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AN INTELLIGENT SYSTEM TO RECOMMEND APPROPRIATE CORRELATIONS FOR VERTICAL MULTIPHASE FLOW

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ปัญญาประดิษฐ์ได้ถูกสร้างและพัฒนามาอย่างต่อเนื่อง โดยการเลียนแบบการทำงานของเซลสมองมนุษย์ที่มีความสามารถในการวิเคราะห์และแก้ปัญหาโดยการเรียนรู้จากข้อมูลจริง วิทยานิพนธ์ฉบับนี้ได้ทำการประยุกต์ใช้ปัญญาประดิษฐ์เพื่อทำการแนะนำสมการของการไหลสหภาคที่เหมาะสมภายใต้สภาพหลุมที่กำหนด เพื่อที่จะนำสมการที่ได้มาใช้ทำการคำนวณแรงดันภายในหลุมผลิตปิโตรเลียมได้อย่างถูกต้องแม่นยำ การแนะนำสมการโดยปัญญาประดิษฐ์ได้แบ่งออกเป็นหลายการทดลองตามระดับความแม่นยำที่ยอมรับได้ กล่าวคือระดับความแม่นยำที่ยอมรับได้ไม่เกิน 20% และ 10% ตามลำดับ และการทำนายสมการที่จะคำนวณแรงดันในก้นหลุมผลิตได้แม่นยำที่สุด การทดลองที่แบ่งโดยใช้ระดับความแม่นยำอยู่ในเกณฑ์ที่รับได้ จะเปรียบเทียบความดันก้นหลุมที่วัดได้จริงกับความดันที่คำนวณโดยสมการที่เป็นที่ยอมรับและนำมาเป็นตัวเลือกสำหรับปัญญาประดิษฐ์ในการแนะนำ

จากผลการทดลองและทดสอบปัญญาประดิษฐ์ภายใต้การทดลองที่กล่าวมา ปัญญาประดิษฐ์จากสองการทดลองถูกเลือกมาให้สามารถใช้งานได้จริง โดยมาจากการทดลองที่มีค่าผิดพลาดในเกณฑ์ไม่เกิน 10% และปัญญาประดิษฐ์จากการทดลองที่มุ่งแนะนำสมการที่ให้ผลได้แม่นยำที่สุด สำหรับปัญญาประดิษฐ์ที่แนะนำความสัมพันธ์การไหลแบบสหภาคที่มีค่าผิดพลาดไม่เกิน 10% มีค่าความผิดพลาดในการทำนายความสัมพันธ์การไหลแบบสหภาค 17.23% โดยวัดจากความแตกต่างระหว่างผลลัพธ์จริงกับค่าผลลัพธ์ที่ปัญญาประดิษฐ์ทำนายออกมา (ผลลัพธ์จะถูกแปลงเป็นเลข 1 หรือ"จริง" หากสมการสามารถคำนวณความดันก้นหลุมได้โดยมีความผิดพลาดน้อยกว่า 10% มิฉะนั้นผลลัพธ์จะถูกแปลงเป็นเลข 0 หรือ"เท็จ") ส่วนทางเลือกที่สองคือใช้ปัญญาประดิษฐ์ที่สามารถทำนายความผิดพลาดในการคำนวณการไหลแบบสหภาคได้ดีที่สุด โดยปัญญาประดิษฐ์ที่เลือกมานั้นมีค่าความแตกต่างเฉลี่ยระหว่างความผิดพลาดจากการทำนายและความผิดพลาดที่แท้จริงเพียง 7.84%

ภาควิชาวิศวกรรมเหมืองแร่และปิโตรเลียม ลายมือชื่อนิสิต Ruttapone C.
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Artificial neural networks were used to identify appropriate correlations based on given levels of accuracy of bottomhole pressure calculation as well as the most accurate computation of the bottomhole pressure under given wellbore, fluid, and flowing conditions. Neural networks have ability to discriminate relationships between input of flow conditions and output of candidate correlations of vertical multiphase flow by learning from real samples. Therefore, neural networks were trained with training and validating data sets.

After training several neural networks in several scenarios, two neural networks were chosen to provide prediction of acceptable and best multiphase flow correlation. In the first scenario, the best neural network that can predict correlations that yield an error between actual pressure measurement and computed pressure less than 10% was chosen. The chosen network yields 17.23% difference between the actual coded outputs and predicted coded outputs (The output is coded as 1 for correlation that has less than 10% error and 0 otherwise). In the second scenario, the best neural network that can predict the errors close to the actual errors was selected. The chosen neural network yields 7.84% average absolute difference between actual and predicted errors.

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Field of Study: Petroleum Engineering Advisor's signature...Suwat Athichanagorn...
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CHAPTER I

INTRODUCTION

Producing petroleum from vertical oil wells causes liquid and gas to flow together where both phases may be mixed along the tubing up to the surface depending on pressure and temperature. Several correlations for simultaneous, continuous flow of oil, water, and gas that have been published can be used to predict pressure losses in vertical oil well tubings. Due to complexity of multiphase flow, researches on this particular area have been conducted since 1950 and have not been completed yet. There are two approaches of pressure drop prediction in vertical multiphase flow which are empirical correlation and mechanistic model.

Empirical correlation has either been developed in laboratory or from experimentation of well observation where rough hypothesis of homogeneous flow of oil and gas is assumed. Therefore, it does not represent the entire complexities of flow behavior. Numerous improvements and new correlations have been introduced to the industry. As far as the industry concerned, no further improvements could be achieved through this approach. Hence, mechanistic model has emerged to enhance flow behavior description in terms of mathematical model. There are several investigation attempts that would demonstrate the enhancement of accuracy and applicability of mechanistic models, which applied data from new oil fields that never been used to develop and test empirical correlations and mechanistic models before. Due to several studies about accuracy between empirical correlation and mechanistic model, it is discovered that mechanistic model makes insignificant improvement over empirical correlation. Consequently, investigators have been trying to use statistical method which defines the best correlation in overall ranges. Studies have proven that none of existing vertical multiphase flow models could gain adaptation in general applications, since their prediction errors may vary in different ranges of flow conditions.

While there are no clear statements on accuracy and applicability among multiphase flow prediction methods, Artificial Neural Networks (ANNs) was introduced as an alternative approach to recommend the most accurate vertical multiphase flow correlation for given flow conditions. In order to develop the neural networks, several processes are performed as follows: (1) determine inputs and outputs of the neural network model, (2) screen data before using them for neural network, (3) develop procedures and explain a criterion for convergence of neural net training, and (4) investigate the effect of inputs to accuracy of prediction from neural net model. The artificial neural network models developed in this study should assist the petroleum engineer in selecting the most accurate method for his problem.

Chapter 2 outlines a list of related work on artificial neural networks for solving multiphase flow problem in petroleum industry.

Chapter 3 describes the fundamentals of artificial neural networks.

Chapter 4 discusses the steps of constructing artificial neural networks model to select multiphase flow correlation. Results of neural network model are also discussed in this chapter.

Chapter 5 makes conclusion and provides recommendation for future works.

CHAPTER II

LITERATURE REVIEW

This chapter describes some of related works where neural networks application is used to solve problems in multiphase flow area.

Ternyik, Bilgesu, and Rose [1] presented two artificial neural network models to predict high and low pressure range of flowing bottom hole pressure where multiphase flow occurs in tubing. Such models could be applied to a variety of wells, including vertical wells and various degrees of inclinations. Moreover, the models can handle three phases of oil, water, and gas flow in well bores. The first model consists of information from many real oil fields which have high pressure input/output. The second model was developed from laboratory data with a pipe size of 1.5 in. and is considered as low pressure input/output. Statistical results illustrate that the new neural network gives a better performance in comparison with existing commercial multiphase flow correlations.

Ternyik and Bilgesu [2] utilized two neural network models to predict liquid holdup and flow pattern in pipes under various angles of inclinations. The neural network models developed based on experimental information from Mukherjeee's Ph.D. Dissertation where pipe diameter is limited to 1.5 in. and operated in low pressure ranges. The model predicts liquid holdup more precisely than Mukherjee' correlation. Furthermore, another neural network was developed to identify the flow pattern based on slug, bubble, annular mist, and stratified flows, resulting in a better prediction performance for all patterns compared to Mukherjee's method.

Spek and Thomas [3] used the neural network to identify the flow regime with band spectra of flow generated sound. They concluded that the flow regime can be classified as accurate as experienced engineer who has worked with sound logging for years. Successful application of neural networks classification of the flow regime from sound logs in the field brings several benefits. The application will allow prediction of hydraulic model, for specific flow regime, evaluating in horizontal well, and allow more consistency check of recorded production logging data where traditional sound log interpretation could not be performed. Moreover, another advantage of neural network is rapid processing information in comparison with traditional computation.

Osman [4] presented two neural network models for identifying the flow regime and predicting the liquid holdup for horizontal multiphase flow. The published data sets which have been used to train and test accuracy of neural networks models. There are similar to the one used to develop their empirical correlations. The results indicate that neural network models provide better prediction accuracy than all empirical correlations developed specifically for these data groups. Although, this study concentrates on horizontal flow, some empirical correlations have been developed from vertical flow but widely used for horizontal flow applications.

Shippen and Scott [5] developed a neural network model for predicting liquid holdup for two phase horizontal flow using data from five independent studies in training and testing processes of the model. They evaluated the accuracy of the neural network model, compared results from neural network model with liquid holdup empirical correlations and mechanistic models. Performance analysis showed that the neural network model exhibits a better performance than existing empirical correlations and mechanistic models. Furthermore, the neural network was able to consistently predict liquid holdup across flow patterns for all ranges of liquid holdup values with increased accuracy.

Osman [6] presented two artificial neural network models to identify the flow regime and calculate liquid holdup for horizontal multiphase flow. Published experimental data were used to train and test the developed neural network models. The results show that the developed models provide better predictions and accuracy than empirical correlations developed specifically for these data groups.

Osman and Aggour [7] used artificial neural networks model to predict bottom hole flowing pressure and pressure drop for vertical multiphase flow. Data for neural network model development came from field data base. Many fields are in the Middle East. The trained neural network model was inspected for performance by comparing results obtained from the neural network against existing correlations and mechanistic models. Statistical accuracy determination revealed that the neural network model consistently outperformed all correlations and mechanistic models in all data ranges of the studied parameters. The developed model has better accuracy than conventional methods. The authors believe even better accuracy may be achieved if more data were used in the training.

In the literature review of this study, neural network application has been applied to solve multiphase flow problems where the conventional methods provide insufficient accuracy for engineering requirement. Moreover, neural network typically takes considerably less computational time than the usual process when a new problem is introduced. The neural network application has been used the most to predict liquid holdup and classify flow regime for various degrees of inclination. Logging engineers have used neural network to interpret signal from cased hole logging. Interpreted signal can be used to identify the flow regime and flow rate inside the tubing. Neural networks have been used for prediction of bottom hole and pressure loss in tubing.

CHAPTER III

FUNDAMENTALS OF ARTIFICIAL NEURAL NETWORKS

Artificial neural network is a powerful tool to solve complex problems that might not have a tractable solution. A major advantage is that the neural network does not have to be programmed similar to conventional calculation. The neural networks can learn to form representations of complex relationships between input and output provided as examples. Due to the ability described, artificial neural networks have been used successfully in applications such as pattern recognition or pattern classification, speech recognition, and statistical forecasting.

This chapter describes fundamentals of artificial neural networks. The first part describes motivation from biological nerve cells that is implemented to artificial neural networks. The latter part explains architecture and algorithm of the neural network.

3.1 Biological Motivation

Artificial neural network is an information processing system which is inspired by the capabilities of biological neural networks. The neural networks consist of highly interconnected neurons such as parallel and serial processing of the incoming information. The learning of the biological neural networks is viewed as the establishment of new connections between processing units (neurons) or the modification of existing connections. Artificial neural networks utilize the same concept by creating artificial neurons which are simple processing elements massively interconnected in order to imitate the information processing ability of the biological neural network. The development of artificial neural networks is based on the following assumptions:

1. Information processing occurs at many simple elements called neurons.

2. Signals are passed between neurons over connection links.

3. Each connection link has an associated weight, which, in a typical neural net, multiplies the signal transmitted.

4. Each neuron applies an activation function (usually nonlinear) to its net input (sum of weighted input signals) to determine its output signal.

These concepts are inspired by the architecture of biological neuron. A large number of brain cells or biological neurons are interconnected with each other to process signals before sending them from one nerve cell to other cells. A biological neuron consists of three main components which are dendrites, cell body, and axon. Figure 3.1 illustrates the schematic diagram of a simple biological neuron. The dendrites are branching input structure from a cell body which receive signals from other neurons or axons. The small space between the axon and dendrite is called the synapse. In this region, the electric signal from the axon must be converted to a chemical signal through a series of biochemical events before being transmitted to the dendrite. Consequently, the biochemical events are the process to amplify or condense the signal strength before sending them to the subsequent transmission path. This process is applied to artificial neurons in the artificial neural networks as weight adjustment of interconnected links between neurons. After receiving the signal by dendrites, the cell body sums all incoming signals and activates the summed signals with activation function (commonly nonlinear). If the total signal received at the cell body from the dendrites exceeds a certain level (the firing threshold), a neuron fires an electrochemical signal along the axon as the output to other dendrites or next neurons.

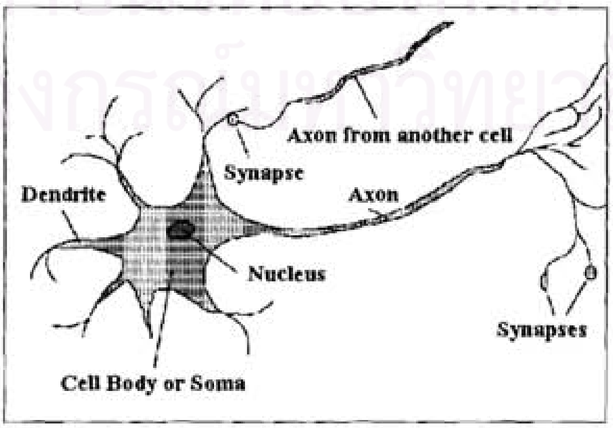


Figure 3.1: Schematic diagram of simple biological neuron.

3.2 Artificial Neural Networks

The basic elements of neural networks are the neurons and their connection strengths or weights. The artificial neural networks must have at least an input and output layer and one or more hidden layers. Figure 3.2 illustrates a schematic diagram of three layer artificial neural networks. The first layer is an input layer which is a pre-processing layer that simply distributes the inputs to the next layer. The second layer is a hidden layer. Hidden neurons in this layer process all incoming signals before sending an output to the output layer. The third layer is the output layer. Each layer consists of processing units or neurons. There is no restriction on the number of neurons in each layer. Every neuron in a layer is connected to every neuron in adjacent layers through connection links. However, a neuron is not connected to other neurons in the same layer. Each connection link has its own associated weight representing the ability to transport signal. Associated weights could either have positive or negative values. The positive weight represents a strong connection between neurons, and the negative weight corresponds to a weak linkage between neurons.

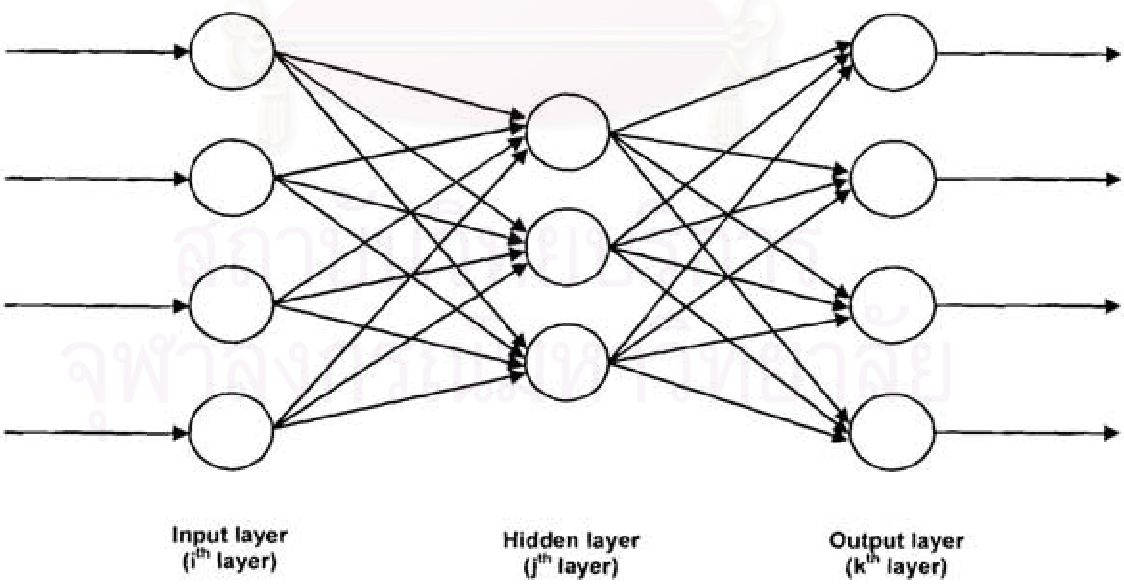


Figure 3.2: Schematic diagram of artificial neural networks.

The neural network determines output signal or activation level from all the processing units in the layers next to the input layer. The neurons receive weighted inputs from each of the neurons in the previous layer and perform two tasks: (1) compute a linear combination of its weighted input signals and then (2) pass the resulting summation through a threshold function or activation function. The activation function is nonlinear, smooth, differentiable function and has an S-shape or sigmoidal shape. The Sigmoidal function has an output ranges between 0 and 1, increasing monotonically with its input. The output is 1 when the input is a large positive number and 0 when the input is a large negative number. The sigmoidal function is illustrated in Figure 3.3, and the mathematical description of the neuron output is written as:

$$O_j = \frac{1}{1+\exp(-net_j)} \tag{3.1}$$

where O_j is the output from a processing unit in the j-th layer and net_j is the summation of weighted inputs from the previous layer. The net_j can be expressed as follows:

$$net_j = \sum_{i=1} w_{ji} O_i \tag{3.2}$$

where w_{ji} is the associated weight of connecting link between a processing unit in the i-th layer to a processing unit in the j-th layer and O_i is the output from the processing unit in the i-th layer.

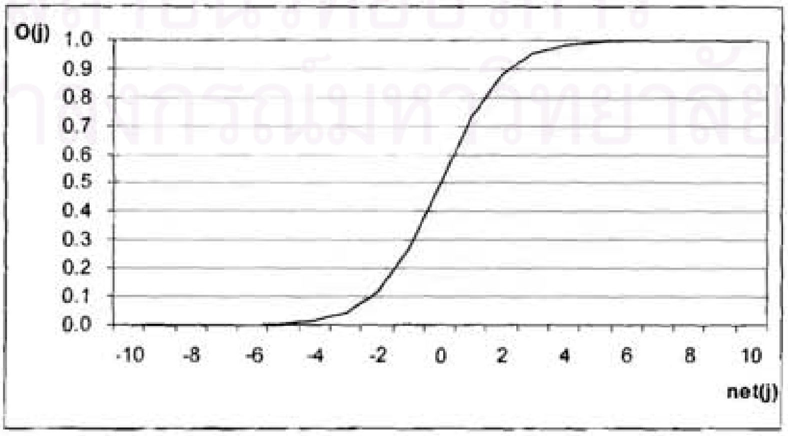


Figure 3.3: Sigmoidal function.

An important feature of an artificial neural network is the learning process which is based on the learning samples. However, sample values must be normalized from 0 to 1 in order to perform any computation. During the training process, the weights of the network are adjusted continuously based on error signal generated by the difference between output of the network and the actual output of the training samples. This is accomplished by learning algorithms designed to minimize the total output error. Many different architectures are used to decrease the error between desired and calculated outputs but the most popular architecture is the back-propagation algorithm. The training of back propagation neural network is an iterative process involving the changing of the weight of the network, typically by means of a gradient descent method, in order to minimize an error criterion, that is:

$$w_{ji}(n+1) = w_{ji(t)} + \Delta w_{ji} \tag{3.3}$$

where

$$\Delta w_{ji} = \tau \, \xi \, x_{ji} + \alpha \, \Delta w_{ji}\,(n) \tag{3.4}$$

and where $\Delta w_{ji}(n)$ is the weight update performed during the n^{th} iteration ,τ is the learning rate, α is momentum , and ξ is the error criterion, i.e.

$$\xi = \frac{1}{2}\sum_j (T_{o,j} - v_{o,j})^2 \tag{3.5}$$

based on the difference between the desired ($T_{o,j}$) and the actual outputs ($v_{o,j}$) of the unit. Since the error ξ is propagated back through the network and readjusts each associated weight of the connection link in the next iteration until a commensurable error is achieved.

In order to specify an appropriate condition to stop weight update loop or to stop training the neural network, one obvious choice is to continue training until the error on the training samples falls below some significant value. However, this is a poor strategy because the back-propagation is susceptible to over-fitting the training examples. This phenomenon causes the decrease of generalization accuracy over unseen examples. Consequently, in order to develop a neural network model which has been generalized to the problem, the sample pool is partitioned into training, validating, and testing sets. Several common partition ratios such as 2:1:1, 3:1:1, and 4:1:1 may be used. These ratios were obtained from the literature. Several investigators recommended that the ratio of 4:1:1 would yield the best result. Therefore, this ratio was used throughout this study. Weight adjustment is done while learning from the training data set. The validating data set functions as a generalization indicator which periodically tests the neural network while it is in the learning phase. However, to ensure that the trained neural network model has sufficient generalization accuracy over unseen examples, a set of testing data is used. This data set has never been seen by the model. Moreover, each data set discussed should cover all possible range of input variables to ensure that the trained neural network has a wide range of coverage.

CHAPTER IV

ARTIFICIAL NEURAL NETWORK MODEL DEVELOPMENT

In this study, artificial neural networks were used to propose appropriate multiphase flow correlations based on given levels of accuracy of bottom hole pressure calculation as well as the most accurate computation of the bottom hole pressure under given flow conditions. This chapter discusses the details of neural net models and procedure to develop the models. The data required for model development are flow variables that are used in pressure drop computation for vertical multiphase flow. The neural networks used these data directly as input of the model. Commonly used vertical multiphase flow correlations were selected as candidate outputs of the neural networks. In order to ensure that the trained neural networks have a good performance to recommend flow correlation, accuracy of the neural network was computed and the results are discussed in the latter part of this chapter.

4.1 Neural Network Models

Artificial neural networks in this study require 11 variables or flow conditions as inputs which are tubing diameter (inside diameter), tubing depth, wellhead temperature (WHT), bottomhole temperature (BHT), oil density, gas specific gravity, wellhead pressure (WHP), gas oil ratio (GOR), water cut, oil flow rate, and measured bottomhole pressure (BHP). The outputs of the neural network are commonly used vertical multiphase flow correlations in petroleum fields which are Duns and Ros (original), Duns and Ros (modified), Hagedorn and Brown, Fancher and Brown, Mukherjee and Brill, Beggs and Brill, and Orkiszewski. The original Duns and Ros is the original published method which performs well in mist flow. The modified Duns and Ros has been enhanced and optimized for cases with condensates. Figure 4.1 illustrates a schematic diagram of neural networks used in this study.

The input data of neural networks were obtained from five published SPE papers [8-12]. These papers attempted to propose new vertical multiphase flow correlations developed from measured data or modified from previous investigators. Consequently, the accuracy of the new correlations was determined against commonly used vertical multiphase flow correlations. All investigators applied their own measurement data from the real fields to determine the accuracy of the correlations. A total 208 data sets could be obtained from the five papers. Table 4.1 shows sample sets of data from the five papers. Table 4.2 shows the parameters and their ranges. Details of all data are shown in Appendix A.

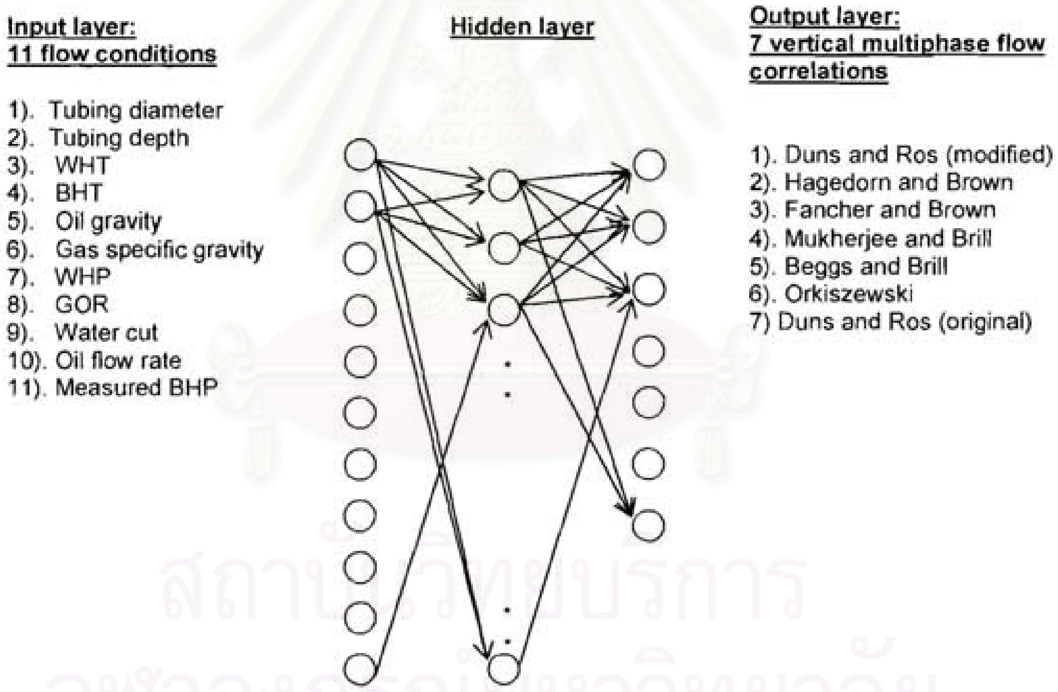


Figure 4.1: Schematic diagram of neural networks.

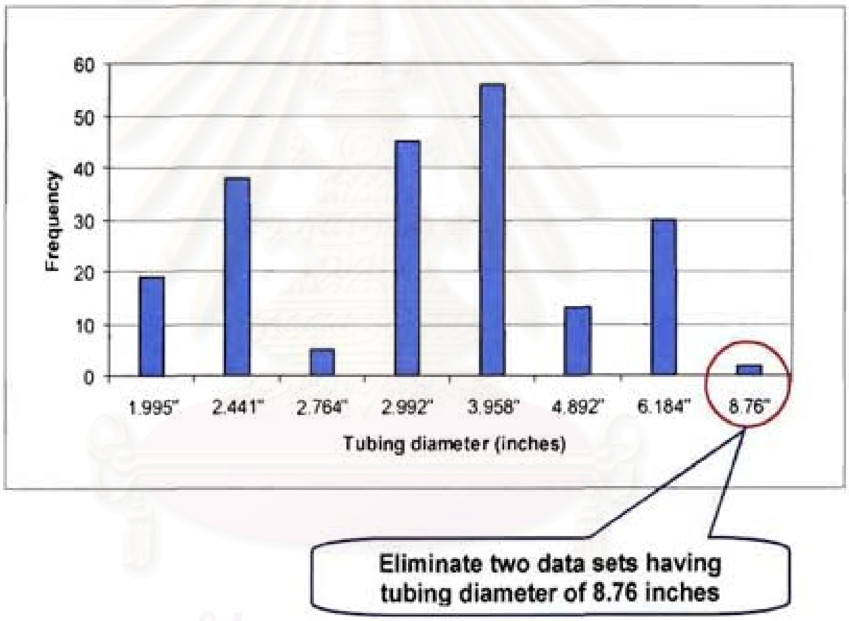
Table 4.1: Flow parameters as a set.

Data Set No.	Tbg Dia (inch)	Depth (ft)	WHT (°F)	BHT (°F)	Oil (°API)	Gas SpGr (air=1)	WHP (psia)	GOR (scf/bbl)	WaterCut (%)	Qo (bbl/d)	MeaBHP (psia)
1	1.995	7450	75	189	54	0.752	1645	3393	0	82	3300
2	1.995	7350	75	189	54	0.752	1635	3393	0	125	3290
3	1.995	9620	75	189	54	0.752	1455	3393	0	480	3365
4	1.995	7850	75	189	38.8	0.9349	990	1019	0	187	3190
5	1.995	6550	75	189	42	0.8225	985	1245	0	167	2665
6	1.995	6570	75	189	42	0.8225	665	1245	0	138	2555
7	1.995	7800	75	189	42.6	0.84	1261	1747	0	168	3141
8	1.995	8070	75	189	42.6	0.84	1229	1747	0	259.2	3199
9	1.995	8000	75	189	42.6	0.84	1221	1747	0	91.2	3251
10	1.995	8480	75	189	43.9	0.8287	1665	3588	0	131	3260
11	1.995	4410	75	189	41.3	1.048	145	192	0	245.3	1419
12	1.995	3000	75	189	41.3	1.048	175	189	0	160.3	1083
13	1.995	4410	75	189	41.3	1.048	105	230	0	392.4	1229
14	1.995	3363	86	168.8	15.6	0.78	199.7	944.7	60.4	42.6096	1485.3
15	1.995	3395.7	86	172.4	15.6	0.68	193.8	787.6	51	41.013	1509.9
16	1.995	3362.9	86	168.8	15.6	0.78	250.6	7029.3	56	14.652	1506.7
17	1.995	3395	86	158	15.6	0.62	107.2	2475.1	14	12.986	1513.8

Table 4.2: Flow parameters and their ranges from published SPE papers.

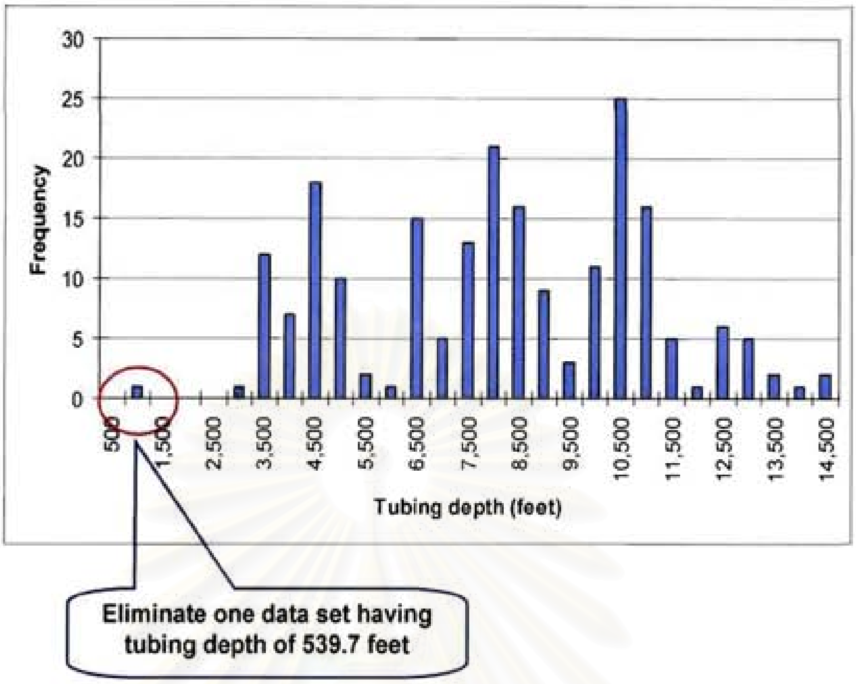
No.	Variable	Minimum	Maximum
1	Tubing inside diameter (inches)	1.995	8.76
2	Depth (feet)	540	14,330
3	Wellhead temperature (°F)	68	200
4	Bottomhole temperature (°F)	150	378
5	Oil gravity (°API)	8	87
6	Gas specific gravity (air=1)	0.49	1.71
7	Wellhead pressure (psia)	100	4,432
8	Gas oil ratio (scf/stb)	129	9,798
9	Water cut (%)	0	60
10	Oil flow rate (stb/day)	13	27,270
11	Measured bottomhole pressure (psia)	1,015	6,906

The histograms of all parameters were plotted in order to observe the distribution of each variable as illustrated in Figure 4.2. Most of the distributions are similar to normal distribution except that of wellhead pressure, gas oil ratio, water cut, and oil flow rate. These curves show that there are large amounts of data at the lower end of the curves. However, we notice that some of the data are not in the same range as the majority of the data. Therefore, these data sets were removed from the database before being used in the development of neural networks. The data sets that were removed are the ones that have tubing diameter of 8.76 inches (2 sets), tubing depth of 539.7 feet (1 set), bottomhole temperature of 306°F and 378°F (2 sets), oil gravity of 87.202°API (1 set), and gas oil ratio of 9,798.4 scf/stb (1 set). Therefore, a total of 201 sets of data were left from such screening process. Table 4.3 shows summary of data after the screening process.

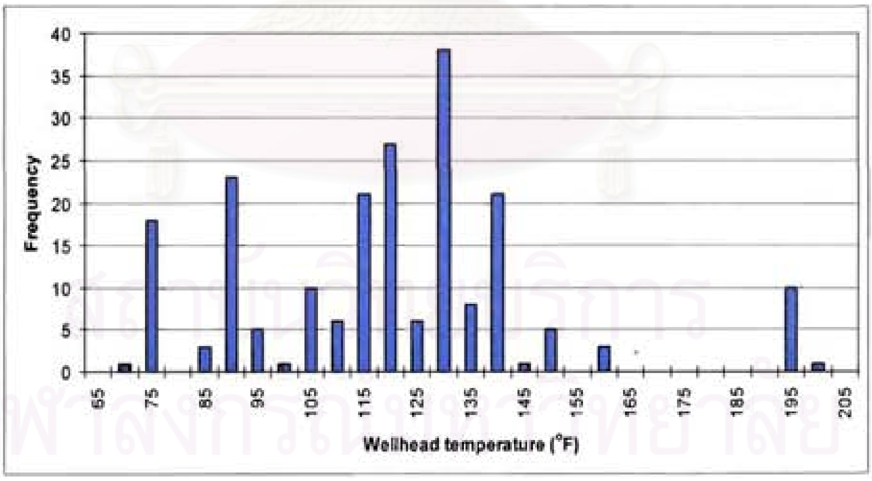


1) Histogram of tubing diameter.

Figure 4.2: Histograms of total data.

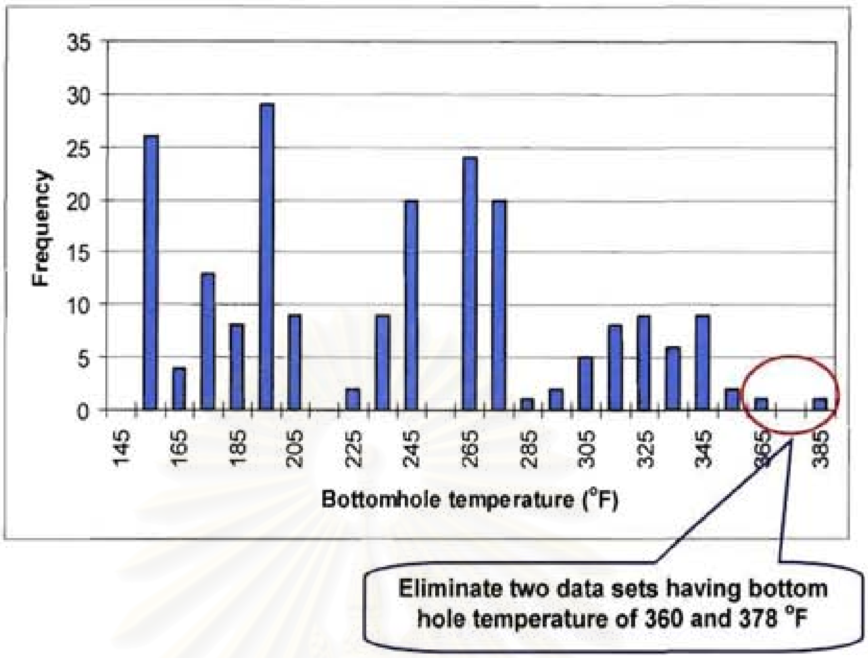


2) Histogram of tubing depth.

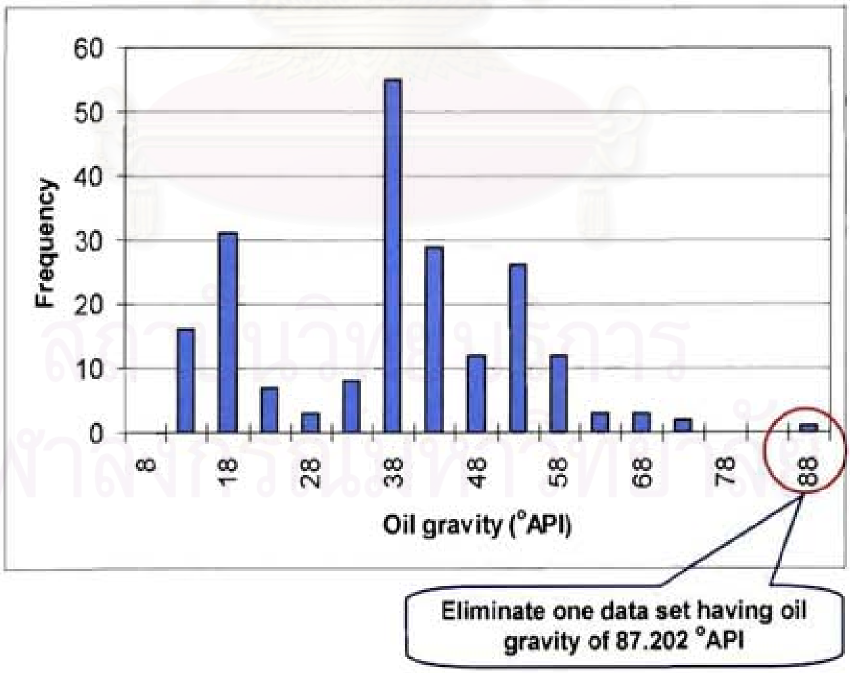


3) Histogram of wellhead temperature.

Figure 4.2: Histograms of total data (continued).

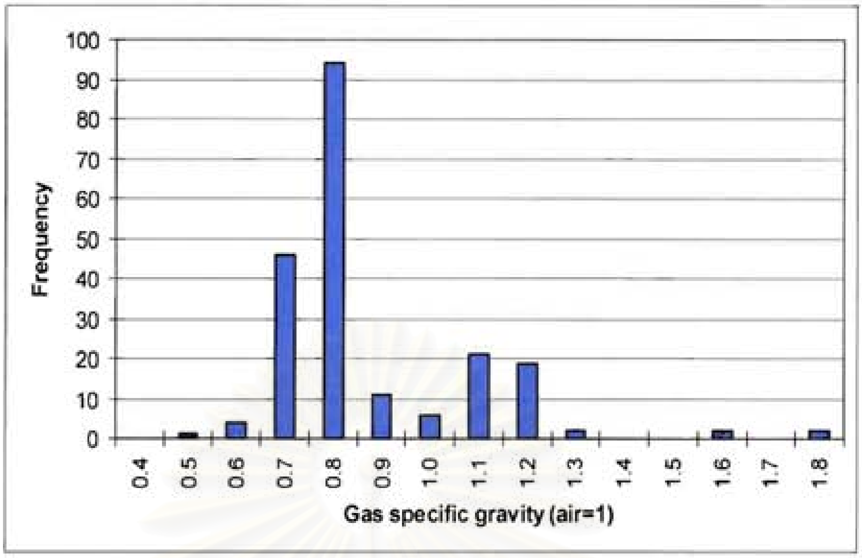


4) Histogram of bottomhole temperature.

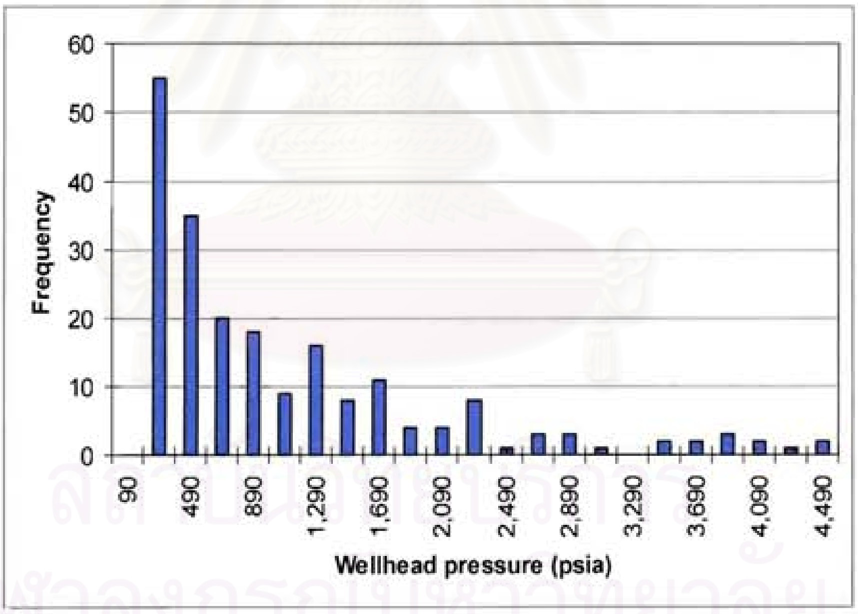


5) Histogram of oil gravity.

Figure 4.2: Histograms of total data (continued).

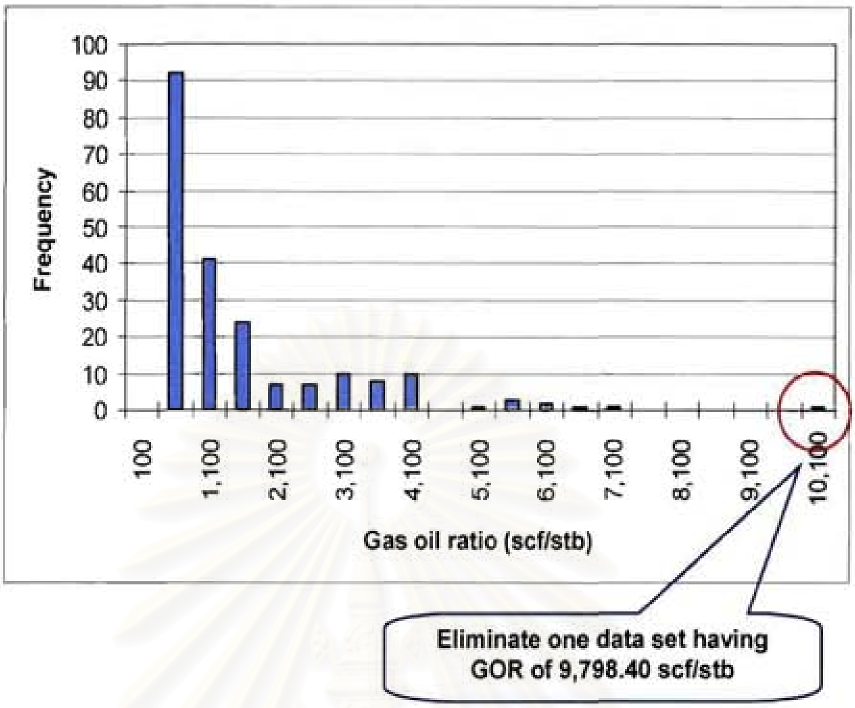


6) Histogram of gas specific gravity.

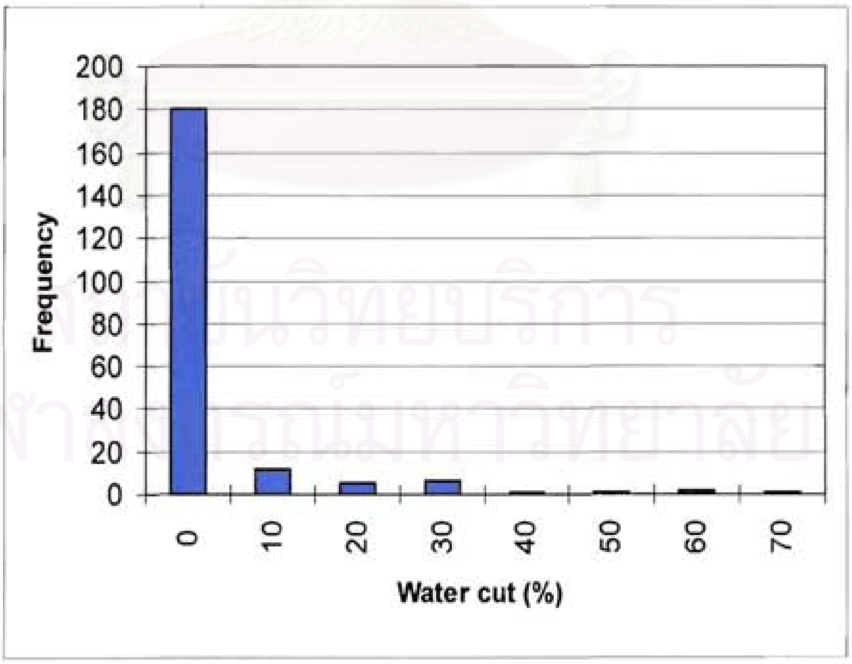


7) Histogram of wellhead pressure.

Figure 4.2: Histograms of total data (continued).

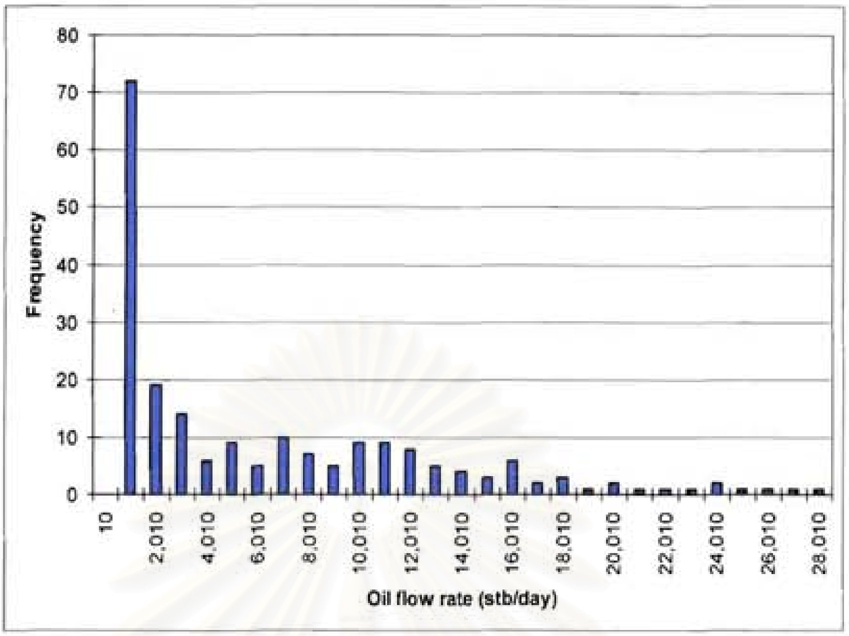


8) Histogram of gas oil ratio.

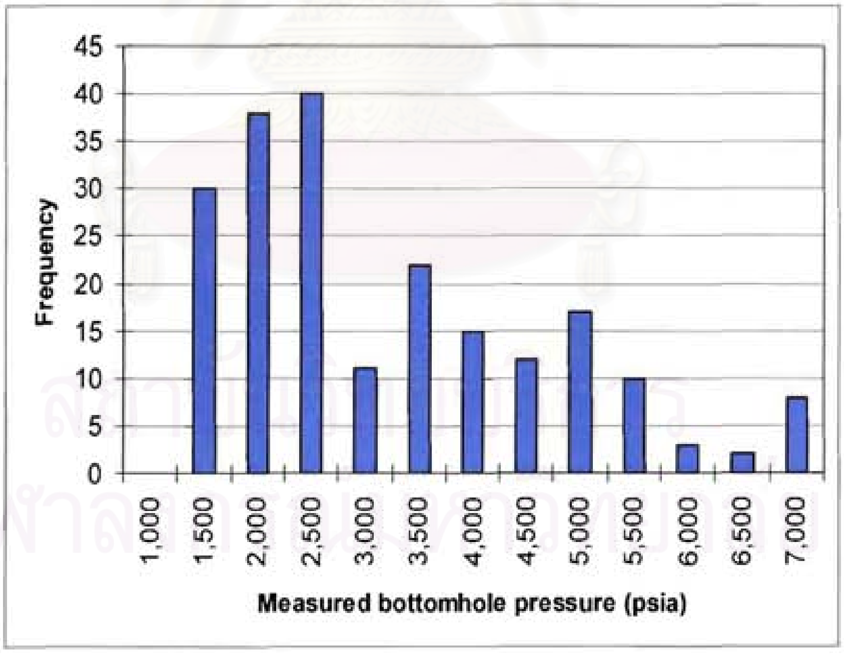


9) Histogram of water cut.

Figure 4.2: Histograms of total data (continued).



10) Histogram of oil flow rate.



11) Histogram of measured bottomhole pressure.

Figure 4.2: Histograms of total data (continued).

Table 4.3: Summary of range of parameter after screening.

No.	Variable	Minimum	Maximum
1	Tubing inside diameter (inches)	1.995	6.184
2	Depth (feet)	3,000	14,330
3	Wellhead temperature (°F)	68	200
4	Bottomhole temperature (°F)	150	350
5	Oil gravity (°API)	8	72
6	Gas specific gravity (air=1)	0.49	1.71
7	Wellhead pressure (psia)	100	4,432
8	Gas oil ratio (scf/stb)	129	7,029
9	Water cut (%)	0	60
10	Oil flow rate (stb/day)	13	27,270
11	Measured bottomhole pressure (psia)	1,015	6,906

A commercial software called *PROSPER* (**PRO**duction and **S**ystems **PER**formance) was used to compute the pressure at the bottom hole. This software contains the seven vertical multiphase flow correlations mentioned earlier. Table 4.4 shows sample calculations of the bottomhole pressure obtained from *PROSPER*. The software was used to calculate the bottom hole pressure using each of the seven correlations for 201 sets of data. The error of these correlations in terms of percentage can be expressed as the following equation:

$$\left|\frac{p_{measured} - p_{calculated}}{p_{measured}}\right| \times 100 = error\ in\ percentage \qquad (4.1)$$

where

$P_{measured}$ = measured bottom hole pressure, psia

$P_{calculated}$ = calculated bottom hole pressure from *PROSPER* software, psia

Table 4.5 shows the errors in percentage of the seven correlations for the data sets shown in Table 4.4. These seven correlations have different amounts of error since they were derived based on different flow conditions.

Table 4.4: Calculated bottomhole pressure from *PROSPER*.

Data set no.	Measured BHP (psia)	Calculated bottom hole pressure from PROSPER software						
		D&R (M)	H&B	F&B	M&B	B&B	Ork	D&R (O)
1	3300	2837	2546	2546	3066	3347	3094	2984
2	3290	2733	2514	2514	2522	2875	2924	2905
3	3365	2709	2721	2646	2746	3044	2789	2792
4	3190	3049	2762	2762	2971	2952	2968	3014
5	2665	2321	2079	2079	2442	2401	2423	2393
6	2555	1798	1484	1464	1989	2157	1967	1957
7	3141	2891	2574	2574	2835	2905	2911	2905
8	3199	3662	3399	3398	3525	3537	3451	3568
9	3251	3580	3635	3401	3940	3879	3754	3665
10	3260	3110	2814	2814	2821	3214	3213	3295
11	1419	1513	1415	1411	1504	1505	1485	1515
12	1083	1081	1048	1021	1141	1135	1116	1106
13	1229	1378	1142	1083	1303	1312	1064	1298
14	1485	858	895	589	1521	1368	1091	1255
15	1510	837	918	559	1522	1447	1147	1282
16	1507	514	612	320	904	886	748	942
17	1514	435	421	144	793	782	943	1050

Table 4.5: Errors of the correlations.

Data set no.	Measured BHP (psia)	Error between measured and calculated BHP (%)						
		D&R (M)	H&B	F&B	M&B	B&B	Ork	D&R (O)
1	3300	14.0%	22.8%	22.8%	7.1%	1.4%	6.2%	9.6%
2	3290	16.9%	23.6%	23.6%	23.3%	12.6%	11.1%	11.7%
3	3365	19.5%	19.1%	21.4%	18.4%	9.5%	17.1%	17.0%
4	3190	4.4%	13.4%	13.4%	6.9%	7.5%	7.0%	5.5%
5	2665	12.9%	22.0%	22.0%	8.4%	9.9%	9.1%	10.2%
6	2555	29.6%	41.9%	42.7%	22.2%	15.6%	23.0%	23.4%
7	3141	8.0%	18.1%	18.1%	9.7%	7.5%	7.3%	7.5%
8	3199	14.5%	6.3%	6.2%	10.2%	10.6%	7.9%	11.5%
9	3251	10.1%	11.8%	4.6%	21.2%	19.3%	15.5%	12.7%
10	3260	4.6%	13.7%	13.7%	13.5%	1.4%	1.4%	1.1%
11	1419	6.6%	0.3%	0.6%	6.0%	6.1%	4.7%	6.8%
12	1083	0.2%	3.2%	5.7%	5.4%	4.8%	3.0%	2.1%
13	1229	12.1%	7.1%	11.9%	6.0%	6.8%	13.4%	5.6%
14	1485	42.2%	39.7%	60.3%	2.4%	7.9%	26.5%	15.5%
15	1510	44.6%	39.2%	63.0%	0.8%	4.2%	24.0%	15.1%
16	1507	65.9%	59.4%	78.8%	40.0%	41.2%	50.4%	37.5%
17	1514	71.3%	72.2%	90.5%	47.6%	48.3%	37.7%	30.6%

In this study, we used the neural networks in four different approaches to propose appropriate multiphase flow correlations:

- Case 1: 20% maximum error

In this case, we used the neural network to propose multiphase flow correlations that yield the error of the bottomhole pressure calculation less than 20%.

- Case 2: 10% maximum error

In this case, we used the neural network to propose multiphase flow correlations that yield the error of the bottomhole pressure calculation less than 10%.

- Case 3: best correlation

In this case, a multiphase flow correlation that yields the lowest error of the bottomhole pressure calculation would be proposed.

- Case 4: percentage error

In this case, we used the neural network to propose correlations with percentage of error for given wellbore, fluids, and flow conditions.

For the first two cases, the errors in percentage as shown in Table 4.5 were transformed to 0 or 1 before they were provided to the neural networks as outputs. The error was changed to "1" if its value was lower than the maximum error. Otherwise, the output was transformed to "0". For the third case, the correlation which provides the lowest error was set to have a value of 1 while the rest of the correlations were set to 0. These transformed values were used as known outputs while training, validating, and testing the neural network. Tables 4.6, 4.7, and 4.8 show examples of the errors that were changed to binary numbers for Cases 1, 2, and 3, respectively. For the fourth case, we used errors in percentage as shown in Table 4.5 as outputs directly to the neural networks.

