 min

Time, min.	Pressure, psi	Temperature, deg. F.
0	1,750	80
2	2,030	83
4	2,310	86
6	2,580	89
8	2,860	92
10	3,140	95
12	3,420	98
14	3,700	101
16	3,970	104
18	4,250	107
20	4,530	110
22	4,810	113
24	5,090	116
26	5,370	119
28	5,650	122
30	5,920	125
32	6,200	128
34	6,480	131
36	6,760	134
38	7,040	137
40	7,320	140
42	7,600	143
44	7,880	146
46	8,160	149
48	8,440	152
50	8,710	155
52	8,990	158
54	9,270	161
56	9,550	164
58	9,830	167
60	10,110	170
62	10,390	173
64	10,670	176
66	10,950	179
68	11,230	182
70	11,500	185
72	11,780	188
74	12,060	191
76	12,340	194
78	12,620	197
80	12,900	200
82	13,180	203
84	13,390	206

Final temperature and pressure should be held constant to completion of test, within ±2 F and ±10 psi respectively.

SCHEDULE 9
16,000-ft CASING-CEMENTING
WELL-SIMULATION TEST

Field Conditions Assumed

Surface temperature:	80 F
Surface pressure:	2000 psi
Size of job:	300 sacks
Mud weight:	17 lb per gal
	127.2 lb per cu ft
Bottom-hole temperature:	248 F
Bottom-hole pressure:	16,140 psi
Mixing time:	18 min
Total cementing time:	91 min

Time, min.	Pressure, psi	Temperature, deg. F.
0	2,000	80
2	2,310	84
4	2,620	87
6	2,930	91
8	3,240	95
10	3,550	99
12	3,860	102
14	4,170	106
16	4,480	110
18	4,790	113
20	5,100	117
22	5,410	121
24	5,720	124
26	6,030	128
28	6,340	132
30	6,650	135
32	6,960	139
34	7,270	143
36	7,580	147
38	7,890	150
40	8,200	154
42	8,510	158
44	8,820	161
46	9,130	165
48	9,440	169
50	9,750	172
52	10,060	176
54	10,370	180
56	10,680	183
58	10,990	187
60	11,300	191
62	11,610	194
64	11,920	198
66	12,230	202
68	12,540	206
70	12,850	209
72	13,160	213
74	13,470	217
76	13,780	220
78	14,090	224
80	14,400	228
82	14,710	231
84	15,020	235
86	15,330	239
88	15,640	243
90	15,950	246
91	16,140	248

Final temperature and pressure should be held constant to completion of test, within ±2 F and ±10 psi respectively.

SCHEDULE 10
18,000-ft CASING-CEMENTING
WELL-SIMULATION TEST

Field Conditions Assumed

Surface temperature:	80 F
Surface pressure:	8000 psi
Size of job:	300 sacks
Mud weight:	18 lb per gal
	134.6 lb per cu ft
Bottom-hole temperature:	300 F
Bottom-hole pressure:	18,800 psi
Mixing time:	18 min
Total cementing time:	100 min

Time, min.	Pressure, psi	Temperature, deg. F.
0	2,000	80
2	2,340	84
4	2,670	89
6	3,010	93
8	3,340	98
10	3,680	102
12	4,020	106
14	4,350	111
16	4,690	115
18	5,020	120
20	5,360	124
22	5,700	128
24	6,030	133
26	6,370	137
28	6,700	142
30	7,040	146
32	7,380	150
34	7,710	155
36	8,050	159
38	8,380	164
40	8,720	168
42	9,060	172
44	9,390	177
46	9,730	181
48	10,060	186
50	10,400	190
52	10,740	194
54	11,070	199
56	11,410	203
58	11,740	208
60	12,080	212
62	12,420	216
64	12,750	221
66	13,090	225
68	13,420	230
70	13,760	234
72	14,100	238
74	14,430	243
76	14,770	247
78	15,100	252
80	15,440	256
82	15,780	260
84	16,110	265
86	16,450	269
88	16,780	274
90	17,120	278
92	17,460	282
94	17,790	287
96	18,130	291
98	18,460	296
100	18,800	300

Final temperature and pressure should be held constant to completion of test, within ±2 F and ±10 psi respectively.

NOTE: Data for Schedule 11, "20,000-ft Casing-Cementing Well-Simulation Test" has not yet been developed.

SCHEDULE 12
1000-ft SQUEEZE-CEMENTING WELL-SIMULATION TEST

Field Conditions Assumed

Surface temperature:	80 F
Surface pressure:	500 psi
Size of job:	100 sacks
Mud weight:	10 lb per gal
	74.8 lb per cu ft
Bottom-hole temperature:	89 F
Bottom-hole pressure:*	3300 psi
Mixing time:	8 min
Total cementing time:	29 min

Time, min.	Pressure, psi	Temperature, deg. F.
0	500	80
1	900	83
2	1200	86
3	1300	89
4	1300	89
25	1300	89
26	1300	89
27	2300	89
28	2800	89
29	3300	89

Final temperature and pressure should be held constant to completion of test, within ±2 F and ±10 psi respectively.

SCHEDULE 13
2000-ft SQUEEZE-CEMENTING WELL-SIMULATION TEST

Field Conditions Assumed

Surface temperature:	80 F
Surface pressure:	500 psi
Size of job:	100 sacks
Mud weight:	10 lb per gal
	74.8 lb per cu ft
Bottom-hole temperature:	98 F
Bottom-hole pressure:*	4200 psi
Mixing time:	8 min
Total cementing time:	31 min

Time, min.	Pressure, psi	Temperature, deg. F.
0	500	80
1	900	84
2	1200	87
3	1600	91
4	1900	94
5	2300	98
6	2300	98
27	2300	98
28	2800	98
29	3300	98
30	3300	98
31	4200	98

Final temperature and pressure should be held constant to completion of test, within ±2 F and ±10 psi respectively.

*Bottom-hole pressure is the final squeeze pressure and is equal to the calculated static pressure plus 2500 psi surface pressure.

SCHEDULE 14
4000-ft SQUEEZE-CEMENTING WELL-SIMULATION TEST

Field Conditions Assumed

Surface temperature:	80 F
Surface pressure:	500 psi
Size of job:	100 sacks
Mud weight:	10 lb per gal
	74.8 lb per cu ft
Bottom-hole temperature:	116 F
Bottom-hole pressure:*	5600 psi
Mixing time:	8 min
Total cementing time:	35 min

Time, min.	Pressure, psi	Temperature, deg. F.
0	500	80
1	900	84
2	1200	88
3	1600	92
4	1900	96
5	2300	100
6	2700	104
7	3000	108
8	3400	112
9	3600	116
10	3600	116
31	3600	116
32	4100	116
33	4600	116
34	5100	116
35	5600	116

Final temperature and pressure should be held constant to completion of test, within ±2 F and ±10 psi respectively.

SCHEDULE 15
6000-ft SQUEEZE-CEMENTING WELL-SIMULATION TEST

Field Conditions Assumed

Surface temperature:	80 F
Surface pressure:	800 psi
Size of job:	100 sacks
Mud weight:	10 lb per gal
	74.8 lb per cu ft
Bottom-hole temperature:	136 F
Bottom-hole pressure:*	6700 psi
Mixing time:	8 min
Total cementing time:	40 min

Time, min.	Pressure, psi	Temperature, deg. F.
0	800	80
1	1200	84
2	1500	88
3	1900	92
4	2200	96
5	2600	100
6	3000	104
7	3300	108
8	3700	112
9	3900	116
10	4100	120
11	4300	124
12	4600	128
13	4800	132
14	5000	136
15	5000	136
36	5000	136
37	5400	136
38	5900	136
39	6300	136
40	6700	136

Final temperature and pressure should be held constant to completion of test, within ±2 F and ±10 psi respectively.

SCHEDULE 16
8000-ft SQUEEZE-CEMENTING WELL-SIMULATION TEST

Field Conditions Assumed

Surface temperature:	80 F
Surface pressure:	1000 psi
Size of job:	100 sacks
Mud weight:	10 lb per gal
	74.8 lb per cu ft
Bottom-hole temperature:	159 F
Bottom-hole pressure:*	7800 psi
Mixing time:	8 min
Total cementing time:	45 min

Time, min.	Pressure, psi	Temperature, deg. F.
0	1000	80
1	1400	84
2	1700	88
3	2100	93
4	2400	97
5	2800	101
6	3200	105
7	3500	109
8	3900	114
9	4100	118
10	4300	122
11	4500	126
12	4800	131
13	5000	135
14	5200	139
15	5400	143
16	5600	148
17	5900	152
18	6100	156
19	6300	159
20	6300	159
41	6300	159
42	6600	159
43	7000	159
44	7400	159
45	7800	159

Final temperature and pressure should be held constant to completion of test, within ±2 F and ±10 psi respectively.

*Bottom-hole pressure is the final squeeze pressure and is equal to the calculated static pressure plus 2500 psi surface pressure.

SCHEDULE 16A
9000-ft SQUEEZE-CEMENTING WELL-SIMULATION TEST

Field Conditions Assumed

Surface temperature:	80 F
Surface pressure:	1200 psi
Size of job:	100 sacks
Mud weight:	11 lb per gal
	82.3 lb per cu ft
Bottom-hole temperature:	171 F
Bottom-hole pressure:*	8500 psi
Mixing time:	8 min
Total cementing time:	47 min

Time, min.	Pressure, psi	Temperature, deg. F.
0	1200	80
1	1500	84
2	1800	89
3	2100	93
4	2300	97
5	2600	102
6	2900	106
7	3200	110
8	3500	115
9	3800	119
10	4100	123
11	4300	128
12	4600	132
13	4900	136
14	5200	141
15	5500	145
16	5800	149
17	6100	154
18	6300	158
19	6600	162
20	6900	167
21	7200	171
43	7200	171
44	7500	171
45	7900	171
46	8200	171
47	8500	171

Final temperature and pressure should be held constant to completion of test, within ±2 F and ±10 psi respectively.

SCHEDULE 17
10,000-ft SQUEEZE-CEMENTING WELL-SIMULATION TEST

Field Conditions Assumed

Surface temperature:	80 F
Surface pressure:	1300 psi
Size of job:	100 sacks
Mud weight:	12 lb per gal
	89.8 lb per cu ft
Bottom-hole temperature:	186 F
Bottom-hole pressure:*	9400 psi
Mixing time:	8 min
Total cementing time:	49 min

Time, min.	Pressure, psi	Temperature, deg. F.
0	1300	80
1	1700	85
2	2000	89
3	2400	94
4	2700	98
5	3100	103
6	3500	108
7	3800	112
8	4200	117
9	4500	121
10	4700	126
11	5000	131
12	5300	135
13	5500	140
14	5800	144
15	6100	149
16	6300	154
17	6600	158
18	6900	163
19	7200	167
20	7400	172
21	7700	177
22	8000	181
23	8200	186
24	8200	186
45	8200	186
46	8500	186
47	8800	186
48	9100	186
49	9400	186

Final temperature and pressure should be held constant to completion of test, within ±2 F and ±10 psi respectively.

SCHEDULE 18
12,000-ft SQUEEZE-CEMENTING WELL-SIMULATION TEST

Field Conditions Assumed

Surface temperature:	80 F
Surface pressure:	1500 psi
Size of job:	100 sacks
Mud weight:	14 lb per gal
	104.7 lb per cu ft
Bottom-hole temperature:	213 F
Bottom-hole pressure:*	11,800 psi
Mixing time:	8 min
Total cementing time:	50 min

Time, min.	Pressure, psi	Temperature, deg. F.
0	1,500	80
1	1,900	85
2	2,200	90
3	2,600	94
4	2,900	99
5	3,300	104
6	3,700	109
7	4,000	113
8	4,400	118
9	4,700	123
10	5,000	128
11	5,300	132
12	5,700	137
13	6,100	142
14	6,400	147
15	6,700	151
16	7,000	156
17	7,300	161
18	7,600	166
19	8,000	170
20	8,300	175
21	8,600	180
22	8,900	184
23	9,200	189
24	9,500	194
25	9,800	199
26	10,200	203
27	10,500	208
28	10,800	213
29	10,800	213
46	10,800	213
47	11,000	213
48	11,200	213
49	11,500	213
50	11,800	213

Final temperature and pressure should be held constant to completion of test, within ±2 F and ±10 psi respectively.

*Bottom-hole pressure is the final squeeze pressure and is equal to the calculated static pressure plus 2500 psi surface pressure.

SCHEDULE 19

14,000-ft SQUEEZE-CEMENTING WELL-SIMULATION TEST

Field Conditions Assumed

Surface temperature:	80 F
Surface pressure:	1800 psi
Size of job:	100 sacks
Mud weight:	16 lb per gal
	119.7 lb per cu ft
Bottom-hole temperature:	242 F
Bottom-hole pressure:*	14,000 psi
Mixing time:	8 min
Total cementing time:	55 min

Time, min.	Pressure, psi	Temperature, deg. F.
0	1,800	80
1	2,200	85
2	2,500	90
3	2,900	95
4	3,200	100
5	3,600	105
6	4,000	110
7	4,300	115
8	4,700	120
9	5,000	125
10	5,400	130
11	5,800	135
12	6,100	140
13	6,500	145
14	6,800	150
15	7,200	155
16	7,600	160
17	7,900	165
18	8,300	170
19	8,600	175
20	9,000	180
21	9,400	185
22	9,700	190
23	10,100	195
24	10,400	200
25	10,800	205
26	11,200	210
27	11,500	215
28	11,900	220
29	12,200	225
30	12,600	231
31	13,000	237
32	13,300	242
33	13,300	242
51	13,300	242
52	13,500	242
53	13,700	242
54	13,900	242
55	14,000	242

Final temperature and pressure should be held constant to completion of test, within ±2 F and ±10 psi respectively.

SCHEDULE 20

16,000-ft SQUEEZE-CEMENTING WELL-SIMULATION TEST

Field Conditions Assumed

Surface temperature:	80 F
Surface pressure:	2000 psi
Size of job:	100 sacks
Mud weight:	17 lb per gal
	127.2 lb per cu ft
Bottom-hole temperature:	271 F
Bottom-hole pressure:*	16,500 psi
Mixing time:	8 min
Total cementing time:	60 min

Time, min.	Pressure, psi	Temperature, deg. F.
0	2,000	80
1	2,400	85
2	2,700	90
3	3,100	95
4	3,400	100
5	3,800	106
6	4,200	111
7	4,500	116
8	4,900	121
9	5,300	126
10	5,600	131
11	6,000	136
12	6,400	141
13	6,800	146
14	7,200	151
15	7,600	157
16	7,900	162
17	8,300	167
18	8,700	172
19	9,100	177
20	9,500	182
21	9,800	187
22	10,200	192
23	10,600	197
24	11,000	202
25	11,400	208
26	11,300	213
27	12,100	218
28	12,500	223
29	12,900	228
30	13,300	233
31	13,700	238
32	14,000	243
33	14,400	248
34	14,800	253
35	15,200	259
36	15,600	265
37	16,000	271
38	16,000	271
56	16,000	271
57	16,100	271
58	16,200	271
59	16,300	271
60	16,500	271

Final temperature and pressure should be held constant to completion of test, within ±2 F and ±10 psi respectively.

*Bottom-hole pressure is the final squeeze pressure and is equal to the calculated static pressure plus 2500 psi surface pressure.

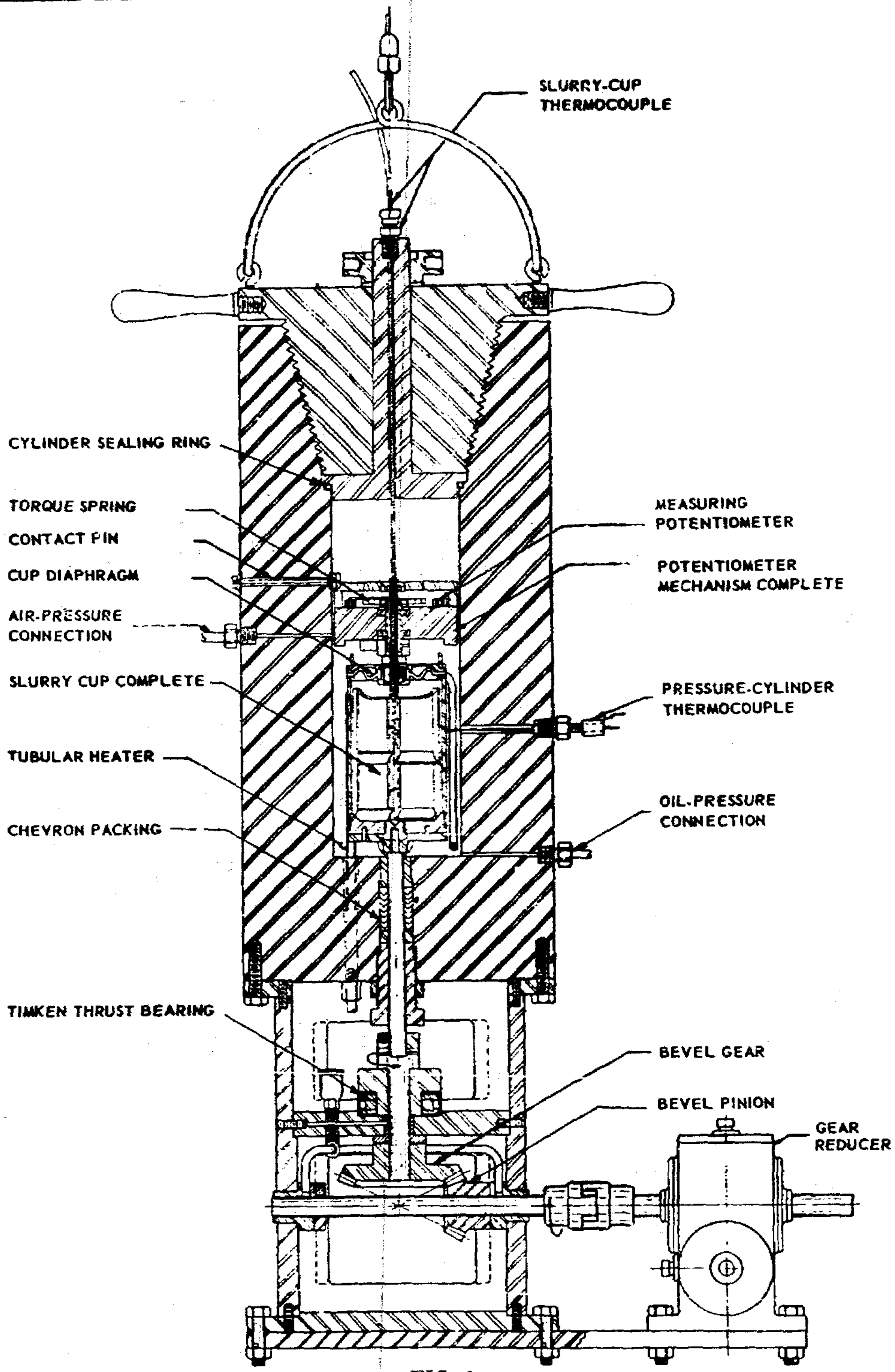


FIG. 8
ASSEMBLY
PAN AMERICAN[1] THICKENING-TIME TESTER

[1]Formerly Stanolind.

NOTES:

1. MATERIAL: STAINLESS STEEL EXCEPT DIAPHRAGM HUB.
2. CONTAINER PRESSURE: 20,000 PSI.
3. HEAT RATE: 5 DEG. F. PER MIN.

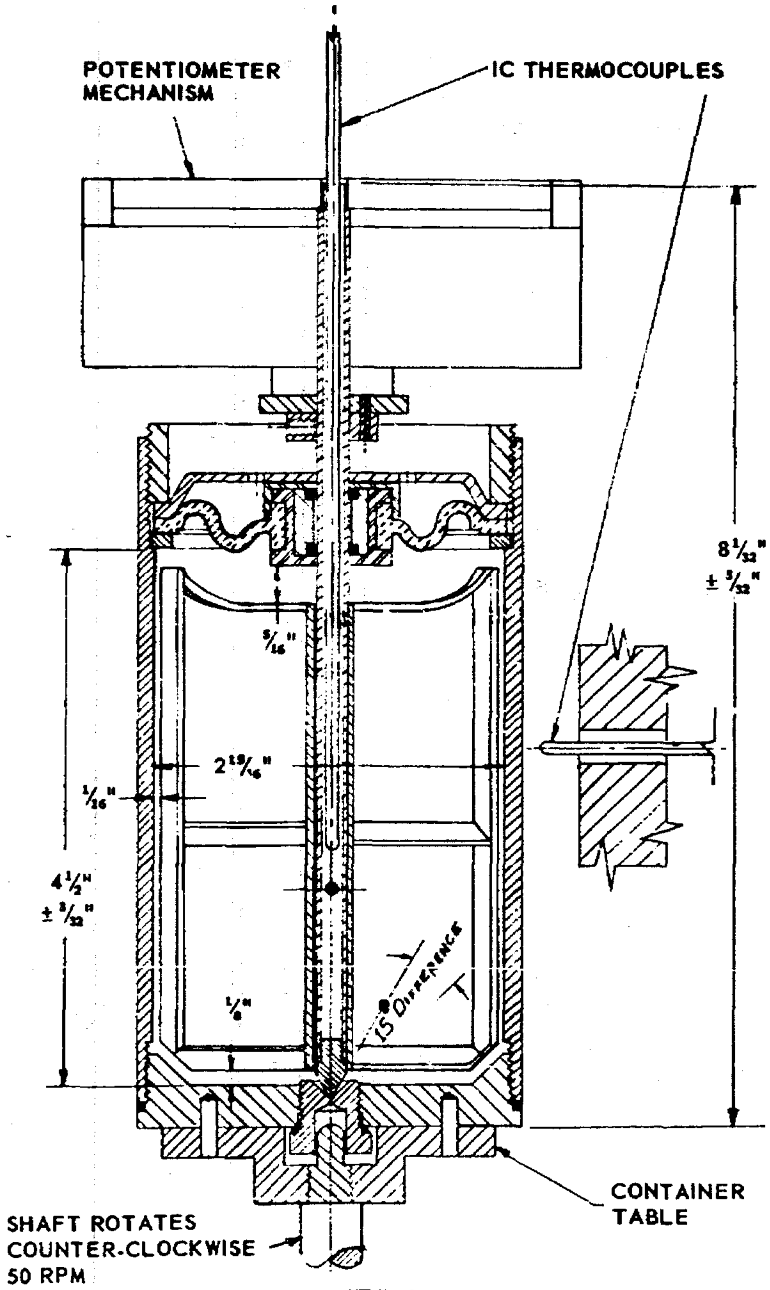


FIG. 9

SLURRY CONTAINER

PAN AMERICAN[1] THICKENING-TIME TESTER

[1]Formerly Stanolind.

