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WATER FLOWS AND PRESSURES OBTAINABLE WITH FORESTRY PUMPS AND HOSE

by

G. Williams-Leir

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OTTAWA

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PREFACE

The Division recognizes a special responsibility to assist government departments and agencies both federal and provincial with problems coming within the scope of its work. It has for some time been assisting the Associate Committee on Forest Fire Protection, upon which all provinces are represented, in the testing and evaluation of forestry fire hose. The work which is now reported grew in part out of current deliberations over specification requirements with regard to permissible hose leakage.

For the planning of firefighting operations it is necessary to know what flow of water at what pressure can be obtained with given equipment under given conditions. Tables already exist that supply this information, but in their calculation the effect of percolation or leakage has been neglected. It recently became apparent that modern developments in the field of computing devices make it practicable to calculate flows and pressures for unlined hose, which is widely used in Canada for forest fire protection, while taking into account the loss of water by leakage. When this was pointed out, interest was shown and arrangements were accordingly made to develop such information.

The author of this report is a research officer with the Fire Section of the Division.

Ottawa
February 1960

N. B. Hutcheon
Assistant Director

WATER FLOWS AND PRESSURES OBTAINABLE

WITH FORESTRY PUMPS AND HOSE

by

G. Williams-Leir

The objectives of the work now reported are threefold:

1. To supply information necessary to compile tables of water flows and pressures for fighting forest fires.

2. To assist those responsible for the choice of fire-fighting equipment.

3. To assist those responsible for preparing specifications for linen fire hose.

1. The usefulness of the jet of water directed by a fire-fighter is limited by the volume of flow and the pressure available at the nozzle. These in turn are governed by the characteristics of the pump, the hose, and the nozzle, by the distance horizontally and vertically that the water has to be transported, and by the atmospheric pressure at the pump, which affects the engine output. In forest firefighting, water is often pumped for long distances, so that for optimum deployment of resources the firefighter needs to know the result of calculations that can hardly be done on the spot. Figures 3 to 45 show the flows and pressures of water that may be expected from certain pumps, lengths and types of hose, nozzles, and gradients. Figures 46 and 47 are examples of how the same information can be rearranged in a form that may be more convenient to the firefighter.

2. Many factors must be considered in the choice of equipment. In particular, the decision whether to use linen or rubber-lined hose depends upon a balance between several considerations, including weight, initial cost, leakage, friction loss, and heat endurance. The leakage from linen hose serves to protect it from damage when it has to be dragged over ground where embers of a fire are still smouldering. However, a price has to be paid for this protection in terms of loss of water pressure resulting from leakage and increased friction. Rubber-lined hose has about half the friction loss and substantially no leakage. Given an estimate of the length of hose likely to be needed the information given in Figs. 48 to 56 makes it possible to estimate how much extra hose and pumping capacity will be needed for a given water power at the fire if linen hose is decided on.

3. In preparing specifications for linen fire hose an upper limit must be set to the permissible leakage from hose. Too low a limit will mean rejection of serviceable hose; too high a limit will mean that flow will diminish to a trickle over too short a hose line. The results of the work to be described are thought to indicate that the permissible leakage is appropriate as stipulated in the current specification, 13-GP-1a, of the Canadian Government Specifications Board (10).

RELATION OF THIS STUDY TO PREVIOUS WORK

Water flows and pressures have already been tabulated for a variety of conditions by Macleod (1). This work made no allowance for leakage, and relied on the conclusion of Hewson (2) that for new hose and pressures below 200 pounds per square inch leakage was negligible. Modern pumps, however, can give pressures in excess of this value and thus can deliver useful amounts of water through longer lengths of hose. The main difference between the present work and that of Macleod is that leakage has been allowed for, a leakage equal to the maximum permitted by the specification having been assumed in all cases. Since hose that has been accepted will normally be better than the worst acceptable, the results given are conservative, and the flows and pressures obtained in practice should be somewhat better than those tabulated, at least until the hose has deteriorated with age and service.

Calculations have confirmed that leakage is in fact negligible for short lines of hose up to say 1000 feet. At the other extreme, on long hose lines a point is reached where, through friction loss and leakage, the water power available is so low that the line is not worth laying. However, there is an important range between these extremes within which a useful amount of water can be obtained even though the ratio of leakage to nozzle flow is appreciable.

Since leakage has been allowed for, the flows and pressures indicated are in all cases lower than those in Macleod's tables. For good new hose the results found in practice may well be nearer to Macleod's, especially for short lines.

Analytical solutions for other problems similar to but distinct from the leaky hose problem have been published by Olson for the case of laminar flow with leakage proportional to the square root of pressure (3), and by Richardson for laminar flow with leakage proportional to pressure (4).

SOURCES OF EQUATIONS AND CONSTANTS

Pumps

The first essential is to know the output of the combination of a motor and a pump. This is given by a characteristic, a graph in which pressure delivered is plotted against flow. In the exploratory stage of the work there was no reason to prefer any particular pump and the characteristic for pump B was used.

When the procedure had been worked out, a decision had to be made regarding the choice of pumps for which the main calculations would be done. Advice on this point was sought and received to the effect that pumps of types W and D were the most widely used. Type W pump is the one most commonly procured at present for use in forestry service; type D pumps, although no longer being made, are also still in wide use. In view of this, pumps of types W and D were used for the calculations.

Pumps B and D are those so referred to in Macleod's report (1), from which their characteristics were taken. The characteristic for pump W was taken from a report by Sharp (3). The conditions under which this was determined were: "Inlet: 2-inch pipe. After muddy water test." This particular characteristic was selected so that the results would be typical of a pump that had seen some service rather than of a new one.

Elevation at Pump

If a pump is operating considerably above sea level the efficiency of the gasoline engine driving it is reduced. Characteristics for pumps B and D are available (1) for two different elevations, sea level and 4,000 feet. Apart from using the appropriate characteristic, the calculations are unaltered.

Hose Friction

The equation of Colebrook and White (6) for friction loss in rough pipes is as follows:

$$\frac{1}{\sqrt{f}} = -2 \log_{10} \left(\frac{E}{3.7d} + \frac{2.51}{R\sqrt{f}} \right) \qquad (1)$$

where f = the Darcy-Weisbach friction factor

$$\left.\begin{array}{l} E = \text{roughness} \\ d = \text{diameter} \end{array}\right\} \text{ in the same units}$$

R = Reynolds number

This equation may be used to co-ordinate the results of various experimenters. Roughness has been calculated from the friction losses reported for various sizes of hose (Table I). The calculation was simplified by working from the highest pair of values in each table quoted and neglecting the second term on the right-hand side of Equation (1), which is small at the higher Reynolds numbers. Nominal diameters were used.

TABLE I

ROUGHNESS OF UNLINED FIRE HOSE

Reference	Diameter (inches)	Roughness (inches)
Underwriters' Laboratories as reported by King (7)	2.5	.018
NFPA tables (8)	1.25	.019
ditto	1.5	.018
ditto	2.0	.021
ditto	2.5	.024
J.F. Fry (9)	1.75	.038
ditto	2.75	.040
ditto	3.5	.046
D.T. Hewson (2)	1.5	.021
M. Marchetti (12)	1.77	.090
ditto	2.76	.117
ditto	3.94	.086

The hemp hose used in Marchetti's experiments and the hose used by Fry in his tests would appear to be significantly rougher than that used by other workers. The other measurements agree in indicating a roughness close to 0.02 inch. If this value is then applied in Equation (1) for $1\frac{1}{2}$-inch hose the pressure drops in the first line of Table II are obtained. If, as before, the second term in Equation (1) is neglected, E = 0.02 inch, leads to f = 0.0419 in the Darcy-Weisbach formula:

$$\frac{h}{L} = \frac{8f\ Q'^2}{\pi^2\ g\ D^5} \qquad (2)$$

where h = friction head (feet)

L = length of hose (feet)

Q' = **rate of flow** (cubic feet per second)

D = diameter (feet)

This leads to the values tabulated in the second line of Table II. Hewson's experimental results (2) follow in the third line, and the fourth contains values calculated from Equation (3), based on the Hazen-Williams equation and the NFPA table.

$$\frac{dp}{dx} = -FQ^g \qquad (3)$$

where p = pressure (pounds per square inch)

x = distance (feet)

Q = flow (imperial gallons per minute)

g = 1.85

F = 2×10^{-4} for unlined hose, or 0.92×10^{-4} for rubber-lined hose.

For flows up to 60 gallons per minute the discrepancies between the different values are not serious. Equation (3) was used in the computations to be described.

TABLE II

COMPARISON OF FORMULAE FOR FRICTION LOSS IN UNLINED HOSE

Flow (imperial gallons per minute)		20	40	60	80
Pressure drop per 100 feet of hose, according to:	Equation (1)	4.4	17.4	38.8	69.5
	Equation (2)	4.3	17.1	38.5	68.4
	Hewson experiments (2)	5.4	18.5	39*	--
	Equation (3)	5.1	18.4	38.8	66.2

* Extrapolated

Gravity Head

The reduction in pressure on moving one foot upwards in stationary water is 62.4/144 or 0.434 pounds per square inch. If water is being pumped up a gradient, this effect may be allowed for by increasing the pressure loss from friction by $k \sin \alpha$ pounds per square inch per foot run of hose, where α radians is the inclination of the hose to the horizontal and $k = 0.434$.

Thus friction and gravity loss may together be represented by:

$$\frac{dp}{dx} = -FQ^g - k \sin \alpha \qquad (4)$$

Hose Leakage

For rubber-lined hose, leakage may be treated as negligible.

Hewson's measurements of leakage of linen hose as a function of pressure are somewhat confounded with the effect of wetting, since he started each series of tests with dry hose.

An estimate may be made, however, by comparing the last leakage measurement before each pressure increase with the measurement immediately following. Averaging the ratio for eight pairs of values in each case, a ratio of 7.55 is found between leakage at 200 and at 100 pounds per square inch and of 5.33 between leakage at 300 and at 200 pounds per square inch. If a relationship of the following form is assumed:

$$\frac{dQ}{dx} = -mp^n \qquad (5)$$

(where m and n are constants) then the index n is determined as 3.36.

It remains to estimate m. It is desirable that the calculations to follow should have a conservative basis. Accordingly a value of m has been used such that the hypothetical hose for which the calculations are exact is one that only just complies with the current specification (10), that is, one that has exactly the maximum permitted leakage, as determined under the conditions laid down. Most accepted hose comes well within the maximum and consequently should give better deliveries than those tabulated in Figs. 3 to 45.

The leakage at 200 pounds per square inch governs: 0.5 imperial fluid ounces per foot per minute,

whence $m = 5.8 \times 10^{-11}$

The available information does not permit great confidence in the value chosen for n, and one-figure accuracy is all that can be expected.

If we set $n = 3$, m becomes 4×10^{-10}

Effect of Wetting Time on Leakage

Another important factor governing the behaviour of unlined linen hose is the length of time since first wetting the hose. Initially, linen hose is very leaky, but as the fibres absorb water and swell they gradually reduce the size of the interstices. The current specification (10) stipulates that leakage be measured at 200 pounds per square inch from 27 minutes to 37 minutes after first wetting the hose. Thus the m value, and consequently all results derived for linen hose, may be taken as applicable to hose that has been exposed to water for about half an hour. Before this the leakage will be greater and the delivery less; after half an hour the reverse should apply, though any further improvement in delivery will probably be small.

Nozzle Discharge

If frictional losses are neglected, it may be shown from first principles that:

$$Q = \frac{\pi}{2\sqrt{2}} d^2 \sqrt{\frac{p}{s}} \qquad (6)$$

where Q is the volume per unit time of a liquid of density s driven through a nozzle of diameter d by a pressure p, all in centimetre-gram-second units.

Introducing a coefficient of discharge c to allow for friction, converting to engineering units, and restricting the discussion to water:

$$Q = 24.9\ cd^2 \sqrt{p} \qquad (7)$$

A coefficient of discharge 0.98 has been assumed for all sizes of nozzle in calculating the "nozzle curves" shown in Figs. 3 to 45.

SOLUTIONS

Let p and Q take the values p_o and Q_o at the pump,

where $n = 0$; and p_n and Q_n at the nozzle,

where $x = x_n$.

These quantities are related by Equations (4) and (5) and by the following:

From Equation (6)

$$Q_n = ad^2 \sqrt{p_n} \qquad (8)$$

(where $a = 24.9 \times 0.98$)

For the pump characteristic,

$$Q_o = f\ (p_o). \qquad (9)$$

Solution For Rubber-lined Hose

Where leakage is negligible,

$m = o$,

$Q_n = Q_o$, and Equations (4) and (5) are readily solved:

$$p = p_o - x\ (FQ_o^g + k \sin \alpha) \qquad (10)$$

At the nozzle:

$$p_n = p_o - x_n\ (FQ_o^g + k \sin \alpha) \qquad (11)$$

$$= (Q_o / ad^2)^2 \qquad (12)$$

Therefore, $$p_o = Q_o^2 / a^2 d^4 + x_n\ (FQ_o^g + k \sin \alpha) \qquad (13)$$

Equations (9) and (13) now describe the problem. For each set of values of α, x_n, and d, a curve may be plotted of Q_o against p_o from Equation (13). The intersection with the pump characteristic, Equation (9), is the solution for p_o and $Q_o = Q_n$; p_n may then readily be found from Equation (12).

Solution for the Case of Linen Hose

The analytical solution for zero leakage is not available for linen hose, where leakage cannot be neglected. When m is not zero there is no longer a simple solution to the simultaneous differential Equations (4) and (5).

The problem is well suited to solution, however, by means of an electronic analogue computer. In the circuit (Fig. 1) consider the function switch F_1 to be in the down position. When $p_o/4$ is fed in at P10 it is applied as an initial condition to A2 and at the same time Q_o is produced by the function generator in which is stored the pump characteristic, Equation (9). Considering the output of A2 to be P/4, the expression on the right-hand side of Equation (5) is generated in DFG 2 and then integrated by A1 producing Q. Thence a potential representing Q is fed to DFG 4. The output, after multiplying by a constant for the friction factor of the hose, and adding one or other of the constant potentials from P5 and P6 for the gravity head, is the right-hand side of Equation (4). When this is integrated by A2 the output is P/4, as postulated above, thus completing a loop.

Pressure and flow are thus represented by potentials; and since the integrations were performed with respect to time, time represents distance along the hose line. The results could have been presented by causing a recorder to plot each of these potentials against time. It was more convenient, however, to plot pressure and flow against one another, and to superimpose a time marker each second to represent a given increment of distance along the hose; the remainder of the circuit exists to generate this marker. It is delivered through P11, which adjusts its size, to function switch F3, which permits it to be applied as a horizontal or vertical blip, whichever will show best on the record.

The operating procedure was as follows. Starting with an arbitrarily chosen value of p_0, the solution was examined until either p or Q approached zero. It was then repeated with a new value of p_0, on the same recorder chart until sufficient of the range of possible values was filled in.

The locus of the first blip on each curve then represents conditions at a uniform distance along the hose, specifically, 500 feet from the pump. It is in effect a characteristic for the combination of a pump and 500 feet of hose. Similarly the locus of the second blip represents 1000 feet along the hose and so on.

These loci are the downward-sloping curves in Figs. 3 to 45; they will henceforth be called "hose curves". On each graph a family of parabolas has been superimposed, representing Equation (8) for a range of nozzle diameters d. Calling these "nozzle curves", it will be seen that each intersection of a hose curve and a nozzle curve represents a solution of the problem.

Once the computer has been set up for the linen hose problem it is a simple matter to arrange function switch F_1 so that the constants can be adjusted to those appropriate for rubber-lined hose. Though, as already shown, this problem can be solved without a computer, it is much more quickly solved with one, and consequently each case was worked out for each of the two types of hose. The results for rubber-lined hose, which can be independently checked provide valuable reassurance of the correct functioning of the computer on both problems.

RESULTS

1. Graphs at Constant Gradient

Consider any one of the graphs in Figs. 3 to 45. Suppose that water is being pumped uphill a height v vertically though a length x of hose. The gradient is then v/x. Each case has been worked for five gradients from nil to approximately 16 per cent. Having found the graph appropriate to the type of pump, the elevation at the pump, the type of hose, and the gradient, first select the hose curve appropriate to the distance from pump to nozzle, and then select the nozzle curve appropriate to the size of nozzle. Where the hose curve and the nozzle curve intersect, both the pressure at the nozzle and the flow through the nozzle may be determined.

This is the form in which it has been practical to compute the results. However, it is possible to present the same information in a form more convenient to the user. If the results are to be presented on two-dimensional graph paper the required quantity may be shown as a function of not more than two independent variables, with all other parameters held constant.

For instance, in each of Figs. 3 to 45, flow is shown as a function of pressure and length of hose or length of hose and nozzle size with gradient, type of hose, and type of pump held constant. A solution is available for just five values of gradient, and since the position where water is needed is not under the operator's control, interpolation will be necessary in most cases. Thus it is more convenient to present flow as a function of gradient and length of hose, with pressure and other parameters held constant. The independent variables are equivalent to horizontal and vertical distance from pump to nozzle, and in Figs. 46 and 47 flow is shown in terms of these distances.

2. Graphs at Constant Pressure

Figures 46 and 47 give information on the conditions under which 20 pounds per square inch will be attained at the nozzle. For each nozzle size the limiting distance and lift may be read off, and since flow and length of stream both depend only on nozzle size and pressure both these quantities can be marked on each curve as well as nozzle size (the relationship giving length of stream being that given by Hewson (11)).

Twenty pounds per square inch was chosen as a useful firefighting pressure, but graphs for other pressures can be computed just as readily.

In the case of rubber-lined hose, the graphs at constant pressure may be derived from the treatment above, as follows:

From Equation (11)

$$x_n \left(FQ_o^g + k \sin \alpha\right) = p_o - p_n \qquad (14)$$

Let h and v be the horizontal and vertical co-ordinates of a point on a nozzle curve such as those in Fig. 46; then

$$v = x_n \sin \alpha, \text{ and, so long as } \alpha \text{ is small,}$$

$$h = x_n \cos \alpha \sim x_n$$

Substituting, we have the equation of the nozzle curve:

$$FQ_o^g \, h + kv = p_o - p_n \qquad (15)$$

Since p_n is constant along each nozzle curve, and therefore Q_o and p_o are constant also, this equation indicates that the nozzle curves are straight lines passing through

$$\left(0, \frac{p_o - p_n}{k}\right) \text{ and } \left(\frac{p_o - p_n}{FQ_o^g}, 0\right)$$

Figure 46 was obtained in this way.

The same result could have been obtained by transposing the data shown in Figs. 8 to 12, subject to some possible error. For linen hose transposition is the only method available.

In the case that has been worked, Fig. 47, the points appear to fall on a family of straight lines reasonably similar to those found for the rubber-lined hose. This greatly facilitates the interpolation.

As an example of the use of these curves, suppose that water is needed at a point 3000 feet from the source and 250 feet up. With linen hose a 3/8-inch nozzle must be used and 15 gallons a minute is obtained; with rubber-lined hose a ½-inch nozzle can be used and 27 gallons a minute are obtained, assuming that a pressure of 20 pounds per square inch is necessary in each case.

Similar graphs can readily be prepared for other pumps, elevations, and nozzle pressures.

3. Waterpower Curves

The water power at the nozzle, or the rate at which the stream of water could do work if suitably harnessed, can be expressed in horsepower as:

$$W = 0.000699\, p_n Q_n \qquad (16)$$

For instance, 50 gallons per minute at 30 pounds per square inch represents about 1 horsepower. If a single figure is required to represent the merit of a set of conditions, the waterpower may serve.

The computer circuit can readily be rearranged to generate this product, as shown in Fig. 2; only the four connections shown by dashed lines need be altered. The computer then plots waterpower against distance for any value of initial pressure p_o that is fed in. By repeating this operation with a series of values of p_o an envelope is built up representing the maximum available waterpower for the conditions, i.e., the power available if exactly the optimum size of nozzle were used.

Figures 48 to 53 give these envelopes.

The information provided by these curves may be used in various ways, of which examples are given in Figs. 54 to 56. These graphs show maximum waterpower available if linen hose is used as a proportion of what it would be if rubber-lined hose were used. It will be seen that for short distances - say up to 1000 feet - the penalty for using linen hose is not great; but at a mile less than half the waterpower is available. When this knowledge is weighed against the well-known advantages of linen hose - heat endurance, for example - an informed decision can be taken on which type of hose should be procured for a given service.

Acknowledgments

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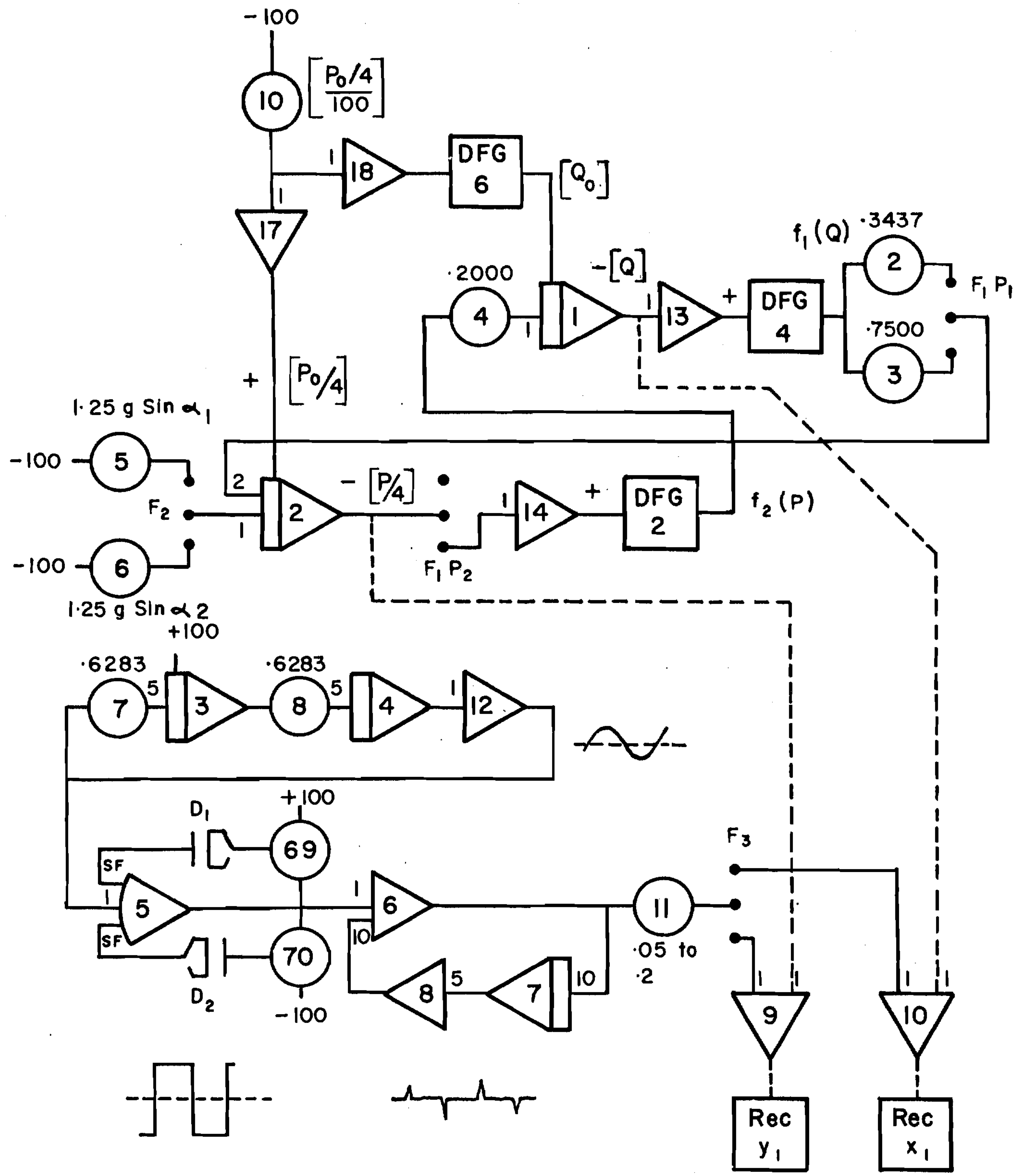


FIGURE 1 COMPUTER CIRCUIT — MODE 1

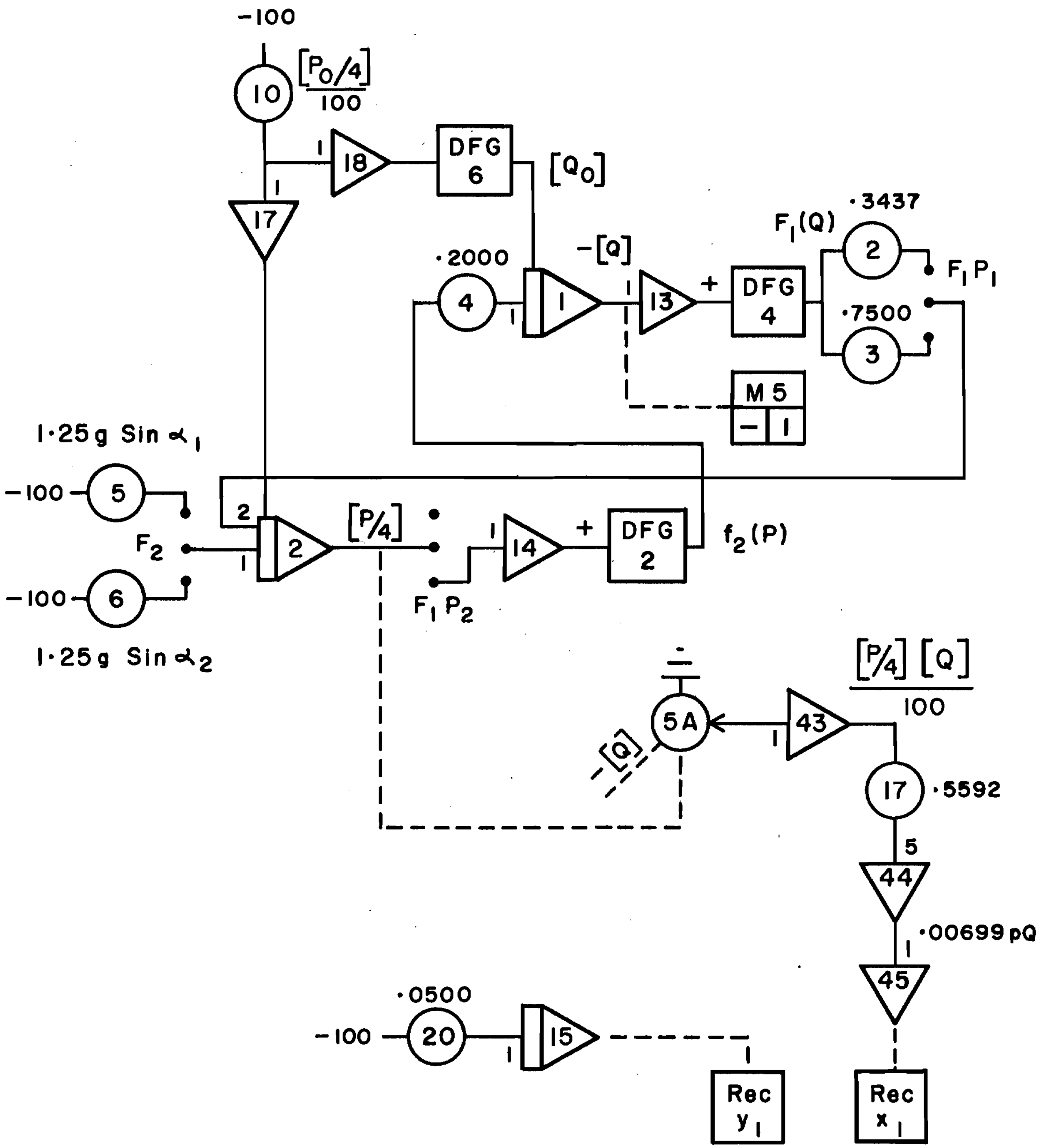


FIGURE 2 COMPUTER CIRCUIT – MODE 2

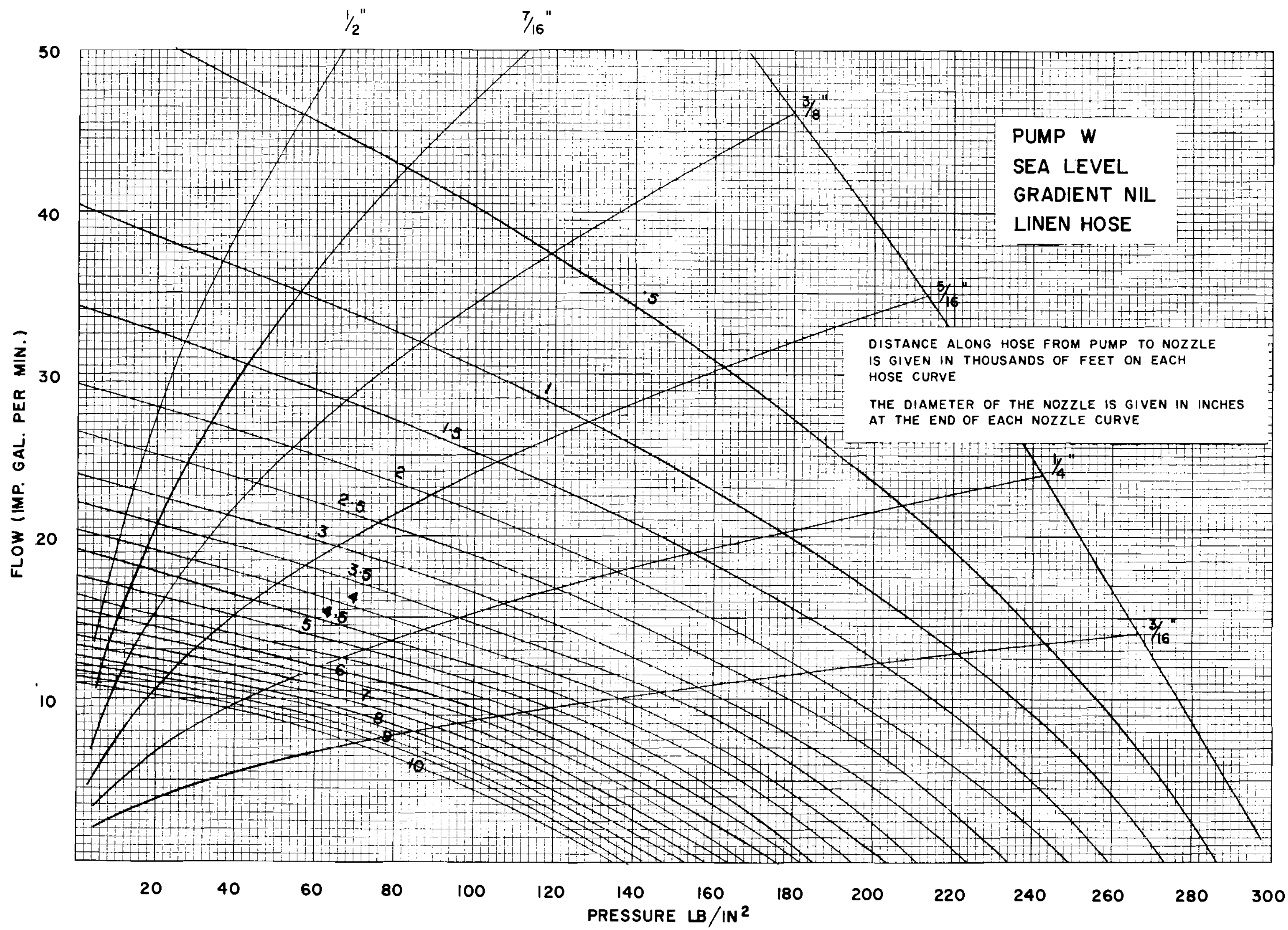

PUMP W
SEA LEVEL
GRADIENT NIL
LINEN HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
·5
1
1·5
2
2·5
3
3·5
4
4·5
5
6
7
8
9
10
FLOW (IMP. GAL. PER MIN.)
10
20
30
40
50
PRESSURE LB/IN²
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