Table 4.6: Binary output of Case 1 (20% maximum error).

Data set no.	Case 1: 20% maximum error														
	D&R (M)		H&B		F&B		M&B		B&B		Ork		D&R (O)	
	%	Binary	%	Binary	%	Binary	%	Binary	%	Binary	%	Binary	%	Binary
1	14.0%	1	22.8%	0	22.8%	0	7.1%	1	1.4%	1	6.2%	1	9.6%	1
2	16.9%	1	23.6%	0	23.6%	0	23.3%	0	12.6%	1	11.1%	1	11.7%	1
3	19.5%	1	19.1%	1	21.4%	0	18.4%	1	9.5%	1	17.1%	1	17.0%	1
4	4.4%	1	13.4%	1	13.4%	1	6.9%	1	7.5%	1	7.0%	1	5.5%	1
5	12.9%	1	22.0%	0	22.0%	0	8.4%	1	9.9%	1	9.1%	1	10.2%	1
6	29.6%	0	41.9%	0	42.7%	0	22.2%	0	15.6%	1	23.0%	0	23.4%	0
7	8.0%	1	18.1%	1	18.1%	1	9.7%	1	7.5%	1	7.3%	1	7.5%	1
8	14.5%	1	6.3%	1	6.2%	1	10.2%	1	10.6%	1	7.9%	1	11.5%	1
9	10.1%	1	11.8%	1	4.6%	1	21.2%	0	19.3%	1	15.5%	1	12.7%	1
10	4.6%	1	13.7%	1	13.7%	1	13.5%	1	1.4%	1	1.4%	1	1.1%	1
11	6.6%	1	0.3%	1	0.6%	1	6.0%	1	6.1%	1	4.7%	1	6.8%	1
12	0.2%	1	3.2%	1	5.7%	1	5.4%	1	4.8%	1	3.0%	1	2.1%	1
13	12.1%	1	7.1%	1	11.9%	1	6.0%	1	6.8%	1	13.4%	1	5.6%	1
14	42.2%	0	39.7%	0	60.3%	0	2.4%	1	7.9%	1	26.5%	0	15.5%	1
15	44.6%	0	39.2%	0	63.0%	0	0.8%	1	4.2%	1	24.0%	0	15.1%	1
16	65.9%	0	59.4%	0	78.8%	0	40.0%	0	41.2%	0	50.4%	0	37.5%	0
17	71.3%	0	72.2%	0	90.5%	0	47.6%	0	48.3%	0	37.7%	0	30.6%	0

Table 4.7: Binary output of Case 2 (10% maximum error).

Data set no.	Case 2: 10% maximum error													
	D&R (M)		H&B		F&B		M&B		B&B		Ork		D&R (O)	
	%	Binary	%	Binary	%	Binary	%	Binary	%	Binary	%	Binary	%	Binary
1	14.0%	0	22.8%	0	22.8%	0	7.1%	1	1.4%	1	6.2%	1	9.6%	1
2	16.9%	0	23.6%	0	23.6%	0	23.3%	0	12.6%	0	11.1%	0	11.7%	0
3	19.5%	0	19.1%	0	21.4%	0	18.4%	0	9.5%	1	17.1%	0	17.0%	0
4	4.4%	1	13.4%	0	13.4%	0	6.9%	1	7.5%	1	7.0%	1	5.5%	1
5	12.9%	0	22.0%	0	22.0%	0	8.4%	1	9.9%	1	9.1%	1	10.2%	0
6	29.6%	0	41.9%	0	42.7%	0	22.2%	0	15.6%	0	23.0%	0	23.4%	0
7	8.0%	1	18.1%	0	18.1%	0	9.7%	1	7.5%	1	7.3%	1	7.5%	1
8	14.5%	0	6.3%	1	6.2%	1	10.2%	0	10.6%	0	7.9%	1	11.5%	0
9	10.1%	0	11.8%	0	4.6%	1	21.2%	0	19.3%	0	15.5%	0	12.7%	0
10	4.6%	1	13.7%	0	13.7%	0	13.5%	0	1.4%	1	1.4%	1	1.1%	1
11	6.6%	1	0.3%	1	0.6%	1	6.0%	1	6.1%	1	4.7%	1	6.8%	1
12	0.2%	1	3.2%	1	5.7%	1	5.4%	1	4.8%	1	3.0%	1	2.1%	1
13	12.1%	0	7.1%	1	11.9%	0	6.0%	1	6.8%	1	13.4%	0	5.6%	1
14	42.2%	0	39.7%	0	60.3%	0	2.4%	1	7.9%	1	26.5%	0	15.5%	0
15	44.6%	0	39.2%	0	63.0%	0	0.8%	1	4.2%	1	24.0%	0	15.1%	0
16	65.9%	0	59.4%	0	78.8%	0	40.0%	0	41.2%	0	50.4%	0	37.5%	0
17	71.3%	0	72.2%	0	90.5%	0	47.6%	0	48.3%	0	37.7%	0	30.6%	0

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Table 4.8: Binary output of Case 3 (best correlation).

Data set no.	Case 3: best correlation													
	D&R (M)		H&B		F&B		M&B		B&B		Ork		D&R (O)	
	%	Binary	%	Binary	%	Binary	%	Binary	%	Binary	%	Binary	%	Binary
1	14.0%	0	22.8%	0	22.8%	0	7.1%	0	1.4%	1	6.2%	0	9.6%	0
2	16.9%	0	23.6%	0	23.6%	0	23.3%	0	12.6%	0	11.1%	1	11.7%	0
3	19.5%	0	19.1%	0	21.4%	0	18.4%	0	9.5%	1	17.1%	0	17.0%	0
4	4.4%	1	13.4%	0	13.4%	0	6.9%	0	7.5%	0	7.0%	0	5.5%	0
5	12.9%	0	22.0%	0	22.0%	0	8.4%	1	9.9%	0	9.1%	0	10.2%	0
6	29.6%	0	41.9%	0	42.7%	0	22.2%	0	15.6%	1	23.0%	0	23.4%	0
7	8.0%	0	18.1%	0	18.1%	0	9.7%	0	7.5%	0	7.3%	1	7.5%	0
8	14.5%	0	6.3%	0	6.2%	1	10.2%	0	10.6%	0	7.9%	0	11.5%	0
9	10.1%	0	11.8%	0	4.6%	1	21.2%	0	19.3%	0	15.5%	0	12.7%	0
10	4.6%	0	13.7%	0	13.7%	0	13.5%	0	1.4%	0	1.4%	0	1.1%	1
11	6.6%	0	0.3%	1	0.6%	0	6.0%	0	6.1%	0	4.7%	0	6.8%	0
12	0.2%	1	3.2%	0	5.7%	0	5.4%	0	4.8%	0	3.0%	0	2.1%	0
13	12.1%	0	7.1%	0	11.9%	0	6.0%	0	6.8%	0	13.4%	0	5.6%	1
14	42.2%	0	39.7%	0	60.3%	0	2.4%	1	7.9%	0	26.5%	0	15.5%	0
15	44.6%	0	39.2%	0	63.0%	0	0.8%	1	4.2%	0	24.0%	0	15.1%	0
16	65.9%	0	59.4%	0	78.8%	0	40.0%	0	41.2%	0	50.4%	0	37.5%	1
17	71.3%	0	72.2%	0	90.5%	0	47.6%	0	48.3%	0	37.7%	0	30.6%	1

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An artificial neural network software named *EasyNN-plus* was used to develop the neural network models in this study. *EasyNN-plus* is a general purpose software with learning algorithm of back propagation and feed forward connection type which is written in C++ computer language. The software version 7.0g was developed by a group of professionals in England. Figure 4.3 illustrates the front page of *EasyNN-plus*.

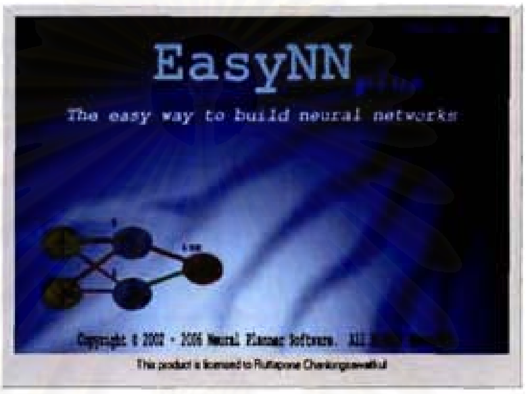


Figure 4.3: Artificial neural network software, *EasyNN-plus*.

Neural networks require partitioning data into training, validating, and testing sets. The software has a function to randomly select data for training, validating, and testing. Based on 4:1:1 ratio, the numbers of data sets for training, validating, and testing are 133, 34, and 34, respectively.

Before the training phase could be started, the software always propose initial configurations (such as numbers of hidden neurons, learning rate, momentum). However, the configurations can be adjusted afterward. The learning phase of the network is weight adjustment which requires setting the value of the learning rate and momentum to indicate how much weight could be changed in each iteration.

The learning rate can be manually set to any positive values ranging from 0.1 to 10 while the momentum can be manually set to any positive values from 0 to 0.9. The learning rate and momentum can be used as a constant value throughout the learning phase of the model or automatically decayed during the learning if erratic learning or oscillations in the learning curve occurs. If the decay function is selected, the learning rate and momentum of the neural network are reduced from the initial value to the minimum value of 0.1 and 0, respectively. Figure 4.4 shows the input window for randomly selected data and manually set number of hidden layer, hidden nodes, learning rate, and momentum.

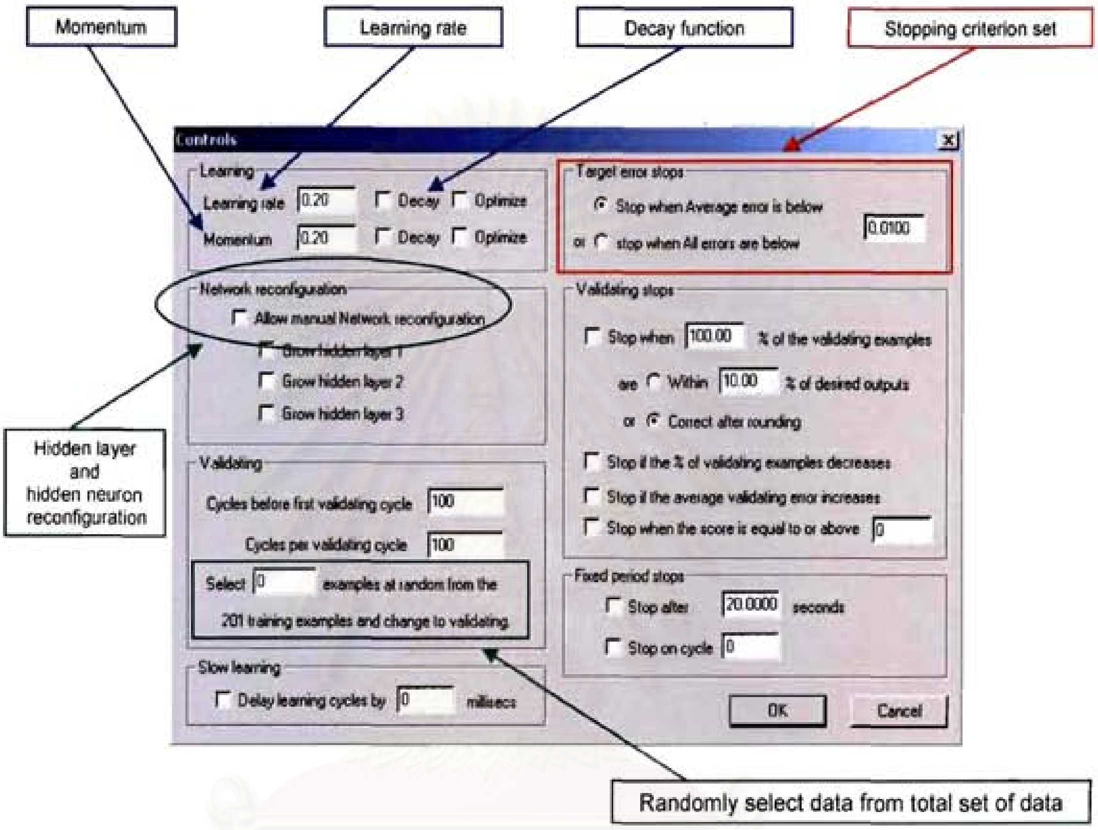


Figure 4.4: An input window for *EasyNN-plus* to select examples at random.

The numerical values of the input for the neural networks are normalized automatically by the software. Similarly, the software also calculates error of outputs for training data as normalized value. The software computes three types of errors which are maximum error, average error, and minimum error. The maximum error is the highest difference in between binary numbers of actual and calculated outputs which was compared among correlations of all data sets. The average error is the average amounts of total difference between actual and calculated output. The minimum error is the lowest difference value in between binary numbers of actual and calculated outputs which was compared among correlations of all data sets. Figure 4.5 illustrates a window that shows the three types of error as learning curves versus learning cycle. The red line is the maximum error; the green line is the average error;

and the blue line is the minimum error. The left hand vertical axis shows the normalized error. The learning curve indicates the progress during learning and the current value of errors. The horizontal axis is nonlinear to allow the whole learning progress to be displayed regardless of the number of cycles executed. As more cycles are executed the graph is squashed to the left.

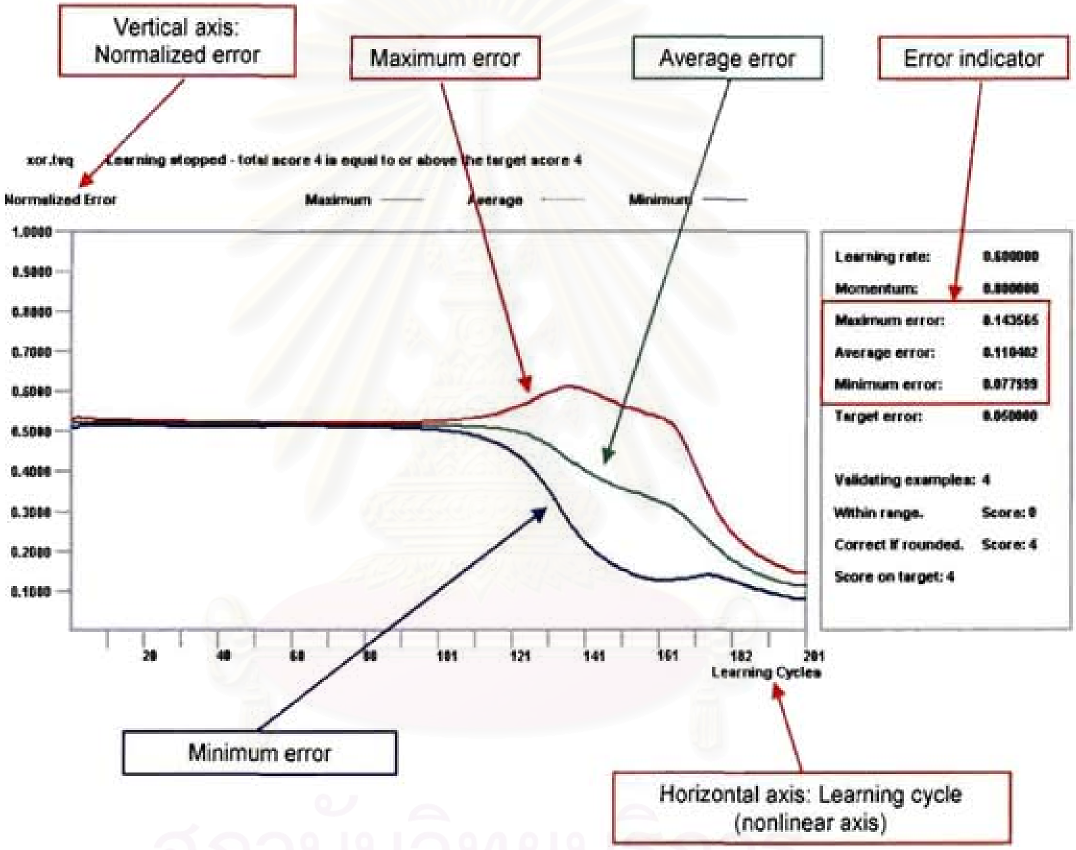


Figure 4.5: Learning progress of neural network.

In order to specify the convergence criterion to stop training the neural networks, we chose to train the models until the average absolute error of training examples is lower than 1%. This error is the summation of differences between computed outputs of the training set and actual outputs and then averaged by the total number of training sets multiplied by the number of output nodes (each set consists of seven outputs). The average absolute error is calculated as the following equation:

$$Average\ absolute\ error = \frac{\Sigma\left|Desired\ output - calculated\ output\right|}{Number\ of\ training\ data\ sets \times n} \qquad (4.2)$$

where

Desired output = Binary number of desired output

Calculated output = Binary number of calculated output

Number of training data set = amount of training sets of data

n = number of output nodes (number of correlations)

In this study, several neural networks were trained for each case. In order to choose the best performer, the errors based on incapability to identify correct correlation(s) which we called "mismatches" were computed for all the models and then compared. The model with the lowest number of mismatches was chosen as the most appropriate neural network. In order to determine the mismatch, the computed outputs from the neural network were transformed to either 0 or 1. If the activation level of the output node was lower than 0.7, the output was considered having a value of 0. Otherwise, the output was considered having a value of 1. The mismatch is the difference between the binary numbers of actual and calculated outputs. The total numbers of mismatches for all the models were compared, and the model that has the lowest number of mismatches in the testing data set would be chosen.

4.2 Case 1: 20% Maximum Error

In this case, the neural network was trained to propose all correlations that have the error in bottomhole pressure calculation less than 20%. In order to achieve the convergence criterion, the number of hidden layers and the number of neurons in the hidden layers were chosen by trial and error. Several combinations of hidden layers and numbers of neurons in the hidden layers were initially tried and the average error for each model was observed. New models with readjusted configurations were tried until achieving convergence. The trial and error was stopped when the average error was not reduced for more than 100,000 cycles. A total of 14 different runs were tried. The parameters used in each try are tabulated in Table 4.9. The results of trial tests are discussed as follows:

Table 4.9: Neural network models for Case 1: 20% maximum error.

Model No.	Number of neurons		Learning rate	Momentum	Average training error	Condition
	Hidden layer 1	Hidden layer 2				
1	9	0	0.6 (proposed)	0.7 (proposed)	0.027927	Stopped
2	9	0	0.2	0.2	0.023631	Stopped
3	9	0	0.1	0.05	0.018262	Stopped
4	10	0	0.1	0.05	0.012891	Stopped
5	11	0	0.6 (proposed)	0.7 (proposed)	0.011382	Stopped
6	11	0	0.6 (decay)	0.7 (decay)	0.01129	Stopped
7	15	0	0.3	0.3	0.020408	Stopped
8	25	0	0.6 (proposed)	0.7 (proposed)	0.010251	Stopped
9	25	0	0.1 (decay)	0 (decay)	0.011288	Stopped
10	50	0	0.1	0.05	0.009999	Converged
11	70	0	0.2	0.2	0.021489	Stopped
12	10	5	0.2	0.2	0.016112	Stopped
13	20	5	0.2	0.2	0.009302	Converged
14	20	10	0.2	0.2	0.010741	Stopped

Model number 1 which has one hidden layer and 9 hidden neurons were tried as the first model. The number of hidden layers and hidden neurons as well as the learning rate of 0.6 and momentum of 0.7 were initially proposed by the software. We trained this model until the average error was constant at 0.027927 for more than 100,000 cycles. Model number 2 was set with a new value of learning rate of 0.2 and momentum of 0.2 and using the same amount of hidden layer and hidden neurons as Model number 1. In this case, the average error of 0.023631 was steady for more than 100,000 cycles; so, we stopped the learning process. We noticed that the average error of Model number 2 is lower than that of Model number 1. Therefore, we lowered the learning rate and momentum to 0.1 and 0.05, respectively in the third model. The average error of Model number 3 was decreased to 0.018262 which is the lowest one compared to those of Model numbers 1 and 2. We then increased the amount of hidden neurons in model number 4 to 10 neurons then trained and observed the results. The error was steady at 0.012891 and then the training was terminated. Two models of 11 hidden neurons were tried with different learning rates and momentums. Model number 5 utilized the learning rate of 0.6 and the momentum of 0.7. These values were proposed by the software. Model number 6 used the technique of decay with learning rate and momentum. Initially, the learning rate and momentum were set to 0.6 and 0.7, respectively and then reduced to 0.1 and 0, respectively. These two models were trained until the average error was steady and could not be reduced further.

From several trial models, there is high possibility that the average error of neural network was reduced close to convergence criterion if we used many number of hidden nodes. Consequently, we increased the number of hidden nodes in Model number 7 which has one hidden layer and 15 hidden neurons. The model used the learning rate and momentum of 0.3 similarly and then we observed the result of the average error on this value of learning rate and momentum. The average error of Model number 7 is steady at 0.020408.

We noticed from Model 7 that the average error was reduced if the amount of hidden neurons were increased. However, the average error of Model 7 was higher than that of Model 6. The learning rate of 0.3 and momentum of 0.3 in Model number 7 may be the reason for high error. Therefore, we set another two models which have one hidden layer with 25 neurons but having different learning rates and momentums. One is Model number 8 with a learning rate of 0.6 and momentum of 0.7. These values were proposed by the software. The other one is Model number 9 which used the technique of decay with learning rate and momentum. Model number 9 were set with the learning rate of 0.6 and momentum of 0.7 as initial values. The average errors of these two models were closed to each other and the errors were lower than that of the Model number 7. Between Model numbers 8 and 9, the learning rate and momentum have not many effects. After experimenting with Model numbers 1 to 9, we observed that Model numbers 3, 4, 6, and 9 have average errors closed to convergence criterion and these models have small learning rates and momentums.

Model number 10 which has one hidden layer and 50 hidden neurons was set with a small learning rate of 0.1 and momentum of 0.05. The average error of the model achieved convergence criterion at learning cycle of 269,065. Figure 4.6 shows the learning curve of Model number 10. We supposed that the high amount of neurons may cause more degree of freedom and let the neural net model be able to reduce the error down below the criterion of 0.01. Therefore, Model number 11 which has one hidden layer and 70 hidden neurons with a small learning rate of 0.2 and momentum of 0.2 was then tried. The error of Model number 11 was reduced in the early times and then steady at 0.021489 for more than 100,000 cycles; so, we stopped the learning process.

So far, we had tried neural network models with only one hidden layer. The next step was to try training the neural net with two hidden layers. Next trails of two hidden layers were all set with the small learning rate of 0.2 and momentum of 0.2. Model number 12 was set with 10 and 5 neurons for the first and second layers, respectively. The error of this model is steady at 0.016112; so, we stopped the training process. Then, we increased the number of the hidden neurons in the first layer for the next trial. Model number 13 was set with 20 and 5 neurons in the first and second layers, respectively. Model number 13 achieved the convergence criterion at learning cycle of 239,285. Figure 4.7 shows learning curve of Model number 13. Then, we increased the number of hidden neurons in the second layer in the next trial. We started the next trial (Model number 14) with 20 and 10 neurons in the first and second hidden layers, respectively. The error of the model was steady at 0.010741 ; so, we terminated the training process.

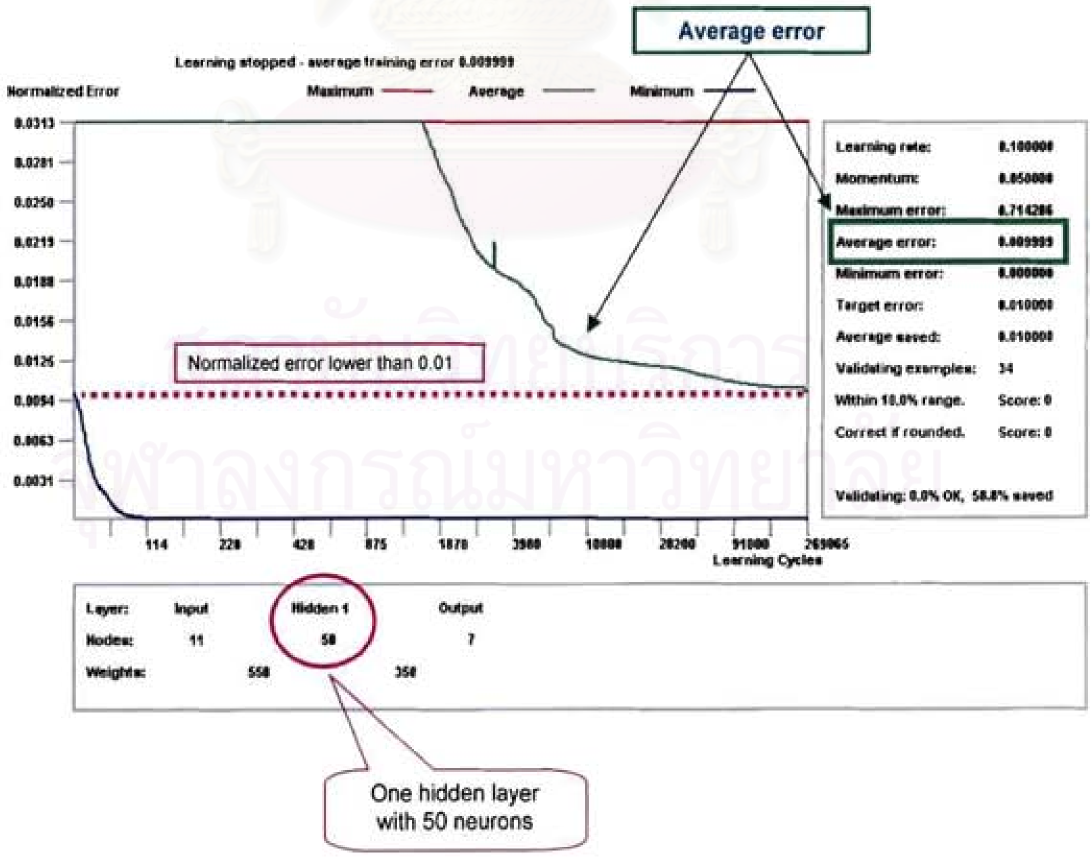


Figure 4.6: Learning curve of Model 10 (one hidden layer and 50 neurons).

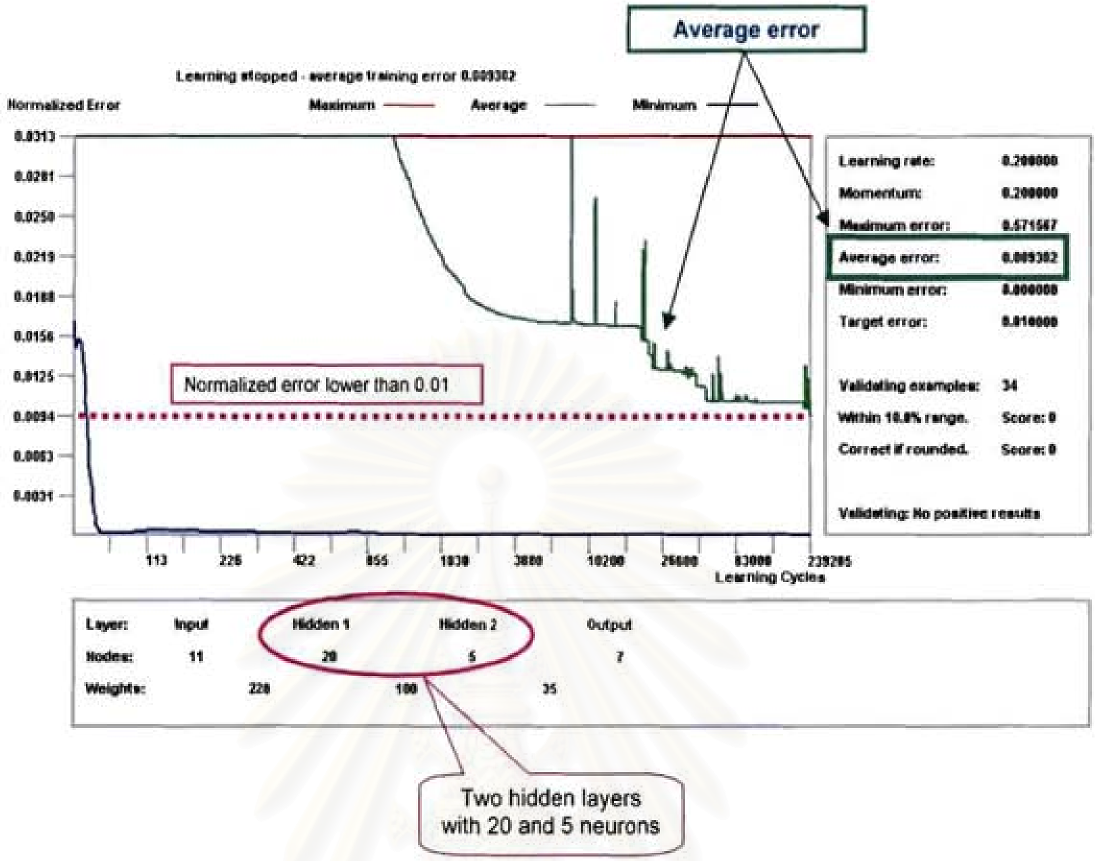


Figure 4.7: Learning curve of Model 13 (2 hidden layers with 20 and 5 neurons).

From trial and error, only two models achieved convergence. One is Model 10 which has one hidden layer with 50 neurons, and the other is Model 13 which has 2 hidden layers with 20 and 5 neurons in the first and second layers, respectively. To choose the best neural net model, we need to determine the total number of mismatches. Since there are seven nodes for the output and 201 sets of data, the highest possible number of total mismatches is 1,407. The mismatches of outputs of the testing data set of the two models were computed and compared. Table 4.10 shows the number of mismatches for these two neural network models. It was observed that the neural network model having one hidden layer with 50 neurons has a lower number of mismatches in the testing than the other one. Therefore, we used this model to represent the neural net model for case 1 (20% maximum error). Figure 4.8 shows desired and calculated outputs of the chosen neural network. A complete set of results is shown in Appendix B. Figure 4.9 shows the outputs of the neural network after applying the activation level of 0.7 in order to transform the answers binary values of 1 and 0.

Table 4.10: Mismatches of desired and computed outputs for two neural net models in Case 1.

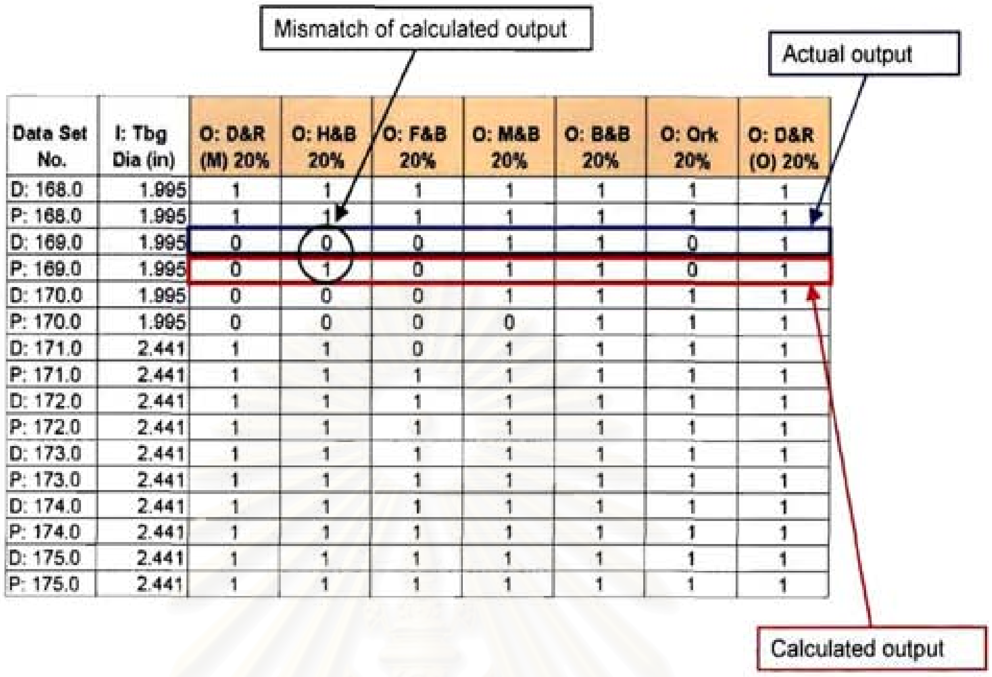
Model No.	Number of nodes		Number of mismatches in data set		
	Hidden layer 1	Hidden layer 2	Training	Validating	Testing
10	50	0	10	37	41
13	20	5	10	177	53

Actual output

Data Set No.	I: Tbg Dia (in)	O: D&R (M) 20%	O: H&B 20%	O: F&B 20%	O: M&B 20%	O: B&B 20%	O: Ork 20%	O: D&R (O) 20%
D: 168.0	1.995	1	1	1	1	1	1	1
P: 168.0	1.995	1	1	1	1	1	1	1
D: 169.0	1.995	0	0	0	1	1	0	1
P: 169.0	1.995	0.0004	0.7035	0.3215	1	0.9998	0.1652	1
D: 170.0	1.995	0	0	0	1	1	1	1
P: 170.0	1.995	0	0	0	0.0034	0.9998	0.9558	0.9595
D: 171.0	2.441	1	1	0	1	1	1	1
P: 171.0	2.441	1	0.9996	1	1	1	1	1
D: 172.0	2.441	1	1	1	1	1	1	1
P: 172.0	2.441	1	1	1	1	1	1	1
D: 173.0	2.441	1	1	1	1	1	1	1
P: 173.0	2.441	1	1	1	1	1	0.9987	0.9988
D: 174.0	2.441	1	1	1	1	1	1	1
P: 174.0	2.441	1	1	1	1	1	1	1
D: 175.0	2.441	1	1	1	1	1	1	1
P: 175.0	2.441	1	1	1	1	1	1	1

Calculated output

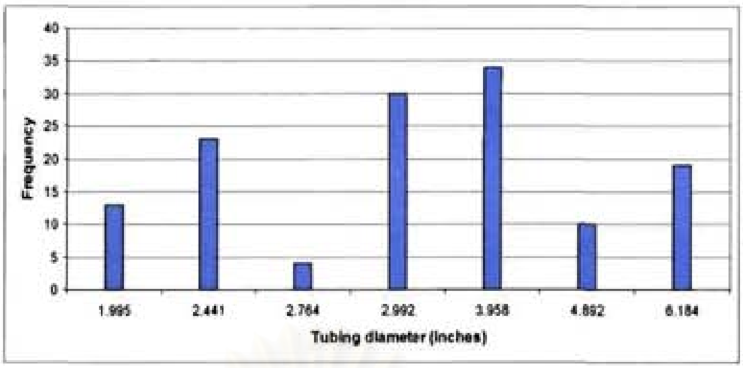
Figure 4.8: Samples of actual and calculated outputs for Model 10.



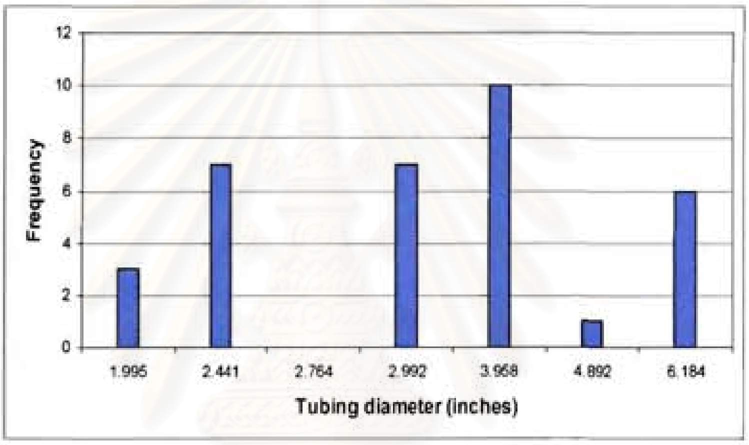
Data Set No.	I: Tbg Dia (in)	O: D&R (M) 20%	O: H&B 20%	O: F&B 20%	O: M&B 20%	O: B&B 20%	O: Ork 20%	O: D&R (O) 20%
D: 168.0	1.995	1	1	1	1	1	1	1
P: 168.0	1.995	1	1	1	1	1	1	1
D: 169.0	1.995	0	0	0	1	1	0	1
P: 169.0	1.995	0	1	0	1	1	0	1
D: 170.0	1.995	0	0	0	1	1	1	1
P: 170.0	1.995	0	0	0	0	1	1	1
D: 171.0	2.441	1	1	0	1	1	1	1
P: 171.0	2.441	1	1	1	1	1	1	1
D: 172.0	2.441	1	1	1	1	1	1	1
P: 172.0	2.441	1	1	1	1	1	1	1
D: 173.0	2.441	1	1	1	1	1	1	1
P: 173.0	2.441	1	1	1	1	1	1	1
D: 174.0	2.441	1	1	1	1	1	1	1
P: 174.0	2.441	1	1	1	1	1	1	1
D: 175.0	2.441	1	1	1	1	1	1	1
P: 175.0	2.441	1	1	1	1	1	1	1

Figure 4.9: Comparison between actual and calculated outputs (after transforming to binary numbers) for Model 10.

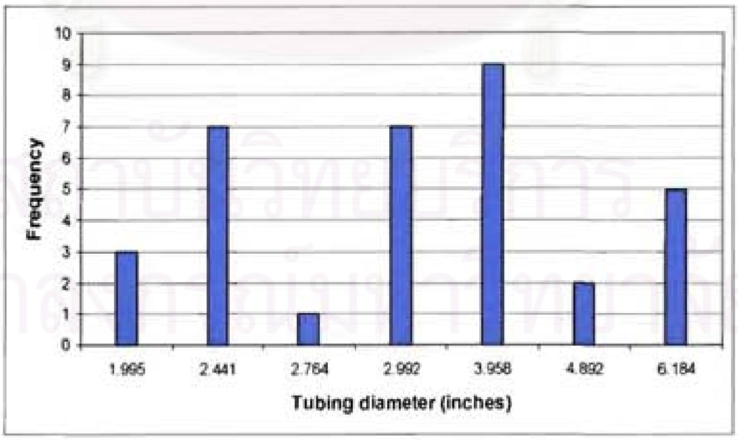
To be assured that the neural network achieved generalization, the three partitioned data sets should have more or less similar distribution which covers all possible ranges of information. Since the software partitioned the data set randomly, histograms of training, validating, and testing sets were plotted in order to check for similarities in the distribution of each partitioned data set. Figures 4.10 through 4.20 compare histograms of the 11 input parameters in the training, validating, and testing data. The histograms of each parameter have similar distributions to that of the original data which is shown in Figure 4.2.



1) Data distribution of training sets.

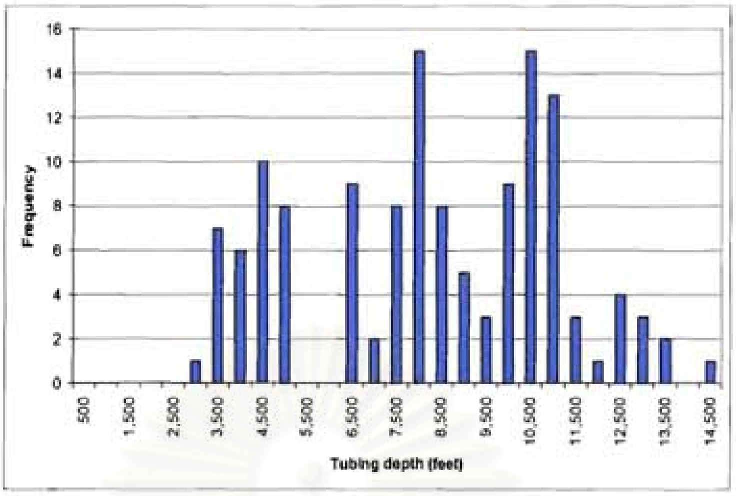


2) Data distribution of validating sets.

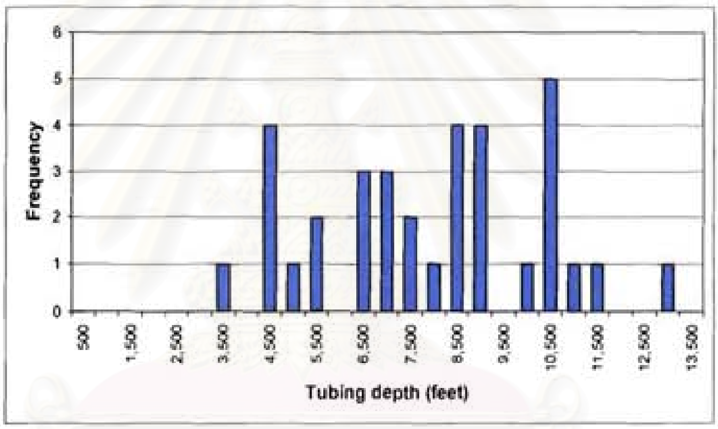


3) Data distribution of testing sets.

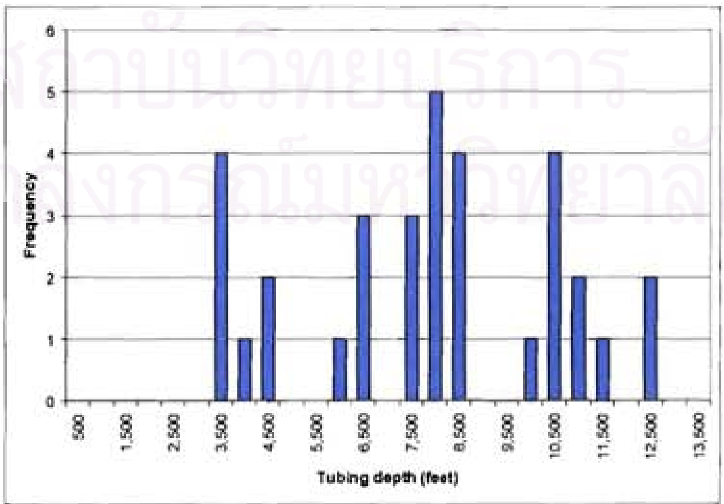
Figure 4.10: Histograms of tubing diameter.



1) Data distribution of training sets.

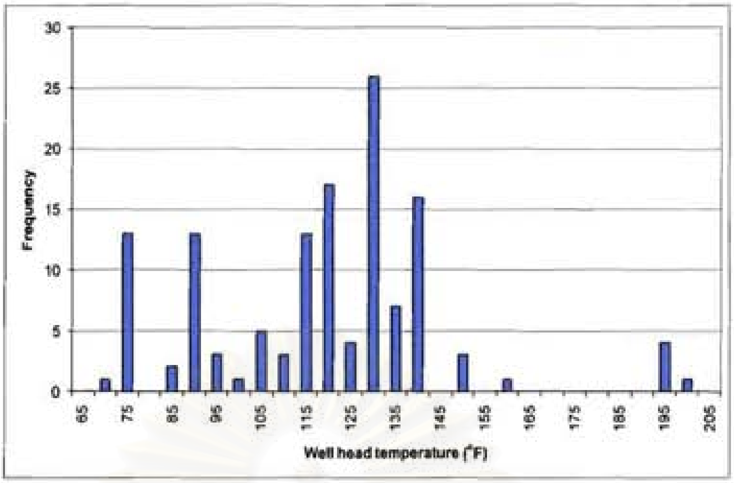


2) Data distribution of validating sets.

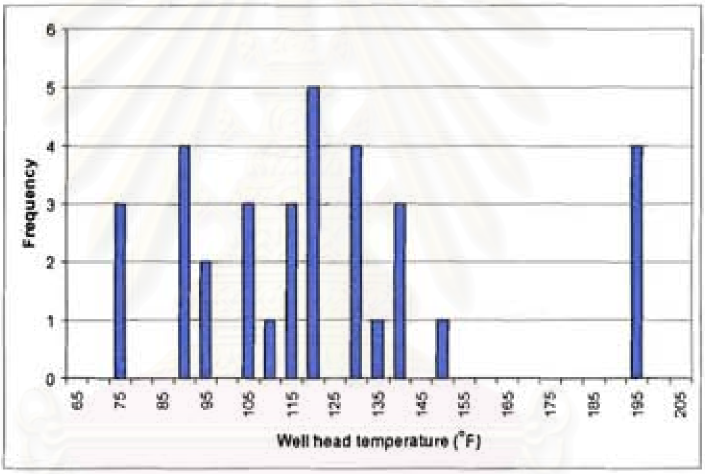


3) Data distribution of testing sets.

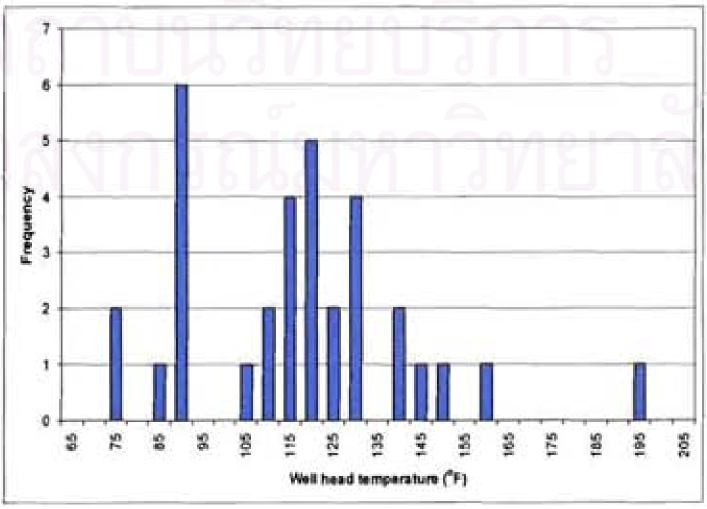
Figure 4.11: Histograms of tubing depth.



1) Data distribution of training sets.

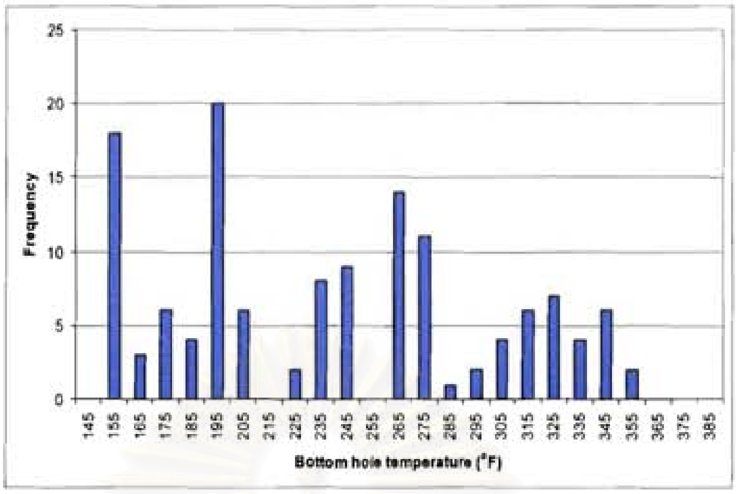


2) Data distribution of validating sets.

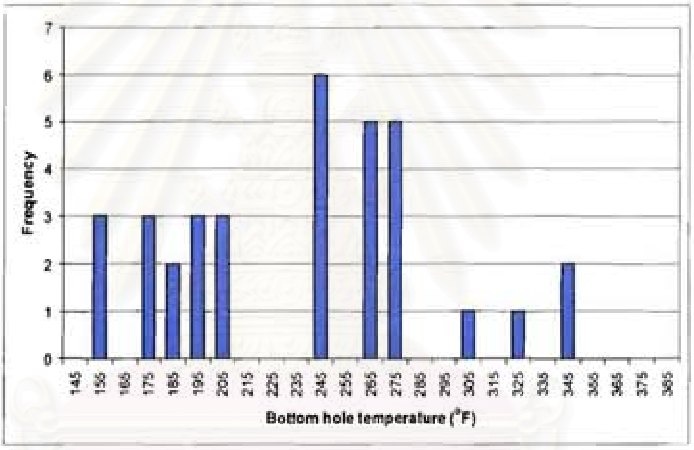


3) Data distribution of testing sets.

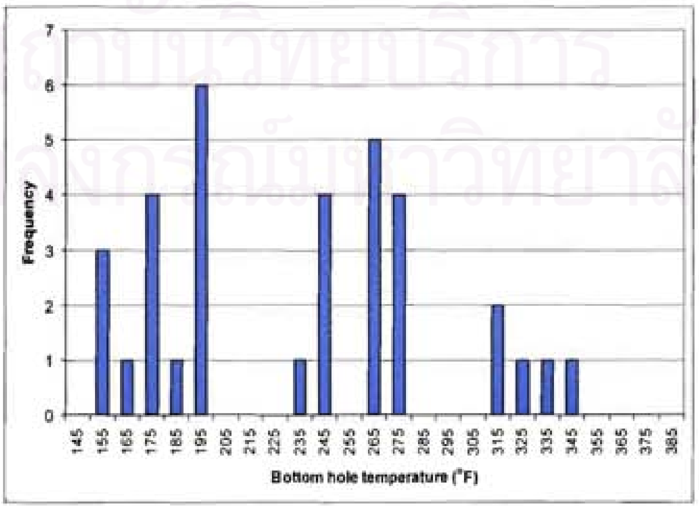
Figure 4.12: Histograms of wellhead temperature.



1) Data distribution of training sets.

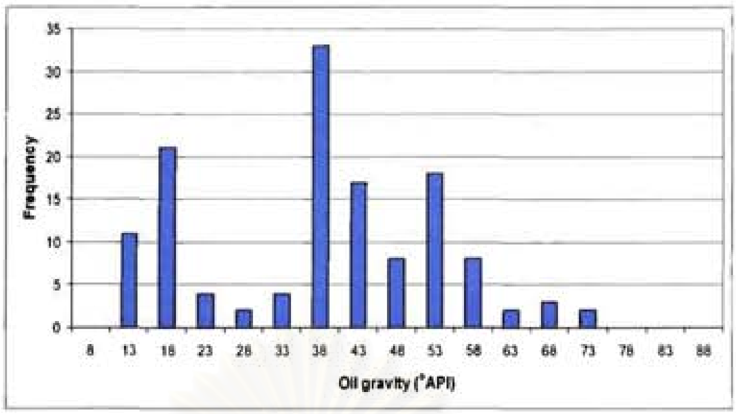


2) Data distribution of validating sets.

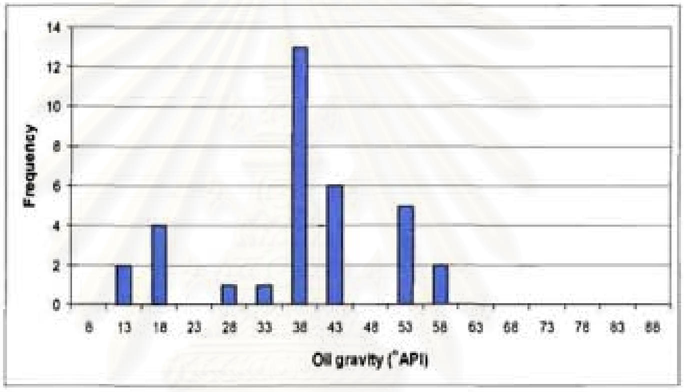


3) Data distribution of testing sets.

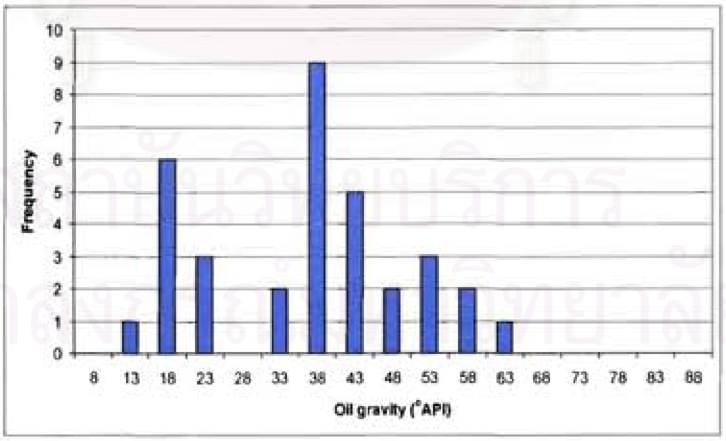
Figure 4.13: Histograms of bottomhole temperature.



1) Data distribution of training sets.

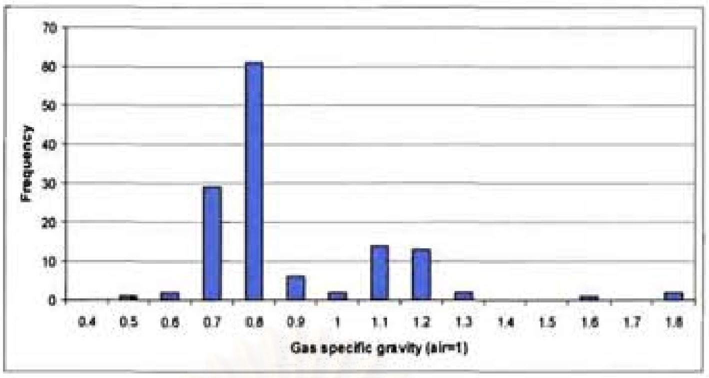


2) Data distribution of validating sets.

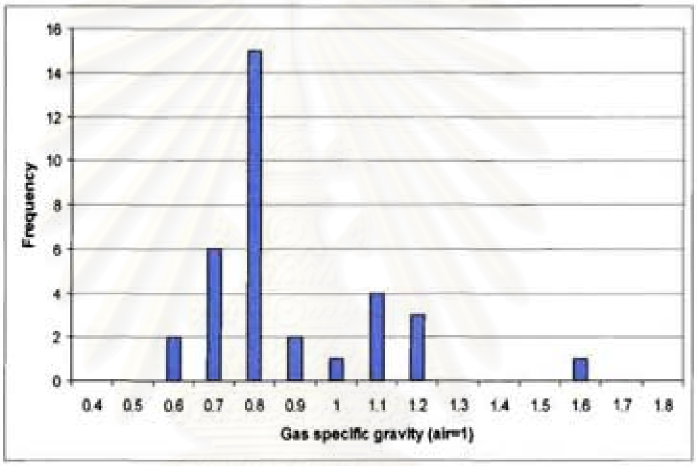


3) Data distribution of testing sets.

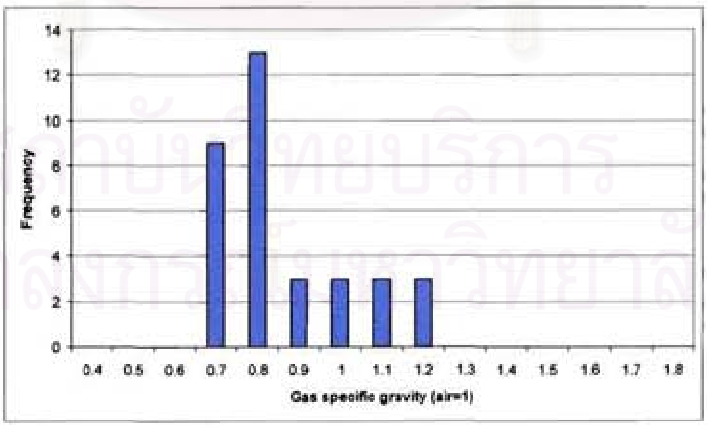
Figure 4.14: Histograms of oil gravity.