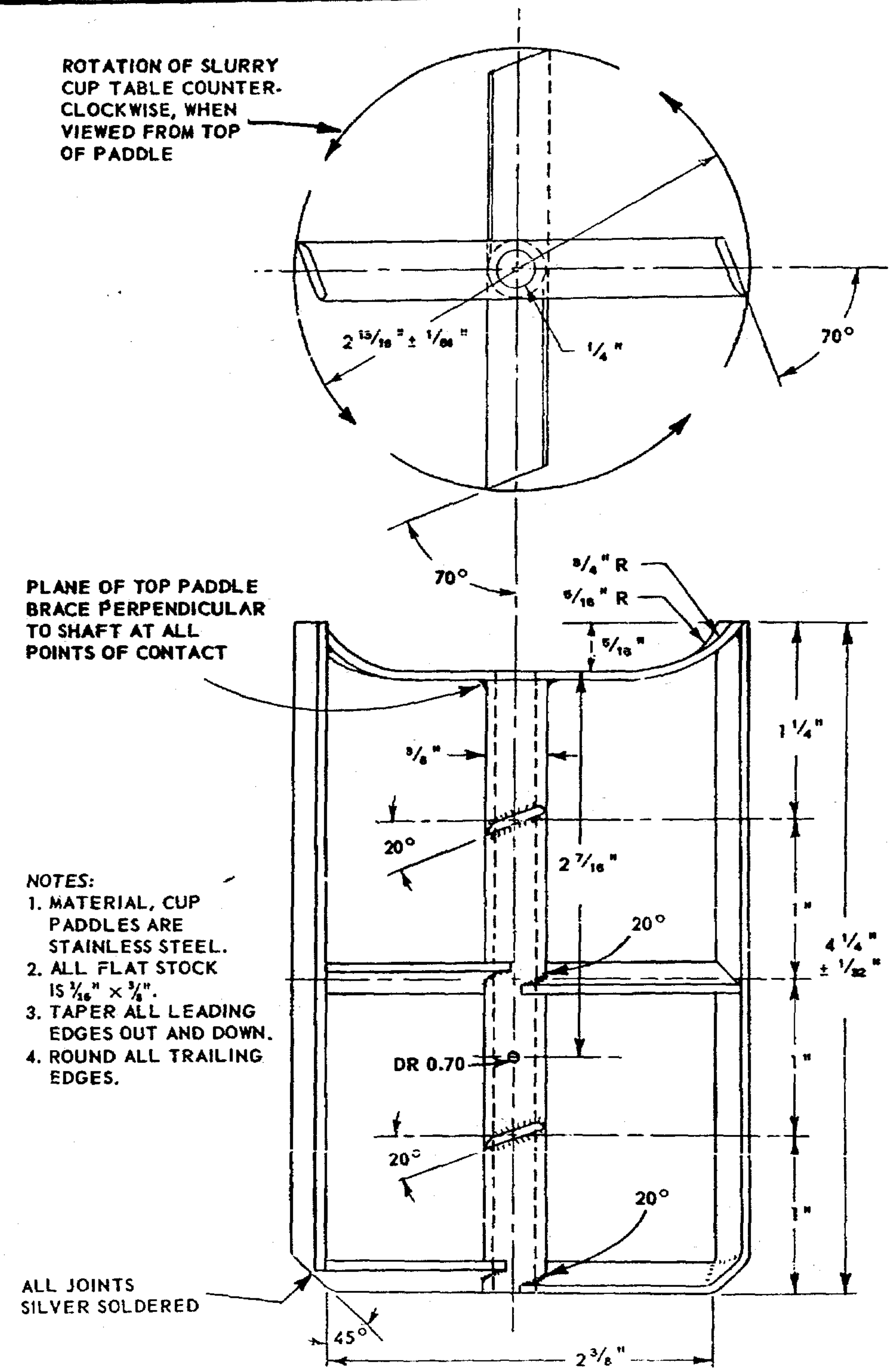


FIG. 10
PADDLE
PAN AMERICAN[1] THICKENING-TIME TESTER

[1]Formerly Stanolind.

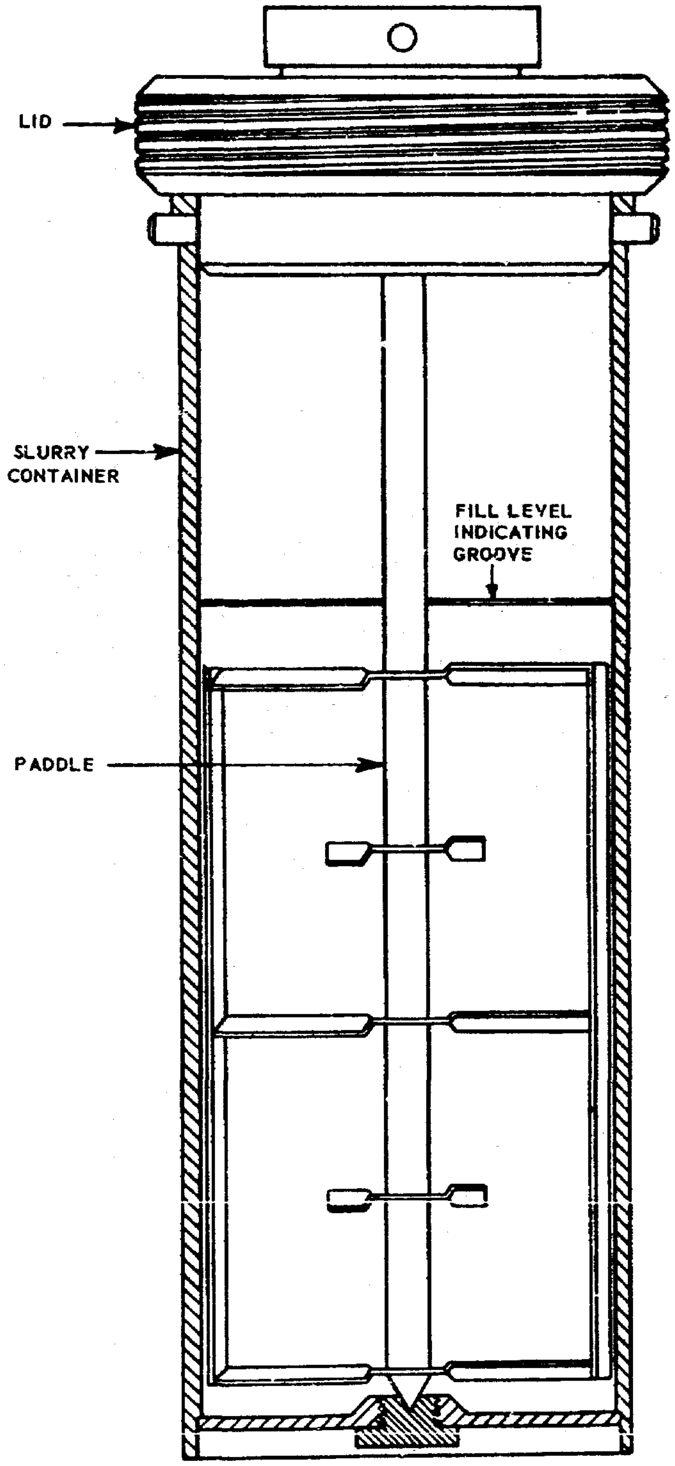


FIG. 11
ASSEMBLY
HALLIBURTON THICKENING-TIME TESTER

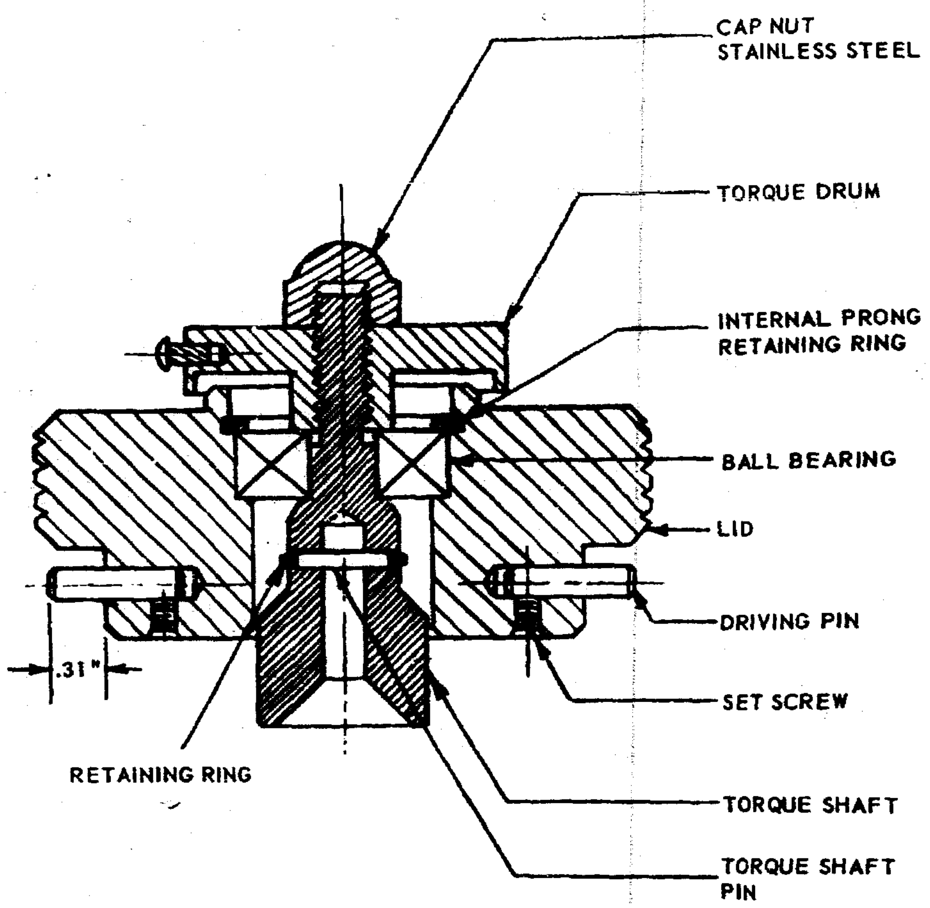


FIG. 12
SLURRY CONTAINER LID
HALLIBURTON THICKENING-TIME TESTER

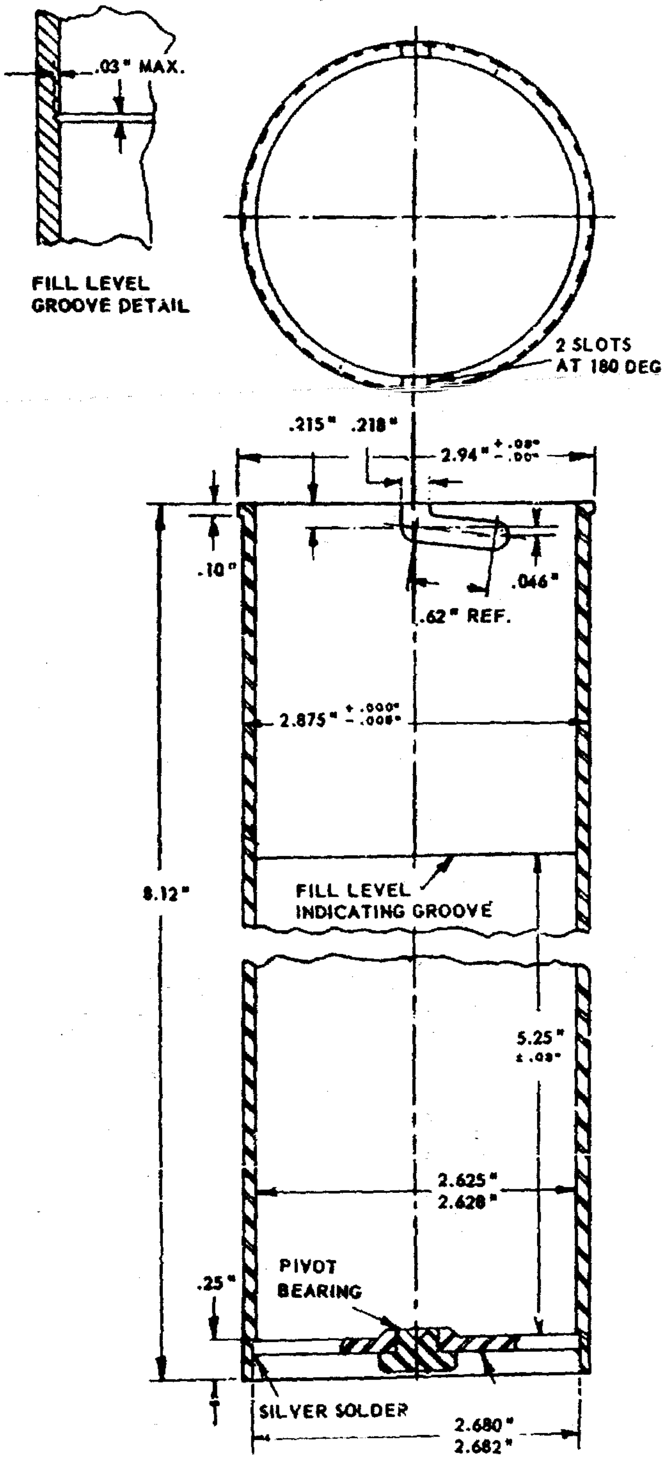


FIG. 13
SLURRY CONTAINER
HALLIBURTON THICKENING-TIME TESTER

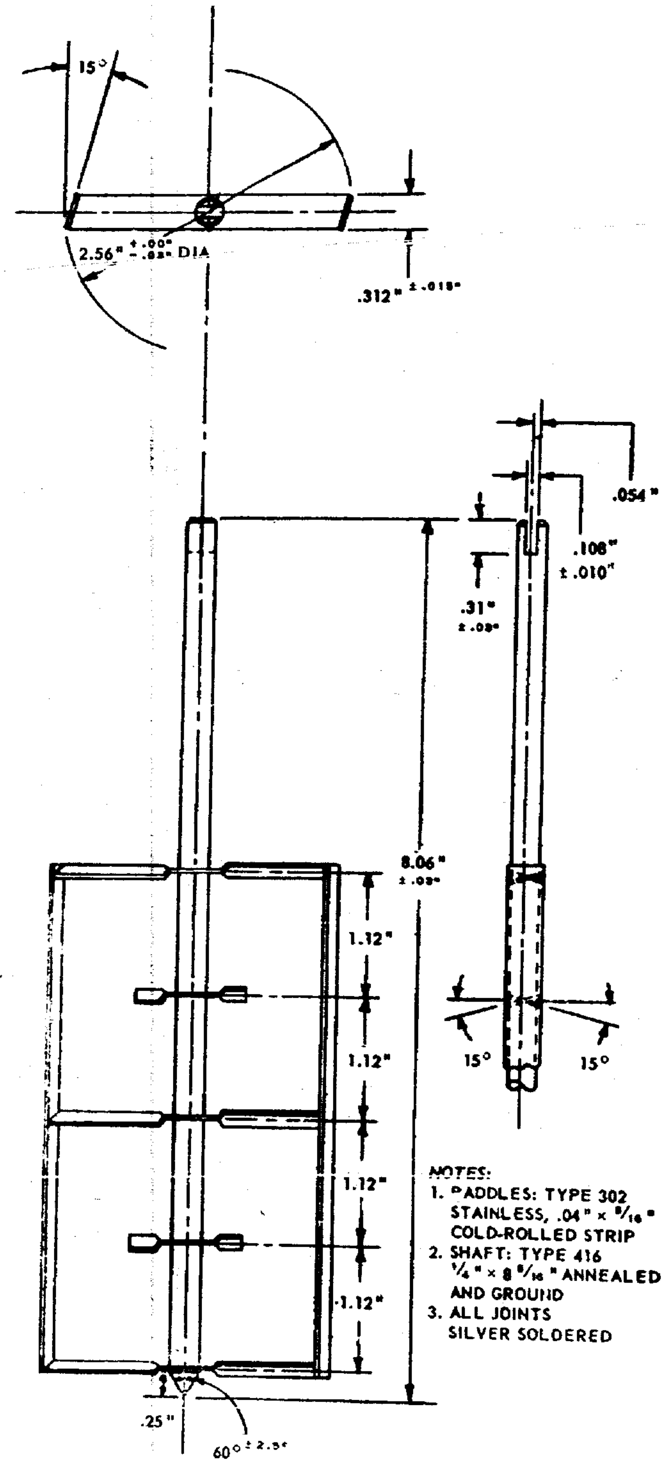


FIG. 14
PADDLE
HALLIBURTON THICKENING-TIME TESTER

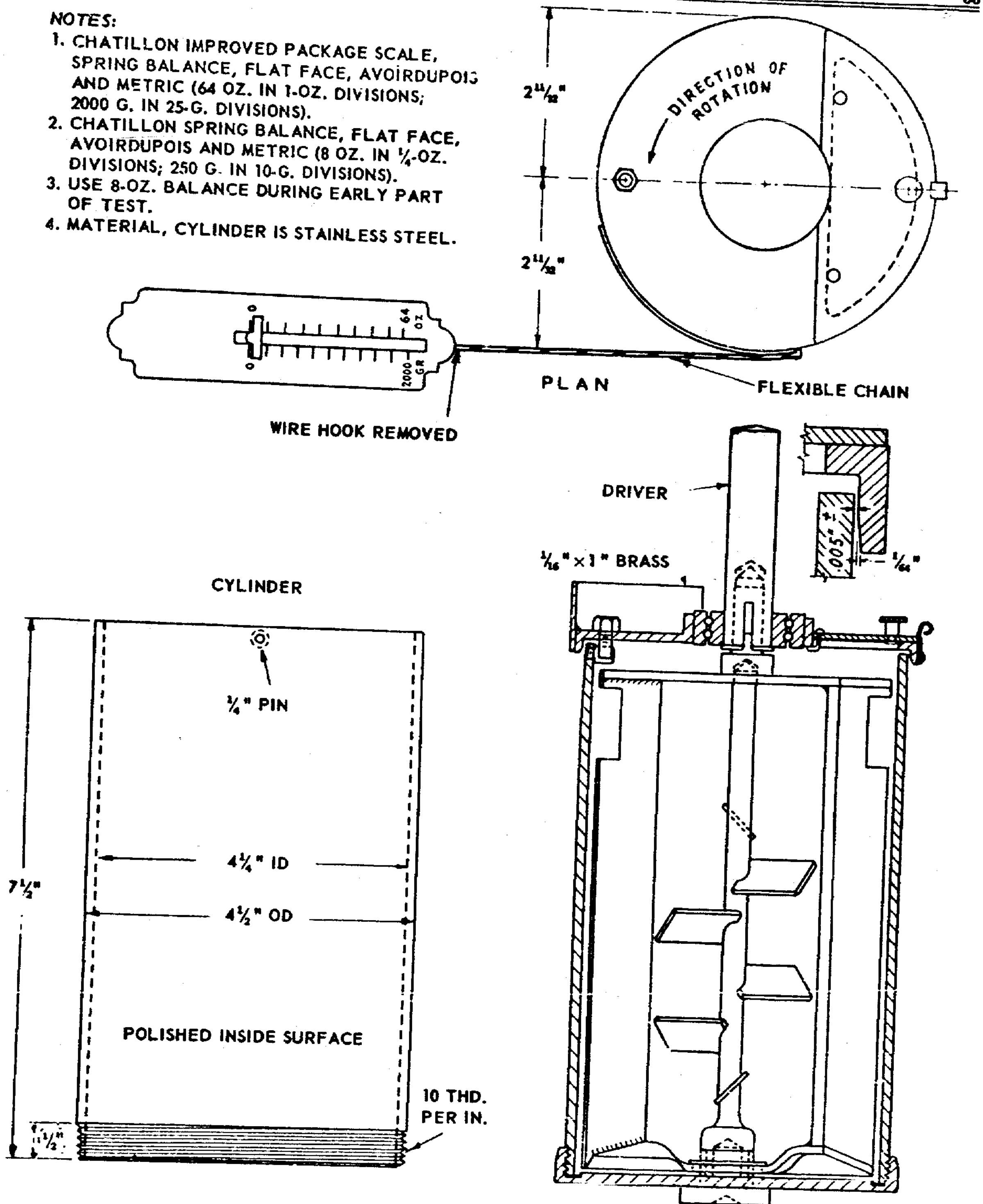
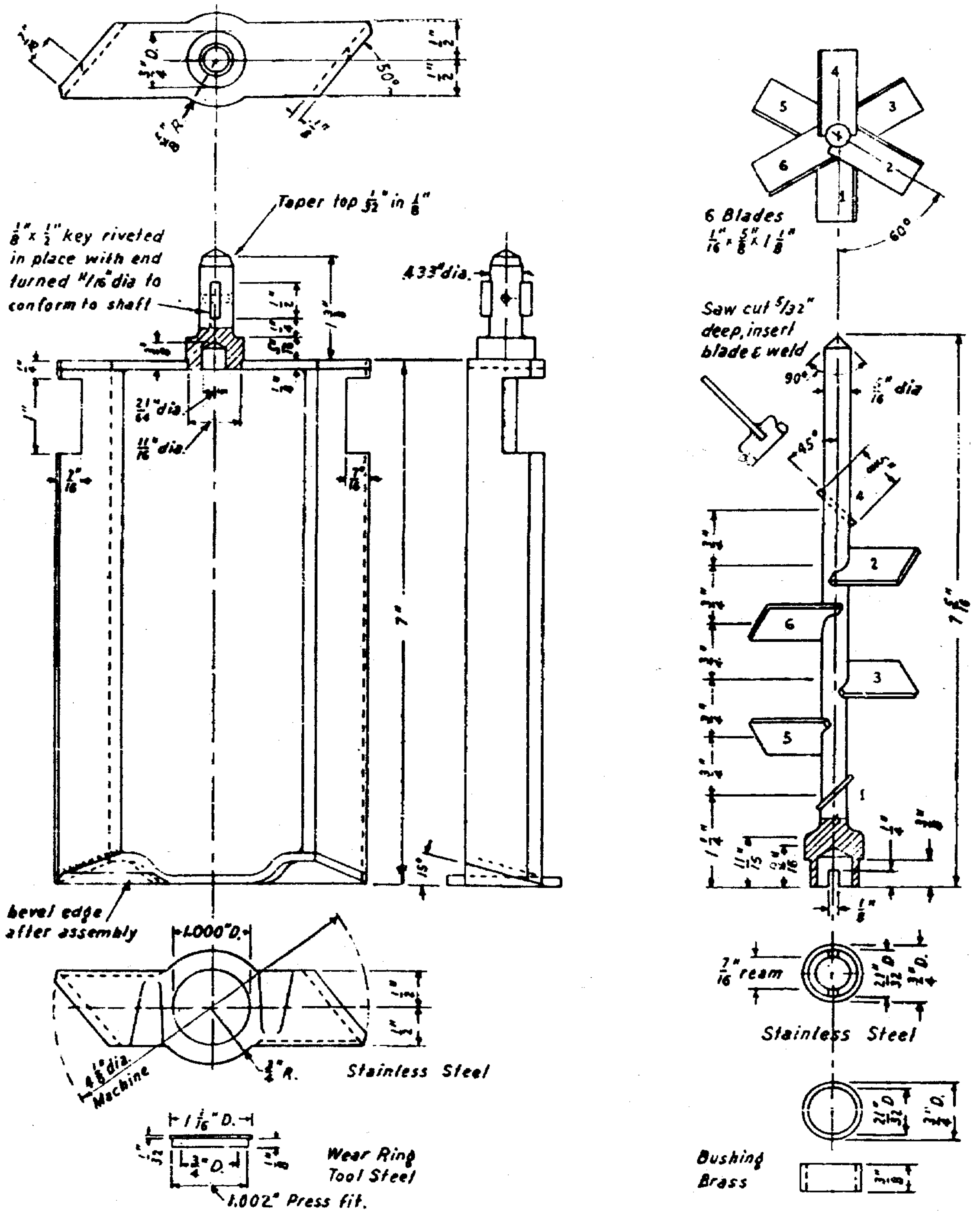


FIG. 15
ASSEMBLY
STANDARD OIL COMPANY OF CALIFORNIA THICKENING-TIME TESTER



MOVING PADDLE

STATIONARY PADDLE

FIG. 16
PADDLES
STANDARD OIL COMPANY OF CALIFORNIA THICKENING-TIME TESTER

BEFORE THE OIL CONSERVATION COMMISSION
OF THE STATE OF NEW MEXICO

IN THE MATTER OF THE HEARING
CALLED BY THE OIL CONSERVATION
COMMISSION OF THE STATE OF NEW
MEXICO FOR THE PURPOSE OF
CONSIDERING:

CASE NO. 1369
Order No. R-1173

IN THE MATTER OF THE HEARING
CALLED ON THE MOTION OF THE
OIL CONSERVATION COMMISSION AT
THE REQUEST OF ATLANTIC REFINING
COMPANY TO REVISE RULE 107 OF THE
COMMISSION RULES AND REGULATIONS
PERTAINING TO CASING, TUBING, AND
CEMENTING REQUIREMENTS.

ORDER OF THE COMMISSION

BY THE COMMISSION:

This cause came on for hearing at 9 o'clock a.m. on January 15, 1958, and again on February 13, 1958, at Santa Fe, New Mexico, before the Oil Conservation Commission, hereinafter referred to as the "Commission."

NOW, on this 5th day of May, 1958, the Commission, a quorum being present, having considered the testimony and evidence adduced, and being fully advised in the premises,

FINDS:

(1) That due public notice having been given as required by law, the Commission has jurisdiction of this cause and the subject matter thereof.

(2) That Rule 107 of the Commission Rules and Regulations should be revised since advances in technology and equipment within the last several years make certain changes desirable.

IT IS THEREFORE ORDERED:

That effective June 1, 1958, Rule 107 of the Commission Rules and Regulations be and the same is hereby revised to read as follows:

RULE 107 - CASING AND TUBING REQUIREMENTS

(a) All wells drilled for oil or natural gas shall be completed with a string of casing which shall be properly cemented at a sufficient depth to protect adequately the oil or natural gas bearing strata to be produced. In addition thereto, such other casing and cement shall be used as necessary in order to seal off all oil, gas, and water strata which may be encountered in the well, except the interval(s) to be produced.