FIGURE 3

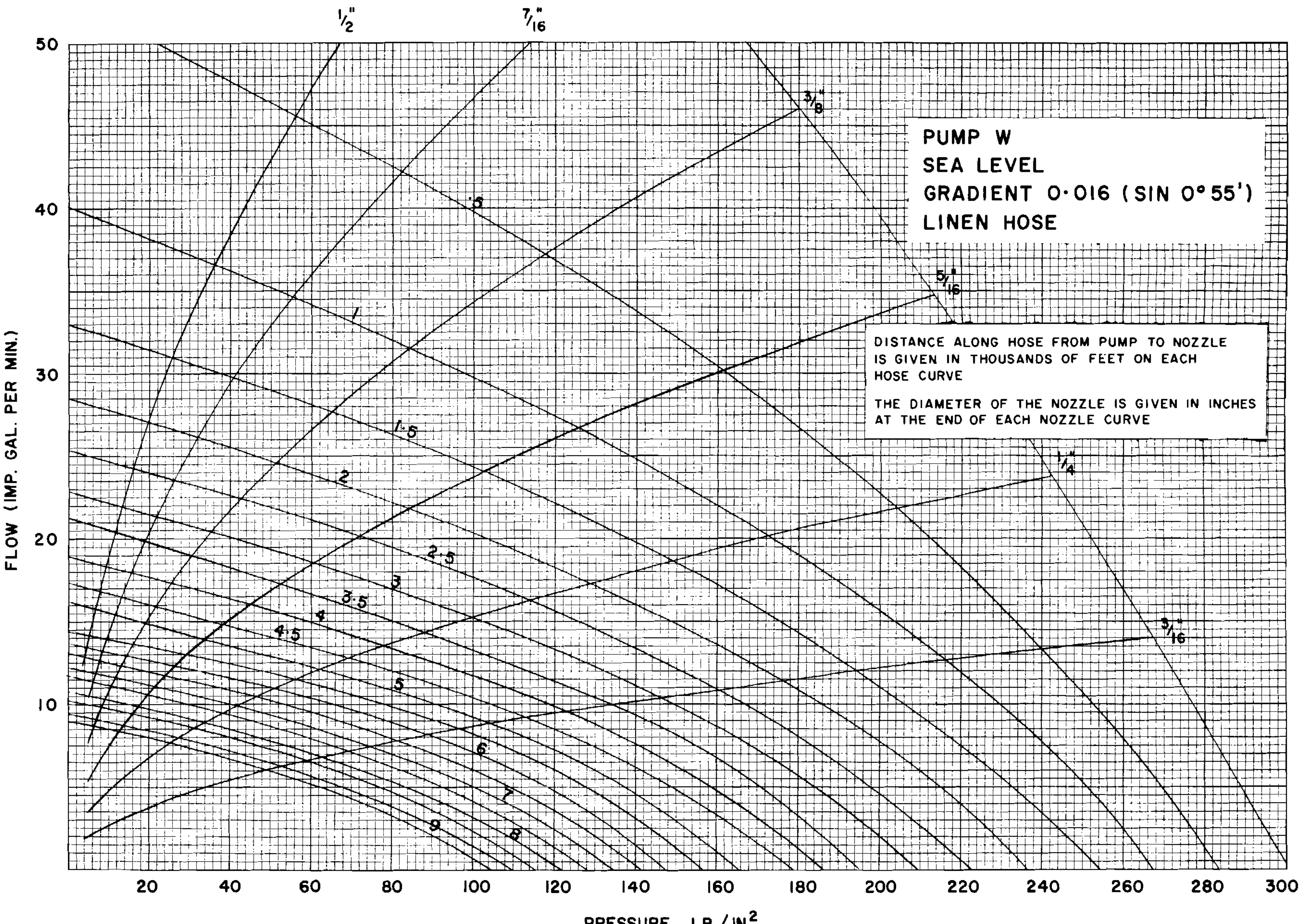

PUMP W
SEA LEVEL
GRADIENT 0·016 (SIN 0° 55')
LINEN HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
·5
1
1·5
2
2·5
3
3·5
4
4·5
5
6
7
8
9
FLOW (IMP. GAL. PER MIN.)
PRESSURE LB / IN²
10
20
30
40
50
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

FIGURE 4

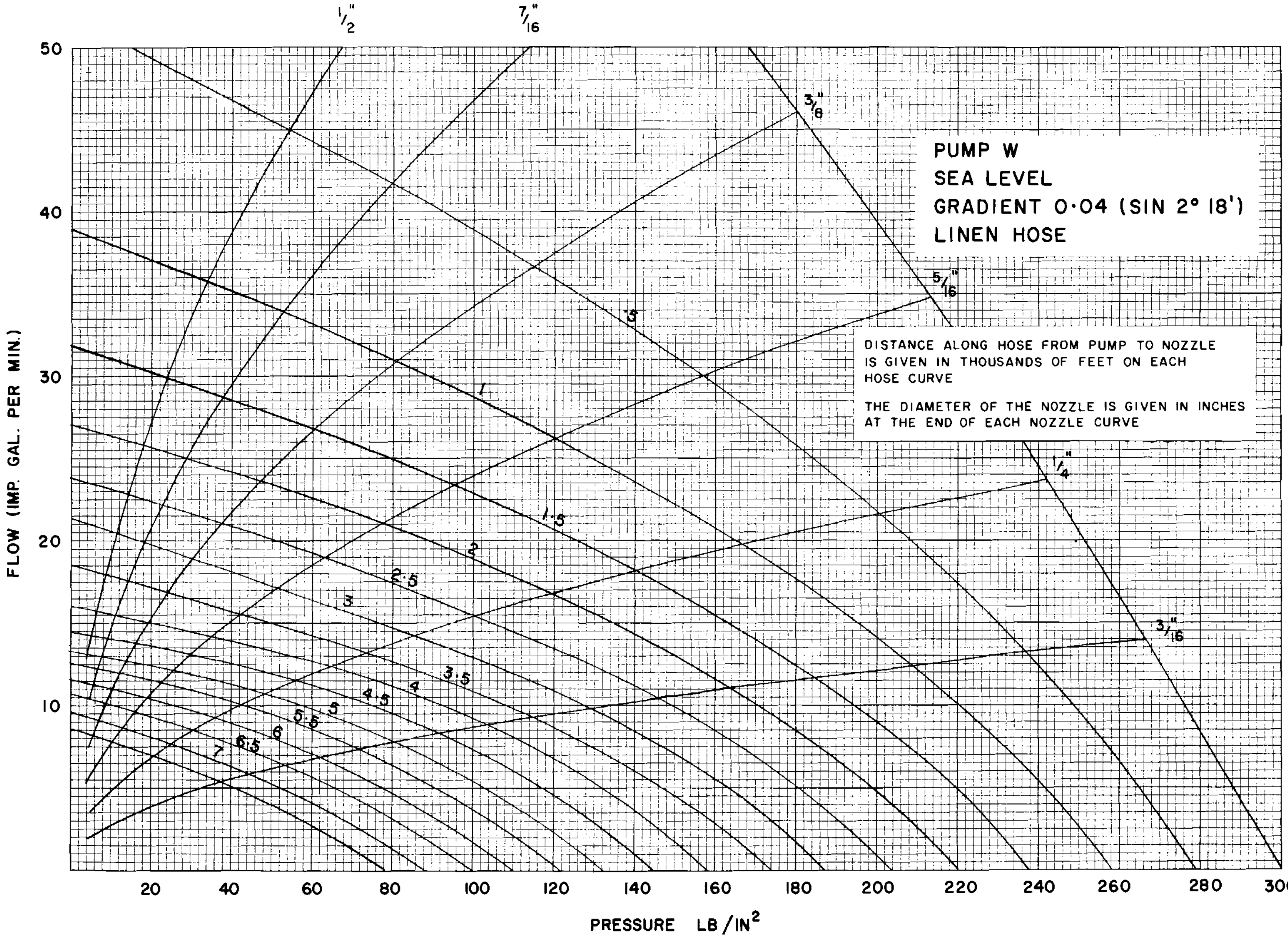
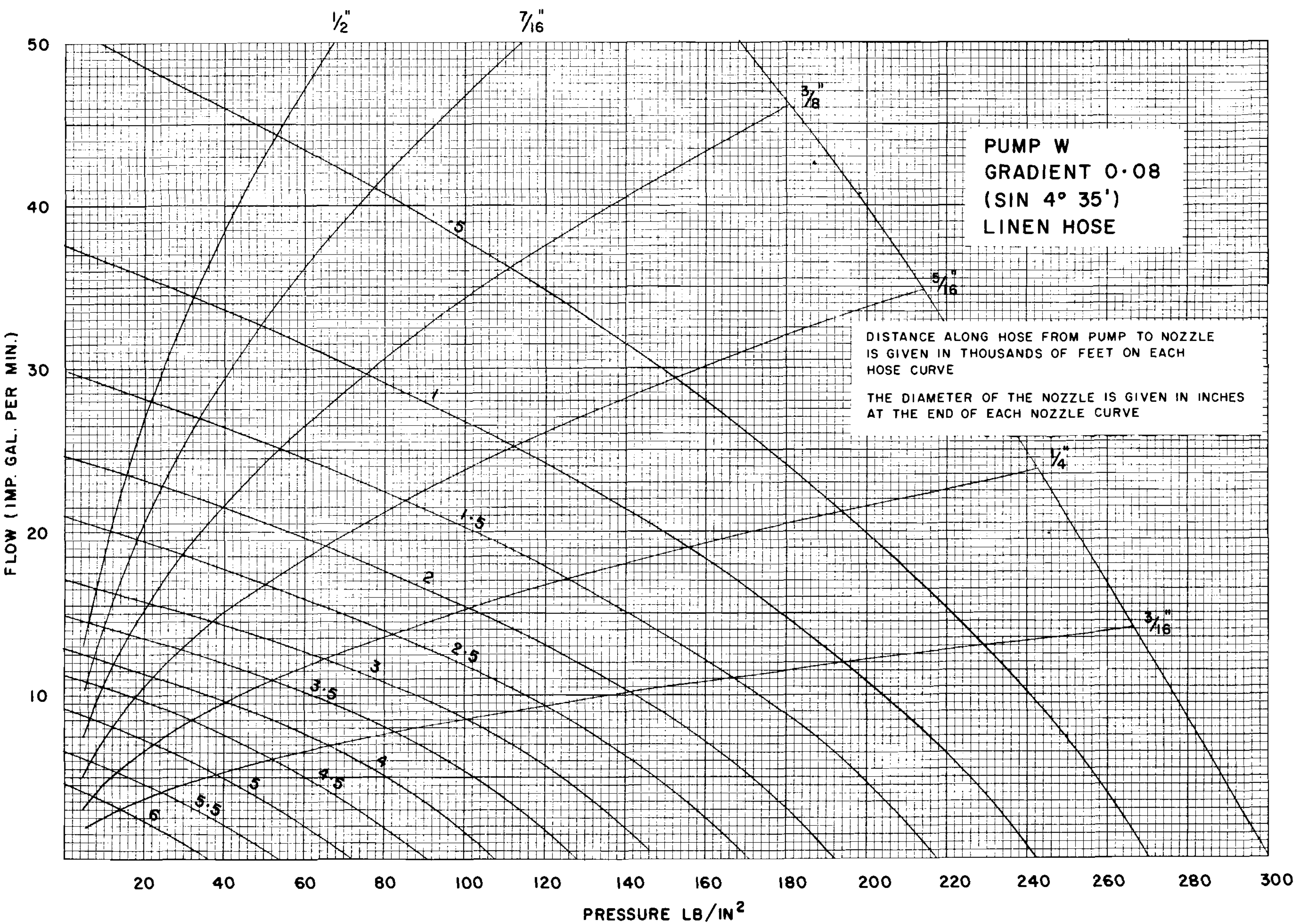
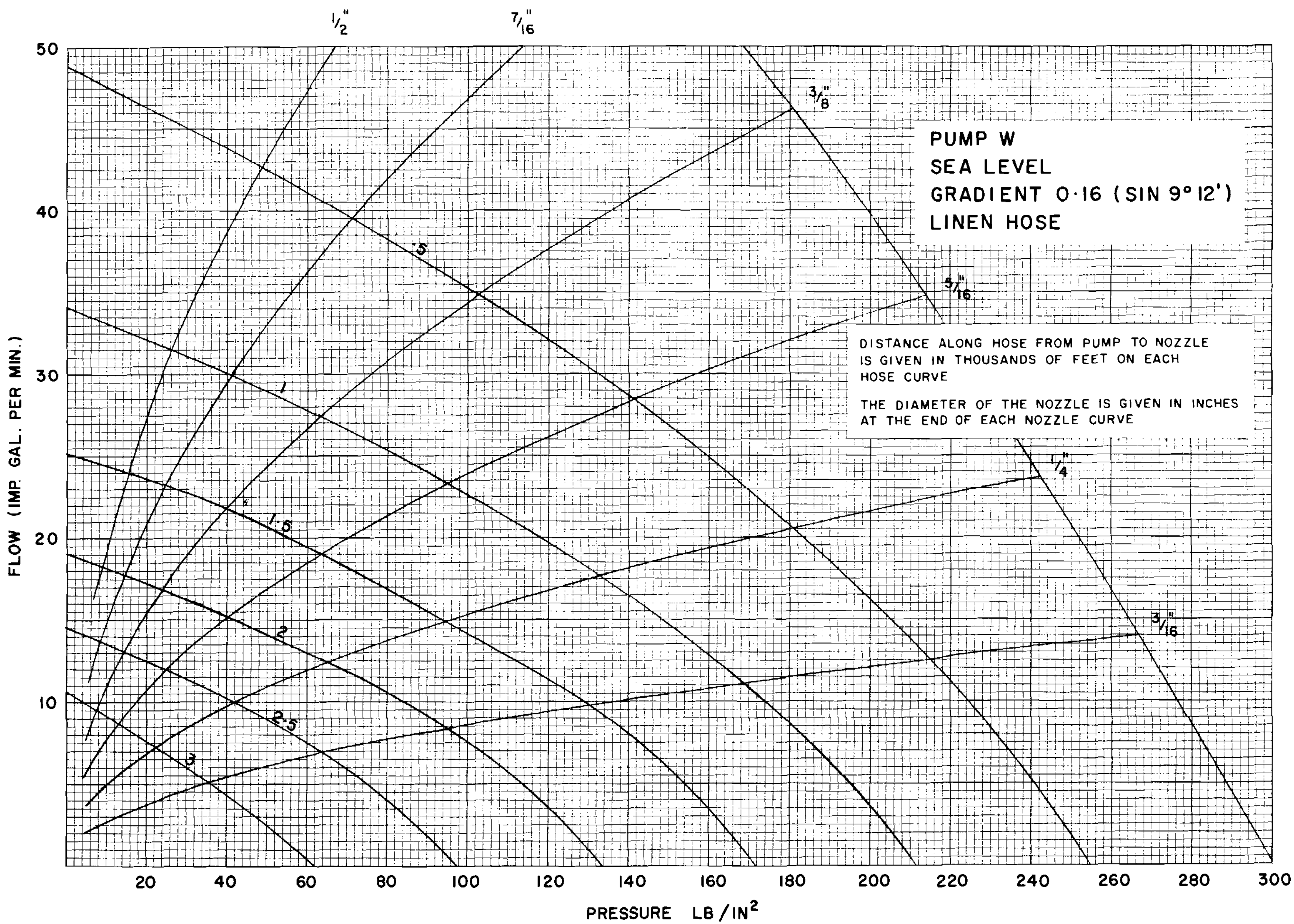

PUMP W
SEA LEVEL
GRADIENT 0·04 (SIN 2° 18')
LINEN HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
·5
1
1·5
2
2·5
3
3·5
4
4·5
5
5·5
6
6·5
7
FLOW (IMP. GAL. PER MIN.)
PRESSURE LB/IN²
50
40
30
20
10
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

FIGURE 5



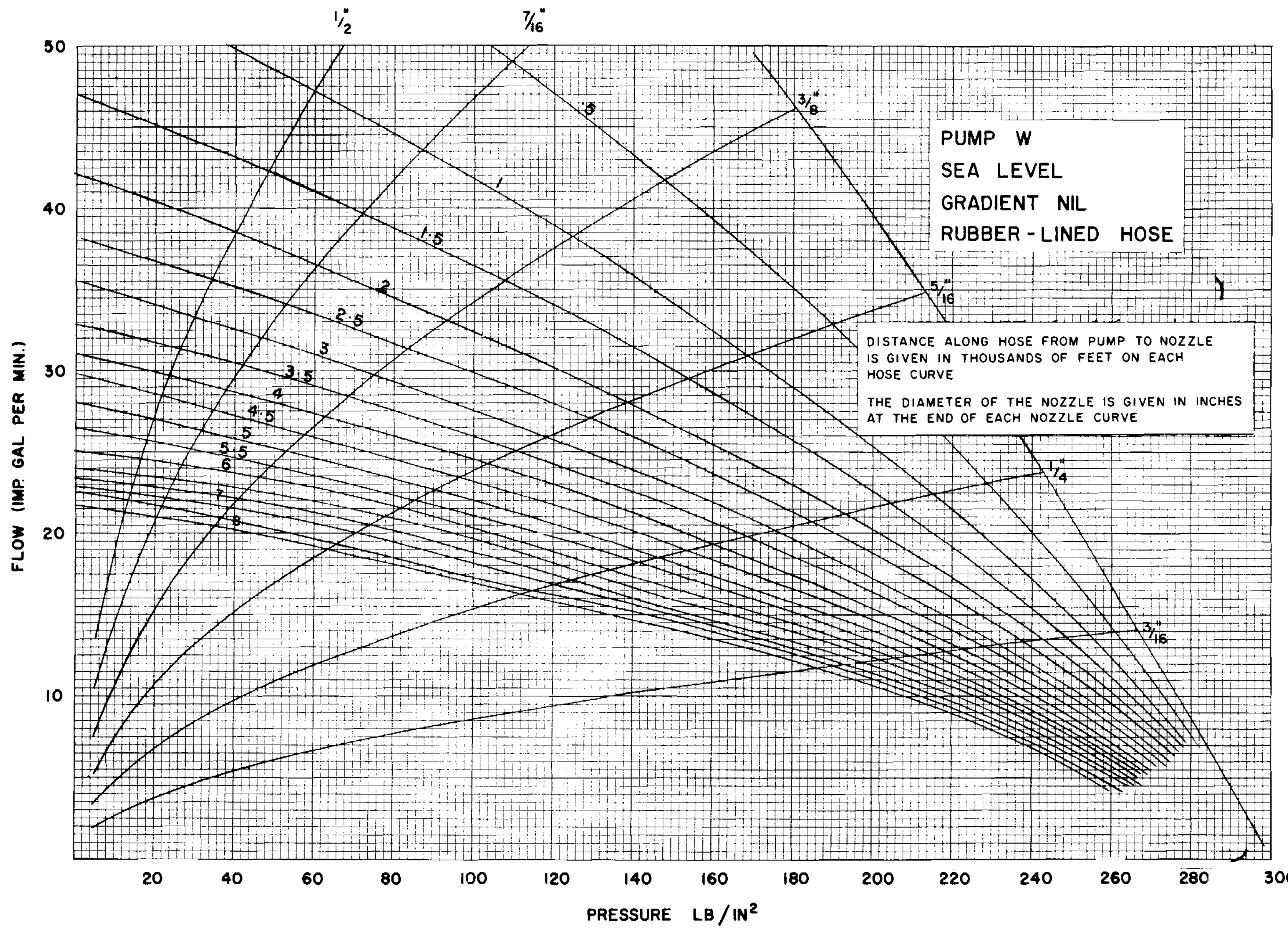
PUMP W
GRADIENT 0·08
(SIN 4° 35')
LINEN HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
FLOW (IMP. GAL. PER MIN.)
PRESSURE LB/IN²
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
·5
1
1·5
2
2·5
3
3·5
4
4·5
5
5·5
6

FIGURE 6



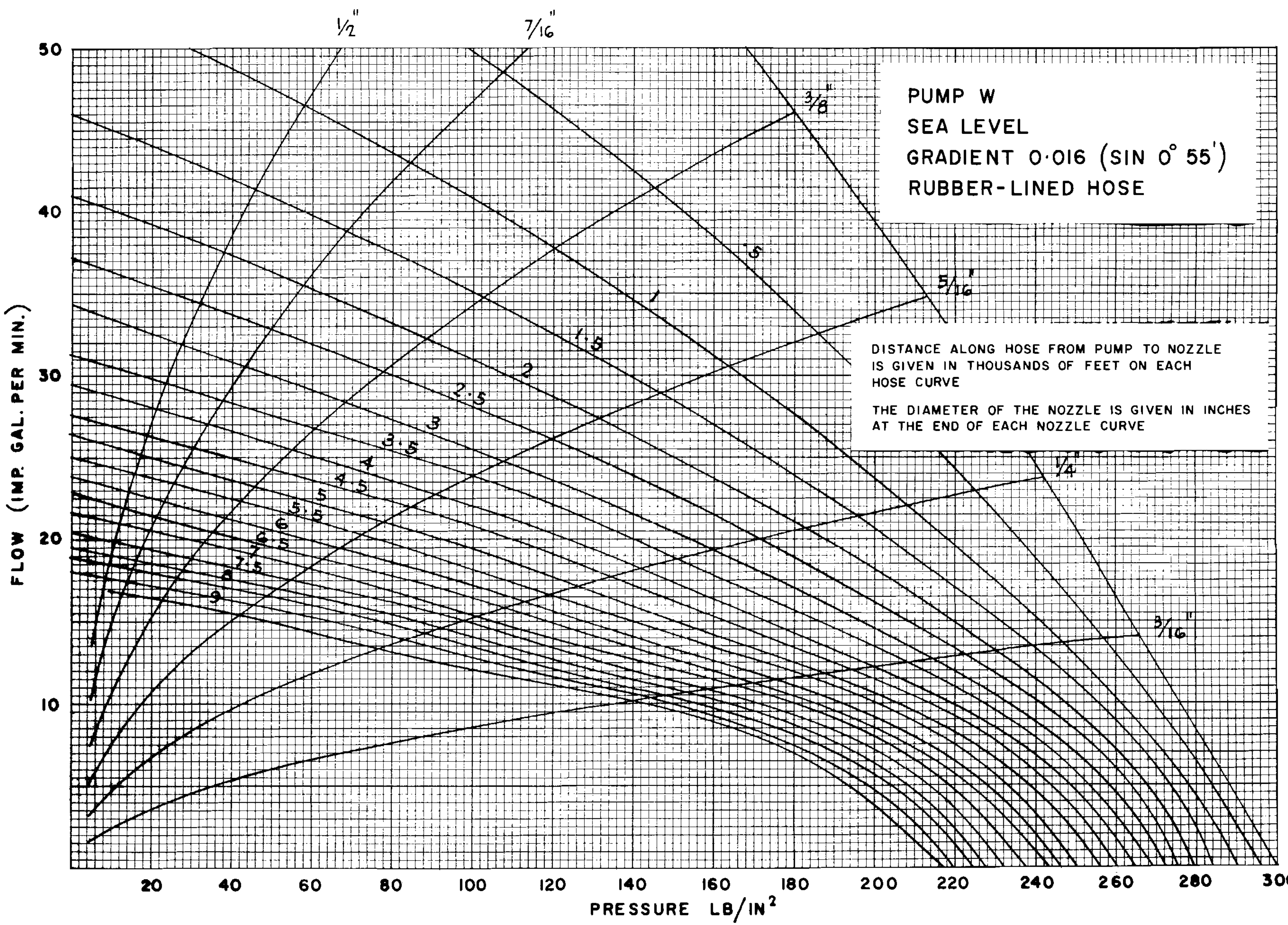
PUMP W
SEA LEVEL
GRADIENT 0·16 (SIN 9° 12')
LINEN HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
FLOW (IMP. GAL. PER MIN.)
PRESSURE LB/IN²
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
·5
1
1·5
2
2·5
3

FIGURE 7



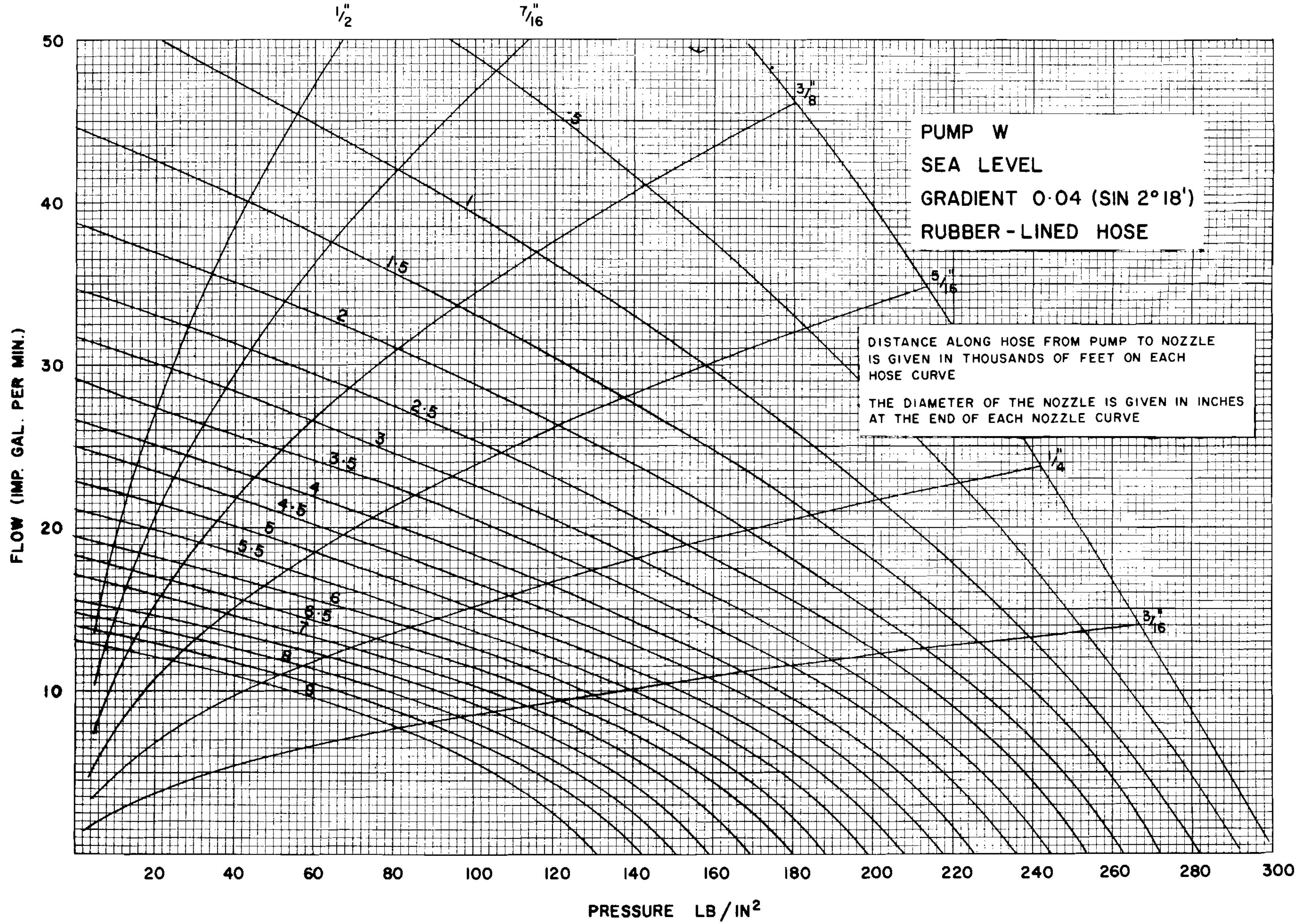
PUMP W
SEA LEVEL
GRADIENT NIL
RUBBER - LINED HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
FLOW (IMP. GAL PER MIN.)
PRESSURE LB / IN²
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
·5
1
1·5
2
2·5
3
3·5
4
4·5
5
5·5
6
7
8