1) Data distribution of training sets.

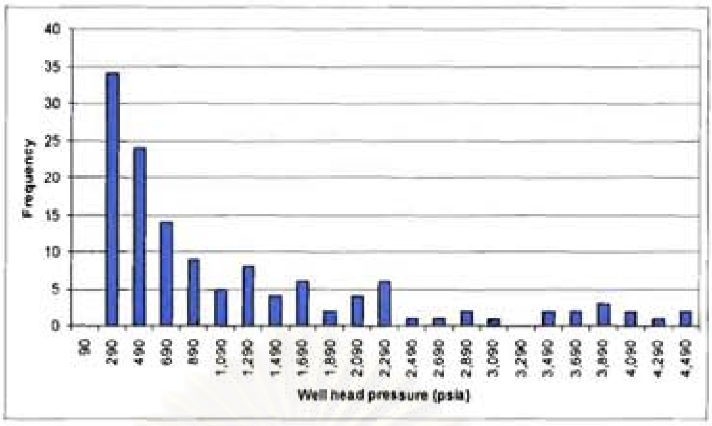


2) Data distribution of validating sets.

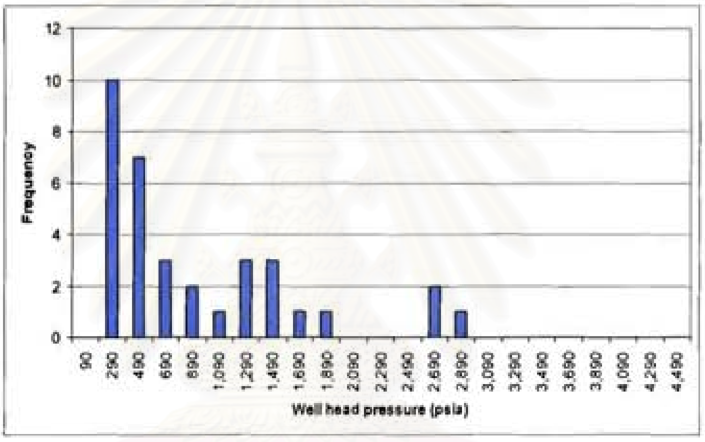


3) Data distribution of testing sets.

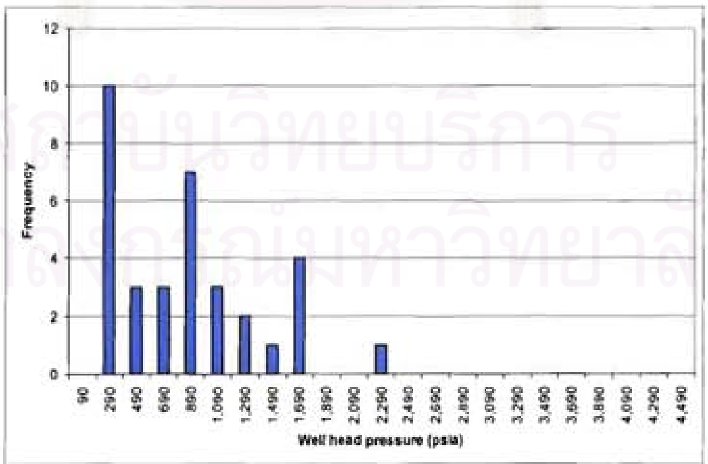
Figure 4.15: Histograms of gas specific gravity.



1) Data distribution of training sets.

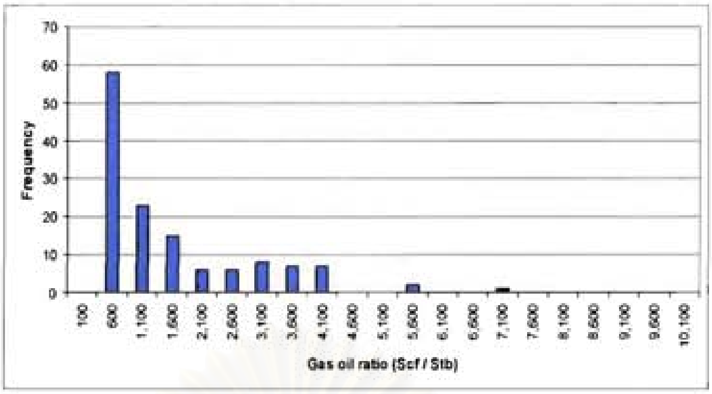


2) Data distribution of validating sets.

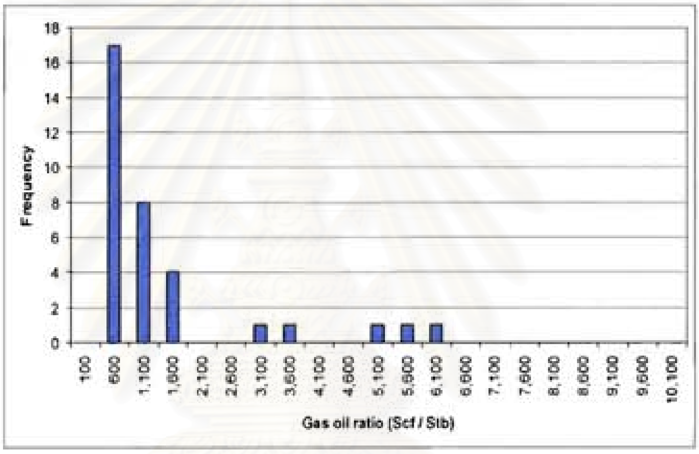


3) Data distribution of testing sets.

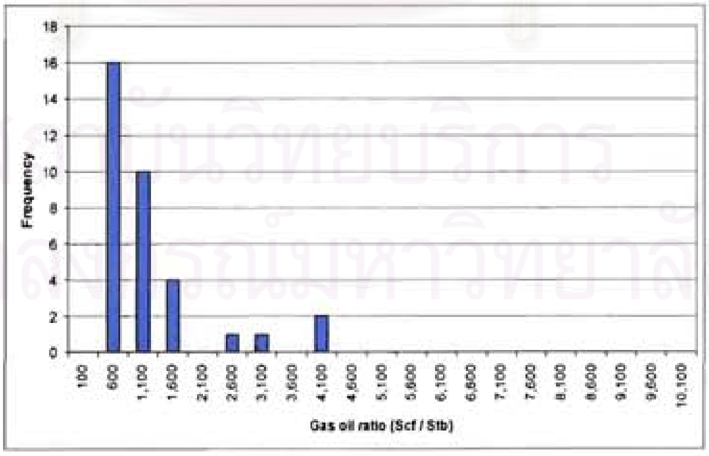
Figure 4.16: Histograms of wellhead pressure.



1) Data distribution of training sets.

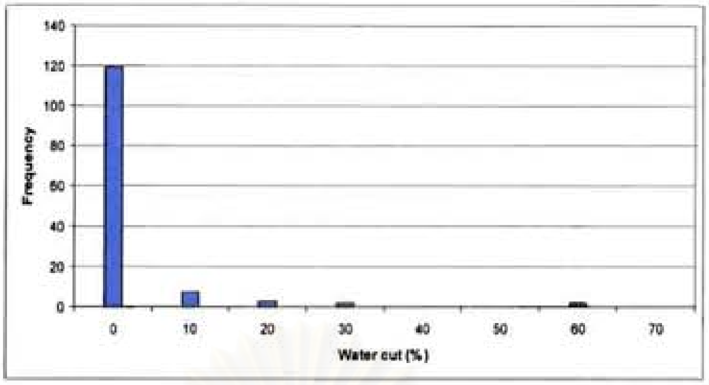


2) Data distribution of validating sets.

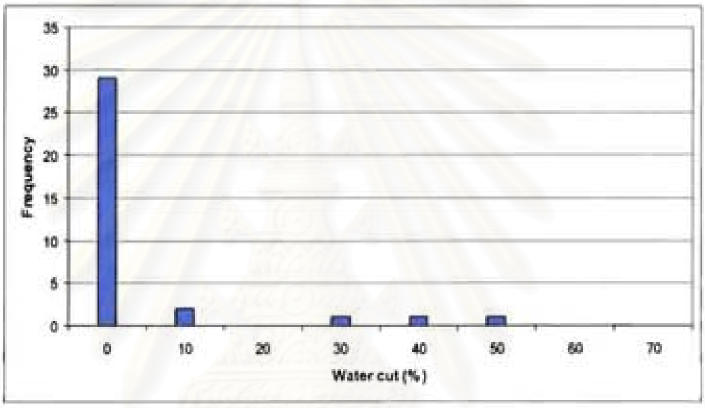


3) Data distribution of testing sets.

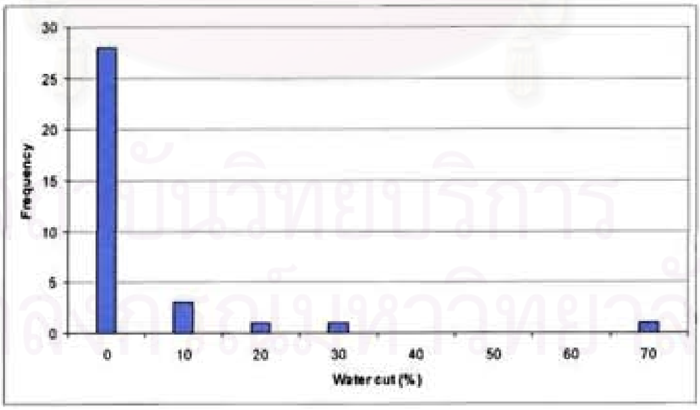
Figure 4.17: Histograms of gas oil ratio.



1) Data distribution of training sets.

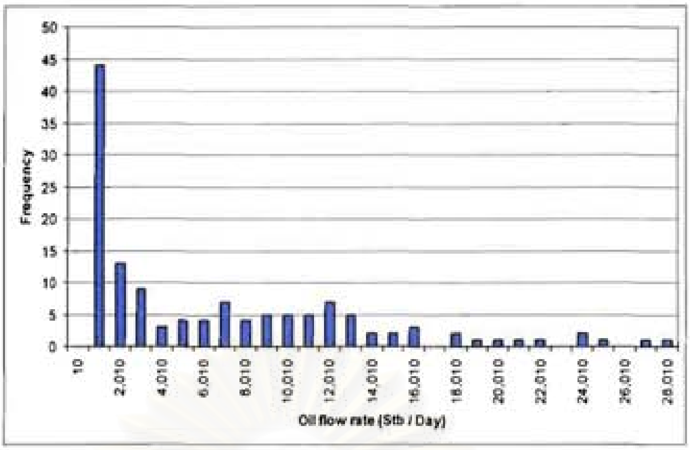


2) Data distribution of validating sets.

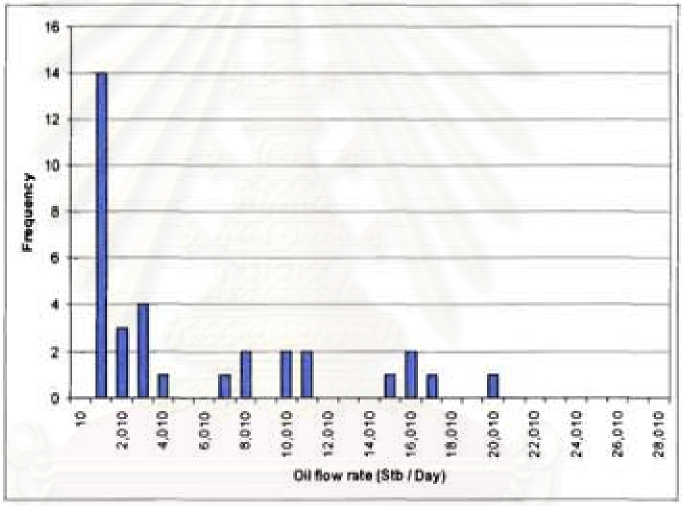


3) Data distribution of testing sets.

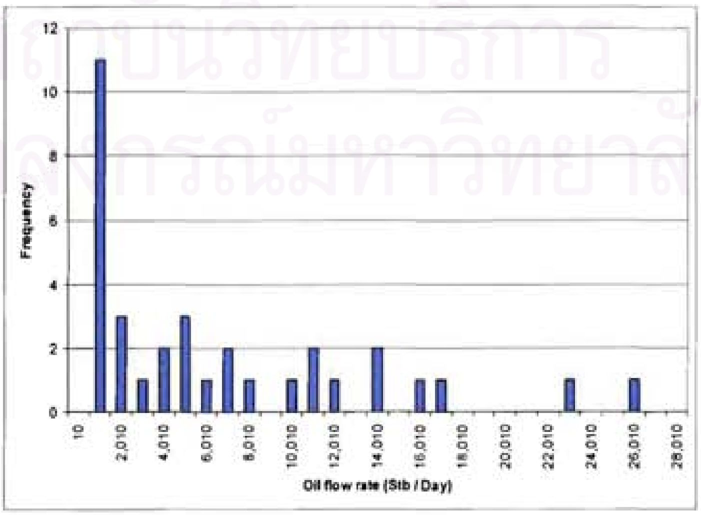
Figure 4.18: Histograms of water cut.



1) Data distribution of training sets.

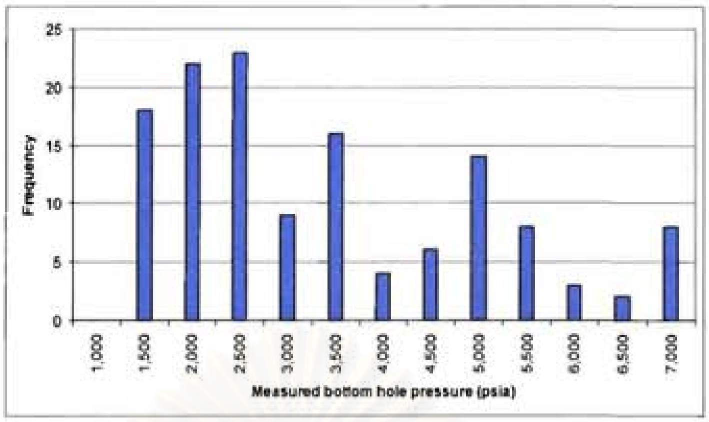


2) Data distribution of validating sets.

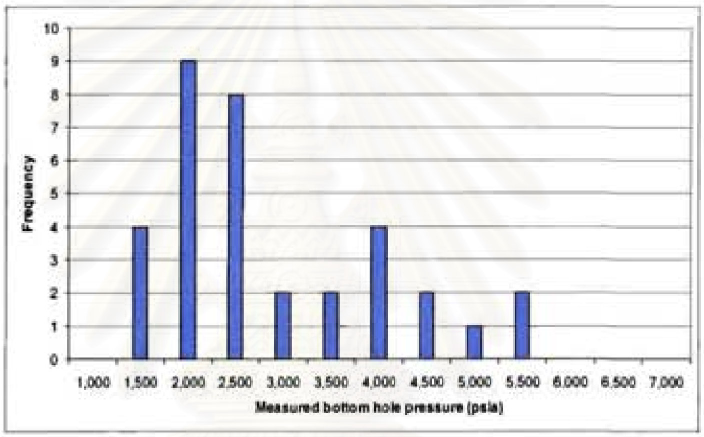


3) Data distribution of testing sets.

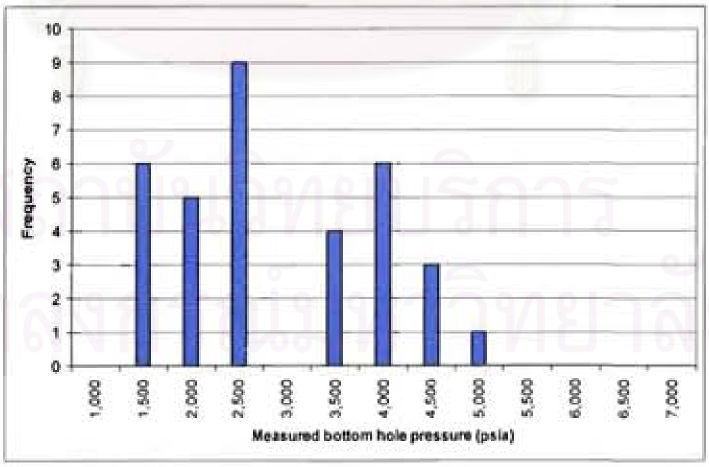
Figure 4.19: Histograms of oil flow rate.



1) Data distribution of training sets.



2) Data distribution of validating sets.



3) Data distribution of testing sets.

Figure 4.20: Histograms of measured bottomhole pressure.

4.2.1 Results and Discussion

The best neural net model (Model number 10) in this case could perform the lowest difference of prediction of 17.23% in testing data sets. In this section, we discuss the mismatches in details which the mismatches are represented in ranges of each flow condition. Figure 4.21 shows distribution of the mismatches of testing data. In order to investigate the effect of input parameters to the accuracy of the prediction, the percentage of false identification or mismatch is calculated for every value of each input and plotted as histogram. The effect of input parameters on the mismatched is discussed as follows:

1) Tubing diameter

Figure 4.21 (1) shows percentage of false identification for different tubing diameters. The internal tubing diameters (ID) of the wells used in the testing phase of the neural network are 1.995", 2.441", 2.764", 2.992", 3.958", 4.892", and 6.184". The tubing diameter of 2.764" has the highest percentage of misidentification. This error may be caused by the least amount of training and validating data sets compared to those for other tubing sizes (4 sets of training and 0 set of validating as shown in Figure 4.10). Tubing sizes that have the next highest percentage of mismatch are 3.958" and 2.992" which have mismatch percentage of 25.40% and 24.49%, respectively. Some of tubing diameters have the percentage of mismatch lower than 10% such as diameter of 1.995", 2.441", and 4.892". Tubing size of 6.184" has no mismatch at all.

2) Tubing depth

Figure 4.21 (2) illustrates percentage of false identification for different tubing depths. The tubing depths of the wells used in the testing phase of the neural network are 3,182 to 14,322 feet. The depth of 11,001 to 11,500 feet has the highest percentage of misidentification. The error may be caused by the small amount of training and validating data sets compared to those of other tubing depths (3 sets of training and 1 set of validating as shown in figure 4.11). The depths of the tubing that have the next highest percentage of mismatch are 12,001 to 12,500 feet and 12,501 to 14,322 feet which have mismatch percentage of 50% and 42.86%, respectively. Tubing depths of 3,182 to 3,500 feet and 5,501 to 6,000 feet have the similar mismatch in percentage of 28.57%. Tubing depths that have the percentage of mismatch between 10% and 20% such as 6,001 to 7,500 feet and 9,501 to 10,500 feet. Tubing depths that have the percentage of mismatch lower than 10% are 4,001 to 4,500 feet, 7,501 to 8,000 feet, and 10,501 to 11,000 feet. Tubing depths of 3,501 to 4,000 feet and 8,001 to 8,500 feet have no mismatch at all.

3) Wellhead temperature

Figure 4.21 (3) shows percentage of false identification for different wellhead temperatures. The wellhead temperatures of the wells used in the testing phase of the neural network are 75 to 195°F. The temperature of 101 to 105°F has the highest percentage of misidentification. This error may be caused by the small amount of training and validating data sets compared to those for other wellhead temperatures (5 sets of training and 3 sets for validating as shown in Figure 4.12). Wellhead temperatures that have the next highest percentage of mismatch are 121 to 125°F, 156 to 160°F, 136 to 140°F, and 146 to 150°F which have mismatch percentage of 57.14%, 42.86%, 35.71%, 28.57%, respectively. The wellhead temperatures that have mismatch percentage between 10% and 20% are the temperatures of 86 to 90°F and 126 to 130°F. Wellhead temperatures that have the percentage of mismatch lower than 10% such as temperature of 75°F and 111 to 120°F. Wellhead temperatures of 81 to 85°F, 106 to 110°F, 141 to 145°F, and 191 to 195°F have no mismatch at all.

4) Bottomhole temperature

Figure 4.21 (4) illustrates percentage of false identification for different bottomhole temperatures. The bottomhole temperatures of the wells used in the training phase of the neural network are 150 to 342°F. The bottomhole temperature of 306 to 315°F has the highest percentage of misidentification. This error may be caused by small amount of training and validating data sets compared to those of other bottomhole temperatures (6 sets of training and 0 set of validating as shown in Figure 4.13). The bottomhole temperatures that have the next highest percentage of mismatch are 156 to 165°F, 236 to 245°F, and 226 to 235°F which have mismatch percentage of 42.86%, 42.86%, and 28.57%, respectively. Bottomhole temperatures that have the percentage of mismatch between 14% and 18% such as 166 to 175°F and 336 to 342°F. Bottomhole temperatures that have the mismatch in percentage lower than 10% such as 150 to 155°F, 186 to 195°F, and 256 to 265°F. Bottomhole temperatures of 176 to 185°F, 266 to 275°F, and 316 to 335°F have no mismatch at all.

5) Oil gravity

Figure 4.21 (5) shows percentage of false identification for different oil gravities. The oil gravities of the wells used in the testing phase of the neural network are 11.8 to 62.3°API. The oil gravity of 44 to 48°API has the highest percentage of misidentification. This error may be caused by small amount of training and validating data sets compared to those of other oil gravities (8 set of training, 0 set of validating as shown in Figure 4.14). Oil gravity that has the next highest percentage of mismatch is 54 to 58°API, 49 to 53°API, 39 to 43°API, 14 to 18°API, and 59 to 62.3°API which have mismatch percentage of 35.71%, 33.33%, 22.86%, 21.43%, and 14.29%, respectively. Oil gravities that have the percentage of mismatch lower than 5% such as oil gravitie of 19 to 23°API and 34 to 38°API. Oil gravities of 11.8 to 13°API and 29 to 33°API have no mismatch at all.

6) Gas specific gravity

Figure 4.21 (6) illustrates percentage of false identification for different gas specific gravities. The gas specific gravities of the wells used in the testing phase of the neural network are 0.65 to 1.122 (air=1). The gas specific gravity of 0.81 to 0.9 has the highest percentage of misidentification. This error may be caused by small amount of training and validating data sets compared to those of other gas specific gravities (training data of 6 sets and validating data of 2 sets as shown in Figure 4.15). Gas specific gravities that have the next highest percentage of mismatch are 0.65 to 0.7 and 0.71 to 0.8 which have mismatch percentage of 31.75% and 14.29%, respectively. Gas specific gravities of 0.91 to 1.122 have no mismatch at all.

7) Wellhead pressure

Figure 4.21 (7) illustrates percentage of false identification for different wellhead pressures. The wellhead pressures of the wells used in the testing phase of the neural network are 157 to 2,274 psia. The wellhead pressures of 491 to 690 psia and 1,091 to 1,290 psia have the highest percentage of misidentification. Wellhead pressures that have the next highest percentage of mismatch are 1,491 to 1,690 psia, 157 to 290 psia, and 691 to 890 psia which have mismatch percentage of 28.57%, 15.71%, and 12.24%, respectively. Wellhead pressure that has the percentage of mismatch lower than 5% is 291 to 490 psia. Wellhead pressures of 891 to 1,090 psia, 1,291 to 1,490 psia, and 2,091 to 2,274 psia have no mismatch at all.

8) Gas oil ratio

Figure 4.21 (8) shows percentage of false identification for different gas oil ratios. The gas oil ratios of the wells used in the testing phase of the neural network are 168 to 4,065 scf/stb. The gas oil ratio of 2,601 to 3,100 scf/stb has the highest percentage of misidentification. Gas oil ratio that has the next highest percentage of mismatch is 3,601 to 4,065 scf/stb which has mismatch percentage of 42.86%. Gas oil ratios of 168 to 600 scf/stb, 2,101 to 2,600 scf/stb, and 601 to 1,100 scf/stb have the mismatch percentage of 16.07%, 14.29%, and 11.43%, respectively. Gas oil ratio that has mismatch percentage lower than 10% is 1,101 to 1,600 scf/stb. There is no gas oil ratio that has no mismatch in case 1 (20% maximum error).

9) Water cut

Figure 4.21 (9) shows percentage of false identification for different water cuts. The water cuts of the wells used in the testing phase of the neural network are 0 to

60.4%. The water cut of 11 to 20% has the highest percentage of misidentification. Water cut that has the next highest percentage of mismatch is 1 to 10% which has mismatch percentage of 28.57%. Water cuts that have the percentage of mismatch about 15% such as 0%, 21 to 30%, and 61 to 70%. There is no water cuts that has no misidentification in case 1 (20% maximum error).

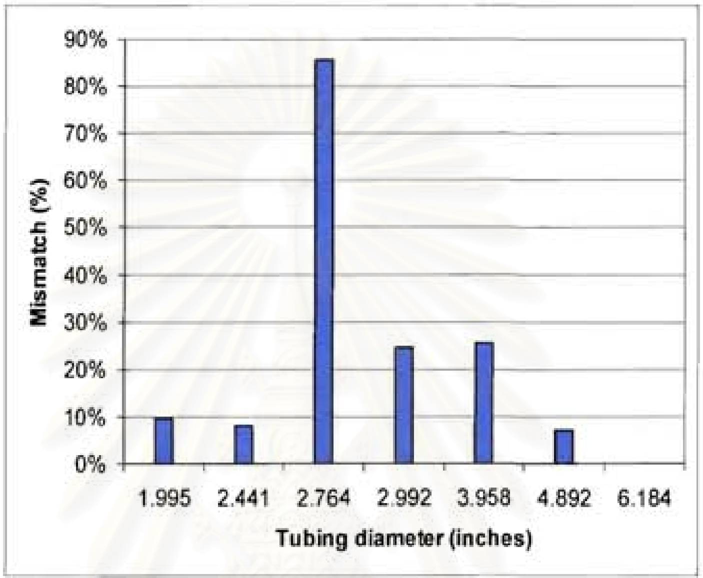
10) Oil flow rate

Figure 4.21 (10) illustrates percentage of false identification for different oil flow rates. The oil flow rates of the wells used in the testing phase of the neural network are 16 to 25,205 stb/day. The oil flow rate of 5,011 to 6,010 stb/day has 100 percentage of misidentification. Oil flow rates that has the next highest percentage of mismatch are 11,011 to 12,010 stb/day which has mismatch percentage of 71.43%. Oil flow rates that have the percentage of mismatch about 20% such as oil flow rate of 16 to 1,010 stb/day and 3,011 to 5,010 stb/day. Oil flow rates that have mismatch percentage of 14.29% are oil flow rate of 6,011 to 7,010 stb/day and 15,011 to 16,010 stb/day. Oil flow rate that has the percentage of mismatch lower than 5% is oil flow rate of 1,011 to 2,010 stb/day. Oil flow rates of 2,011 to 3,010 stb/day, 7,011 to 8,010, 9,011 to 11,010 stb/day, 13,011 to 14,010 stb/day, 16,011 to 17,010, 22,011 to 23,010, and 25,011 to 25,205 stb/day have no mismatch at all.

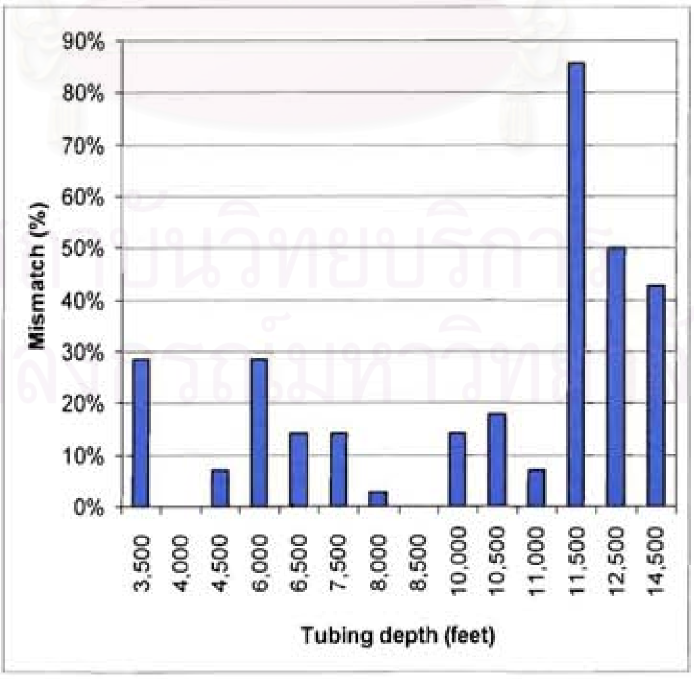
11) Measure bottomhole pressure

Figure 4.21 (11) shows percentage of false identification for different bottomhole pressures. The measured bottomhole pressures of the wells used in the training phase of the neural network are 1,287 to 4,761 psia. The measured bottomhole pressure of 1,287 to 1,500 psia has the highest percentage of misidentification. The bottomhole pressures that have the next highest percentage of mismatch are 3,501 to 4,000 psia, 1,501 to 2,000 psia, and 4,501 to 4,761 psia which have mismatch percentage of 30.95%, 22.86%, and 14.29%, respectively. Measured bottom hole pressures that have the percentage of mismatch lower than 5% such as pressure of 2,001 to 2,500 psia and 3,001 to 3,500 psia. Measured bottom hole pressure of 4,001 to 4,500 psia has no mismatch at all.

In summary, the main reason for false identification or mismatch is lack of data in the training and validating phase of the neural network.

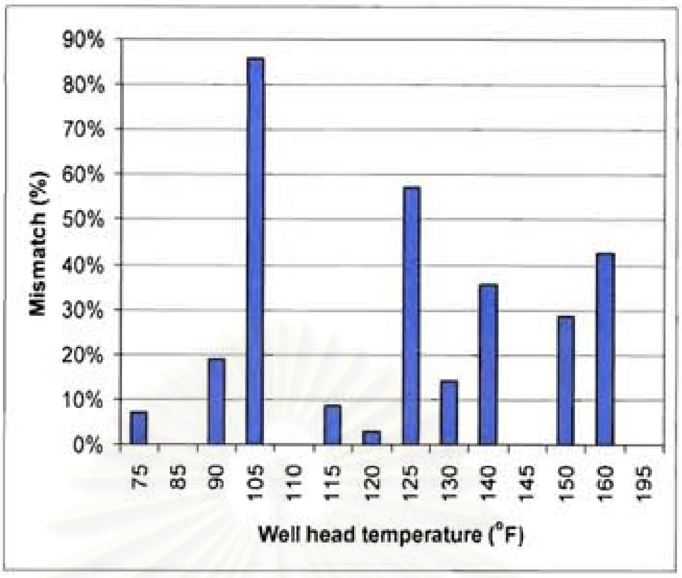


1) Percentage of false identification for different tubing diameters.

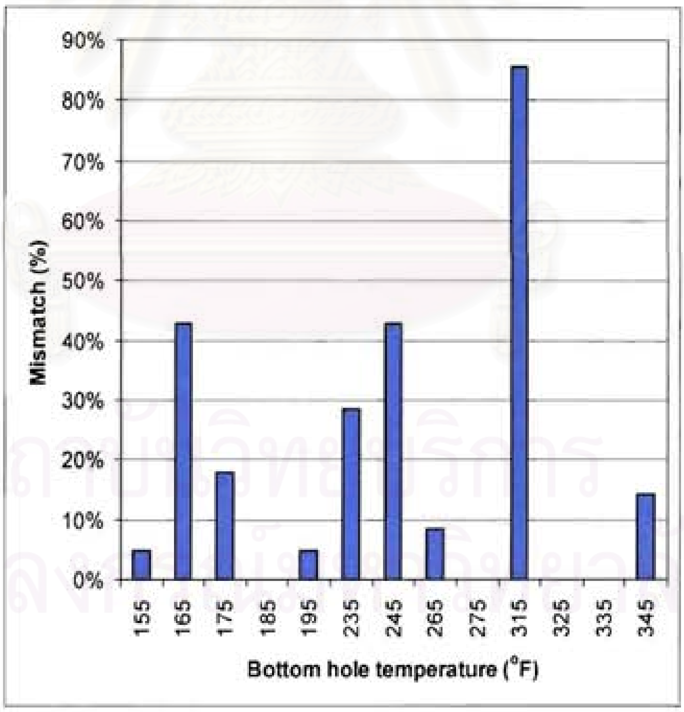


2) Percentage of false identification for different tubing depths.

Figure 4.21: Mismatch histograms for Case 1.

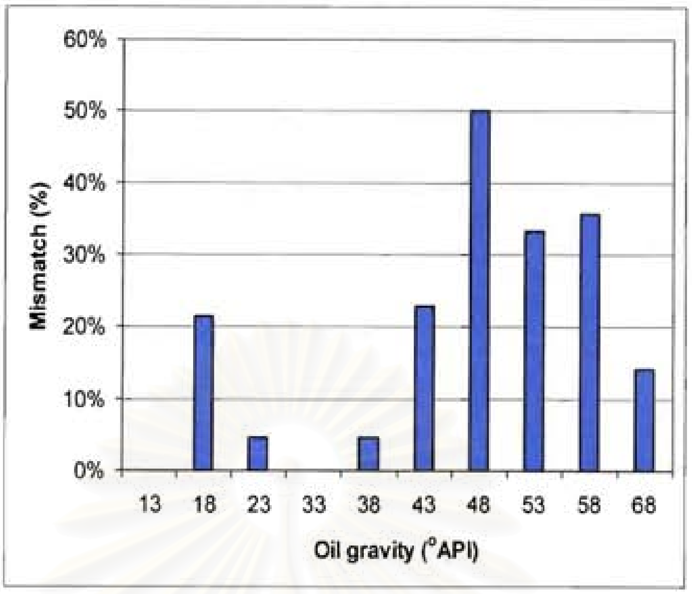


3) Percentage of false identification for different wellhead temperatures.

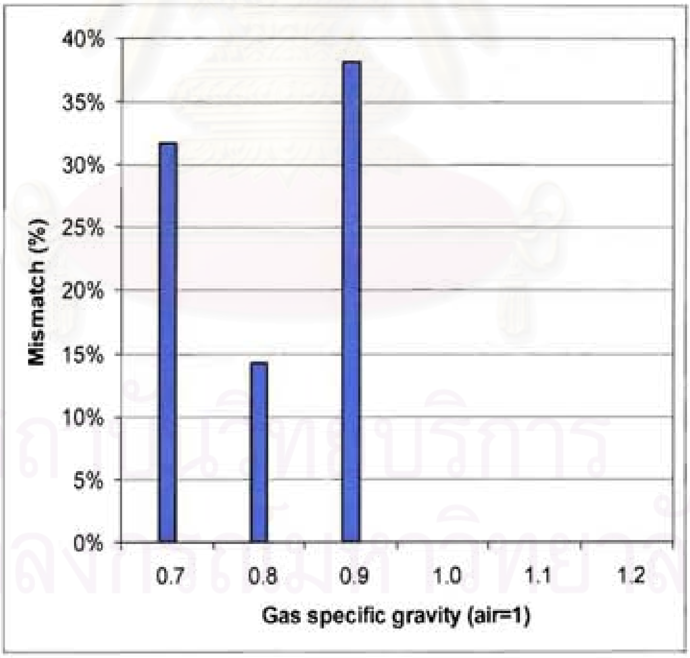


4) Percentage of false identification for different bottomhole temperatures.

Figure 4.21: Mismatch histograms for Case 1 (continued).

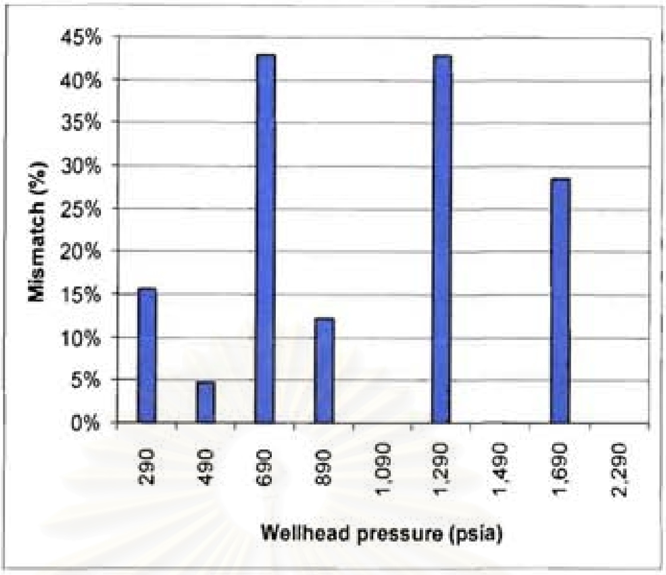


5) Percentage of false identification for different oil gravities.

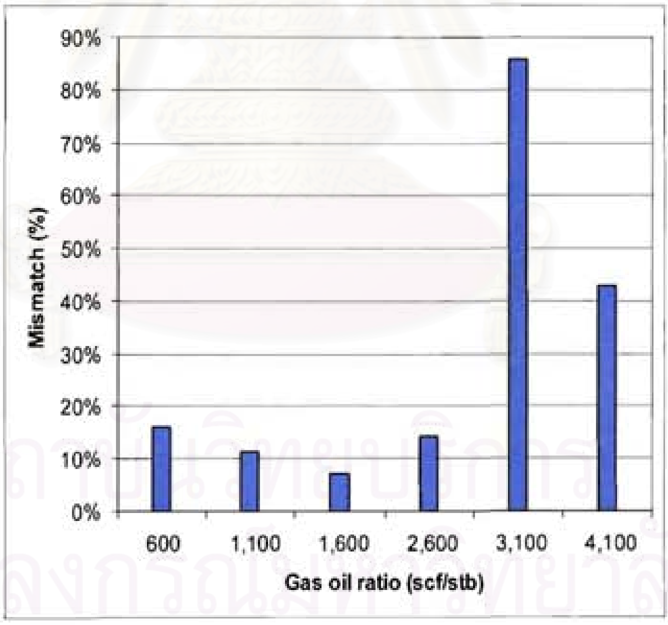


6) Percentage of false identification for different gas specific gravities.

Figure 4.21: Mismatch histograms for Case 1 (continued).

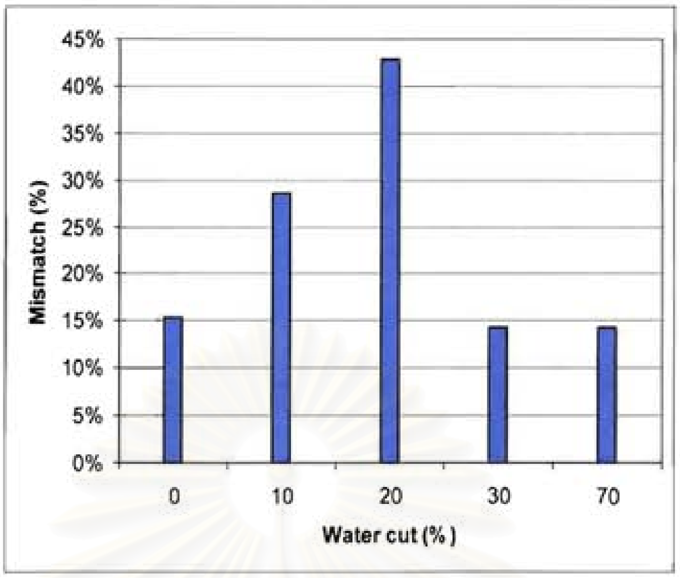


7) Percentage of false identification for different wellhead pressures.

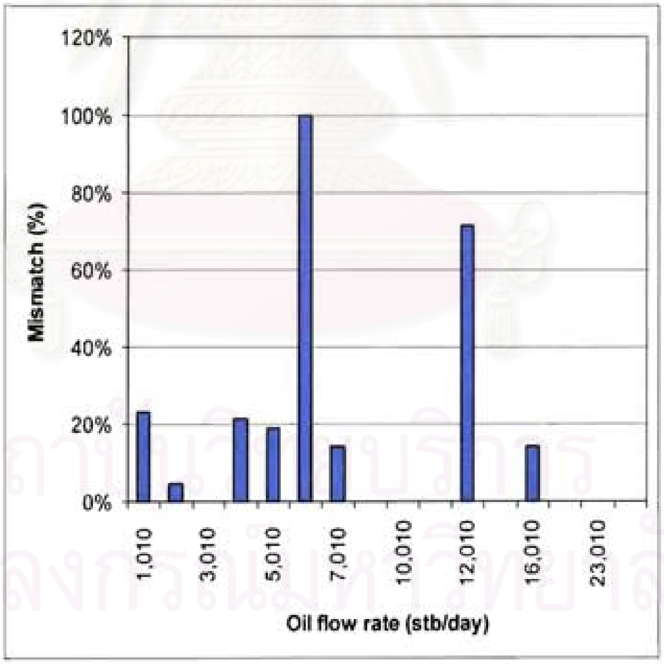


8) Percentage of false identification for different gas oil ratios.

Figure 4.21: Mismatch histograms for Case 1 (continued).

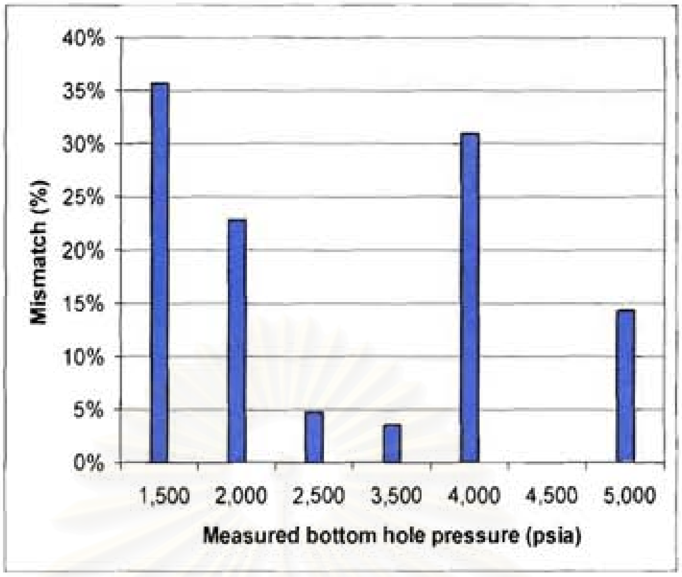


9) Percentage of false identification for different water cuts.



10) Percentage of false identification for different oil flow rates.

Figure 4.21: Mismatch histograms for Case 1 (continued).



11) Percentage of false identification for different measured bottomhole pressures.

Figure 4.21: Mismatch histograms for Case 1.

4.3 Case 2: 10% Maximum Error

In this case, the neural network was trained to propose all correlations that have the error in bottomhole pressure calculation less than 10%. In order to achieve the convergence criterion, the number of hidden layers and the number of neurons in the hidden layers were chosen by trial and error. Several combinations of hidden layers and numbers of neurons in the hidden layers were initially tried and the average error for each model was observed. New models with readjusted configurations were tried until achieving convergence criterion. The trial and error was stopped when the average error was not reduced more than 100,000 cycles. A total of 19 different runs were tried. The parameters used in each try are tabulated in Table 4.11. The results of trial tests are discussed as follows:

Table 4.11: Neural network models for Case 2: 10% maximum error.

Model No.	Number of neurons		Learning rate	Momentum	Average error	Condition
	Hidden layer 1	Hidden layer 2				
1	9	0	0.6 (optimize)	0.7 (optimize)	0.160834	Stopped
2	10	0	0.7	0.8	0.249583	Stopped
3	10	0	0.1	0.05	0.030087	Stopped
4	15	0	0.2	0.2	0.019338	Stopped
5	50	0	0.7 (optimize)	0.8 (optimize)	0.01675	Stopped
6	50	0	0.1 Decay	0 Decay	0.019967	Stopped
7	50	0	0.3	0.3	0.016772	Stopped
8	50	0	0.2	0.2	0.016113	Stopped
9	50	0	0.2	0.1	0.019993	Stopped
10	50	0	0.1	0.05	0.016719	Stopped
11	70	0	0.2	0.2	0.01289	Stopped
12	15	5	0.2	0.2	0.03867	Stopped
13	30	10	0.2	0.2	0.010742	Stopped
14	30	10	0.1	0.05	0.008593	Converged
15	40	10	0.2	0.2	0.023736	Stopped
16	40	20	0.2	0.2	0.009962	Converged
17	40	30	0.2	0.2	0.009274	Converged
18	40	35	0.2	0.2	0.009288	Converged
19	40	40	0.2	0.2	0.009619	Converged

Model number 1 which has one hidden layer and 9 hidden neurons were tried as the first model. The number of hidden layers and hidden neurons as well as the learning rate of 0.6 and momentum of 0.7 were initially proposed by the software. We trained this model until the average error was constant at 0.160834, then we stopped the training process. Model number 2 has one hidden layer and 10 neurons in the hidden layer which the model was set with a new value of learning rate of 0.7 and momentum of 0.8. In this case, the average error of 0.249583 was steady for more than 100,000 cycles; so, we terminated the training process. We noticed that the average error of Model number 2 is higher than that of Model number 1 which it may caused by high values of learning rate and momentum. Therefore, we lowered the learning rate and momentum to 0.01 and 0.05, respectively in the third model. The average error of Model number 3 was deceased to 0.030087 which is the lowest one compared to those of model numbers 1 and 2. We then increased the amount of hidden neurons to 15 neurons in Model number 4 and set the learning rate of 0.2 and momentum of 0.2. We then trained and observed the results of this model. The error of Model number 4 was steady at 0.019338, and then the training process was stopped.

From Model numbers 1 to 4, there is high possibility that the average error of neural network was reduced close to convergence criterion if we used many amounts of hidden nodes. Therefore, we tried the next six models (Model numbers 5 to 10) with one hidden layer and 50 hidden neurons in the hidden layer. We used combinations of the learning rates and momentums, and observed the average error of the models. Model number 5 utilized the learning rate of 0.7 and momentum of 0.8. These values were proposed by the software. The average error of Model number 5 was decreased and steady at 0.01675. Model number 6 used the technique of decay with the learning rate and momentum. The average error of the Model number 6 was decreased to 0.019967 and then no further reduction; so, we stopped the training process. Model number 7 was set with learning rate of 0.3 and momentum of 0.3. We observed the average error of Model number 7 which reduced and steady at 0.016772. We noticed the error of Model number 7 was lower than that of the model number 6 which used the technique of decay with the learning rate and momentum. Then we tried the Models numbers 8, 9, and 10 with small values of learning rates and momentums. We tried with Model number 8 which used the learning rate of 0.2 and momentum of 0.2. The average error of Model number 8 was constant at 0.016113. Model number 8 has lower average error than that of Model number 7 which may caused by small values of the learning rate and momentum. Therefore, we lowered the learning rate and momentum to 0.2 and 0.1, respectively in Model number 9. We trained this model until the average error was constant at 0.019993 for more than 100,000 cycles. We tried to lower the learning rate and momentum to 0.1 and 0.05, respectively in the Model number 10 which is the last model for one hidden layer. Model number 10 has one hidden layer and 50 neurons in the hidden layer. The average error of Model number 10 was steady at 0.016719; so, we stopped the training process. The average errors these models were closed to each other but it all still higher than that of the convergence criterion of 0.01. In this case (10% maximum error), the model that has one hidden layer and 50 hidden neurons could not achieved the criterion as case 1 (20% maximum error). We considered to increase the numbers of hidden neurons in one hidden layer model. Model number 11 has one hidden layer and 70 neurons in the hidden layer; and used learning rate of 0.2 and momentum of 0.2. However, the average error was constant at 0.01289 and could not be reduced further.

Several attempts of one hidden layer model were tried but none of them achieved the convergence criterion. The next step was to try training the neural net with two hidden layers. Next trials of two hidden layers were all used the small learning rate of 0.2 and momentum of 0.2. Model number 12 was set with 15 and 5 neurons for the first and second layers, respectively. The error of this model is steady at 0.03867 for more than 100,000 cycles, then we stopped training process. Model number 13 which has 30 hidden neurons in the first layer and 10 hidden neurons in the second layers was trained and observed the result. The error of Model number 13 was steady at 0.010742 which closed to the convergence criterion of 0.01. Model number 14 was set with the values of learning rate of 0.1 and momentum of 0.05 and using the same amount of hidden layers and hidden neurons as Model number 13. In this case, the model achieved the convergence criterion. Figure 4.22 shows the learning curve of model number 14. We supposed that the high amount of neurons may cause more degree of freedom and let the neural net model be able to reduce the error down below the criterion of 0.01. Model number 15 which has 40 neurons in the first layer and 10 neurons in the second layers was tried and observed the result. The average error of this model was steady at 0.023736; so, we stopped the training process. Model number 16 was set with 40 and 20 neurons for the first layer and second layers, respectively. This model achieved the criterion at 79,542 cycles. Figure 4.23 shows the learning curve of Model number 16. Model number 17 which has 40 and 30 neurons in the first and second layers was then tried and observed the result. The average error of Model number 17 achieved the convergence criterion at 272,761 cycles. Figure 4.24 shows the learning curve of Model number 17. We tried the next model of Model number 18 which has 40 neurons in the first layer and 35 neurons in the second layers. This model achieved the criterion at 5,373 cycles. Figure 4.25 shows the learning curve of Model number 18. Model number 19 has 40 and 40 neurons in the first and second layers was then tried and observed the result. The average error of Model number 19 achieved the criterion at 39,388 cycles. Figure 4.25 shows the learning curve of Model number 19.