Case No. 1369
Order No. R-1173

Sufficient cement shall be used on surface casing to fill the annular space back of the casing to the top of the hole, provided however, that authorized field personnel of the Commission may, at their discretion, allow deviations from the foregoing requirement when known conditions in a given area render the same impracticable.

All cementing shall be by pump and plug method unless some other method is expressly authorized by the Commission.

All casing strings shall be tested and proved satisfactory as provided in paragraph (c) below.

(b) After cementing, but before commencing tests required in paragraph (c) below, all casing strings shall stand cemented in accordance with Option 1 or Option 2 below. Regardless of which option is taken, the casing shall remain stationary and under pressure for at least eight hours after the cement has been placed. Casing shall be considered to be "under pressure" if some acceptable means of holding pressure is used or if one or more float valves are employed to hold the cement in place.

Option 1. Allow all casing strings to stand cemented a minimum of eighteen (18) hours prior to commencing tests. Operators using this option shall report on Form C-103 the actual time the cement was in place before initiating tests.

Option 2. (May be used in the Counties of San Juan, Rio Arriba, McKinley, Sandoval, Lea, Eddy, Chaves, and Roosevelt only.) Allow all casing strings to stand cemented until the cement has reached a compressive strength of at least 500 pounds per square inch in the "zone of interest" before commencing tests, provided however, that no tests shall be commenced until the cement has been in place for at least eight (8) hours.

The "zone of interest" for surface and intermediate casing strings shall be the bottom 20 percent of the casing string, but shall be no more than 1000 feet nor less than 300 feet of the bottom part of the casing unless the casing is set at less than 300 feet. The "zone of interest" for production casing strings shall include the interval or intervals where immediate completion is contemplated.

To determine that a minimum compressive strength of 500 pounds per square inch has been attained, operators shall use the typical performance data for the particular cement mix used in the well, at the minimum temperature indicated for the zone of interest by Figure 107-A, Temperature Gradient Curves. Typical performance data used shall be that data furnished by the cement manufacturer or by a competent materials testing agency, as determined in accordance with the latest edition of API Code RP 10 B "Recommended Practice for Testing Oil-Well Cements."

Operators using the compressive strength criterion (Option 2) shall report the following information on Form C-103:

1. Volume of cement slurry (cubic feet).

2. Brand name of cement and additives, percent additives used, and sequence of placement if more than one type cement slurry is used.

3. Approximate temperature of cement slurry when mixed.

4. Estimated minimum formation temperature in zone of interest.

5. Estimate of cement strength at time of testing.

6. Actual time cement in place prior to starting casing test.

(c) All casing strings except conductor pipe shall be tested after cementing and before commencing any other operations on the well. Form C-103 shall be filed for each casing string reporting the grade and weight of pipe used. In the case of combination strings utilizing pipe of varied grades or weights, the footage of each grade and weight used shall be reported. The results of the casing test, including actual pressure held on pipe and the pressure drop observed shall also be reported on the same Form C-103.

(1) Casing strings in wells drilled with rotary tools shall be pressure tested. Minimum casing test pressure shall be approximately one-third of the manufacturer's rated internal yield pressure except that the test pressure shall not be less than 600 pounds per square inch and need not be greater than 1500 pounds per square inch. In cases where combination strings are involved, the above test pressures shall apply to the lowest pressure rated casing used. Test pressures shall be applied for a period of 30 minutes. If a drop of more than 10 percent of the test pressure should occur, the casing shall be considered defective and corrective measures shall be applied.

(2) Casing strings in wells drilled with cable tools may be tested as outlined in sub-paragraph (c) (1) above, or by bailing the well dry in which case the hole must remain satisfactorily dry for a period of at least one (1) hour before commencing any further operations on the well.

(d) (1) All flowing oil wells shall be tubed.

(2) All gas wells shall be tubed.

(3) Tubing shall be set as near the bottom as practical and tubing perforations shall not be more than 250 feet above the top of the pay.

(4) The Secretary-Director of the Commission may, upon proper application, grant administrative exceptions to the provisions of sub-paragraphs (2) and (3) above, without notice and hearing, provided waste will not be caused thereby.

DONE at Santa Fe, New Mexico, on the day and year hereinabove designated.

STATE OF NEW MEXICO
OIL CONSERVATION COMMISSION

EDWIN L. MECHEM, Chairman

MURRAY E. MORGAN, Member

A. L. PORTER, Jr., Member & Secretary

ir/

EXHIBIT "A"

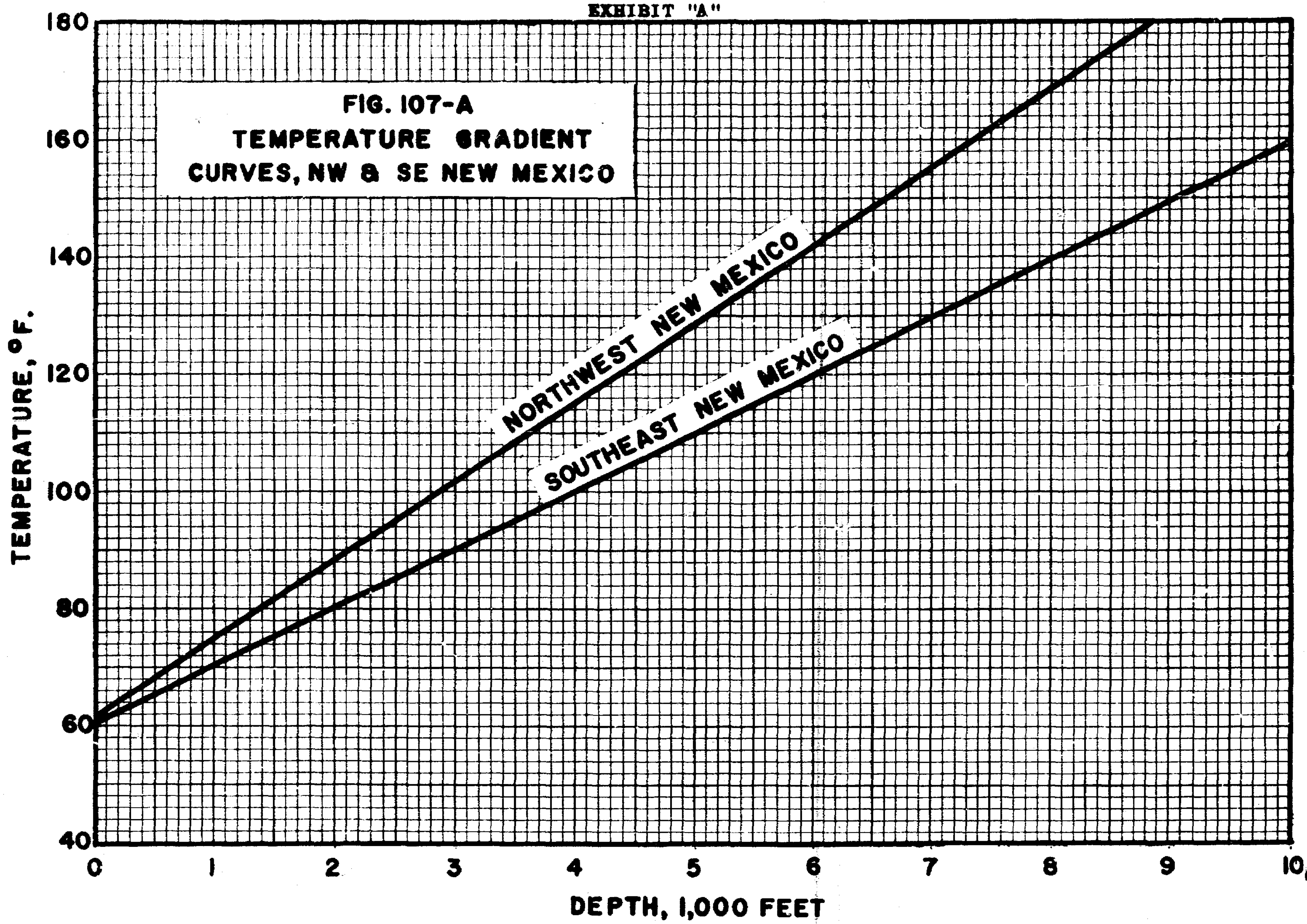


FIG. 107-A
TEMPERATURE GRADIENT
CURVES, NW & SE NEW MEXICO
NORTHWEST NEW MEXICO
SOUTHEAST NEW MEXICO
TEMPERATURE, °F.
180
160
140
120
100
80
60
40
0
1
2
3
4
5
6
7
8
9
10
DEPTH, 1,000 FEET

THE ANACONDA COMPANY

New Mexico Operations

P. O. Box 638, Grants, New Mexico

April 13, 1959

Mr. D. S. Nutter, Chief Engineer
New Mexico Oil Conservation Commission
107 Mabry Hall
Capitol Building
Santa Fe, New Mexico

Dear Mr. Nutter:

I am returning the transcript of proceedings for the two hearings in the matter of Oil and Gas Conservation Commission, Case No. 1369, dated January 15, 1958 and February 13, 1958, with this letter.

Acting on your prior approval we copied both hearings.

Thank you for making the transcript of Case No. 1369 available to us.

Sincerely,

R D Lynn

R. D. Lynn

RDL:vm
Incl.

PROPOSED RULE CHANGE PROPOSED RULE CHANGE PROPOSED RULE CHANGE

Rule 107 - Casing and Tubing Requirements

(a) All wells drilled for oil or natural gas shall be completed with a string of casing which shall be properly cemented at a sufficient depth to protect adequately the oil or natural gas bearing strata to be produced. In addition thereto such other casing and cement shall be used as necessary in order to seal off all oil, gas, and water strata which may be encountered in the well, except the one or ones to be produced. Sufficient cement shall be used on surface casing to fill the annular space back of the casing to the top of the hole. All cementing shall be by pump and plug method, or such other method approved by the Commission. All casing strings shall be tested and proved satisfactory as provided in paragraph (c) below.

(b) Before initiating tests (as in (c) below), all casing strings shall stand cemented a minimum of

(1) eighteen (18) hours, or

(2) until the compressive strength is at least 500 pounds per square inch in the "zone of interest," provided however, that no tests shall be commenced until the cement has been in place for at least eight (8) hours.

The "zone of interest" for surface, intermediate, and protection casing strings shall be the bottom 20 percent of the casing string, but shall be no greater than 1000 feet nor less than 300 feet of the bottom part of the casing unless the casing is set at a depth less than 300 feet. In the case of the production casing string the "zone of interest" shall include the interval or intervals where immediate completion is contemplated. Operators using the minimum 18-hour criterion of cement strength shall report on Form C-103 the actual time the cement was in place before initiating tests. Operators using compressive strength criterion shall report the following information on Form C-103:

(1) Volume of cement slurry (cubic feet).
(2) Brand name of cement together with additives showing sequence of placement if more than one type cement slurry is used.
(3) Approximate temperature of cement slurry when mixed.
(4) Estimated native bottom hole formation temperature.
(5) Estimate of cement strength at time of testing.
(6) Time interval between plug down and starting of casing test.

BEFORE THE
OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO
Atlantic EXHIBIT No. 6
CASE 1369

(c) All casing strings except conductor pipe shall be tested after cementing and before commencing any other operations on the well.

(1) Wells drilled with rotary tools shall be pressure tested. Minimum casing test pressure shall be approximately one-third manufacturer's rated internal yield pressure except that the test pressure shall not be less than 600 pounds per square inch and need not be greater than ~~2600~~ 1500 pounds per square inch. In cases where combination strings are involved, the above test pressures shall apply to the lowest pressure rated casing used. Test pressures shall be applied for a period of 30 minutes. If a drop of more than 10 percent of the test pressure should occur, the casing shall be considered defective and corrective measures shall be applied.

(2) Wells drilled with cable tools may be tested as outlined in sub-paragraph (c) (1) above, or by bailing the well dry in which case the hole must satisfactorily remain dry for a period of at least six hours (6) before commencing any further operations on the well.

(over)

The results of casing tests on each string shall be reported on Form C-103.

(d) All flowing wells shall be tubed, and the tubing shall be set as near the bottom as practical; tubing perforations shall not be more than 250 feet above the top of the pay, unless authorized by the Commission.

RULE 107

(d) All flowing oil wells and gas wells that produce liquids shall be tubed, and the tubing shall be set as near the bottom as practical; tubing perforations shall not be more than 250 feet above the top of the pay. The Secretary - Director of the Oil Conservation Commission may, upon application from an operator, grant administrative exceptions to the provisions of this section relating to bottoming of tubing and location of tubing perforations.

BEFORE THE
OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO
Pan Am EXHIBIT No. 1
CASE 1369

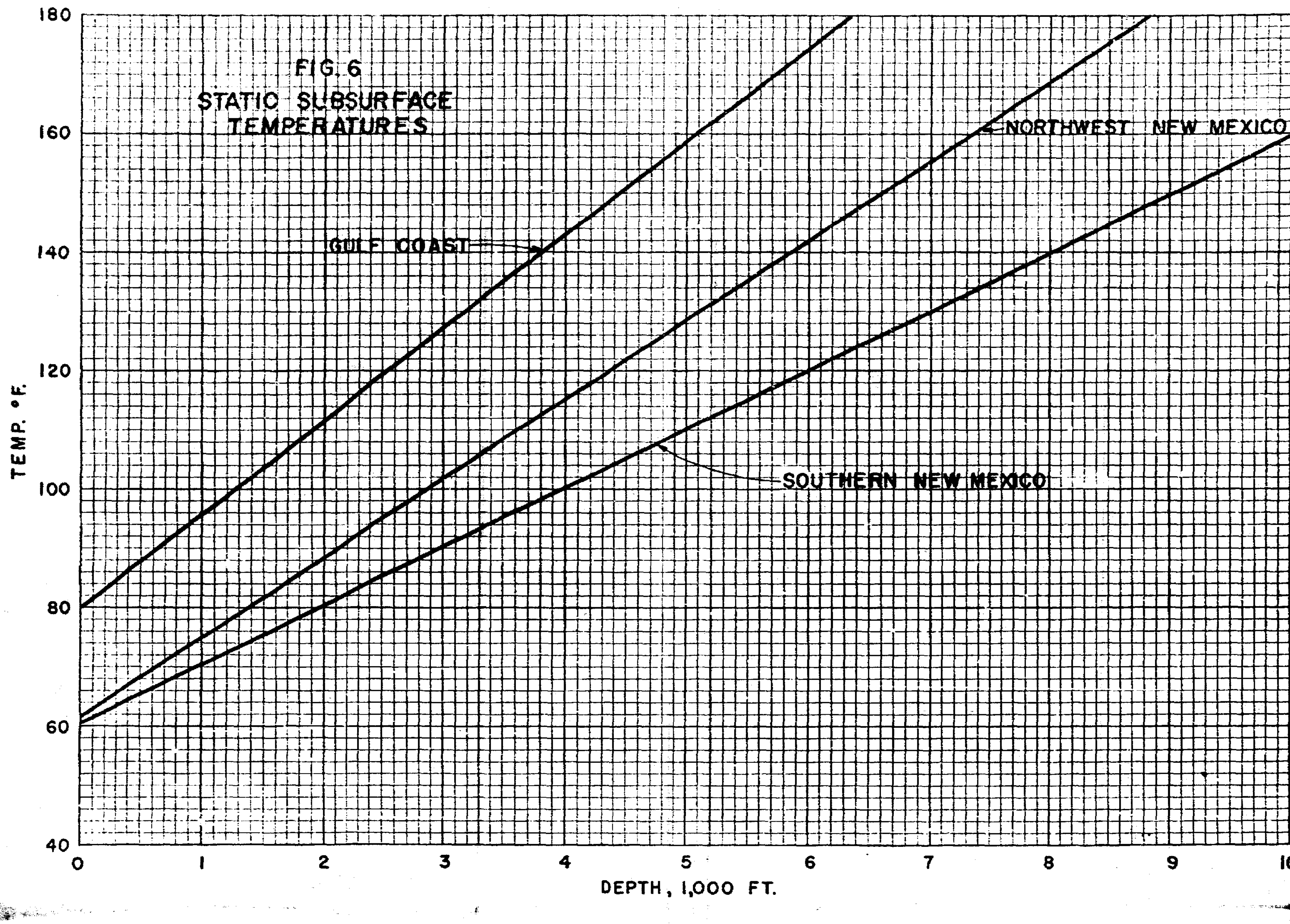
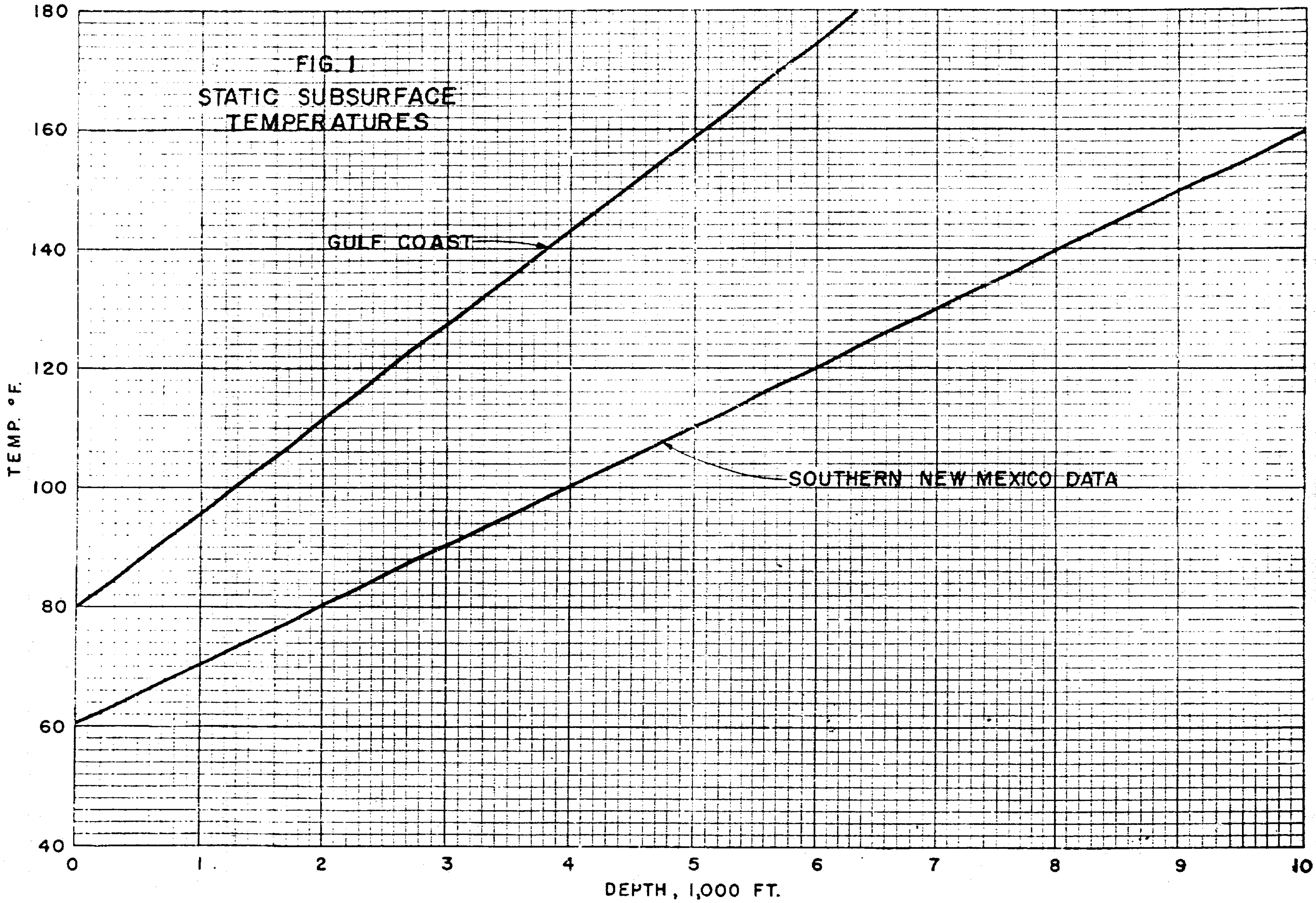


FIG. 6
STATIC SUBSURFACE TEMPERATURES
NORTHWEST NEW MEXICO
GULF COAST
SOUTHERN NEW MEXICO
TEMP. °F.
180
160
140
120
100
80
60
40
0
1
2
3
4
5
6
7
8
9
10
DEPTH, 1,000 FT.

K+E 10 X 10 TO THE INCH 359-5
KEUFFEL & ESSER CO.



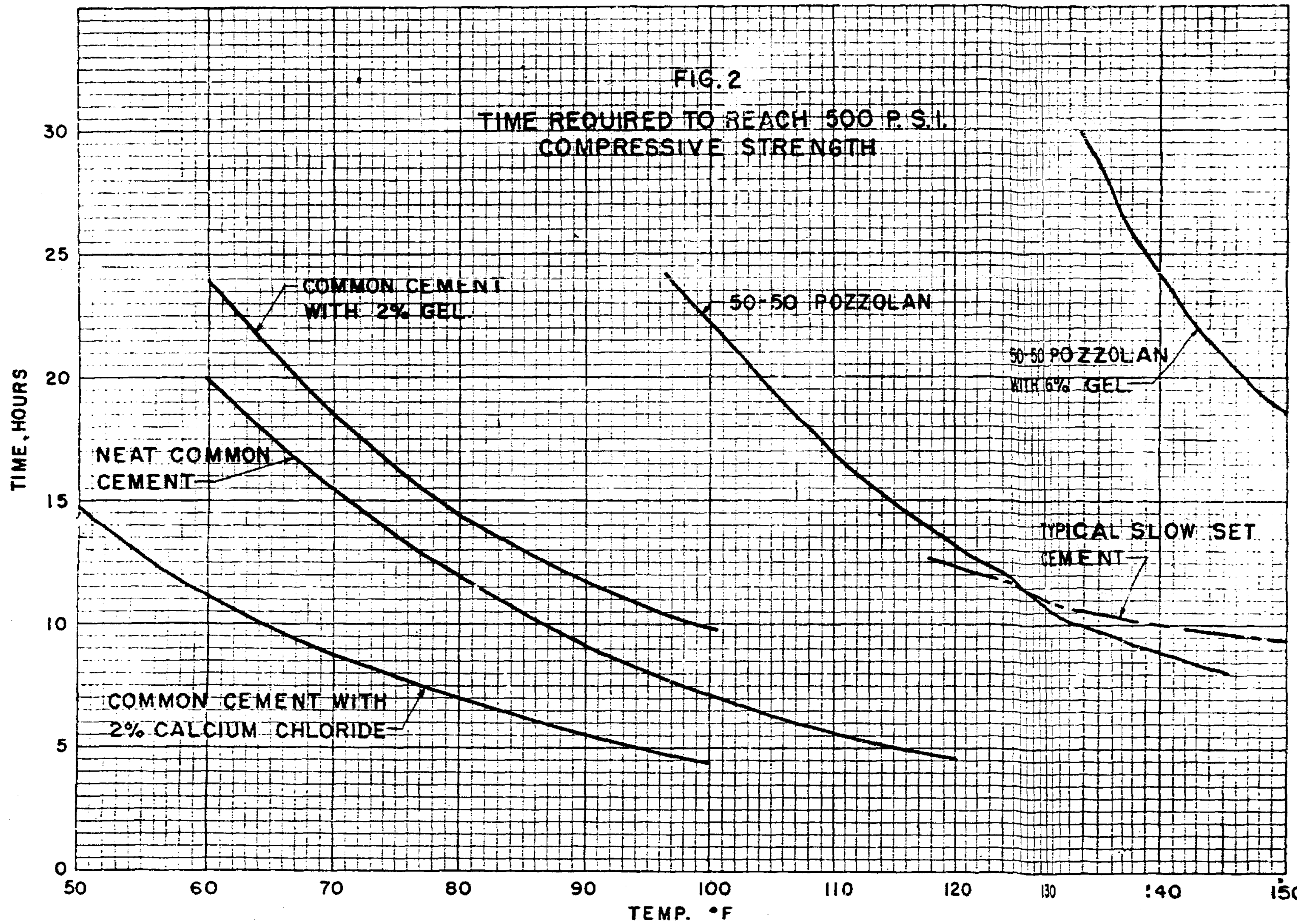


FIG. 2
TIME REQUIRED TO REACH 500 P.S.I. COMPRESSIVE STRENGTH
TIME, HOURS
TEMP. °F
COMMON CEMENT WITH 2% GEL
50-50 POZZOLAN
50-50 POZZOLAN WITH 6% GEL
NEAT COMMON CEMENT
TYPICAL SLOW SET CEMENT
COMMON CEMENT WITH 2% CALCIUM CHLORIDE
0
5
10
15
20
25
30
50
60
70
80
90
100
110
120
130
140
150