FIGURE 8



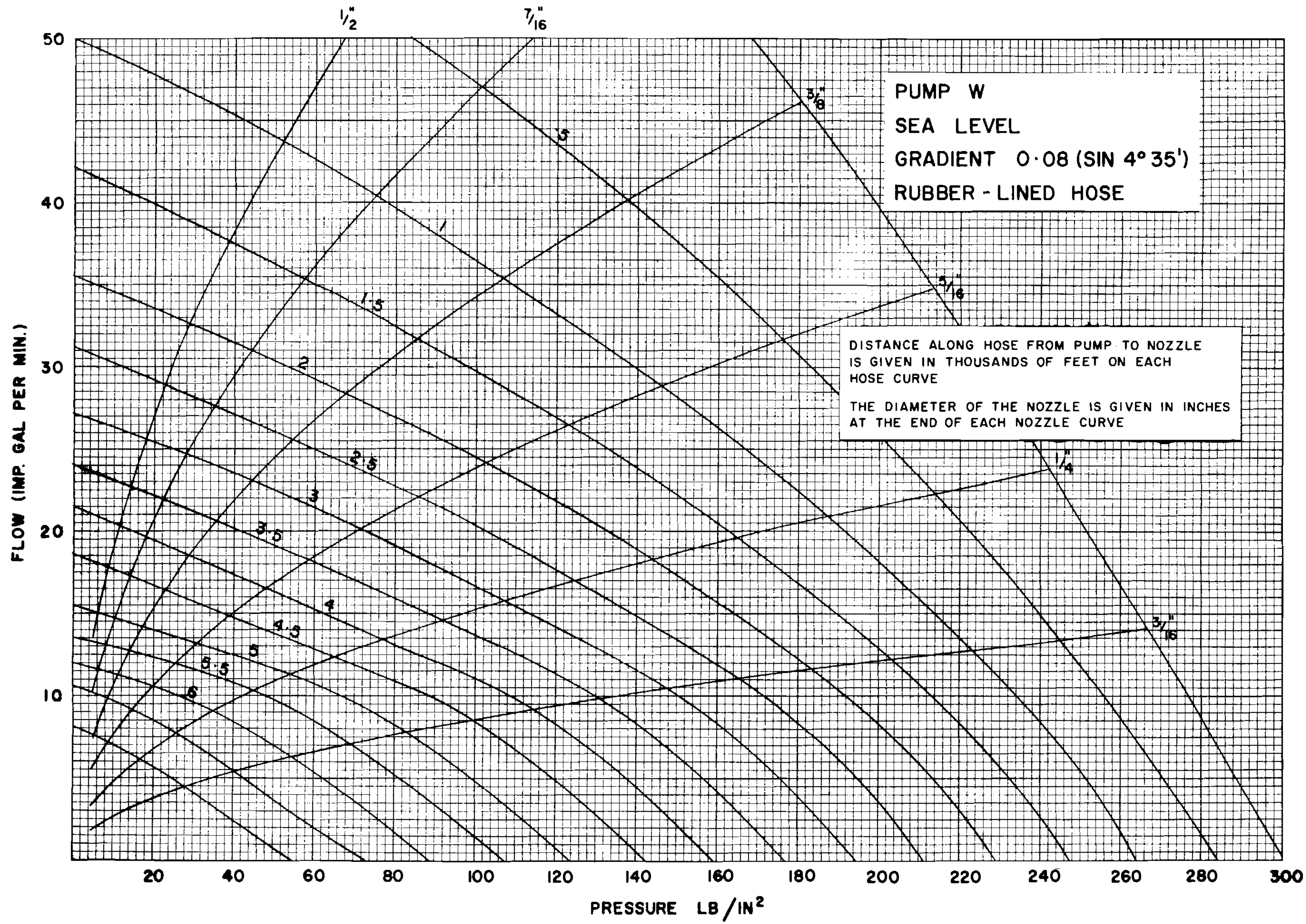
PUMP W
SEA LEVEL
GRADIENT 0·016 (SIN 0° 55')
RUBBER-LINED HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
FLOW (IMP. GAL. PER MIN.)
PRESSURE LB/IN²

FIGURE 9



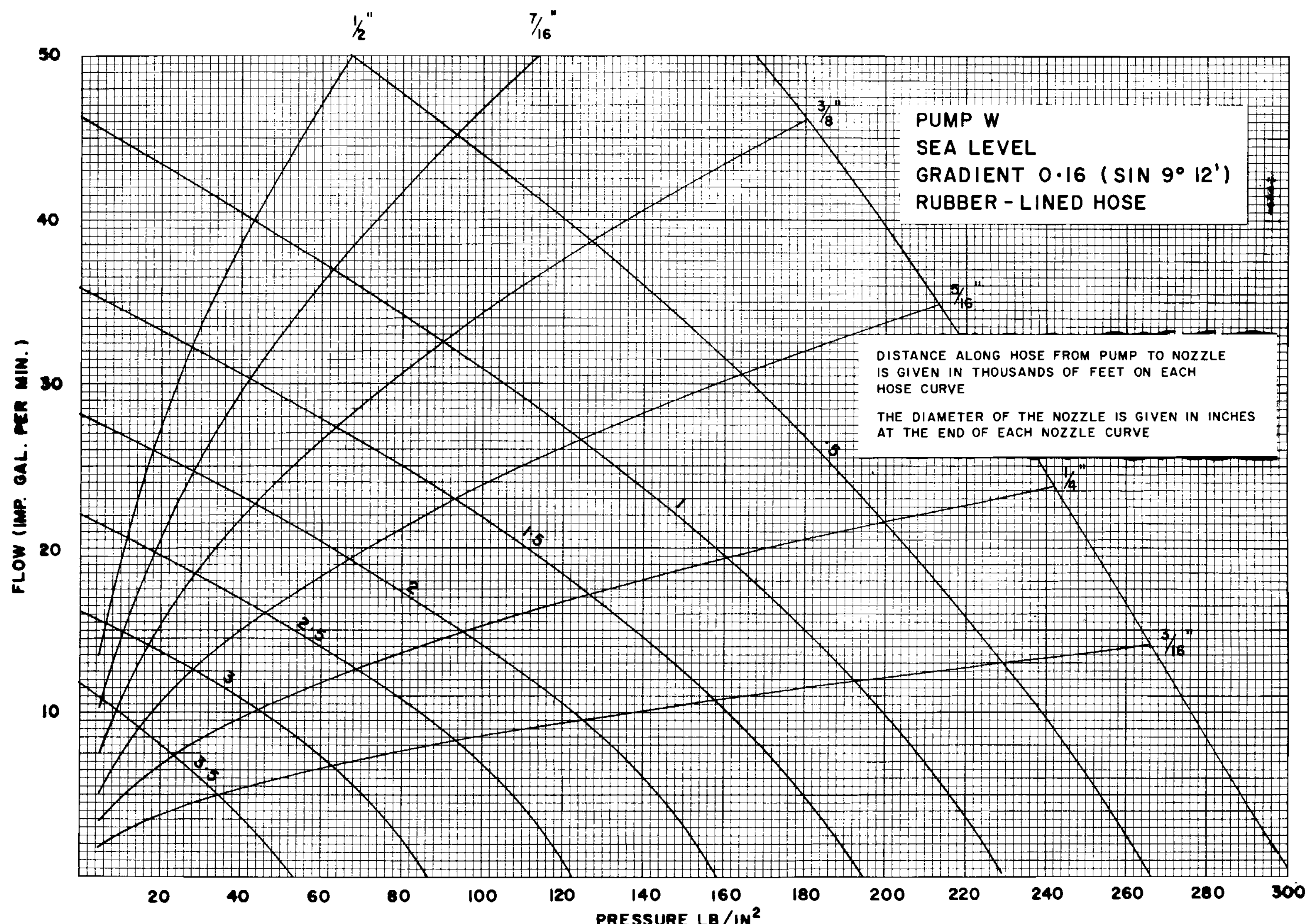
PUMP W
SEA LEVEL
GRADIENT 0·04 (SIN 2° 18')
RUBBER - LINED HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
FLOW (IMP. GAL. PER MIN.)
PRESSURE LB / IN²
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
·5
1
1·5
2
2·5
3
3·5
4
4·5
5
5·5
6
6·5
7
8
9

FIGURE 10



PUMP W
SEA LEVEL
GRADIENT 0·08 (SIN 4° 35')
RUBBER - LINED HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
FLOW (IMP. GAL PER MIN.)
PRESSURE LB/IN²
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
·5
1
1·5
2
2·5
3
3·5
4
4·5
5
5·5
6

FIGURE 11



PUMP W
SEA LEVEL
GRADIENT 0·16 (SIN 9° 12')
RUBBER - LINED HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
FLOW (IMP. GAL. PER MIN.)
PRESSURE LB/IN²
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
·5
1
1·5
2
2·5
3
3·5

FIGURE 12

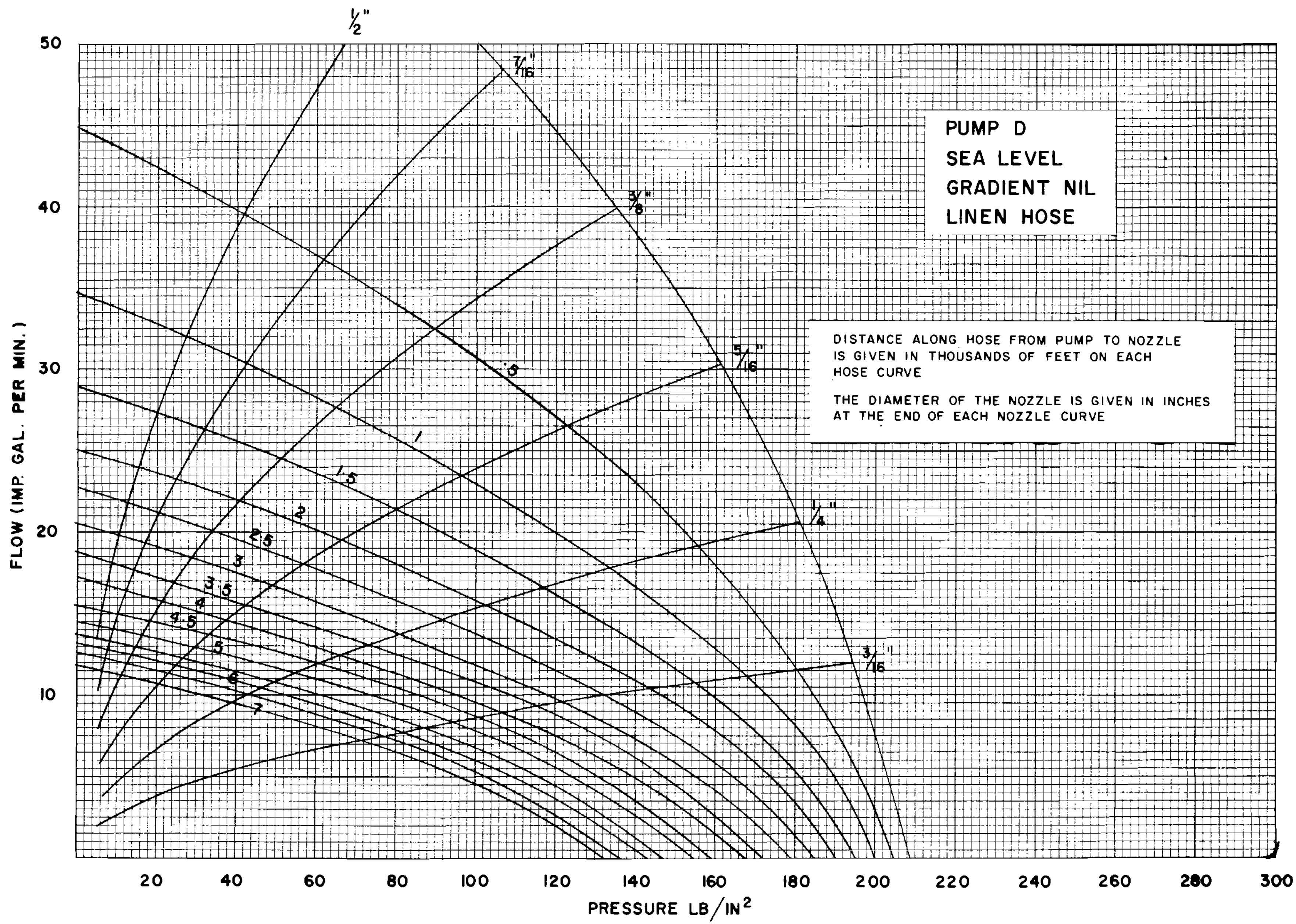

PUMP D
SEA LEVEL
GRADIENT NIL
LINEN HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
FLOW (IMP. GAL. PER MIN.)
PRESSURE LB/IN²
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
.5
1
1.5
2
2.5
3
3.5
4
4.5
5
6
7
10
20
30
40
50
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

FIGURE 13

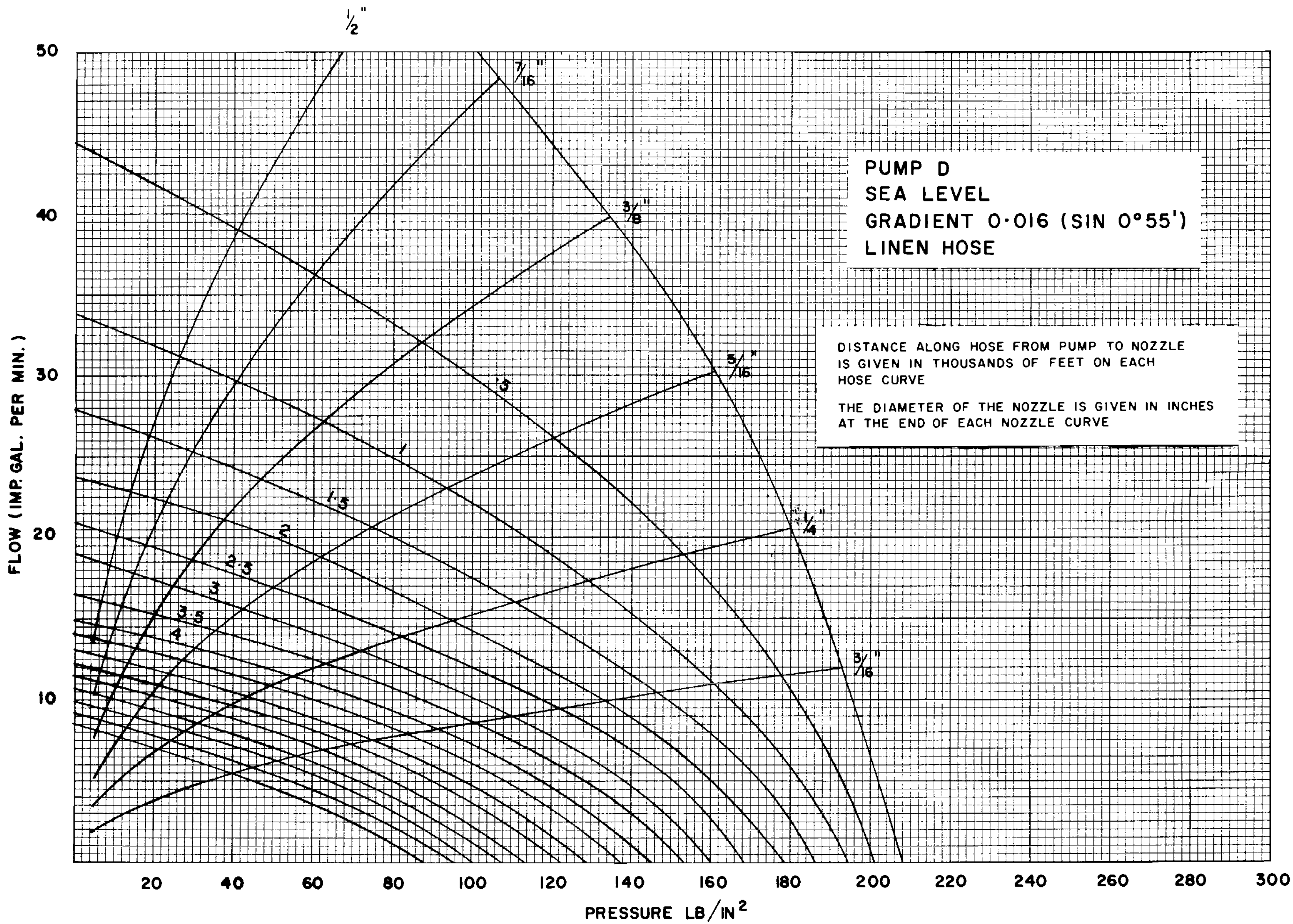
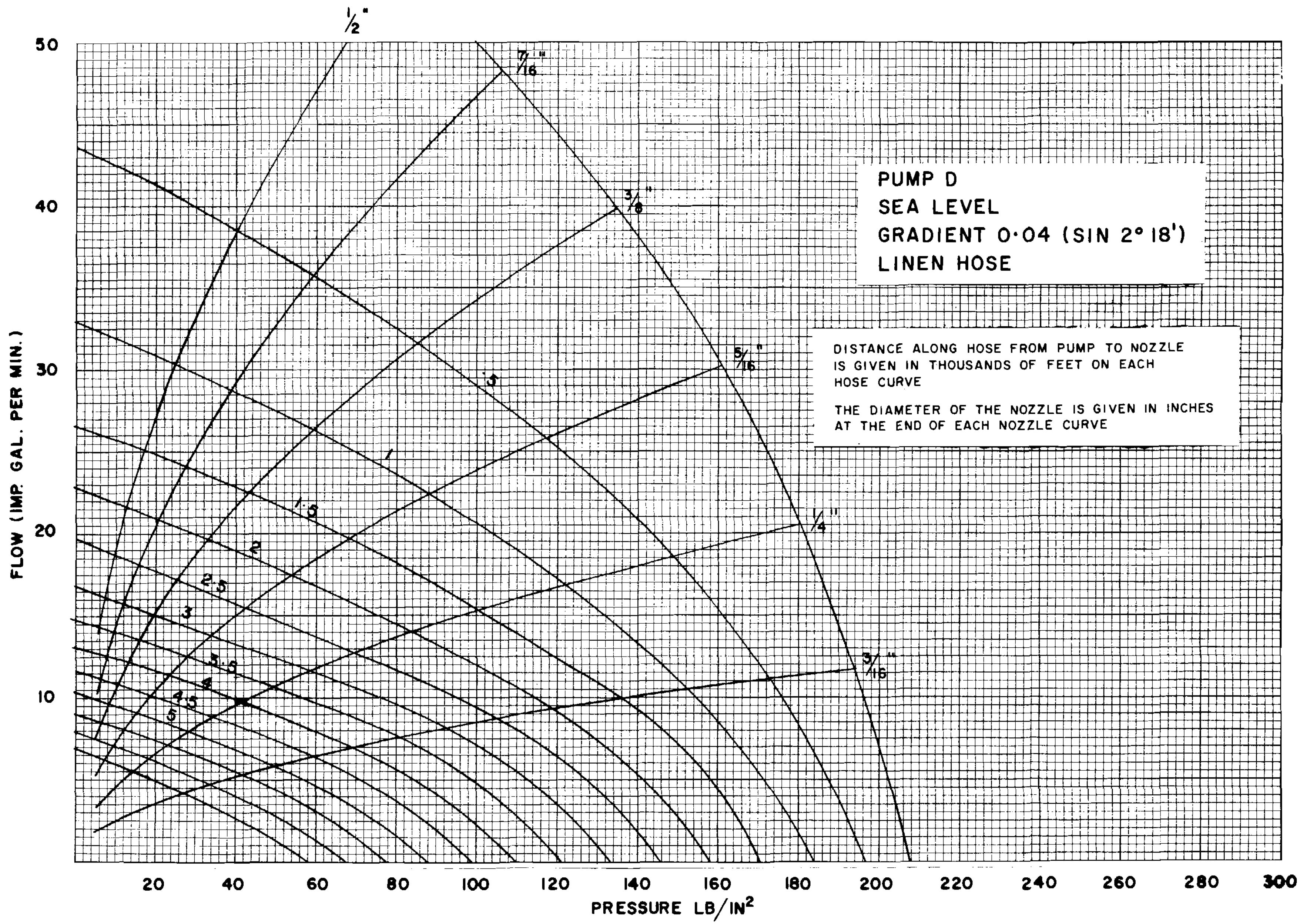

PUMP D
SEA LEVEL
GRADIENT 0·016 (SIN 0°55')
LINEN HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
·5
1
1·5
2
2·5
3
3·5
4
FLOW (IMP. GAL. PER MIN.)
50
40
30
20
10
PRESSURE LB/IN²
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

FIGURE 14



PUMP D
SEA LEVEL
GRADIENT 0·04 (SIN 2° 18')
LINEN HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
FLOW (IMP. GAL. PER MIN.)
PRESSURE LB/IN²
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
·5
1
1·5
2
2·5
3
3·5
4
4·5
5

FIGURE 15

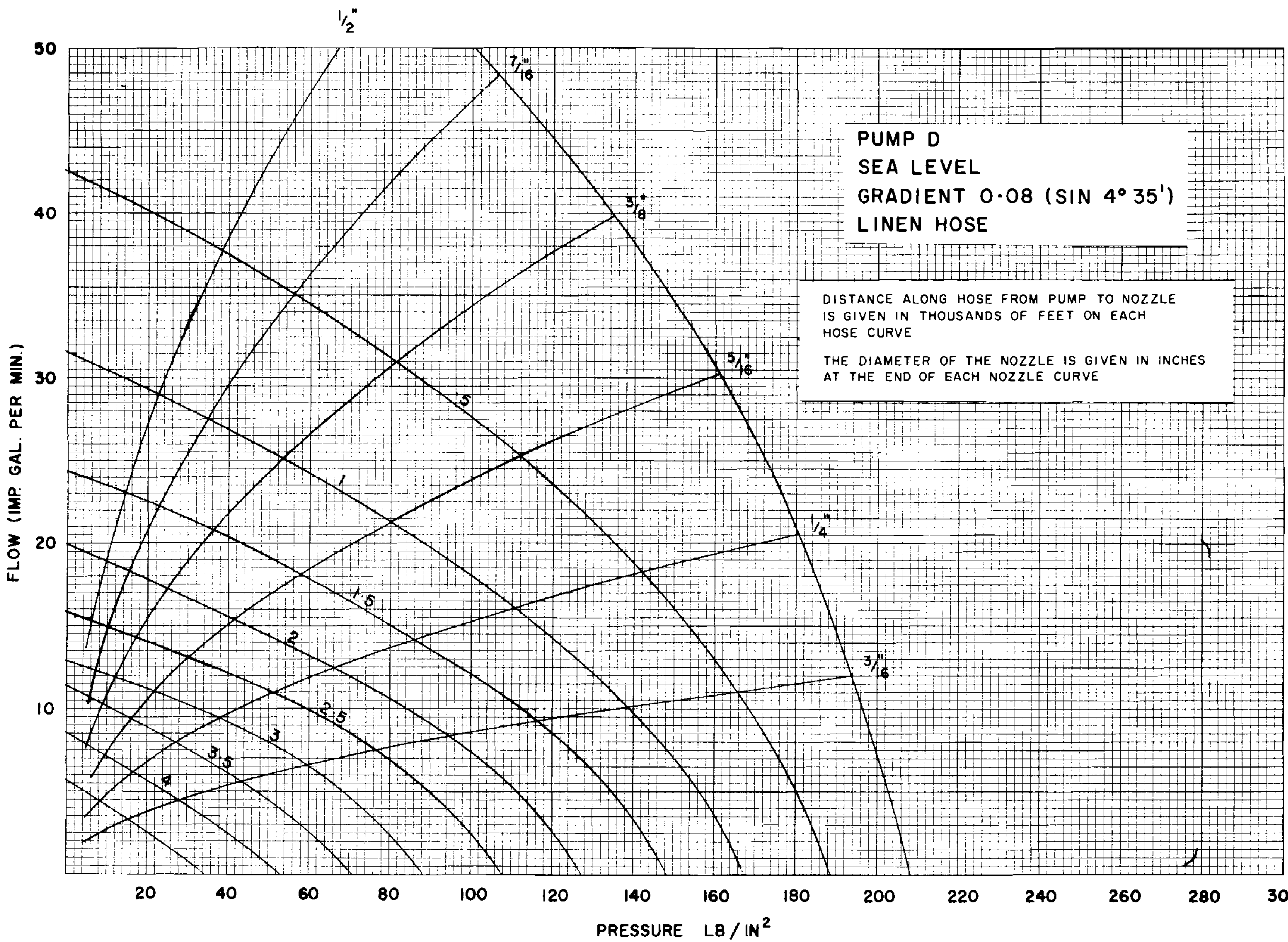
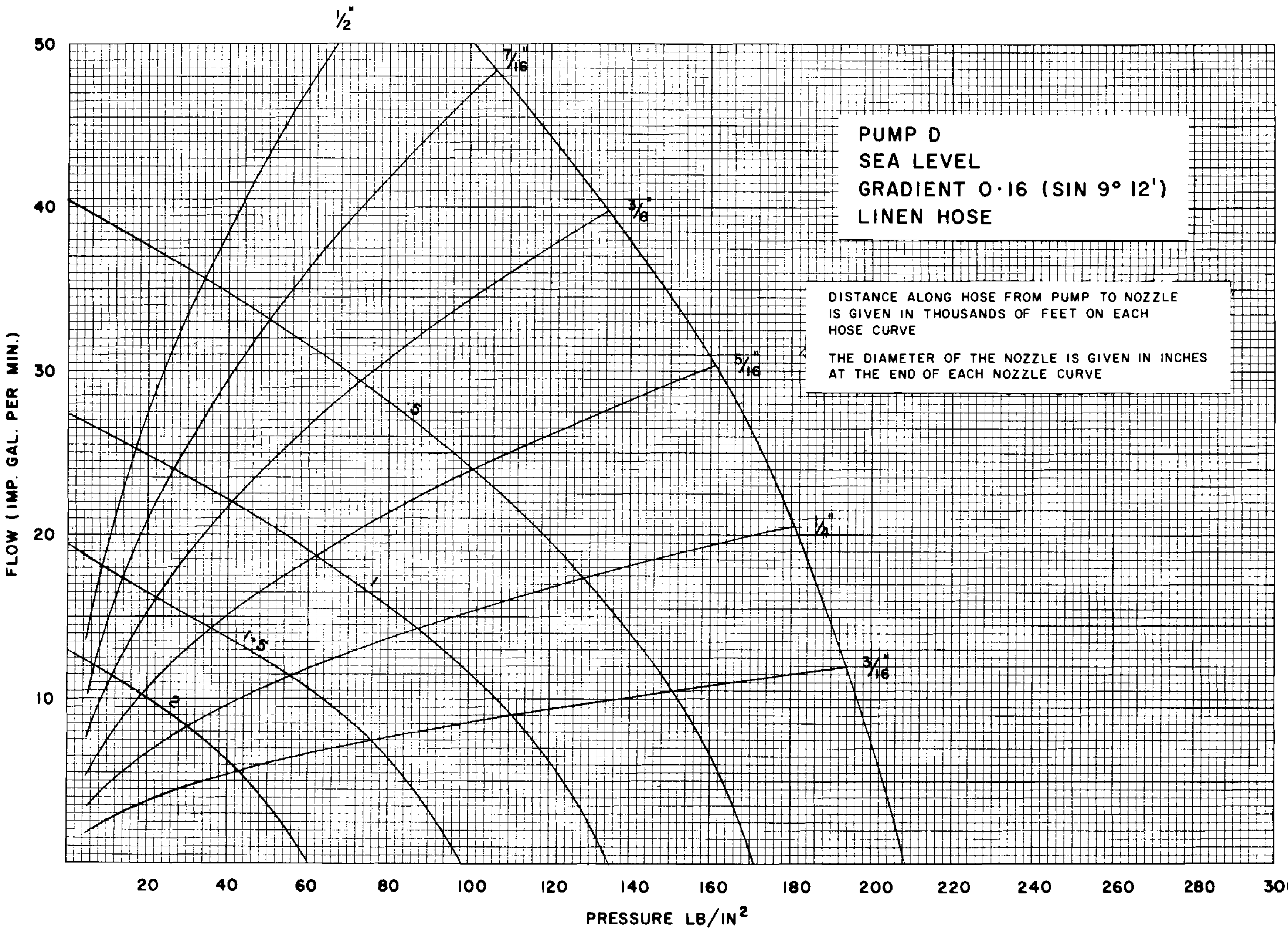
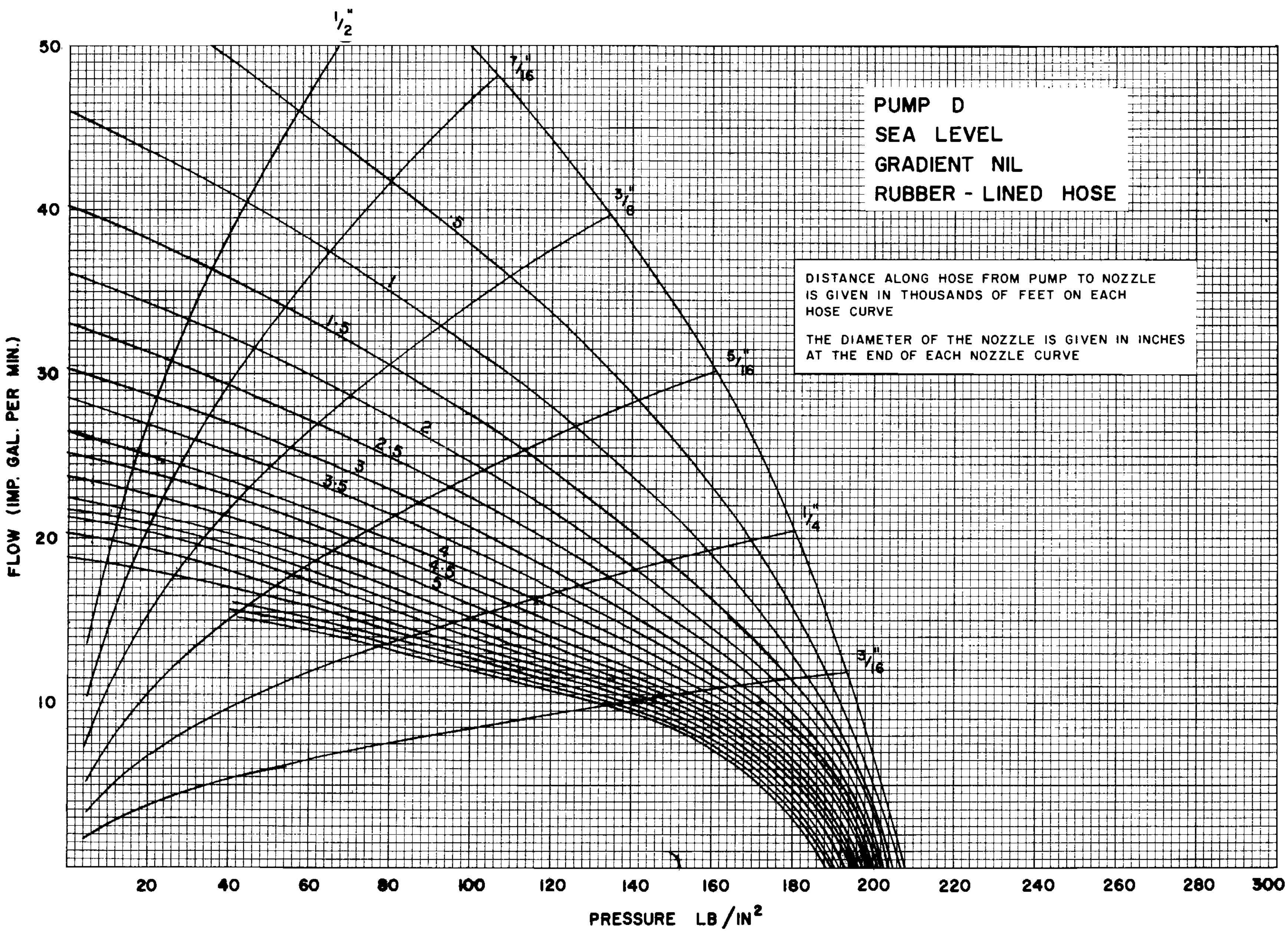

PUMP D
SEA LEVEL
GRADIENT 0·08 (SIN 4° 35')
LINEN HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
·5
1
1·5
2
2·5
3
3·5
4
FLOW (IMP. GAL. PER MIN.)
PRESSURE LB / IN²
50
40
30
20
10
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

FIGURE 16



PUMP D
SEA LEVEL
GRADIENT 0·16 (SIN 9° 12')
LINEN HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
½"
7/16"
3/8"
5/16"
¼"
3/16"
·5
1
1·5
2
FLOW (IMP. GAL. PER MIN.)
PRESSURE LB/IN²