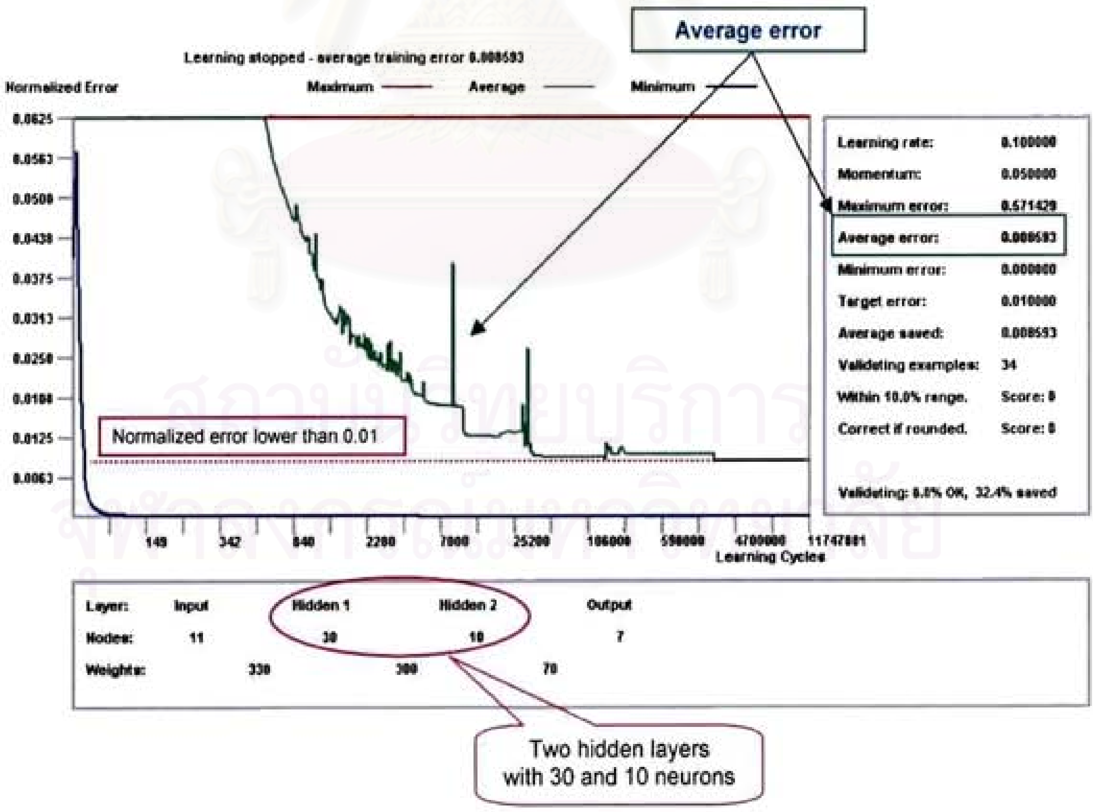


Figure 4.22: Learning curve of Model 14 (two hidden layer with 30 and 10 neurons in the first and second layers, respectively)

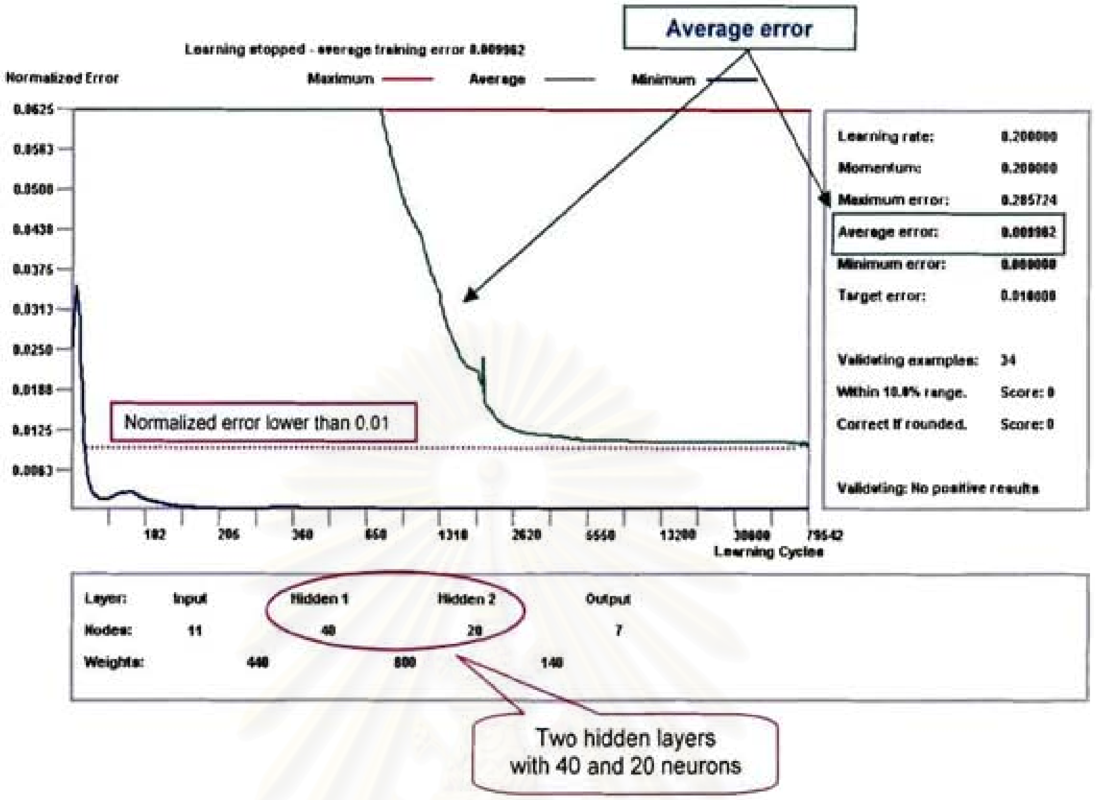


Figure 4.23: Learning curve of Model 16 (two hidden layer with 40 and 20 neurons in the first and second layers, respectively)

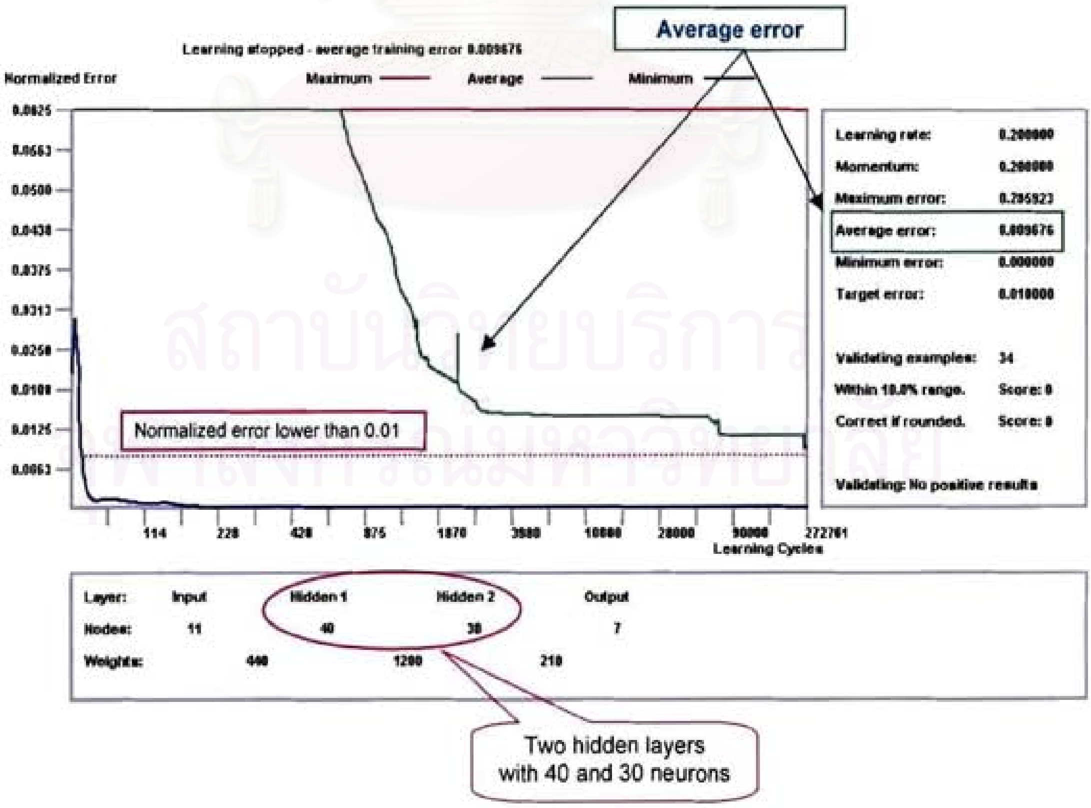


Figure 4.24: Learning curve of Model 17 (two hidden layer with 40 and 30 neurons in the first and second layers, respectively)

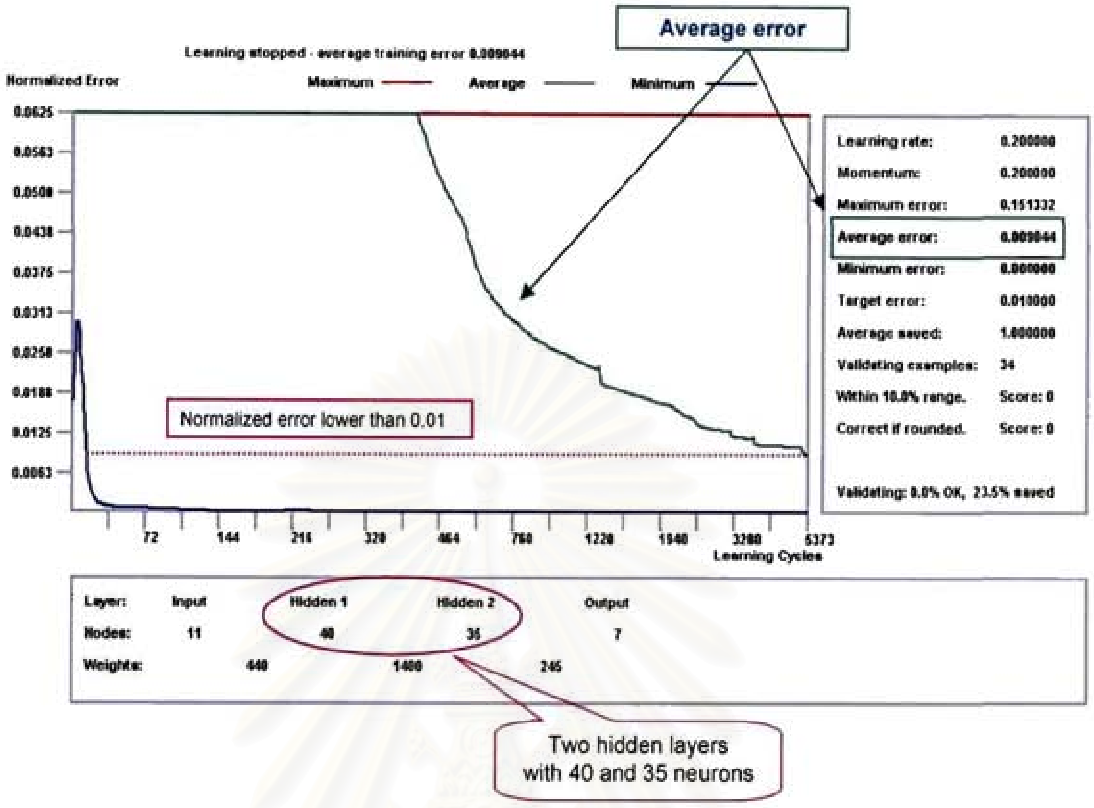


Figure 4.25: Learning curve of Model 18 (two hidden layer with 40 and 35 neurons in the first and second layers, respectively)

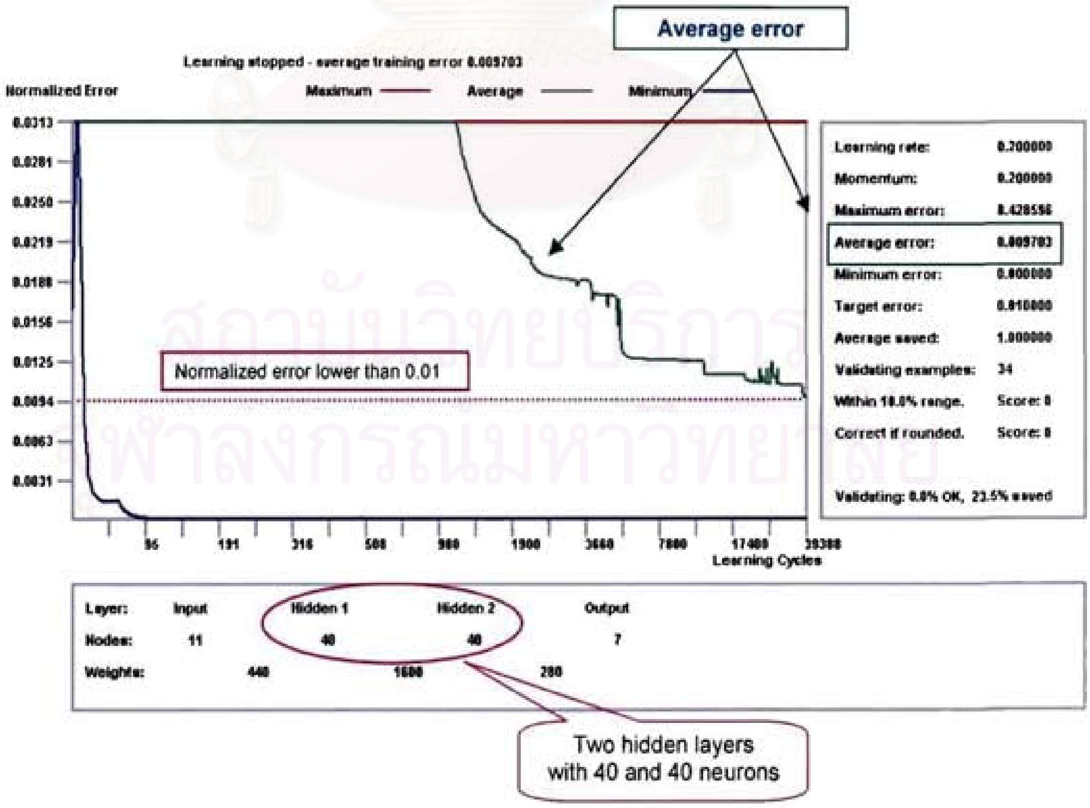


Figure 4.26: Learning curve of Model 19 (two hidden layer with 40 and 40 neurons in the first and second layers, respectively)

From the trial and error, there are five neural net models that achieved the convergence criterion and all models are two hidden layers. The first model that achieved the criterion is Model 14 which has 30 and 10 neurons in the first and second layers, respectively. The second model is Model number 16 which has 40 neurons in the first layer and 20 neurons in the second layers. The third model is Model number 17 which has 40 and 30 neurons in the first and second layers, respectively. The fourth model is Model number 18 which has 40 neurons in the first layer and 35 neurons in the second layers. The last converged model is Model number 19 which has 40 and 40 neurons in the first and second layers, respectively. To choose the best neural net model, we need to determine the total number of mismatches. Since there are seven nodes for the output and 201 sets of data, the highest possible number of total mismatches is 1,407. The mismatches of outputs of the testing data sets of the five models were computed and compared. Table 4.12 shows the number of mismatches for these five neural net models. It was observed that the neural network model having 30 neurons in the first layer and 10 neurons in the second layers has a lowest number of mismatches in the testing than the other models. Consequently, we used this model to represent the neural net model for Case 2 (10% maximum error). Figure 4.27 shows desired and calculated outputs of the chosen neural network. A complete set of results is shown in Appendix C. Figure 4.28 shows outputs of the neural network after applying the activation level of 0.7 in order to transform the answers binary values of 1 and 0.

Table 4.12: Mismatches of desired and computed outputs for five neural net models in Case 2.

Model No.	Number of Nodes		Number of Mismatches in data set		
	Hidden layer 1	Hidden layer 2	Training	Validating	Testing
14	30	10	8	98	63
16	40	20	14	89	75
17	40	30	11	88	67
18	40	35	13	84	66
19	40	40	10	87	68

Actual output

Data Set No.	I: Tbg Dia (In)	O: D&R (M) 10%	O: H&B 10%	O: F&B 10%	O: M&B 10%	O: B&B 10%	O: Ork 10%	O: D&R (O) 10%
D: 3.0	1.995	0	0	0	0	1	0	0
P: 3.0	1.995	0	0.0001	0	0	0	0.002	0
D: 5.0	1.995	0	0	0	1	1	1	0
P: 5.0	1.995	0	0.8348	0	0	1	0.0001	1
D: 15.0	1.995	0	0	0	1	1	0	0
P: 15.0	1.995	0	0	0	0.9993	1	0	0.0008
D: 24.0	2.441	1	0	0	0	0	0	0
P: 24.0	2.441	0	0	0	0.9993	1	0	0.0008
D: 31.0	2.441	0	0	0	0	0	0	0
P: 31.0	2.441	0.0004	1	1	1	0.0016	0.9999	0
D: 33.0	2.441	1	1	1	1	0	1	0
P: 33.0	2.441	1	1	1	1	0.9929	1	1
D: 35.0	2.441	0	0	0	0	0	0	0
P: 35.0	2.441	0.0002	1	1	1	0.0005	0.9999	0
D: 42.0	2.441	1	1	1	1	1	1	1
P: 42.0	2.441	1	1	1	1	1	1	1
D: 43.0	2.441	1	1	1	1	1	1	1
P: 43.0	2.441	1	1	1	1	1	1	1

Calculated output

Figure 4.27: Samples of actual and calculated outputs for Model 14.

Mismatch of calculated output

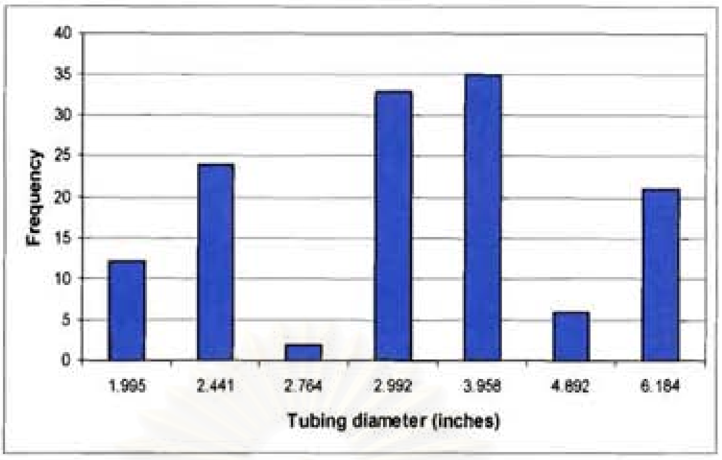
Actual output

Data Set No.	I: Tbg Dia (In)	O: D&R (M) 10%	O: H&B 10%	O: F&B 10%	O: M&B 10%	O: B&B 10%	O: Ork 10%	O: D&R (O) 10%
D: 3.0	1.995	0	0	0	0	1	0	0
P: 3.0	1.995	0	0	0	0	0	0	0
D: 5.0	1.995	0	0	0	1	1	1	0
P: 5.0	1.995	0	1	0	0	1	0	1
D: 15.0	1.995	0	0	0	1	1	0	0
P: 15.0	1.995	0	0	0	1	1	0	0
D: 24.0	2.441	1	0	0	0	0	0	0
P: 24.0	2.441	0	0	0	1	1	0	0
D: 31.0	2.441	0	0	0	0	0	0	0
P: 31.0	2.441	0	1	1	1	0	1	0
D: 33.0	2.441	1	1	1	1	0	1	0
P: 33.0	2.441	1	1	1	1	1	1	1
D: 35.0	2.441	0	0	0	0	0	0	0
P: 35.0	2.441	0	1	1	1	0	1	0
D: 42.0	2.441	1	1	1	1	1	1	1
P: 42.0	2.441	1	1	1	1	1	1	1
D: 43.0	2.441	1	1	1	1	1	1	1
P: 43.0	2.441	1	1	1	1	1	1	1

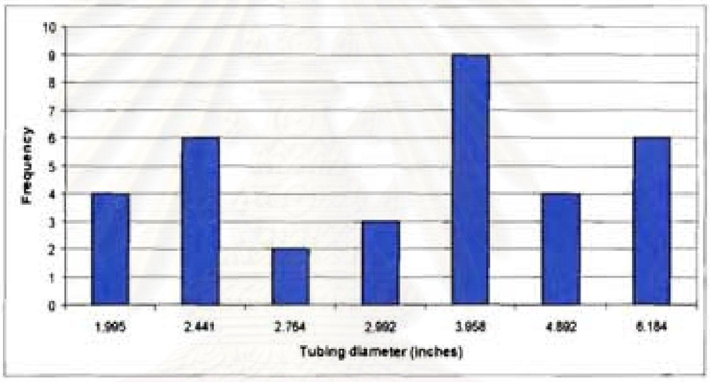
Calculated output

Figure 4.28: Comparison between actual and calculated outputs (after transforming to binary numbers) for Model 14.

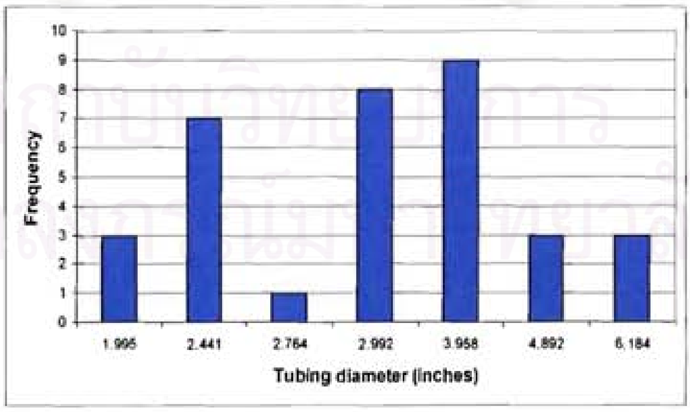
To be assured that neural network achieved generalization, the three partitioned data sets should have more or less similar distribution which covers all possible ranges of information. Since the software partitioned the data set randomly, histograms of training, validating, and testing sets were plotted in order to check for similarities in distribution of each partitioned data set. Figure 4.29 through 4.39 compare histograms of the 11 input parameters in the training, validating, and testing data. The histograms of each parameter have similar distributions to that of the original data which is shown in Figure 4.2.



1) Data distribution of training sets.

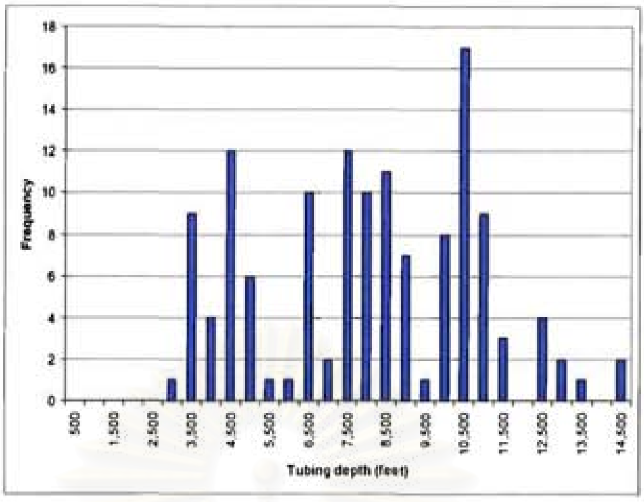


2) Data distribution of validating sets.

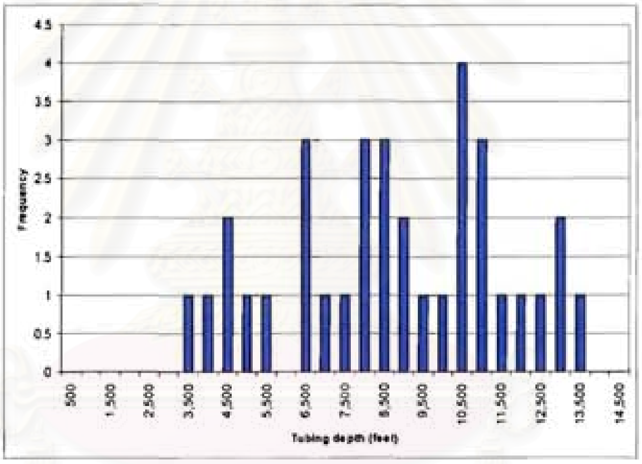


3) Data distribution of testing sets.

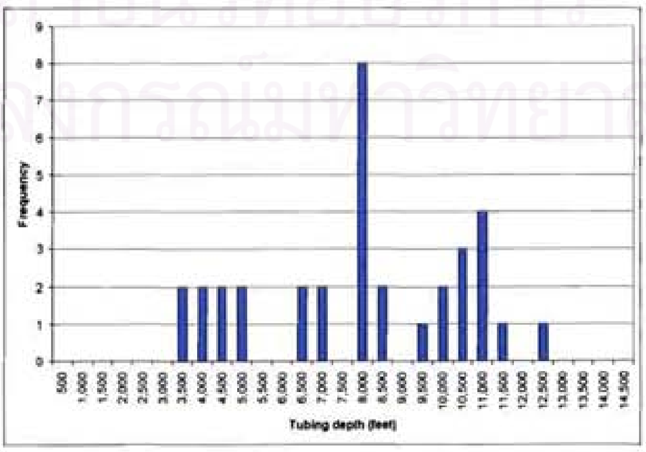
Figure 4.29: Histograms of tubing diameter.



1) Data distribution of training sets.

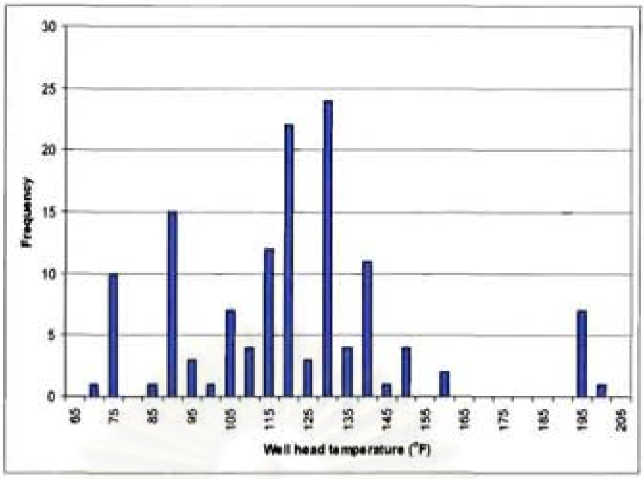


2) Data distribution of validating sets.

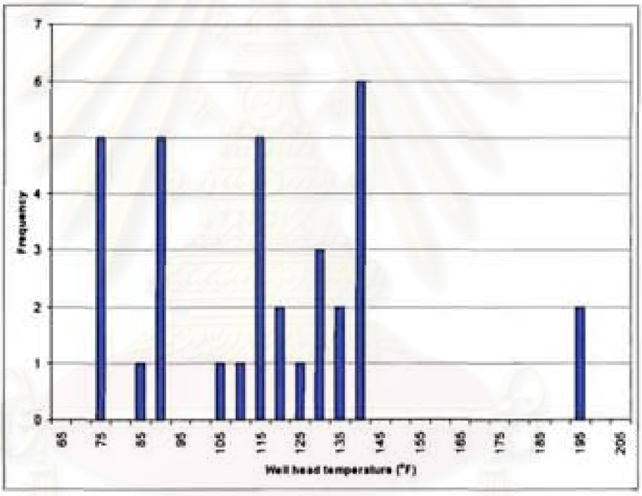


3) Data distribution of testing sets.

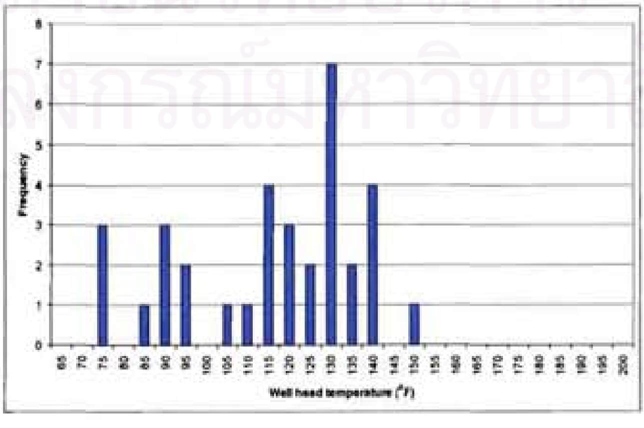
Figure 4.30: Histograms of tubing depth.



1) Data distribution of training sets.

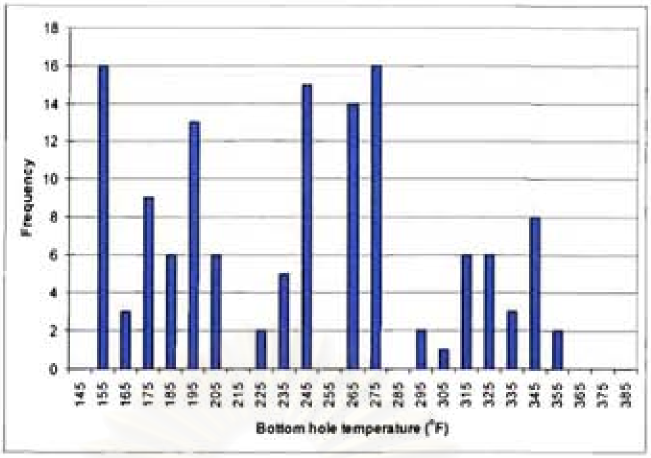


2) Data distribution of validating sets.

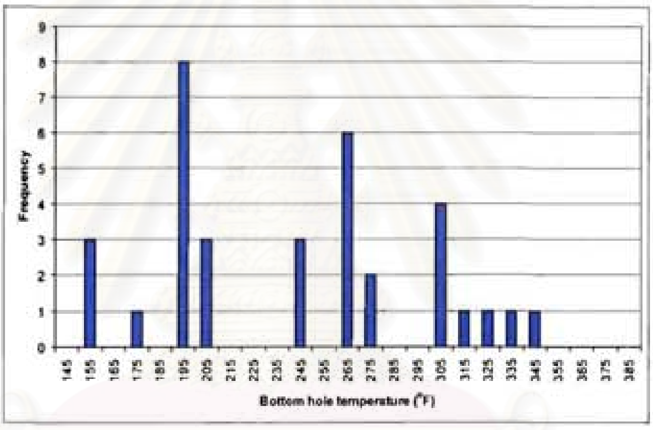


3) Data distribution of testing sets.

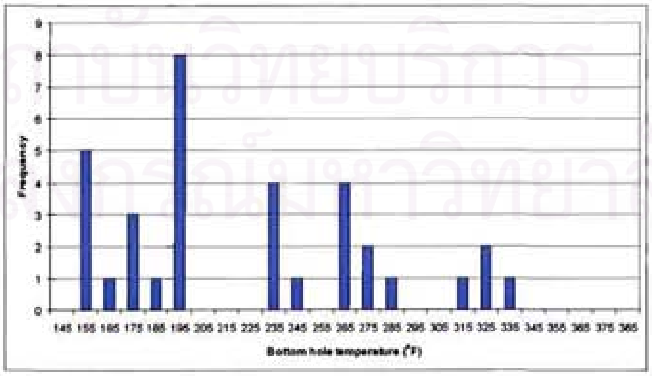
Figure 4.31: Histograms of wellhead temperature.



1) Data distribution of training sets.

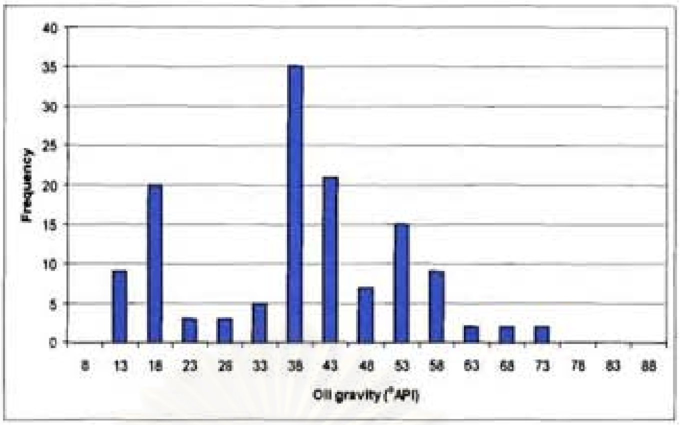


2) Data distribution of validating sets.

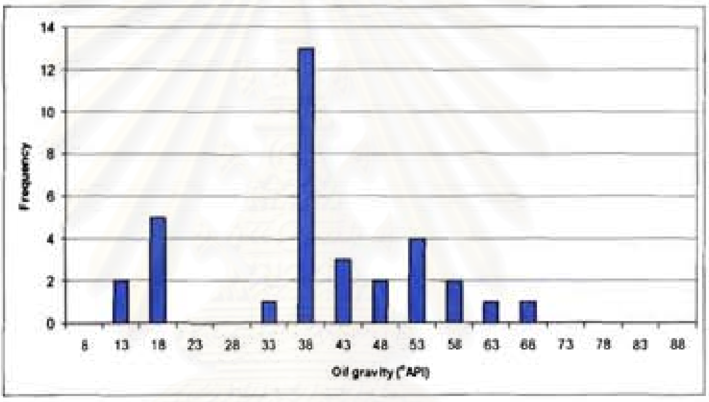


3) Data distribution of testing sets.

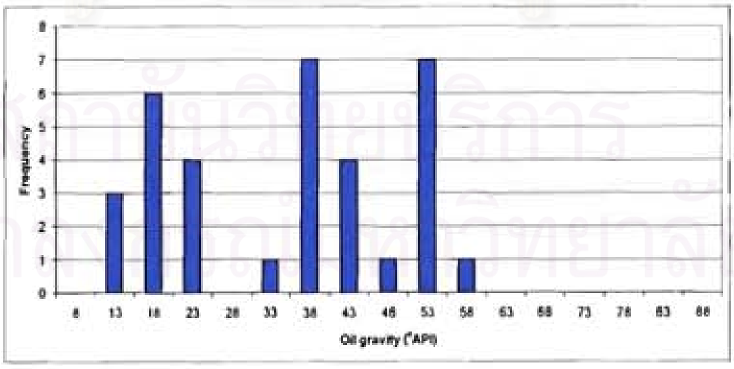
Figure 4.32: Histograms of bottomhole temperature.



1) Data distribution of training sets.

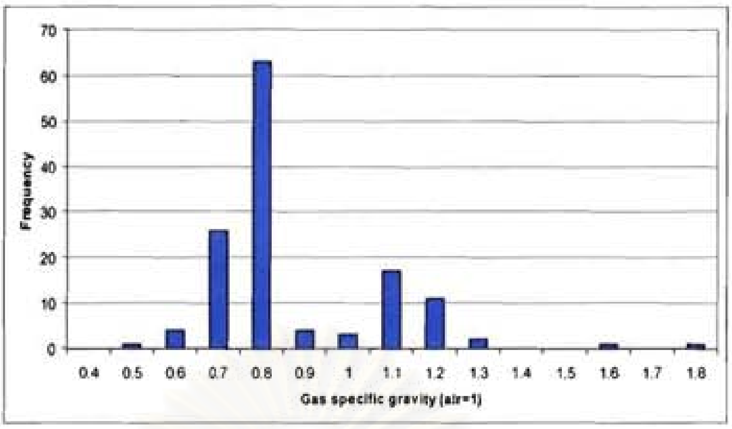


2) Data distribution of validating sets.

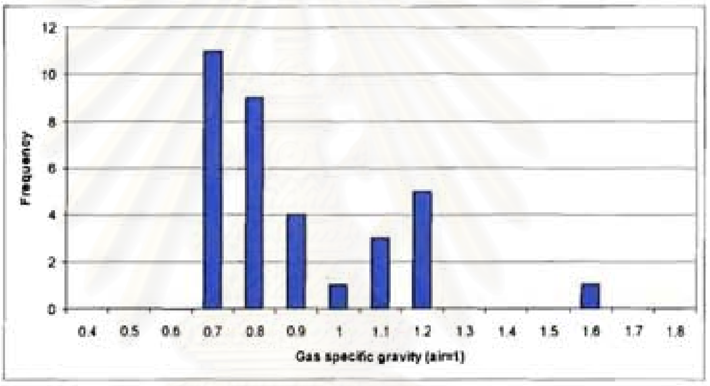


3) Data distribution of testing sets.

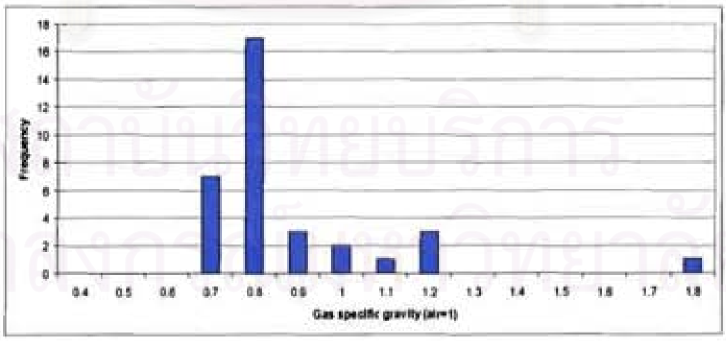
Figure 4.33: Histograms of oil gravity.



1) Data distribution of training sets.

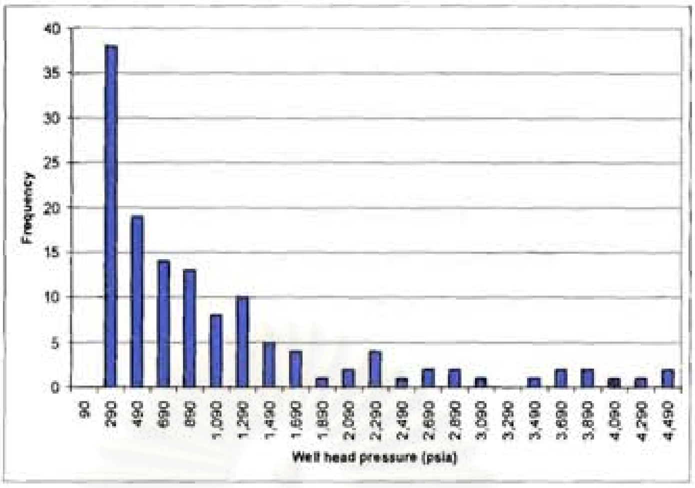


2) Data distribution of validating sets.

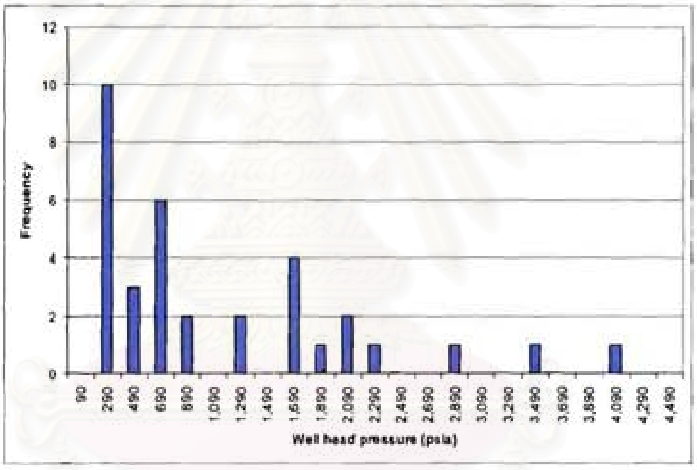


3) Data distribution of testing sets.

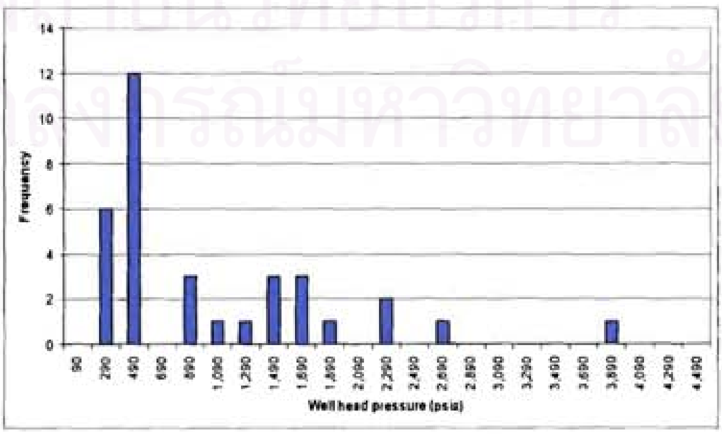
Figure 4.34: Histograms of gas specific gravity.



1) Data distribution of training sets.

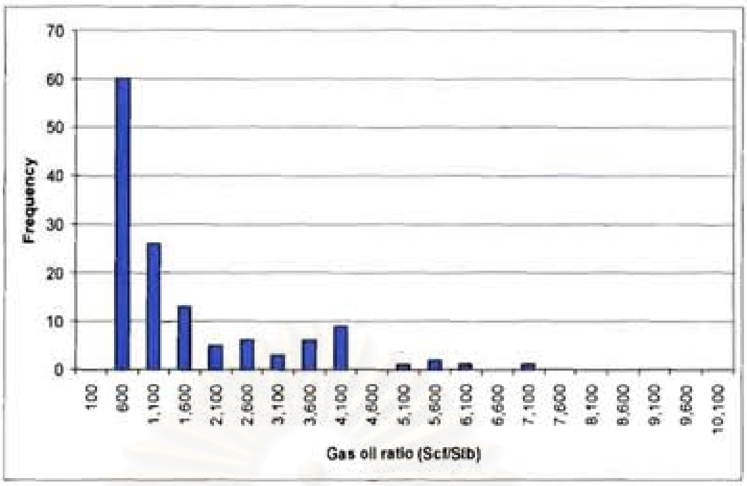


2) Data distribution of validating sets.

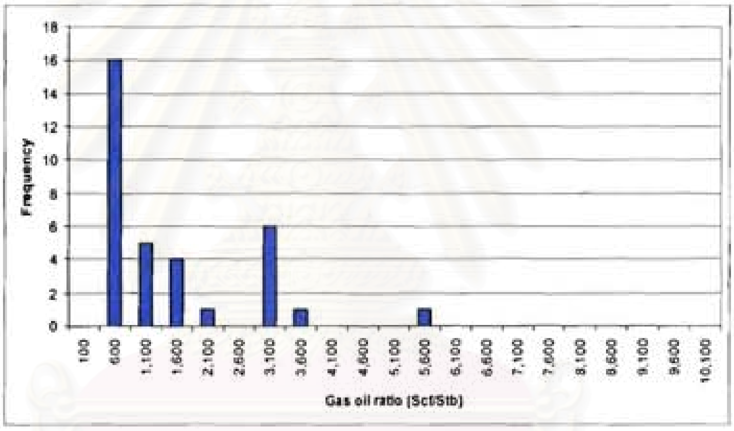


3) Data distribution of testing sets.

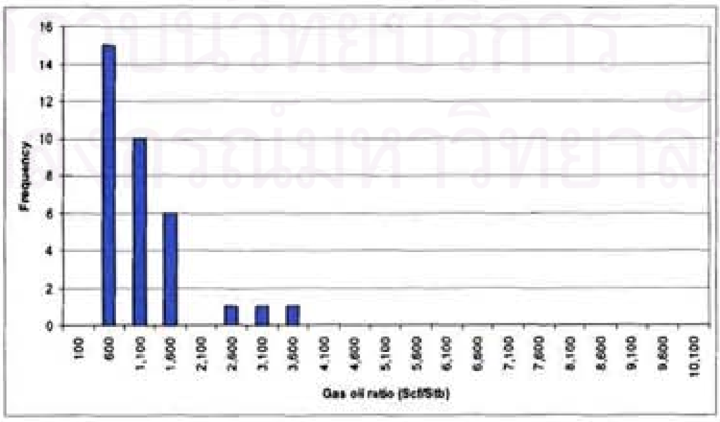
Figure 4.35: Histograms of wellhead pressure.



1) Data distribution of training sets.

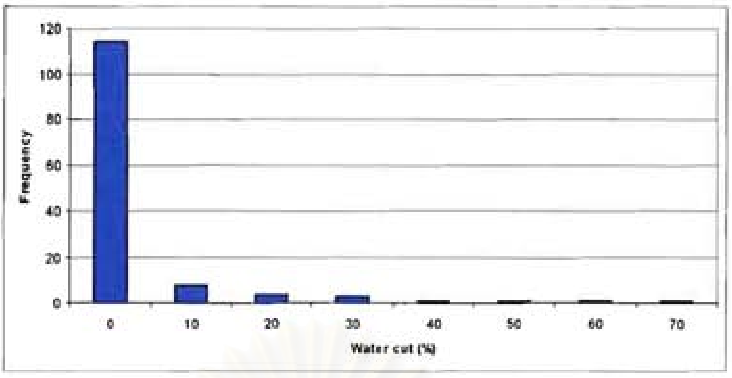


2) Data distribution of validating sets.

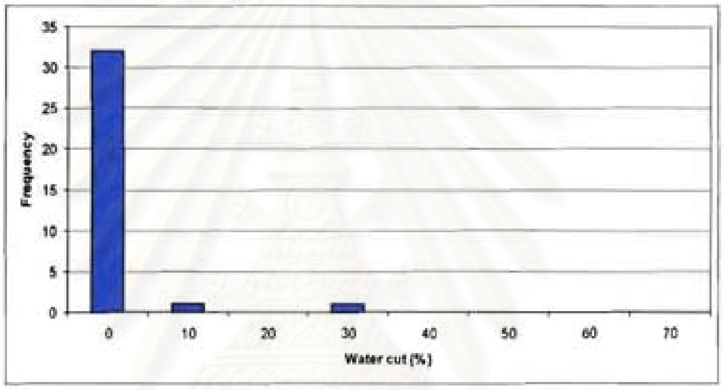


3) Data distribution of testing sets.

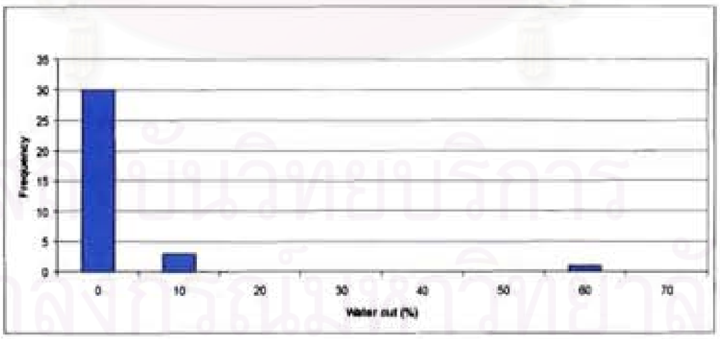
Figure 4.36: Histograms of gas oil ratio.



1) Data distribution of training sets.

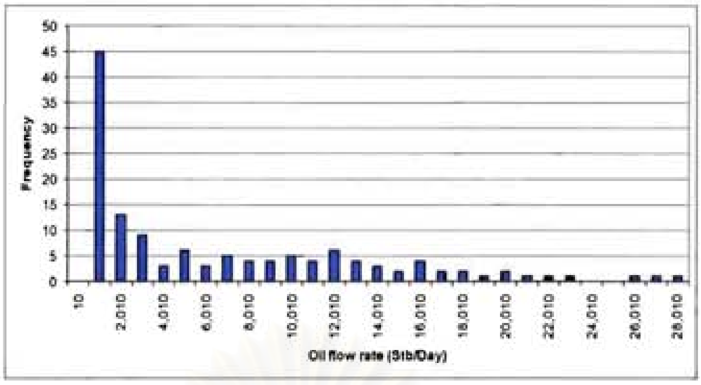


2) Data distribution of validating sets.

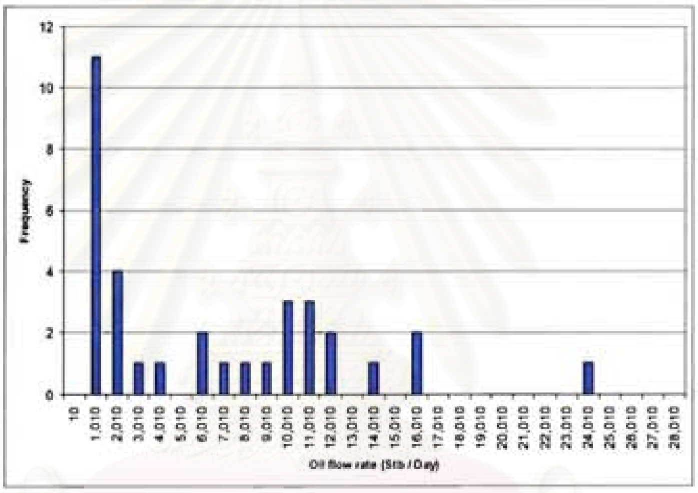


3) Data distribution of testing sets.

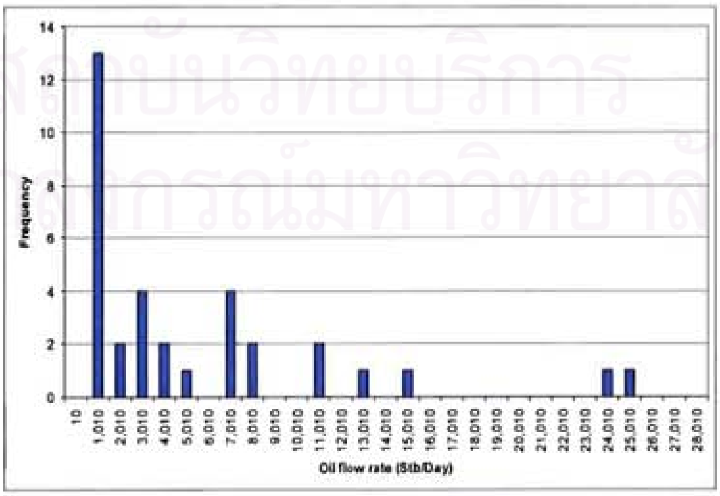
Figure 4.37: Histograms of water cut.



1) Data distribution of training sets.

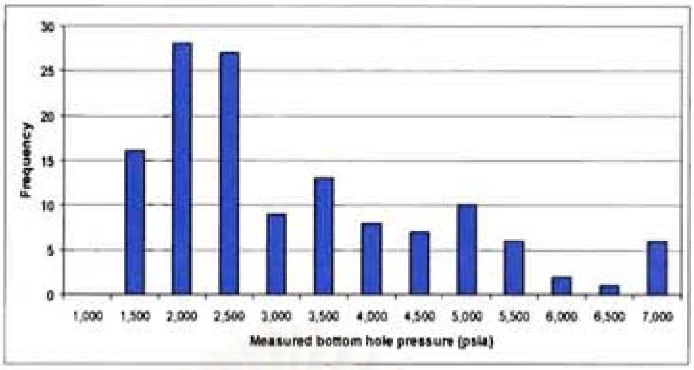


2) Data distribution of validating sets.

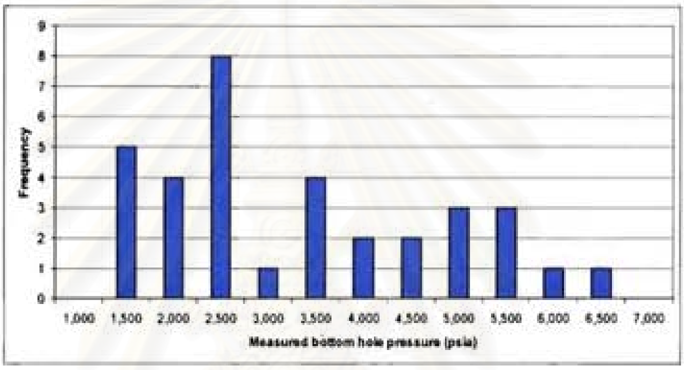


3) Data distribution of testing sets.

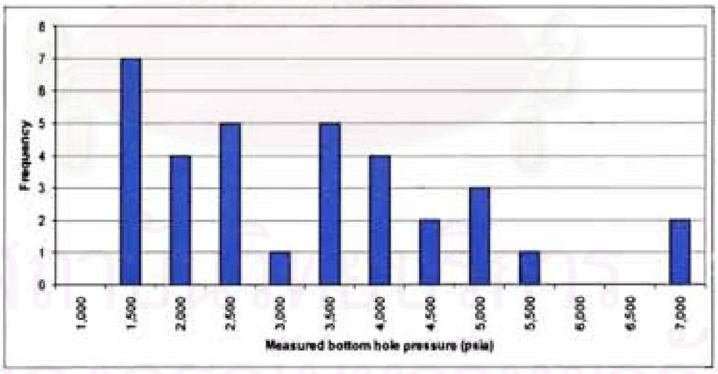
Figure 4.38: Histograms of oil flow rate.



1) Data distribution of training sets.



2) Data distribution of validating sets.



3) Data distribution of testing sets.

Figure 4.39: Histograms of measured bottomhole pressure.

4.3.1 Results and Discussion

The best neural net model (Model number 14) in this case could perform the lowest difference of prediction of 26.47% in testing data sets. In this section, we discuss the mismatches in details which the mismatches are represented in ranges of each flow condition. Figure 4.40 shows distribution of the mismatches of testing data. In order to investigate the effect of input parameters to the accuracy of the prediction, the percentage of false identification or mismatch is calculated for every value of each input and plotted as histogram. The effect of input parameters on the mismatched is discussed as follows:

1) Tubing diameter

Figure 4.40 (1) shows percentage of false identification for different tubing diameters. The internal tubing diameters (ID) of the wells used in the testing phase of the neural network are 1.995", 2.441", 2.764", 2.992", 3.958", 4.892", and 6.184". The tubing diameter of 2.992" has the highest percentage of misidentification. Tubing sizes that have the next highest percentage of mismatch are 4.892", 2.441", 1.995" and 3.958" which have the mismatch percentage of 33.33%, 26.53%, 23.81% and 22.22%, respectively. Tubing sizes of 2.764" and 6.184" have no mismatch at all.

2) Tubing depth

Figure 4.40 (2) illustrates percentage of false identification for different tubing depths. The tubing depths of the wells used in the testing phase of the neural network are 3,182 to 12,062 feet. The depth of 3,501 to 4,000 feet and 4,501 to 5,000 feet have the highest percentage of misidentification. This error may be caused by small amount of training and validating data sets compared to those for other tubing depths (4 sets of training and 1 set of validating as shown in Figure 4.30) for depth 3,501 to 4,000 feet; and (6 sets of training and 1 set of validating as shown in Figure 4.30) for depth 4,501 to 5,000 feet). Tubing depths that have the next highest percentage of mismatch are 6,501 to 7,000 feet, and 4,001 to 4,500 feet which have mismatch percentage of 50% and 35.71%. Tubing depths that have similar percentage of mismatch are 6,001 to 6,500 feet, 7,501 to 8,000 feet, 9,001 to 9,500 feet, and 12,001 to 12,062 feet which have mismatch percentage of 28.57%. Tubing depths of 10,501 to 11,010 feet and 10,001 to 10,500 feet have mismatch percentage of 17.86% and 14.29%, respectively. Tubing depth has the percentage of mismatch lower than 10% is depth of 9,501 to 10,000 feet. Tubing depths of 3,182 to 3,500 feet, 8,001 to 8,500 feet, and 11,011 to 11,500 feet have no mismatch at all.

3) Wellhead temperature

Figure 4.40 (3) shows percentage of false identification for different wellhead temperatures. The wellhead temperatures of the wells used in the testing phase of the neural network are 75 to 150°F. The temperature of 141 to 150°F has the highest percentage of misidentification. This error may be caused by the small amount of training and validating data sets compared to those for other wellhead temperatures (4 sets of training and 0 set for validating as shown in Figure 4.31). Wellhead temperatures that have the next highest percentage of mismatch are 106 to 110°F, 126 to 130°F, 75°F, 121 to 125°F, 136 to 140°F, and 81 to 85°F which have mismatch percentage of 71.43%, 42.86%, 38.10%, 35.71%, 35.71%, and 28.57%, respectively. Wellhead temperature of 116 to 120°F and 101 to 105°F have mismatch percentage of 19.05% and 14.29%, respectively. Wellhead temperature that has percentage of mismatch lower than 10% is 111 to 115°F. Wellhead temperatures of 86 to 95°F and 131 to 135°F have no mismatch at all.

4) Bottomhole temperature

Figure 4.40 (4) illustrates percentage of false identification for different bottomhole temperature. The bottomhole temperatures of the wells used in the training phase of the neural network are 150 to 330°F. The bottomhole temperature of

150 to 155°F has the highest percentage of misidentification. The bottomhole temperatures that have the next highest percentage of mismatch are 186 to 195°F, 236 to 245°F, 326 to 335oF, 226 to 235oF, 266 to 275oF which have mismatch percentage of 44.64%, 42.86%, 28.57%, 25%, and 21.43%, respectively. Bottomhole temperatures that have the percentage of mismatch lower than 20% such as temperature of 176 to 185°F and 256 to 265°F. Bottomhole temperatures of 156 to 175°F, 276 to 285°F, and 316 to 325°F have no mismatch at all.

5) Oil gravity

Figure 4.40 (5) shows percentage of false identification for different oil gravities. The oil gravities of the wells used in the testing phase of the neural network are 8.3 to 54°API. The oil gravity of 19 to 23°API has the highest percentage of misidentification. This error may be caused by the least amount of training and validating data compared to those for other oil gravities (3 set sof training, 0 set of validating as shown in Figure 4.33). Oil gravities that have the next highest percentage of mismatch are 14 to 18°API and 39 to 43°API which have mismatch percentage of 38.10% and 35.71%, respectively. Oil gravities that have the percentage of mismatch lower than 20% such as oil gravities of 8.3 to 13°API, 24 to 38°API, and 49 to 54°API. Oil gravity of 44 to 48°API has no mismatch at all.

6) Gas specific gravity

Figure 4.40 (6) illustrates percentage of false identification for different gas specific gravities. The gas specific gravities of the wells used in the testing phase of the neural network are 0.68 to 1.705 (air=1). The gas specific gravity of 0.71 to 0.8 has the highest percentage of misidentification. Gas specific gravities that have the next highest percentage of mismatch are 0.81 to 0.9, 1.01 to 1.1, and 0.91 to 1.00 which have mismatch percentage of 38.10%, 28.57%, and 21.43%, respectively. Gas specific gravity of 0.68 to 0.7 has mismatch percentage lower than 5%. Gas specific gravity of 1.11 to 1.705 has no mismatch at all.

7) Wellhead pressure

Figure 4.40 (7) shows percentage of false identification for different wellhead pressures. The wellhead pressures of the wells use in the testing phase of the neural network are 181 to 3,744 psia. The wellhead pressure of 1,091 to 1,290 psia has the highest percentage of misidentification. Wellhead pressures that have the next highest percentage of mismatch are 891 to 1,090 psia, 691 to 890 psia, 291 to 490 psia, and 181 to 290 psia which have mismatch percentage of 57.14%, 47.62%, 35.71%, and 21.43%, respectively. Wellhead pressure of 1,491 to 1,690 psia has mismatch percentage of 14.29%. Wellhead pressures that have the percentage of mismatch lower than 10% such as pressure of 1,291 to 1,490 psia and 2,091 to 2,290 psia. Wellhead pressures of 1,691 to 1,890 psia, 2,491 to 2,690 psia, and 3,691 to 3,744 psia have no mismatch at all.

8) Gas oil ratio

Figure 4.40 (8) illustrates percentage of false identification for different gas oil ratios. The gas oil ratios of the wells used in the testing phase of the neural network are 146 to 3,393 scf/stb. The gas oil ratio of 2,601 to 3,100 scf/stb has the highest percentage of misidentification. Gas oil ratio that have the next highest percentage of mismatch are 146 to 600 scf/stb and 1,101 to 1,600 scf/stb which have the mismatch percentage of 33.33% and 23.81%, respectively. Gas oil ratios that have the percentage of mismatch lower than 20% such as gas oil ratio of 601 to 1,100 scf/stb and 3,101 to 3,600 scf/stb. Gas oil ratio of 2,101 to 2,600 scf/stb has no mismatch at all.