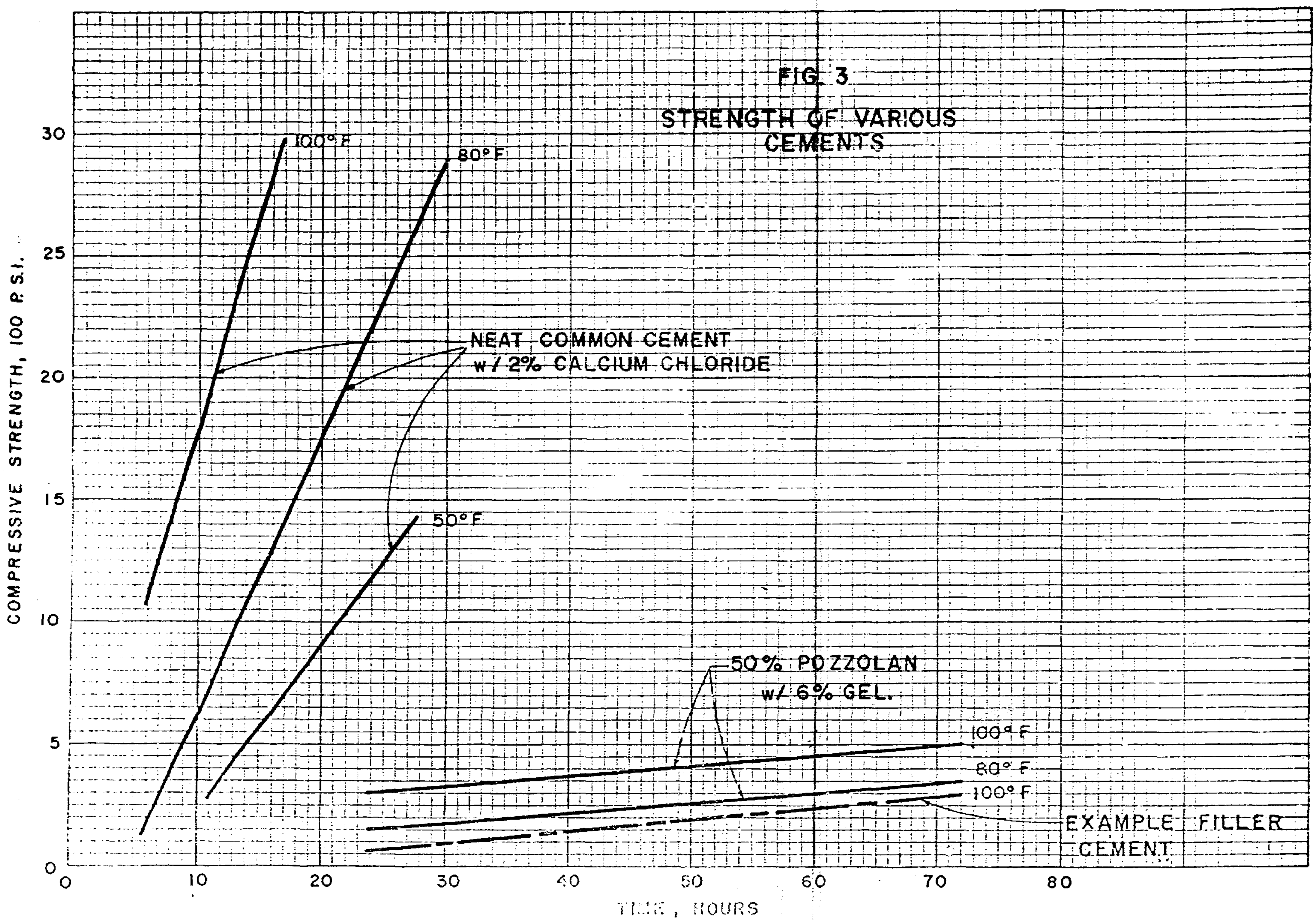
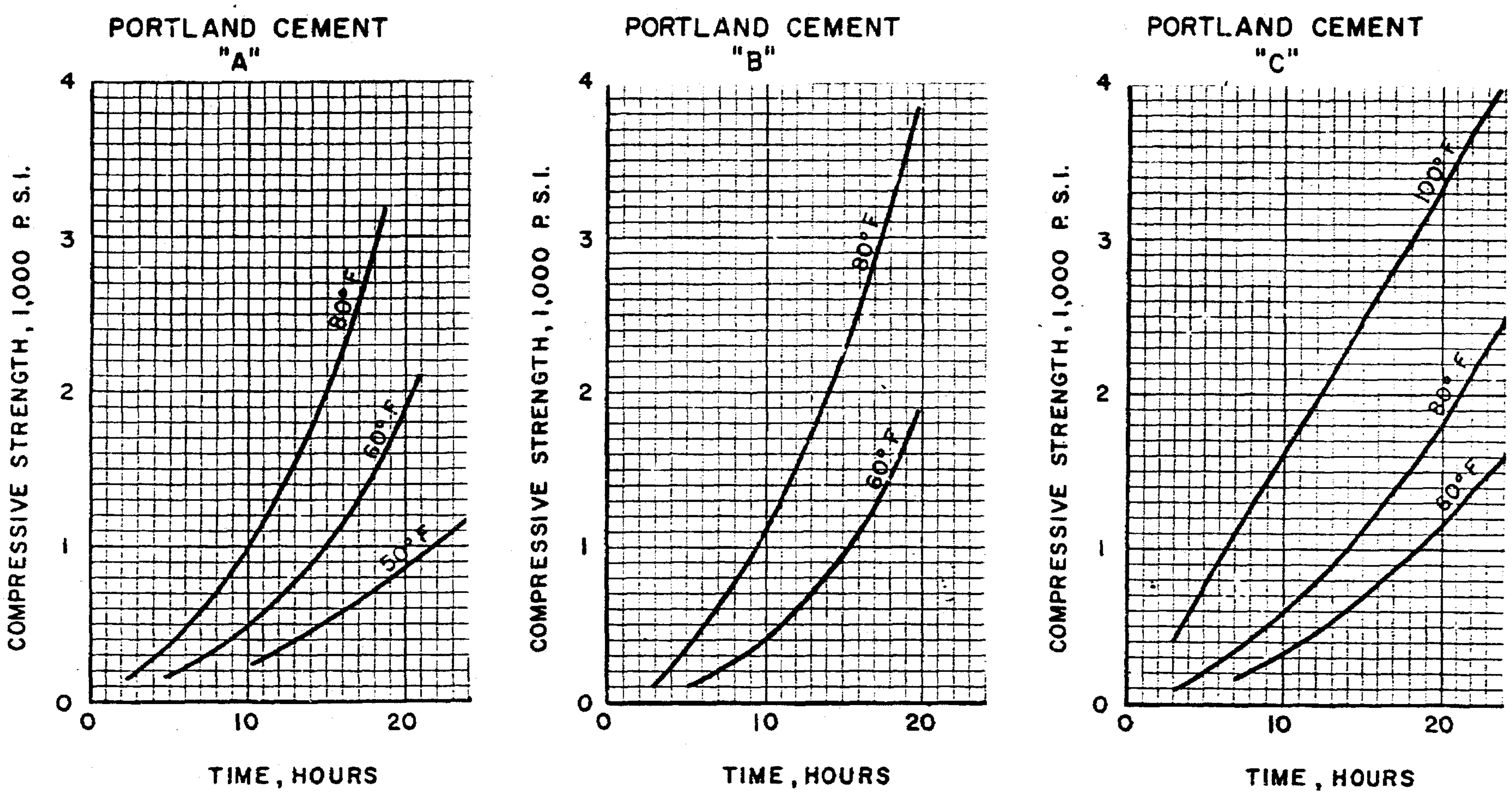


FIG. 3
STRENGTH OF VARIOUS CEMENTS
100° F
80° F
50° F
NEAT COMMON CEMENT
w/ 2% CALCIUM CHLORIDE
50% POZZOLAN
w/ 6% GEL.
100° F
80° F
100° F
EXAMPLE FILLER CEMENT
COMPRESSIVE STRENGTH, 100 P.S.I.
TIME, HOURS
0
5
10
15
20
25
30
0
10
20
30
40
50
60
70
80

FIG. 4

STRENGTH OF EXAMPLE ACCELERATED CEMENTS*

* NOTE: 2% CALCIUM CHLORIDE USED WITH ALL CEMENTS TOGETHER WITH 5.2 GAL. WATER PER SACK. SLURRY DENSITY OF ALL CEMENTS = 15.6# / GAL.



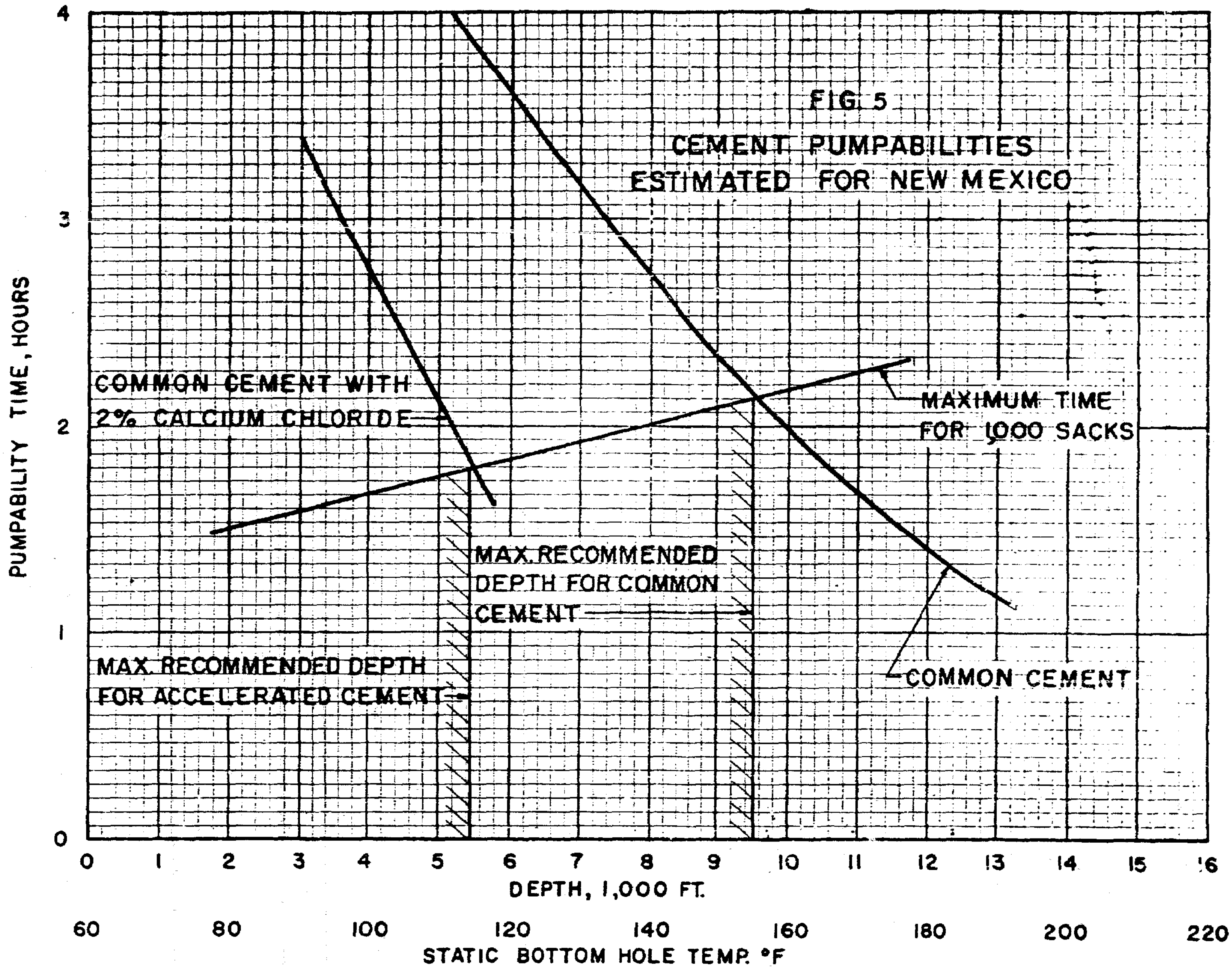
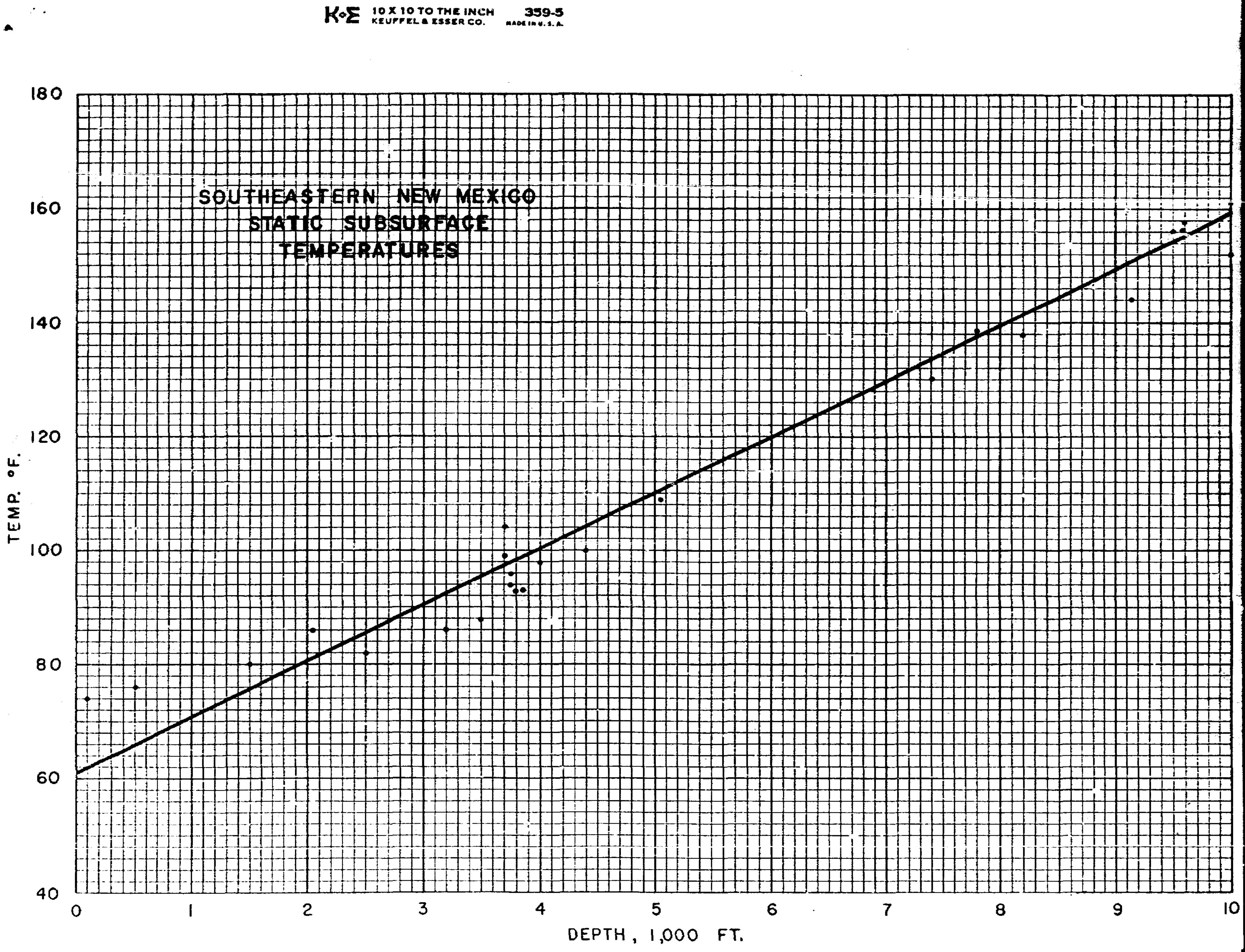
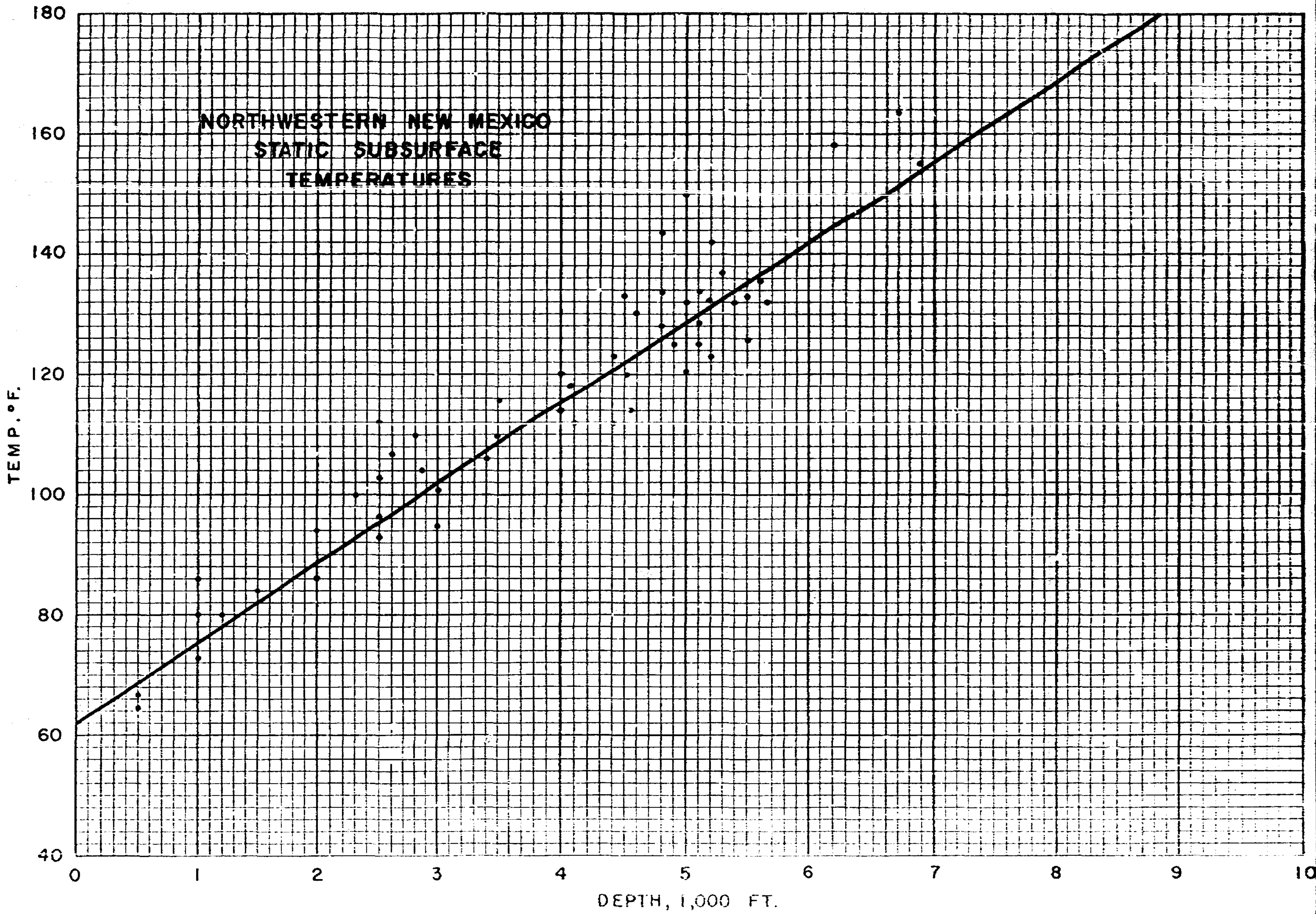
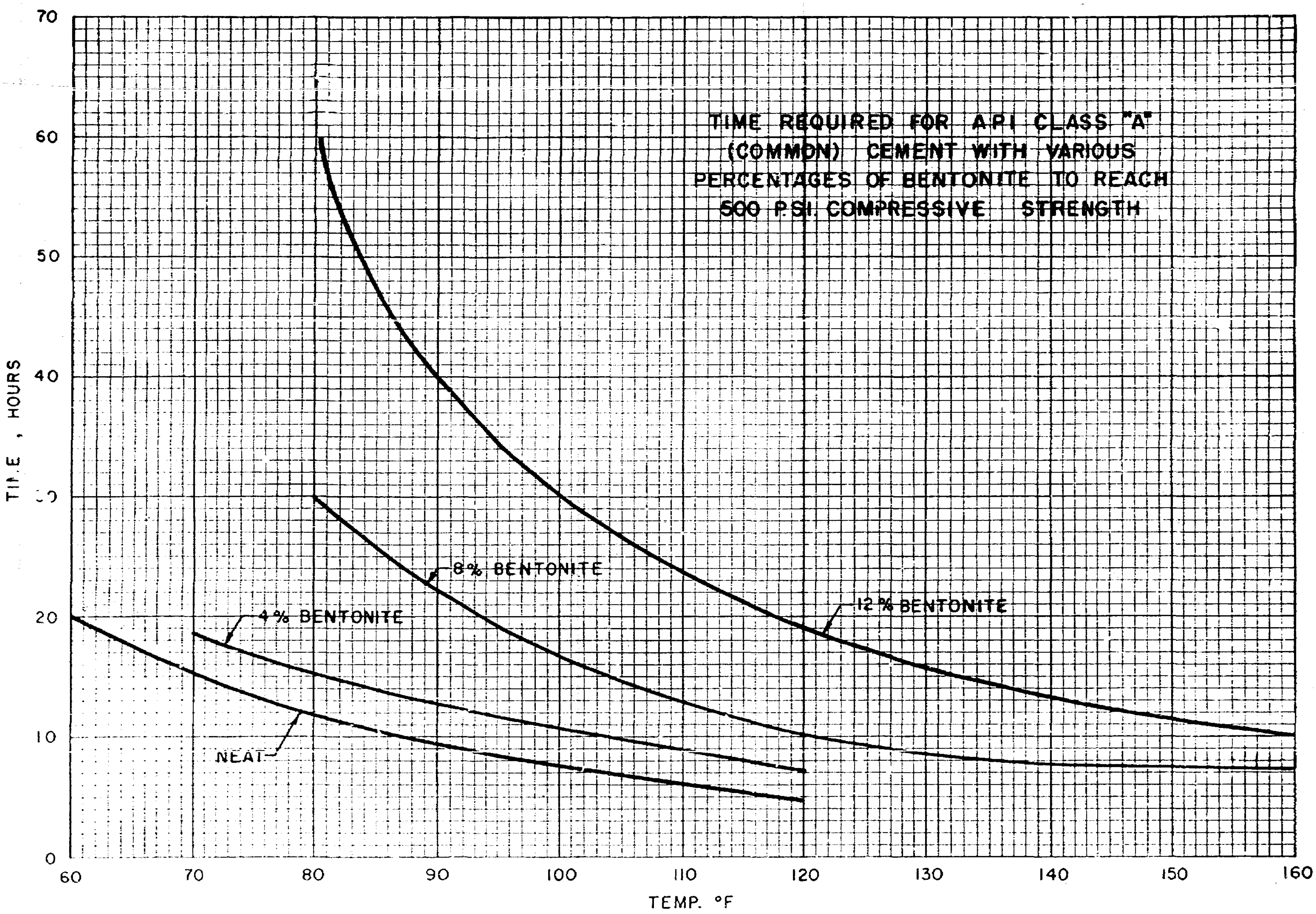


FIG. 5
CEMENT PUMPABILITIES
ESTIMATED FOR NEW MEXICO
PUMPABILITY TIME, HOURS
COMMON CEMENT WITH
2% CALCIUM CHLORIDE
MAXIMUM TIME
FOR 1,000 SACKS
MAX. RECOMMENDED
DEPTH FOR COMMON
CEMENT
MAX. RECOMMENDED DEPTH
FOR ACCELERATED CEMENT
COMMON CEMENT
DEPTH, 1,000 FT.
STATIC BOTTOM HOLE TEMP. °F
0
1
2
3
4
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
60
80
100
120
140
160
180
200
220