FIGURE 17



PUMP D
SEA LEVEL
GRADIENT NIL
RUBBER - LINED HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
.5
1
1.5
2
2.5
3
3.5
4
4.5
5
FLOW (IMP. GAL. PER MIN.)
PRESSURE LB/IN²
50
40
30
20
10
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

FIGURE 18

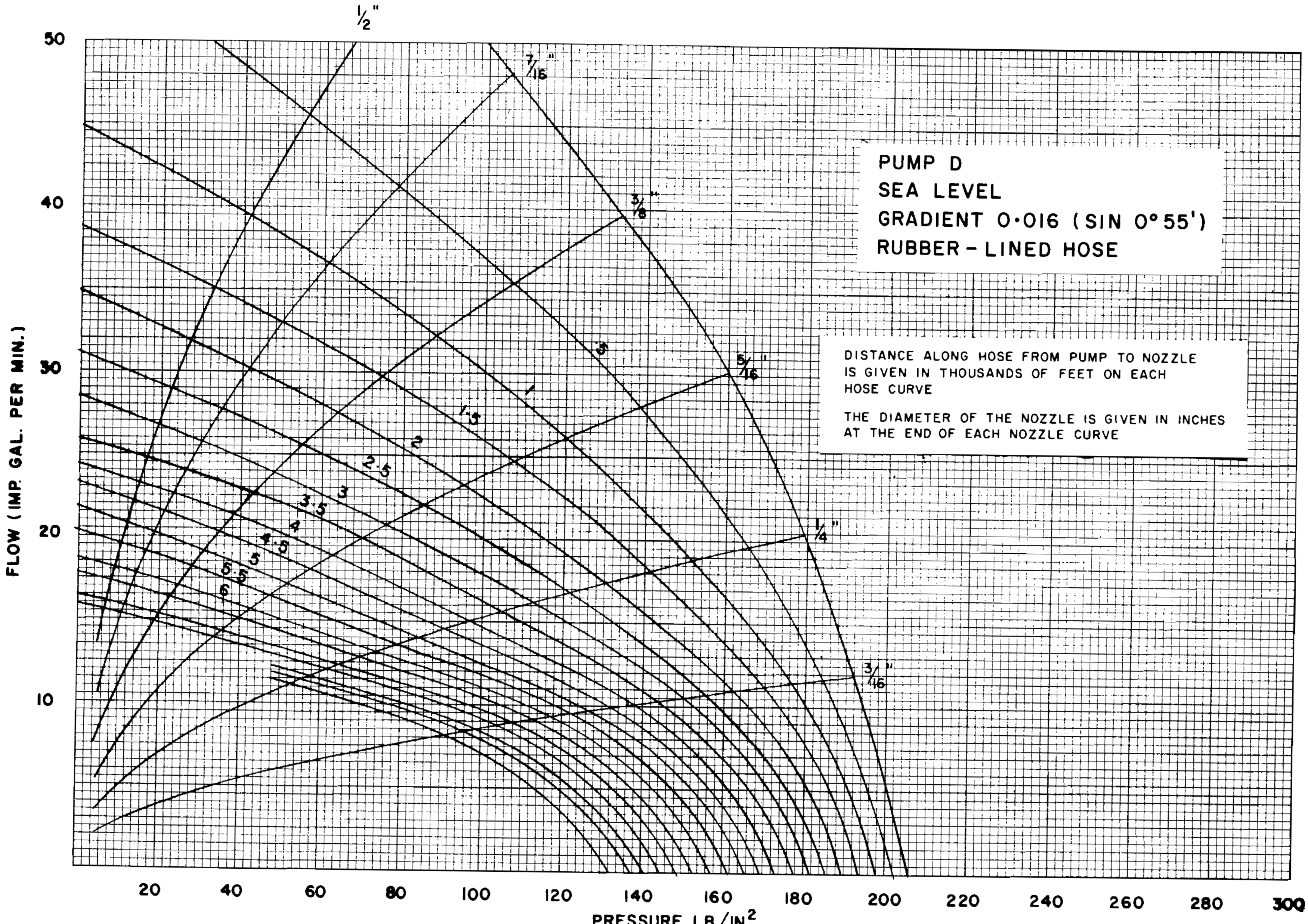
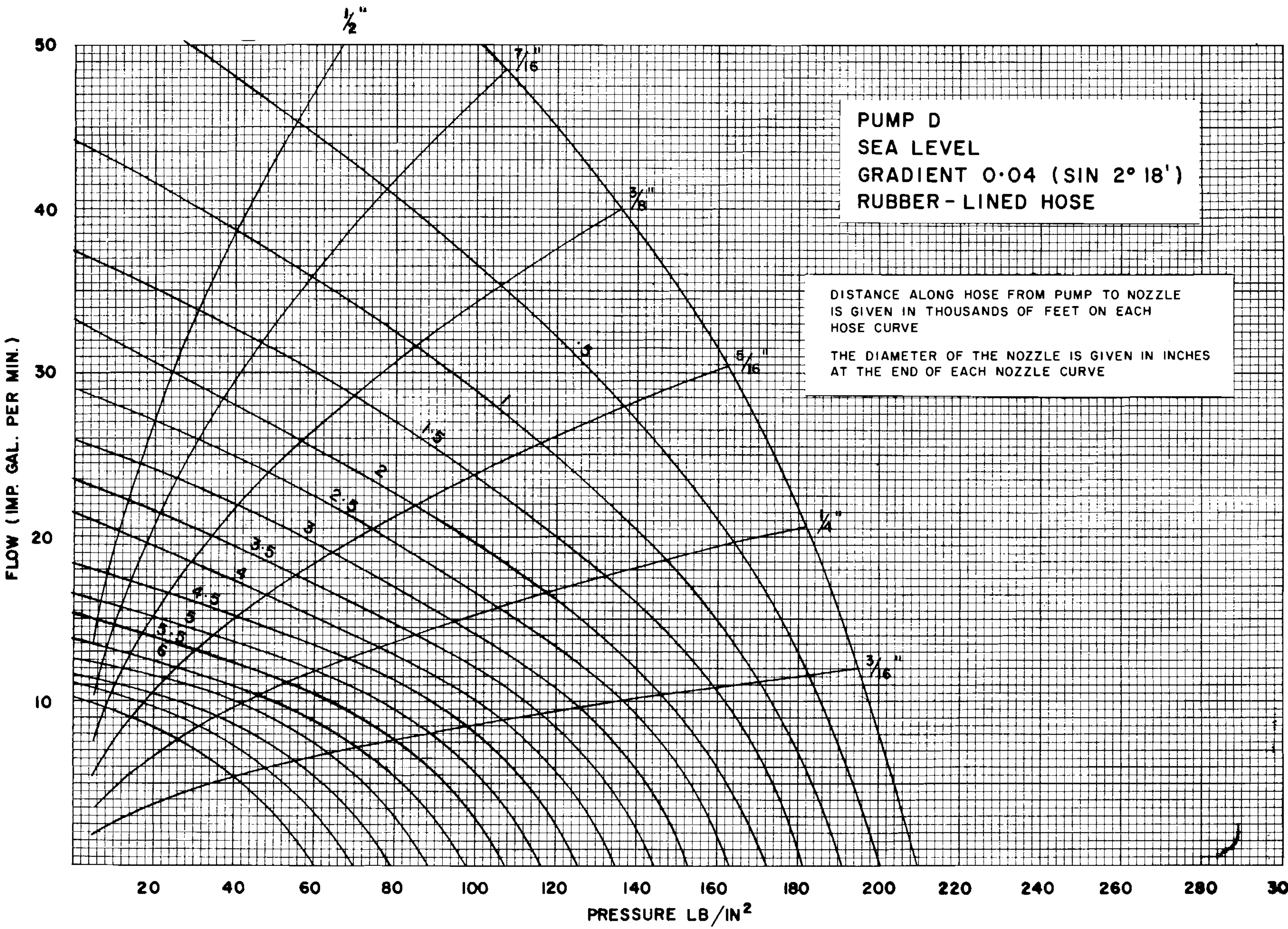

PUMP D
SEA LEVEL
GRADIENT 0·016 (SIN 0°55')
RUBBER - LINED HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
½"
7/16"
3/8"
5/16"
1/4"
3/16"
·5
1
1·5
2
2·5
3
3·5
4
4·5
5
5·5
6
FLOW (IMP. GAL. PER MIN.)
PRESSURE LB/IN²
50
40
30
20
10
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

FIGURE 19



PUMP D
SEA LEVEL
GRADIENT 0·04 (SIN 2° 18')
RUBBER - LINED HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
FLOW (IMP. GAL. PER MIN.)
PRESSURE LB/IN²
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
·5
1
1·5
2
2·5
3
3·5
4
4·5
5
5·5
6

FIGURE 20

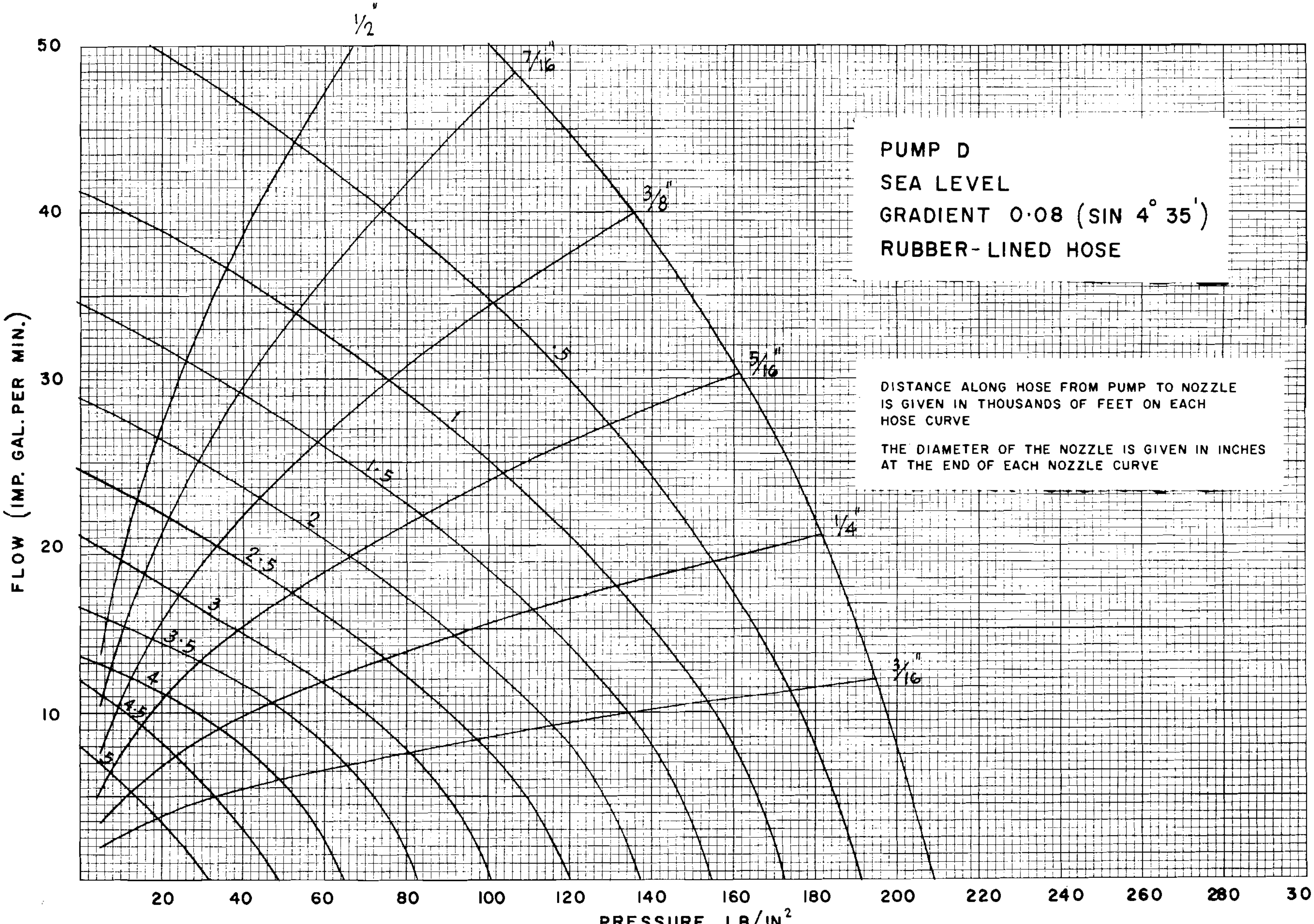

PUMP D
SEA LEVEL
GRADIENT 0·08 (SIN 4° 35')
RUBBER-LINED HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
FLOW (IMP. GAL. PER MIN.)
PRESSURE LB/IN²
½"
7/16"
3/8"
5/16"
¼"
3/16"
·5
1
1·5
2
2·5
3
3·5
4
4·5
5
50
40
30
20
10
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

FIGURE 21

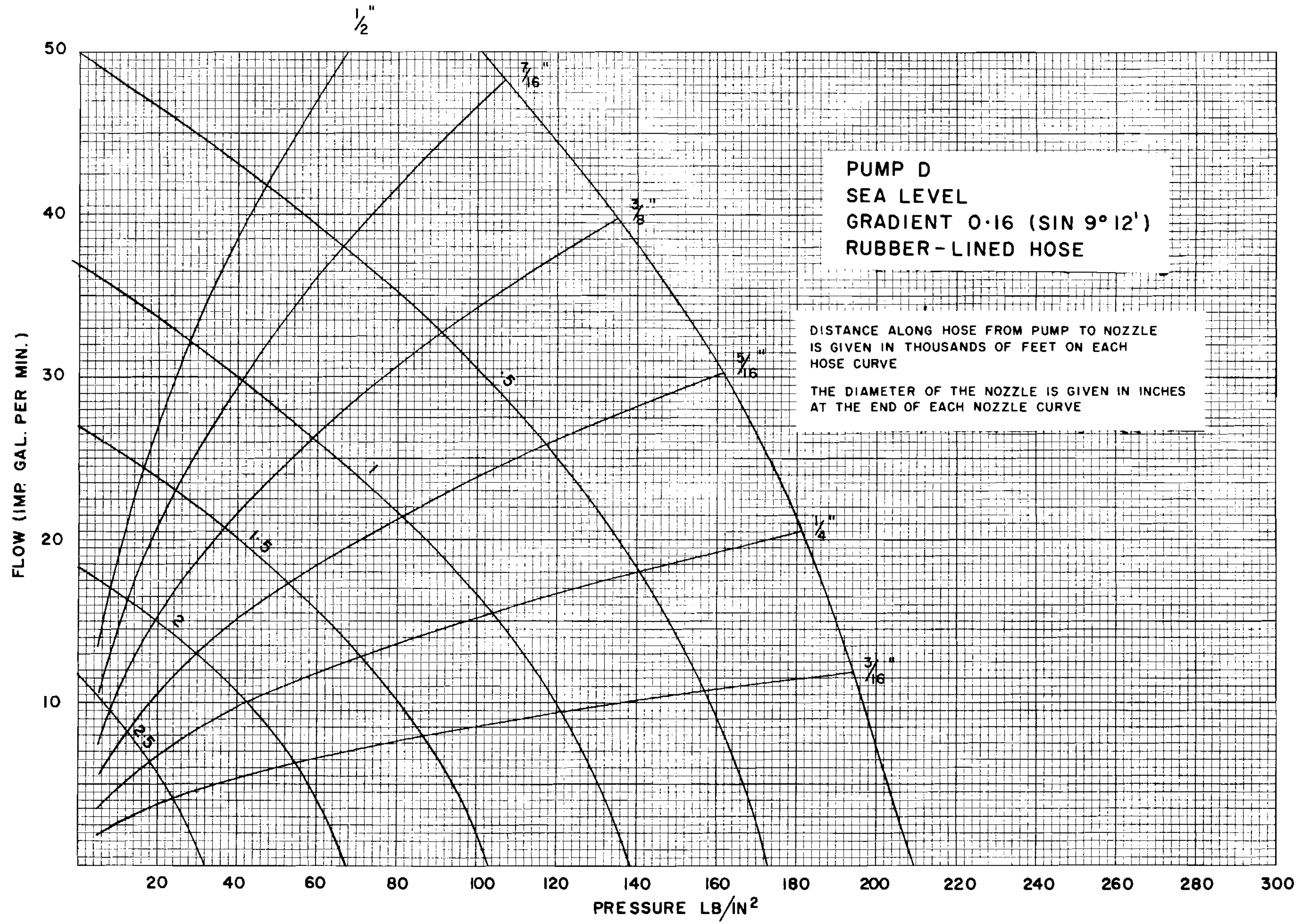
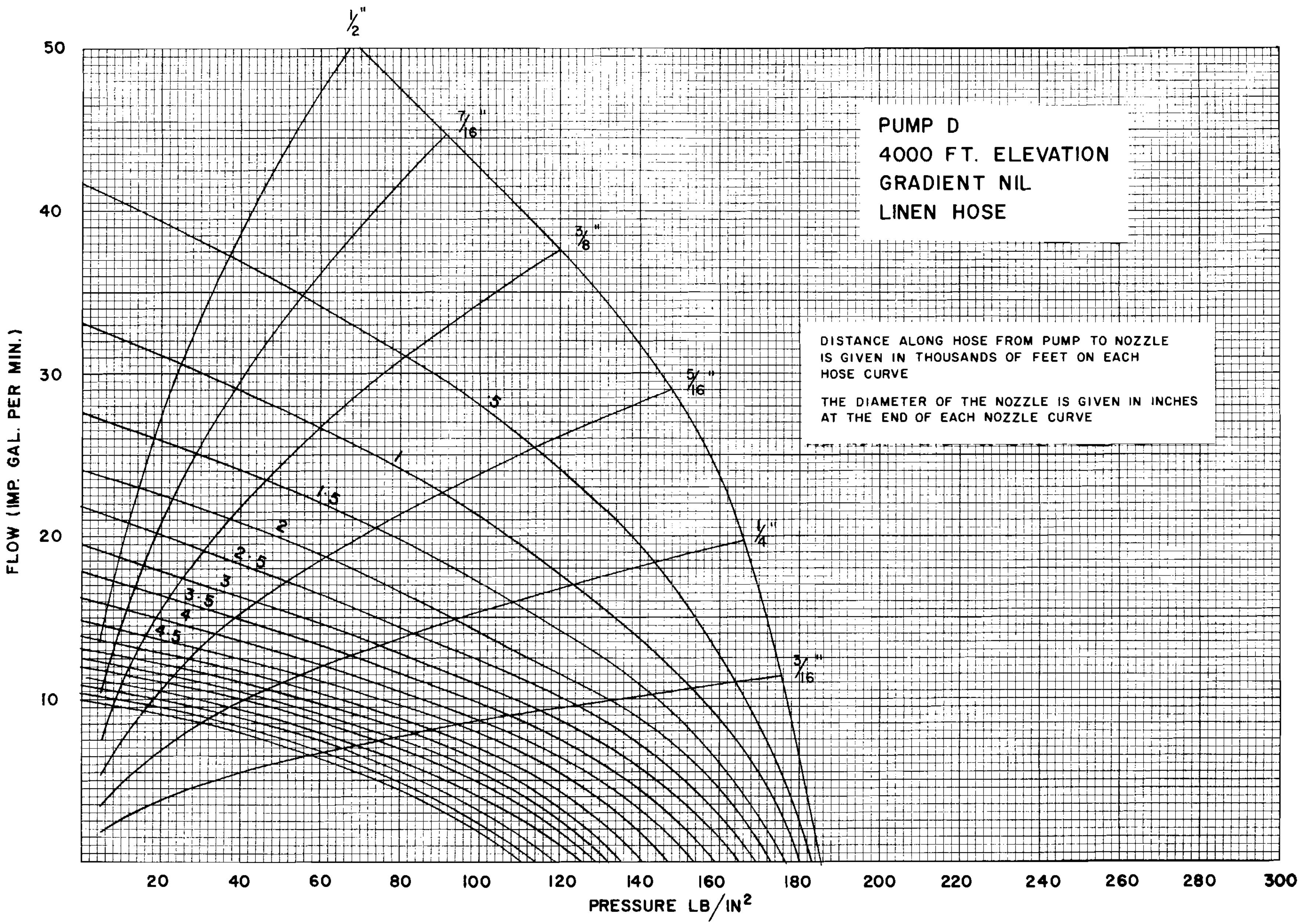
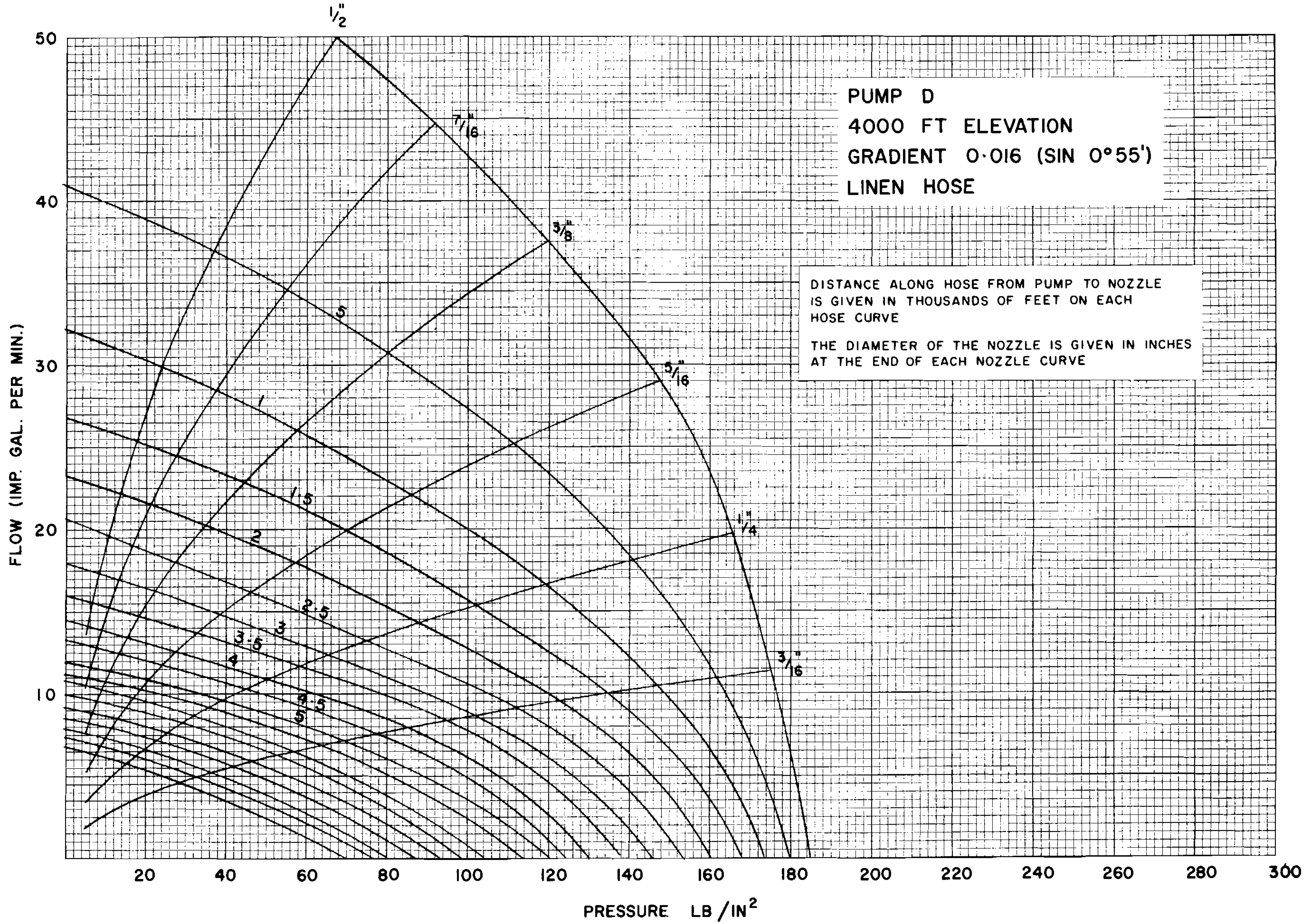

PUMP D
SEA LEVEL
GRADIENT 0·16 (SIN 9° 12')
RUBBER-LINED HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
·5
1
1·5
2
2·5
FLOW (IMP. GAL. PER MIN.)
50
40
30
20
10
PRESSURE LB/IN²
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

FIGURE 22



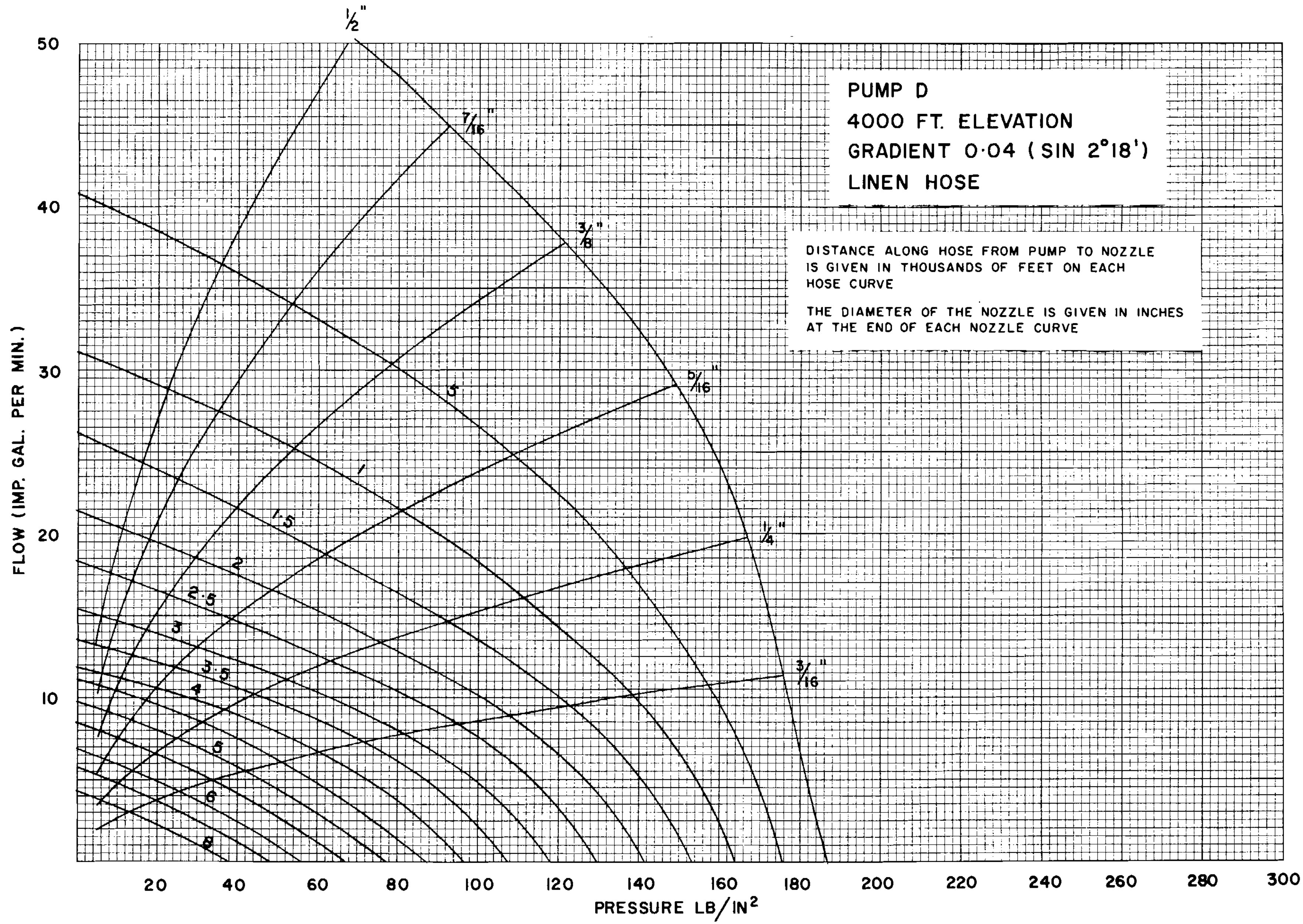
PUMP D
4000 FT. ELEVATION
GRADIENT NIL
LINEN HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
FLOW (IMP. GAL. PER MIN.)
PRESSURE LB/IN²
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
.5
1
1.5
2
2.5
3
3.5
4
4.5

FIGURE 23



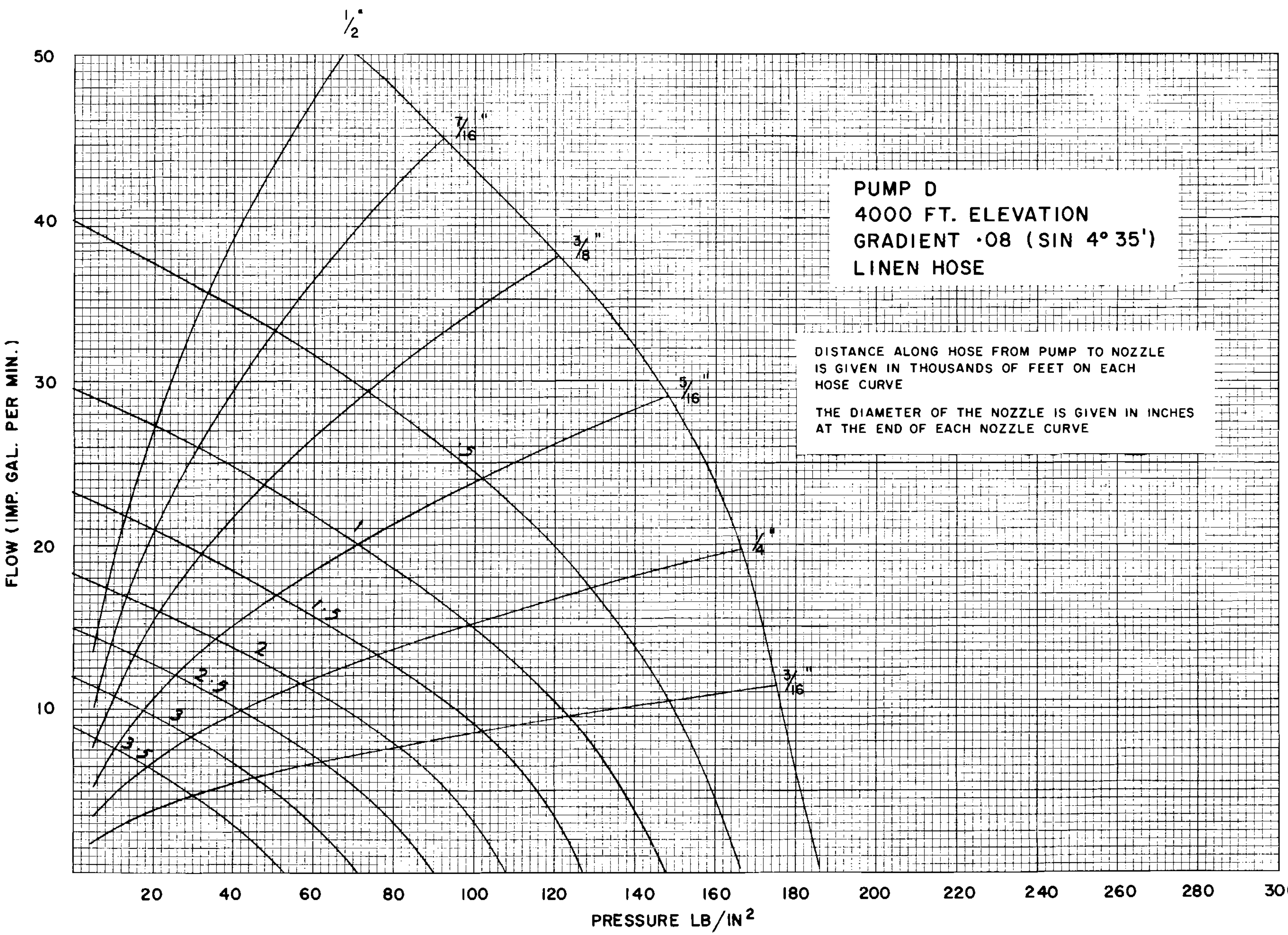
PUMP D
4000 FT ELEVATION
GRADIENT 0·016 (SIN 0°55')
LINEN HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
FLOW (IMP. GAL. PER MIN.)
PRESSURE LB / IN²
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"