9) Water cut

Figure 4.40 (9) shows percentage of false identification for different water cuts. The water cuts of the wells used in the testing phase of the neural network are 0 to 60%. The water cut of 0% has the highest percentage of misidentification. Water cut that has the next highest percentage of mismatch is 1 to 10% which has mismatch percentage of 9.52%. Water cut of 51 to 60% has no misidentification.

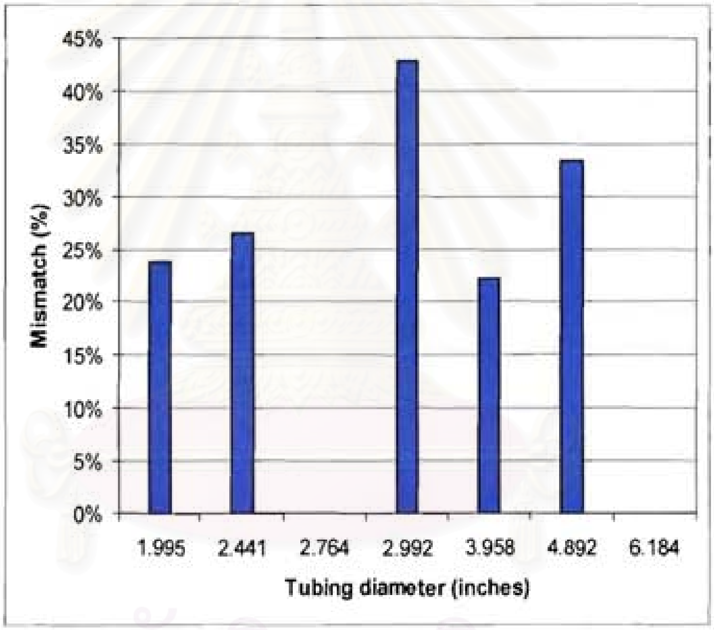
10) Oil flow rate

Figure 4.40 (10) illustrates percentage of false identification for different oil flow rates. The oil flow rates of the wells used in the testing phase of the neural network are 41 to 24,200 stb/day. The oil flow rate of 4,011 to 5,010 stb/day has the highest percentage of misidentification. Oil flow rates that have the next highest percentage of mismatch are 1,011 to 2,010 stb/day, 2,011 to 4,010 stb/day, 6,011 to 7,010 stb/day, and 41 to 1,010 stb/day which have mismatch percentage of 42.86%, 35.71%, 32.14%, and 26.37%, respectively. Oil flow rates 7,011 to 8,010 stb/day and 9,011 to 11,010 stb/day have mismatch percentage of 14.29%. Oil flow rates that have the percentage of mismatch lower than 15% such as flow rate of 7,011 to 8,010 and 10,011 to 11,010 stb/day. Oil flow rates of 12,011 to 13,010 stb/day, 14,011 to 15,010 stb/day, and 23,011 to 24,200 stb/day have no mismatch at all.

11) Measure bottomhole pressure

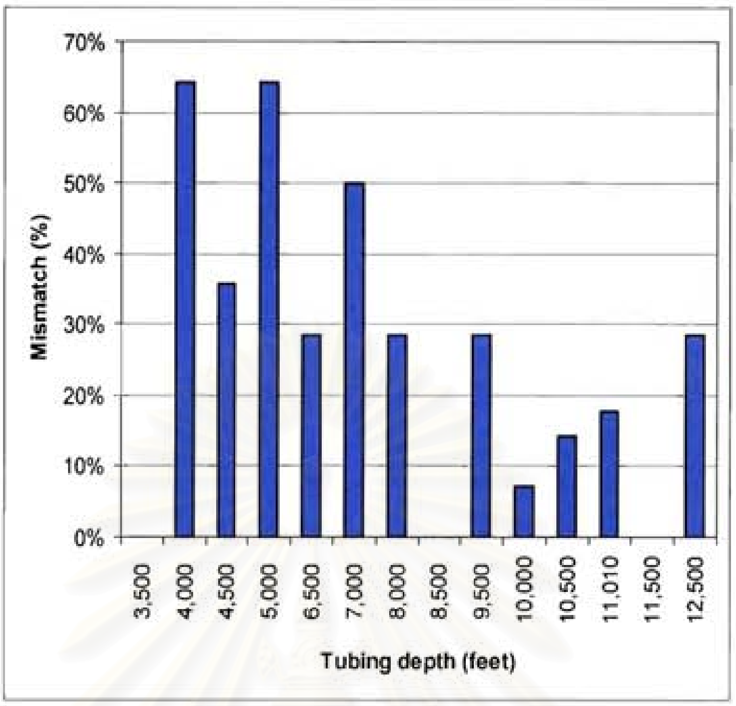
Figure 4.40 (11) shows percentage of false identification for different measured bottomhole pressures. The measured bottomhole pressures of the wells used in the training phase of the neural network are 1,164 to 6,695 psia. The measured bottomhole pressure of 2,501 to 3,000 psia has the highest percentage of misidentification. The pressures that have the next highest percentage of mismatch are 3,001 to 3,500 psia, 1,501 to 2,000 psia, and 1,164 to 1,500 psia which have mismatch percentage of 45.71%, 39.29%, and 38.79%, respectively. Measured bottomhole pressures that have the percentage of mismatch about 20% such as pressure of 2,001 to 2,500 psia and 4,001 to 4,500 psia. Measured bottomhole pressures that have the percentage of mismatch lower than 10% such as pressure of 3,501 to 4,000 psia and 4,501 to 5,000 psia, respectively. Measured bottomhole pressures of 5,001 to 5,500 psia and 6,501 to 6,695 psia have no mismatch at all.

In summary, the main reason for false identification or mismatch is lack of data in the training and validating phase of the neural network.

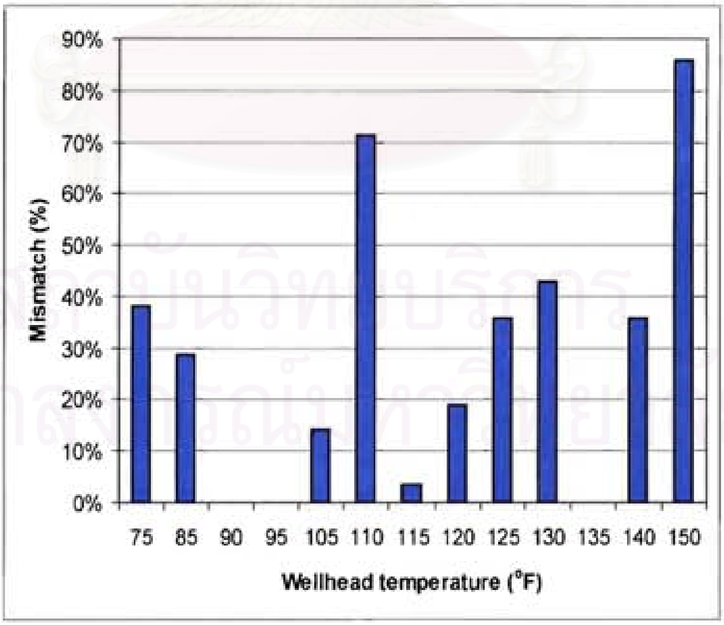


1) Percentage of false identification for different tubing diameters.

Figure 4.40: Mismatch histograms for Case 2.

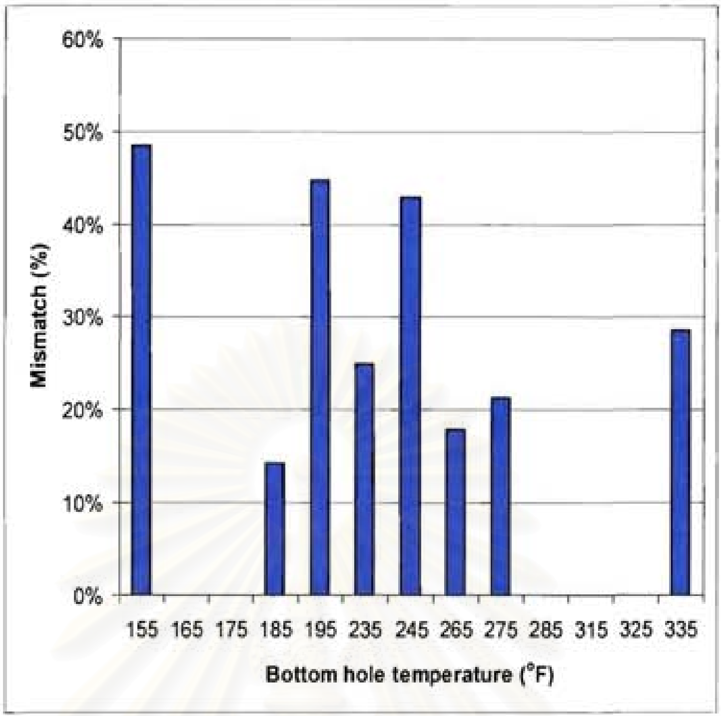


2) Percentage of false identification for different tubing depths.

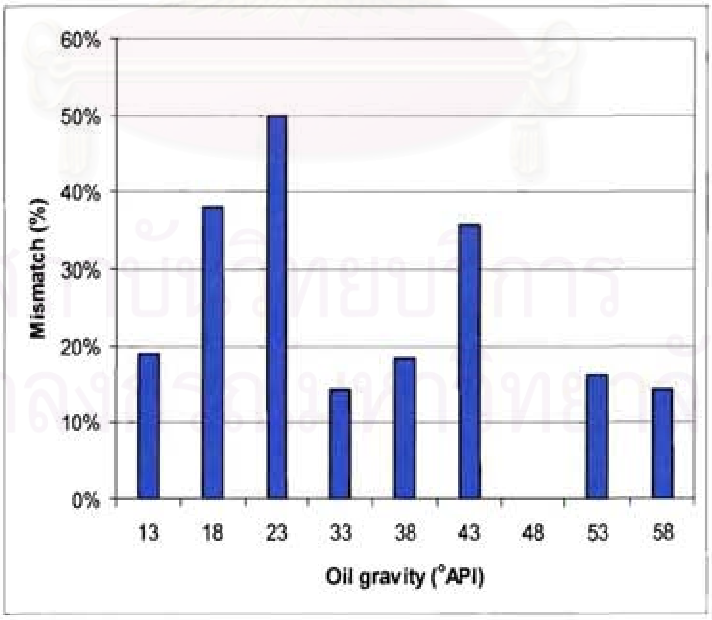


3) Percentage of false identification for different wellhead temperatures

Figure 4.40: Mismatch histograms for Case 2 (continued).

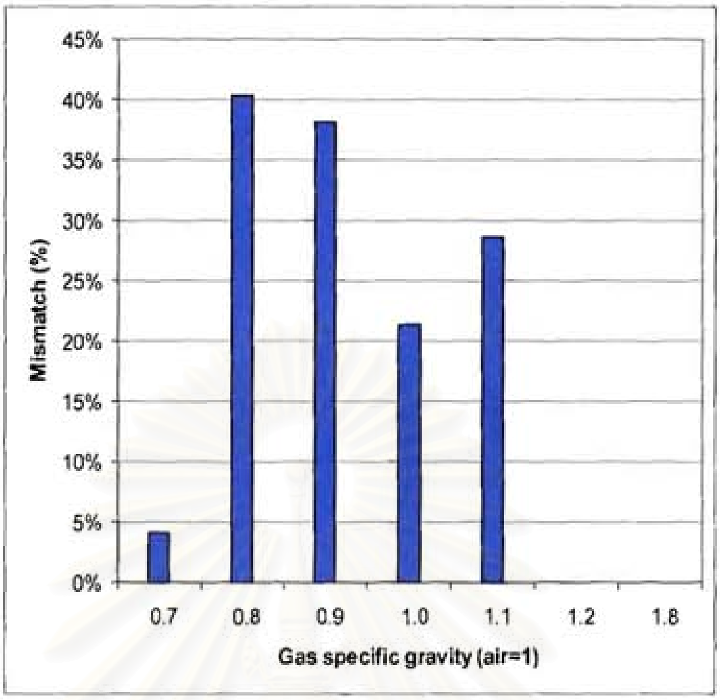


4) Percentage of false identification for different bottomhole temperatures.

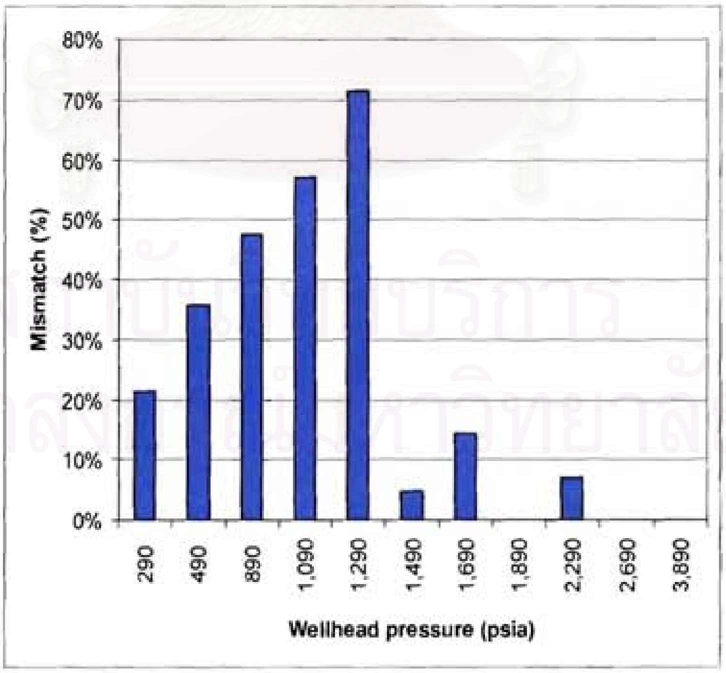


5) Percentage of false identification for different oil gravities.

Figure 4.40: Mismatch histograms for Case 2 (continued).

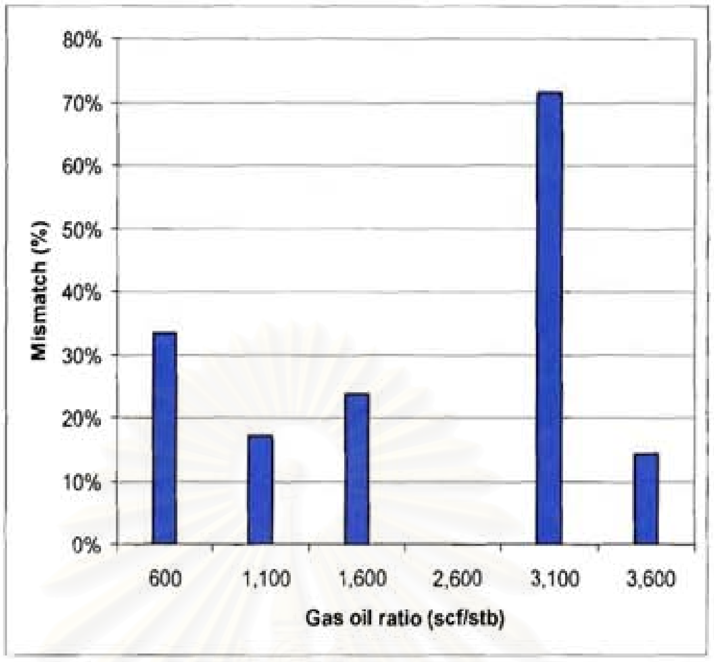


6) Percentage of false identification for different gas specific gravities.

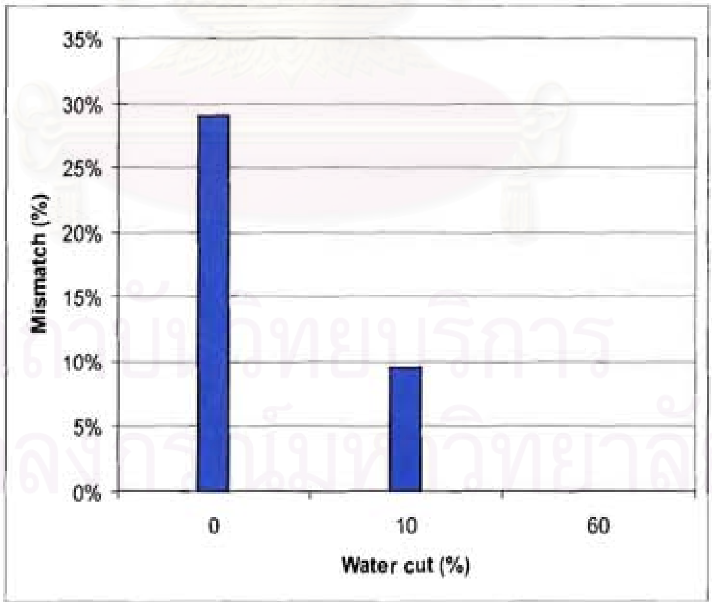


7) Percentage of false identification for different wellhead pressures.

Figure 4.40: Mismatch histograms for Case 2 (continued).

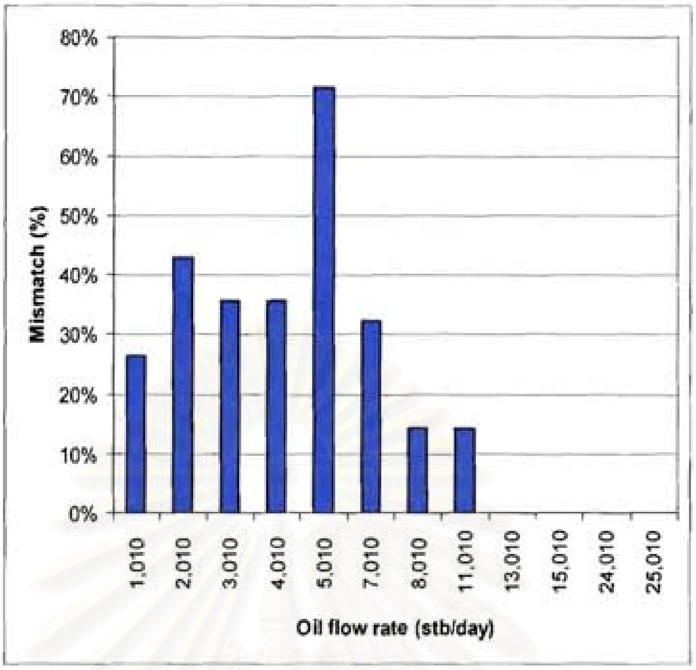


8) Percentage of false identification for different gas oil ratios.

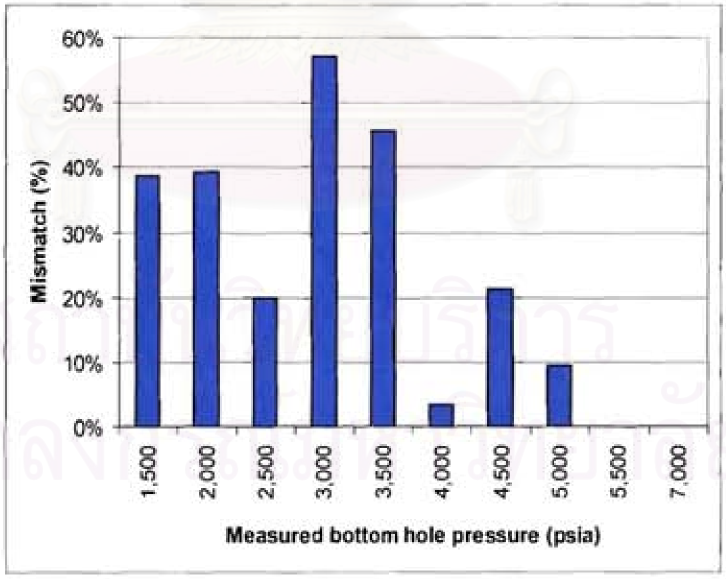


9) Percentage of false identification for different water cuts.

Figure 4.40: Mismatch histograms for Case 2 (continued).



10) Percentage of false identification for different oil flow rates



11) Percentage of false identification for different measured bottomhole pressures

Figure 4.40: Mismatch histograms for Case 2 (continued).

4.4 Case 3: Best Correlation

In this case, the neural network was trained in order to propose the most accurate multiphase flow correlation based on given flow conditions. In order to achieve the convergence criterion, the number of hidden layers and the number of neurons in the hidden layers were chosen by trial and error. Several combinations of hidden layers and numbers of neurons in the hidden layers were initially tried and the average error for each model was observed. The trial and error was stopped when the average error was not reduced more than 100,000 cycles. A total of 13 different runs were tried. The parameters used in each try are tabulated in Table 4.13. The results of trial tests are discussed as follows:

Table 4.13: Neural network models for Case 3: best correlation.

Model No.	Number of neurons		Learning rate	Momentum	Average error	Condition
	Hidden layer 1	Hidden layer 2				
1	50	0	0.2	0.2	0.015039	Stopped
2	70	0	0.2	0.2	0.012894	Stopped
3	30	5	0.2	0.2	0.017186	Stopped
4	30	20	0.2	0.2	0.01289	Stopped
5	40	5	0.2	0.2	0.032905	Stopped
6	40	10	0.2	0.2	0.009745	Converged
7	40	13	0.2	0.2	0.013966	Stopped
8	40	15	0.2	0.2	0.012891	Stopped
9	40	17	0.2	0.2	0.017188	Stopped
10	40	20	0.2	0.2	0.009728	Converged
11	40	30	0.2	0.2	0.013964	Stopped
12	40	40	0.2	0.2	0.011816	Stopped
13	40	50	0.2	0.2	0.009925	Converged

As experimenting in the first two cases (Case 1 and 2) of 20% and 10% maximum error, we noticed that the converged models were set with the small learning rates and momentums. Therefore, we used the learning rate of 0.2 and momentum of 0.2 in every trail models for this case. We started Model number 1 which has one hidden layer and 50 hidden neurons similar to the converged model (Model number 10) in the case 1 (20% maximum error). The average error was decreased and steady to 0.015039. Model number 2 was set with one hidden layer and

70 neurons in the hidden layer. In this case, the average error of 0.012894 was steady for more than 100,000 cycles; so, we stopped the learning process. We noticed from Model number 1 and 2 that the average error was reduced if the amount of hidden neurons were increased. Therefore, we used the models with two hidden layers for the next trials. Model number 3 which has 30 hidden neurons in the first layer and 5 hidden neurons in the second layer was trained and observed the result. The error was steady at 0.017186 and then the training was terminated. We tried Model number 4 which has 30 and 20 neurons in the first and second layers, respectively. The average error of this model was constant at 0.01289, we then terminated training process. Model number 4 has average error closed to the convergence criterion. We then increased the numbers of hidden neurons in the first and second layer to 40 and 5 neurons, respectively in Model number 5. The average error of this model was reduced and steady at 0.032905 for more than 100,000 cycles, we then stopped the training process. Model number 6 was set with 40 and 10 hidden neurons in the first and second layers, respectively. This model achieved the convergence criterion at 596,643 cycles. Figure 4.41 illustrates the learning curve of Model number 6. We then tried the next seven models (Model numbers 7 to 13) which every models have 40 neurons in the first layer and varied the numbers of neurons in the second layers.

Model number 7 has 40 and 13 hidden neurons in the first and second layer, respectively. The average error of the model was steady at 0.013966 for more than 100,000 cycles; so, we stopped the training process. Model number 8 which has 40 neurons in the first layer and 15 neurons in the second layers was trained and observed the result. The average error of Model number 8 was steady at 0.012891. Model number 9 has 40 and 17 neurons in the first and second layers, respectively. The average error of Model number 9 was constant at 0.017188 for more than 100,000 cycles; we then terminated the training process. Model number 10 which has 40 hidden neurons in the first layer and 20 hidden neurons in the second layers achieved the convergence criterion at 34,537 cycles. Figure 4.42 shows the learning curve of model number 10. Model number 11 which has 40 and 30 neurons in the first and second layers, repectively was trained and observed the result. This model has the average error steady at 0.013964. We tried Model numbers 12 which has 40 neurons in the first layer and 40 neurons in the second layers. The average error was reduced and steady at 0.011816. Model number 13 was set with 40 and 50 neurons in the first and second layers, respectively. The Model number 13 achieved the convergence criterion at 134,560 cycles. Figure 4.43 illustrates learning curve of model number 13.

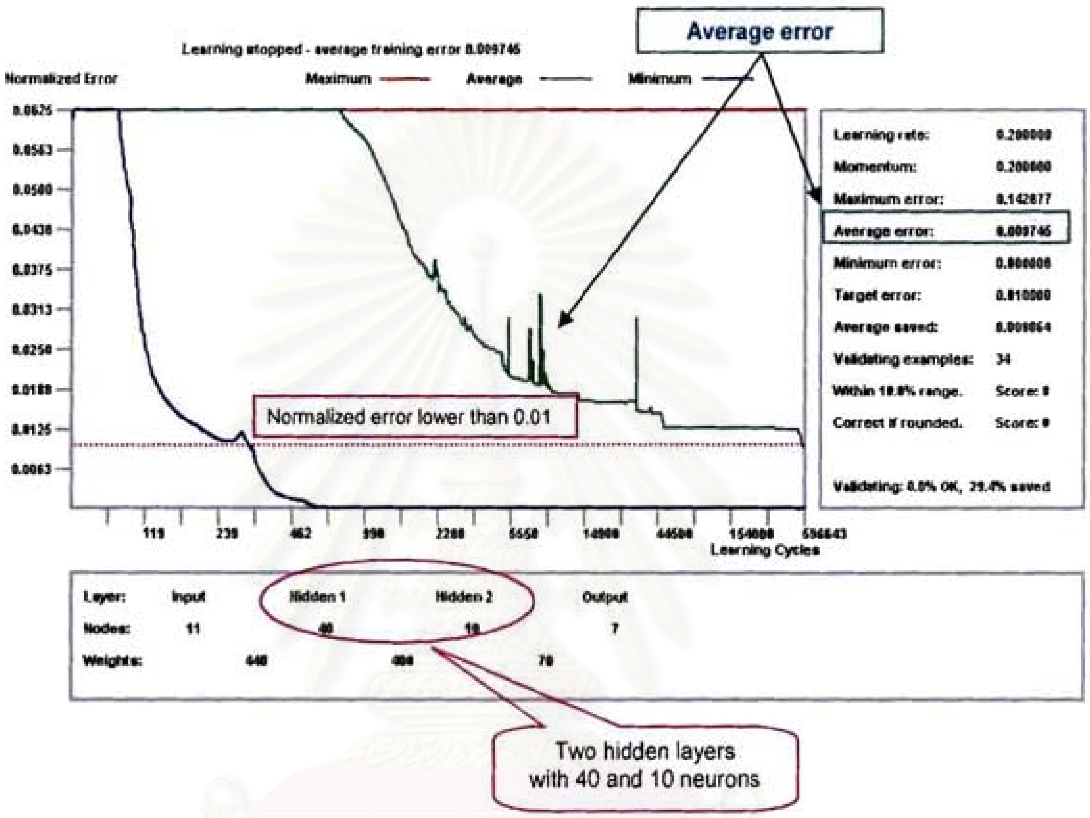


Figure 4.41: Learning curve of Model 6 (two hidden layers which 40 neurons in the first layer and 10 neurons in the second layer)

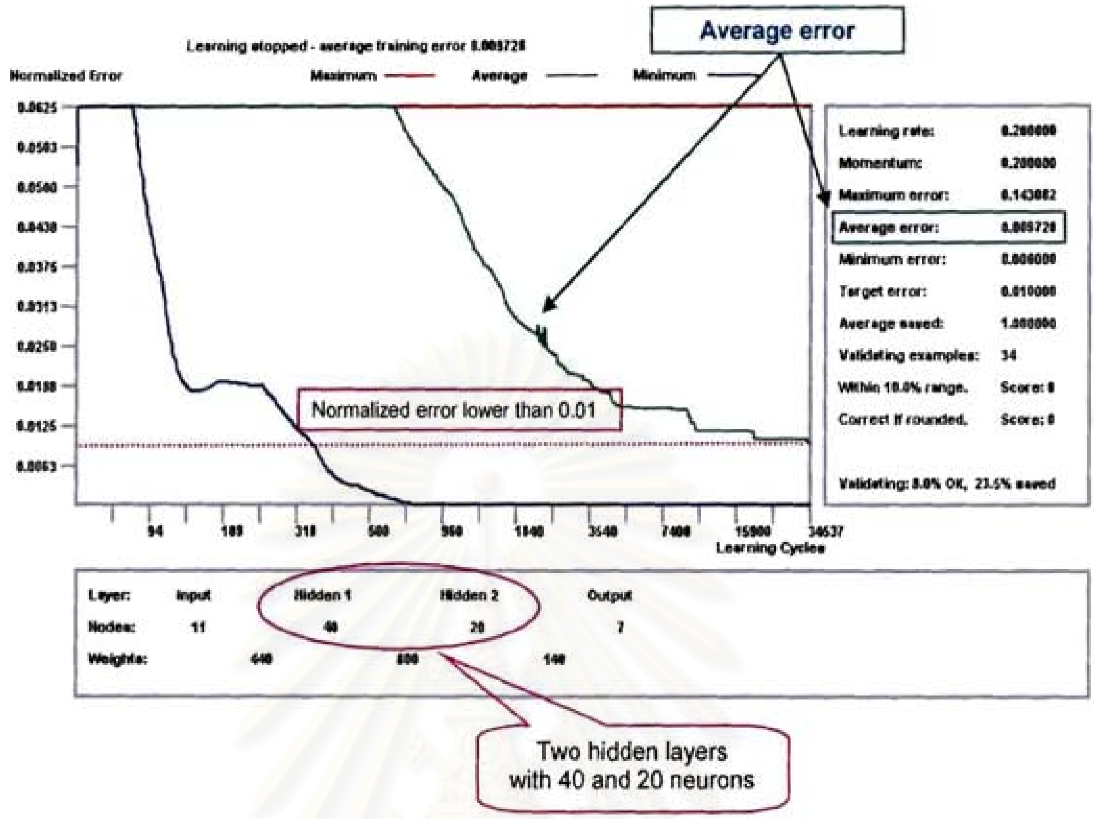


Figure 4.42: Learning curve of Model 10 (two hidden layers which 40 neurons in the first layer and 20 neurons in the second layer)

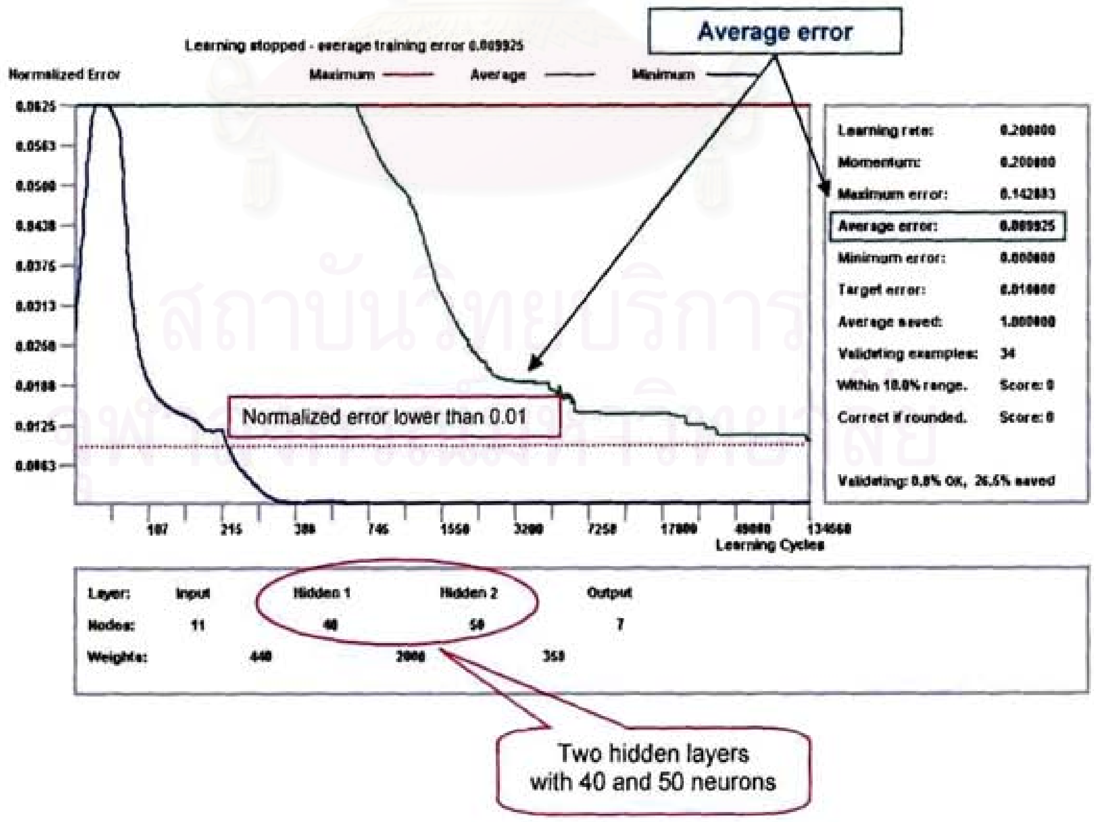


Figure 4.43: Learning curve of Model 13 (two hidden layers which 40 neurons in the first layer and 50 neurons in the second layer)

From the trial and error, there are three neural net models that achieved the convergence criterion and all models are two hidden layers. The first model is Model number 6 which has 40 and 10 neurons in the first and second layers, respectively. The second model is Model number 10 which has 40 neurons in the first layer and 20 neurons in the second layers. The last model that achieved the criterion is Model number 13 which has 40 and 50 neurons in the first and second layers, respectively. To choose the best neural net model, we need to determine the total number of mismatches. Since there are seven nodes for the output and 201 sets of data, the highest possible number of total mismatches is 1,407. The mismatches of outputs of the testing data sets of the three models were computed and compared. Table 4.14 shows the number of mismatches for these three neural network models. It was observed that the neural network model having 40 neurons in the first layer and 20 neurons in the second layers has a lowest number of mismatches in the testing than the other models. Therefore, we used this model to represent the neural net model for Case 3 (Best Correlation). Figure 4.44 shows desired and calculated outputs of the chosen neural network. A complete set of results is shown in Appendix D. Figure 4.45 shows the outputs of the neural network after applying the activation level of 0.7 in order to transform the answers binary values of 1 and 0.

Table 4.14: Mismatches of desired and computed outputs for three neural net models in Case 3.

Model No.	Number of nodes		Numbers of mismatches in data set		
	Hidden layer 1	Hidden layer 2	Training	Validating	Testing
6	40	10	10	45	51
10	40	20	9	45	49
13	40	50	9	42	52

Actual output

Data Set No.	I: Tbg Dia (in)	O: D&R (M)	O: H&B	O: F&B	O: M&B	O: B&B	O: Ork	O: D&R (O)
D: 3.0	1.995	0	0	0	0	1	0	0
P: 3.0	1.995	0	0.0542	0	0	0.3767	0	0.9999
D: 15.0	1.995	0	0	0	1	0	0	0
P: 15.0	1.995	0	0	0.0018	0.9986	0	0.0003	0.0005
D: 24.0	2.441	1	0	0	0	0	0	0
P: 24.0	2.441	0	0	0.0003	0.0006	0.0087	0	1
D: 25.0	2.441	0	0	0	0	1	0	0
P: 25.0	2.441	0	0	0	0	0	0	1
D: 27.0	2.441	0	0	0	0	0	0	1
P: 27.0	2.441	0.8982	0.0016	0	0	0	0	0.1116
D: 33.0	2.441	0	0	0	0	0	1	0
P: 33.0	2.441	0	0	0.0001	0	0	0.9999	0.2751
D: 35.0	2.441	0	0	1	0	0	0	0
P: 35.0	2.441	0	0.0002	0.9937	0	0	0.0005	0.0001
D: 42.0	2.441	0	0	0	0	0	0	1
P: 42.0	2.441	0.0013	0	0	0	0	0	0.8864
D: 46.0	2.441	0	0	0	1	0	0	0
P: 46.0	2.441	1	0.0003	0	0	0.0003	0.0001	0

Calculated output

Figure 4.44: Samples of actual and calculated outputs for Model 10.

Mismatch of calculated output

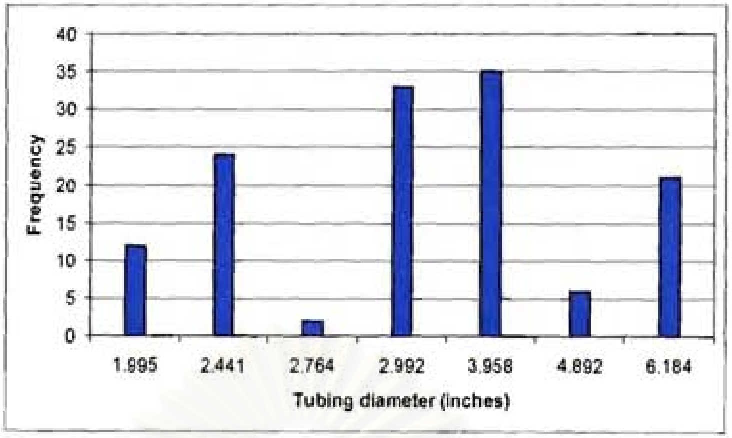
Actual output

Data Set No.	I: Tbg Dia (in)	O: D&R (M)	O: H&B	O: F&B	O: M&B	O: B&B	O: Ork	O: D&R (O)
D: 3.0	1.995	0	0	0	0	1	0	0
P: 3.0	1.995	0	0	0	0	0	0	1
D: 15.0	1.995	0	0	0	1	0	0	0
P: 15.0	1.995	0	0	0	1	0	0	0
D: 24.0	2.441	1	0	0	0	0	0	0
P: 24.0	2.441	0	0	0	0	0	0	1
D: 25.0	2.441	0	0	0	0	1	0	0
P: 25.0	2.441	0	0	0	0	0	0	1
D: 27.0	2.441	0	0	0	0	0	0	1
P: 27.0	2.441	1	0	0	0	0	0	0
D: 33.0	2.441	0	0	0	0	0	1	0
P: 33.0	2.441	0	0	0	0	0	1	0
D: 35.0	2.441	0	0	1	0	0	0	0
P: 35.0	2.441	0	0	1	0	0	0	0
D: 42.0	2.441	0	0	0	0	0	0	1
P: 42.0	2.441	0	0	0	0	0	0	1
D: 46.0	2.441	0	0	0	1	0	0	0
P: 46.0	2.441	1	0	0	0	0	0	0

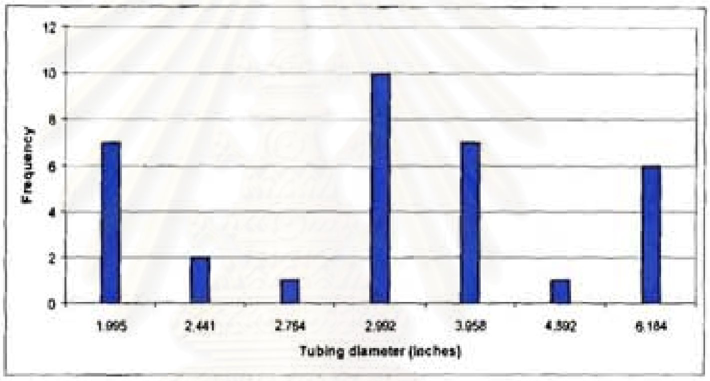
Calculated output

Figure 4.45: Comparison between actual and calculated outputs (after transforming to binary numbers) for Model 10.

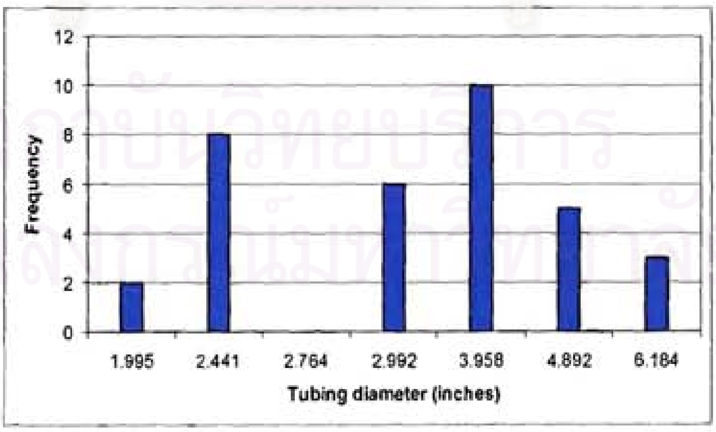
To be assured that neural network achieved generalization, the three partitioned data sets should have more or less similar distribution which covers all possible ranges of information. Since the software partitioned the data set randomly, histograms of training, validating, and testing sets were plotted in order to check for similarities in distribution of each partitioned data set. Figure 4.46 through 4.56 compare histograms of the 11 input parameters in the training, validating, and testing data. The histograms of each parameter have similar distribution to that of the original data which is shown in Figure 4.2.



1) Data distribution of training sets.

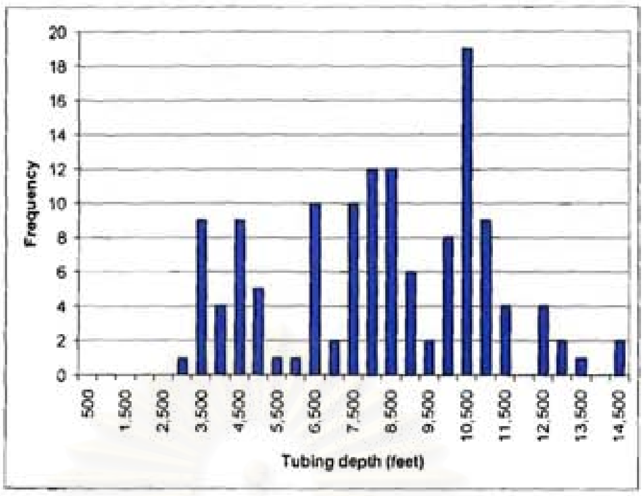


2) Data distribution of validating sets.

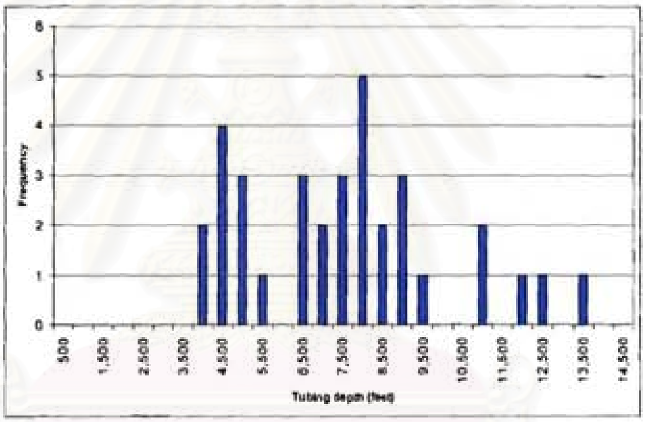


3) Data distribution of testing sets.

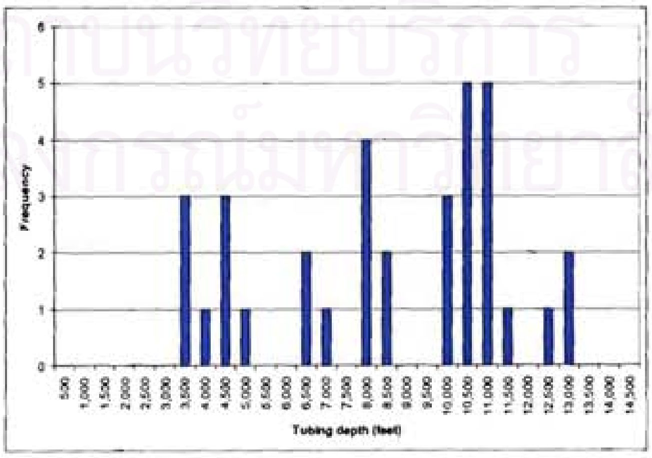
Figure 4.46: Histograms of tubing diameter.



1) Data distribution of training sets.

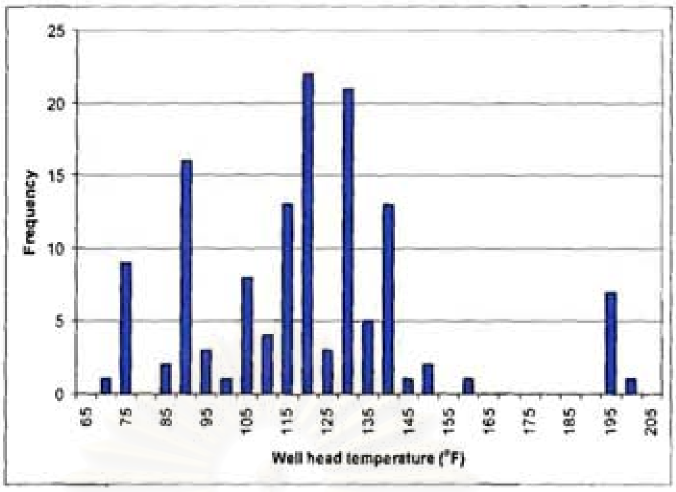


2) Data distribution of validating sets.

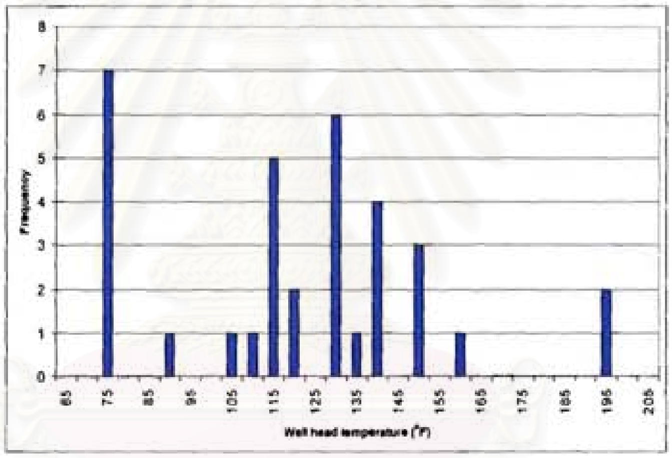


3) Data distribution of testing sets.

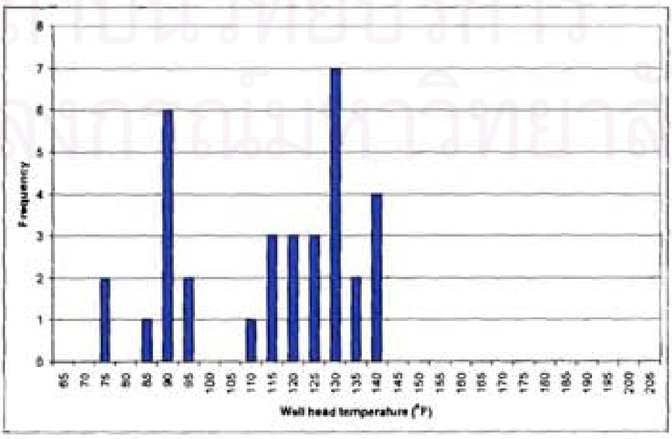
Figure 4.47: Histograms of tubing depth.



1) Data distribution of training sets.

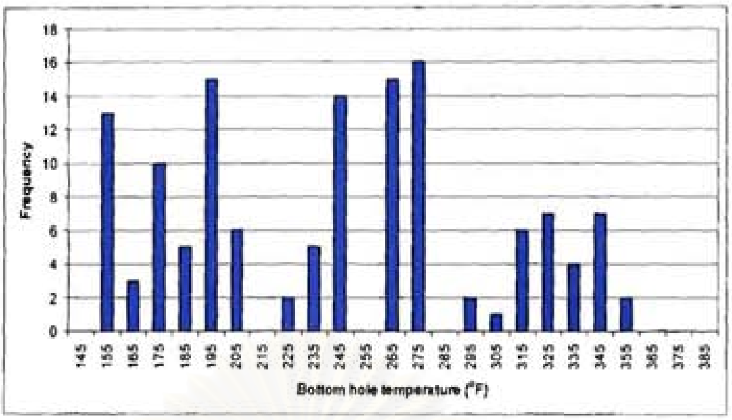


2) Data distribution of validating sets.

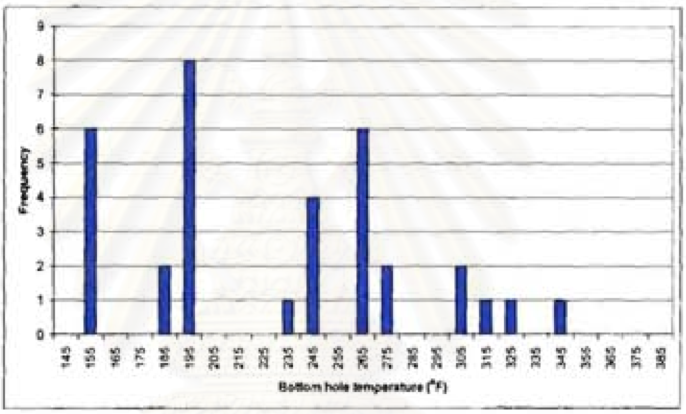


3) Data distribution of testing sets.

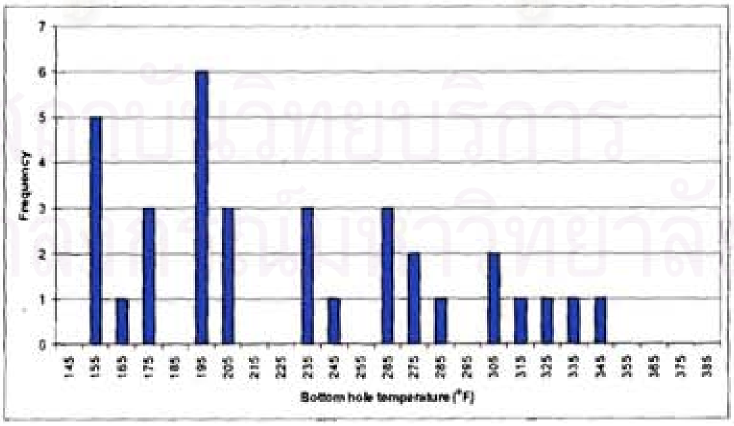
Figure 4.48: Histograms of wellhead temperature.



1) Data distribution of training sets.

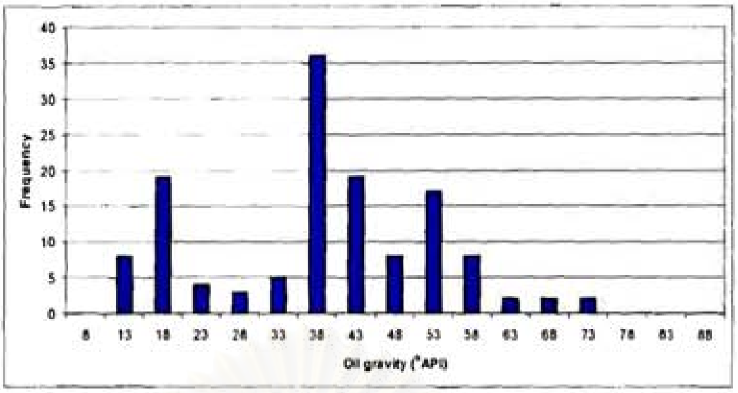


2) Data distribution of validating sets.

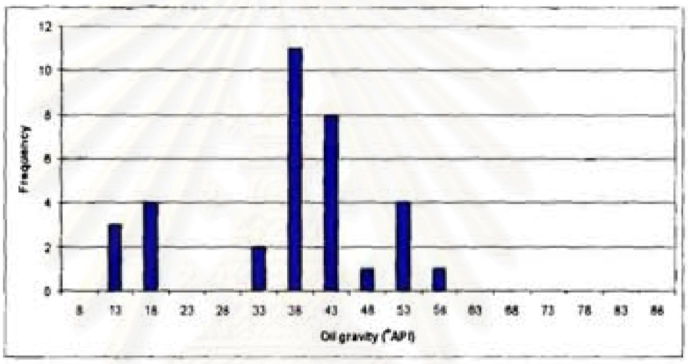


3) Data distribution of testing sets.

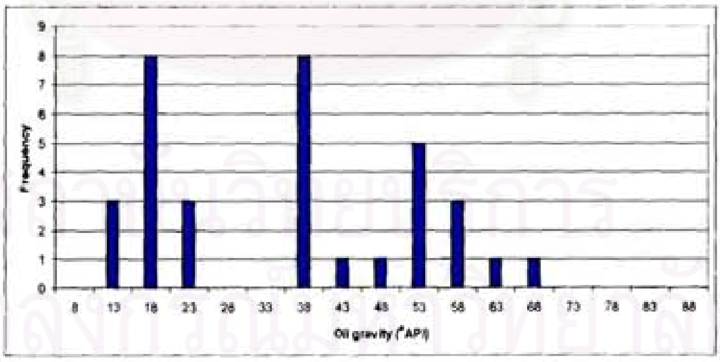
Figure 4.49: Histograms of bottomhole temperature.



1) Data distribution of training sets.

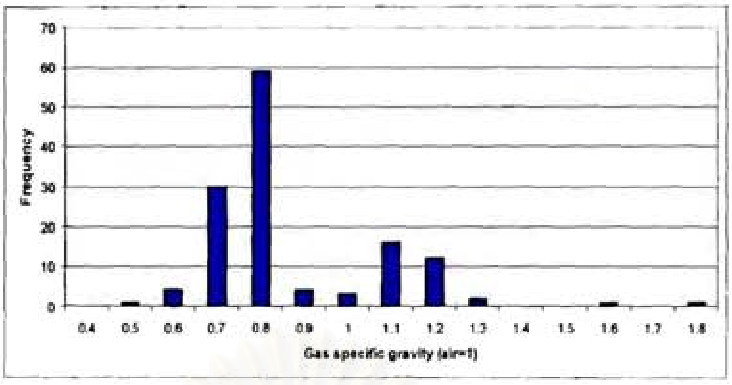


2) Data distribution of validating sets.

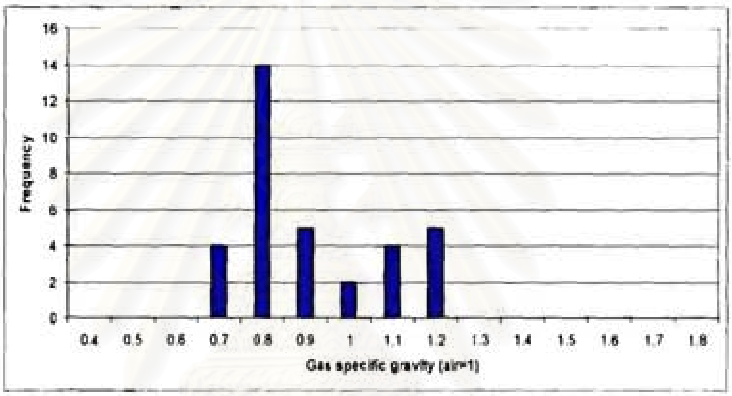


3) Data distribution of testing sets.