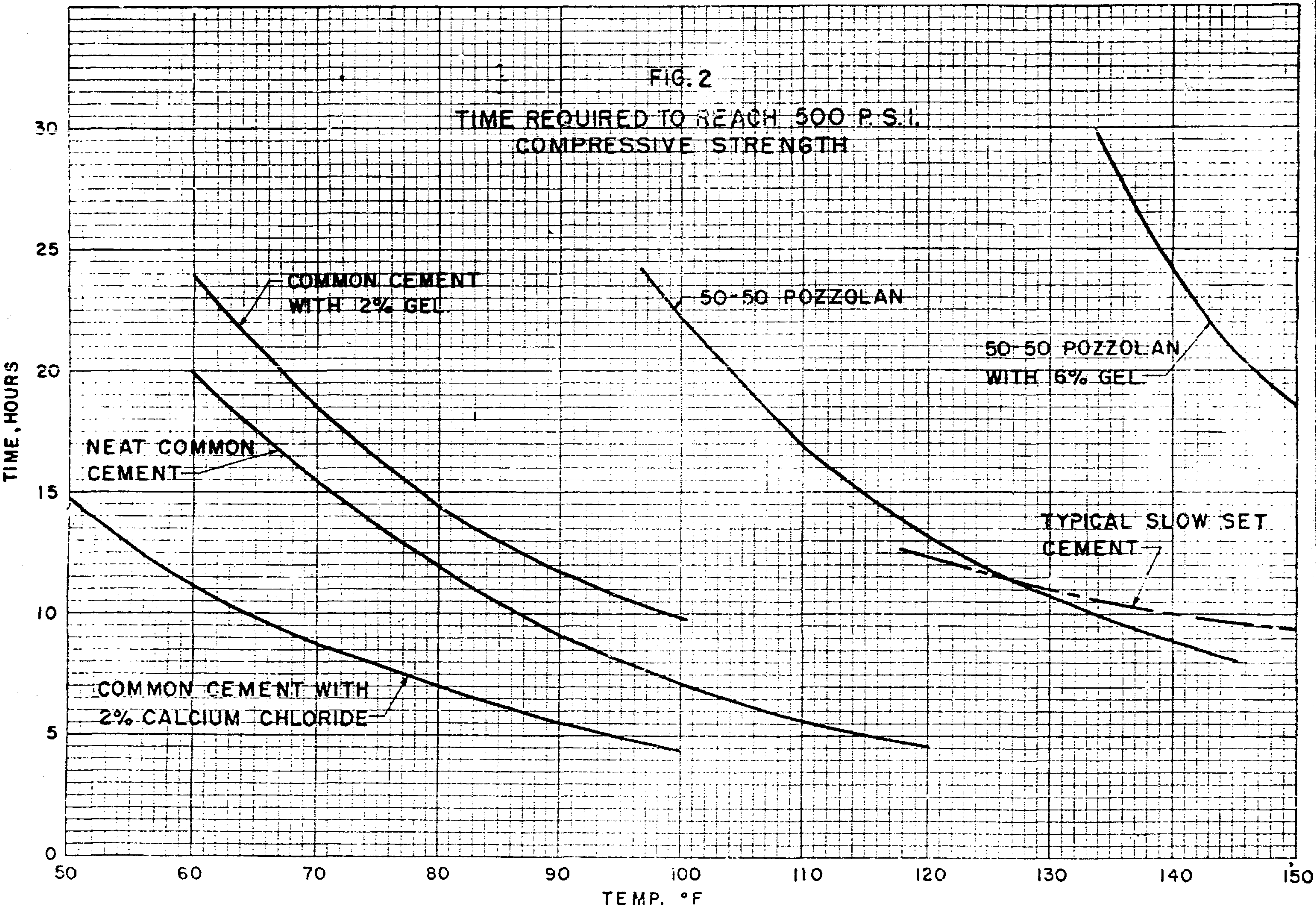

K-E 10 X 10 TO THE INCH KEUFFEL & ESSER CO. 359-5 MADE IN U.S.A.
SOUTHEASTERN NEW MEXICO
STATIC SUBSURFACE
TEMPERATURES
180
160
140
120
100
80
60
40
TEMP. °F.
0
1
2
3
4
5
6
7
8
9
10
DEPTH, 1,000 FT.


NORTHWESTERN NEW MEXICO
STATIC SUBSURFACE
TEMPERATURES
TEMP. °F.
180
160
140
120
100
80
60
40
0
1
2
3
4
5
6
7
8
9
10
DEPTH, 1,000 FT.

K-E 10 X 10 TO THE INCH 359-5
KEUFFEL & ESSER CO. MADE IN U.S.A.



K&E 10 X 10 TO THE INCH 359-5 KEUFFEL & ESSER CO. MADE IN U.S.A.



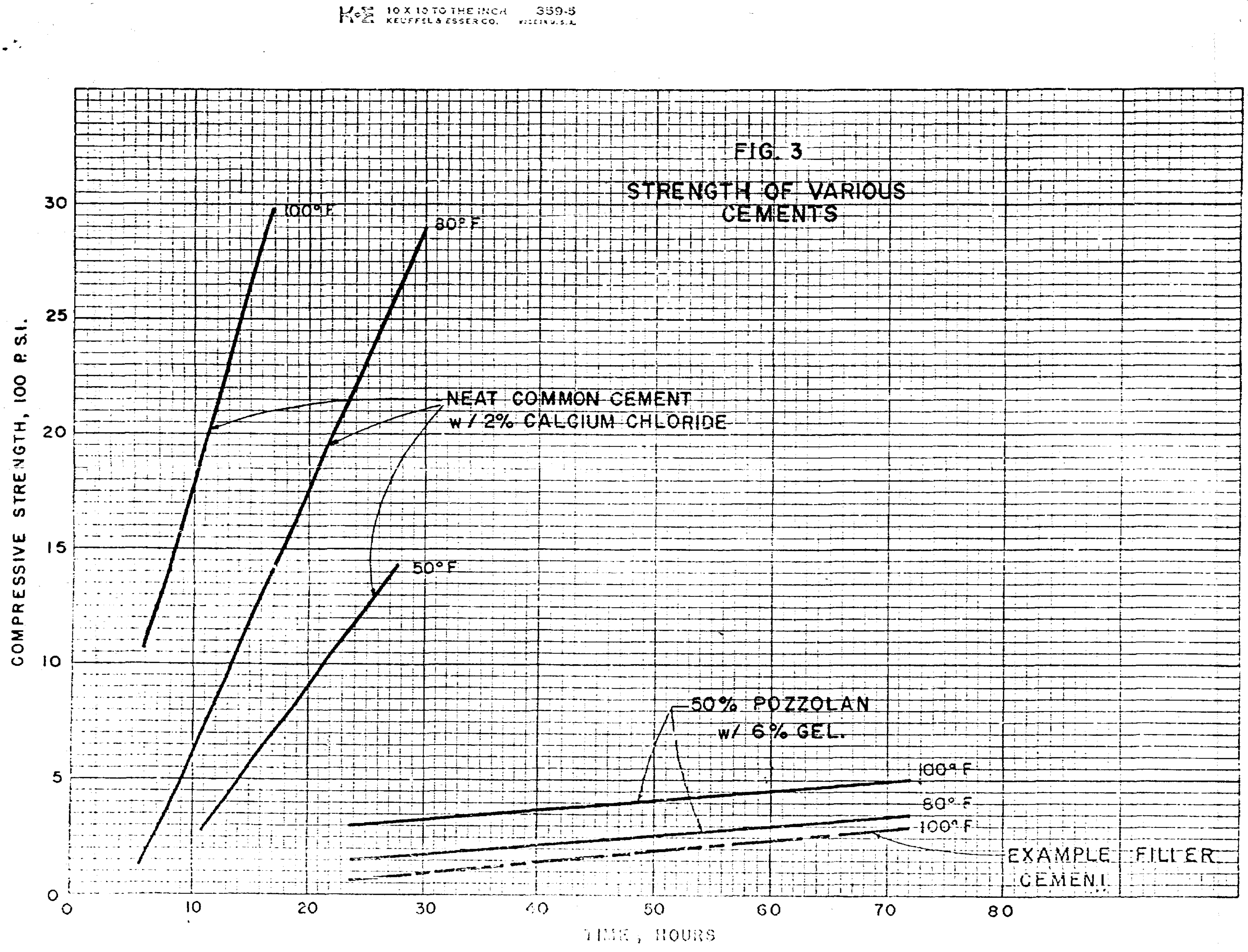
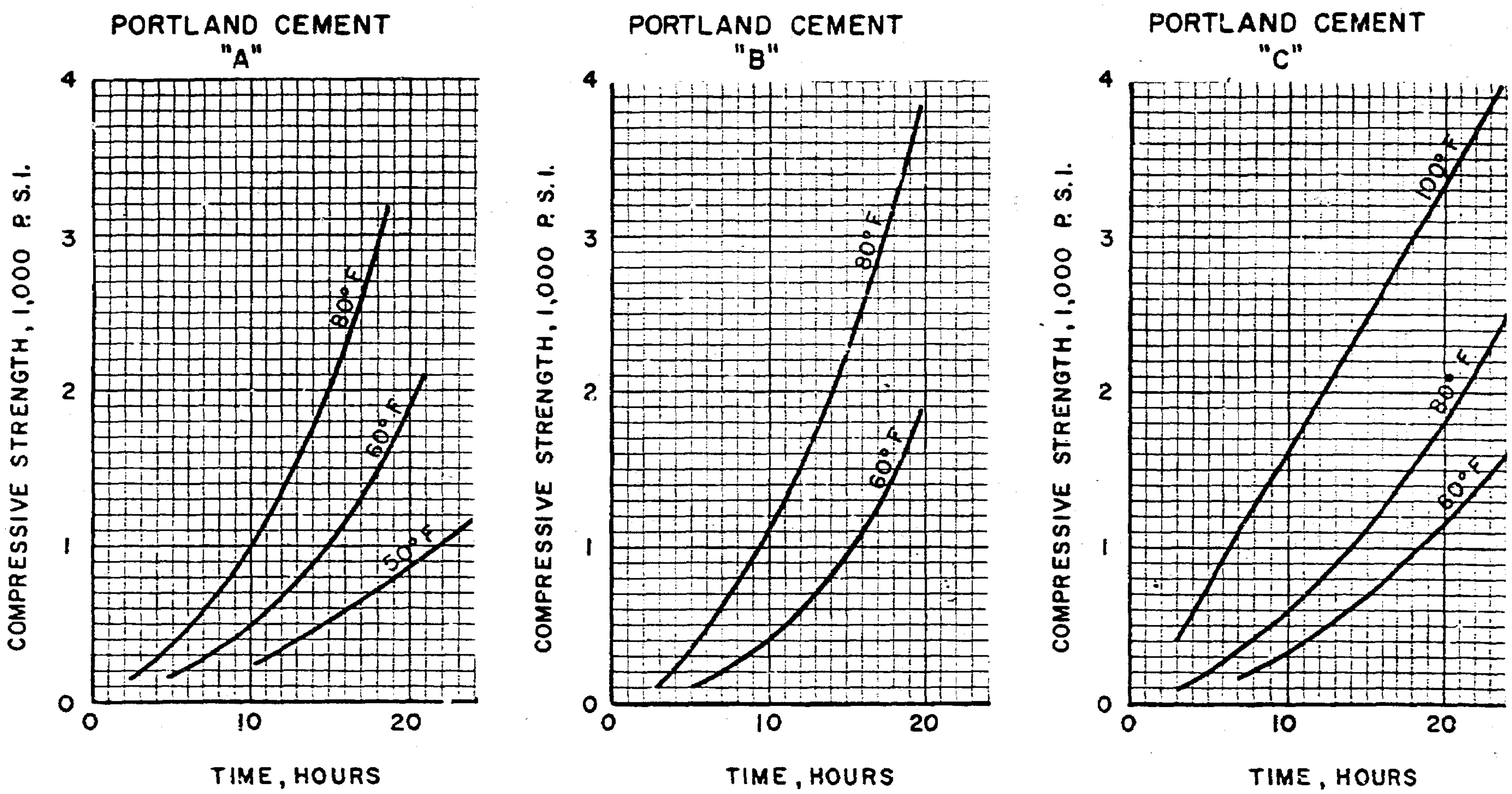

K&E 10 X 10 TO THE INCH 359-5
KEUFFEL & ESSER CO.
FIG. 3
STRENGTH OF VARIOUS CEMENTS
COMPRESSIVE STRENGTH, 100 P.S.I.
TIME, HOURS
0
5
10
15
20
25
30
0
10
20
30
40
50
60
70
80
100°F
80°F
50°F
NEAT COMMON CEMENT
w/ 2% CALCIUM CHLORIDE
50% POZZOLAN
w/ 6% GEL.
100°F
80°F
100°F
EXAMPLE FILLER CEMENT

FIG. 4

STRENGTH OF EXAMPLE ACCELERATED CEMENTS*

* NOTE: 2% CALCIUM CHLORIDE USED WITH ALL CEMENTS TOGETHER WITH 5.2 GAL. WATER PER SACK. SLURRY DENSITY OF ALL CEMENTS = 15.6# / GAL.



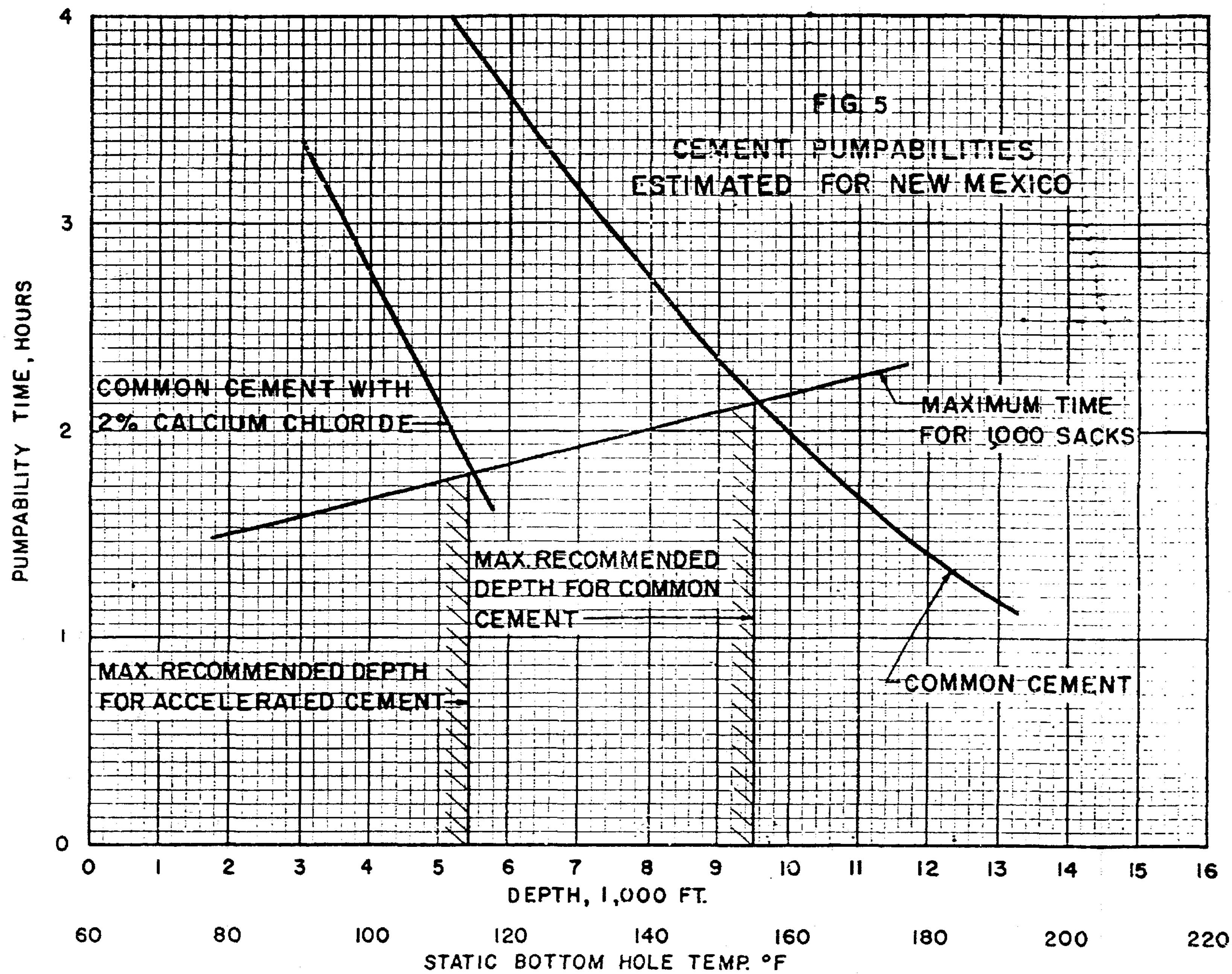


FIG. 5
CEMENT PUMPABILITIES
ESTIMATED FOR NEW MEXICO
PUMPABILITY TIME, HOURS
COMMON CEMENT WITH
2% CALCIUM CHLORIDE
MAXIMUM TIME
FOR 1,000 SACKS
MAX. RECOMMENDED
DEPTH FOR COMMON
CEMENT
MAX. RECOMMENDED DEPTH
FOR ACCELERATED CEMENT
COMMON CEMENT
0
1
2
3
4
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
DEPTH, 1,000 FT.
60
80
100
120
140
160
180
200
220
STATIC BOTTOM HOLE TEMP. °F

EXHIBIT "A"

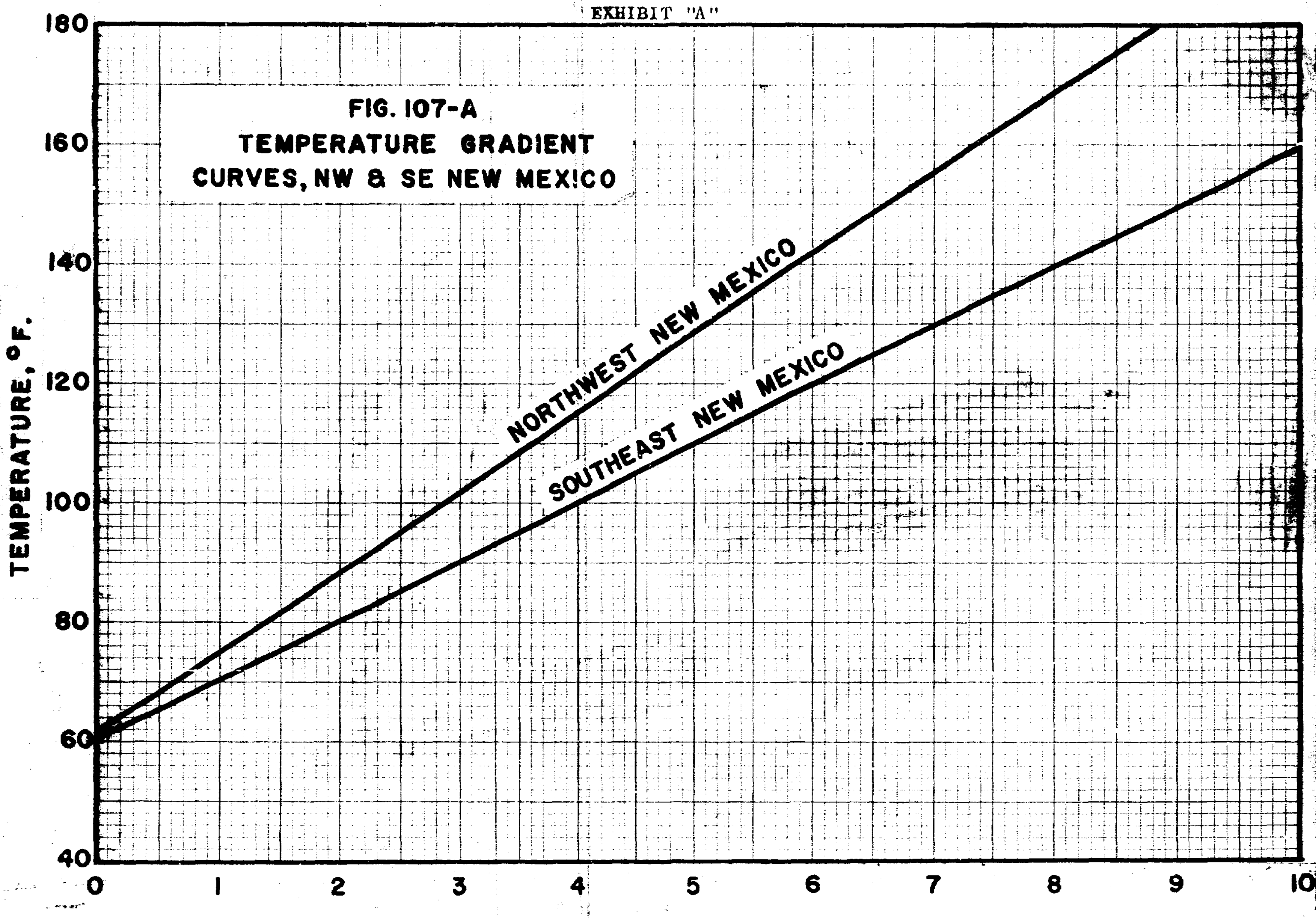
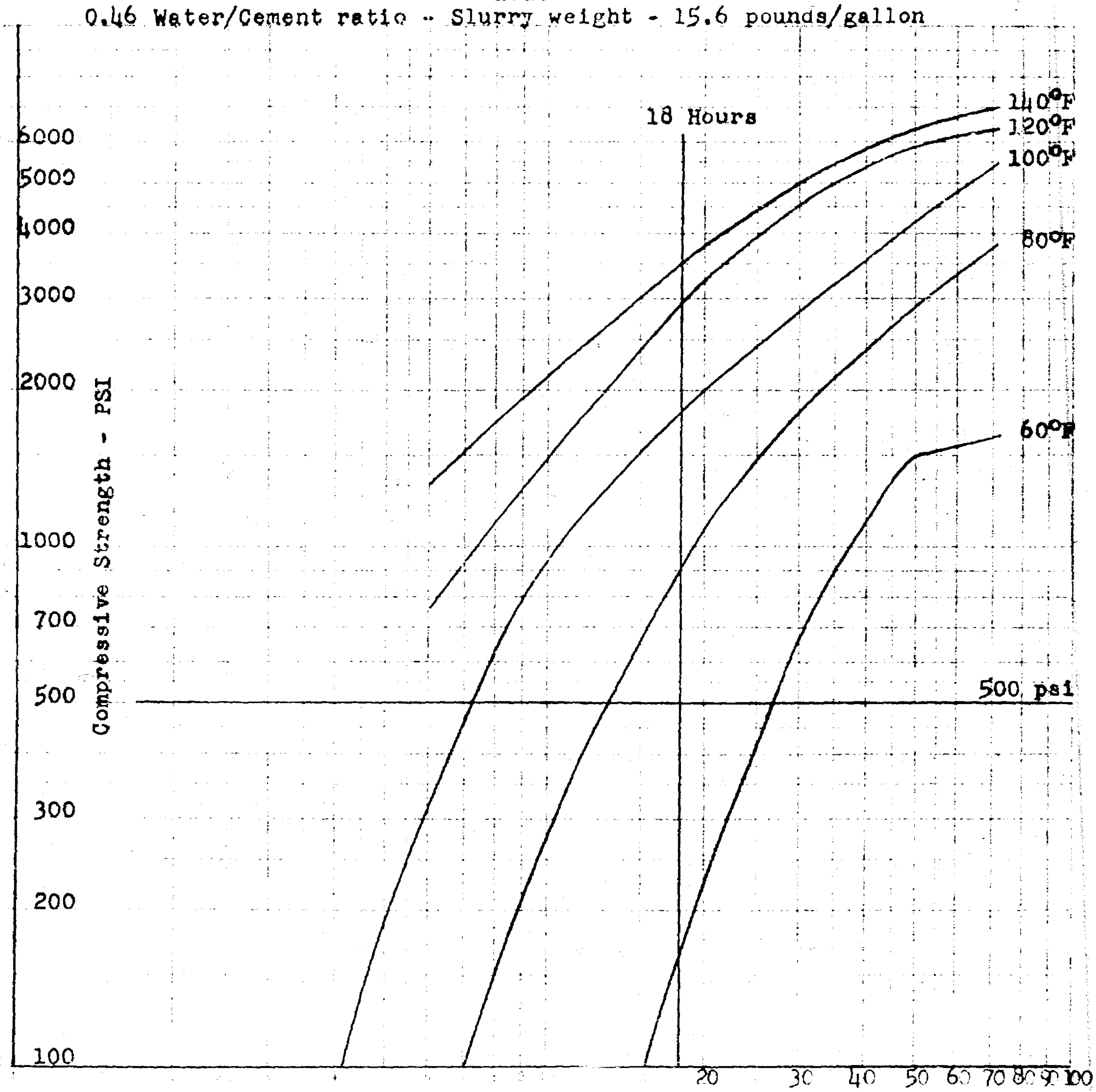