FIGURE 24



PUMP D
4000 FT. ELEVATION
GRADIENT 0·04 (SIN 2°18')
LINEN HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
FLOW (IMP. GAL. PER MIN.)
PRESSURE LB/IN²
½"
7/16"
3/8"
5/16"
¼"
3/16"
.5
1
1.5
2
2.5
3
3.5
4
5
6
8

FIGURE 25



PUMP D
4000 FT. ELEVATION
GRADIENT ·08 (SIN 4° 35')
LINEN HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
·5
1
1·5
2
2·5
3
3·5
FLOW (IMP. GAL. PER MIN.)
10
20
30
40
50
PRESSURE LB/IN²
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

FIGURE 26

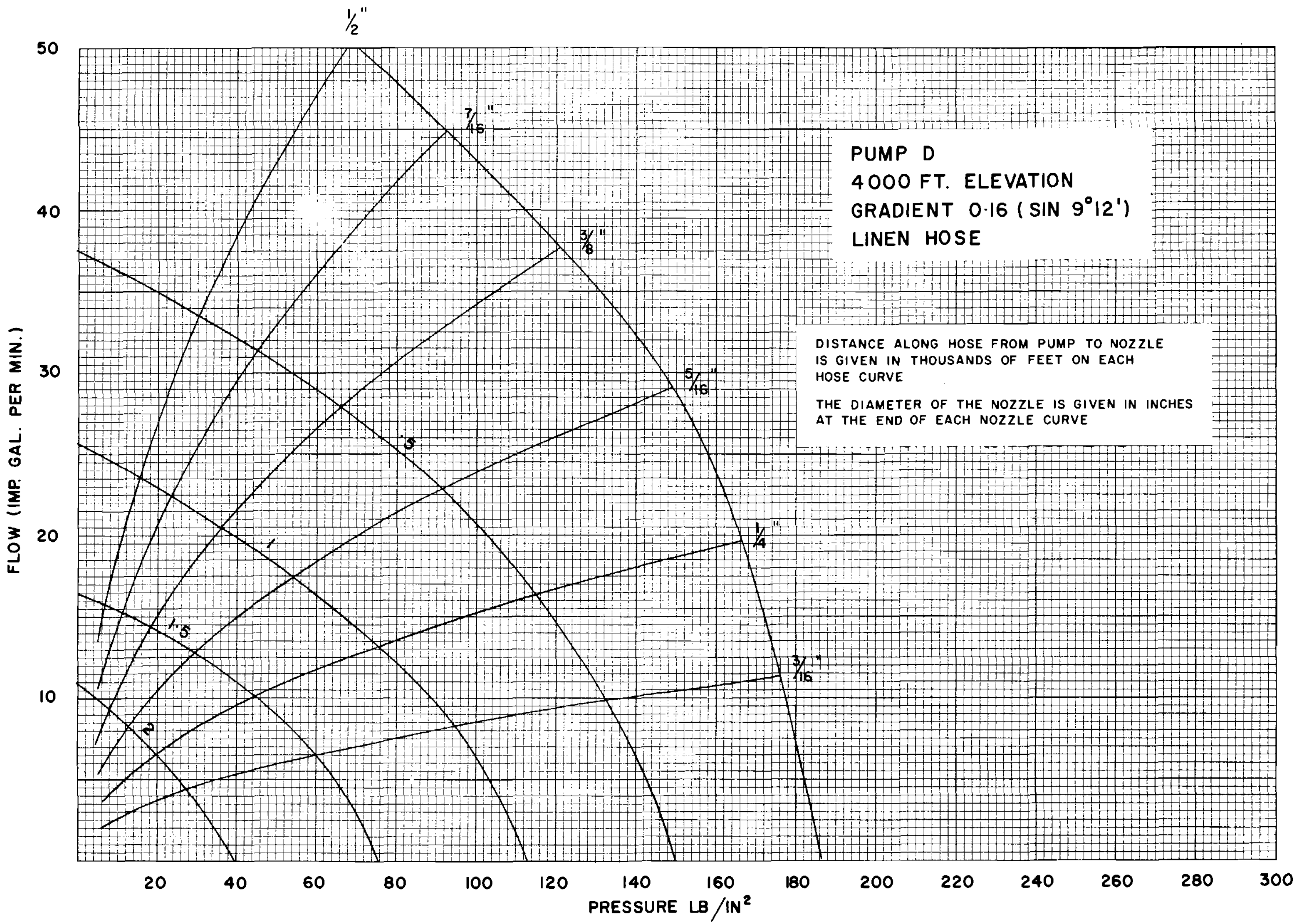

PUMP D
4000 FT. ELEVATION
GRADIENT 0·16 (SIN 9°12')
LINEN HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
·5
1
1·5
2
FLOW (IMP. GAL. PER MIN.)
PRESSURE LB/IN²
50
40
30
20
10
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

FIGURE 27

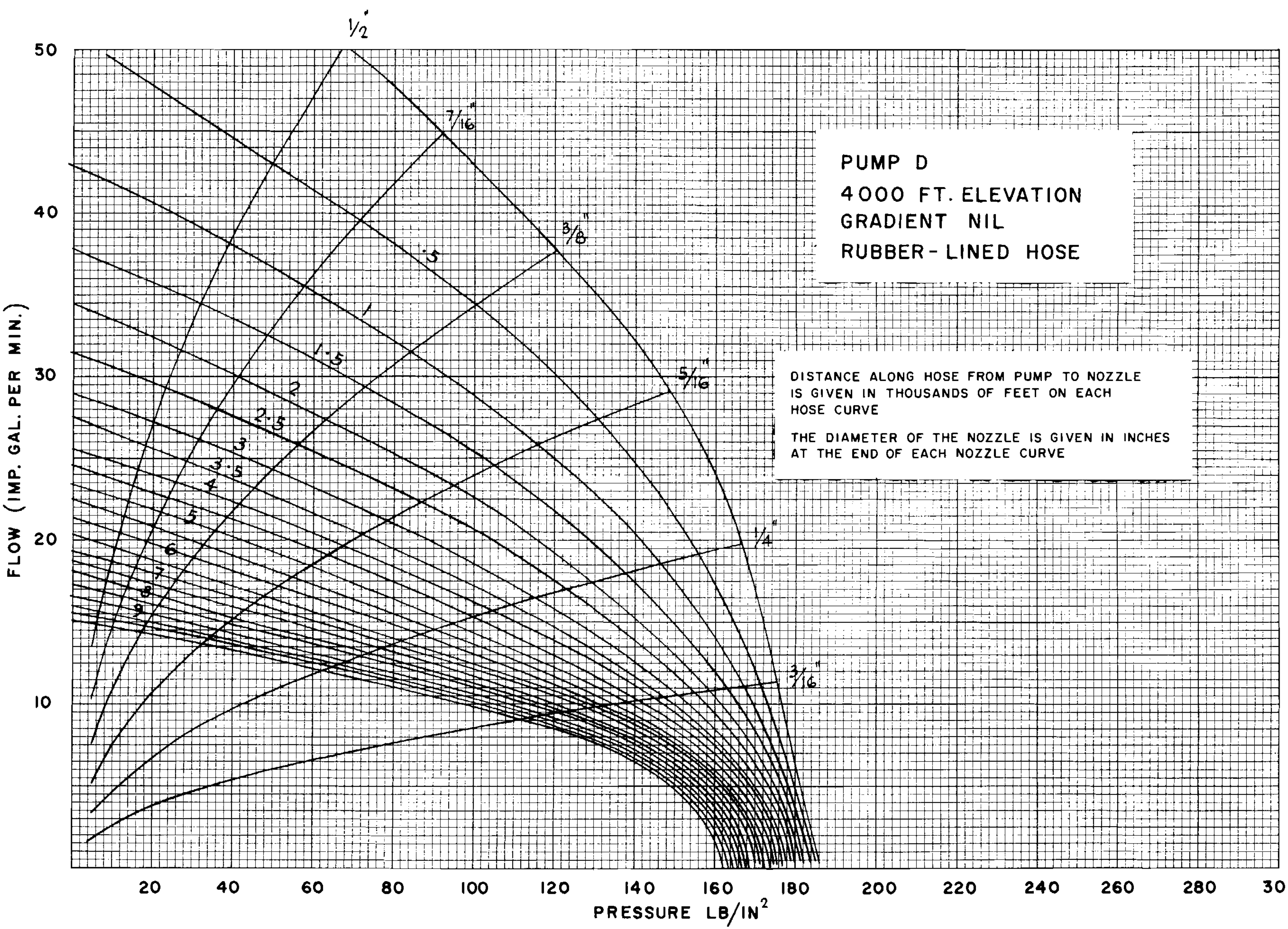
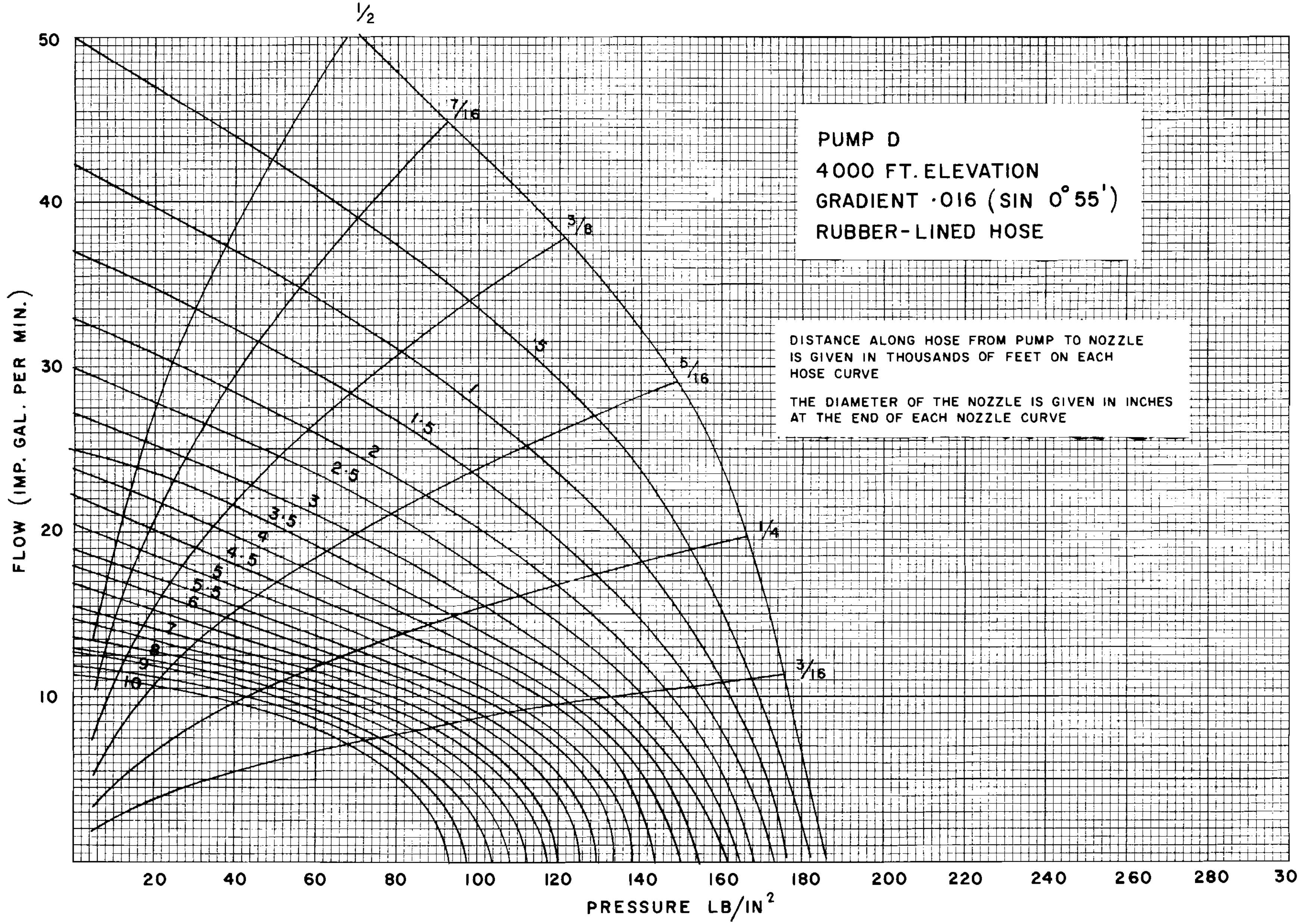

PUMP D
4000 FT. ELEVATION
GRADIENT NIL
RUBBER-LINED HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
FLOW (IMP. GAL. PER MIN.)
PRESSURE LB/IN²
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
·5
1
1·5
2
2·5
3
3·5
4
5
6
7
8
9
10
20
30
40
50
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

FIGURE 28



PUMP D
4000 FT. ELEVATION
GRADIENT ·016 (SIN 0°55')
RUBBER-LINED HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
1/2
7/16
3/8
5/16
1/4
3/16
·5
1
1·5
2
2·5
3
3·5
4
4·5
5
5·5
6
7
8
9
10
FLOW (IMP. GAL. PER MIN.)
PRESSURE LB/IN²

FIGURE 29

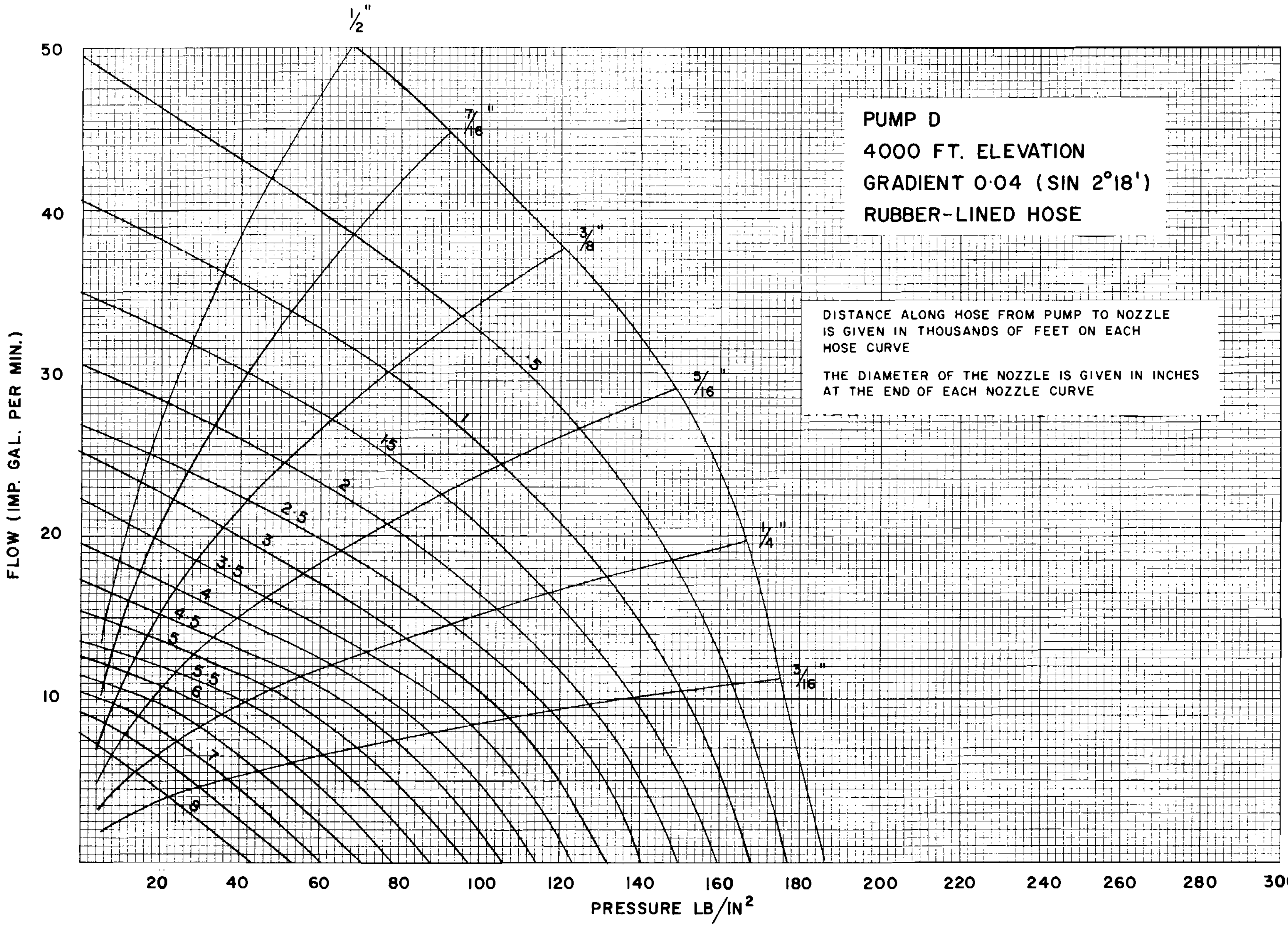
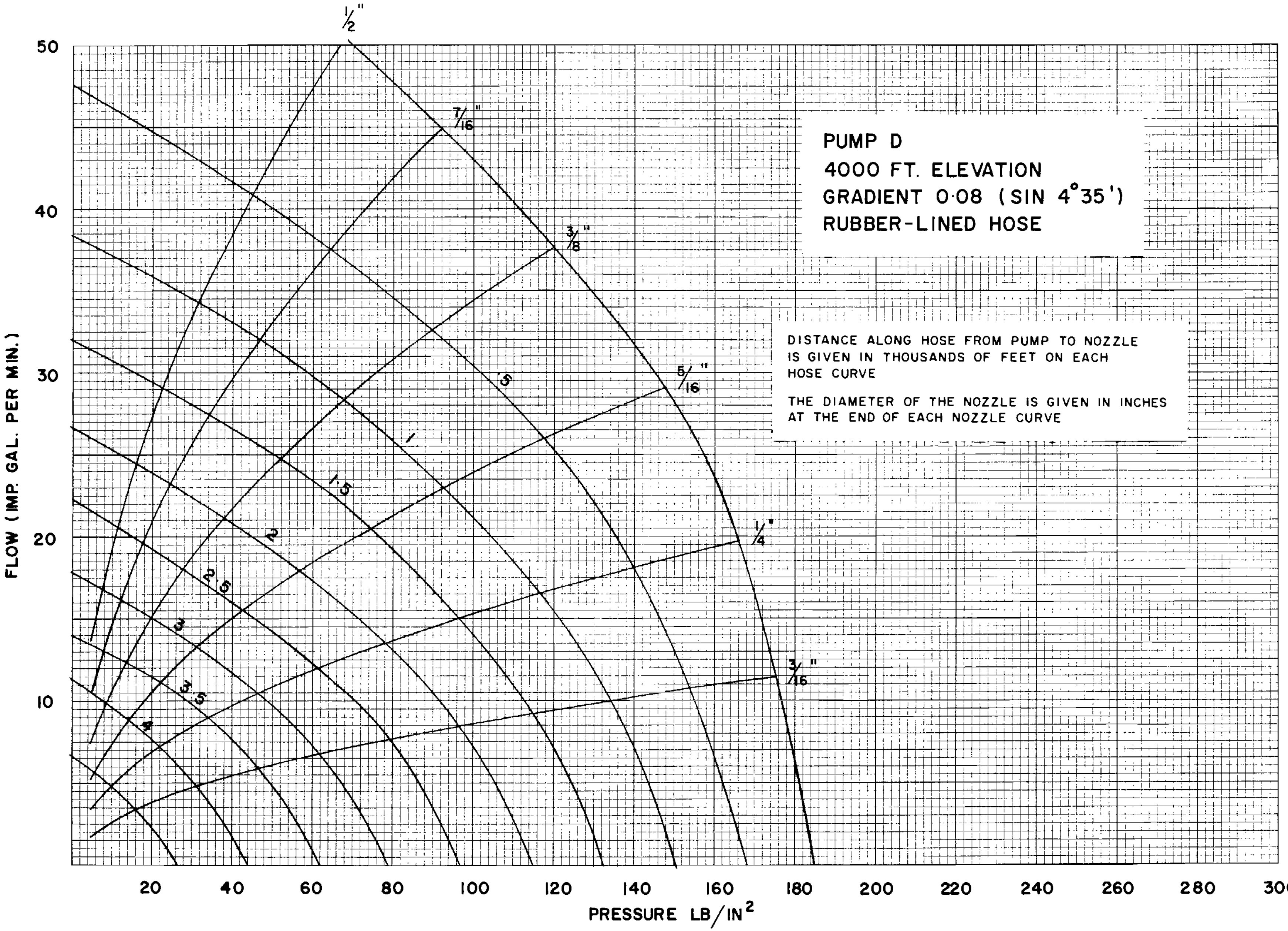

PUMP D
4000 FT. ELEVATION
GRADIENT 0·04 (SIN 2°18')
RUBBER-LINED HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
·5
1
1·5
2
2·5
3
3·5
4
4·5
5
5·5
6
7
8
FLOW (IMP. GAL. PER MIN.)
PRESSURE LB/IN²
10
20
30
40
50
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

FIGURE 30



PUMP D
4000 FT. ELEVATION
GRADIENT 0·08 (SIN 4°35')
RUBBER-LINED HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
·5
1
1·5
2
2·5
3
3·5
4
FLOW (IMP. GAL. PER MIN.)
PRESSURE LB/IN²

FIGURE 31

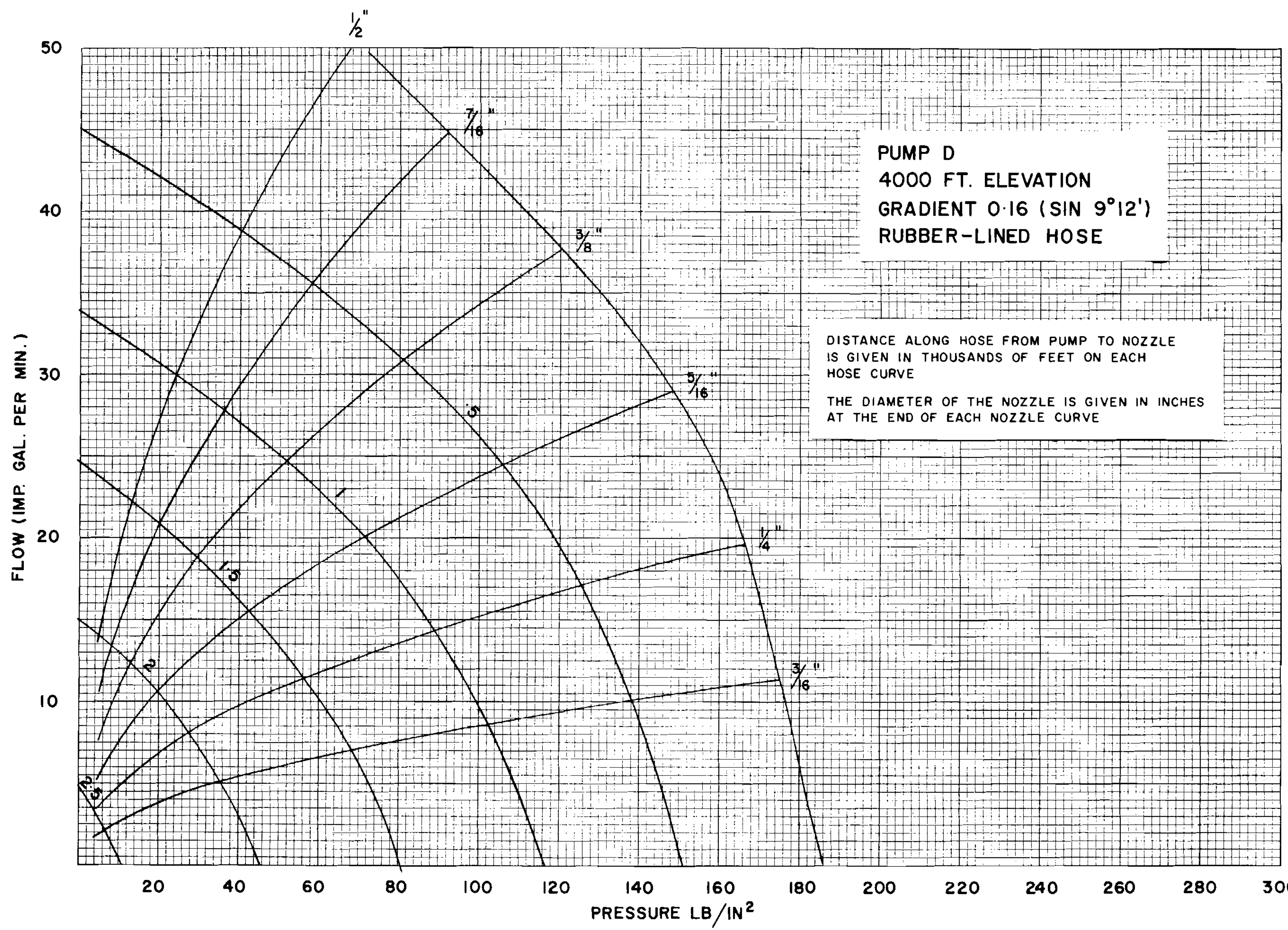
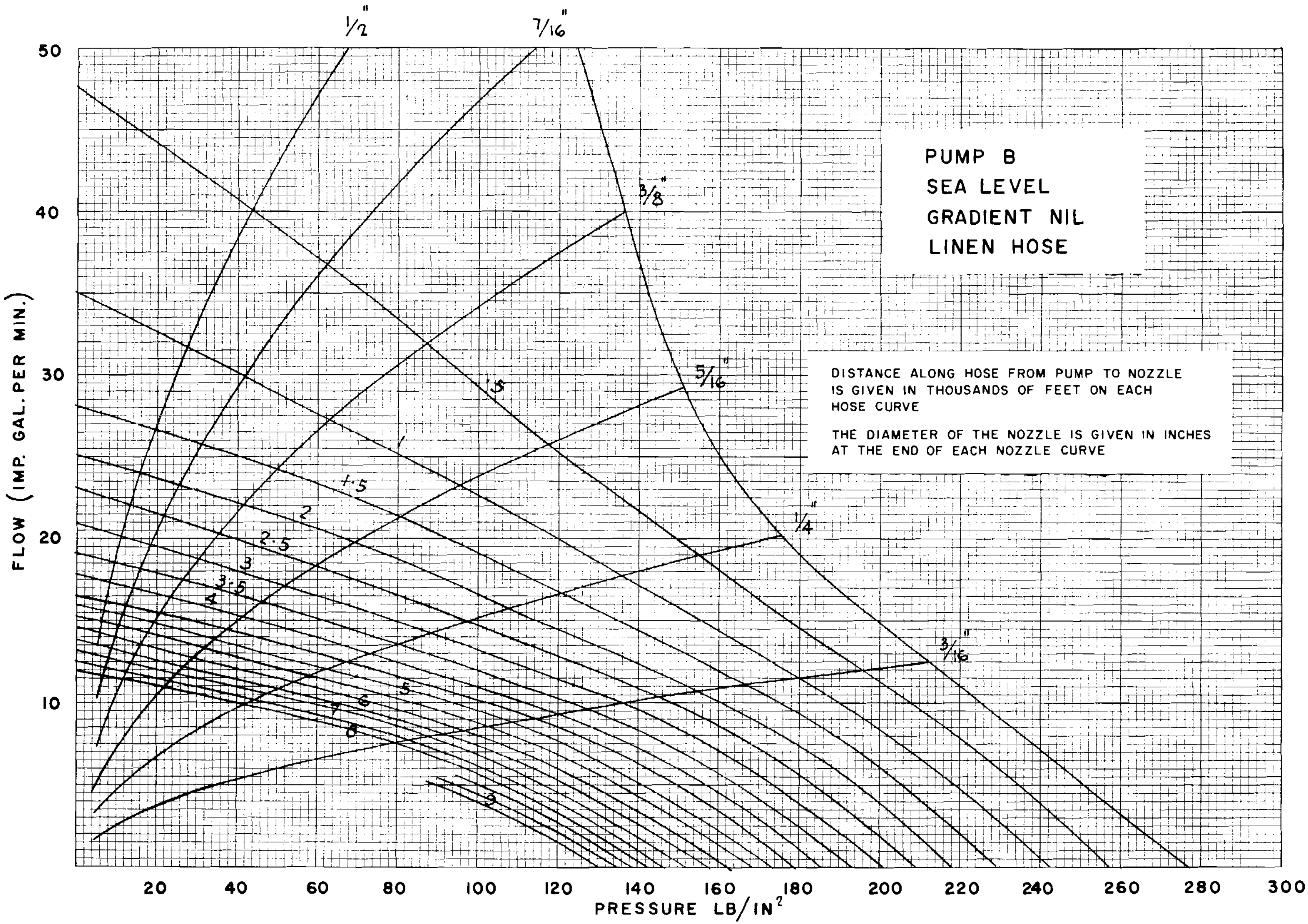

PUMP D
4000 FT. ELEVATION
GRADIENT 0·16 (SIN 9°12')
RUBBER-LINED HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
FLOW (IMP. GAL. PER MIN.)
PRESSURE LB/IN²
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
·5
1
1·5
2
2·5
10
20
30
40
50
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

FIGURE 32



PUMP B
SEA LEVEL
GRADIENT NIL
LINEN HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
FLOW (IMP. GAL. PER MIN.)
PRESSURE LB/IN²
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
·5
1
1·5
2
2·5
3
3·5
4
5
6
7
8
9