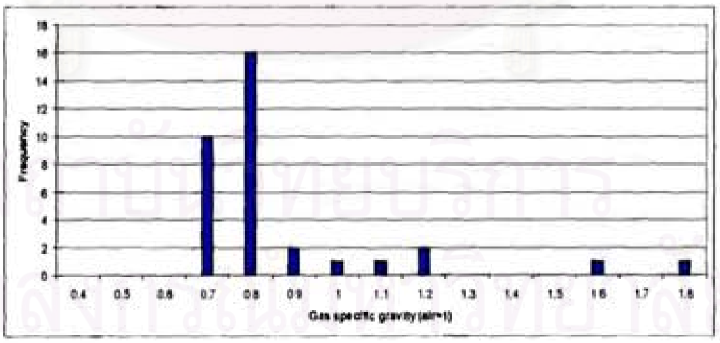
Figure 4.50: Histograms of oil gravity.



1) Data distribution of training sets.

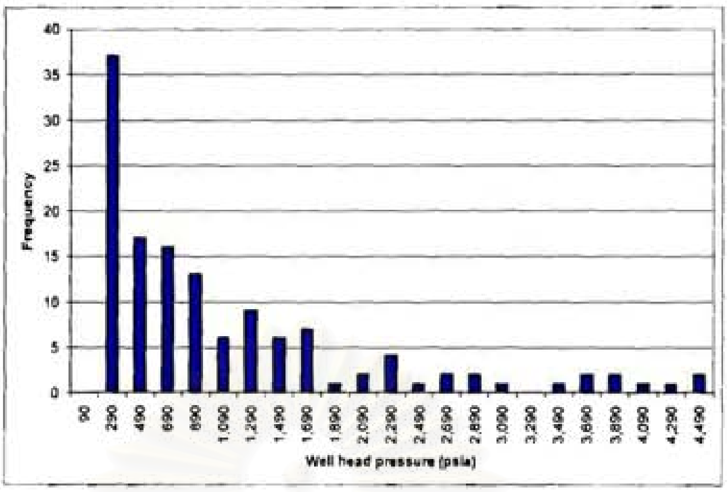


2) Data distribution of validating sets.

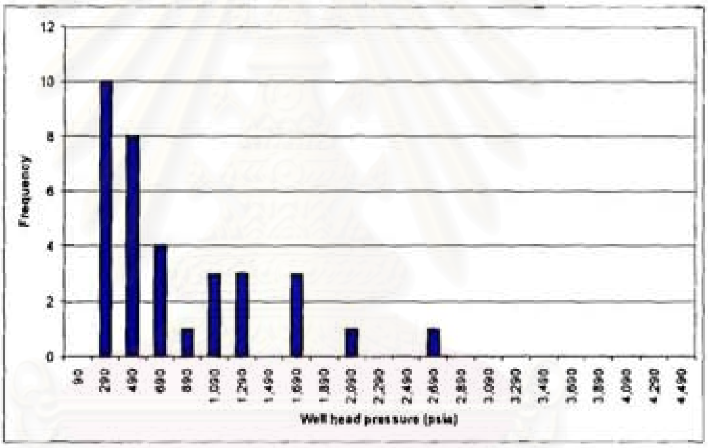


3) Data distribution of testing sets.

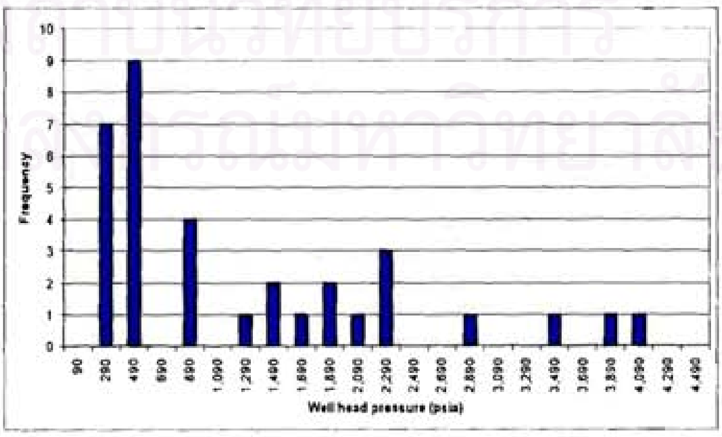
Figure 4.51: Histograms of gas specific gravity.



1) Data distribution of training sets.

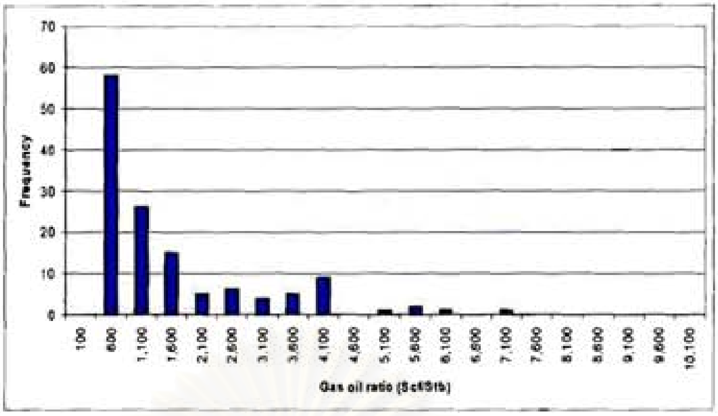


2) Data distribution of validating sets.

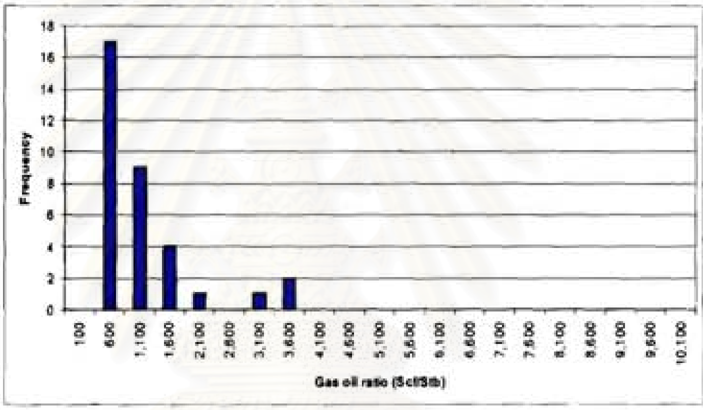


3) Data distribution of testing sets.

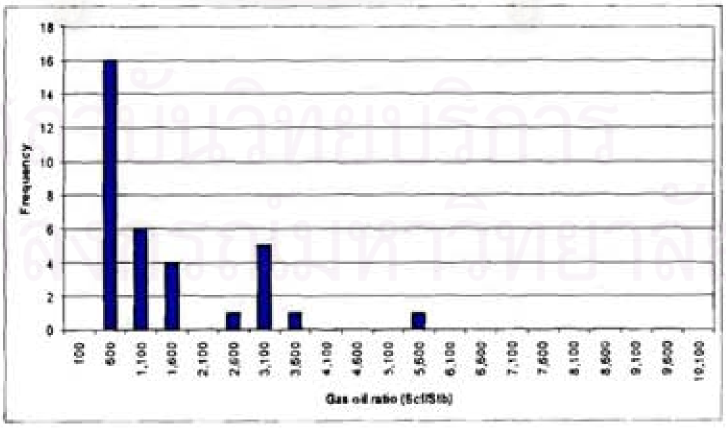
Figure 4.52: Histograms of wellhead pressure.



1) Data distribution of training sets.

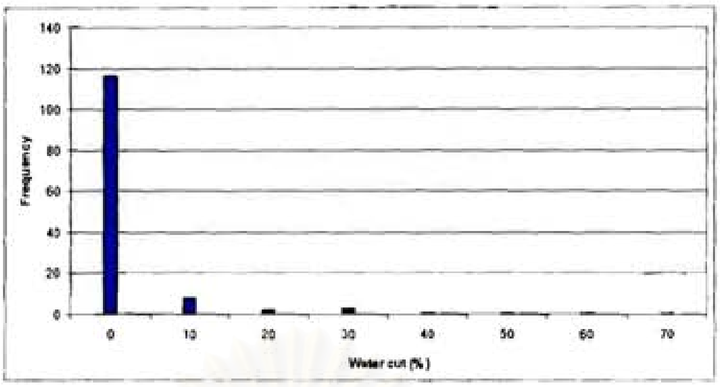


2) Data distribution of validating sets.

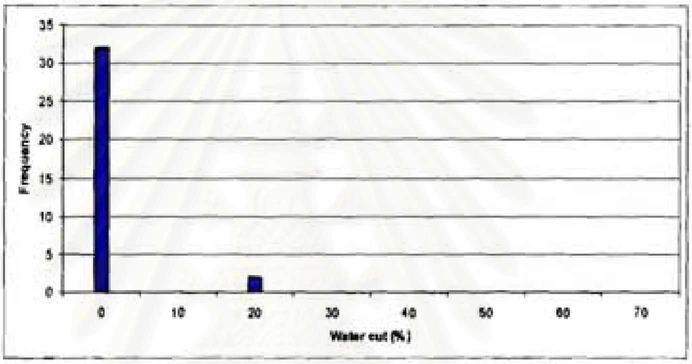


3) Data distribution of testing sets.

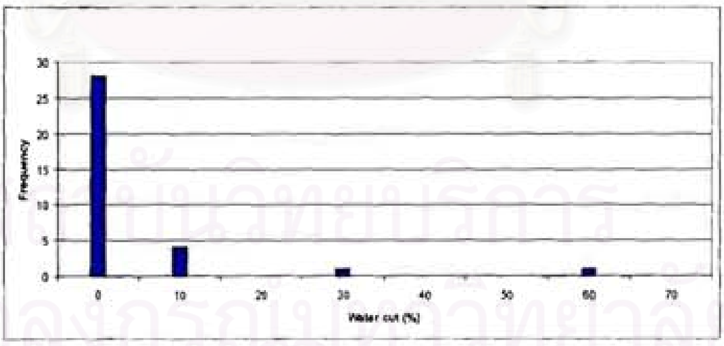
Figure 4.53: Histograms of gas oil ratio.



1) Data distribution of training sets.

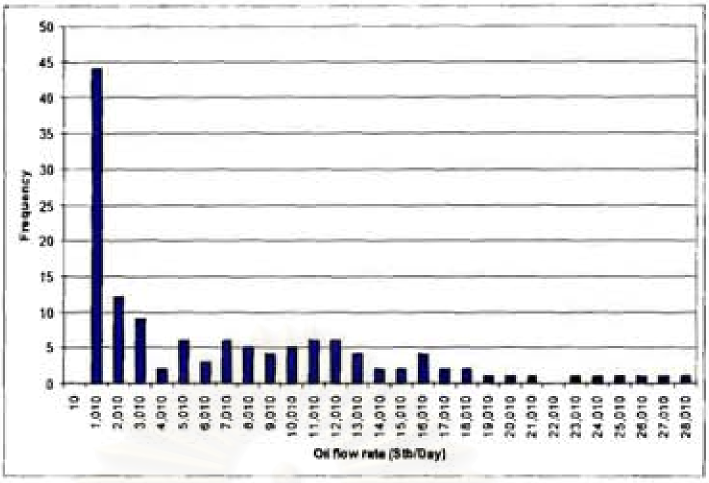


2) Data distribution of validating sets.

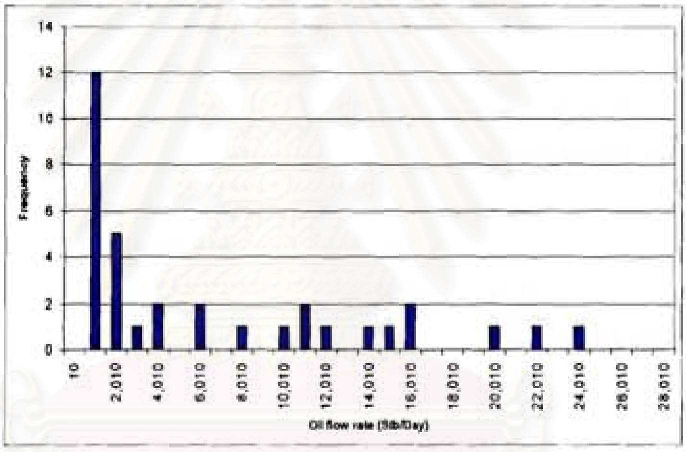


3) Data distribution of testing sets.

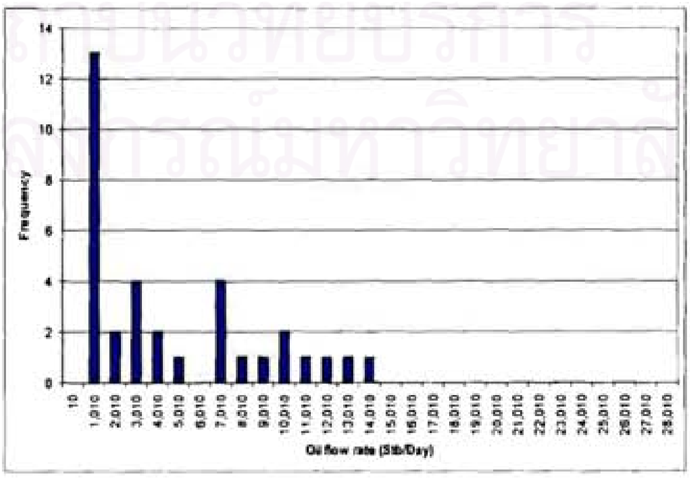
Figure 4.54: Histograms of water cut.



1) Data distribution of training sets.

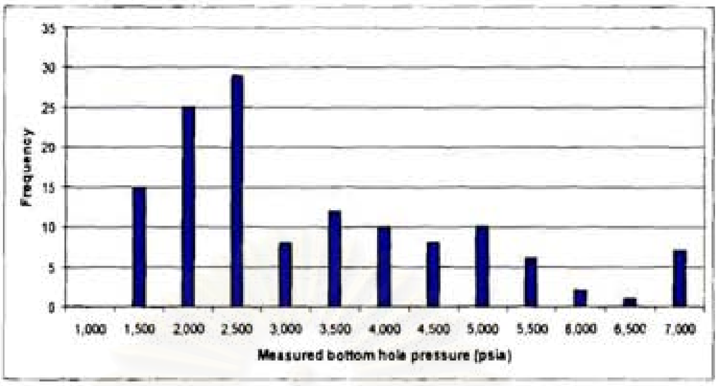


2) Data distribution of validating sets.

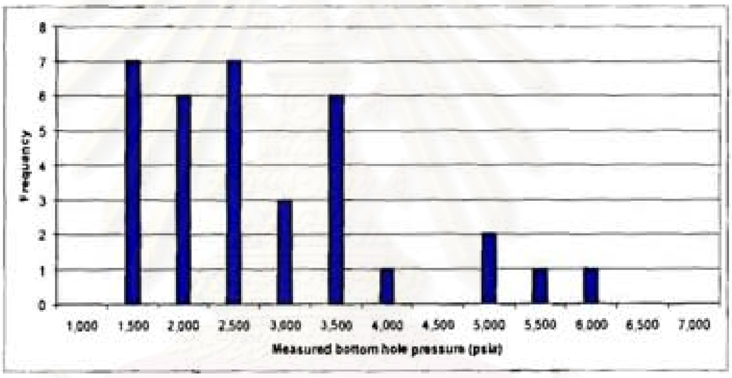


3) Data distribution of testing sets.

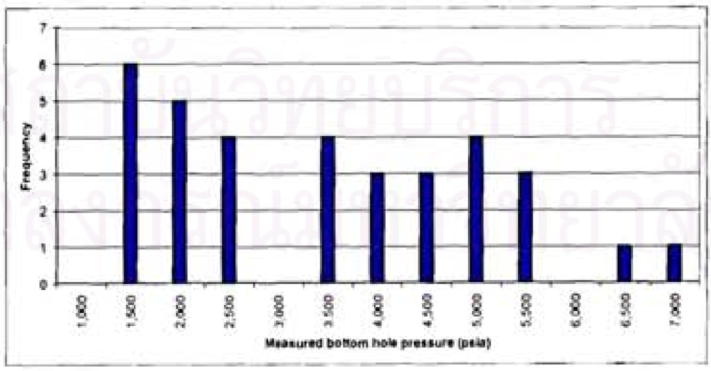
Figure 4.55: Histograms of oil flow rate.



1) Data distribution of training sets.



2) Data distribution of validating sets.



3) Data distribution of testing sets.

Figure 4.56: Histograms of measured bottomhole pressure.

4.4.1 Results and Discussion

The best neural net model (Model number 10) in this case could perform the lowest difference of prediction of 20.59% in testing data sets. In this section, we discuss the mismatches in details which the mismatches are represented in ranges of each flow condition. Figure 4.57 shows distribution of the mismatches of testing data. In order to investigate the effect of input parameters to the accuracy of the prediction, the percentage of false identification or mismatch is calculated for every value of each input and plotted as histogram. The effect of input parameters on the mismatched is discussed as follows:

1) Tubing diameter

Figure 4.57 (1) illustrates percentage of false identification for different tubing diameters. The internal tubing diameters (ID) of the wells used in the testing phase of the neural network are 1.995", 2.441", 2.764", 2.992", 3.958", 4.892", and 6.184". The tubing diameter of 6.184" has the highest percentage of misidentification. Tubing sizes that have the next highest percentage of mismatch are 3.958", 2.992", 2.441", 1.995", and 4.892" which have the mismatch percentage of 24.29%, 21.43%, 17.86%, 14.29%, and 14.29%, respectively. There is no tubing size that has no mismatch in case 3 (best correlation).

2) Tubing depth

Figure 4.57 (2) shows percentage of false identification for different tubing depths. The tubing depths of the wells used in the testing phase of the neural network are 3,182 to 12,861 feet. The depth of 4,501 to 5,000 feet, 6,001 to 7,000 feet, and 12,501 to 12,861 feet have the highest percentage of misidentification. These errors may be caused by the least amount of training and validating data sets compared to those for other tubing depths (5 sets of training and 3 sets of validating as shown in Figure 4.47 for depth 4,501 to 5,000 feet; 2 sets of training and 2 sets of validating as shown in Figure 4.47 for depth 6,501 to 7,000 feet; 2 sets of training and 0 set of validating as shown in Figure 4.47 for depth 12,501 to 12,861 feet). Tubing depths that have the next highest percentage of mismatch are 10,001 to 10,500 feet, 4,001 to 4,500 feet, and 9,501 to 10,000 feet which have mismatch percentage of 25.71%, 23.81%, and 23.81%, respectively. Tubing depths that have the percentage of mismatch lower than 20% such as depth of 3,182 to 3,500 feet, 7,501 to 8,500 feet, and 10,501 to 11,000 feet. Tubing depths of 3,501 to 4,000 feet, 11,001 to 11,500 feet, and 12,001 to 12,500 feet have no mismatch at all.

3) Wellhead temperature

Figure 4.57 (3) illustrates percentage of false identification for different wellhead temperatures. The wellhead temperatures of the wells used in the testing phase of the neural network are 75 to 140°F. The temperature of 106 to 110°F has the highest percentage of misidentification. This error may be caused by small amount of training and validating data sets compared to those for other wellhead temperatures (4 sets of training and 1 set for validating as shown in Figure 4.48). Wellhead temperatures that have the next highest percentage of mismatch are 75°F, 86 to 90°F, 111 to 115°F, 126 to 130°F, and 116 to 125°F which have mismatch percentage of 28.57%, 23.81%, 23.81%, 22.45%, 19.05%, and 19.05%, respectively. Wellhead temperatures that have the percentage of mismatch lower than 15% such as temperature of 81 to 85°F, 91 to 95°F, and 131 to 140°F. There is no wellhead temperature that has no mismatch in case 3 (best correlation).

4) Bottomhole temperature

Figure 4.57 (4) shows percentage of false identification for different bottomhole temperatures. The bottomhole temperatures of the wells used in the testing phase of the neural network are 150 to 342°F. The bottomhole temperature of 256 to 265°F has the highest percentage of misidentification. Bottomhole temperatures that have the next highest percentage of mismatch are 156 to 165°F, 196 to 205°F, 236 to 245°F, 276 to 285°F, and 316 to 335°F which all have similar mismatch percentage of 28.57%. Bottomhole temperatures of 266 to 275°F, 150 to 155°F, 226 to 235°F, 186 to 195°F, and 306 to 315°F have mismatch percentage of 21.43%, 20%, 19.05%, 16.67%, and 14.29%, respectively. Bottomhole temperature that has mismatch percentage lower than 10% is 166 to 175°F. Bottomhole temperatures of 335 to 342°F has no mismatch at all.

5) Oil gravity

Figure 4.57 (5) shows percentage of false identification for different oil gravities. The oil gravities of the wells used in the testing phase of the neural network are 8.3 to 66.7°API. The oil gravities of 34 to 38°API, 44 to 48°API, and 59 to 63°API have the highest percentage of misidentification. These errors may be caused by the least amount of training and validating data sets compared to those for other oil gravities (8 sets of training, 1 set of validating as shown in Figure 4.50 for oil density 44 to 48°API; and 2 sets of training, 0 set of validating as shown in Figure 4.50 for oil density 59 to 63°API). Oil gravities that have the next highest percentage of mismatch are 49 to 53°API, 14 to 18°API, 54 to 58°API, and 8.3 to 13°API which have mismatch percentage of 25.71%, 19.64%, 19.05%, and 14.29%, respectively. Oil gravity that has mismatch percentage lower than 10% is 19 to 23°API. Oil gravities of 39 to 43°API and 64 to 66.7°API have no mismatch at all.

6) Gas specific gravity

Figure 4.57 (6) shows percentage of false identification for different gas specific gravities. The gas specific gravities of the wells used in the testing phase of the neural network are 0.67 to 1.705 (air=1). The gas specific gravities of 1.01 to 1.2 and 1.51 to 1.6 have the highest percentage of misidentification. Gas specific gravities that have the next highest percentage of mismatch are 0.71 to 0.9, 0.67 to 0.7, and 0.91 to 1.0

which have mismatch percentage of 21.43%, 18.57%, and 14.29%, respectively. Gas specific gravity of 1.71 to 1.8 has no mismatch at all.

7) Wellhead pressure

Figure 4.57 (7) illustrates percentage of false identification for different wellhead pressures. The wellhead pressures of the wells use in the testing phase of the neural network are 164 to 4,048 psia. The wellhead pressure of 1,091 to 1,290 psia has the highest percentage of misidentification. Wellhead pressures that have the next highest percentage of mismatch are 1,491 to 1,690 psia, 1,891 to 2,090 psia, 2,691 to 2,890 psia, and 3,691 to 4,090 psia which all have similar mismatch percentage of 28.57%. Wellhead pressures that have the percentage of mismatch between 15% and 25% such as pressure of 164 to 490 psia and 1,691 to 1,890 psia. Wellhead pressures that have the percentage of mismatch lower than 15% such as of 691 to 890 psia, 1,291 to 1,490 psia, and 2,091 to 2,290 psia. Wellhead pressure of 3,291 to 3,490 psia has no mismatch at all.

8) Gas oil ratio

Figure 4.57 (8) shows percentage of false identification for different gas oil ratios. The gas oil ratios of the wells used in the testing phase of the neural network are 129 to 5,160 scf/stb. The gas oil ratios of 2,101 to 2,600 scf/stb, 3,101 to 3,600 scf/stb, and 5,101 to 5,600 scf/stb have the highest percentage of misidentification. Gas oil ratios that have the next highest percentage of mismatch are 2,601 to 3,100 scf/stb, 129 to 600 scf/stb, 601 to 1,100 scf/stb, and 1,101 to 1,600 scf/stb which have the mismatch percentage of 25.71%, 22.32%, 14.29%, and 10.71%, respectively. There is no gas oil ratio that has no mismatch in case 3 (best correlation).

9) Water cut

Figure 4.57 (9) illustrates percentage of false identification for different water cuts. The water cuts of the wells used in the testing phase of the neural network are 0 to 50%. The water cut of 21 to 30% has the highest percentage of misidentification. This error may be caused by small amount of training and validating data sets compared to those for other water cuts (3 sets of training and 0 set of validating as shown in Figure 4.54). Water cuts that have the next highest percentage of mismatch are 0% and 1% to 10% which have mismatch percentage of 21.43% and 17.86%, respectively. Water cut of 41 to 50% has no misidentification at all.

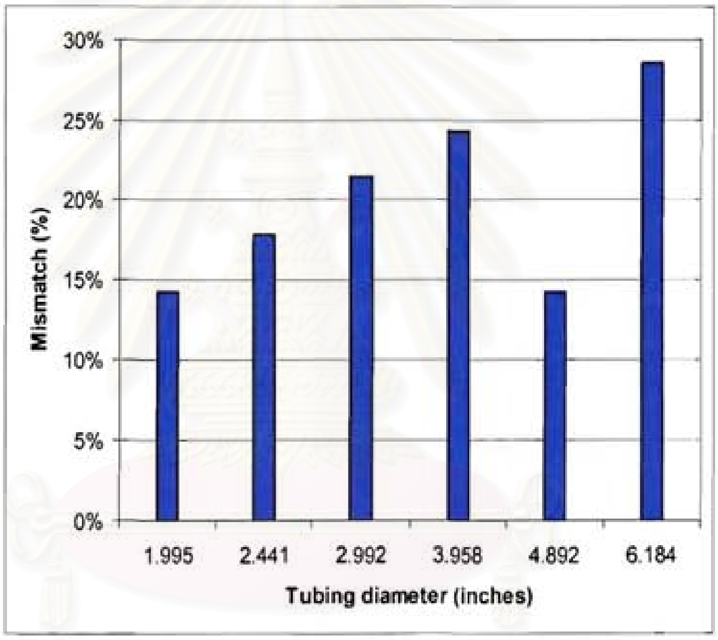
10) Oil flow rate

Figure 4.57 (10) shows percentage of false identification for different oil flow rates. The oil flow rates of the wells used in the testing phase of the neural network are 41 to 13,860 stb/day. The oil flow rates of 1,011 to 3,010 stb/day, 4,011 to 5,010 scf/day, 8,011 to 9,010 stb/day, and 11,011 to 13,860 stb/day have the highest percentage of misidentification. Oil flow rates that have the next highest percentage of mismatch are 6,011 to 7,010 stb/day, 41 to 1,010 stb/day, and 10,011 to 11,010 stb/day which have mismatch percentage of 25%, 20.88%, and 14.29%, respectively. Oil flow rates of 3,011 to 4,010 stb/day, 7,011 to 8,010 stb/day, and 9,011 to 10,010 stb/day have no mismatch at all.

11) Measure bottomhole pressure

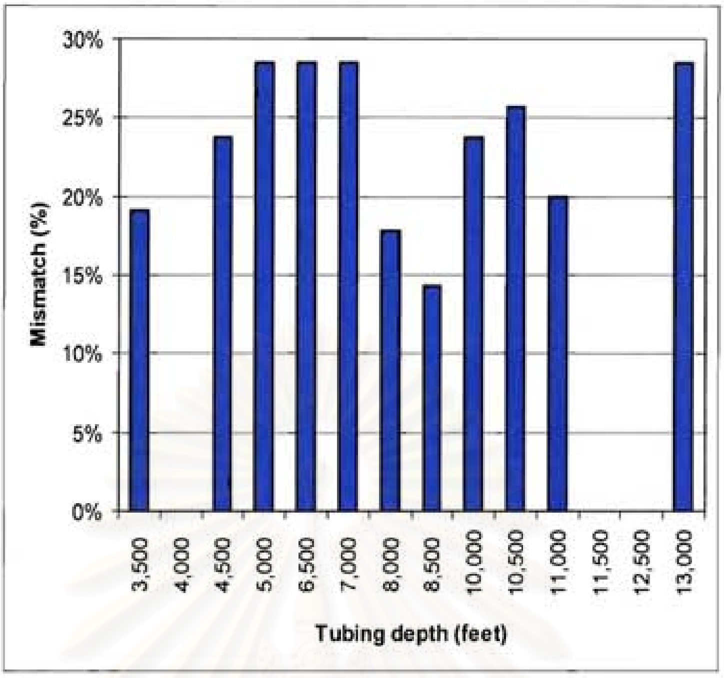
Figure 4.57 (11) illustrates percentage of false identification for different measured bottomhole pressures. The measured bottomhole pressures of the wells used in the training phase of the neural network are 1,201 to 6,570 psia. The measured bottomhole pressure of 2,001 to 2,500 psia has the highest percentage of misidentification. The pressures that have the next highest percentage of mismatch are 6,001 to 6,570 psia, 1,201 to 1,500 psia, 4,001 to 4,500 psia, 1,501 to 2,000 psia, and 5,001 to 5,500 psia which have mismatch percentage of 28.57%, 23.81%, 23.81%, 20%, and 19.05%, respectively. Measured bottom hole pressures that have percentage of mismatch lower than 15% such as 3,001 to 4,000 psia and 4,501 to 5,000 psia. There is no measured bottom hole pressure that has no mismatch in case 3 (best correlation).

In summary, the main reason for false identification or mismatch is lack of data in the training and validating phase of the neural network.

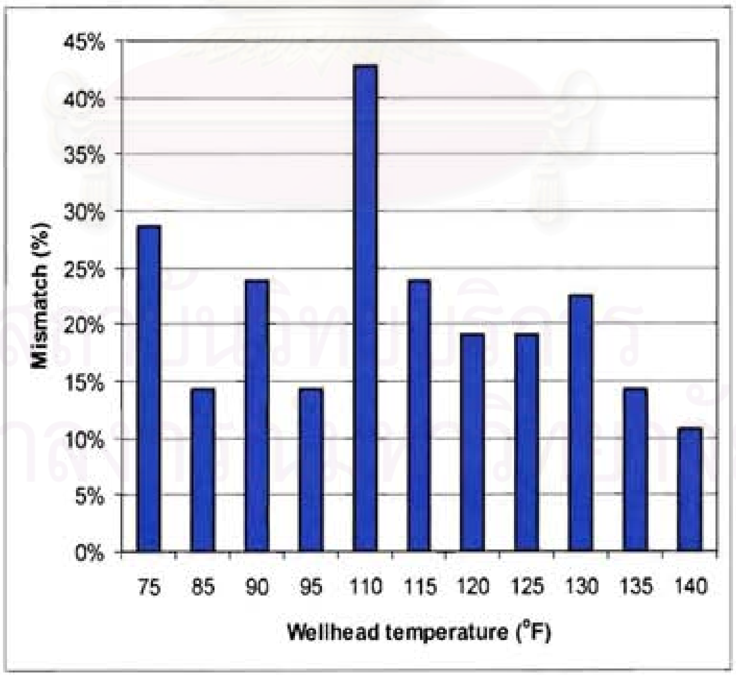


1) Percentage of false identification for different tubing diameters.

Figure 4.57: Mismatch histograms for Case 3.

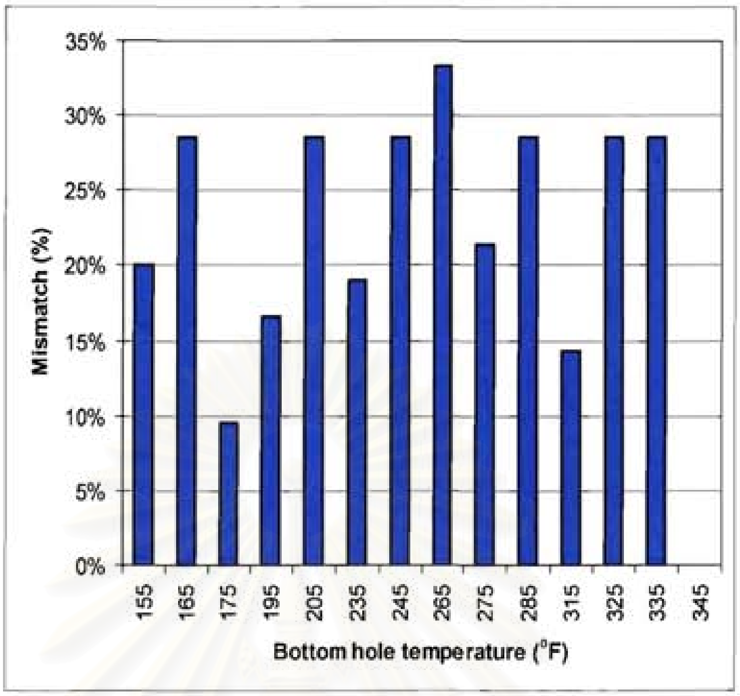


2) Percentage of false identification for different tubing depths.

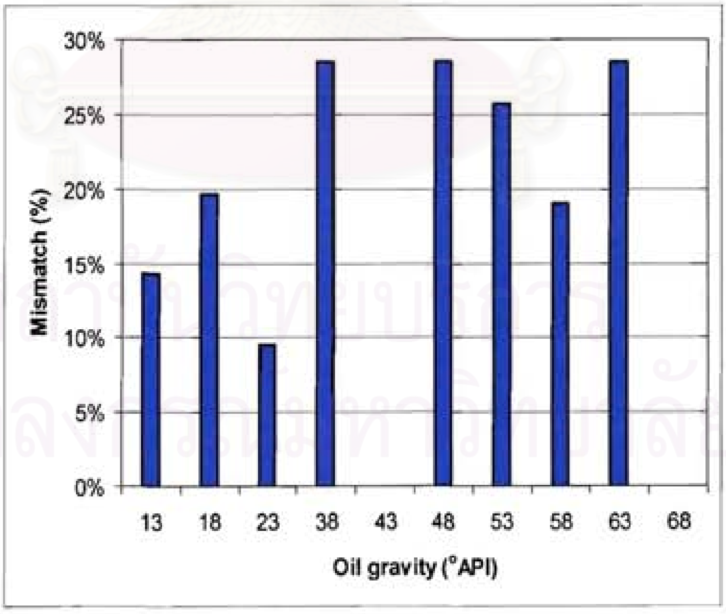


3) Percentage of false identification for different wellhead temperatures.

Figure 4.57: Mismatch histograms for Case 3 (continued).

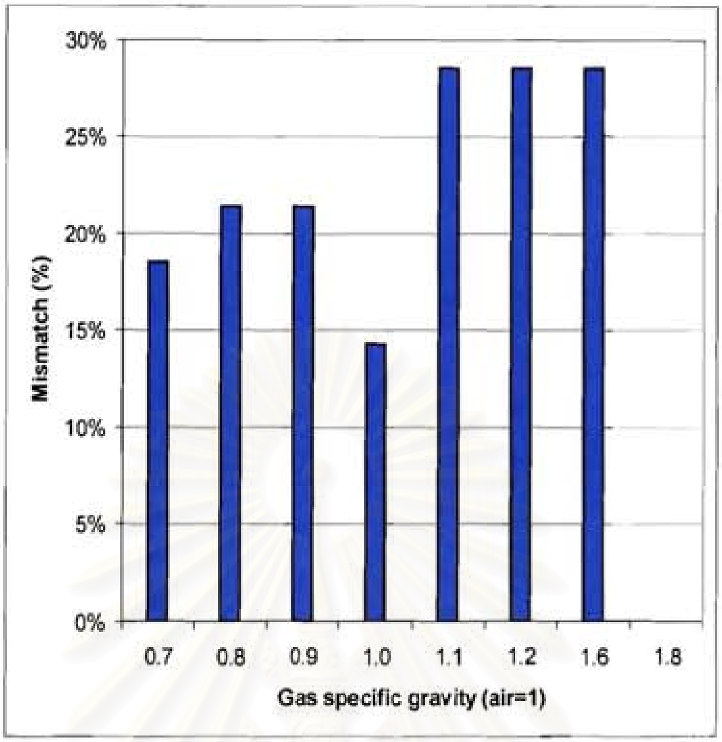


4) Percentage of false identification for different bottomhole temperatures.

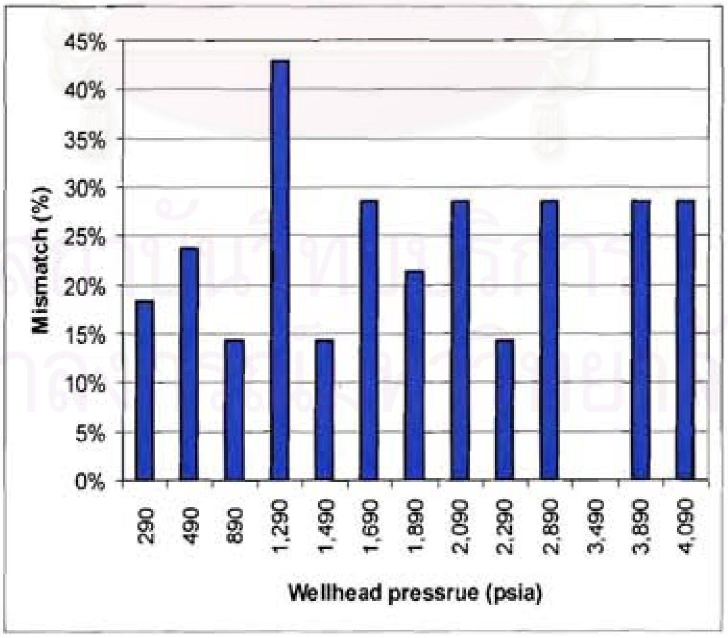


5) Percentage of false identification for different oil gravities.

Figure 4.57: Mismatch histograms for Case 3 (continued).

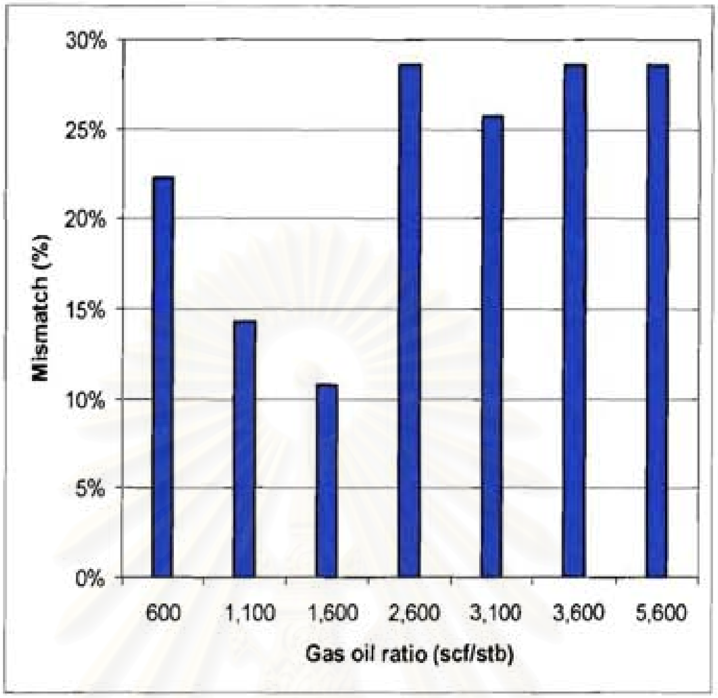


6) Percentage of false identification for different gas specific gravities.

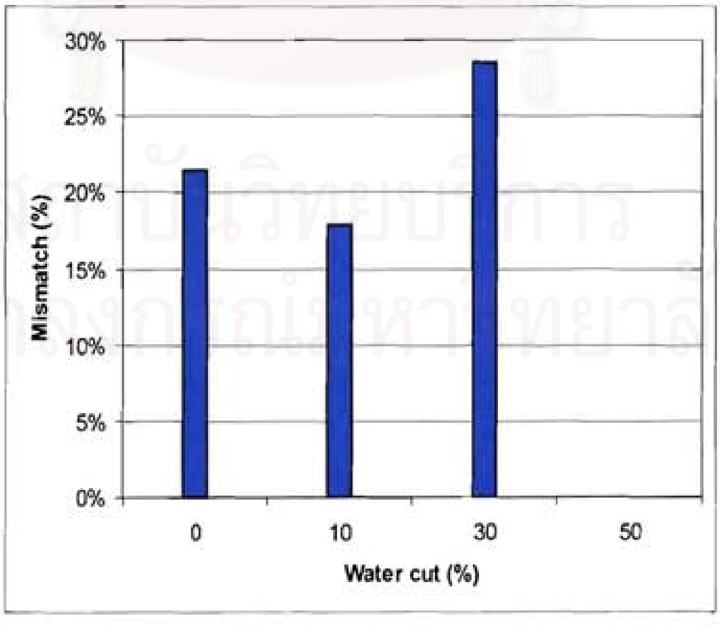


7) Percentage of false identification for different wellhead pressures.

Figure 4.57: Mismatch histograms for Case 3 (continued).

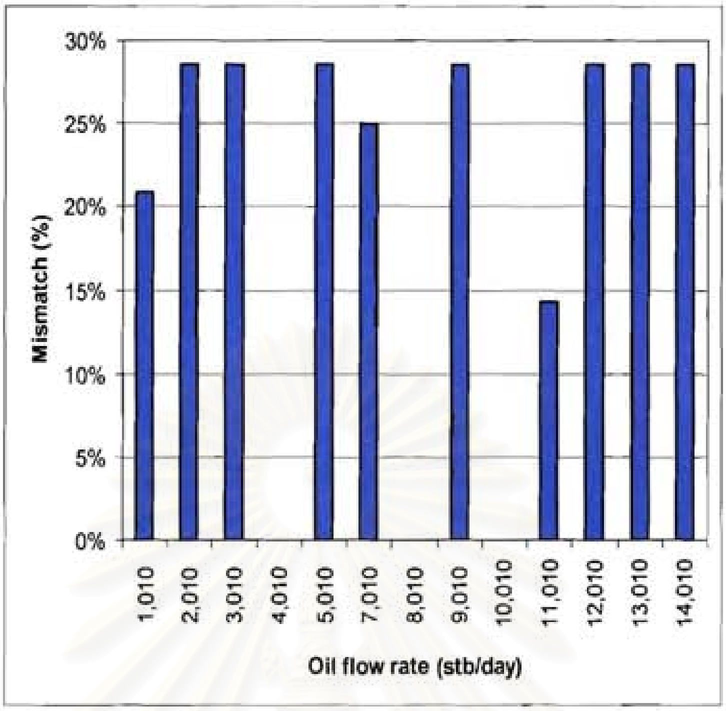


8) Percentage of false identification for different gas oil ratios.

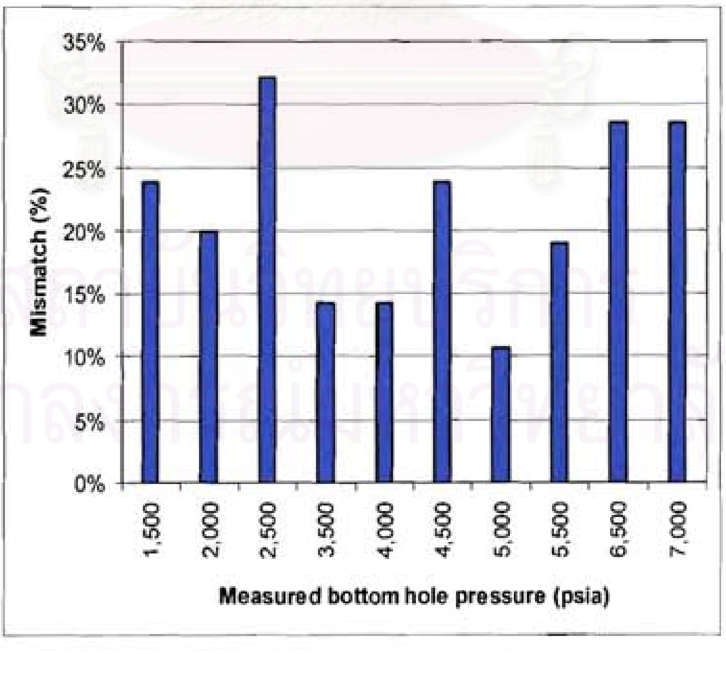


9) Percentage of false identification for different water cuts.

Figure 4.57: Mismatch histograms for Case 3 (continued).



10) Percentage of false identification for different oil flow rates.



11) Percentage of false identification for different measured bottomhole pressures.

Figure 4.57: Mismatch histograms for Case 3 (continued).

4.5 Case 4: Percentage Error

In this case, the neural network was trained in order to propose percentage of error for each correlation. The outputs are the error in percentage of each multiphase flow correlation. The neural network was trained until the average training error is lower than 0.1% which is the convergence criterion of this case. As in Case 3 (best correlation), we set 13 neural net models with the same numbers of hidden layers, hidden neurons, learning rate, and momentum. The parameters of each model are tabulated in Table 4.15.

Table 4.15: Neural network models for Case 4: percentage error.

Model No.	Number of neurons		Learning rate	Momentum	Average error	Condition
	Hidden layer 1	Hidden layer 2				
1	50	0	0.2	0.2	0.001	Converged
2	70	0	0.2	0.2	0.009991	Converged
3	30	5	0.2	0.2	0.009991	Converged
4	30	20	0.2	0.2	0.009981	Converged
5	40	5	0.2	0.2	0.009995	Converged
6	40	10	0.2	0.2	0.000999	Converged
7	40	13	0.2	0.2	0.001	Converged
8	40	15	0.2	0.2	0.000999	Converged
9	40	17	0.2	0.2	0.001	Converged
10	40	20	0.2	0.2	0.001	Converged
11	40	30	0.2	0.2	0.001	Converged
12	40	40	0.2	0.2	0.001	Converged
13	40	50	0.2	0.2	0.001	Converged

As a result of training phase, all 13 neural net models achieved the convergence criterion. To choose the best neural net model, we need to determine the percentage of correct numbers of matches. Since the outputs from the neural networks are percentage of errors between computed and measured pressures, the errors from the seven correlations are compared in order to determine the best correlation. The best correlations for the 34 testing sets of data are then compared with the actual best correlations. The number of matches is then computed. Table 4.16 shows the numbers of data sets that share the same best correlation between computed and actual output. It was observed that the neural net model having 40 neurons in the first layer and 17 neurons in the second layers has the highest number of data sets that matches. Therefore, we use this model to represent the neural net model for Case 4 (percentage error). Figure 4.58 shows actual and calculated outputs of the chosen neural network. A complete set of results is shown in Appendix E.

Table 4.16: Numbers of data sets that match in the best correlation for 13 neural net models in Case 4.

Model No.	Number of nodes		Numbers of data sets that match in the best correlation		
	Hidden layer 1	Hidden layer 2	Training	Validating	Testing
1	50	0	70	6	5
2	70	0	34	10	9
3	30	5	29	8	7
4	30	20	38	12	9
5	40	5	36	9	9
6	40	10	53	5	9
7	40	13	73	14	9
8	40	15	72	8	8
9	40	17	63	10	11
10	40	20	64	11	8
11	40	30	71	9	6
12	40	40	72	9	6
13	40	50	65	7	8

As seen in Table 4.16, the accuracy of identifying the best correlation is quite low. This is due to the fact that the errors between computed and measured bottomhole pressures from the seven correlations are sometime very close. Consequently, it is difficult to determine such differences. The best approach is probably presenting the predicted errors to the users and let the users choose correlation(s) that provide small or acceptable errors.

Match of best correlation

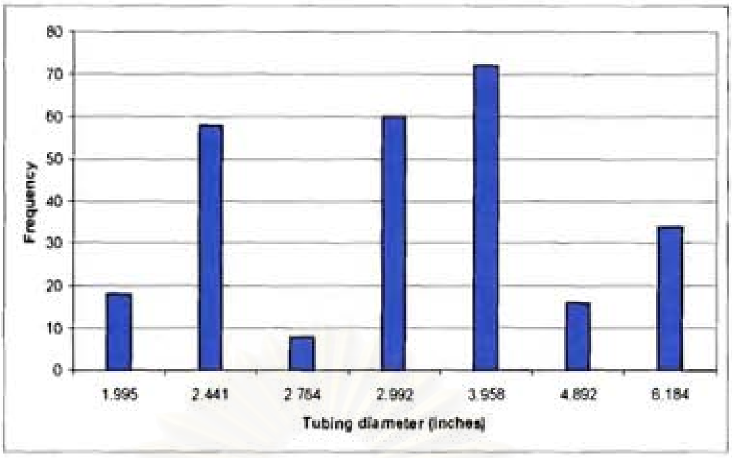
Actual output

Data Set No.	I: Tbg Dia (in)	O: D&R (M)	O: H&B	O: F&B	O: M&B	O: B&B	O: Ork	O: D&R (O)
D: 4.0	1.995	4.42	13.42	13.42	[illegible]	7.46	6.96	5.52
P: 4.0	1.995	2.67	9.95	10.88	[illegible]	2.35	9.66	1.99
D: 5.0	1.995	12.91	[illegible]	21.99	8.37	9.91	9.08	10.21
P: 5.0	1.995	21.16	29.36	31.92	25.54	[illegible]	19.54	20.06
D: 6.0	1.995	29.63	41.92	42.70	22.15	[illegible]	23.01	23.41
P: 6.0	1.995	42.48	[illegible]	60.78	30.44	13.05	32.38	16.50
D: 9.0	1.995	10.12	[illegible]	4.61	21.19	[illegible]	15.47	12.73
P: 9.0	1.995	6.60	[illegible]	17.04	5.23	4.60	7.84	5.53
D: 10.0	1.995	4.60	[illegible]	13.68	13.47	1.41	1.44	1.07
P: 10.0	1.995	5.92	[illegible]	5.36	5.40	8.02	0.46	1.20
D: 11.0	1.995	6.62	0.28	0.56	5.99	6.06	4.65	6.77
P: 11.0	1.995	0.65	0.52	4.15	2.58	7.54	0.55	0.61
D: 33.0	2.441	2.45	[illegible]	2.69	2.62	13.16	0.94	12.00
P: 33.0	2.441	15.37	5.04	14.26	17.30	37.46	15.09	29.71
D: 42.0	2.441	2.10	0.62	6.58	3.66	3.44	1.17	0.37
P: 42.0	2.441	2.01	2.79	4.08	2.93	1.54	3.27	1.50
D: 56.0	2.441	21.46	2.73	41.32	11.74	11.69	2.73	2.18
P: 56.0	2.441	14.83	7.65	39.04	0.50	0.64	44.90	30.34

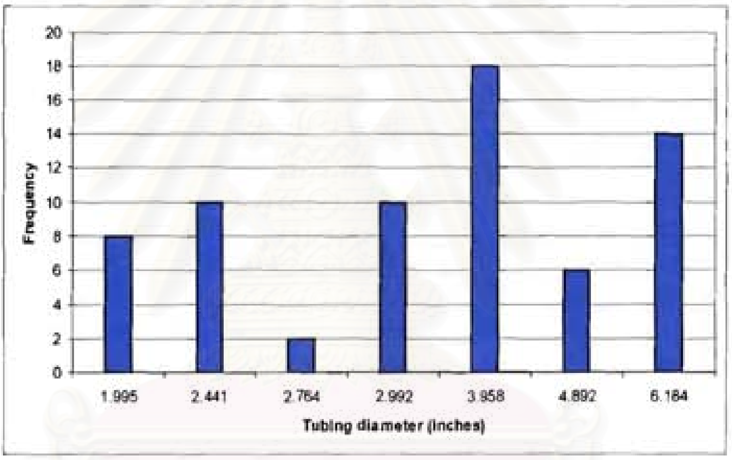
Calculated output

Figure 4.58: Samples of actual and calculated outputs for Model number 9.

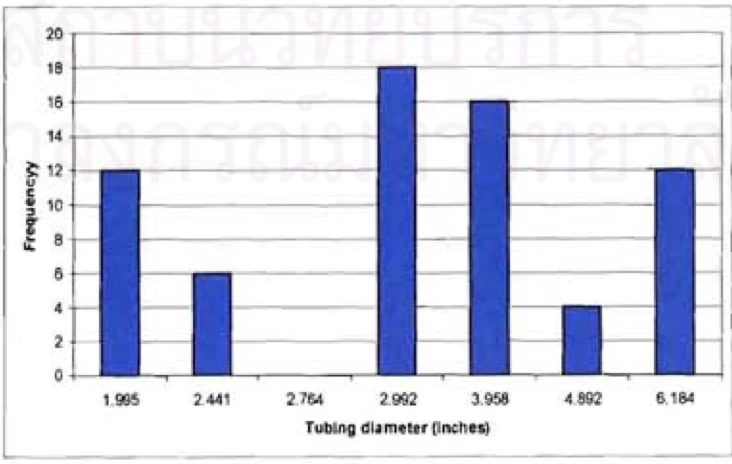
To be assured that neural network achieved generalization, the three partitioned data sets should have more or less similar distribution which covers all possible ranges of information. Since the software partitioned the data set randomly, histograms of training, validating, and testing sets were plotted in order to check for similarities in distribution of each partitioned data set. Figure 4.59 through 4.69 compare histograms of the 11 input parameters in the training, validating, and testing data. The histograms of each parameter have similar distribution to that of the original data which is shown in Figure 4.2.



1) Data distribution of training sets.

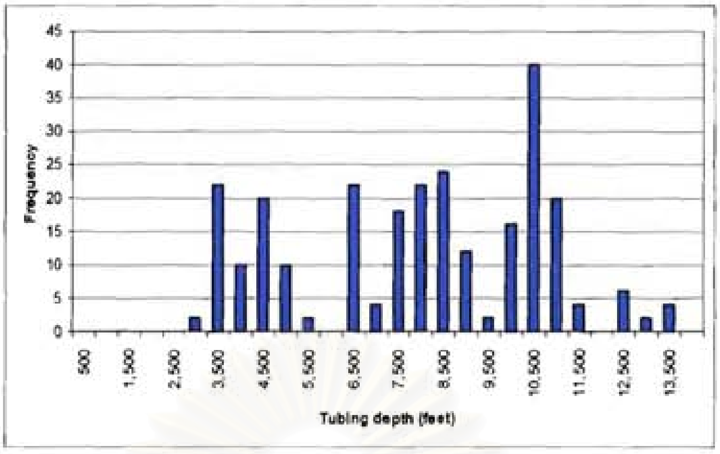


2) Data distribution of validating sets.

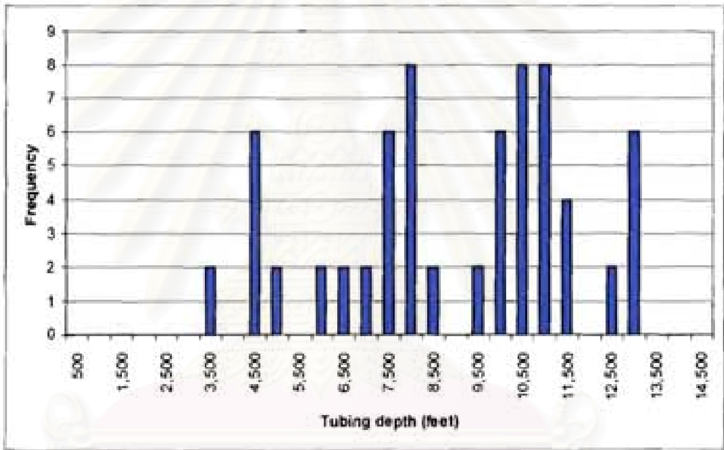


3) Data distribution of testing sets.