FIG. 107-A
TEMPERATURE GRADIENT
CURVES, NW & SE NEW MEXICO
NORTHWEST NEW MEXICO
SOUTHEAST NEW MEXICO
TEMPERATURE, °F.
180
160
140
120
100
80
60
40
0
1
2
3
4
5
6
7
8
9
10

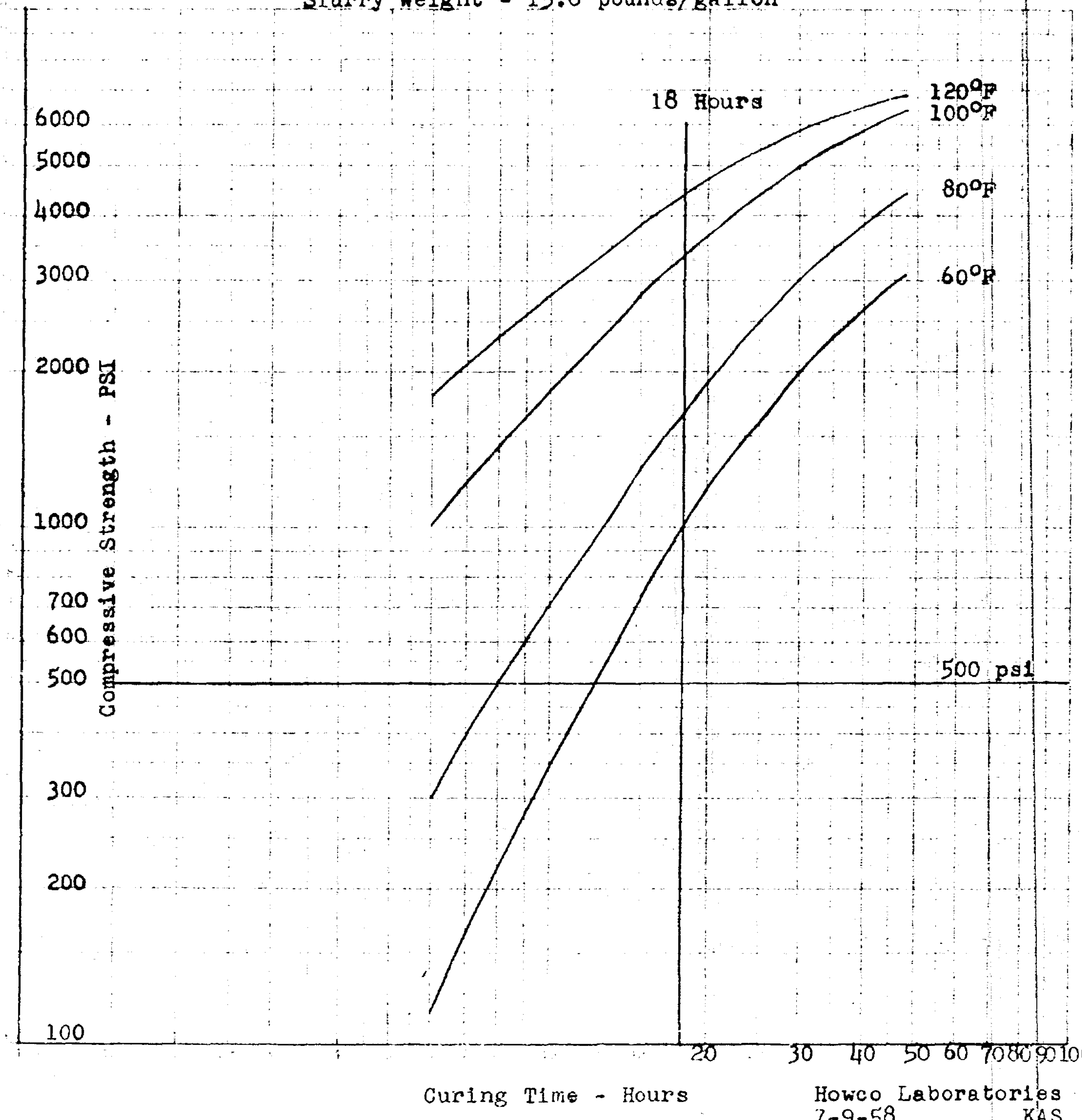
API Class A Cement
Neat
0.46 Water/Cement ratio - Slurry weight - 15.6 pounds/gallon



Curing Time - Hours

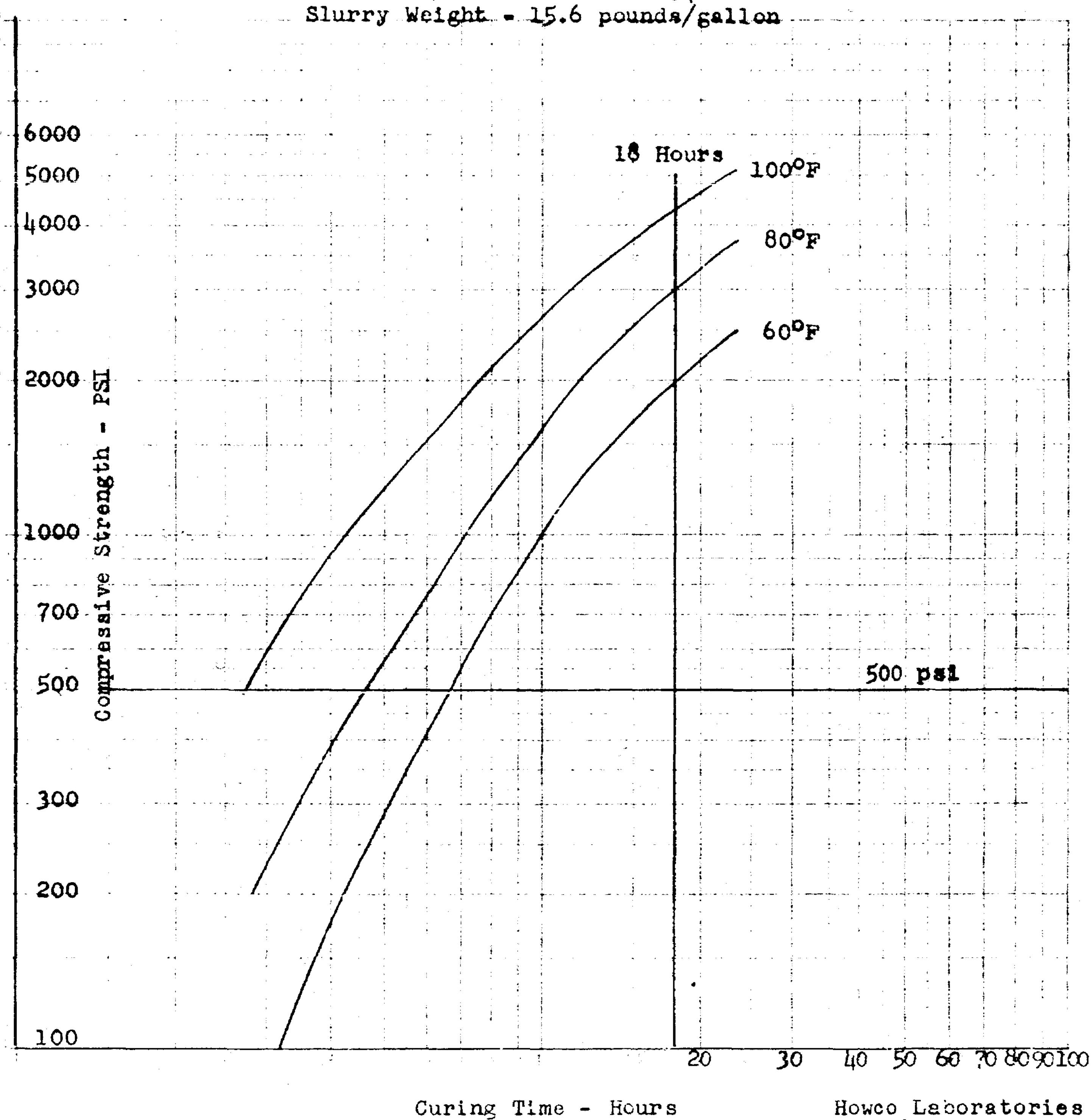
Howco Laboratories
7-9-58 KAS

API Class A Cement
2% Calcium Chloride
Water Ratio - 0.46
Slurry Weight - 15.6 pounds/gallon



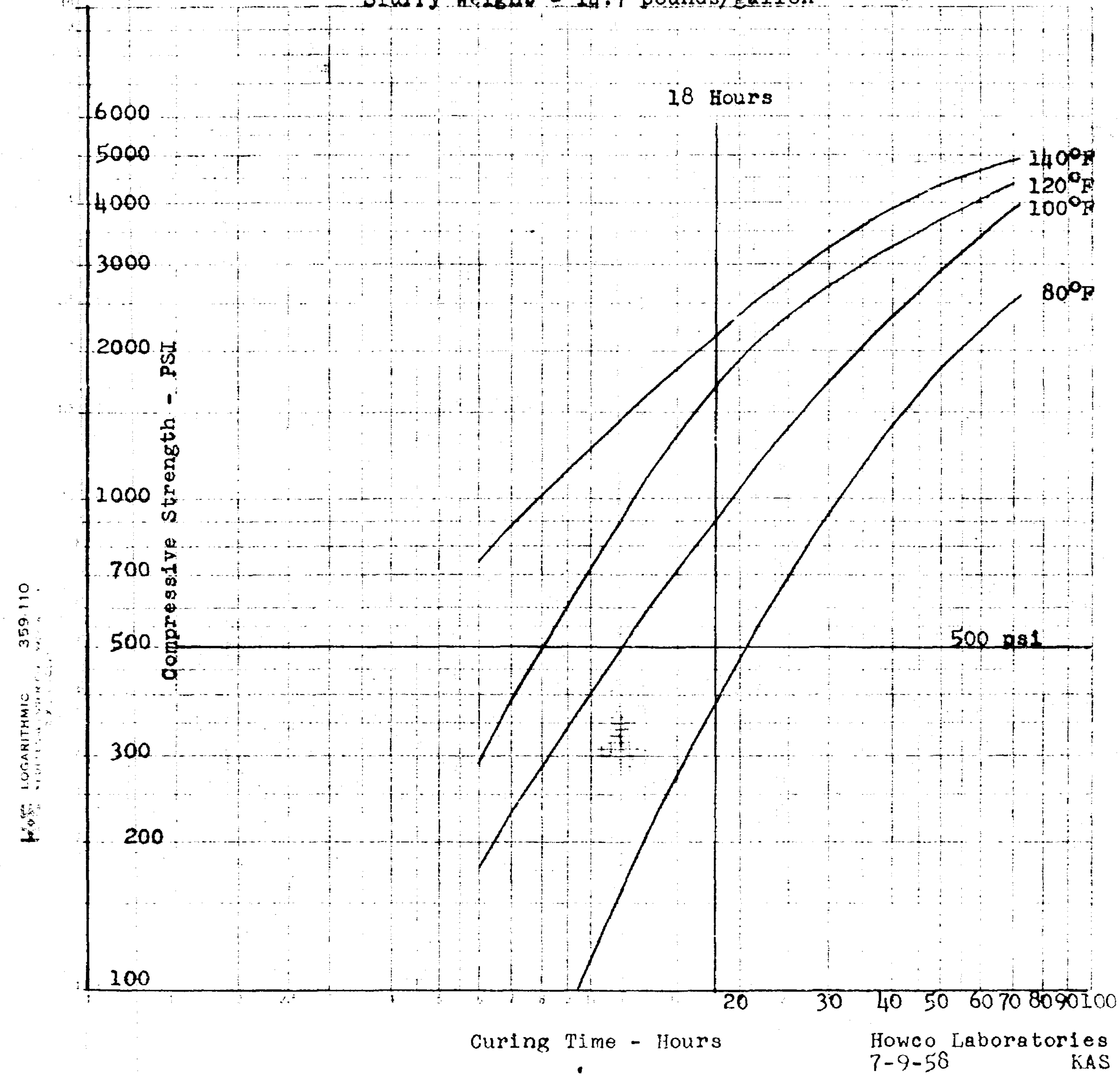
Howco Laboratories
7-9-58 KAS

API Class A Cement
3% HA-5
Water/Cement Ratio - 0.46
Slurry Weight - 15.6 pounds/gallon



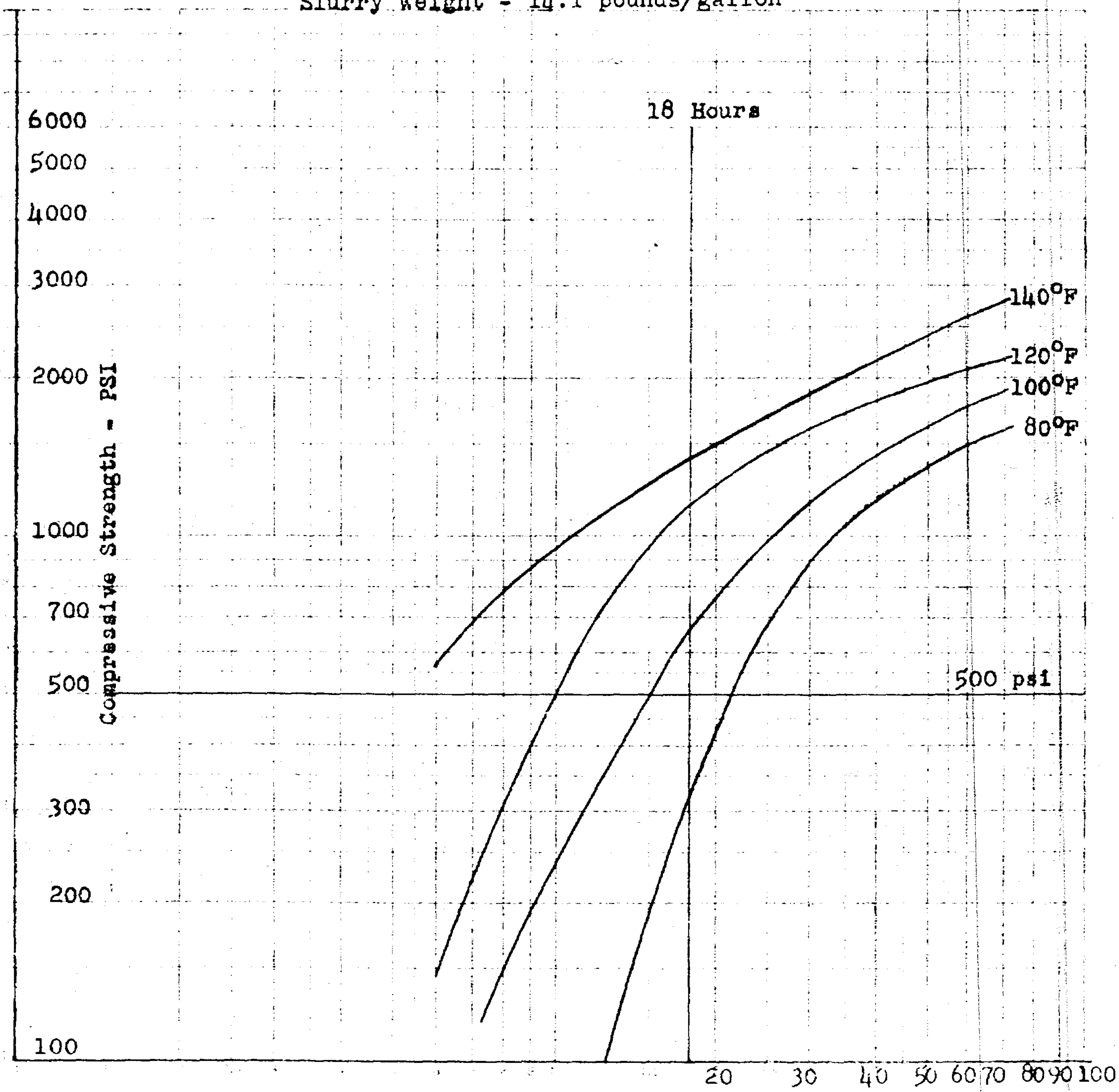
Howco Laboratories
7-9-58 KAS

API Class A Cement
2% Bentonite
Water/Cement Ratio - 0.58
Slurry Weight - 14.7 pounds/gallon



Howco Laboratories
7-9-58 KAS

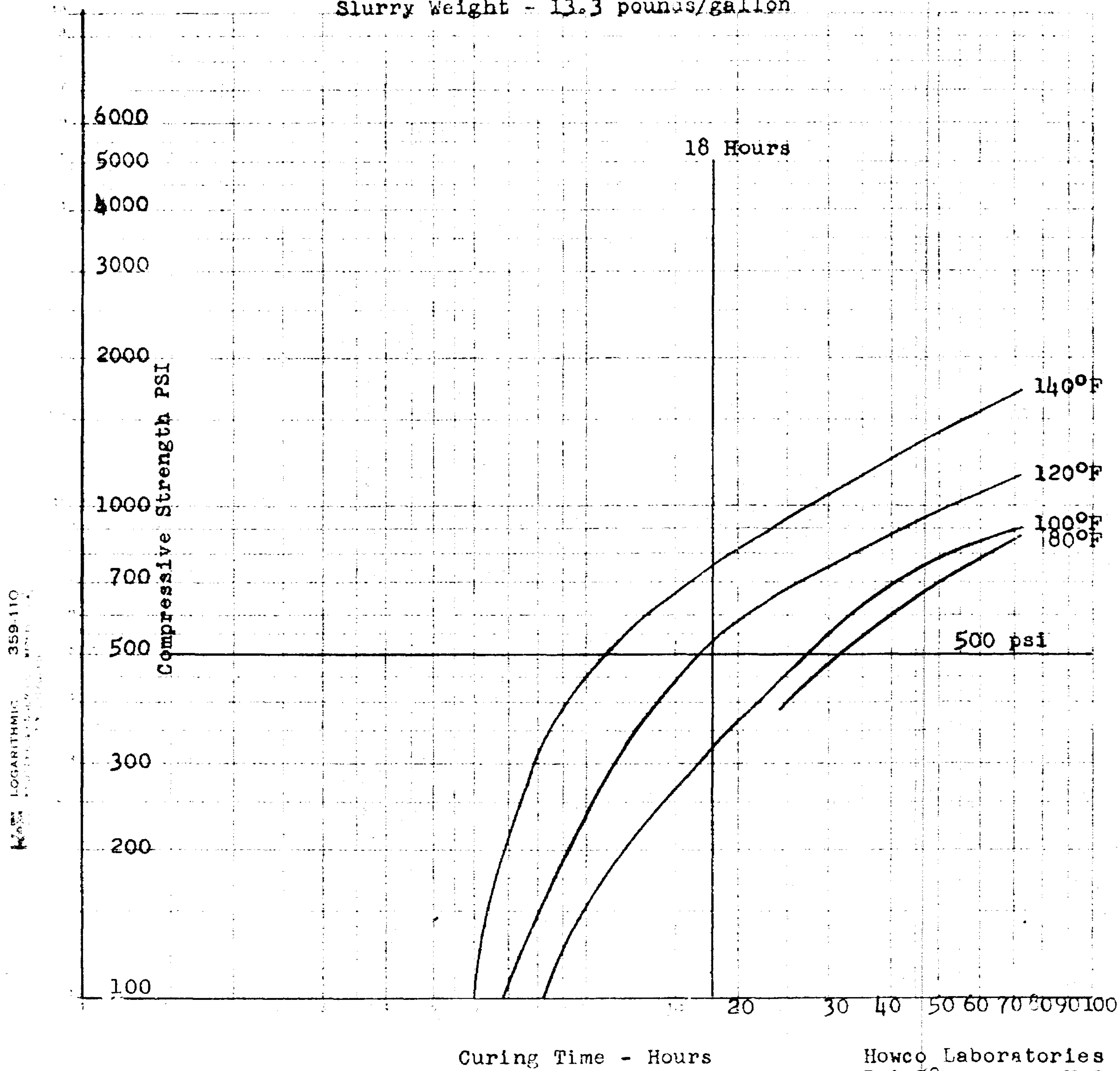
API Class A Cement
4% Bentonite
Water/Cement Ratio - 0.68
Slurry Weight - 14.1 pounds/gallon



Curing Time - Hours

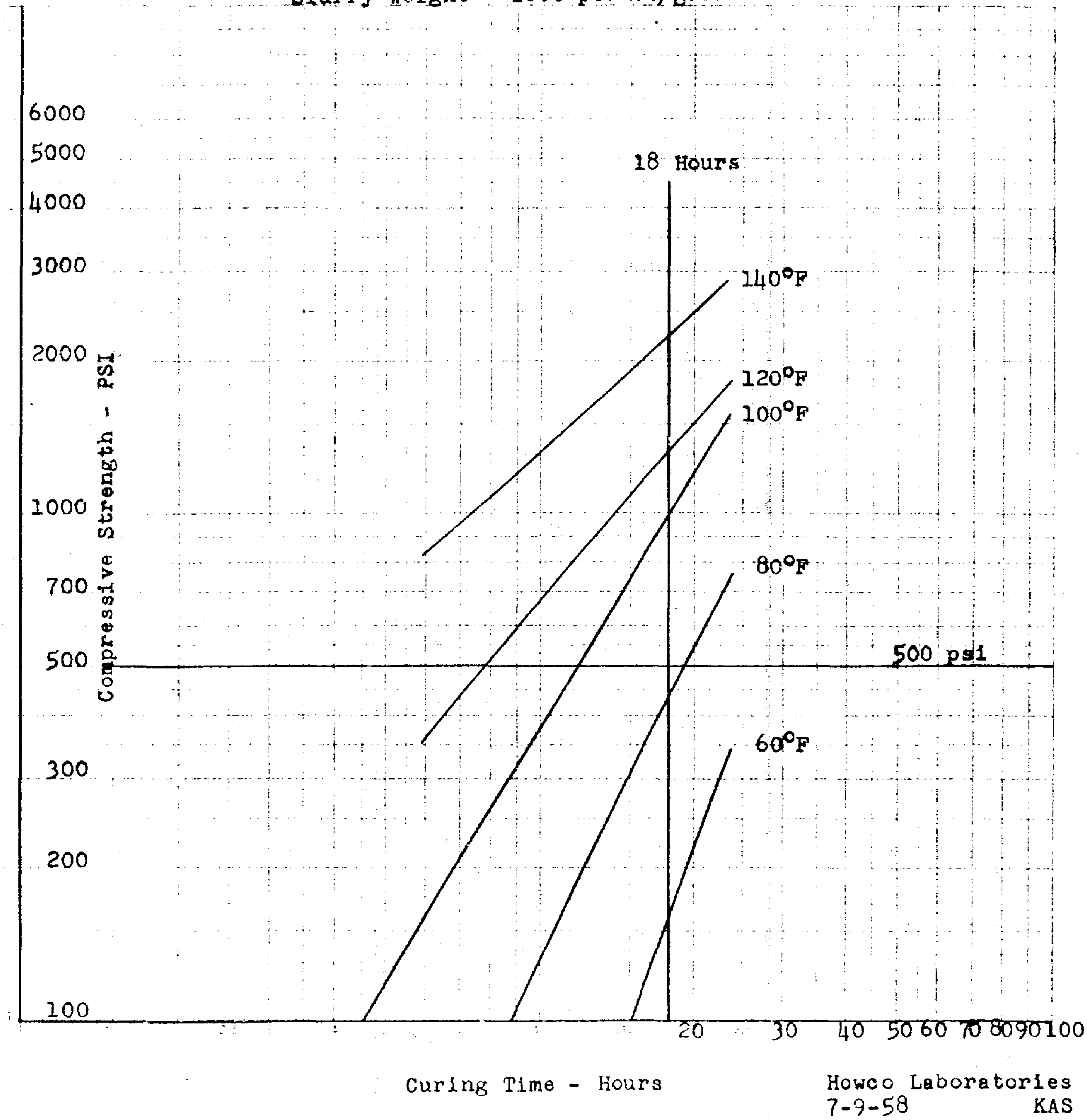
Howco Laboratories
7-9-58 KAS

API Class A Cement
8% Bentonite
Water/Cement Ratio - 0.86
Slurry Weight - 13.3 pounds/gallon