FIGURE 33

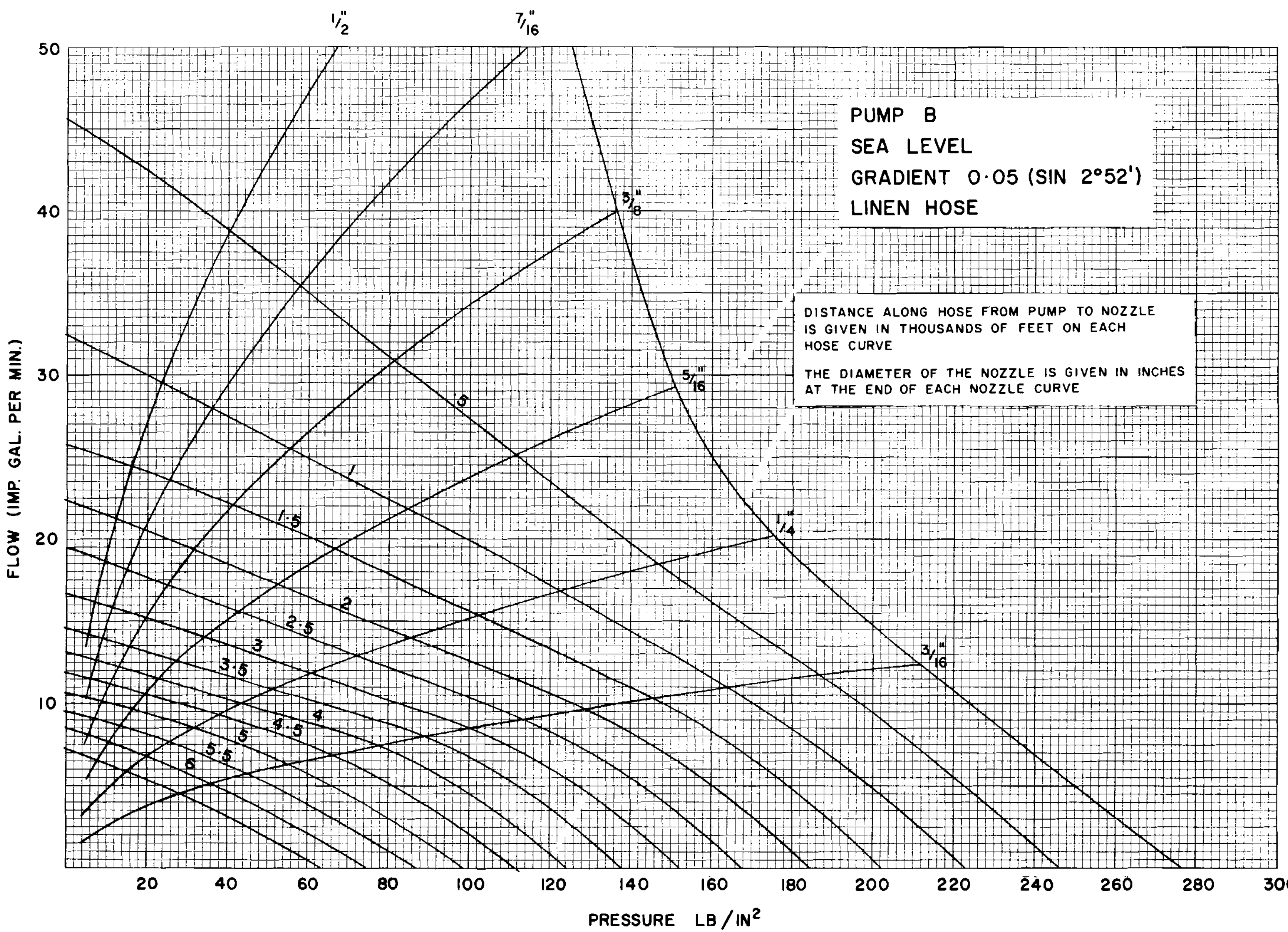

PUMP B
SEA LEVEL
GRADIENT 0·05 (SIN 2°52')
LINEN HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
·5
1
1·5
2
2·5
3
3·5
4
4·5
5
5·5
6
FLOW (IMP. GAL. PER MIN.)
PRESSURE LB/IN²
10
20
30
40
50
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

FIGURE 34

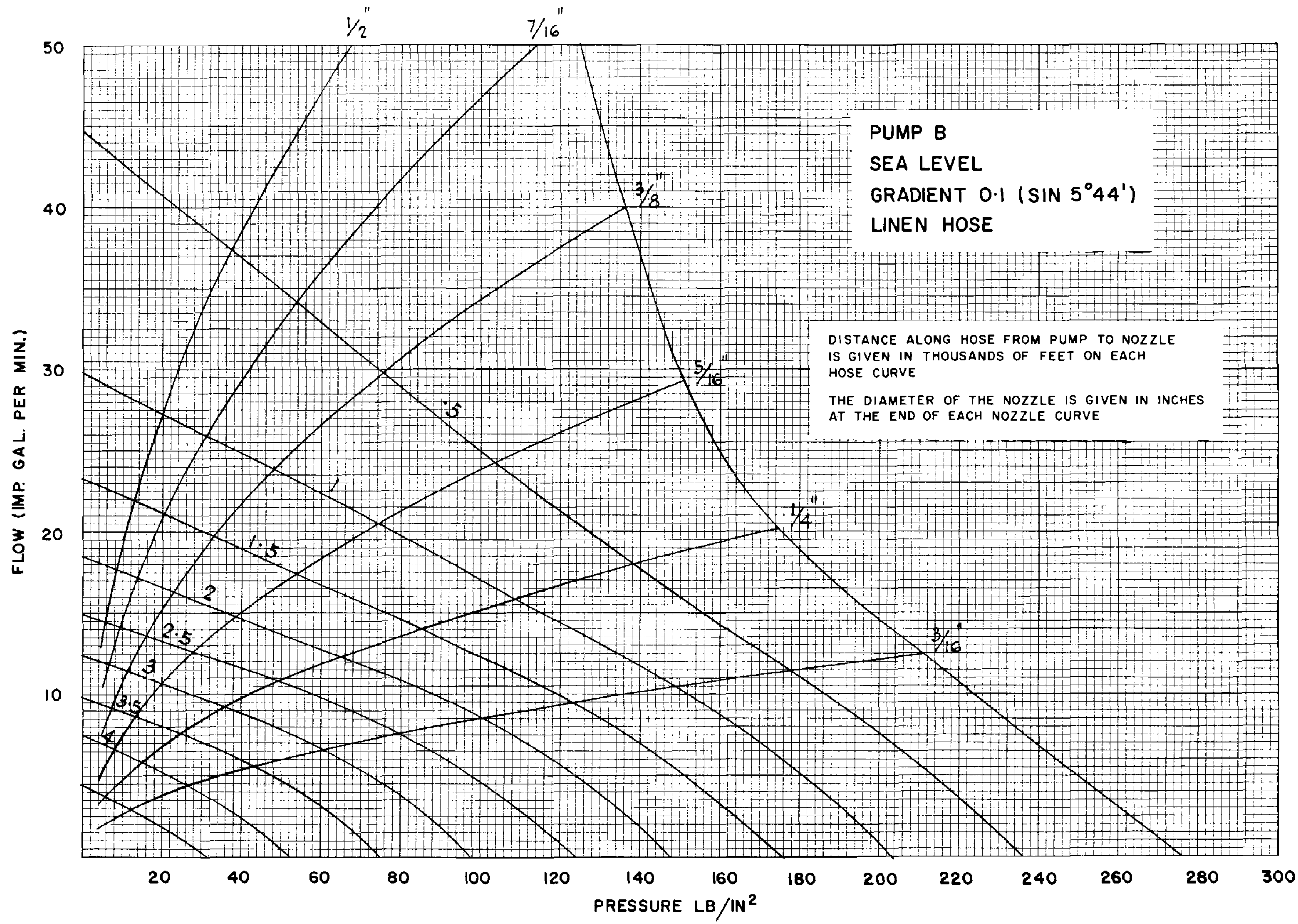
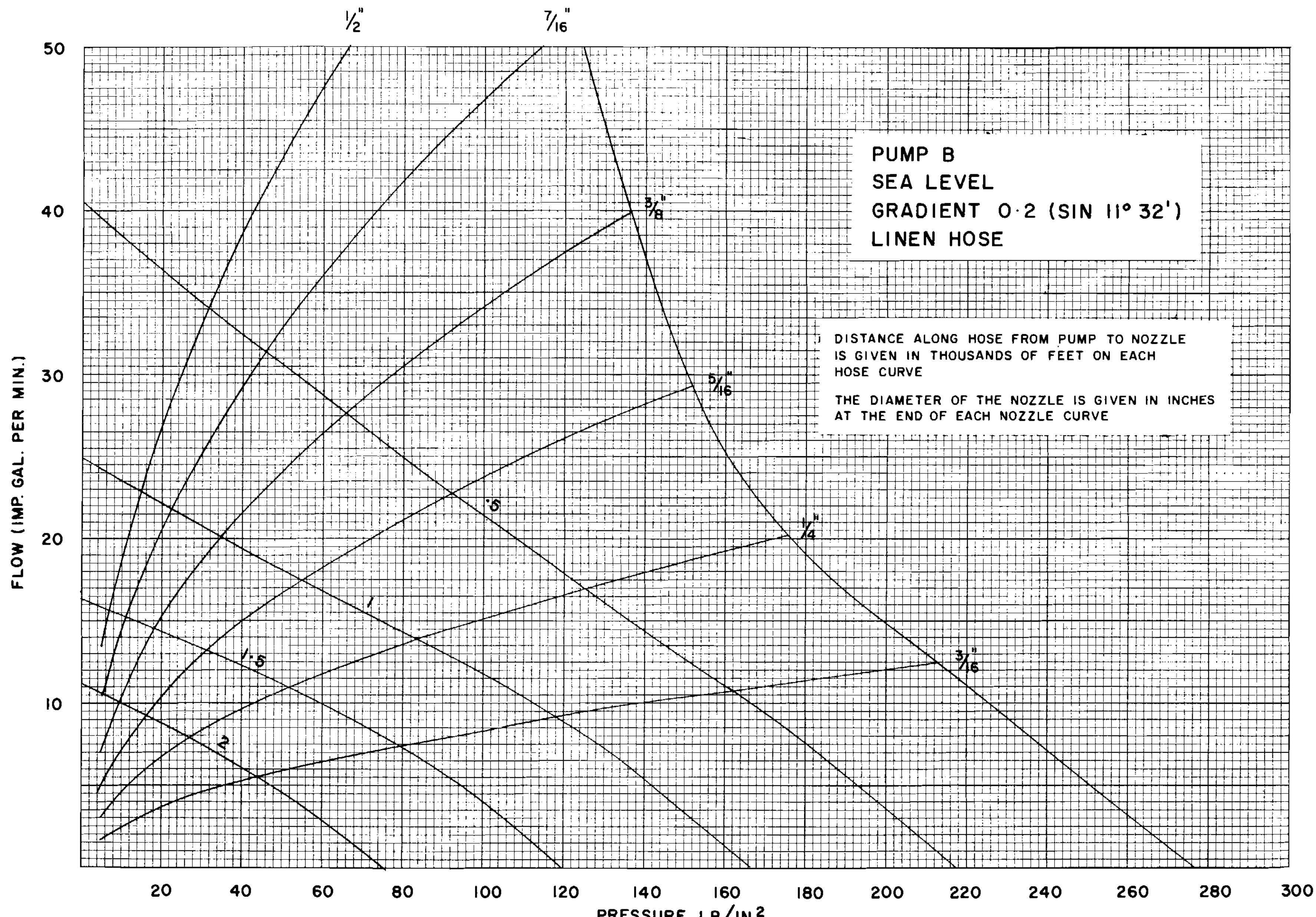
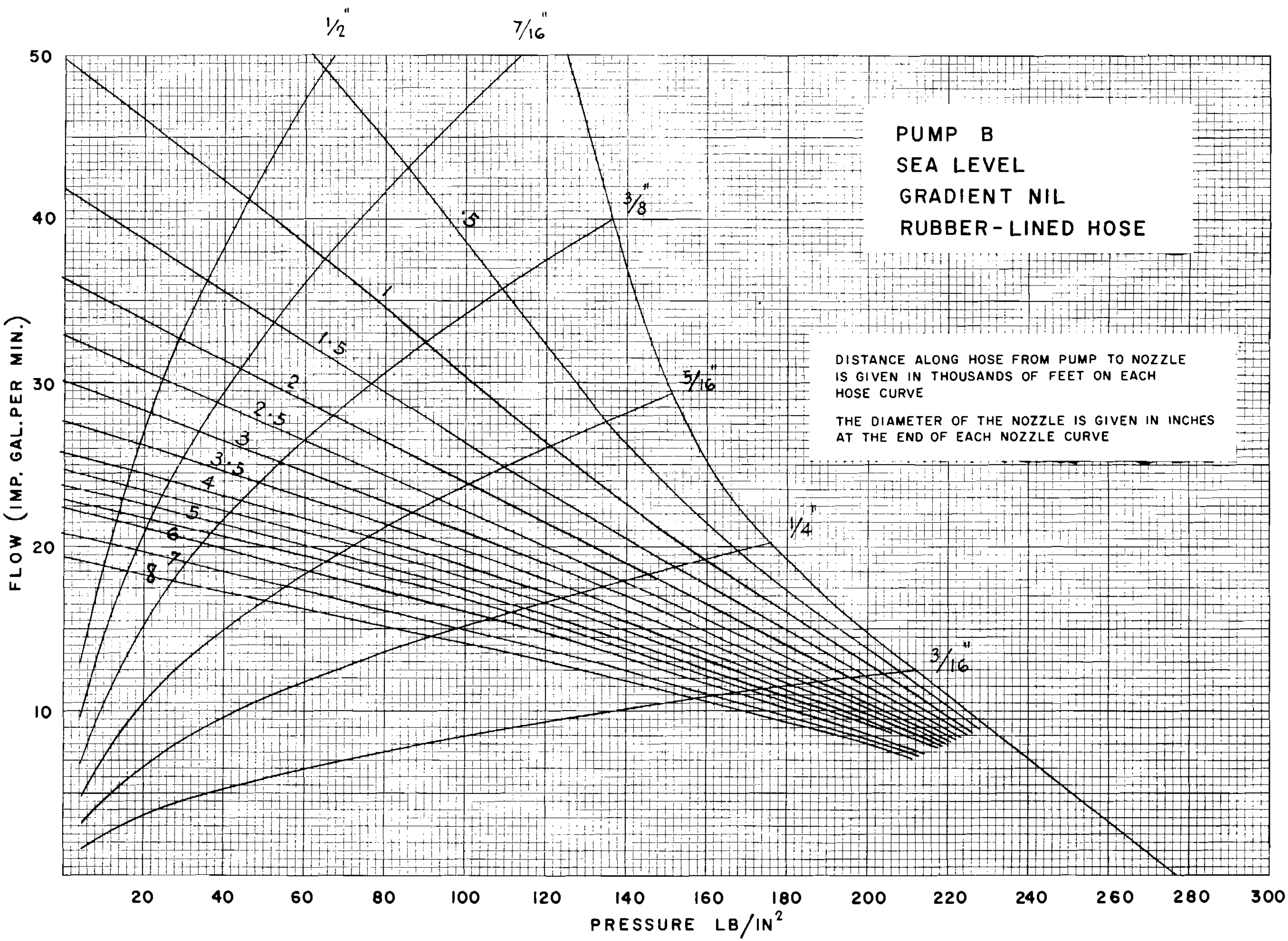

PUMP B
SEA LEVEL
GRADIENT 0·1 (SIN 5°44')
LINEN HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
·5
1
1·5
2
2·5
3
3·5
4
FLOW (IMP. GAL. PER MIN.)
PRESSURE LB/IN²
10
20
30
40
50
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

FIGURE 35



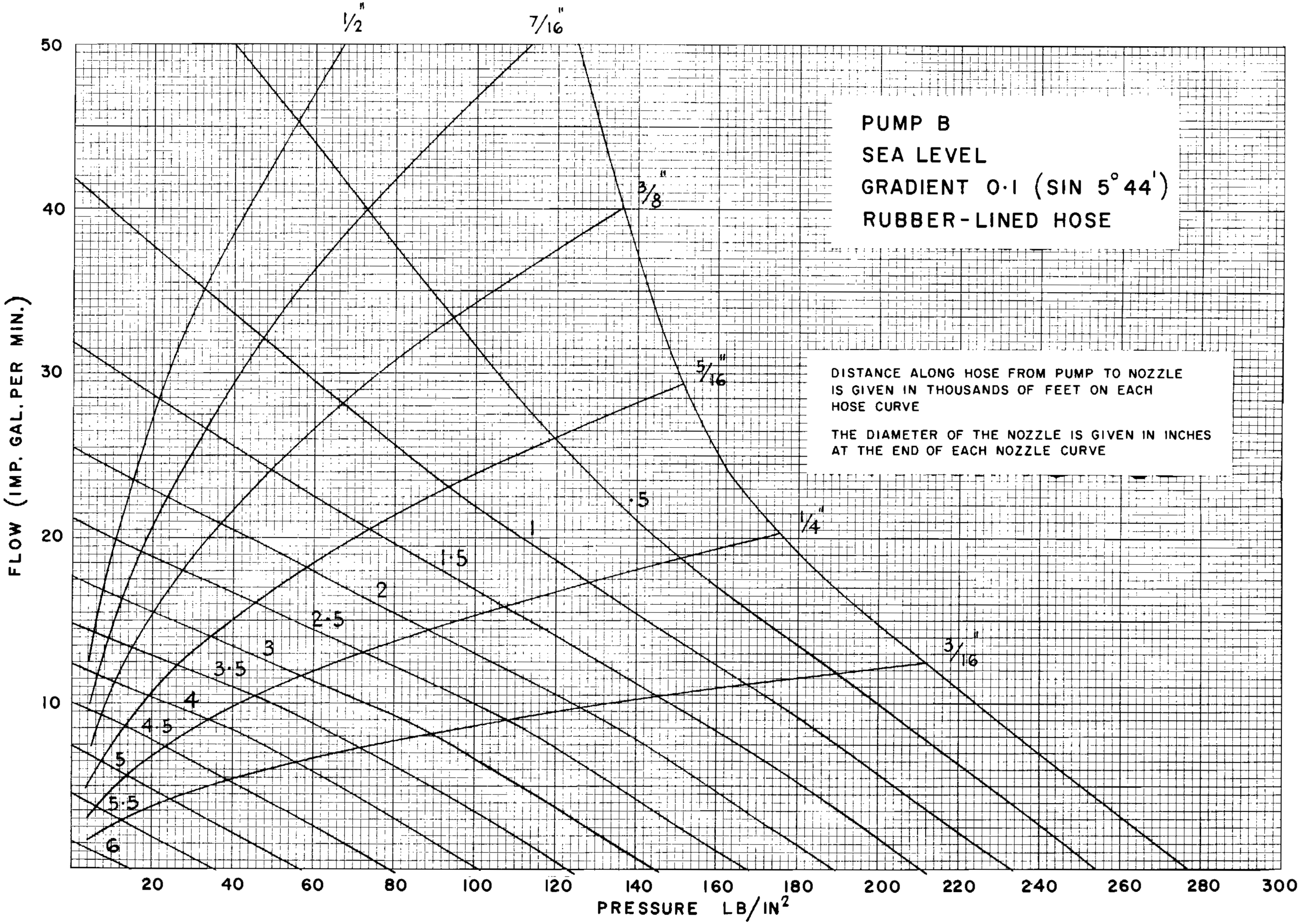
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
·5
1
1·5
2
PUMP B
SEA LEVEL
GRADIENT 0·2 (SIN 11° 32')
LINEN HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
FLOW (IMP. GAL. PER MIN.)
PRESSURE LB/IN²
10
20
30
40
50
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

FIGURE 36



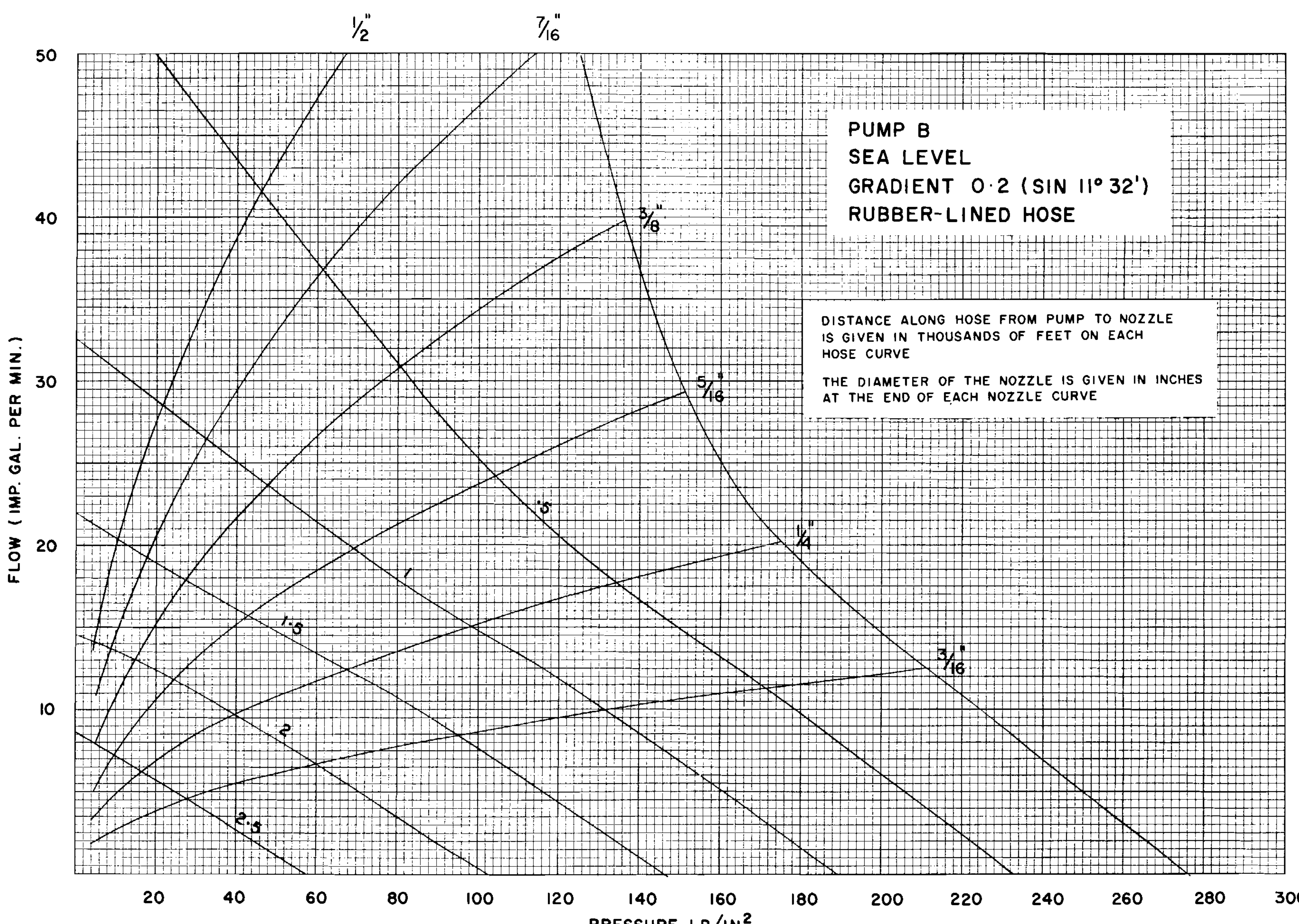
PUMP B
SEA LEVEL
GRADIENT NIL
RUBBER-LINED HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
·5
1
1·5
2
2·5
3
3·5
4
5
6
7
8
FLOW (IMP. GAL. PER MIN.)
PRESSURE LB/IN²

FIGURE 37



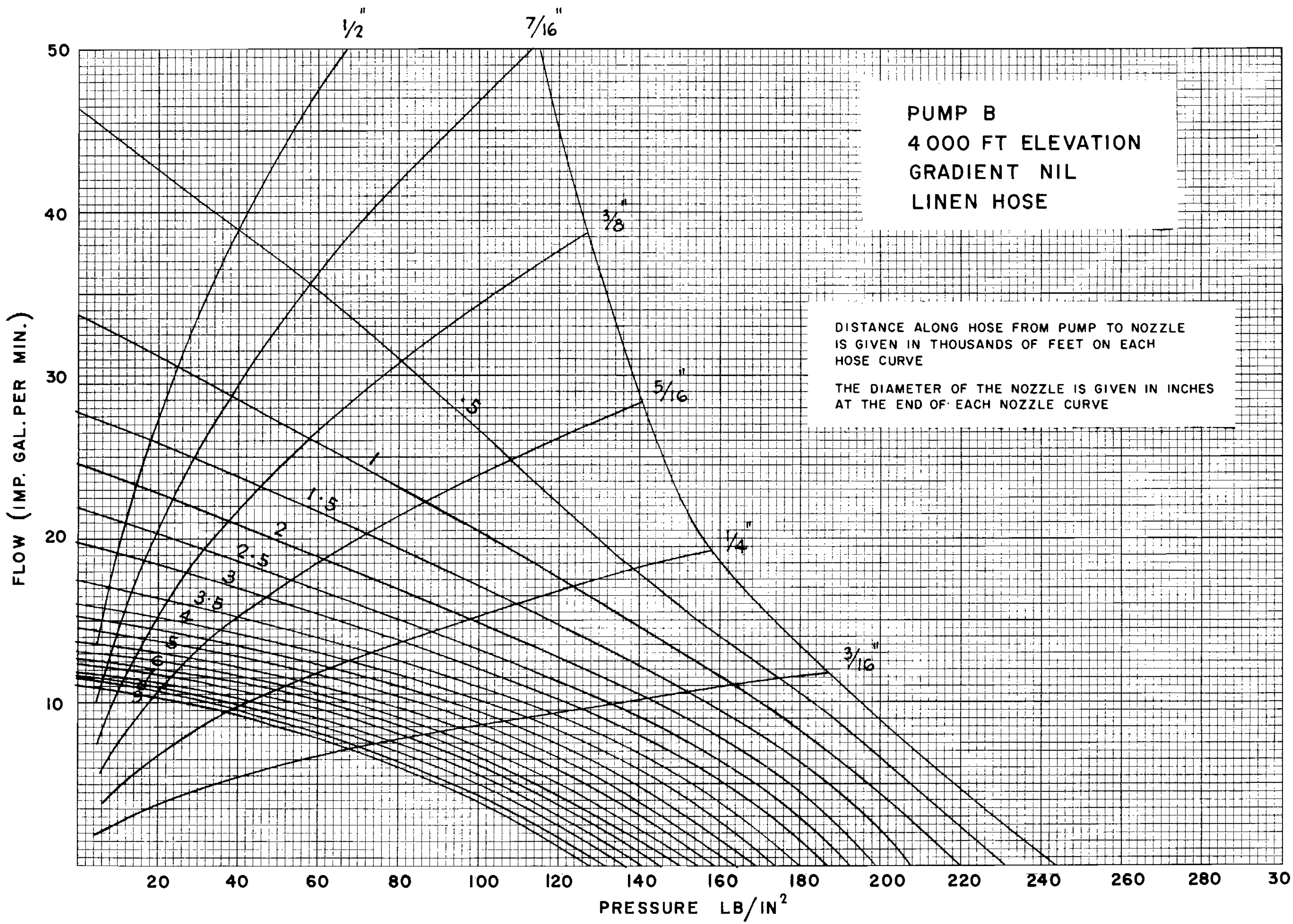
PUMP B
SEA LEVEL
GRADIENT 0·1 (SIN 5° 44')
RUBBER-LINED HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
·5
1
1·5
2
2·5
3
3·5
4
4·5
5
5·5
6
FLOW (IMP. GAL. PER MIN.)
PRESSURE LB/IN²

FIGURE 38



PUMP B
SEA LEVEL
GRADIENT 0·2 (SIN 11° 32')
RUBBER-LINED HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
·5
1
1·5
2
2·5
FLOW (IMP. GAL. PER MIN.)
PRESSURE LB/IN²
10
20
30
40
50
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

FIGURE 39



PUMP B
4 000 FT ELEVATION
GRADIENT NIL
LINEN HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
FLOW (IMP. GAL. PER MIN.)
PRESSURE LB/IN²
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
·5
1
1·5
2
2·5
3
3·5
4
5
6