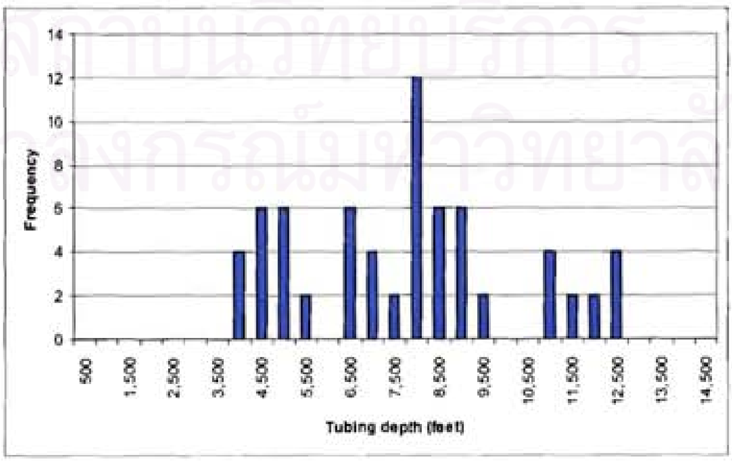
Figure 4.59: Histograms of tubing diameter.



1) Data distribution of training sets.

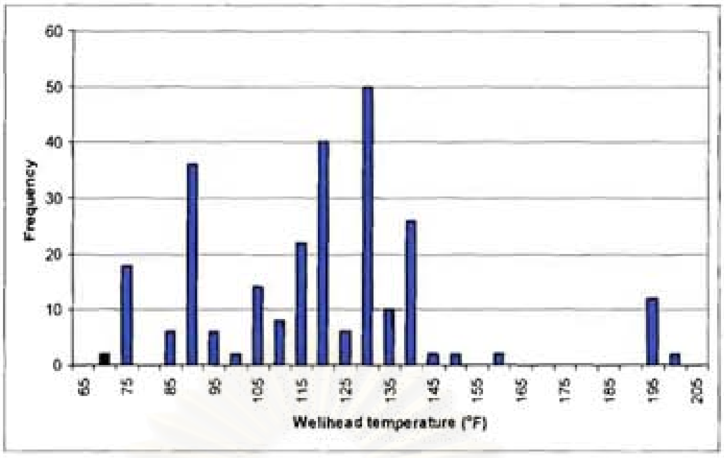


2) Data distribution of validating sets.

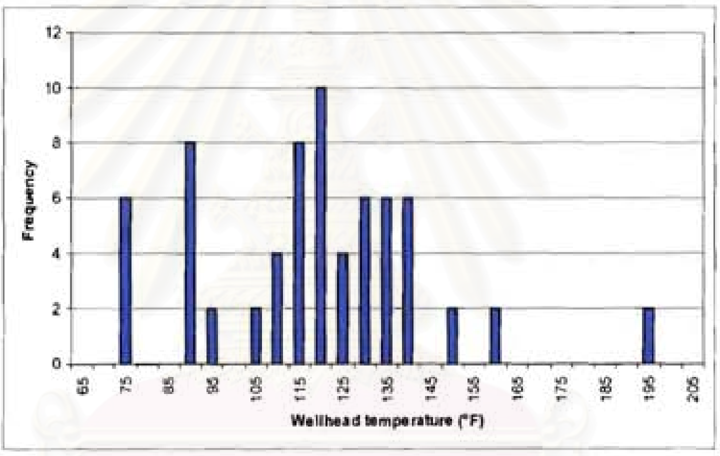


3) Data distribution of testing sets.

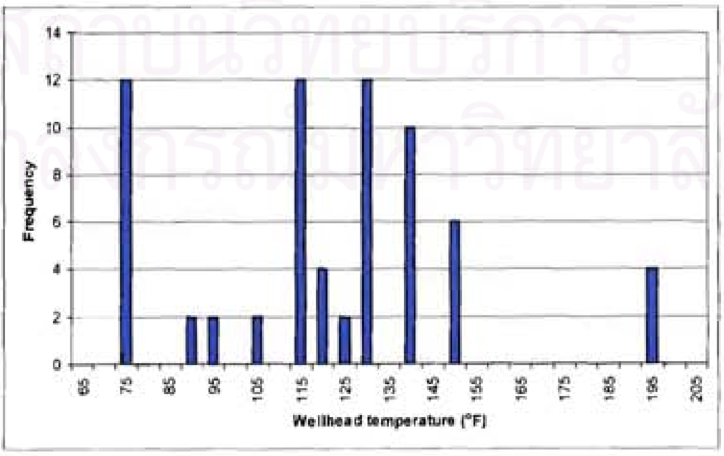
Figure 4.60: Histograms of tubing depth.



1) Data distribution of training sets.

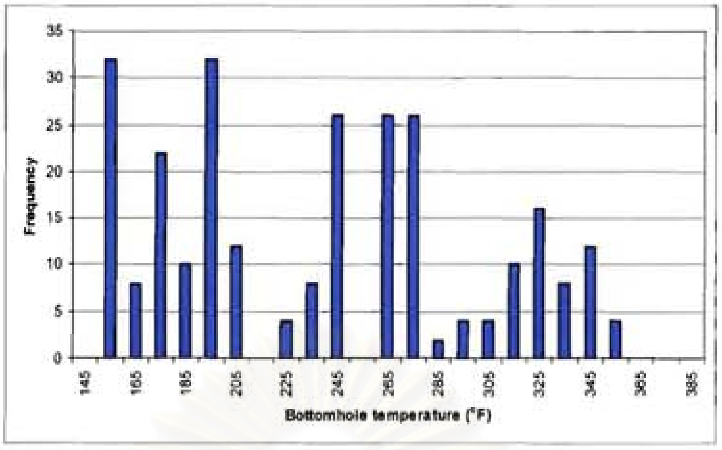


2) Data distribution of validating sets.

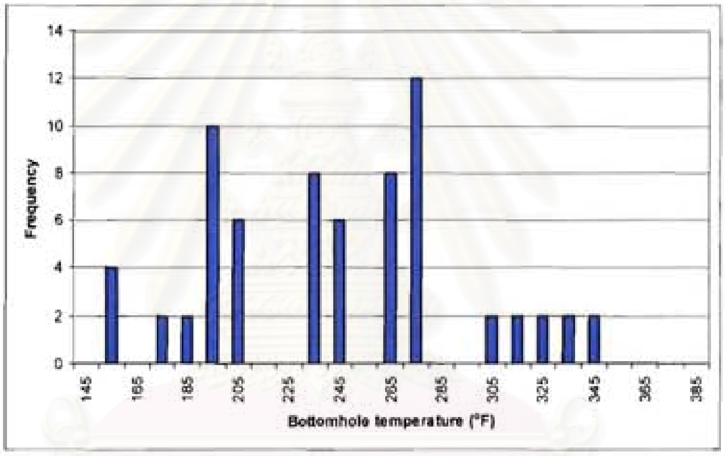


3) Data distribution of testing sets.

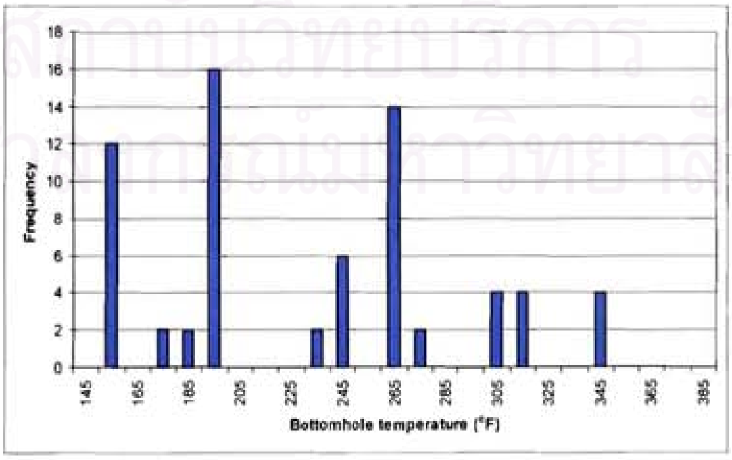
Figure 4.61: Histograms of wellhead temperature.



1) Data distribution of training sets.

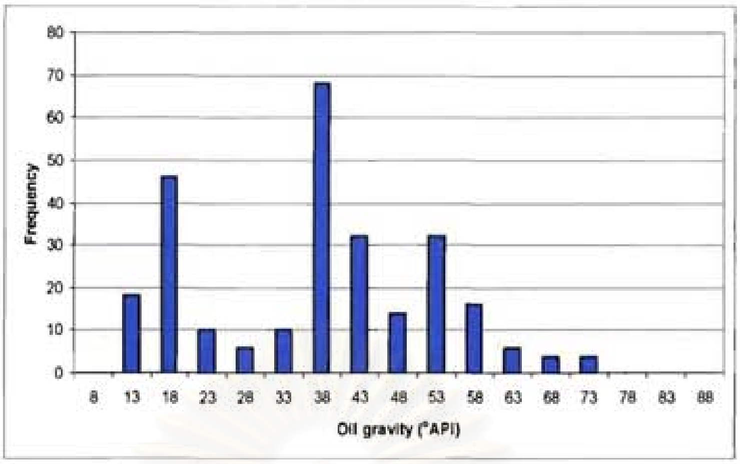


2) Data distribution of validating sets.

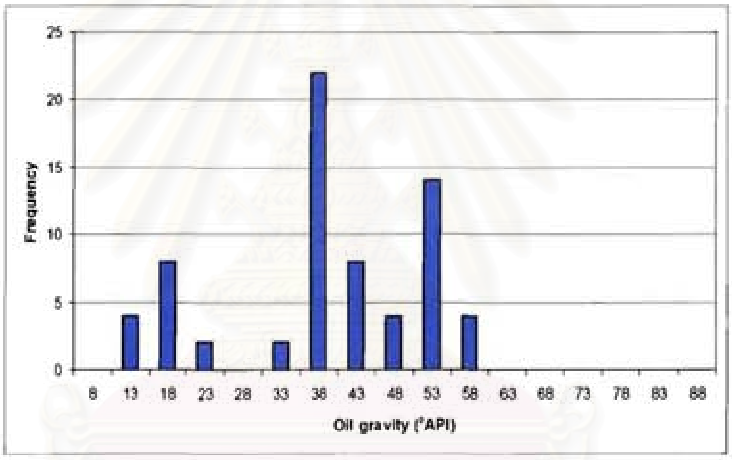


3) Data distribution of testing sets.

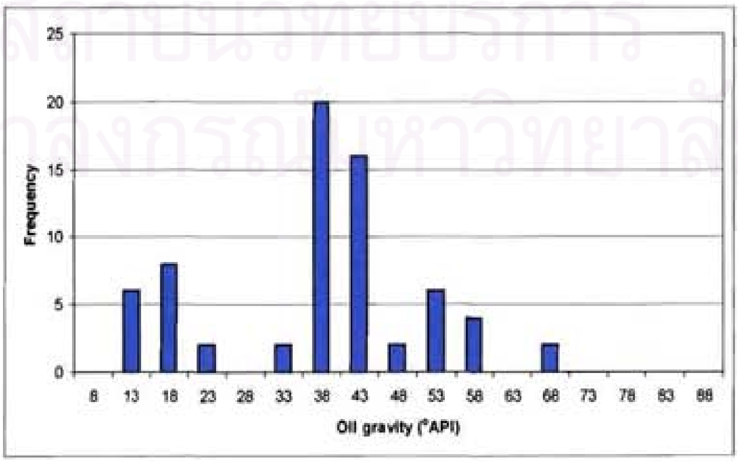
Figure 4.62: Histograms of bottomhole temperature.



1) Data distribution of training sets.

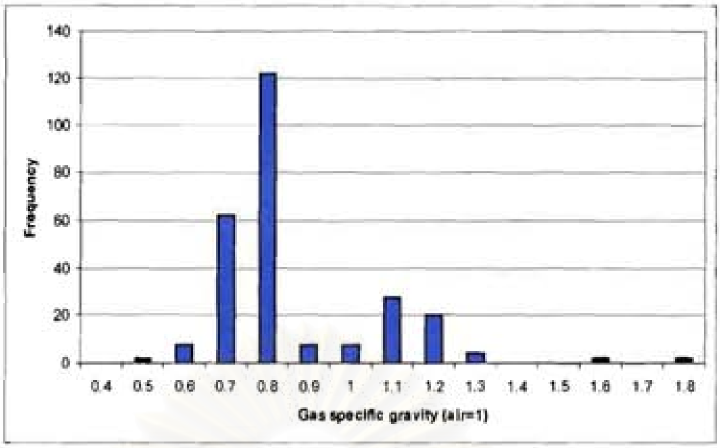


2) Data distribution of validating sets.

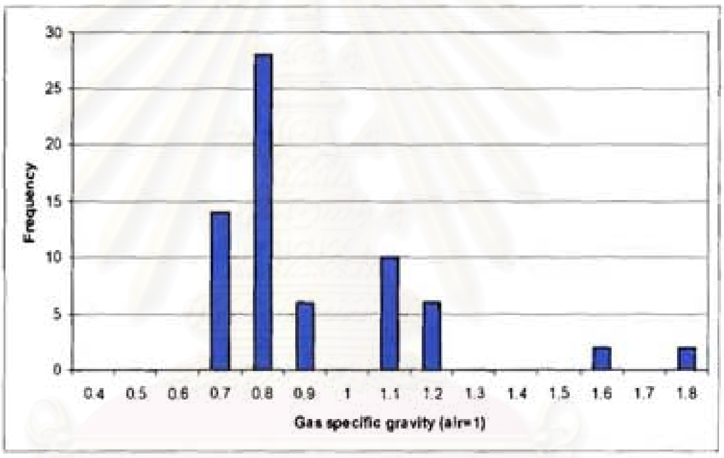


3) Data distribution of testing sets.

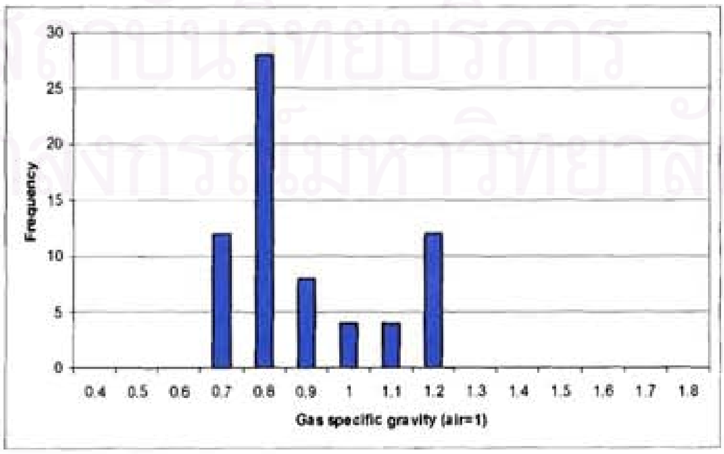
Figure 4.63: Histograms of oil gravity.



1) Data distribution of training sets.

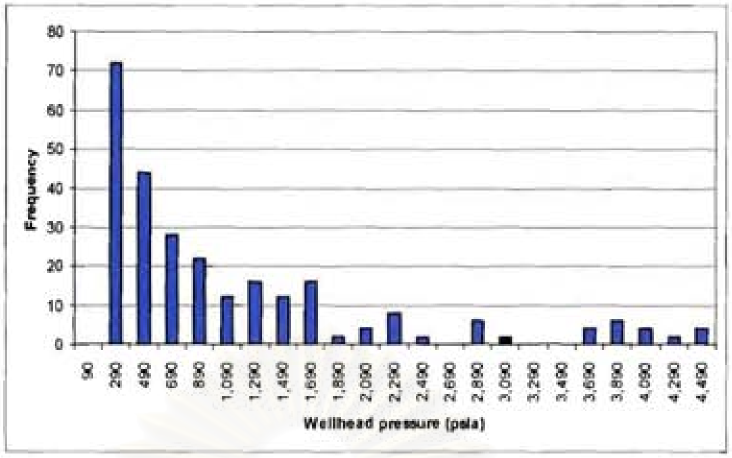


2) Data distribution of validating sets.

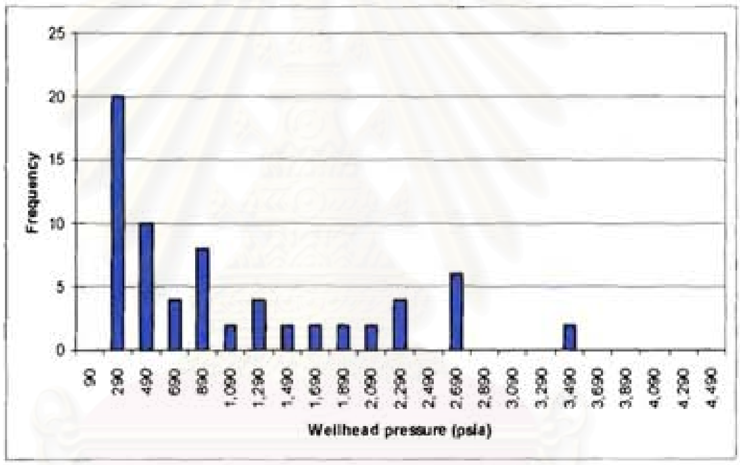


3) Data distribution of testing sets.

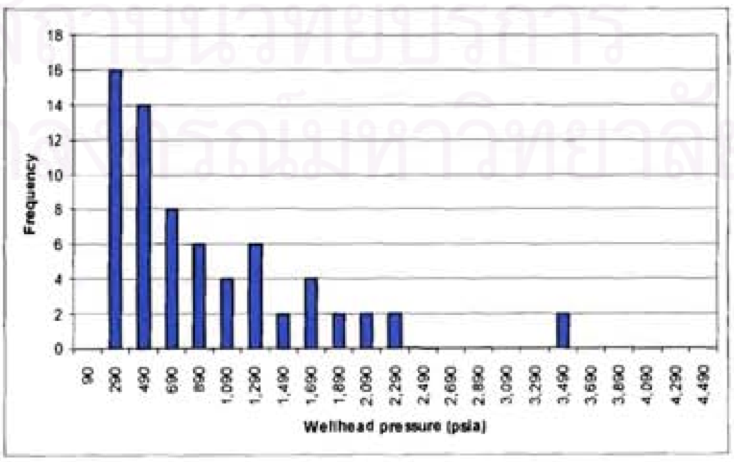
Figure 4.64: Histograms of gas specific gravity.



1) Data distribution of training sets.

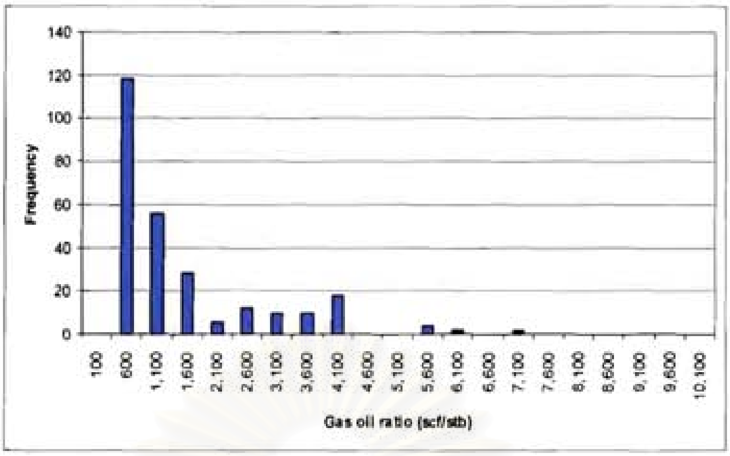


2) Data distribution of validating sets.

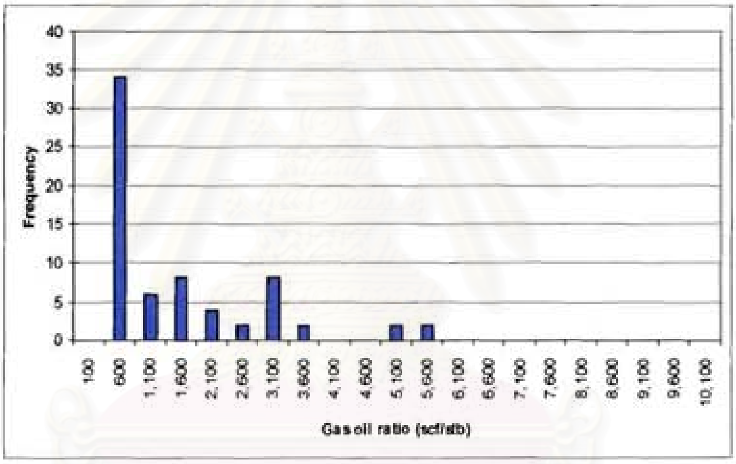


3) Data distribution of testing sets.

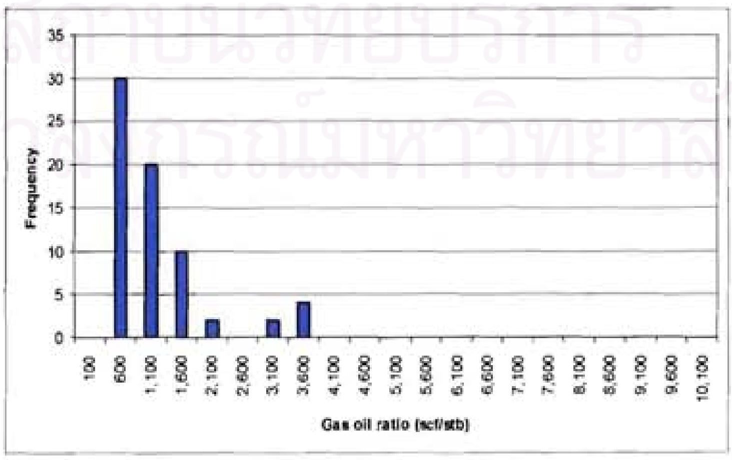
Figure 4.65: Histograms of wellhead pressure.



1) Data distribution of training sets.

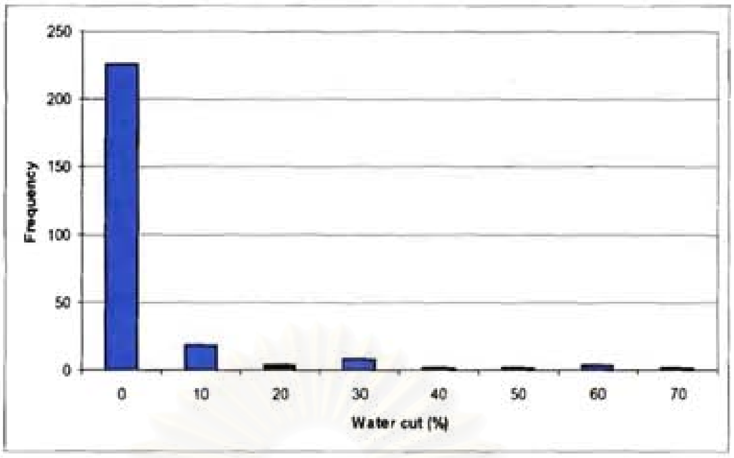


2) Data distribution of validating sets.

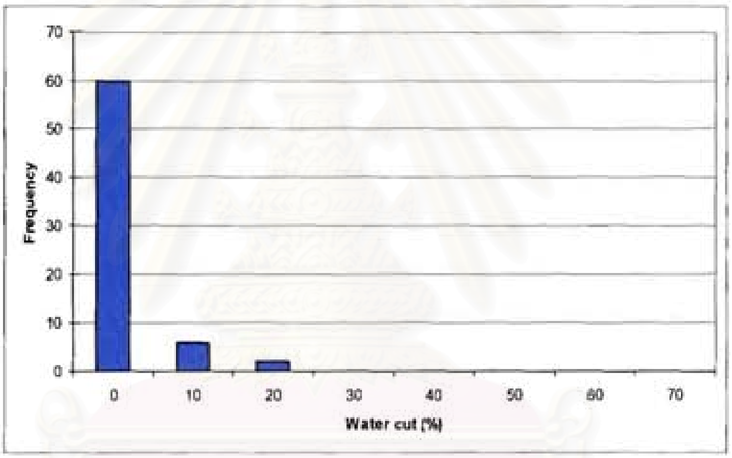


3) Data distribution of testing sets.

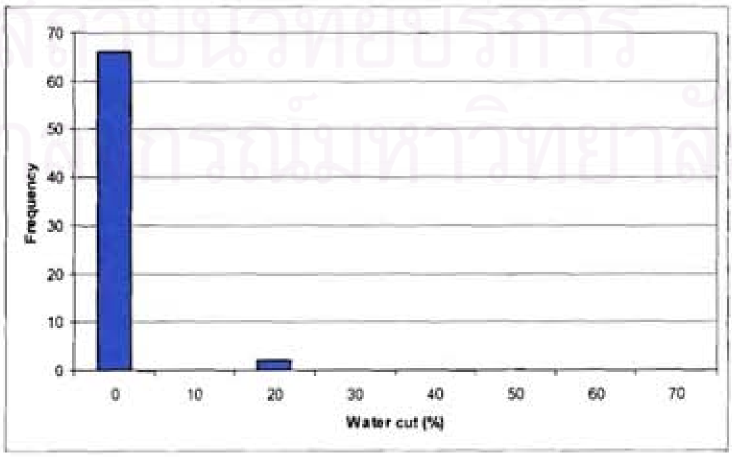
Figure 4.66: Histograms of gas oil ratio.



1) Data distribution of training sets.

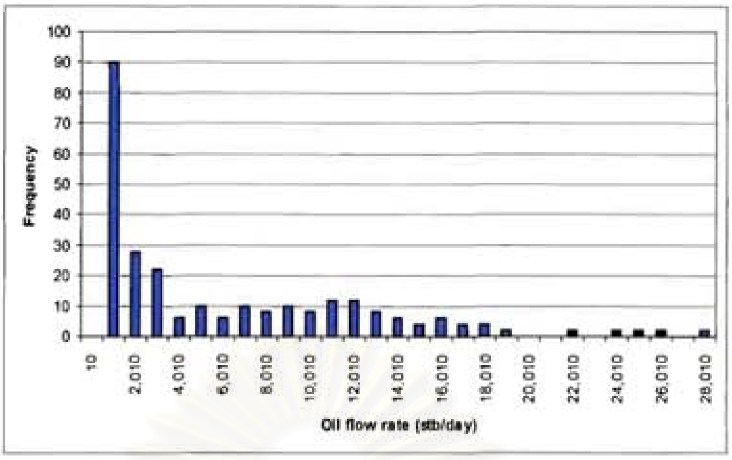


2) Data distribution of validating sets.

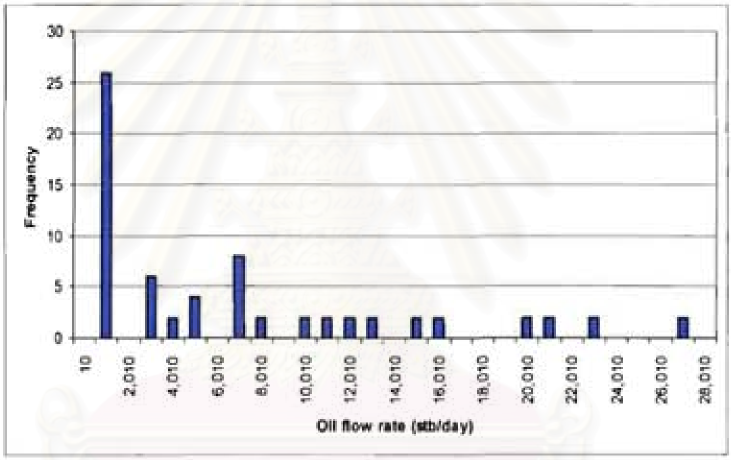


3) Data distribution of testing sets.

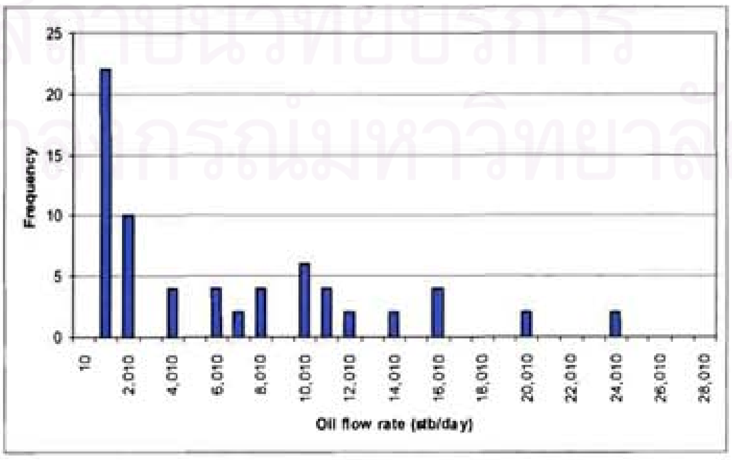
Figure 4.67: Histograms of water cut.



1) Data distribution of training sets.

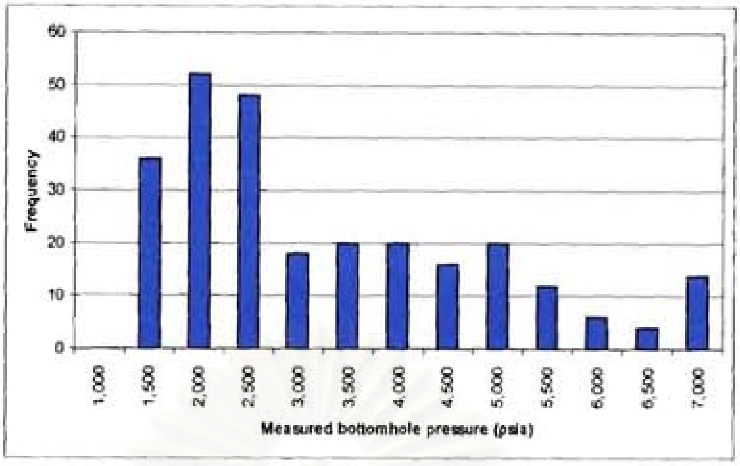


2) Data distribution of validating sets.

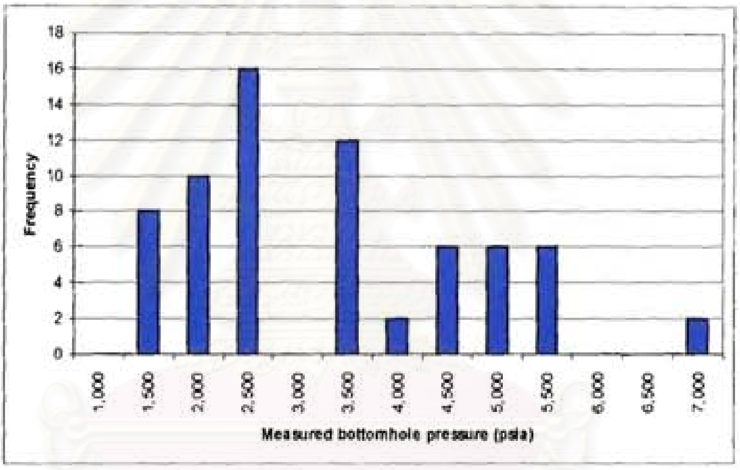


3) Data distribution of testing sets.

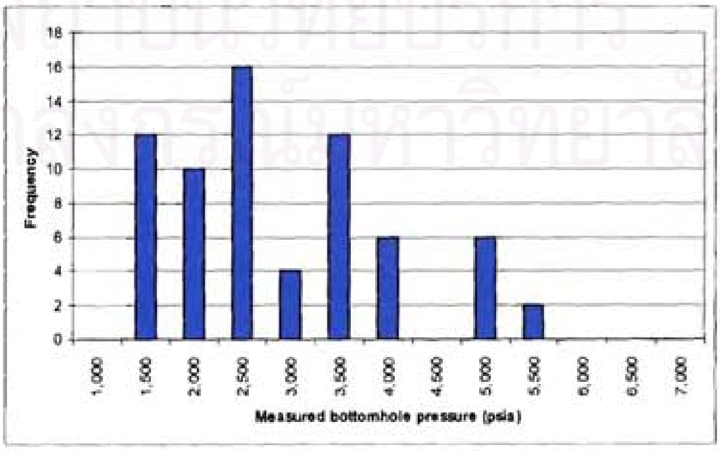
Figure 4.68: Histograms of oil flow rate.



1) Data distribution of training sets.



2) Data distribution of validating sets.



3) Data distribution of testing sets.

Figure 4.69: Histograms of measured bottomhole pressure.

4.5.1 Results and Discussion

The best neural net model (Model number 9) in this case could perform the highest percentage of correct numbers of matches in data set in order to identify the best correlation. Model number 9 yields the highest percentage of correct numbers of matches of 32.35% in testing sets. In this section, we discuss the misidentification as sets of data in details which are represented in ranges of each flow condition. Figure 4.70 shows distribution of the misidentification of testing data. In order to investigate the effect of input parameters to the percentage of correct numbers of matches of the prediction, the percentage of false identification or mismatch as sets of data is calculated for every value of each input and plotted as histogram. The effect of input parameters on the misidentification as sets of data is discussed as follows:

1) Tubing diameter

Figure 4.70 (1) illustrates percentage of match for different tubing diameters. The internal tubing diameters (ID) of the wells used in the testing phase of the neural network are 1.995", 2.441", 2.992", 3.958", 4.892", and 6.184". The tubing diameter of 4.892" has the highest percentage of misidentification. This error may be caused by the least amount of training and validating data sets compared to those for other tubing sizes (8 sets of training and 3 sets of validating as shown in Figure 4.59). Tubing sizes that have the next highest percentage of mismatch are 1.995", 2.441", 2.992", and 6.184" which all have the similar mismatch percentage of 66.67%. Tubing diameter 3.958" has the misidentification of 62.50%. There is no tubing size that has no mismatch in Case 4 (percentage error).

2) Tubing depth

Figure 4.70 (2) shows percentage of false identification for different tubing depths. The tubing depths of the wells used in the testing phase of the neural network are 3,825 to 12,290 feet. The depth of 5,001 to 5,500 feet, 7,001 to 8,000 feet, and

9,501 to 12,000 feet have the highest percentage of misidentification. Tubing depths that have the next highest percentage of mismatch are 4,001 to 5,000 feet and 8,001 to 9,000 feet which have mismatch percentage of 66.67%. The tubing depths that have mismatch of 50% are the depths of 3,825 to 4,000 feet and 6,501 to 7,000 feet. Tubing depth that has mismatch of 33.33% is the depth of 6,001 to 6,500 feet. Tubing depths of 9,001 to 9,500 feet and 12,001 to 12,500 feet have no mismatch at all.

3) Wellhead temperature

Figure 4.70 (3) illustrates percentage of false identification for different wellhead temperatures. The wellhead temperatures of the wells used in the testing phase of the neural network are 75 to 195°F. The temperatures of 86 to 90°F, 101 to 105°F, and 116 to 125°F have the highest percentage of misidentification. Wellhead temperatures that have the next highest percentage of mismatch are 136 to 140°F, 75°F, 106 to 115°F, 126 to 130°F, and 191 to 195°F which have mismatch percentage of 80%, 66.67%, 66.67%, 66.67%, and 50%, respectively. Wellhead temperature that has mismatch of 33.33% is the temperature of 146 to 150°F. Wellhead temperature of 91 to 95°F has no mismatch at all.

4) Bottomhole temperature

Figure 4.70 (4) shows percentage of false identification for different bottomhole temperatures. The bottomhole temperatures of the wells used in the testing phase of the neural network are 150 to 342°F. The bottomhole temperatures of 176 to 185°F, 226 to 235°F, 266 to 275°F, and 306 to 315°F have the highest percentage of misidentification. Bottomhole temperatures that have the next highest percentage of mismatch are 186 to 195°F, 256 to 265°F, 150 to 155°F, 295 to 305°F, and 336 to 345°F which have mismatch percentage of 75%, 71.43%, 66.67%, 50%, and 50%, respectively. Bottomhole temperature of 236 to 245°F has mismatch percentage of 33.33%. Bottomhole temperature of 166 to 175°F has no mismatch at all.

5) Oil gravity

Figure 4.70 (5) shows percentage of false identification for different oil gravities. The oil gravities of the wells used in the testing phase of the neural network are 12.5 to 66.7°API. The oil gravities of 19 to 23°API, 29 to 33°API, 44 to 53°API, and 64 to 68°API have the highest percentage of misidentification. These errors may be caused by the least amount of training and validating data sets compared to those for other oil gravities (5 sets of training, 1 set of validating as shown in Figure 4.63 for oil gravity 19 to 23°API; 5 sets of training, 1 set of validating as shown in Figure 4.63 for oil gravity 29 to 33°API; 7 sets of training, 2 sets of validating as shown in Figure 4.63 for oil gravity 44 to 48°API; 16 sets of training, 7 sets of validating as shown in Figure 4.63 for oil gravity 49 to 53°API; and 2 sets of training, 0 sets of validating as shown in Figure 4.63 for oil gravity 64 to 68°API). Oil gravities that have the next highest percentage of mismatch are 14 to 18°API, 34 to 38°API, 12.5 to 13°API, and 39 to 43°API which have mismatch percentage of 75%, 70%, 66.67%, and 50%, respectively. Oil gravity of 54 to 63°API has no mismatch at all.

6) Gas specific gravity

Figure 4.70 (6) shows percentage of false identification for different gas specific gravities. The gas specific gravities of the wells used in the testing phase of the neural network are 0.65 to 1.12 (air=1). The gas specific gravity of 0.91 to 1.0 has the highest percentage of misidentification. Gas specific gravities that have the next highest percentage of mismatch are 0.65 to 0.7, 0.81 to 0.9, 1.11 to 1.2, 0.71 to 0.8, and 1.01 to 1.1 which have mismatch percentage of 83.33%, 75%, 66.67%, 57.14%, and 50%, respectively. There is no gas specific gravity that has no mismatch in Case 4 (percentage error).

7) Wellhead pressure

Figure 4.70 (7) illustrates percentage of false identification for different wellhead pressures. The wellhead pressures of the wells use in the testing phase of the neural network are 145 to 3,364.7 psia. The wellhead pressures of 891 to 1,090 psia, 1,491 to 2,090 psia, and 3,291 to 3,490 psia have the highest percentage of misidentification. Wellhead pressures that have the next highest percentage of mismatch are 291 to 490 psia, 691 to 890 psia, 1,091 to 1,291 psia, and 145 to 290 psia which have mismatch percentage of 71.43%, 66.67%, 66.67%, and 62.50%. Wellhead pressure of 491 to 690 psia has percentage of misidentification of 50%. Wellhead pressures of 1,291 to 1,490 psia and 2,091 to 2,290 psia have no mismatch at all.

8) Gas oil ratio

Figure 4.70 (8) shows percentage of false identification for different gas oil ratios. The gas oil ratios of the wells used in the testing phase of the neural network are 192 to 3,588 scf/stb. The gas oil ratios of 1,601 to 2,100 scf/stb and 2,601 to 3,100 scf/stb have the highest percentage of misidentification. These errors may be caused by the least amount of training and validating data sets compared to those for other gas oil ratios (3 sets of training, 2 set of validating as shown in Figure 4.66 for gas oil ratio 1,601 to 2,100 scf/stb and 5 sets of training, 4 set of validating as shown in Figure 4.66 for gas oil ratio 2,601 to 3,100 scf/stb). Gas oil ratios that have the next highest percentage of mismatch are 601 to 1,100 scf/stb, 192 to 600 scf/stb, 1,101 to 1,600 scf/stb, and 3,101 to 3,600 scf/stb which have the mismatch percentage of 70%, 66.67%, 60%, and 50%, respectively. There is no gas oil ratio that has no mismatch in Case 4 (percentage error).

9) Water cut

Figure 4.70 (9) illustrates percentage of false identification for different water cuts. The water cuts of the wells used in the testing phase of the neural network are 0 to 20%. The water cut of 0% has the highest percentage of misidentification. Water cut of 11 to 20% has no misidentification at all.

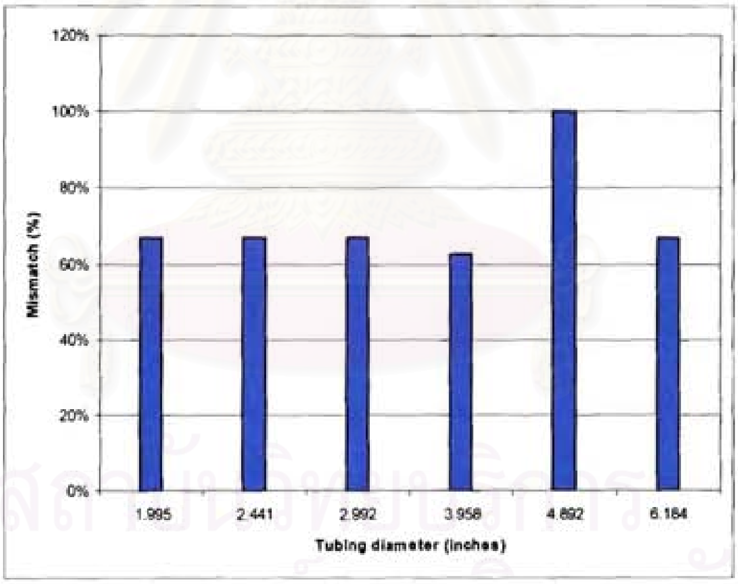
10) Oil flow rate

Figure 4.70 (10) shows percentage of false identification for different oil flow rates. The oil flow rates of the wells used in the testing phase of the neural network are 44 to 23,540 stb/day. The oil flow rates of 3,011 to 4,010 stb/day, 6,011 to 8,010 scf/day, 11,011 to 12,010 stb/day, and 15,011 to 16,010 stb/day have the highest percentage of misidentification. These errors may be caused by the least amount of training and validating data sets compared to those for other oil flow rates (3 sets of training, 1 set of validating as shown in Figure 4.68 for oil flow rate 3,011 to 4,010 stb/day; 5 sets of training, 4 set of validating as shown in Figure 4.68 for oil flow rate 6,011 to 7,010 stb/day; 4 sets of training, 1 set of validating as shown in Figure 4.68 for oil flow rate 7,011 to 8,010 stb/day; 6 sets of training, 1 set of validating as shown in Figure 4.68 for oil flow rate 11,011 to 12,010 stb/day; and 3 sets of training, 1 set of validating as shown in Figure 4.68 for oil flow rate 15,011 to 16,010 stb/day). Oil flow rates that have the next highest percentage of mismatch are 44 to 1,010 stb/day, 9,011 to 10,010 stb/day, 1,011 to 2,010 stb/day which have mismatch percentage of 72.73%, 66.67%, and 60%, respectively. Oil flow rates of 5,011 to 6,010 stb/day and 10,011 to 11,010 stb/day which all have similar mismatch percentage of 50%. Oil flow rates of 13,011 to 14,010 stb/day and 19,011 to 23,540 stb/day have no mismatch at all.

11) Measure bottomhole pressure

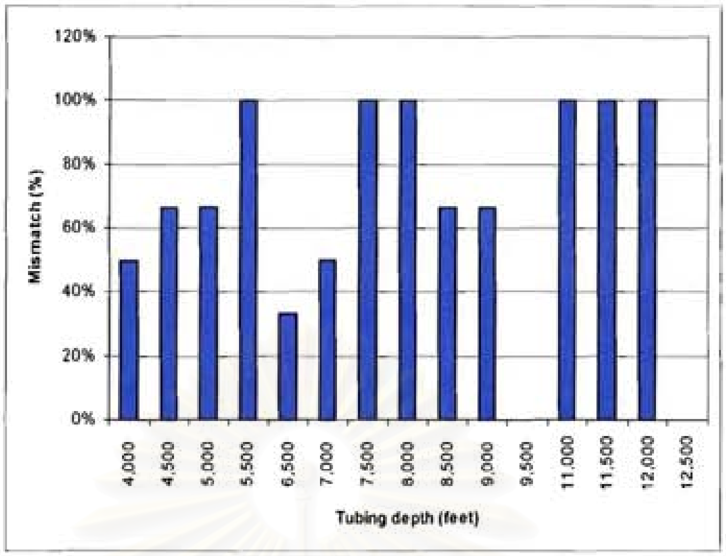
Figure 4.70 (11) illustrates percentage of false identification for different measured bottomhole pressures. The measured bottomhole pressures of the wells used in the training phase of the neural network are 1,165 to 5,319 psia. The measured bottomhole pressures of 1,501 to 2,000, 3,001 to 3,500 psia, and 5,001 to 5,319 psia have the highest percentage of misidentification. The pressures that have the next highest percentage of mismatch are 3,501 to 4,000 psia, 1,165 to 1,500 psia, 2,001 to 3,000 psia which have mismatch percentage of 66.67%, 50%, and 50%, respectively. Measured bottom hole pressures of 4,501 to 5,000 psia has percentage of mismatch of 33.33%. There is no measured bottom hole pressure that has no mismatch in Case 4 (percentage error).

In summary, the main reason for false identification or mismatch is lack of data in the training and validating phase of the neural network.

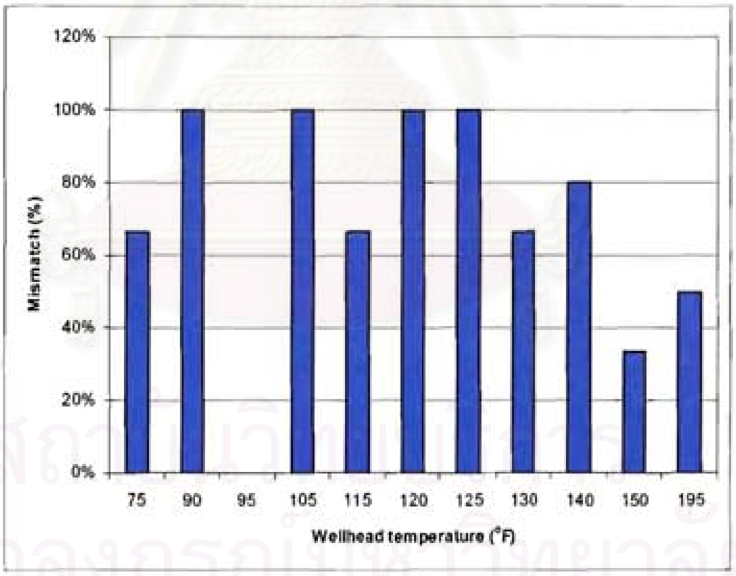


1) Percentage of false identification for different tubing diameters.

Figure 4.70: Mismatch histograms for Case 4.

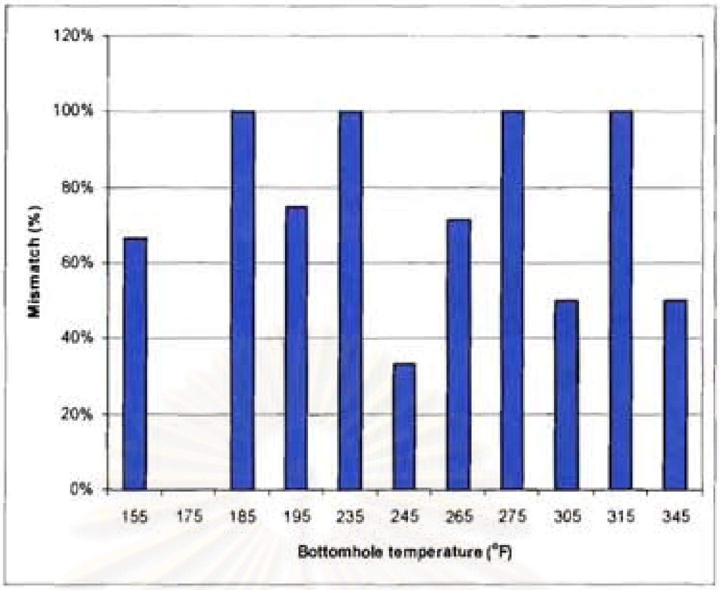


2) Percentage of false identification for different tubing depths.

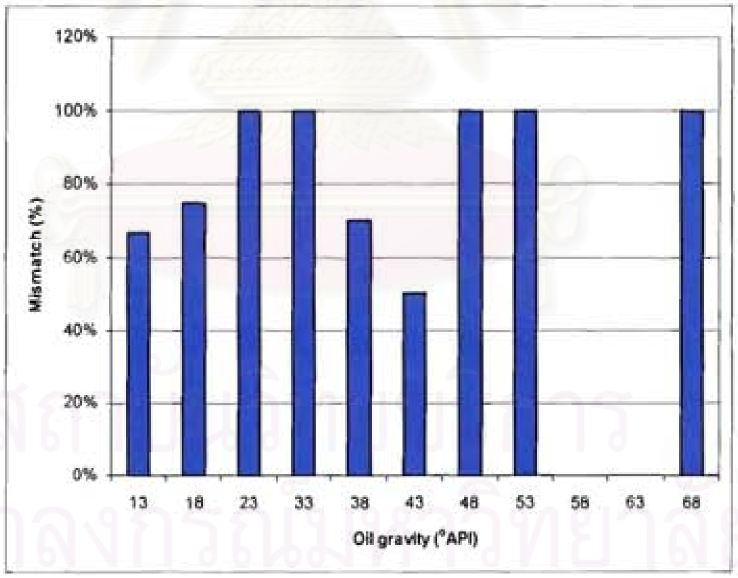


3) Percentage of false identification for different wellhead temperatures.

Figure 4.70: Mismatch histograms for Case 4 (continued).

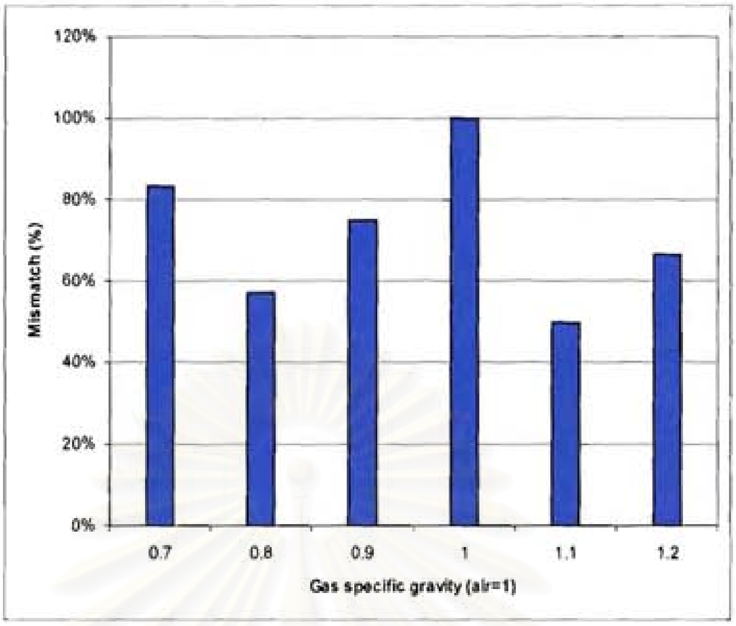


4) Percentage of false identification for different bottomhole temperatures.

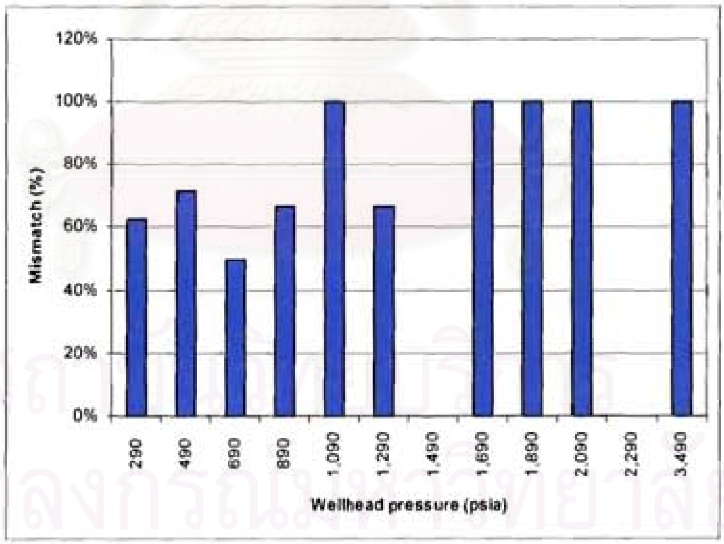


5) Percentage of false identification for different oil gravities.

Figure 4.70: Mismatch histograms for Case 4 (continued).

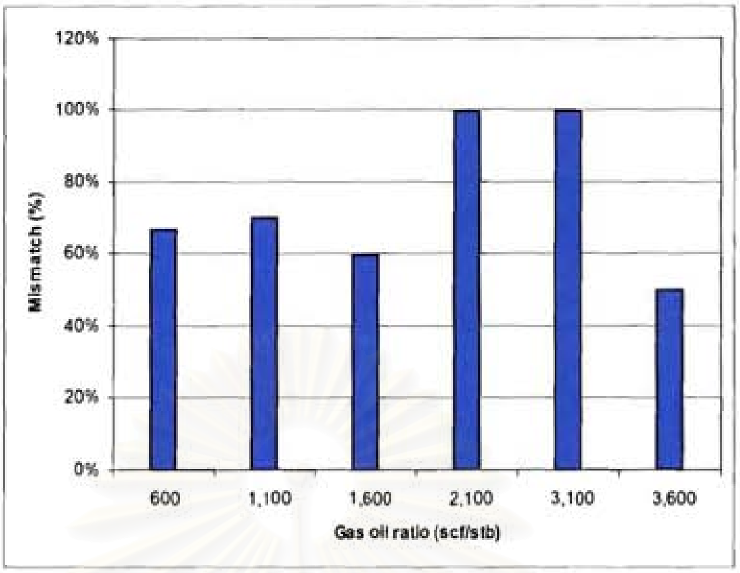


6) Percentage of false identification for different gas specific gravities.

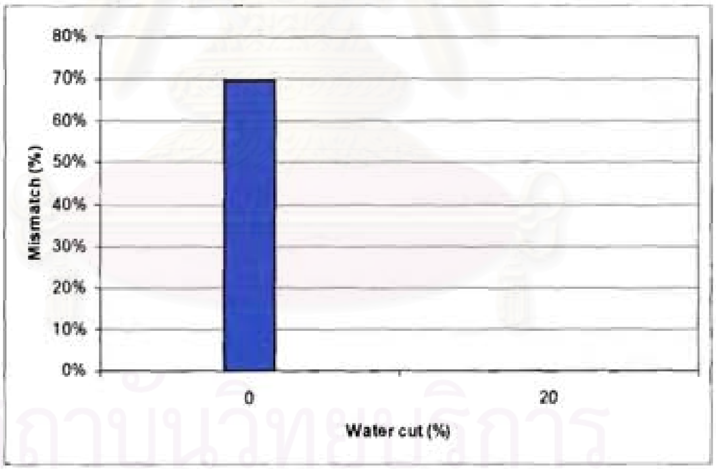


7) Percentage of false identification for different wellhead pressures.