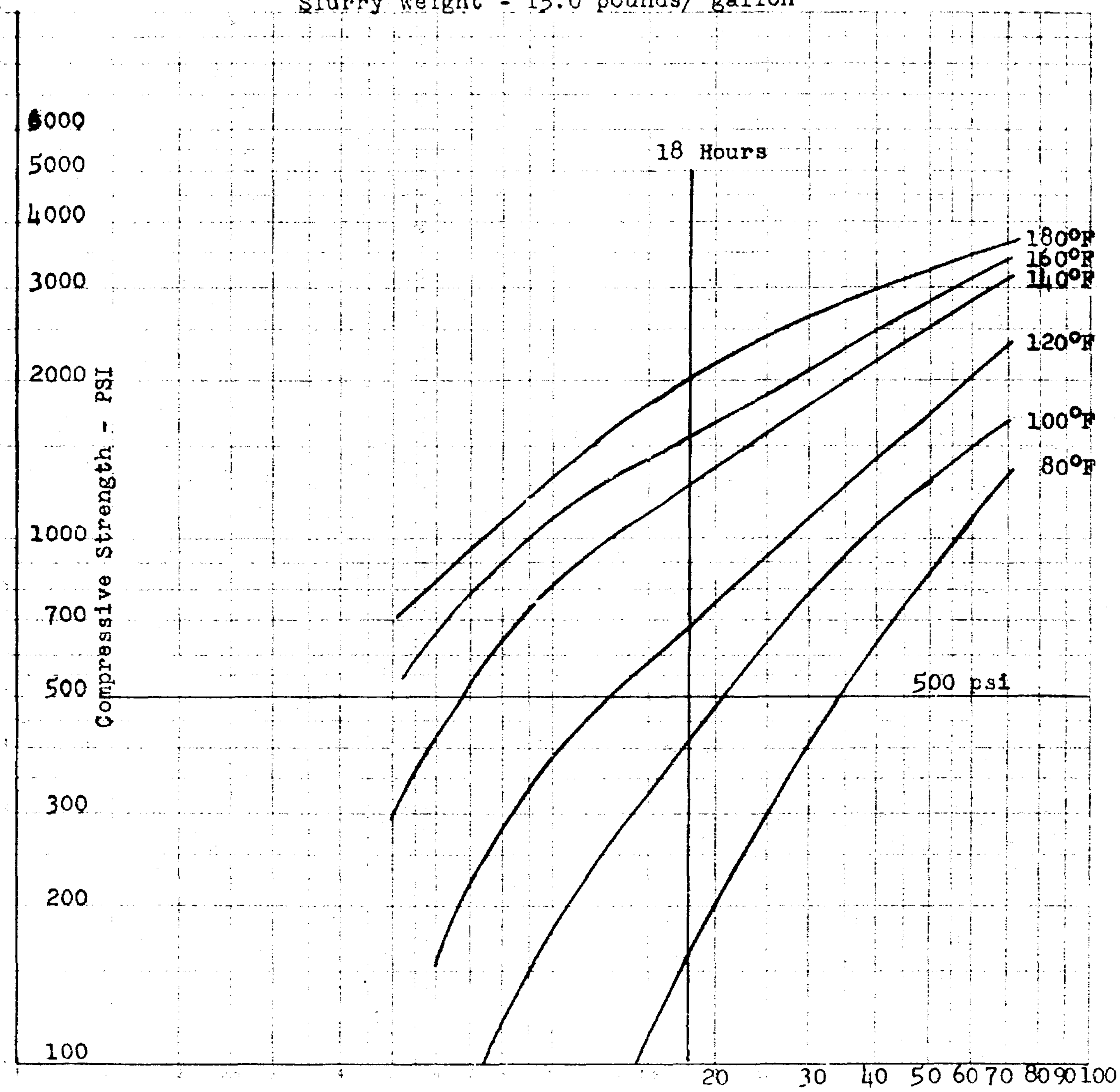
Howco Laboratories
7-9-58 KAS

50-50 Pozmix S-API Class A Cement
0% Bentonite
Water/Solids Ratio - 0.38
Slurry Weight - 16.0 pounds/gallon



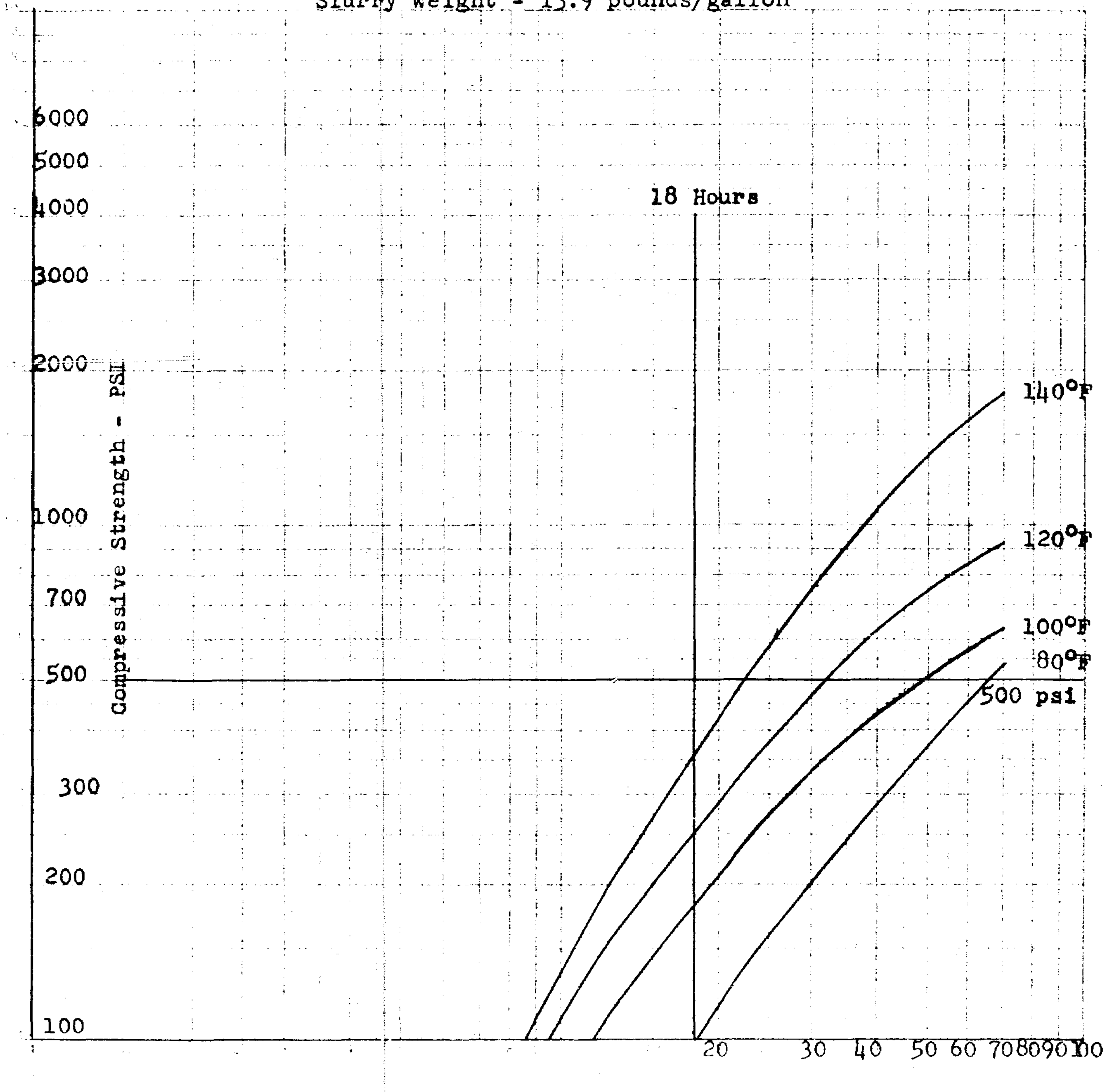
Howco Laboratories
7-9-58 KAS

50-50 Pozmix S-API Class A Cement
2% Bentonite
Water/Solids Ratio - 0.50
Slurry Weight - 15.0 pounds/ gallon



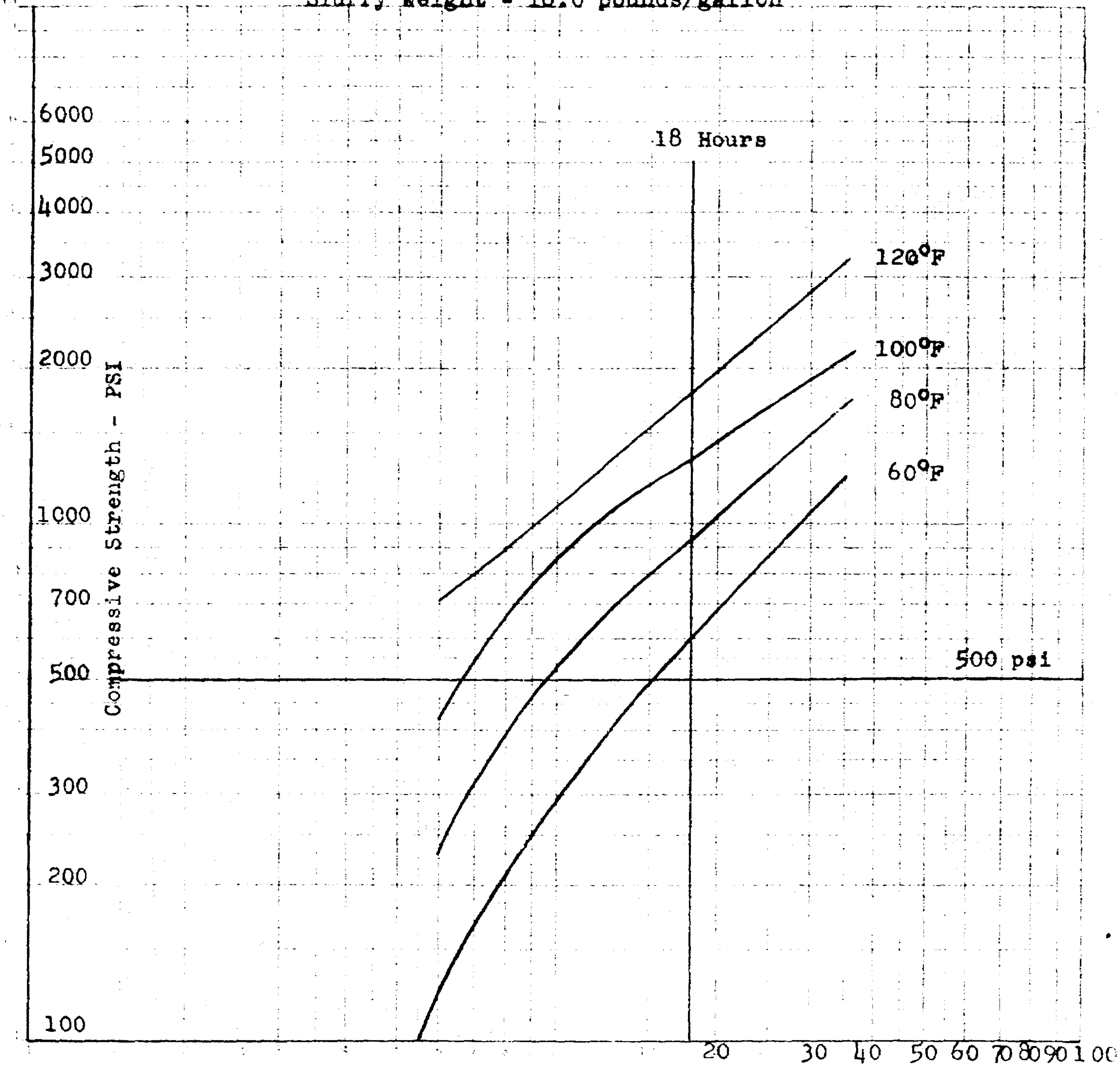
Howco Laboratories
7-9-58 KAS

50-50 Pozmix S-API Class A Cement
4% Bentonite
Water/Solids Ratio - 0.68
Slurry Weight - 13.9 pounds/gallon



Howco Laboratories
7-9-58 KAS

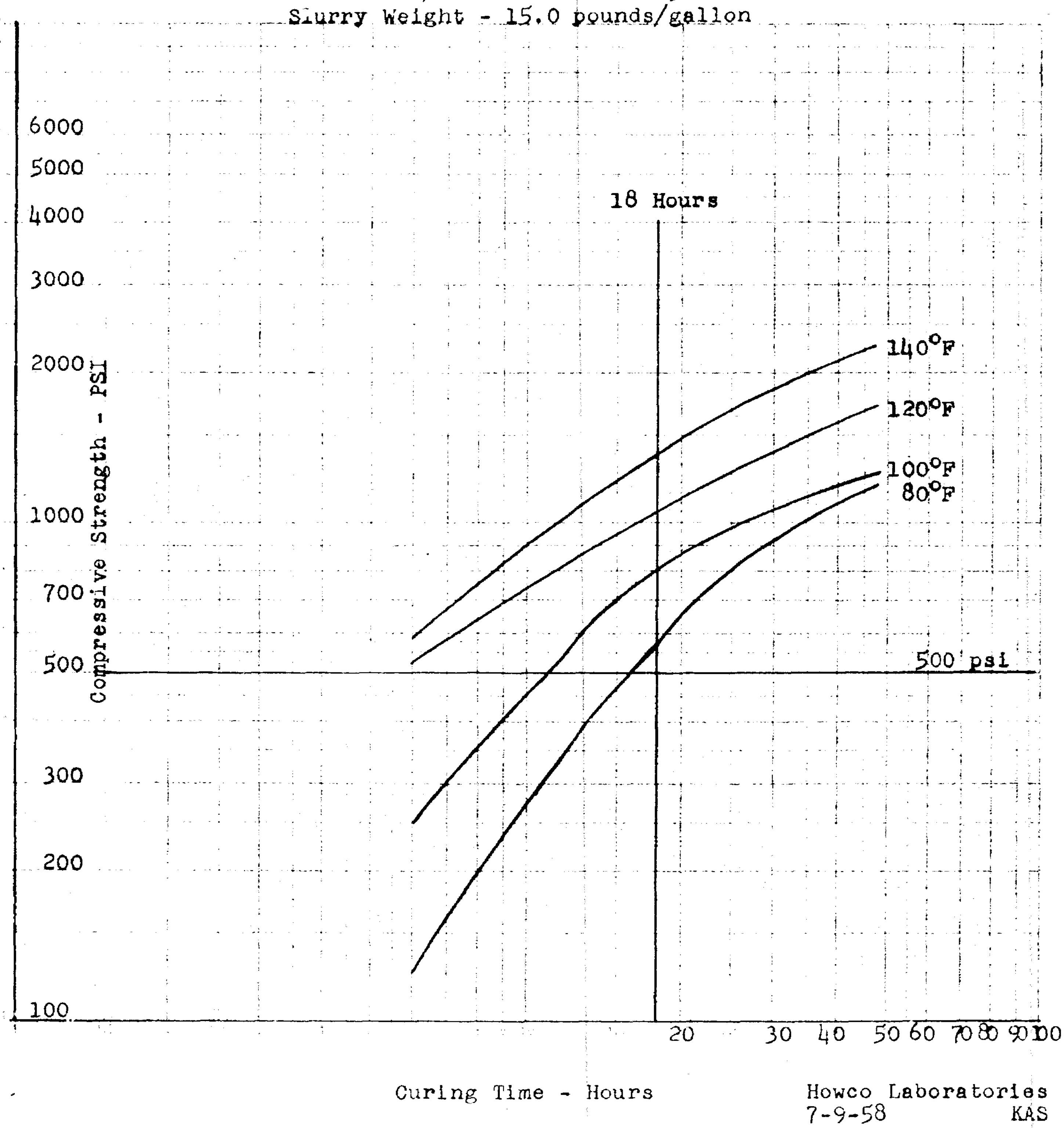
50-50 Pozmix S-API Class A Cement
0% Bentonite
2% Calcium Chloride
Water/Solids Ratio - 0.38
Slurry Weight - 16.0 pounds/gallon



Curing Time - Hours

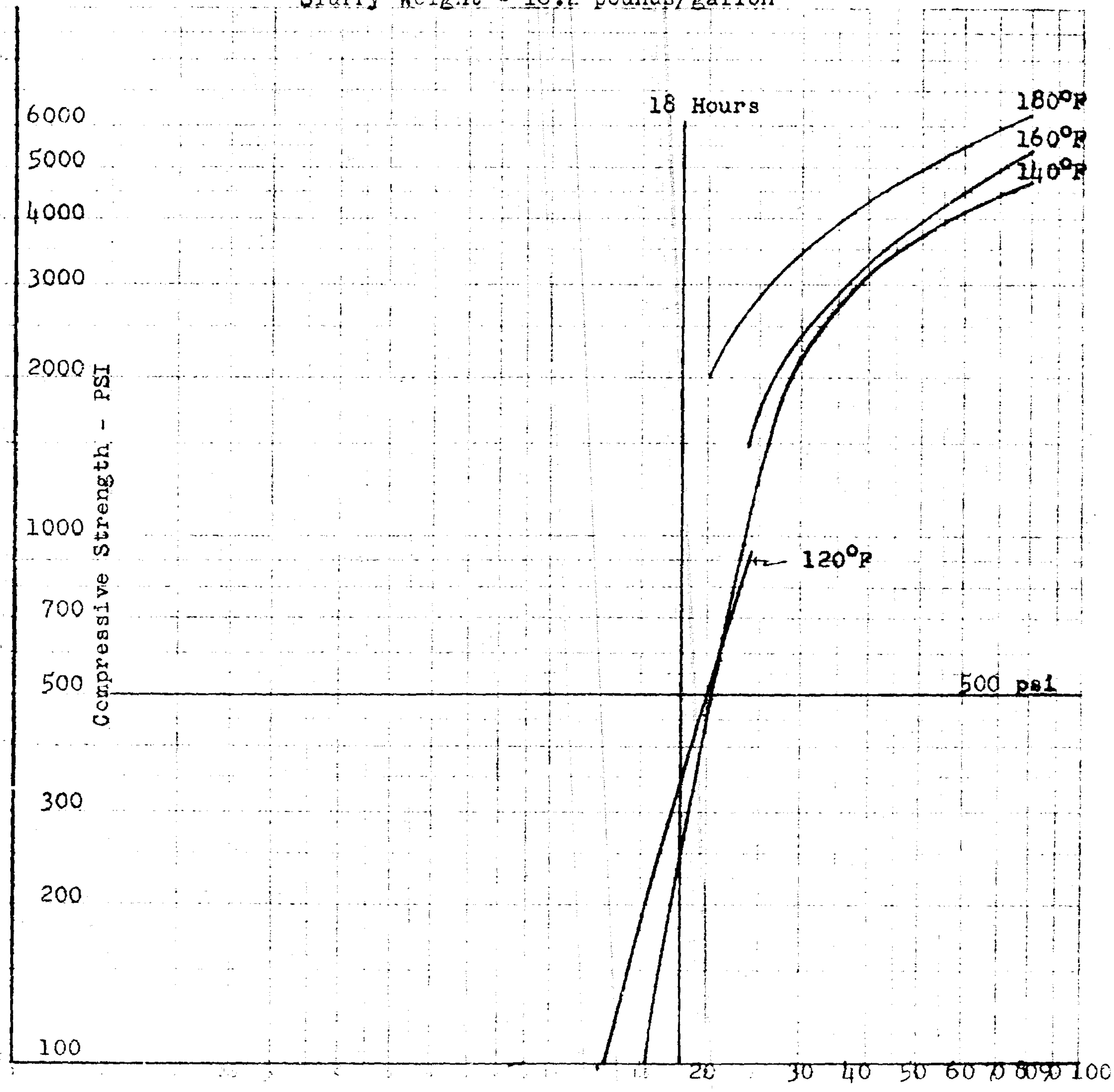
Howco Laboratories
7-9-58 KAS

50-50 Pozmix S-API Class A Cement
2% Bentonite
2% Calcium Chloride
Water/Solids Ratio - 0.50
Slurry Weight - 15.0 pounds/gallon