FIGURE 40

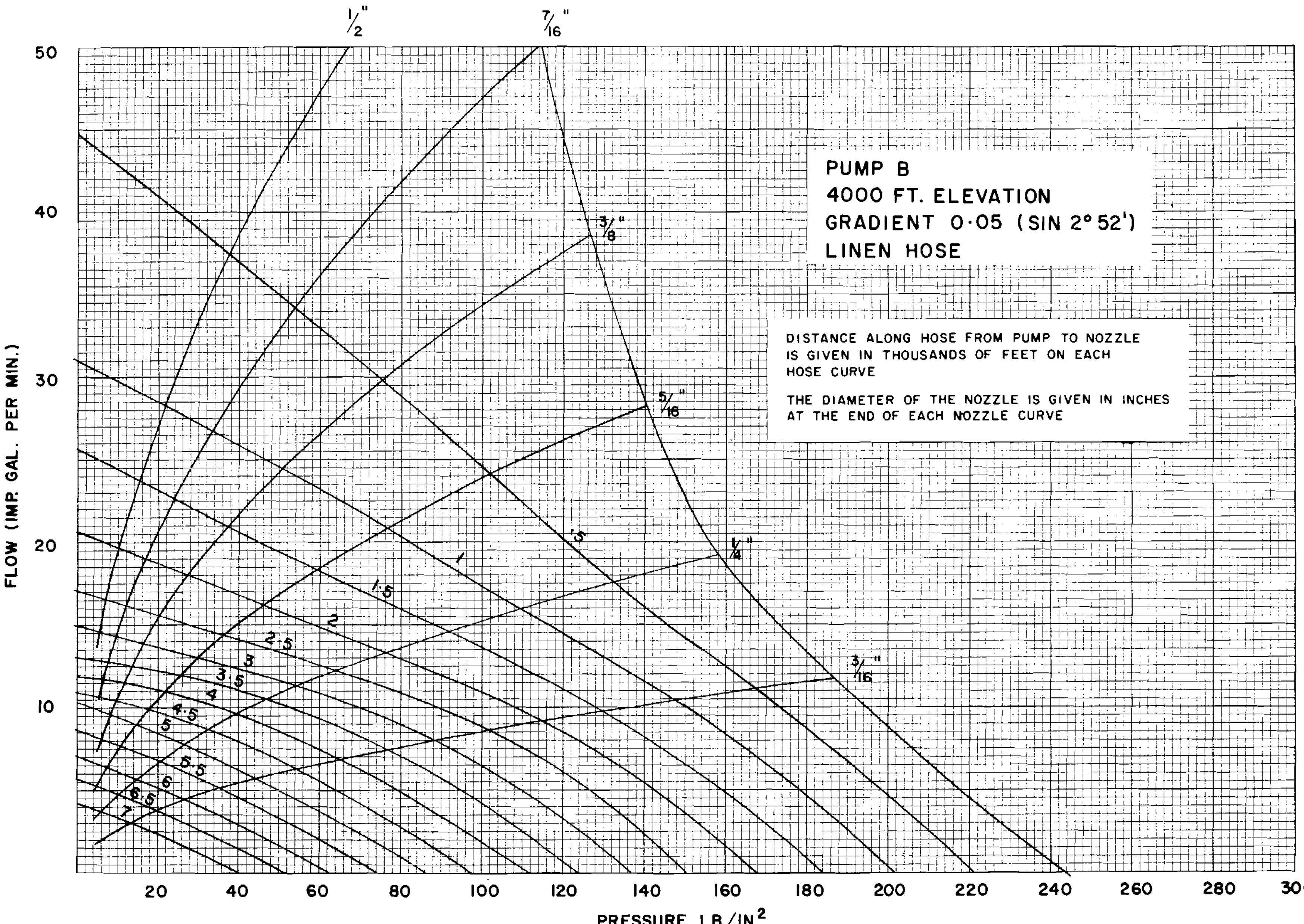
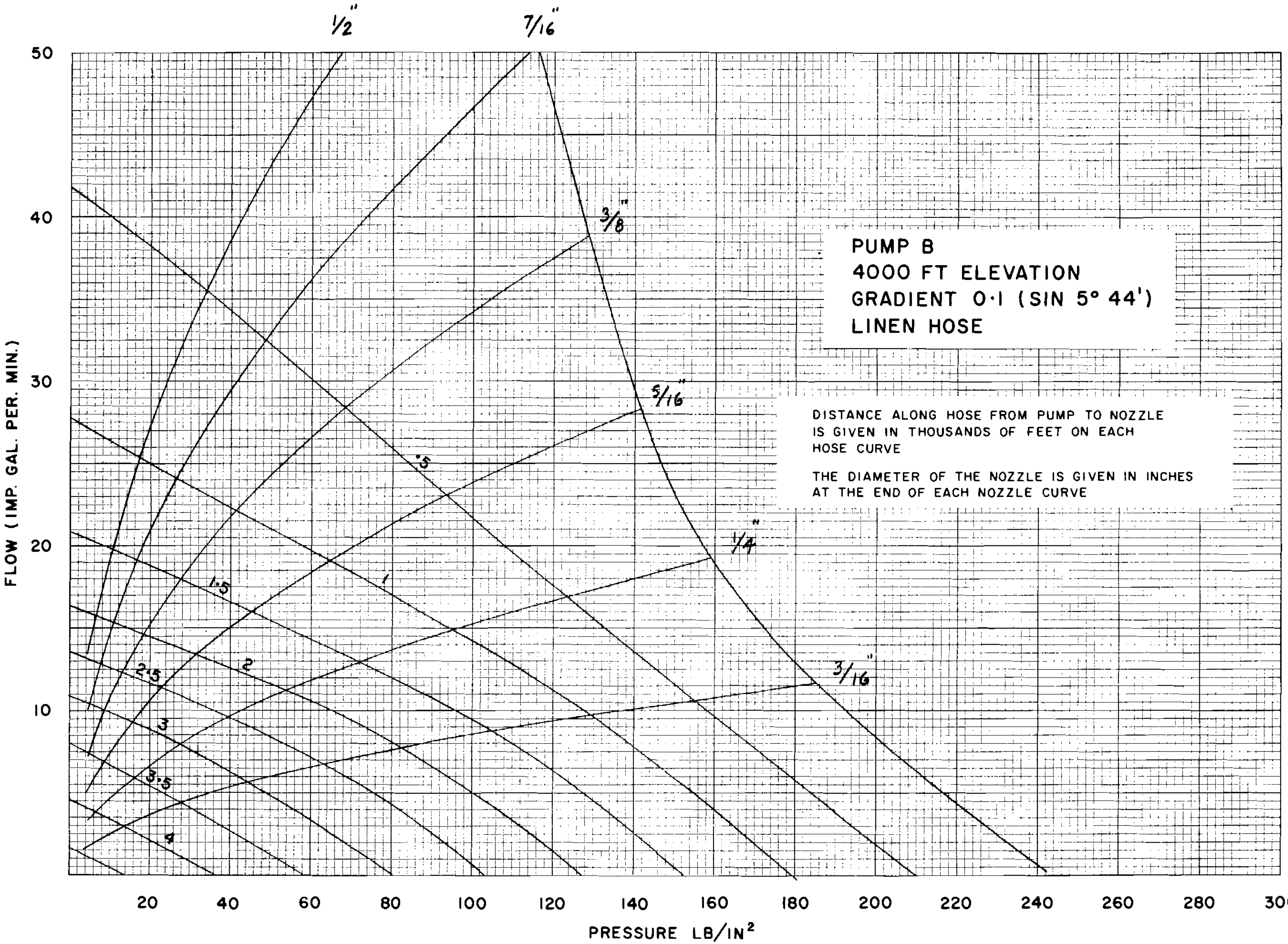

PUMP B
4000 FT. ELEVATION
GRADIENT 0·05 (SIN 2° 52')
LINEN HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
·5
1
1·5
2
2·5
3
3·5
4
4·5
5
5·5
6
6·5
7
FLOW (IMP. GAL. PER MIN.)
PRESSURE LB/IN²
10
20
30
40
50
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

FIGURE 41



PUMP B
4000 FT ELEVATION
GRADIENT 0·1 (SIN 5° 44')
LINEN HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
·5
1
1·5
2
2·5
3
3·5
4
FLOW (IMP. GAL. PER. MIN.)
PRESSURE LB/IN²
50
40
30
20
10
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

FIGURE 42

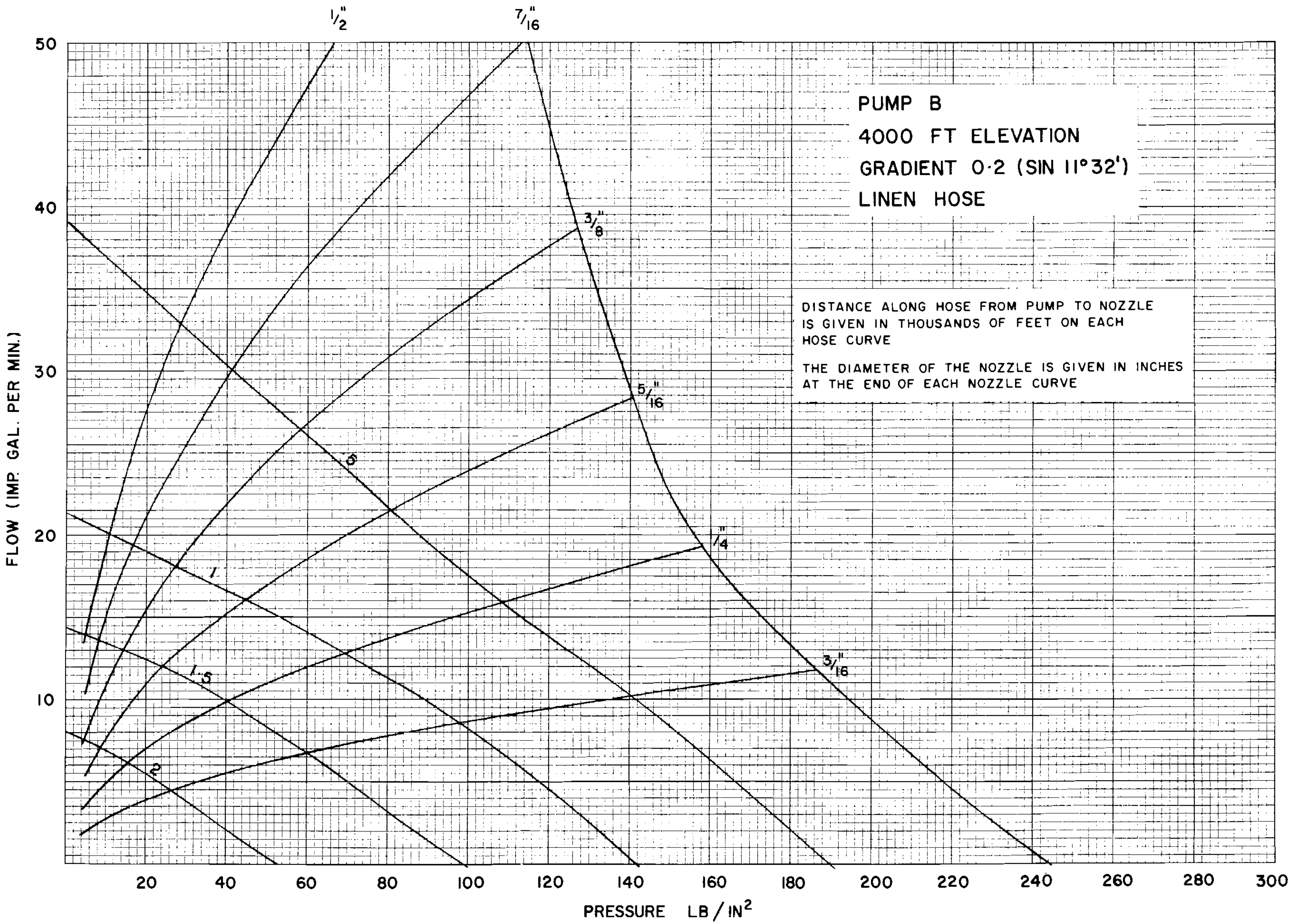

PUMP B
4000 FT ELEVATION
GRADIENT 0·2 (SIN 11°32')
LINEN HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
·5
1
1·5
2
FLOW (IMP. GAL. PER MIN.)
PRESSURE LB / IN²
50
40
30
20
10
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

FIGURE 43

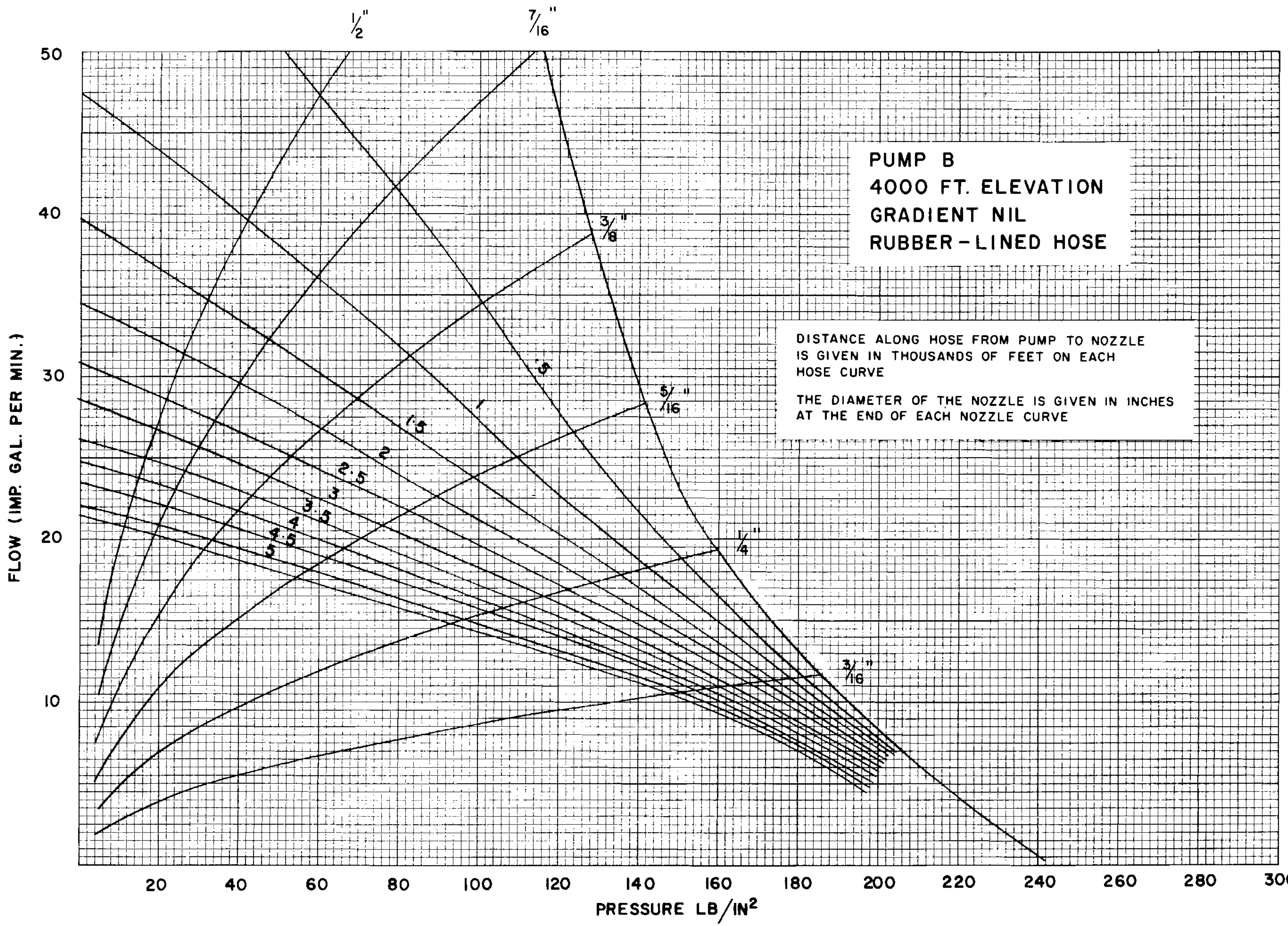
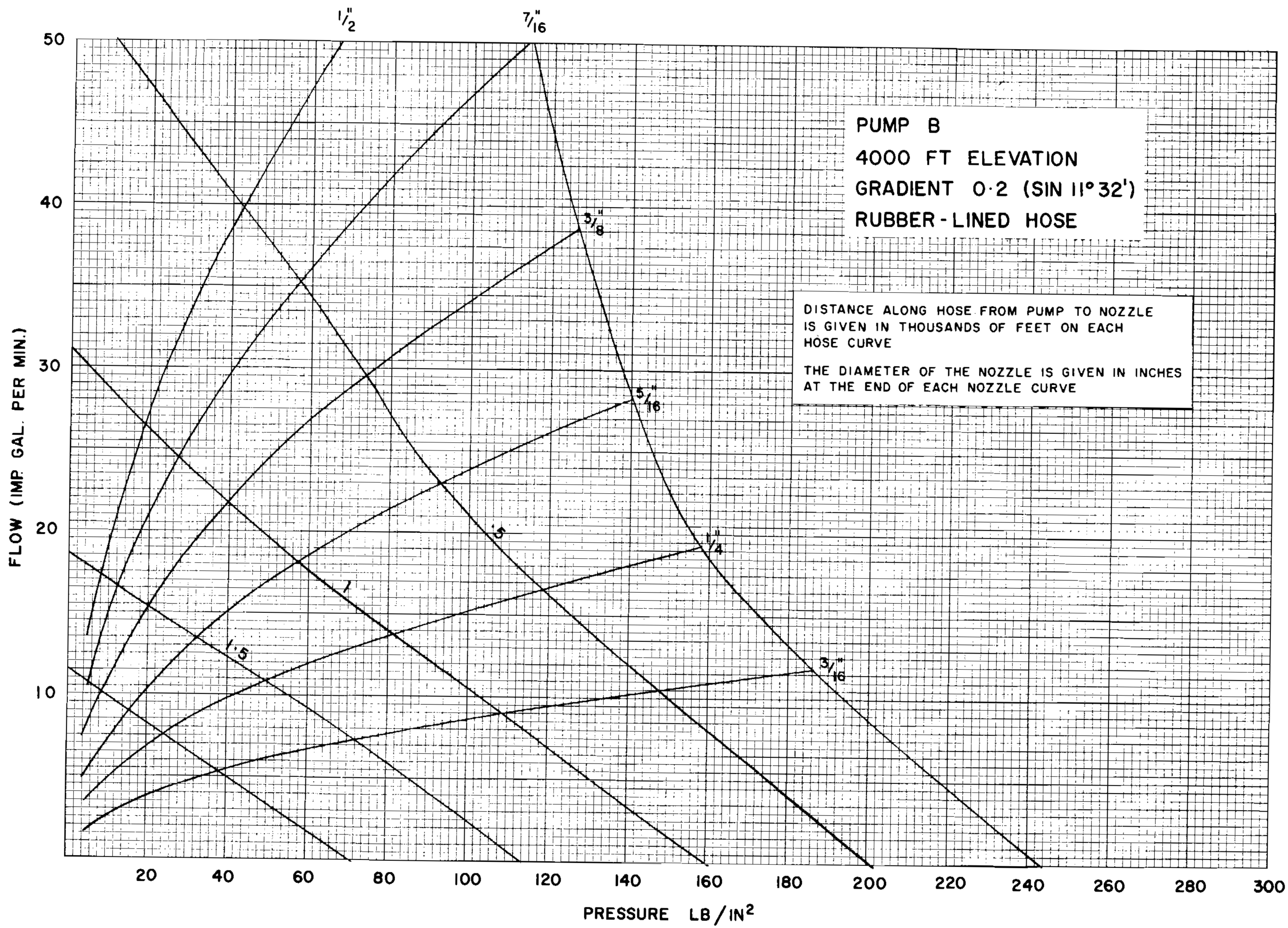

PUMP B
4000 FT. ELEVATION
GRADIENT NIL
RUBBER-LINED HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
FLOW (IMP. GAL. PER MIN.)
PRESSURE LB/IN²
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
.5
1
1.5
2
2.5
3
3.5
4
4.5
5

FIGURE 44



PUMP B
4000 FT ELEVATION
GRADIENT 0·2 (SIN 11° 32')
RUBBER-LINED HOSE
DISTANCE ALONG HOSE FROM PUMP TO NOZZLE IS GIVEN IN THOUSANDS OF FEET ON EACH HOSE CURVE
THE DIAMETER OF THE NOZZLE IS GIVEN IN INCHES AT THE END OF EACH NOZZLE CURVE
1/2"
7/16"
3/8"
5/16"
1/4"
3/16"
·5
1
1·5
FLOW (IMP. GAL. PER MIN.)
PRESSURE LB/IN²

FIGURE 45

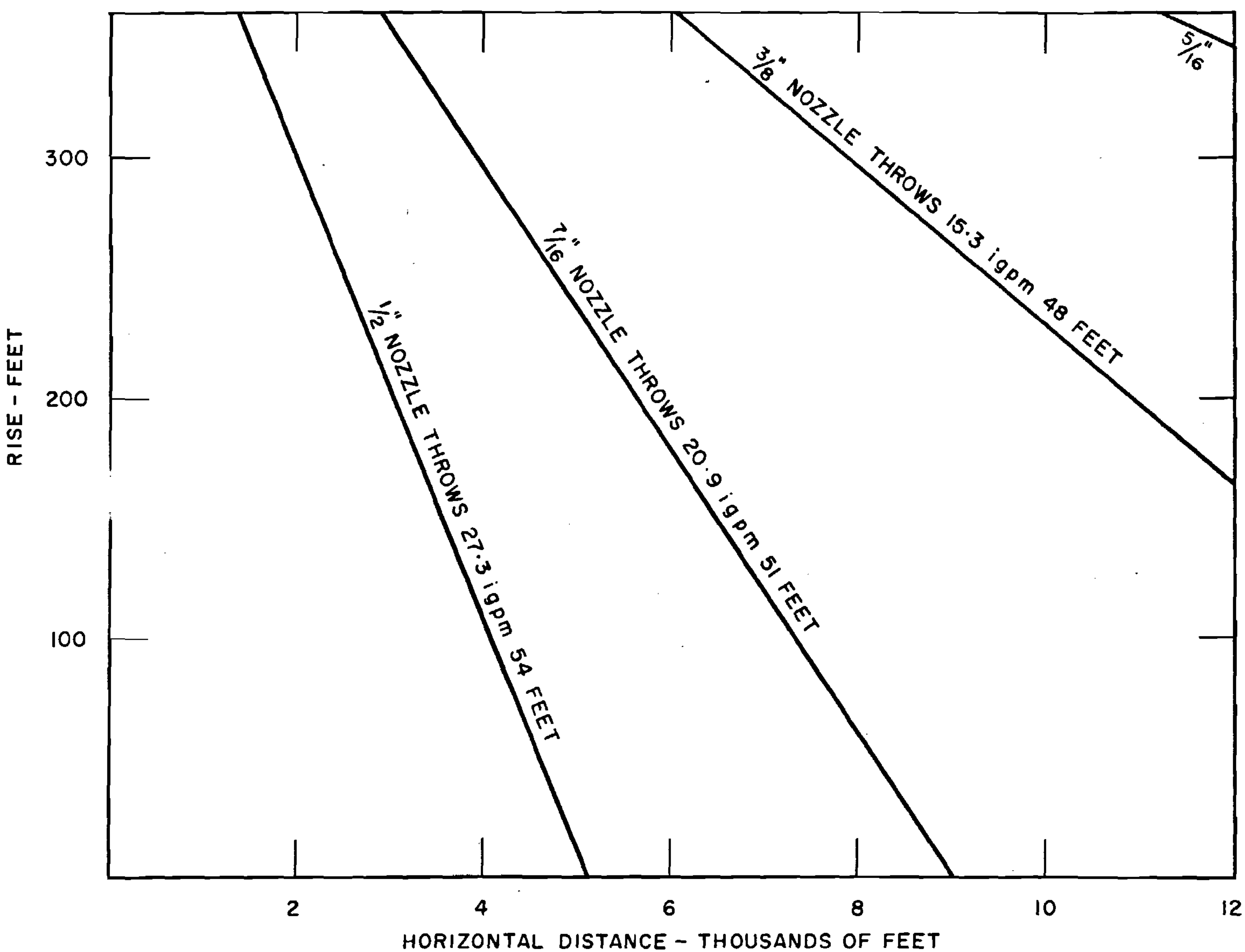


FIGURE 46

LIMITING DISTANCES AND RISES AT WHICH 20 LBS/IN^2 PRESSURE CAN BE HAD AT NOZZLES OF VARIOUS SIZES (FOR PUMP W AT SEA LEVEL WITH RUBBER-LINED HOSE)

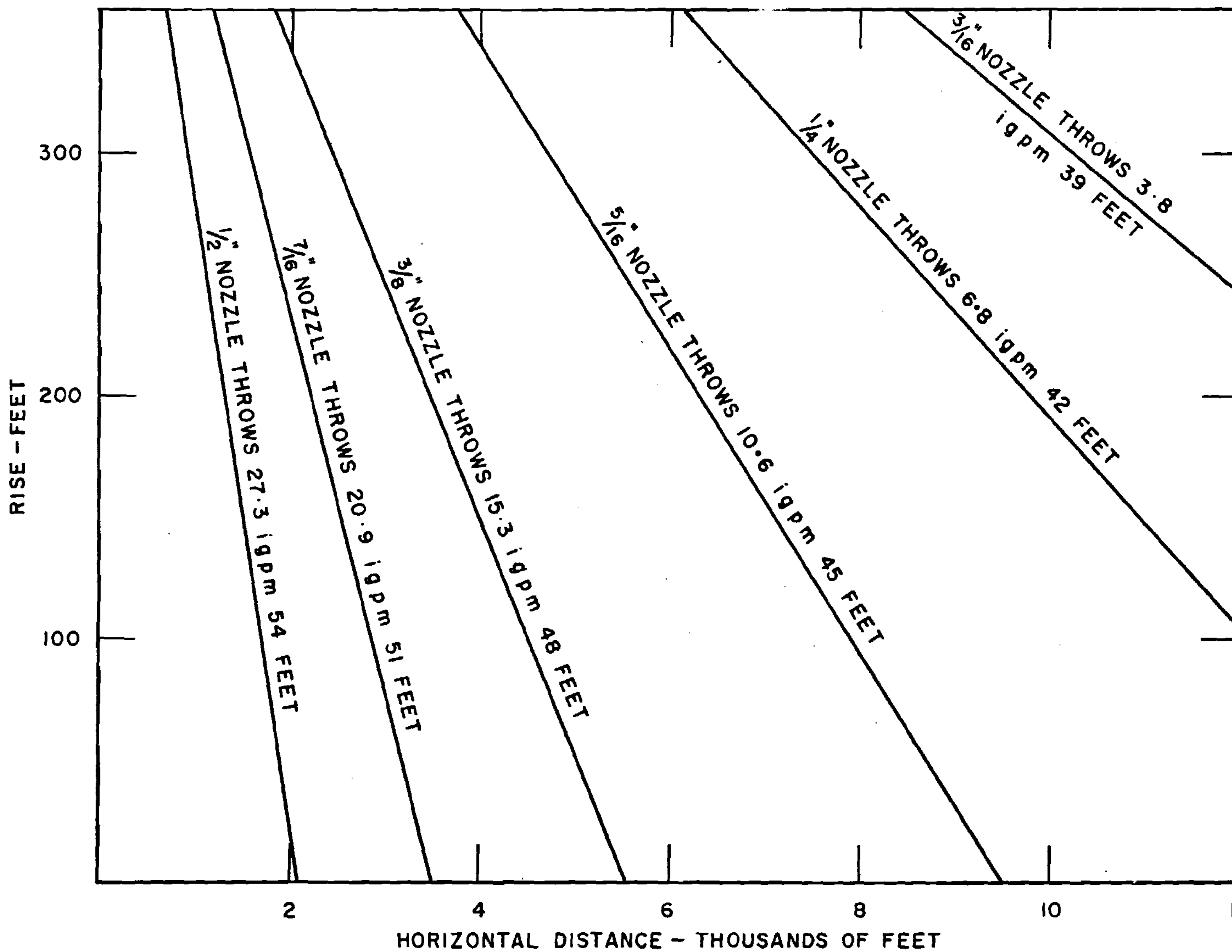


FIGURE 47

LIMITING DISTANCES AND RISES AT WHICH 20 LBS/IN^2 PRESSURE CAN BE HAD AT NOZZLES OF VARIOUS SIZES (FOR PUMP W AT SEA LEVEL WITH LINEN HOSE)

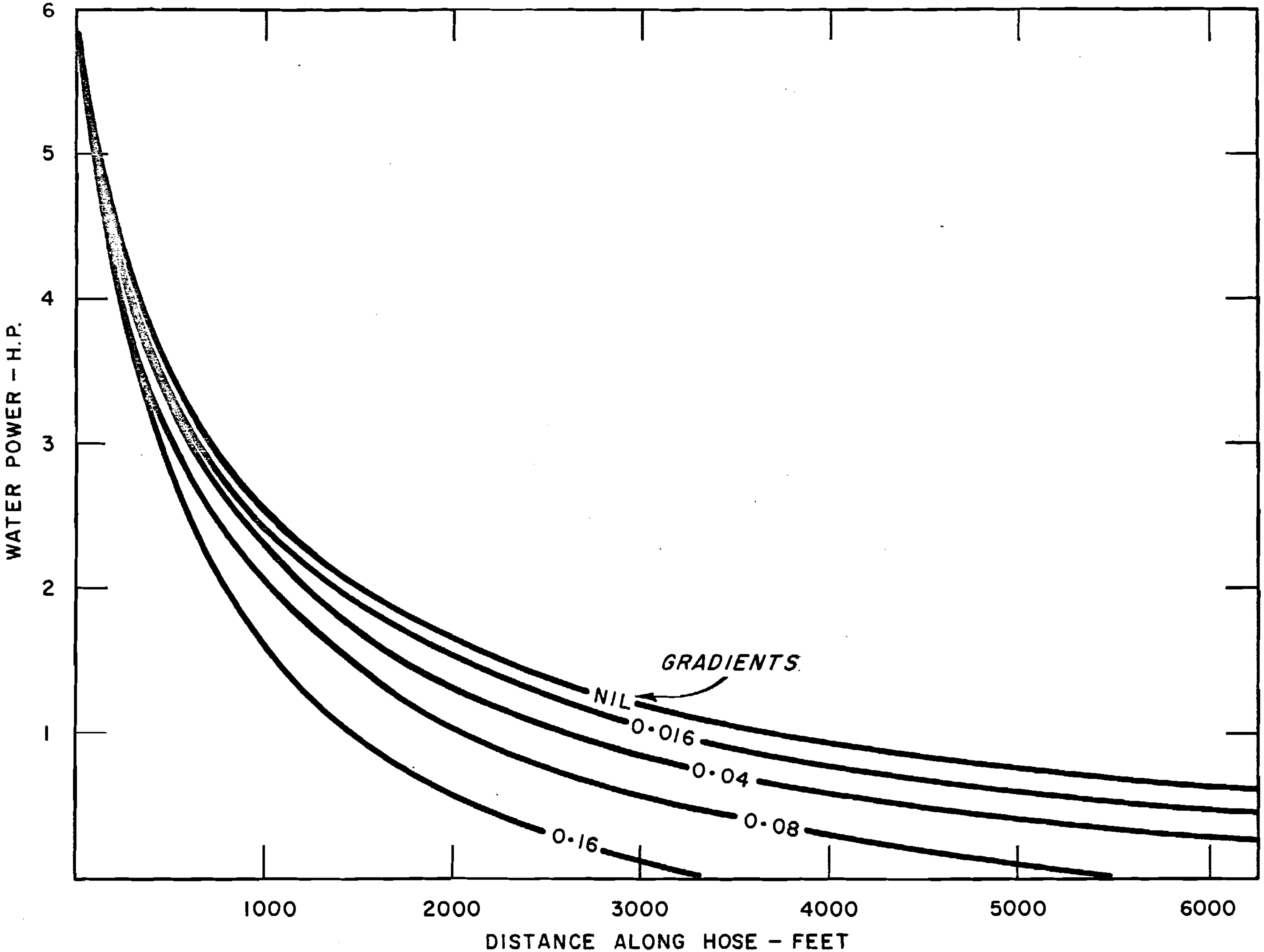


FIGURE 48

MAX. WATERPOWER AT NOZZLE: PUMP W AT SEA LEVEL, LINEN HOSE

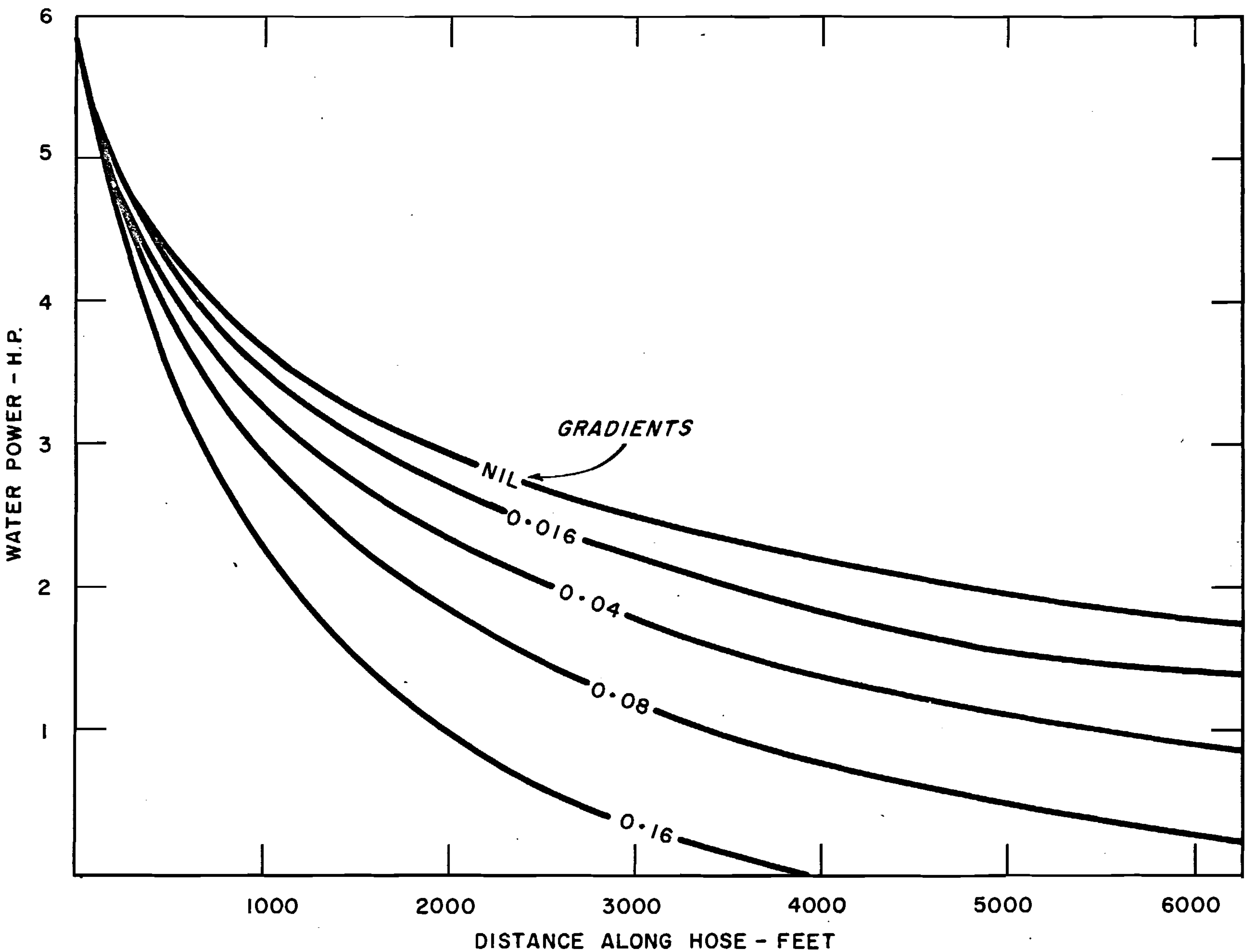


FIGURE 49

MAX. WATERPOWER AT NOZZLE: PUMP W AT SEA LEVEL, RUBBER-LINED HOSE

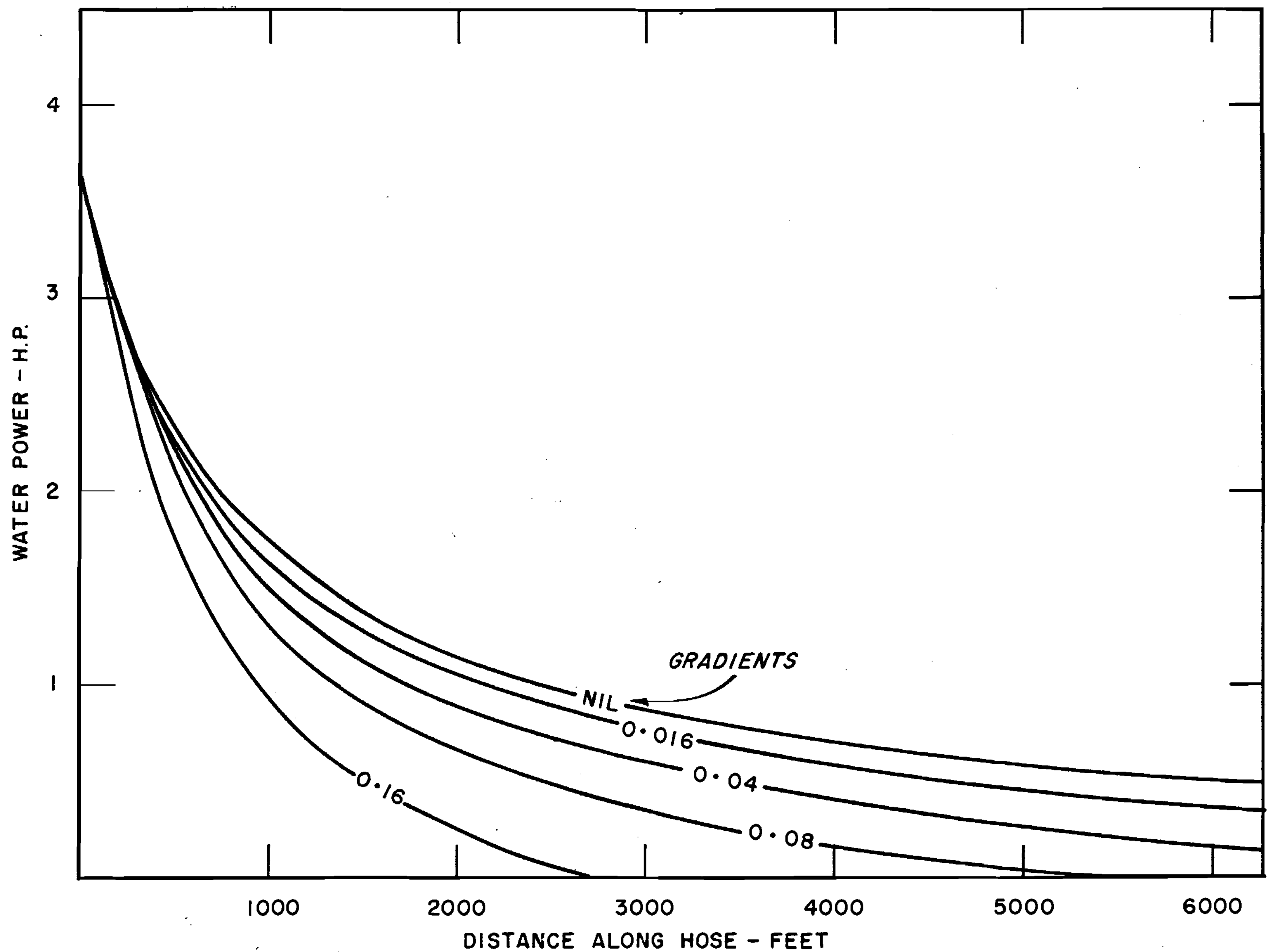


FIGURE 50

MAX. WATERPOWER AT NOZZLE: PUMP D AT SEA LEVEL, LINEN HOSE

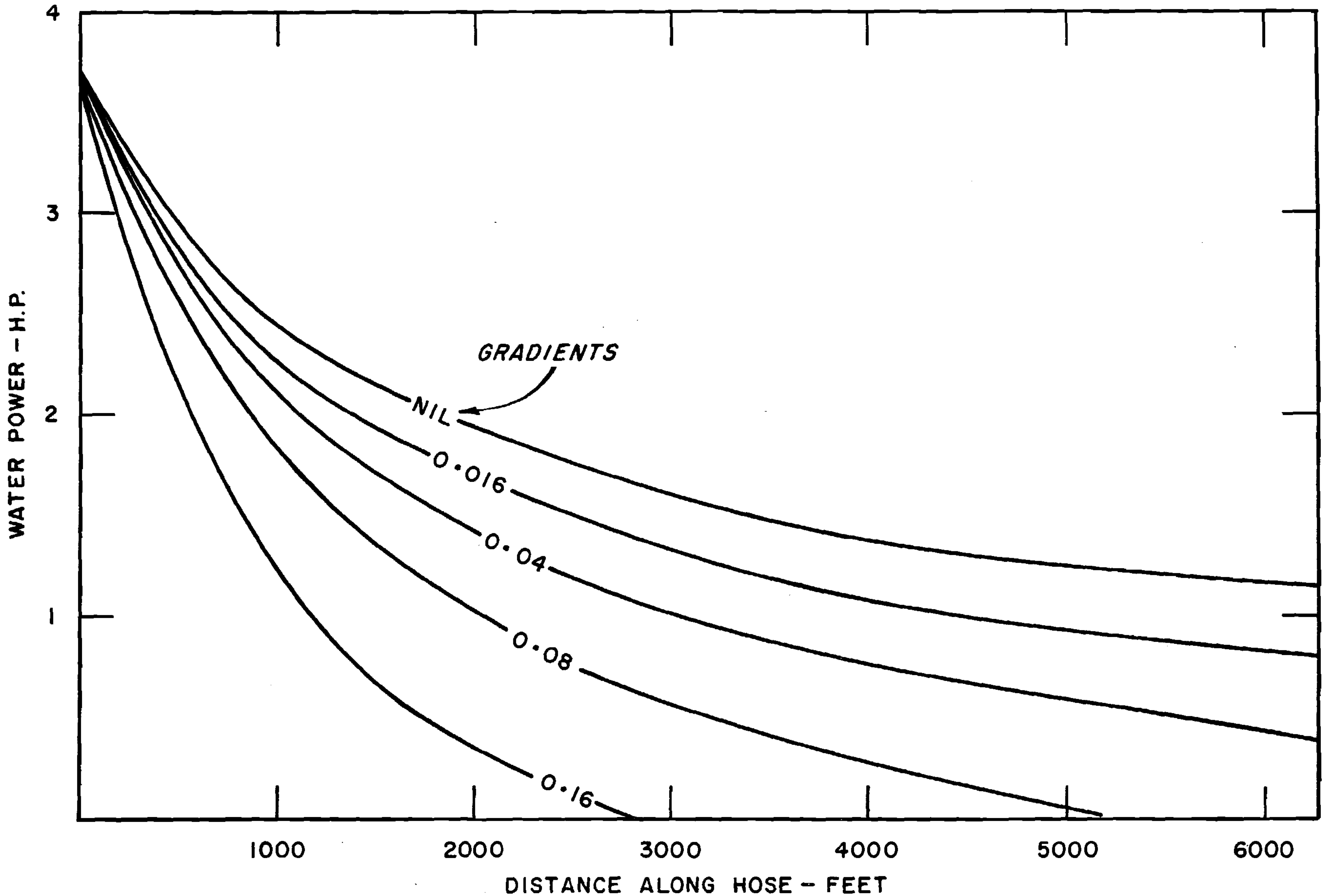


FIGURE 51

MAX. WATERPOWER AT NOZZLE: PUMP D AT SEA LEVEL, RUBBER-LINED HOSE

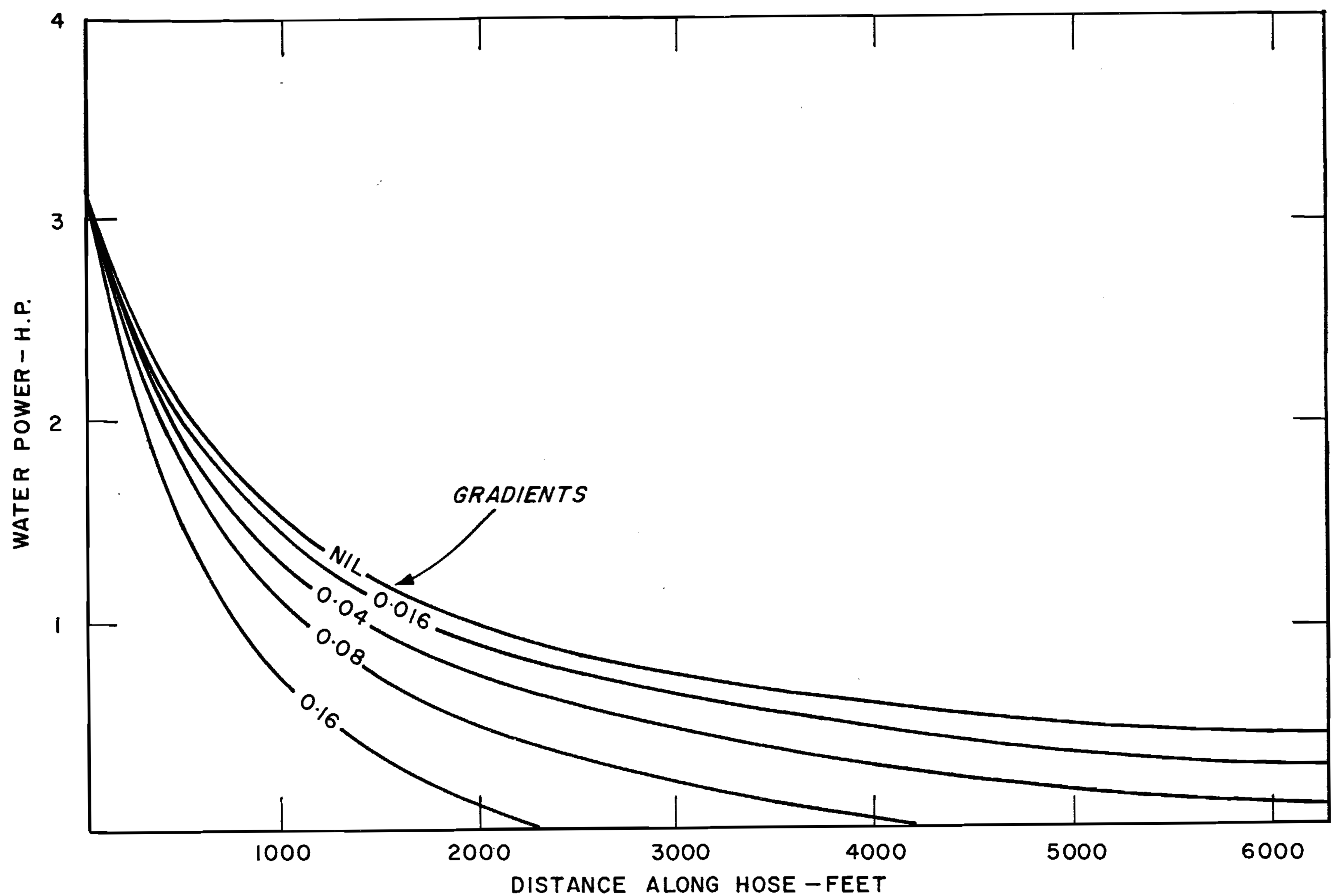


FIGURE 52

MAX. WATERPOWER AT NOZZLE: PUMP D AT 4000 FT. ELEVATION, LINEN HOSE

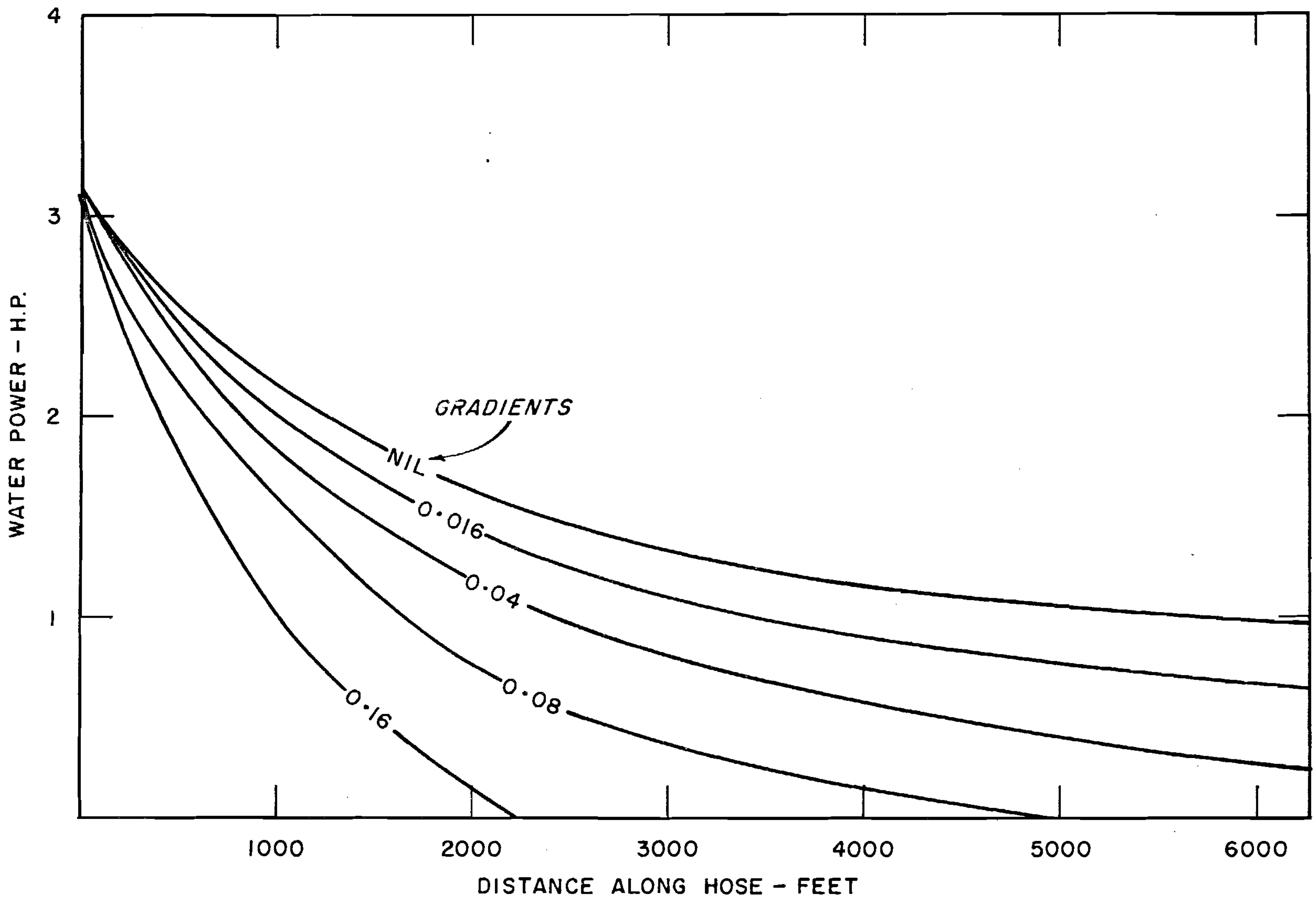


FIGURE 53

MAX. WATERPOWER AT NOZZLE: PUMP D AT 4000 FT ELEVATION, RUBBER-LINED HOSE

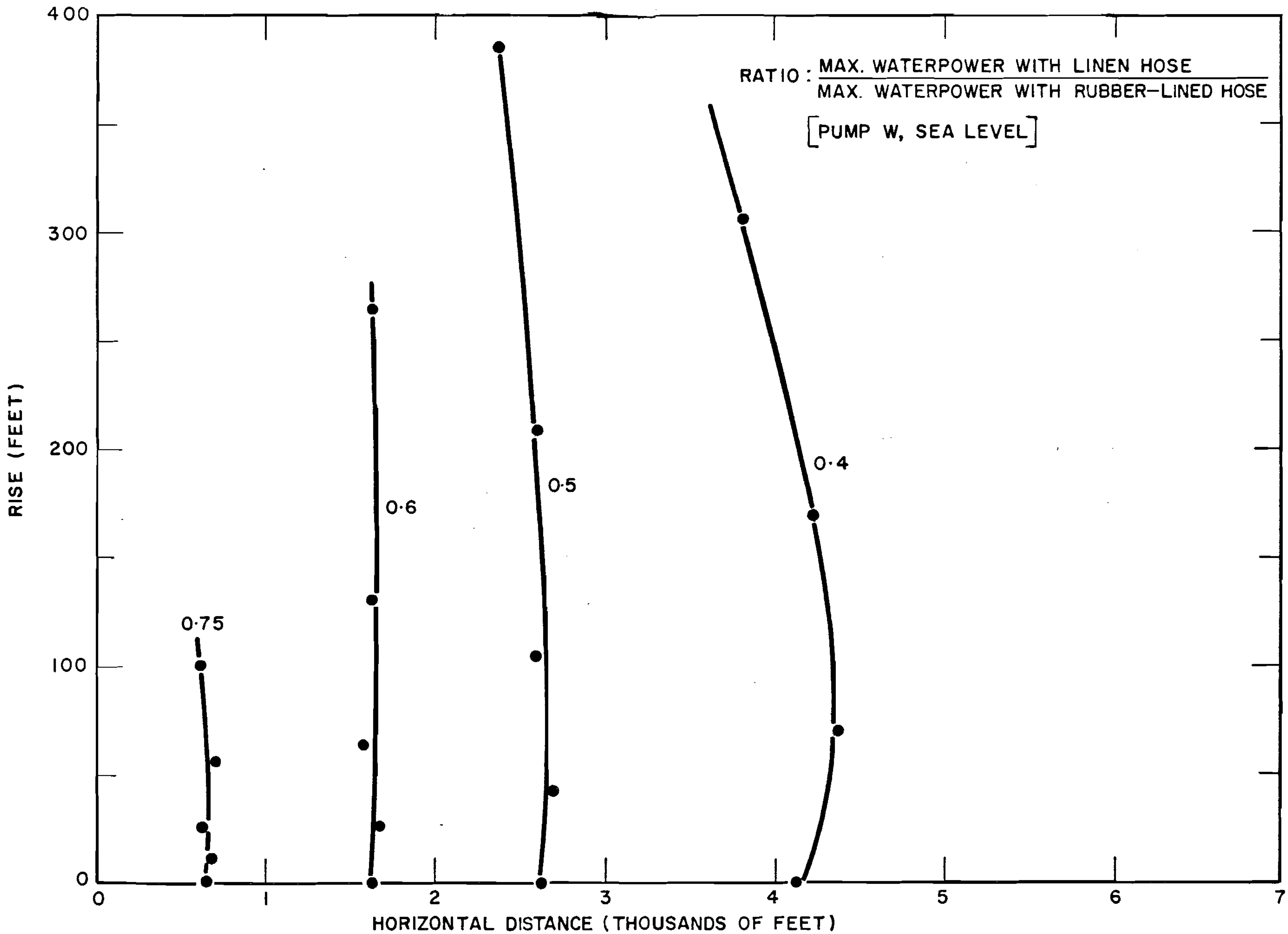
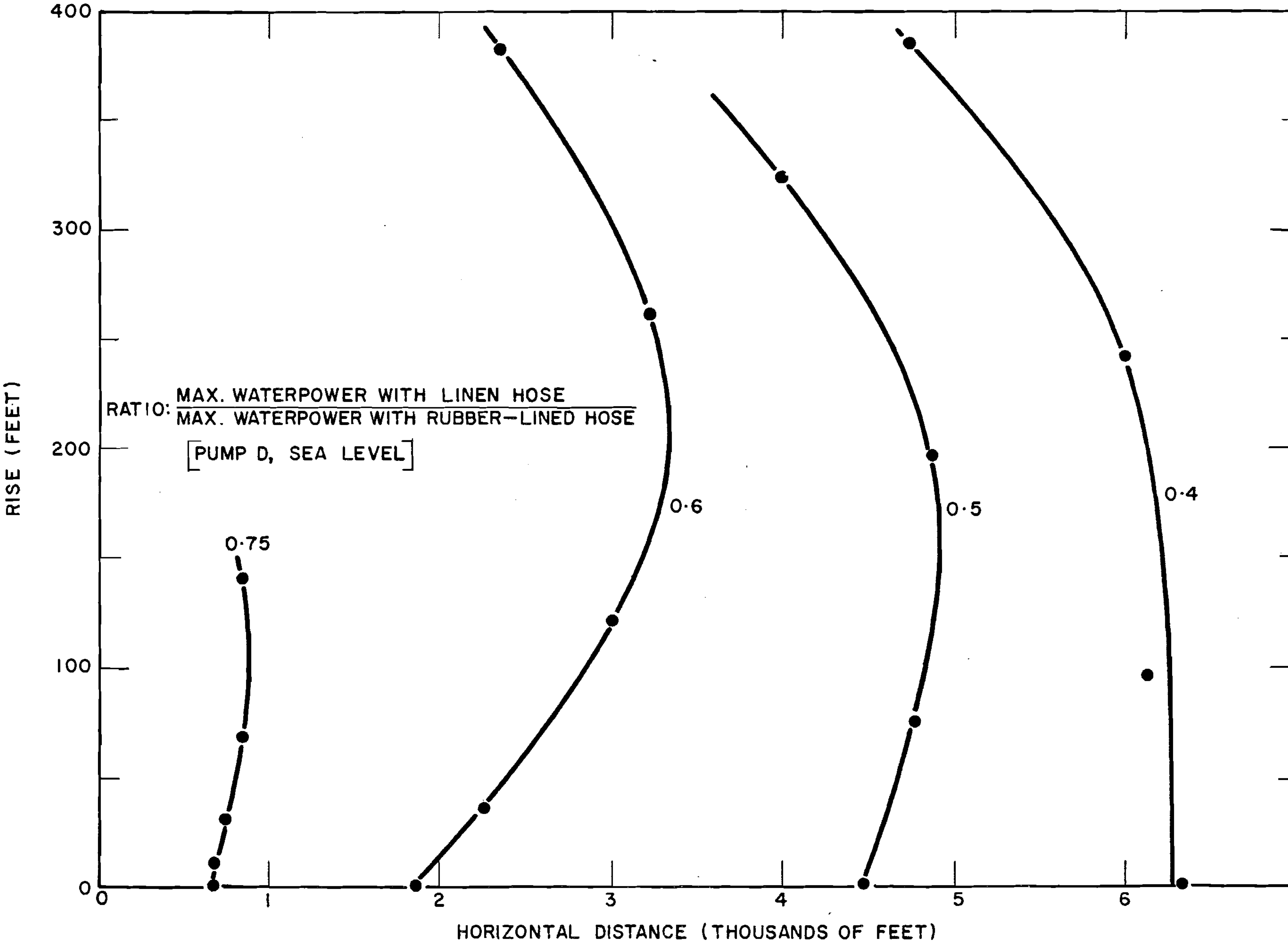

RATIO : MAX. WATERPOWER WITH LINEN HOSE / MAX. WATERPOWER WITH RUBBER-LINED HOSE
[PUMP W, SEA LEVEL]
RISE (FEET)
400
300
200
100
0
HORIZONTAL DISTANCE (THOUSANDS OF FEET)
0
1
2
3
4
5
6
7
0·75
0·6
0·5
0·4

FIGURE 54



400
300
200
100
0
RISE (FEET)
RATIO: MAX. WATERPOWER WITH LINEN HOSE / MAX. WATERPOWER WITH RUBBER-LINED HOSE
[PUMP D, SEA LEVEL]
0·75
0·6
0·5
0·4
0
1
2
3
4
5
6
7
HORIZONTAL DISTANCE (THOUSANDS OF FEET)

FIGURE 55

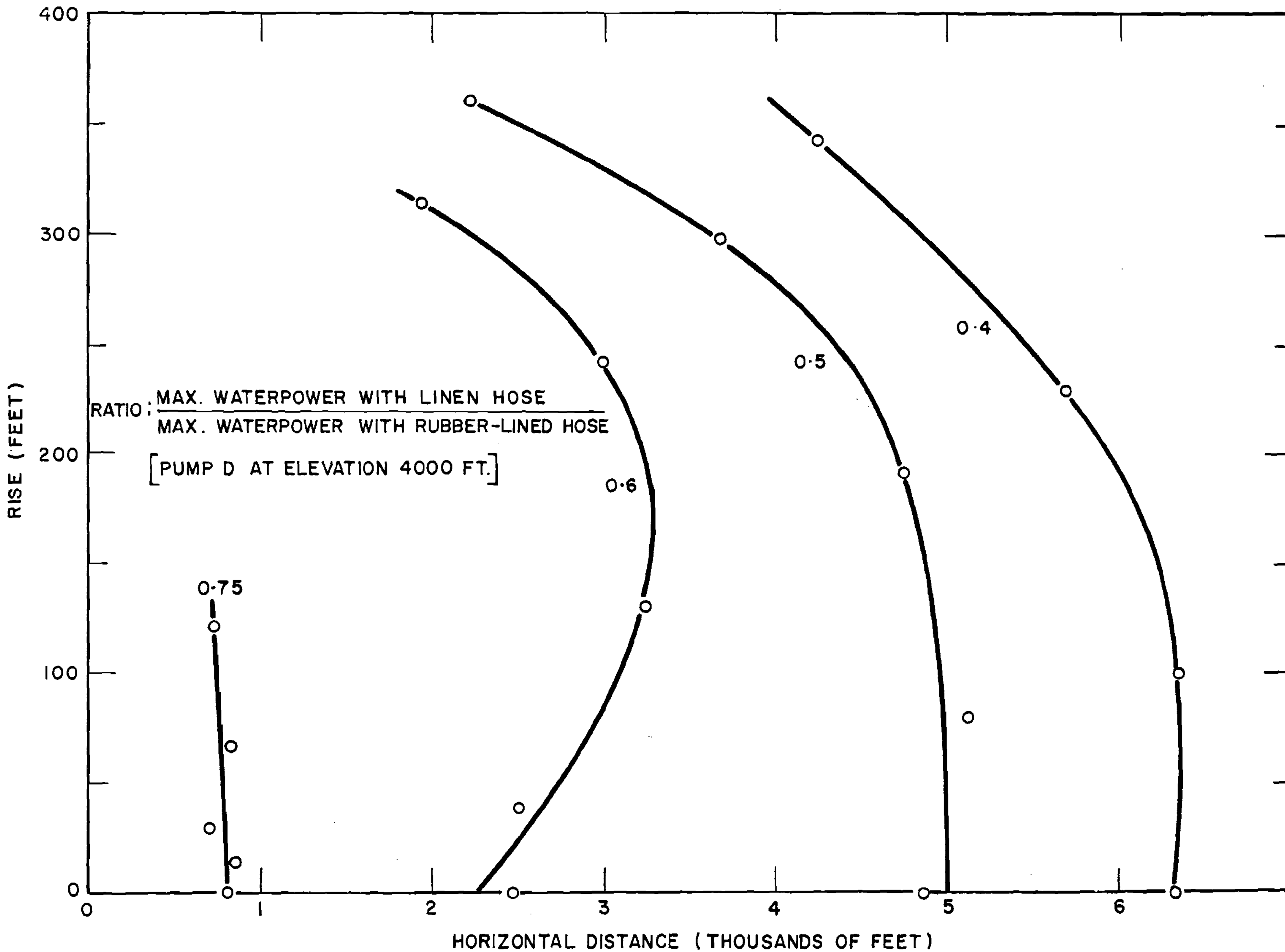

400
300
200
100
0
RISE (FEET)
0
1
2
3
4
5
6
7
HORIZONTAL DISTANCE (THOUSANDS OF FEET)
RATIO: MAX. WATERPOWER WITH LINEN HOSE / MAX. WATERPOWER WITH RUBBER-LINED HOSE
[PUMP D AT ELEVATION 4000 FT.]
0·75
0·6
0·5
0·4

FIGURE 56