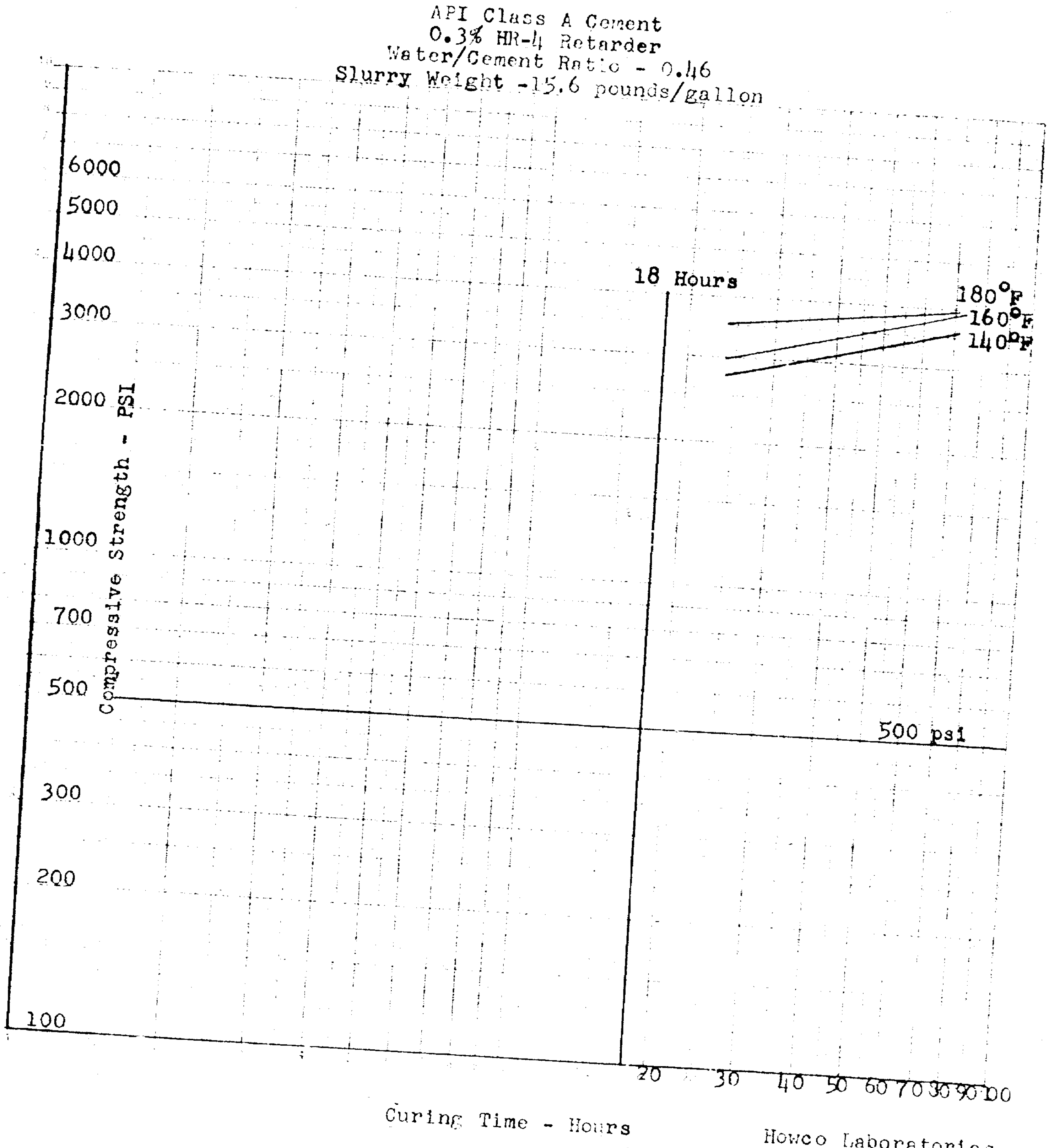
Howco Laboratories
7-9-58 KAS

API Class E Cement
Water/Cement Ratio - 0.40
Slurry Weight - 16.2 pounds/gallon



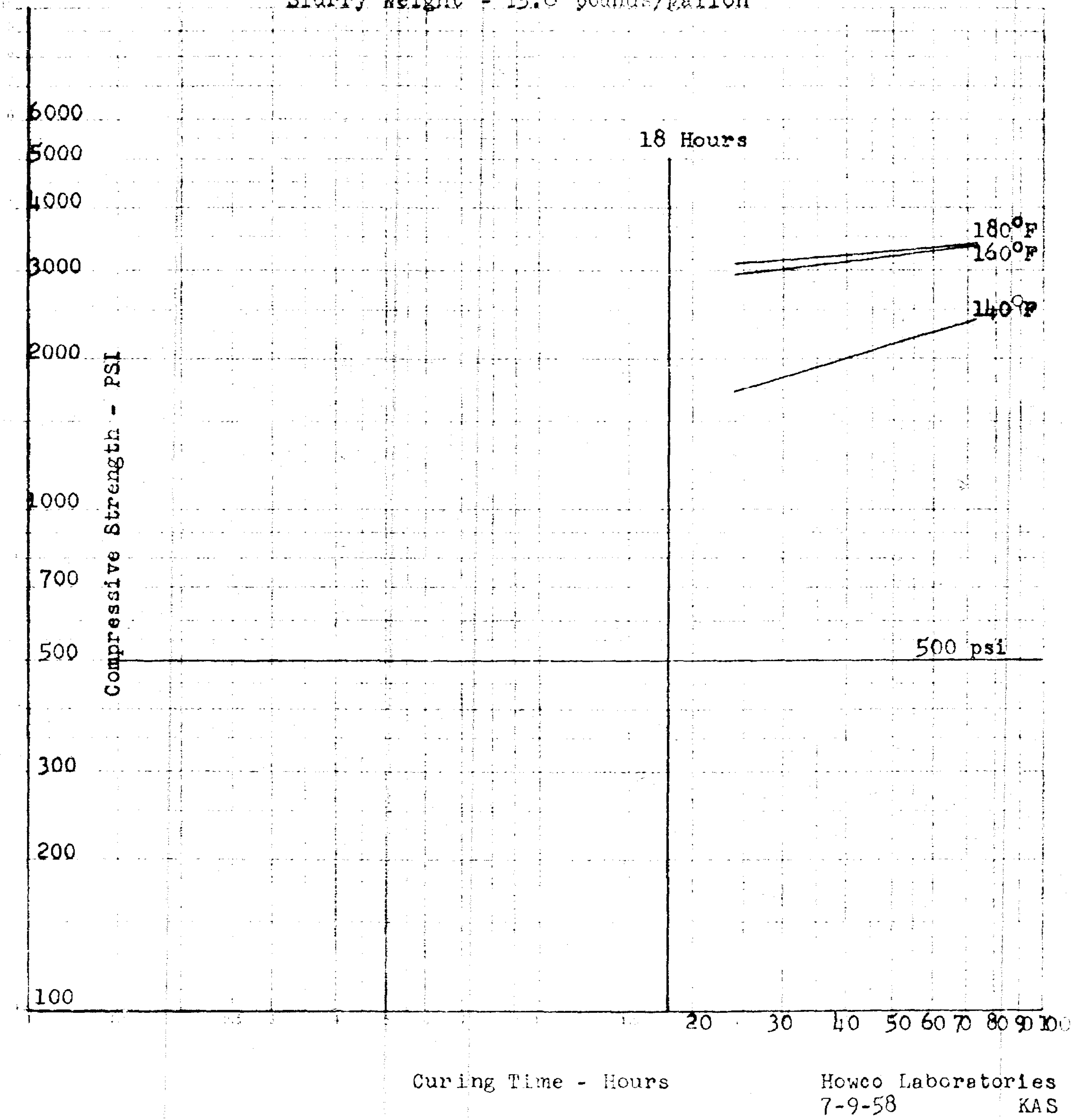
Curing Time - Hours

Howco Laboratories
7-9-58 KAS



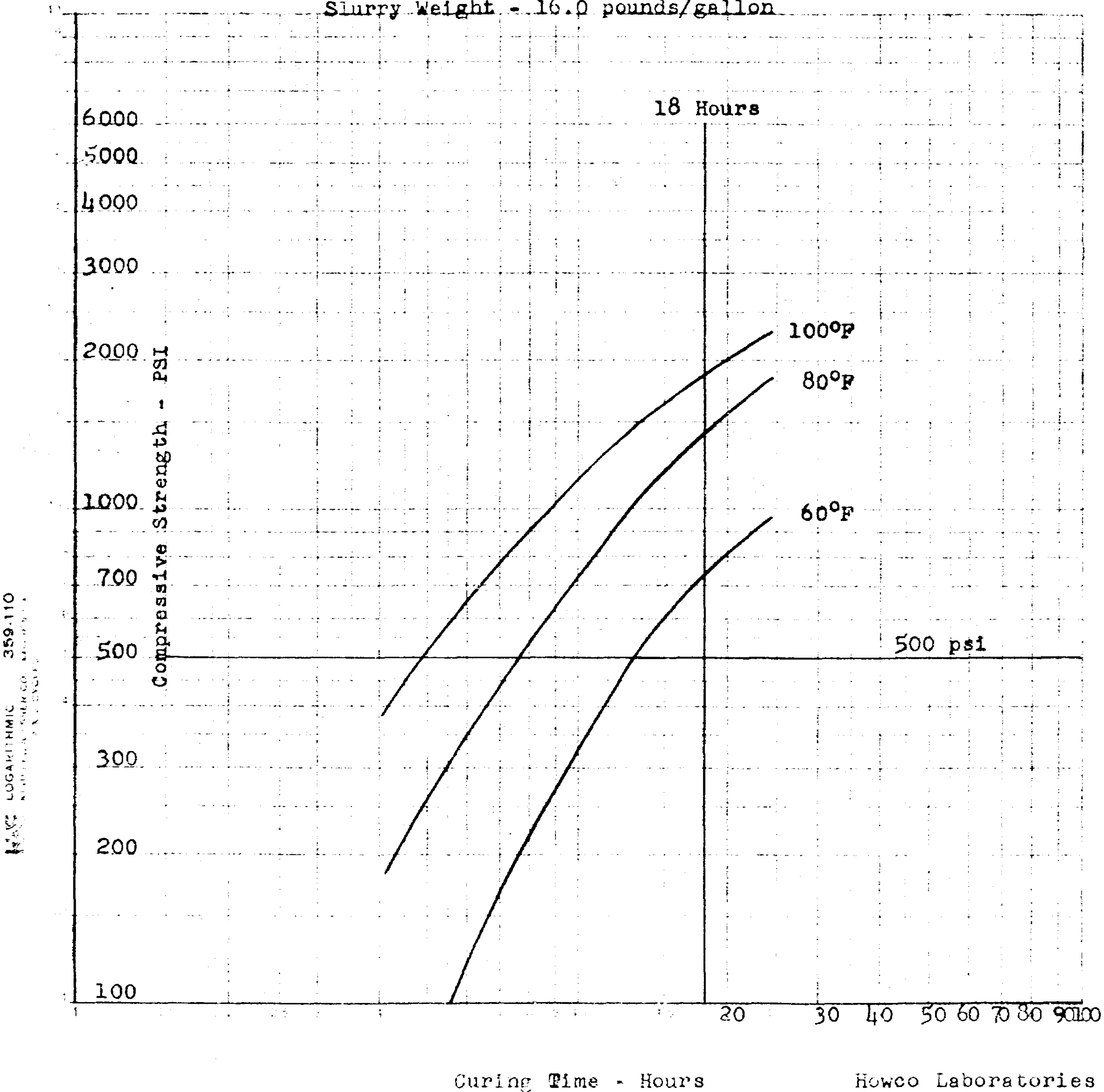
Howco Laboratories
7-9-58 KAS

API Class A Cement
0.5% HR-4 Retarder
Water/Cement Ratio - 0.46
Slurry Weight - 15.6 pounds/gallon



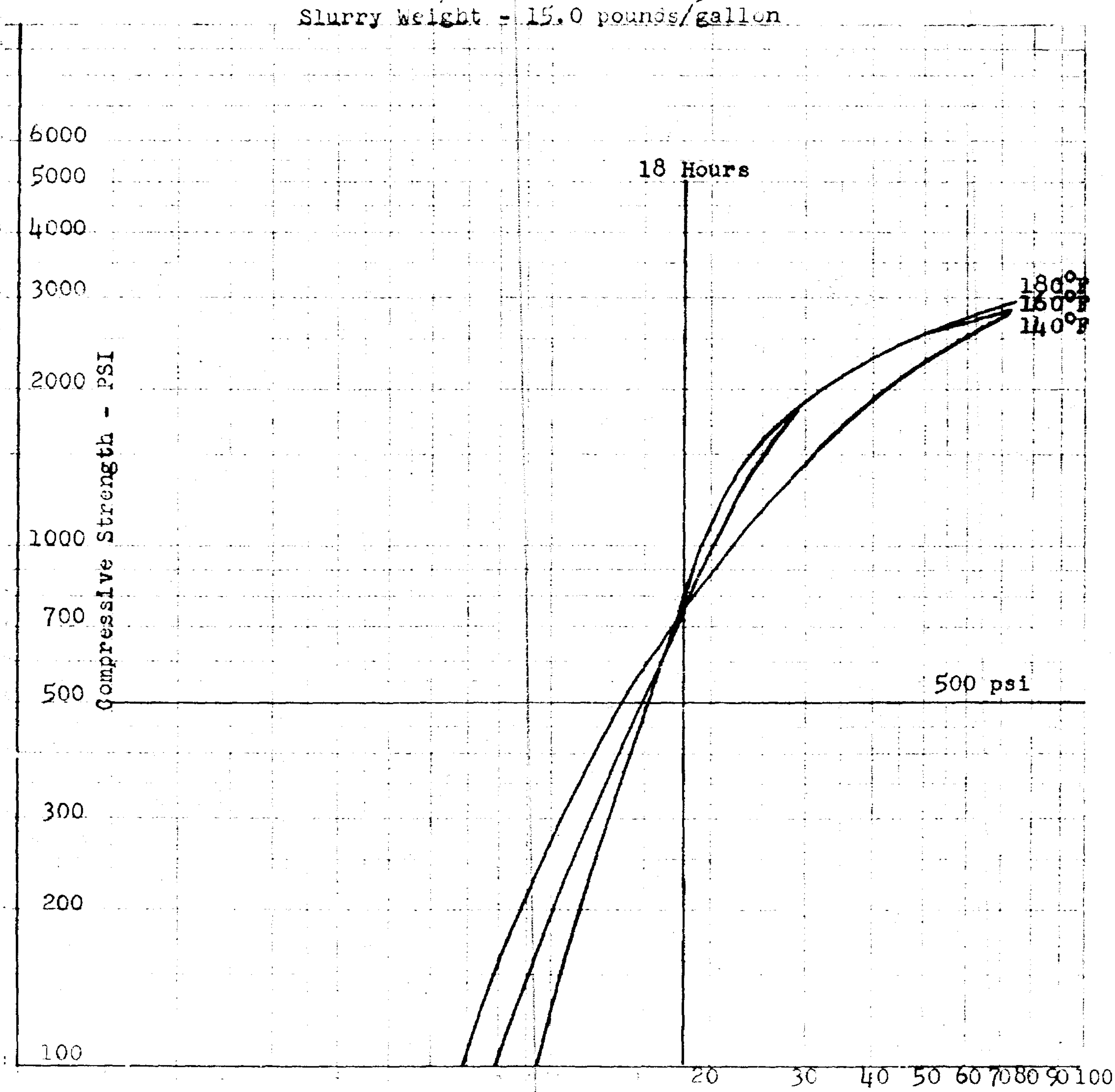
Howco Laboratories
7-9-58 KAS

50-50 Pozmix S-API Class A Cement
0% Bentonite
2% HA-5
Water/Solids Ratio - 0.38
Slurry Weight - 16.0 pounds/gallon



Howco Laboratories
7-9-58 KAS

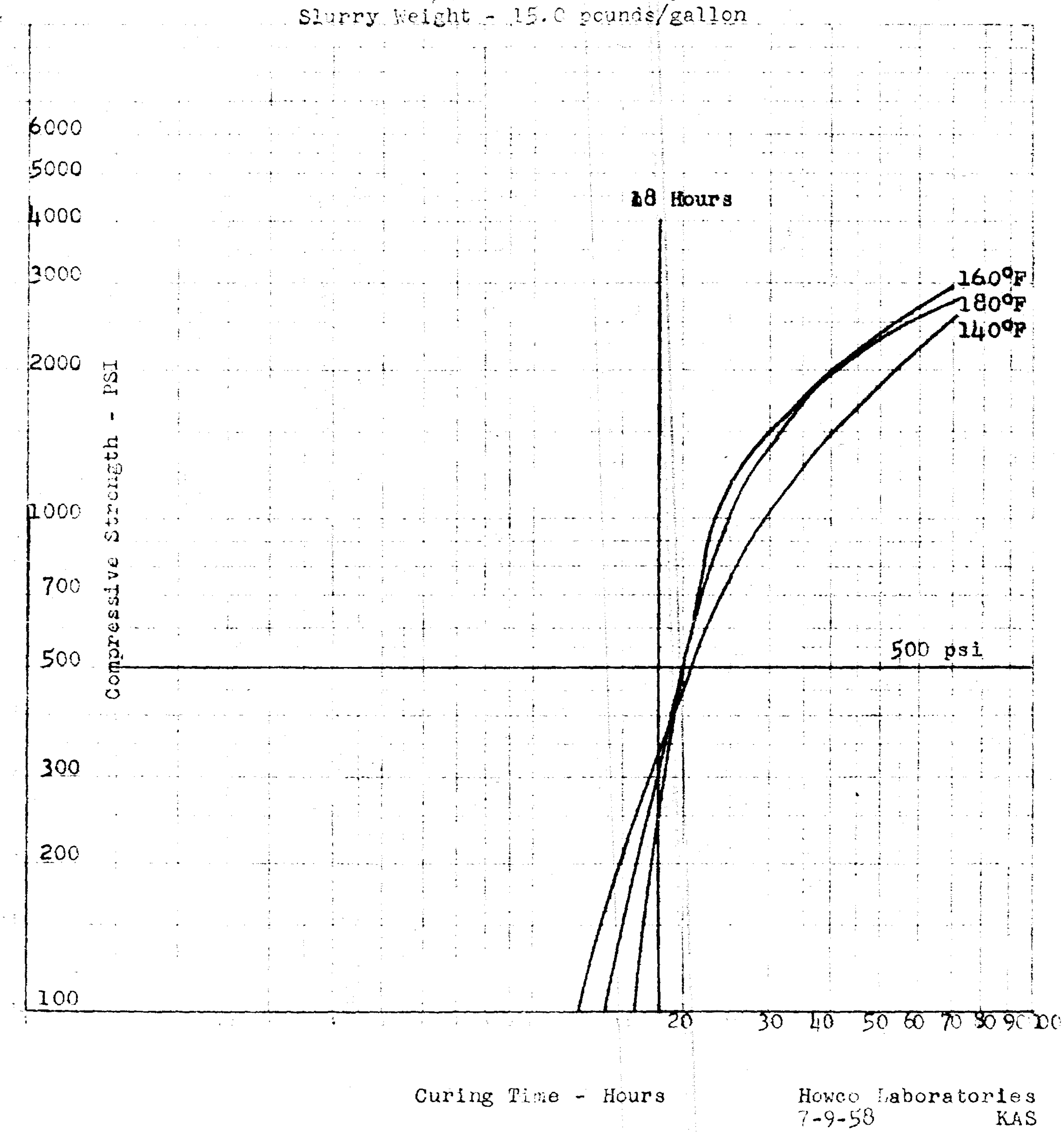
50-50 Pozmix S-API Class A Cement
2% Bentonite
0.3% HR-4 Retarder
Water/Solids Ratio - 0.50
Slurry Weight - 15.0 pounds/gallon



Curing Time - Hours

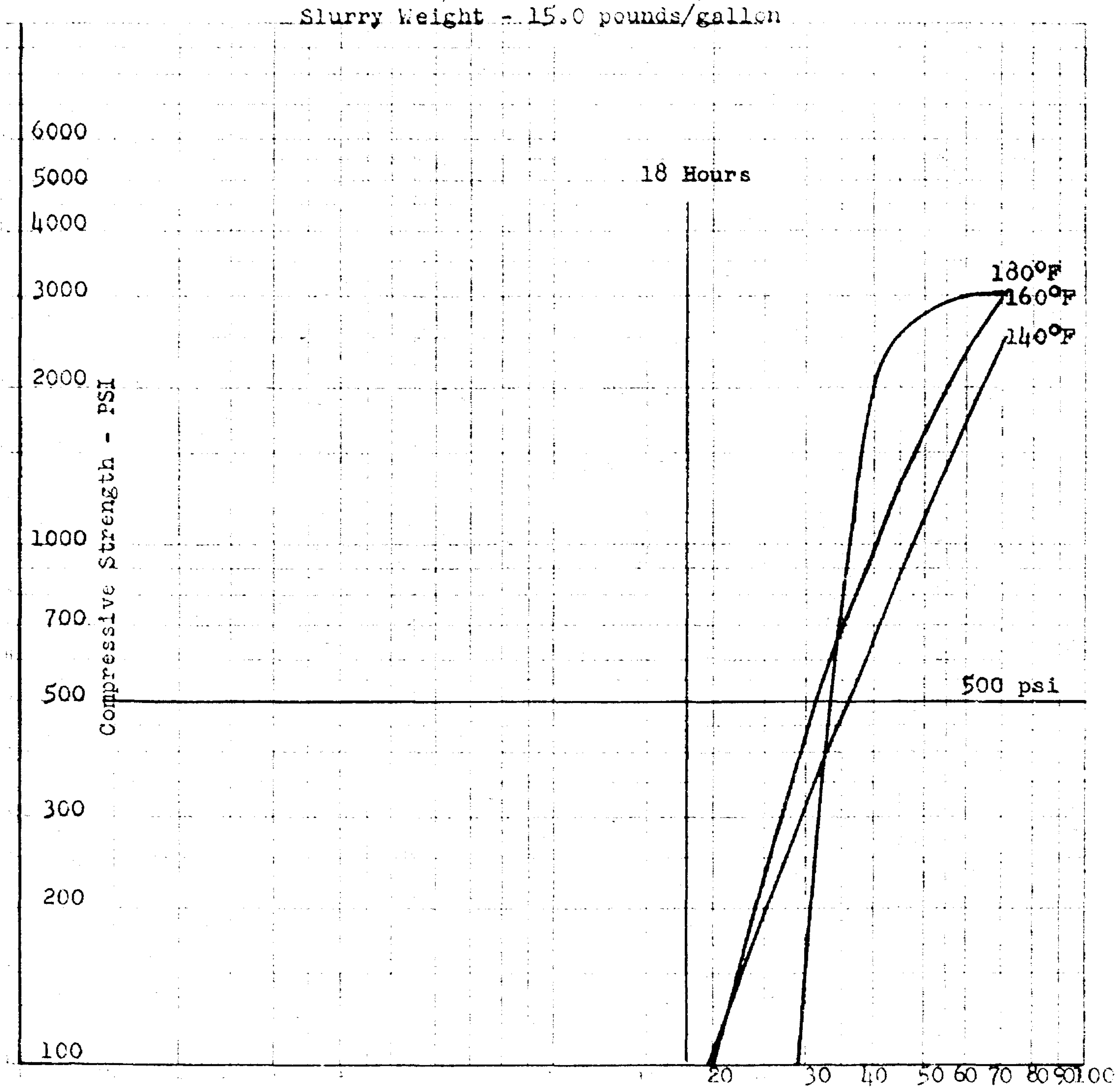
Howco Laboratories
7-9-58 KAS

50-50 Pozmix S-API Class A Cement
2% Bentonite
0.4% HR-4 Retarder
Water/Solids Ratio - 0.50
Slurry Weight - 15.0 pounds/gallon



Howco Laboratories
7-9-58 KAS

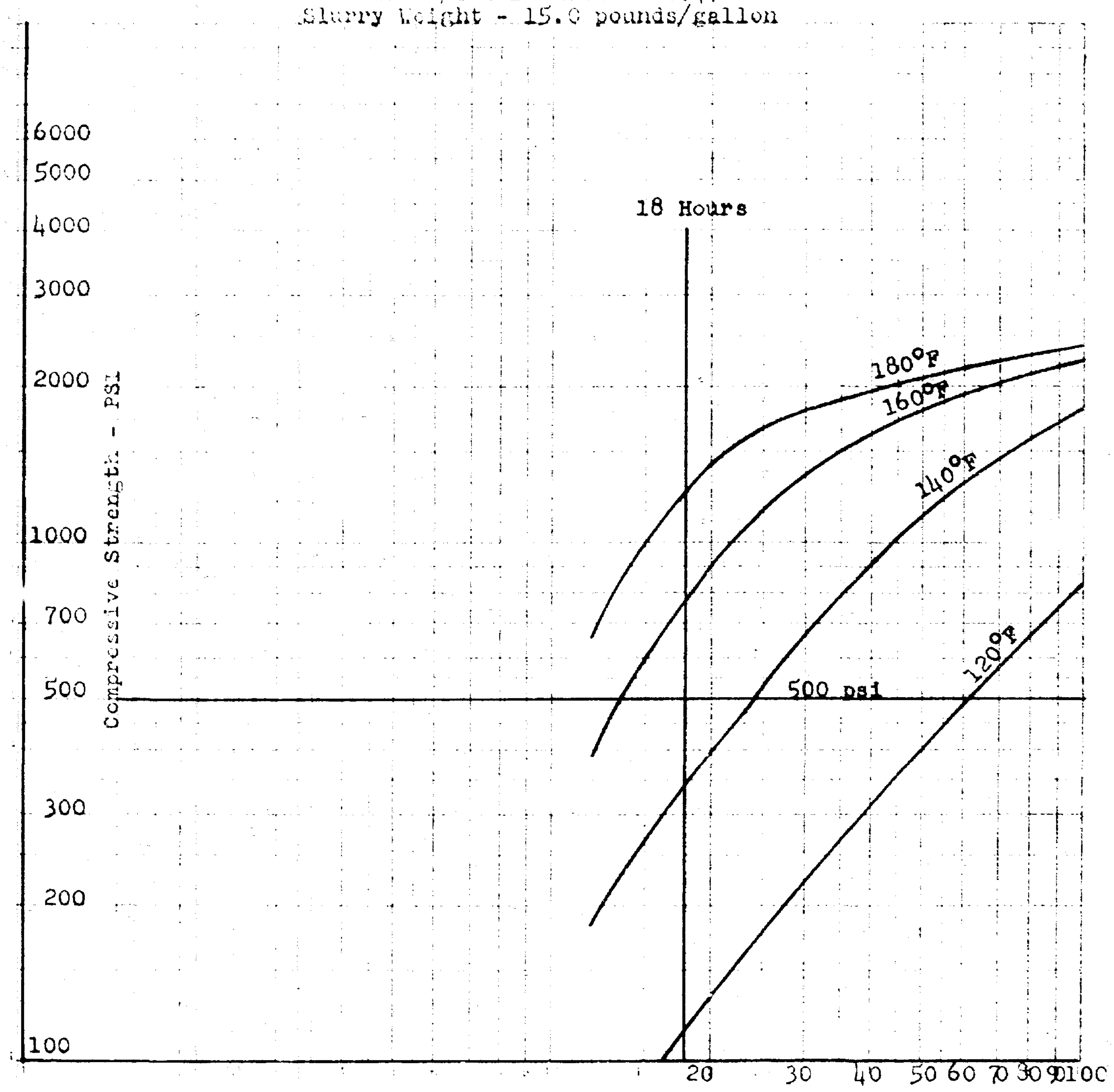
50-50 Pozmix S-API Class A Cement
2% Bentonite
0.5% HR-4 Retarder
Water/Solids Ratio - 0.50
Slurry Weight - 15.0 pounds/gallon



Curing Time - Hours

Howco Laboratories
7-9-58 KAS

Pozmix S 140
Water/Pozmix Ratio - 0.47
Slurry Weight - 15.0 pounds/gallon



Curing Time - Hours

Howco Laboratories
7-9-58 KAS

Halliburton OIL WELL CEMENTING COMPANY
DUNCAN, OKLAHOMA

CHEMICAL RESEARCH LABORATORIES
HAYDEN ROBERTS, SUPERVISOR
FRANCIS M. ANDERSON, ASST. SUPERVISOR

August 4, 1958

Mr. A. L. Porter, Jr.
Oil Conservation Commission
State of New Mexico
P. O. Box 871
Santa Fe, New Mexico

Dear Mr. Porter:

In reply to your letter of June 3, 1958, we have prepared a series of curves illustrating the compressive strength of various cementing compositions presently being used in the state of New Mexico.

These have been prepared from data that we have accumulated in our laboratory and could be expected to be typical values at the time and temperature conditions shown.

As you know there are some variations in the strength of cement between different brands and batches, but this data should be a satisfactory guide for your Commission personnel

I trust this information will assist your personnel and we are happy to be of assistance.

Yours very truly,

Dwight K. Smith

DKS:lh
Encl.
cc: Mr. W. D. Owsley
Mr. Phil Montgomery
Mr. Hayden Roberts
Mr. F. M. Anderson