Figure 4.70: Mismatch histograms for Case 4 (continued).

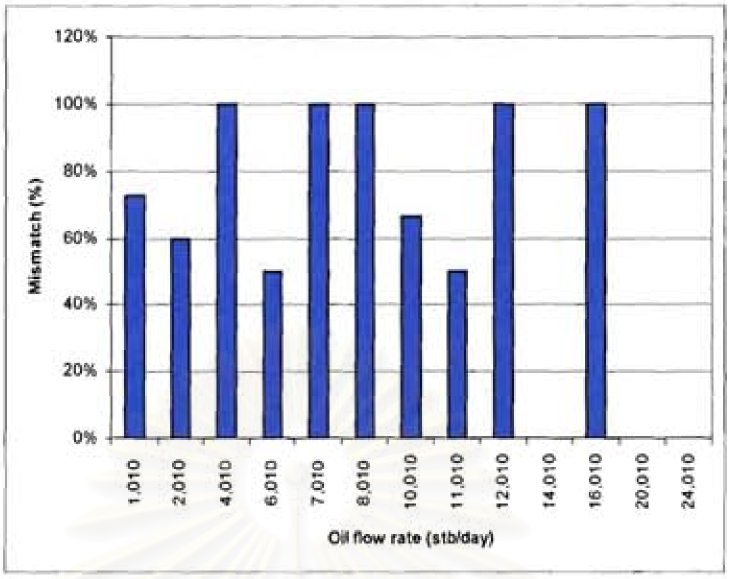


8) Percentage of false identification for different gas oil ratios.

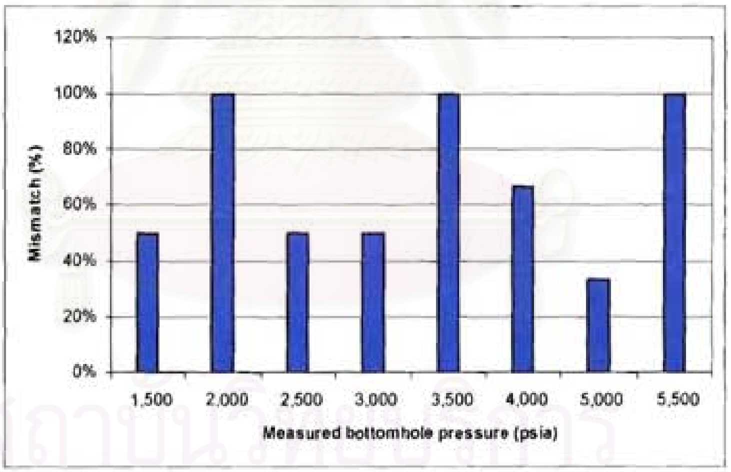


9) Percentage of false identification for different water cuts.

Figure 4.70: Mismatch histograms for Case 4 (continued).



10) Percentage of false identification for different oil flow rates.



11) Percentage of false identification for different measured bottom hole pressures.

Figure 4.70: Mismatch histograms for Case 4 (continued).

In this chapter, we compared the performance of the chosen neural networks among the four cases which calculated the difference between measured and computed outputs of each correlation from the neural networks. The difference was calculated as percentage of mismatch in testing data set. Table 4.17 shows the differences and mismatches in testing data sets for the chosen models of Case 1, 2, and 3. Model number 10 of Case 1 (20% maximum error) yields the lowest difference of 17.23% in testing set of data. The second best model is Model number 10 of Case 3: (best correlation) which has difference of 20.59%. Model number 14 of Case 2 (10% maximum error) has difference of 26.47%. Neural networks in Case 3 and 4 have the similar purpose of predicting the best correlation for given conditions. Therefore, performance of neural networks in Case 3 and 4 should be computed the percentage of correct numbers of matches of testing set. Table 4.18 shows percentage of correct numbers of matches of Case 3 and 4.

Table 4.17: Difference of prediction of the chosen neural networks.

Neural network case No.	Model No. in case	Number of nodes		Number of mismatches	Difference
		Hidden layer 1	Hidden layer 2		
Case 1: (20% maximum error)	10	50	0	41	17.23%
Case 2: (10% maximum error)	14	30	10	63	26.47%
Case 3: (best correlation)	10	40	20	49	20.59%

Table 4.18: Percentage of correct numbers of matches in set of testing data.

Neural network case No.	Model No. in case	Number of nodes		Number of data sets that match in the best correlation	Percentage of correct numbers of matches
		Hidden layer 1	Hidden layer 2		
Case 3: (best correlation)	10	40	20	10	29.41%
Case 4: (percentage error)	9	40	17	11	32.35%

For Model number 9 of Case 4, the errors between measured and computed outputs were calculated. Table 4.19 shows the average percentage of absolute difference between predicted error and calculated error of Model number 9 of Case 4. As seen in the table, the difference is quite small. Therefore, we should use this neural network to predict error obtained under given flow conditions for each correlation and let the users choose the best correlation themselves.

Table 4.19: Average percentage of absolute difference between predicted error and computed error of Model number 9 of Case 4.

Neural network case No.	Model No. in case	Difference in sets of data		
		Training	Validating	Testing
Case 4: percentage error	9	1.27%	10.02%	7.84%

In comparison among the chosen neural networks of the four cases, neural networks of Case 1 and 2 have the difference from Table 4.17 of 17.23% and 26.47%, respectively; neural networks of Case 3 and 4 have percentage of correct numbers of matches from Table 4.18 of 29.14% and 32.35%, respectively. Although the model in Case 1 has the best performance in identifying multiphase flow correlations that have a maximum error of 20%, the level of error is still high. Therefore, the neural network for this case should not be chosen. The neural networks of Case 2 which identify multiphase flow correlations that have a maximum error 10% for given flow conditions should be chosen. In addition to select appropriate correlation, the neural networks of Case 4 which identify percentage of error of each correlation should be the chosen networks as Case 2. Therefore, the user can select the correlation which provides the lowest percentage or acceptable error for given well conditions.

The neural network of Case 2 and Case 4 should be chosen in order to represent as an intelligent system to recommend appropriate correlations for vertical multiphase flow.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

This thesis used artificial neural networks to propose vertical multiphase flow correlations having certain level of accuracy as well as the best vertical multiphase flow correlations. To develop the neural networks, four main steps were followed: (1) determine inputs and outputs of the neural network model, (2) screen data before using them for neural network, (3) develop procedures to train neural networks, and (4) investigate the effect of inputs to accuracy of prediction.

In the first step, inputs and outputs of neural networks were specified. The inputs are 11 flow parameters: tubing diameter (inside diameter), tubing depth, wellhead temperature (WHT), bottomhole temperature (BHT), oil density, gas specific gravity, wellhead pressure (WHP), gas oil ratio (GOR), water cut, oil flow rate, and measured bottomhole pressure (BHP). These variables were obtained from five published SPE papers. The outputs are commonly used vertical multiphase flow correlations in petroleum fields which are Duns and Ros (original), Duns and Ros (modified), Hagedorn and Brown, Fancher and Brown, Mukherjee and Brill, Beggs and Brill, and Orkiszewski.

The next step is to screen the data before using them to develop the neural networks. Data obtained from the published papers were plotted as histograms in order to observe the distribution of each variable. If any data values are not in the majority range, the data were removed. Seven out of 208 sets of data were eliminated in the screening process. Therefore, only 201 sets were used for the development.

Neural networks used 201 sets of data directly as input. Outputs of neural networks are the level of accuracies of vertical multiphase flow correlations. *PROSPER* software was used to compute the bottomhole pressure for each correlation and then the results of pressure were compared with measured bottomhole pressure. The difference between computed and measured bottomhole pressure was calculated in percentage. In Case 1, 2, and 3; the deviation was transformed to binary numbers based on level of accuracy. In Case 4, we used percentage of error of each correlation directly as outputs of the neural networks. Trial and error was performed in order to seek the model which yields an average error less than 1% in the training for Case 1, 2, and 3. Neural networks in Case 4 were tried until the model yields an average error less than 0.1% in the training. The numbers of hidden layers, hidden neurons, the learning rate, and momentum were tried until achieving the criterion. If there is more than one converged model, the best model which is the most accurate in prediction with testing would be chosen.

In order to choose the best performer in Case 1 and 2, the errors based on incapability to identify correct correlation(s) which we called "mismatches" were computed for all the models and then compared. The model with the lowest number of mismatches was chosen as the most appropriate neural network. In order to determine the mismatch, the computed outputs from the neural network were transformed to either 0 or 1. If the activation level of the output node was lower than 0.7, the output was considered having a value of 0. Otherwise, the output was considered having a value of 1. The mismatch is the difference between the binary numbers of actual and calculated outputs. The total numbers of mismatches for all the models were compared, and the model that has the lowest number of mismatches in the testing data set would be chosen.

In order to choose the best performer in Case 3 and 4, the percentage of correct numbers of matches was computed for all sets of testing data and compared. The model with the highest number of data set that neural network predict the same best correlation as actual output was chosen as the most appropriate neural network.

Next, the chosen neural networks were investigated for the effect of input parameters to the accuracy of the prediction. The percentage of false identification or mismatch is calculated for every value of each input and plotted as histogram. Therefore, we can use the neural networks with care since we know the range of input that will yields high error.

The neural networks could be categorized into four cases as follows:

- Case 1: 20% maximum error
- Case 2: 10% maximum error
- Case 3: best correlation
- Case 4: percentage error

After experimenting neural networks with the testing set of data, model of Case 1 (20% maximum error) yields the lowest difference of 17.23% in the testing set of data.

The second best model is Case 2: (10% maximum error) which has the difference of 26.47%. The third best model is Case 4: (percentage error) which has percentage of correct numbers of matches of 32.35%. The worst one in this study is Case 3 (best correlation) which has percentage of numbers of matches of 29.41%.

Although the model in Case 1 has the best performance in identifying multiphase flow correlations that have a maximum error of 20%, the level of error is still high. Therefore, the neural network for this case should not be chosen. The neural networks of Case 2 which identify multiphase flow correlations that have a maximum error 10% and the neural networks of Case 4 which identify percentage of error for each correlation for given flow conditions should be chosen to use in application of pressure loss calculation in tubing.

In order to verify prediction accuracy of the neural networks, we investigated false identification based on each flow variable. Several remarks in using the neural network can be made as follows:

1) Flow variables which are measurement data obtained from the SPE papers have wide ranges of values but low quantity of data exists in certain ranges of variables. Therefore, high prediction error may be caused by limited amount of training data on those ranges.
2) Histogram of mismatch shows the percentage of false identification of prediction performed by the neural network. The histogram demonstrates the effect of flow conditions to the accuracy of the prediction. Before performing prediction with new flow conditions, individual range of variable should be checked with histograms in order to estimate the prediction error.
3) The amount of data for neural network development is limited. The accuracy of the neural network increases as more data are incorporated into the training process. Thus, with additional data, the neural network can adapt to make more accurate prediction over a wider range of flow conditions. Moreover, the additional data could be directly incorporated with the present training data, and the training process can be continued from the current step.
4) The advantage of neural network is to compute the prediction in a very short period of time. Although the training itself takes a very long time, the identification takes only fractions of a second.

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APPENDICES

APPENDIX A

Details of 208 sets of data obtained from the five published SPE papers

Data set No.	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)
1	1.995	7450	75	189	54	0.752	1645	3393	0	82	3300
2	1.995	7350	75	189	54	0.752	1635	3393	0	125	3290
3	1.995	9620	75	189	54	0.752	1455	3393	0	480	3365
4	1.995	7850	75	189	38.8	0.9349	990	1019	0	187	3190
5	1.995	6550	75	189	42	0.8225	985	1245	0	167	2665
6	1.995	6570	75	189	42	0.8225	665	1245	0	138	2555
7	1.995	7800	75	189	42.6	0.84	1261	1747	0	168	3141
8	1.995	8070	75	189	42.6	0.84	1229	1747	0	259.2	3199
9	1.995	8000	75	189	42.6	0.84	1221	1747	0	91.2	3251
10	1.995	8480	75	189	43.9	0.8287	1665	3588	0	131	3260
11	1.995	4410	75	189	41.3	1.048	145	192	0	245.3	1419
12	1.995	3000	75	189	41.3	1.048	175	189	0	160.3	1083
13	1.995	4410	75	189	41.3	1.048	105	230	0	392.4	1229
14	1.995	3363	86	168.8	15.6	0.78	199.7	944.7	60.4	42.6096	1485.3
15	1.995	3395.7	86	172.4	15.6	0.68	193.8	787.6	51	41.013	1509.9
16	1.995	3362.9	86	168.8	15.6	0.78	250.6	7029.3	56	14.652	1506.7
17	1.995	3395	86	158	15.6	0.62	107.2	2475.1	14	12.986	1513.8
18	1.995	3313.6	86	167	15.6	0.67	157	692.8	25	16.05	1458.4
19	1.995	3346.6	86	172.4	15.6	0.72	356.1	889.2	4.4	101.6228	1505.3
20	2.441	9592	75	189	50.8	0.68	2360	3640	0	244.8	4090
21	2.441	10683	75	189	47.6	0.742	1784	2151	0	313.2	4315
22	2.441	10800	75	189	44.4	0.796	1264	2250	0	60	3835
23	2.441	6500	75	189	36.2	0.8225	555	906	0	60	2325

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Data set No.	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)
24	2.441	6500	75	189	36.2	0.8225	455	906	0	106	1635
25	2.441	12861.5	90	200	37	0.7	1579.2	5160.2	0	188.7	4005.6
26	2.441	12861.5	90	200	37	0.7	1294.7	3762	0	283	4049.7
27	2.441	12795.9	90	200	37	0.7	1993.1	2650.3	0	364.8	5032.5
28	2.441	7054.1	107.6	176	32.8	0.7	1003.2	774.9	0	4075	3236.2
29	2.441	8038.4	92.1	167	40.3	0.75	1387.2	942.2	0	191.9	3588.9
30	2.441	10532	93.2	232.1	46	0.71	2270.5	2271.8	0	439.7	4654.2
31	2.441	7579.1	138.9	187.9	19.2	0.71	444.2	509.8	0	6868.7	3264.6
32	2.441	8760.3	104	198.5	25	0.57	128.5	381.8	0	353.5	2819.4
33	2.441	7578.7	118.94	186.8	19.2	0.708	815	512.4	0	3834.3	3444.7
34	2.441	7578.7	132.8	187.88	19.2	0.708	563.2	512.4	0	4226.75	3294
35	2.441	7578.7	138.92	187.88	19.2	0.708	429.5	512.4	0	6868.47	3249.9
36	2.441	8759.8	104	198.5	25	0.571	113.8	383.7	0	255.366	2762.1
37	2.441	8759.8	104	198.5	25	0.571	113.8	383.7	0	353.487	2804.7
38	2.441	7647.6	107.6	192.2	32.2	0.92	1564.5	858.4	0	2616.56	3955.3
39	2.441	7053.8	105.8	176	32.8	0.701	896	744.9	0	2203.95	2972.6
40	2.441	7053.8	107.6	176	32.8	0.701	988.5	756.2	0	3607.84	3164.6
41	2.441	7053.8	107.6	176	32.8	0.701	988.5	778.8	0	4075.8	3221.5
42	2.441	8038.1	92.12	167	40.3	0.75	1372.5	947	0	191.84	3574.2
43	2.441	8038.1	89.6	167	40.3	0.75	1344.1	947	0	330.84	3508.8
44	2.441	8038.1	89.42	167	40.3	0.75	1308.5	947	0	480.54	3436.2
45	2.441	8038.1	98.6	167	40.3	0.75	1173.4	947	0	1125.88	3227.1
46	2.441	10531.5	93.2	232.16	46	0.71	2193.1	2283.3	0	215.74	4640.9
47	2.441	10531.5	93.2	232.16	46	0.71	2255.7	2283.3	0	439.66	4639.5
48	2.441	3346.6	86	167	16.6	0.67	346.1	580.6	23	152.075	1488.1
49	2.441	3346.6	86	168	16.6	0.78	192.5	747.8	9	160.251	1448.6
50	2.441	3379.3	86	172.4	16.67	0.72	225.2	1437.3	1.4	71.978	1512.4

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Data set No.	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)
51	2.441	4625.9	104	183.2	31.2	0.79	1153.9	9798.4	28	142.2	1854.8
52	2.441	4445.7	104	185	14.48	0.6	289.2	283.3	24	172.064	1988.9
53	2.441	8465	90	200	37	0.7	294.9	252.7	50	148.5	3355.6
54	2.441	10007	90	200	37	0.7	606.4	505.3	10	446.04	3745.3
55	2.441	6102.7	90	264	37	0.65	228	701.9	0	36	2253.4
56	2.441	6102.7	90	264	37	0.65	811.2	2027	0	15	2860.7
57	2.441	5249.6	90	264	37	0.65	441.4	606.4	0	44	1974.6
58	2.764	10039	134	320	50.37661	0.7	1620	1116.6	0	10872	6695
59	2.764	13477	135	301	52.98501	0.71	1540	2717.4	0	1104	5840
60	2.764	13477	130	289	52.26623	0.71	2130	3086.3	0	823	6045
61	2.764	11303	103.5	237.5	45.59637	0.667	575	2750	0	720	1400
62	2.764	10876	139	308	66.67927	0.685	3940	2303.4	0	4272	6729
63	2.992	3825	126	150	15.1	0.75	564.65	765	0	1065	1214.7
64	2.992	3940	126	150	14.6	0.75	164.65	252	0	1300	1014.7
65	2.992	3800	126	150	14.4	0.75	714.65	1430	0	3166	1264.7
66	2.992	3720	126	150	14.4	0.75	314.65	232	0	1965	1214.7
67	2.992	4240	126	150	15.6	0.75	714.65	957	0	1165	1564.7
68	2.992	4570	126	150	13.5	0.75	864.65	1500	0	1965	1514.7
69	2.992	4175	126	150	15.6	0.75	314.65	267	0	2700	1514.7
70	2.992	4355	126	150	12.9	0.75	264.65	185	0	855	1714.7
71	2.992	4670	126	150	13.6	0.75	924.65	1565	0	2320	1664.7
72	2.992	4575	126	150	18.6	0.75	664.65	858	0	2480	1564.7
73	2.992	4400	126	150	18.6	0.75	414.65	472	0	1040	1364.7
74	2.992	4065	126	150	13	0.75	514.65	341	0	1490	1564.7
75	2.992	3705	126	150	13.6	0.75	514.65	335	0	1310	1464.7

Data set No.	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)
76	2.992	4160	126	150	12.9	0.75	164.65	185	0	1350	1514.7
77	2.992	4210	126	150	16	0.75	364.65	222	0	788	1764.7
78	2.992	4487	126	150	14.1	0.75	594.65	962	0	1905	1314.7
79	2.992	4766	126	150	13.3	0.75	264.65	193	0	967	1564.7
80	2.992	4505	126	150	12.5	0.75	264.65	385	0	1040	1364.7
81	2.992	4692	126	150	12.9	0.75	414.65	865	0	1585	1164.7
82	2.992	3924	126	150	18.7	0.75	714.65	575	0	1850	1514.7
83	2.992	4240	126	150	15.6	0.75	714.7	957.4	0	1165	1564.7
84	2.992	4175.1	126	150	15.6	0.75	314.7	267.3	0	2700	1514.7
85	2.992	4210	126	150	16	0.75	364.7	223.3	0	788	1764.7
86	2.992	4691.8	126	150	12.9	0.75	414.7	865.8	0	1585	1164.7
87	2.992	7647.64	104	185	31.3	0.92	1587.26	920.43	0	534.63	3850.09
88	2.992	7647.64	104	185	31.3	0.92	1322.71	901.81	0	2654.3	3555.7
89	2.992	3182.5	86	158	17.05	0.69	250.1	989	14	182.32	1390.2
90	2.992	3182.4	86	158	17.05	0.69	181.8	745	7	267.282	1287.7
91	2.992	3346.6	86	158	17.05	0.69	184	1243.2	24	120.004	1465.5
92	2.992	539.7	195	237	39.25	0.75	1284.7	550.3	0	9792	1914.89
93	2.992	4101.3	195	237	39.25	0.75	1284.7	3773.3	0	278	1731.1
94	2.992	4101.3	195	237	39.25	0.75	724.7	3077	0	548	1056.7
95	2.992	4521.2	195	237	39.25	0.75	989.7	6081	0	1555	1490
96	2.992	4921.5	195	230	37.31	0.75	764.7	381.8	0	7226	1976.5
97	2.992	6411.1	200	236.5	38.72	0.75	589.7	651.3	0	5809	1937.6
98	2.992	5800.8	150	235	38.69	0.75	724.7	1207.2	0	6538	1870.7
99	2.992	3948.5	150	235	38.69	0.75	482.7	1021.9	0	213	1178.7
100	2.992	6402	130	236	39	0.75	548.7	746.8	0	943	1568.7

Data set No.	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)
101	2.992	6105.7	130	236	39	0.75	554.7	797.3	0	2482	1319.5
102	2.992	6496.5	130	236	39	0.75	514.7	387.4	0	4286	1562.6
103	2.992	6069.8	130	236	38.72	0.75	414.7	555.9	0	6037	1663.7
104	2.992	6512.8	150	236	38.72	0.75	374.7	589.6	0	2306	1099.7
105	2.992	5006.1	195	237	39.25	0.75	1164.7	5317.4	35.5	655.32	1631.7
106	2.992	6001.7	150	236	38.72	0.75	469.7	589.6	20	5401.6	2030.4
107	2.992	7169.1	160	236	37.62	0.87	202.7	426.7	18	291.1	1754.6
108	3.958	9746	124	306	51.55304	0.7	3314.65	1473.624	0	15696	6516.7
109	3.958	10049	140	337	51.79016	0.7	1289.65	1286.692	0	16080	4281.7
110	3.958	10947	145	321	54.43955	0.7	1084.65	1177.439	0	13368	3686.7
111	3.958	10947	140	304	51.31654	0.7	2014.65	1129.787	0	9400	4662.7
112	3.958	10083	130	286	50.14313	0.7	3684.65	1592.631	0	11616	6509.7
113	3.958	10456	112	270	49.67798	0.844	2274.65	1387.795	0	6096	4223.7
114	3.958	12290	140	305	53.95216	0.7	2141.65	1538.769	0	10008	4645.7
115	3.958	9902	119	280	51.31654	0.7	3744.65	1339.114	0	12456	6570.7
116	3.958	10239	140	300	51.08065	0.7	2814.65	1470.307	0	12528	5598.7
117	3.958	9650	120	306	50.61068	0.7	1941.65	1764.671	0	17040	4862.7
118	3.958	8045	119	269	35.56021	1.1	150.65	322.9485	0	7190	2067.7
119	3.958	8715	119	269	35.56021	1.1	213.65	323.1173	0	2284	2211.7
120	3.958	8600	119	269	35.56021	1.1	168.65	322.9358	0	6540	2096.7
121	3.958	9459	119	269	35.56021	1.1	294.65	323.0053	0	7520	2248.7
122	3.958	10289	119	269	35.56021	1.1	230.65	323.0479	0	7940	2340.7
123	3.958	7900	119	269	35.56021	1.1	202.65	323.012	0	8300	2094.7
124	3.958	8560	115	262	36.55226	1.122	204.65	336.7797	0	11800	2400.7
125	3.958	12249	105	245	47.84094	0.7	1439.65	941.5064	0	2496	3543.7

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Data set No.	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)
126	3.958	10984	140	316	49.67798	0.7	2504.65	990.8027	0	14352	5491.7
127	3.958	12062	138	330	50.14313	0.7	1548.65	1200.441	0	10896	4216.7
128	3.958	11305	136	330	50.14313	0.7	2964.65	1068.405	0	8976	5729.7
129	3.958	11290	124	311	49.91026	0.7	1763.65	965.2972	0	7521	3852.7
130	3.958	11929	140	310	51.08065	0.7	1194.65	1340.326	0	10296	3423.7
131	3.958	14322	114	260	40.64112	0.7	714.65	531.4885	0	3144	2466.7
132	3.958	14330	138	320	43.62376	0.7	664.65	1024.829	0	3504	1872.7
133	3.958	12152	148	336	56.66489	0.72	1184.65	3511.795	0	13056	4625.7
134	3.958	11248	137	337	57.41856	0.72	2599.65	4823.413	0	10080	5303.7
135	3.958	12165	122	310	48.75478	0.7	1589.65	522.9767	0	5832	3631.7
136	3.958	12171	133	334	48.52545	0.72	834.65	1810.195	0	11496	3217.7
137	3.958	13658	160	360	45.59637	0.7	1719.65	1151.079	0	4726	4273.7
138	3.958	12916	120	271	49.67798	0.7	2664.65	1146.368	0	9360	4958.7
139	3.958	12938	130	378	47.61392	0.72	1274.65	1621.819	0	17838	4937.7
140	3.958	9928	120	342	62.33562	0.72	1514.65	3615.565	0	15342	4761.7
141	3.958	9928	120	345	56.66489	0.72	3804.65	4059.934	0	4872	5300.7
142	3.958	9928	120	350	57.41856	0.72	3604.65	3922.005	0	6744	5239.7
143	3.958	9930	120	345	47.84094	0.72	814.65	1597.298	0	11845	2887.7
144	3.958	10318	132	320	49.44629	0.7	2749.65	1156.627	0	9960	5214.7
145	3.958	10336	140	342	52.02789	0.72	1164.65	3335.375	0	14697	4562.7
146	3.958	10158	133	320	54.92951	0.72	3864.65	3139.535	0	11352	5492.7
147	3.958	10158	134	320	53.95216	0.72	2694.65	3064.738	0	11616	5493.7
148	3.958	10202	140	304	48.52545	0.7	1838.65	455.2469	0	6480	3957.7
149	3.958	10218	140	310	56.16578	0.806	1128.65	4065.193	0	11719	3827.7
150	3.958	11400	140	342	50.37661	0.7	1914.65	776.4824	0	13896	5000.7

Data set No.	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)
151	3.958	10945	130	320	52.02789	0.72	844.65	3153.837	0	8171	2770.7
152	3.958	10356	128	320	59.97497	0.716	4274.65	2707.028	0	8936	6632.7
153	3.958	10356	128	332	87.2017	0.691	2223.65	5928.862	0	4920	3752.7
154	3.958	10661	125	332	60.75543	0.715	4048.65	2921.411	0	8958	6483.7
155	3.958	10661	108	260	49.44629	0.702	1134.65	2674.021	0	2629	2178.7
156	3.958	10059	140	310	67.51547	0.702	4431.65	3698.454	0	9312	6905.7
157	3.958	10059	125	334	71.51291	0.49	4336.65	3687.601	0	9936	6870.7
158	3.958	6234.9	195	235.4	37.31	0.75	794.7	471.7	0	10367	2013
159	3.958	6233.9	195	235.4	37.31	0.75	771.7	516.6	0	11111	1977
160	3.958	6480	195	235.4	37.31	0.75	719.7	527.8	0	10845	2023
161	3.958	6447.2	195	235.4	37.31	0.75	591.7	516.6	0	3356	1546.5
162	3.958	6501.8	126.3	238.1	37.6	0.75	464.7	550.3	0	2436.5	1385.7
163	3.958	6250.3	128	234.9	36.33	0.75	384.7	589.6	0	2845	1201.3
164	4.892	10171.1	80.6	190.4	16.7	0.7	235.2	509.8	0	5222.6	4581.7
165	4.892	10847	157	348	69.78023	0.72	2177.7	5525.8	0	10080	4149.7
166	4.892	10838	140	342	66.67927	0.7	3364.7	3091.8	0	9024	5318.7
167	4.892	10826.8	117.5	224.6	8.3	1.705	223.297	146.163	0.3	522.05	4758.93
168	4.892	10826.8	134.6	228.2	8.3	1.705	209.074	146.163	0.15	930.89	4763.19
169	4.892	10498.7	68	194	9	1.567	99.56	129.232	0.2	44.03	4164.4
170	4.892	10498.7	89.6	195.8	9	1.567	164.984	129.232	0.5	924.6	4473.05
171	4.892	10170.6	80.6	190.4	11.8	0.938	220.45	168.736	0.1	144.67	4566.92
172	4.892	10170.6	84.2	192.2	11.8	0.938	524.82	168.736	0.1	836.55	4475.89
173	4.892	10170.6	104	222.8	12.5	1.268	570.33	211.625	0.1	761.07	4521.4
174	4.892	10170.6	136.4	226.4	12.5	1.268	590.24	211.625	0	1100.72	4554.12
175	4.892	7647.64	138.2	188.6	16.7	0.708	605.89	512.415	0	5222.43	3062.15

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Data set No.	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)
176	4.892	7647.64	124.88	188.6	17.2	0.708	770.87	512.415	0	4128.01	3328.12
177	6.184	7877	115	262	36.55226	1.122	240.7	336.8254	0	18900	2325.7
178	6.184	7388	115	262	36.55226	1.122	263.7	336.791	0	26800	2432.7
179	6.184	8103	115	262	36.55226	1.122	334.7	336.7901	0	16200	2437.7
180	6.184	8379	115	262	36.55226	1.122	234.7	336.7949	0	15600	2209.7
181	6.184	8255	115	262	36.55226	1.122	260.7	336.7925	0	10600	2296.7
182	6.184	9180	115	262	36.55226	1.122	266.7	336.7884	0	23540	2239.7
183	6.184	9199	115	262	36.55226	1.122	263.7	336.7794	0	20990	2214.7
184	6.184	7746	115	262	36.55226	1.122	314.7	336.8182	0	24200	2467.7
185	6.184	7480	115	262	36.55226	1.122	275.7	336.7983	0	25205	2296.7
186	6.184	8543	115	262	36.55226	1.122	248.7	336.7857	0	19600	2238.7
187	6.184	7596	119	269	35.56021	1.1	321.7	323.0159	0	15120	2630.7
188	6.184	8349	119	269	35.56021	1.1	219.7	323.0043	0	22235	2153.7
189	6.184	7500	119	269	35.56021	1.1	193.7	322.9901	0	7090	1964.7
190	6.184	6899	119	269	35.56021	1.1	229.7	322.9873	0	19750	2083.7
191	6.184	9599	119	269	35.56021	1.1	214.7	323.0047	0	6390	2145.7
192	6.184	7093	119	269	35.56021	1.1	227.7	323.0146	0	12340	1960.7
193	6.184	8166	119	269	35.56021	1.1	219.7	323.0159	0	13860	2143.7
194	6.184	8674	119	269	35.56021	1.1	295.7	322.9775	0	17800	2368.7
195	6.184	7349	119	269	35.56021	1.1	215.7	323.0034	0	14650	2039.7
196	6.184	8045	119	269	35.56021	1.1	256.7	322.987	0	15400	2232.7
197	6.184	7901	119	269	35.56021	1.1	300.7	322.96	0	12500	2043.7
198	6.184	7999	119	269	35.56021	1.1	387.7	323.0052	0	21656	2502.7
199	6.184	8169	115	262	36.55226	1.122	291.7	336.7803	0	27270	2295.7
200	6.184	9714	115	262	36.55226	1.122	319.7	336.8182	0	11000	2322.7

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Data set No.	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)
201	6.184	10003	115	262	36.55226	1.122	314.7	336.8082	0	7770	2260.7
202	6.184	7900	115	262	36.55226	1.122	332.7	336.8098	0	9780	2340.7
203	6.184	7891	115	262	36.55226	1.122	397.7	336.8502	0	6540	2392.7
204	6.184	7799	115	262	36.55226	1.122	263.7	336.7993	0	23370	2212.7
205	6.184	8950	115	262	36.55226	1.122	231.7	336.8182	0	15400	2214.7
206	6.184	7133	115	262	36.55226	1.122	402.7	336.8293	0	12300	2491.7
207	8.76	4360	126	150	10.3	0.75	264.7	4020	30	320	1074.7
208	8.76	4360	126	150	9.5	0.75	314.7	6450	17	175	1239.7

APPENDIX B

Results of neural network Model number 10 for Case 1: (20% maximum error)

No.	Data type	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)	D&R (M) 20%	H&B 20%	F&B 20%	M&B 20%	B&B 20%	Ork 20%	D&R (O) 20%
1	Train	1.995	7450	75	189	54	0.752	1645	3393	0	82	3300	1	0	0	1	1	1	1
	Calculate	1.995	7450	75	189	54	0.752	1645	3393	0	82	3300	1	0.0022	0.0056	0.9285	1	1	1
2	Train	1.995	7350	75	189	54	0.752	1635	3393	0	125	3290	1	0	0	0	1	1	1
	Calculate	1.995	7350	75	189	54	0.752	1635	3393	0	125	3290	1	0.0008	0.0008	0.0612	1	1	1
3	Train	1.995	6550	75	189	42	0.8225	985	1245	0	167	2665	1	0	0	1	1	1	1
	Calculate	1.995	6550	75	189	42	0.8225	985	1245	0	167	2665	1	0.0041	0.0045	1	1	1	1
4	Train	1.995	7800	75	189	42.6	0.84	1261	1747	0	168	3141	1	1	1	1	1	1	1
	Calculate	1.995	7800	75	189	42.6	0.84	1261	1747	0	168	3141	1	0.9993	1	1	1	1	1
5	Train	1.995	8070	75	189	42.6	0.84	1229	1747	0	259.2	3199	1	1	1	1	1	1	1
	Calculate	1.995	8070	75	189	42.6	0.84	1229	1747	0	259.2	3199	1	0.9998	1	1	1	1	1
6	Train	1.995	8000	75	189	42.6	0.84	1221	1747	0	91.2	3258	1	1	1	0	1	1	1
	Calculate	1.995	8000	75	189	42.6	0.84	1221	1747	0	91.2	3258	1	0.9996	1	1	1	1	1
7	Train	1.995	8480	75	189	43.9	0.8287	1665	3588	0	131	3260	1	1	1	1	1	1	1
	Calculate	1.995	8480	75	189	43.9	0.8287	1665	3588	0	131	3260	1	0.9999	1	1	1	1	1
8	Train	1.995	4410	75	189	41.3	1.048	145	192	0	245.3	1419	1	1	1	1	1	1	1
	Calculate	1.995	4410	75	189	41.3	1.048	145	192	0	245.3	1419	1	0.9994	1	1	1	1	0.9989
9	Train	1.995	3000	75	189	41.3	1.048	175	189	0	160.3	1083	1	1	1	1	1	1	1
	Calculate	1.995	3000	75	189	41.3	1.048	175	189	0	160.3	1083	0.9992	0.9974	1	0.9858	1	1	0.9997
10	Train	1.995	4410	75	189	41.3	1.048	105	230	0	392.4	1229	1	1	1	1	1	1	1
	Calculate	1.995	4410	75	189	41.3	1.048	105	230	0	392.4	1229	0.9999	0.9966	1	1	1	1	0.9821
11	Train	1.995	3395.7	86	172.4	15.6	0.68	193.8	787.6	51	41.013	1509.9	0	0	0	1	1	0	1
	Calculate	1.995	3395.7	86	172.4	15.6	0.68	193.8	787.6	51	41.013	1509.9	0	0.0017	0	1	0.9974	0.0012	1
12	Train	1.995	3362.9	86	168.8	15.6	0.78	250.6	7029.3	56	14.652	1506.7	0	0	0	0	0	0	0
	Calculate	1.995	3362.9	86	168.8	15.6	0.78	250.6	7029.3	56	14.652	1506.7	0	0	0	0	0	0	0.0302
13	Train	1.995	3395	86	158	15.6	0.62	107.2	2475.1	14	12.986	1513.8	0	0	0	0	0	0	0
	Calculate	1.995	3395	86	158	15.6	0.62	107.2	2475.1	14	12.986	1513.8	0	0	0	0	0	0	0.0609
14	Train	2.441	9592	75	189	50.8	0.68	2360	3640	0	244.8	4090	1	1	1	1	1	1	1
	Calculate	2.441	9592	75	189	50.8	0.68	2360	3640	0	244.8	4090	1	0.9999	1	1	1	1	1
15	Train	2.441	10683	75	189	47.6	0.742	1784	2151	0	313.2	4315	1	1	1	1	1	1	1
	Calculate	2.441	10683	75	189	47.6	0.742	1784	2151	0	313.2	4315	1	0.9996	1	1	1	1	1
16	Train	2.441	6500	75	189	36.2	0.8225	555	906	0	60	2325	1	1	0	1	1	1	1
	Calculate	2.441	6500	75	189	36.2	0.8225	555	906	0	60	2325	1	0.9717	0	1	1	1	1
17	Train	2.441	12861.5	90	200	37	0.7	1579.2	5160.2	0	188.7	4005.6	1	0	0	0	1	1	1
	Calculate	2.441	12861.5	90	200	37	0.7	1579.2	5160.2	0	188.7	4005.6	0.9915	0.0001	0.0039	0.0189	1	0.998	0.9991
18	Train	2.441	12861.5	90	200	37	0.7	1294.7	3762	0	283	4049.7	0	0	0	0	1	0	1
	Calculate	2.441	12861.5	90	200	37	0.7	1294.7	3762	0	283	4049.7	0.0094	0	0	0.0038	0.9986	0.0001	0.9718
19	Train	2.441	12795.9	90	200	37	0.7	1993.1	2650.3	0	364.8	5032.5	1	0	0	1	1	0	1
	Calculate	2.441	12795.9	90	200	37	0.7	1993.1	2650.3	0	364.8	5032.5	0.989	0	0.0017	1	0.9998	0.0006	0.991
20	Train	2.441	10532	93.2	232.1	46	0.71	2270.5	2271.8	0	439.7	4654.2	1	1	1	1	1	1	1
	Calculate	2.441	10532	93.2	232.1	46	0.71	2270.5	2271.8	0	439.7	4654.2	1	0.9991	0.9995	1	1	0.9997	0.998
21	Train	2.441	7579.1	138.9	187.9	19.2	0.71	444.2	509.8	0	6868.7	3264.6	0	0	0	0	0	0	0
	Calculate	2.441	7579.1	138.9	187.9	19.2	0.71	444.2	509.8	0	6868.7	3264.6	0.002	0.001	0.0067	0.0004	0	0.0005	0.0359
22	Train	2.441	8760.3	104	198.5	25	0.57	128.5	381.8	0	353.5	2819.4	0	0	0	0	0	0	1
	Calculate	2.441	8760.3	104	198.5	25	0.57	128.5	381.8	0	353.5	2819.4	0	0.0104	0	0.0007	0.0495	0.0609	0.943

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No.	Data type	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)	D&R (M) 20%	H&B 20%	F&B 20%	M&B 20%	B&B 20%	Ork 20%	D&R (O) 20%
23	Train	2.441	7578.7	132.8	187.88	19.2	0.708	563.2	512.4	0	4226.75	3294	1	1	1	1	1	1	1
	Calculate	2.441	7578.7	132.8	187.88	19.2	0.708	563.2	512.4	0	4226.75	3294	0.9972	0.999	0.9988	0.9926	0.9999	0.9993	0.9448
24	Train	2.441	7578.7	138.92	187.88	19.2	0.708	429.5	512.4	0	6868.47	3249.9	0	0	0	0	0	0	0
	Calculate	2.441	7578.7	138.92	187.88	19.2	0.708	429.5	512.4	0	6868.47	3249.9	0.0011	0.0006	0.0035	0.0002	0	0.0003	0.0304
25	Train	2.441	8759.8	104	198.5	25	0.571	113.8	383.7	0	255.366	2762.1	0	0	0	0	1	1	1
	Calculate	2.441	8759.8	104	198.5	25	0.571	113.8	383.7	0	255.366	2762.1	0	0.0032	0	0.0031	0.9538	0.9623	0.9607
26	Train	2.441	7053.8	105.8	176	32.8	0.701	896	744.9	0	2203.95	2972.6	1	1	1	1	1	1	1
	Calculate	2.441	7053.8	105.8	176	32.8	0.701	896	744.9	0	2203.95	2972.6	1	1	1	1	1	1	1
27	Train	2.441	7053.8	107.6	176	32.8	0.701	988.5	756.2	0	3607.84	3164.6	1	1	1	1	1	1	1
	Calculate	2.441	7053.8	107.6	176	32.8	0.701	988.5	756.2	0	3607.84	3164.6	1	1	1	1	1	1	1
28	Train	2.441	7053.8	107.6	176	32.8	0.701	988.5	778.8	0	4075.8	3221.5	1	1	1	1	1	1	1
	Calculate	2.441	7053.8	107.6	176	32.8	0.701	988.5	778.8	0	4075.8	3221.5	1	1	1	1	1	1	1
29	Train	2.441	8038.1	89.42	167	40.3	0.75	1308.5	947	0	480.54	3436.2	1	1	1	1	1	1	1
	Calculate	2.441	8038.1	89.42	167	40.3	0.75	1308.5	947	0	480.54	3436.2	1	1	1	1	1	1	1
30	Train	2.441	8038.1	98.6	167	40.3	0.75	1173.4	947	0	1125.88	3227.1	1	1	1	1	1	1	1
	Calculate	2.441	8038.1	98.6	167	40.3	0.75	1173.4	947	0	1125.88	3227.1	1	1	1	1	1	1	1
31	Train	2.441	10531.5	93.2	232.16	46	0.71	2193.1	2283.3	0	215.74	4640.9	1	1	1	1	1	1	1
	Calculate	2.441	10531.5	93.2	232.16	46	0.71	2193.1	2283.3	0	215.74	4640.9	1	0.9984	0.9966	1	1	0.999	0.9984
32	Train	2.441	10531.5	93.2	232.16	46	0.71	2255.7	2283.3	0	439.66	4639.5	1	1	1	1	1	1	1
	Calculate	2.441	10531.5	93.2	232.16	46	0.71	2255.7	2283.3	0	439.66	4639.5	1	0.9992	0.9995	1	1	0.9997	0.9981
33	Train	2.441	3346.6	86	167	16.6	0.67	346.1	580.6	23	152.075	1488.1	0	0	0	1	1	1	1
	Calculate	2.441	3346.6	86	167	16.6	0.67	346.1	580.6	23	152.075	1488.1	0	0.0001	0	0.9962	1	0.9929	0.9704
34	Train	2.441	3379.3	86	172.4	16.67	0.72	225.2	1437.3	1.4	71.978	1512.4	0	0	0	0	0	0	0
	Calculate	2.441	3379.3	86	172.4	16.67	0.72	225.2	1437.3	1.4	71.978	1512.4	0	0	0	0	0.0034	0.0044	0.0069
35	Train	2.441	10007	90	200	37	0.7	606.4	505.3	10	446.04	3745.3	1	1	1	1	1	1	1
	Calculate	2.441	10007	90	200	37	0.7	606.4	505.3	10	446.04	3745.3	1	1	1	1	0.9997	0.9888	1
36	Train	2.441	6102.7	90	264	37	0.65	811.2	2027	0	15	2860.7	0	1	0	1	1	1	1
	Calculate	2.441	6102.7	90	264	37	0.65	811.2	2027	0	15	2860.7	0.0031	0.9993	0	0.9959	1	0.9991	1
37	Train	2.764	10039	134	320	50.3766	0.7	1620	1116.6	0	10872	6695	1	1	1	1	1	1	1
	Calculate	2.764	10039	134	320	50.3766	0.7	1620	1116.6	0	10872	6695	1	1	0.9974	1	0.994	0.9779	1
38	Train	2.764	13477	135	301	52.985	0.71	1540	2717.4	0	1104	5840	0	0	0	0	0	0	0
	Calculate	2.764	13477	135	301	52.985	0.71	1540	2717.4	0	1104	5840	0	0	0	0	0	0	0.0004
39	Train	2.764	13477	130	289	52.2662	0.71	2130	3086.3	0	823	6045	0	0	0	0	0	0	0
	Calculate	2.764	13477	130	289	52.2662	0.71	2130	3086.3	0	823	6045	0.0004	0.0011	0	0	0.0017	0	0.0017
40	Train	2.764	10876	139	308	66.6793	0.685	3940	2303.4	0	4272	6729	1	1	1	1	1	1	1
	Calculate	2.764	10876	139	308	66.6793	0.685	3940	2303.4	0	4272	6729	1	1	1	1	1	1	0.9997
41	Train	2.992	3825	126	150	15.1	0.75	564.65	765	0	1065	1214.7	1	0	1	1	1	1	0
	Calculate	2.992	3825	126	150	15.1	0.75	564.65	765	0	1065	1214.7	0.9977	0.0123	1	1	0.9958	1	0.0654
42	Train	2.992	3940	126	150	14.6	0.75	164.65	252	0	1300	1014.7	0	0	1	1	1	1	0
	Calculate	2.992	3940	126	150	14.6	0.75	164.65	252	0	1300	1014.7	0.0039	0.001	0.9545	1	0.9858	1	0.0008
43	Train	2.992	3800	126	150	14.4	0.75	714.65	1430	0	3166	1264.7	0	0	1	0	0	1	0
	Calculate	2.992	3800	126	150	14.4	0.75	714.65	1430	0	3166	1264.7	0.0273	0	1	0.001	0	0.9999	0.027
44	Train	2.992	3720	126	150	14.4	0.75	314.65	232	0	1965	1214.7	0	0	1	1	0	1	0
	Calculate	2.992	3720	126	150	14.4	0.75	314.65	232	0	1965	1214.7	0.0569	0.0335	0.9994	1	0.0265	1	0.0129
45	Train	2.992	4570	126	150	13.5	0.75	864.65	1500	0	1965	1514.7	1	0	1	1	0	1	1
	Calculate	2.992	4570	126	150	13.5	0.75	864.65	1500	0	1965	1514.7	1	0.0008	1	0.997	0.0032	1	0.9645
46	Train	2.992	4175	126	150	15.6	0.75	314.65	267	0	2700	1514.7	1	1	1	1	1	1	1
	Calculate	2.992	4175	126	150	15.6	0.75	314.65	267	0	2700	1514.7	0.9989	0.982	0.9923	1	0.9795	1	0.9227

No.	Data type	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)	D&R (M) 20%	H&B 20%	F&B 20%	M&B 20%	B&B 20%	Ork 20%	D&R (O) 20%
47	Train	2.992	4670	126	150	13.6	0.75	924.65	1565	0	2320	1664.7	1	0	1	1	0	1	1
	Calculate	2.992	4670	126	150	13.6	0.75	924.65	1565	0	2320	1664.7	1	0.0015	1	0.9979	0.0041	1	0.9862
48	Train	2.992	4575	126	150	18.6	0.75	664.65	858	0	2480	1564.7	1	1	1	1	1	1	1
	Calculate	2.992	4575	126	150	18.6	0.75	664.65	858	0	2480	1564.7	1	0.992	1	1	1	1	0.9447
49	Train	2.992	4065	126	150	13	0.75	514.65	341	0	1490	1564.7	1	1	1	1	1	1	1
	Calculate	2.992	4065	126	150	13	0.75	514.65	341	0	1490	1564.7	1	0.9976	0.9997	1	0.999	1	0.9699
50	Train	2.992	3705	126	150	13.6	0.75	514.65	335	0	1310	1464.7	1	1	1	1	1	1	1
	Calculate	2.992	3705	126	150	13.6	0.75	514.65	335	0	1310	1464.7	0.9999	0.9864	0.9998	1	0.9994	1	0.893
51	Train	2.992	4160	126	150	12.9	0.75	164.65	185	0	1350	1514.7	1	1	0	1	1	1	1
	Calculate	2.992	4160	126	150	12.9	0.75	164.65	185	0	1350	1514.7	0.963	0.9916	0.0003	1	0.9868	1	0.8238
52	Train	2.992	4210	126	150	16	0.75	364.65	222	0	788	1764.7	1	1	1	1	1	1	1
	Calculate	2.992	4210	126	150	16	0.75	364.65	222	0	788	1764.7	1	1	0.9989	1	1	1	0.9455
53	Train	2.992	4766	126	150	13.3	0.75	264.65	193	0	967	1564.7	1	1	1	1	1	1	0
	Calculate	2.992	4766	126	150	13.3	0.75	264.65	193	0	967	1564.7	1	1	0.975	1	1	1	0.6868
54	Train	2.992	4505	126	150	12.5	0.75	264.65	385	0	1040	1364.7	1	1	0	1	1	1	1
	Calculate	2.992	4505	126	150	12.5	0.75	264.65	385	0	1040	1364.7	0.9953	0.9505	0.0467	1	0.995	1	0.6062
55	Train	2.992	4692	126	150	12.9	0.75	414.65	865	0	1585	1164.7	1	0	1	1	0	1	1
	Calculate	2.992	4692	126	150	12.9	0.75	414.65	865	0	1585	1164.7	0.9929	0.0084	0.9966	1	0.0042	1	0.5156
56	Train	2.992	4175.1	126	150	15.6	0.75	314.7	267.3	0	2700	1514.7	1	1	1	1	1	1	1
	Calculate	2.992	4175.1	126	150	15.6	0.75	314.7	267.3	0	2700	1514.7	0.9989	0.9819	0.9923	1	0.9794	1	0.9227
57	Train	2.992	4210	126	150	16	0.75	364.7	223.3	0	788	1764.7	1	1	1	1	1	1	1
	Calculate	2.992	4210	126	150	16	0.75	364.7	223.3	0	788	1764.7	1	1	0.9989	1	1	1	0.9453
58	Train	2.992	4691.8	126	150	12.9	0.75	414.7	865.8	0	1585	1164.7	1	0	1	1	0	1	0
	Calculate	2.992	4691.8	126	150	12.9	0.75	414.7	865.8	0	1585	1164.7	0.9929	0.0083	0.9966	1	0.0041	1	0.5156
59	Train	2.992	7647.64	104	185	31.3	0.92	1322.71	901.81	0	2654.3	3555.7	1	1	1	1	1	1	1
	Calculate	2.992	7647.64	104	185	31.3	0.92	1322.71	901.81	0	2654.3	3555.7	1	1	1	1	1	1	1
60	Train	2.992	3182.5	86	158	17.05	0.69	250.1	989	14	182.32	1390.2	0	0	0	0	1	0	0
	Calculate	2.992	3182.5	86	158	17.05	0.69	250.1	989	14	182.32	1390.2	0	0	0	0	0.9853	0.0014	0.0028
61	Train	2.992	3346.6	86	158	17.05	0.69	184	1243.2	24	120.004	1465.5	0	0	0	0	0	0	0
	Calculate	2.992	3346.6	86	158	17.05	0.69	184	1243.2	24	120.004	1465.5	0	0	0	0	0.0015	0	0.0023
62	Train	2.992	4101.3	195	237	39.25	0.75	1284.7	3773.3	0	278	1731.1	1	1	1	0	1	1	1
	Calculate	2.992	4101.3	195	237	39.25	0.75	1284.7	3773.3	0	278	1731.1	1	0.9981	1	0	1	1	0.9995
63	Train	2.992	4101.3	195	237	39.25	0.75	724.7	3077	0	548	1056.7	1	1	1	1	1	1	1
	Calculate	2.992	4101.3	195	237	39.25	0.75	724.7	3077	0	548	1056.7	1	1	1	0.9971	1	1	0.9998
64	Train	2.992	4921.5	195	230	37.31	0.75	764.7	381.8	0	7226	1976.5	1	1	1	1	1	1	1
	Calculate	2.992	4921.5	195	230	37.31	0.75	764.7	381.8	0	7226	1976.5	1	1	1	1	1	1	1
65	Train	2.992	6411.1	200	236.5	38.72	0.75	589.7	651.3	0	5809	1937.6	1	1	1	1	1	1	1
	Calculate	2.992	6411.1	200	236.5	38.72	0.75	589.7	651.3	0	5809	1937.6	1	1	1	1	1	1	0.9999
66	Train	2.992	3948.5	150	235	38.69	0.75	482.7	1021.9	0	213	1178.7	1	0	0	0	1	1	1
	Calculate	2.992	3948.5	150	235	38.69	0.75	482.7	1021.9	0	213	1178.7	0.9997	0	0.0008	0.0024	1	1	0.9996
67	Train	2.992	6402	130	236	39	0.75	548.7	746.8	0	943	1568.7	1	0	0	1	1	1	1
	Calculate	2.992	6402	130	236	39	0.75	548.7	746.8	0	943	1568.7	1	0.043	0.0138	1	1	1	0.9996
68	Train	2.992	6105.7	130	236	39	0.75	554.7	797.3	0	2482	1319.5	1	1	1	1	1	1	1
	Calculate	2.992	6105.7	130	236	39	0.75	554.7	797.3	0	2482	1319.5	1	0.9972	0.9976	1	1	1	1
69	Train	2.992	6069.8	130	236	38.72	0.75	414.7	555.9	0	6037	1663.7	1	1	1	1	0	1	1
	Calculate	2.992	6069.8	130	236	38.72	0.75	414.7	555.9	0	6037	1663.7	1	1	1	1	1	1	1
70	Train	2.992	6001.7	150	236	38.72	0.75	469.7	589.6	20	5401.6	2030.4	1	1	1	1	1	1	1
	Calculate	2.992	6001.7	150	236	38.72	0.75	469.7	589.6	20	5401.6	2030.4	1	1	1	1	1	1	1

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No.	Data type	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)	D&R (M) 20%	H&B 20%	F&B 20%	M&B 20%	B&B 20%	Ork 20%	D&R (O) 20%
71	Train	3.958	9746	124	306	51.553	0.7	3314.65	1473.6239	0	15696	6516.7	1	1	1	1	1	1	1
	Calculate	3.958	9746	124	306	51.553	0.7	3314.65	1473.6239	0	15696	6516.7	1	1	1	1	1	1	1
72	Train	3.958	10947	140	304	51.3165	0.7	2014.65	1129.7872	0	9400	4662.7	1	1	1	1	1	1	1
	Calculate	3.958	10947	140	304	51.3165	0.7	2014.65	1129.7872	0	9400	4662.7	1	1	1	1	1	1	1
73	Train	3.958	10083	130	286	50.1431	0.7	3684.65	1592.6309	0	11616	6509.7	1	1	1	1	1	1	1
	Calculate	3.958	10083	130	286	50.1431	0.7	3684.65	1592.6309	0	11616	6509.7	1	1	1	1	1	1	1
74	Train	3.958	12290	140	305	53.9522	0.7	2141.65	1538.769	0	10008	4645.7	1	1	1	1	1	1	1
	Calculate	3.958	12290	140	305	53.9522	0.7	2141.65	1538.769	0	10008	4645.7	1	1	1	1	1	1	0.9986
75	Train	3.958	9902	119	280	51.3165	0.7	3744.65	1339.1137	0	12456	6570.7	1	1	1	1	1	1	1
	Calculate	3.958	9902	119	280	51.3165	0.7	3744.65	1339.1137	0	12456	6570.7	1	1	1	1	1	1	1
76	Train	3.958	10239	140	300	51.0806	0.7	2834.65	1470.3065	0	12528	5598.7	1	1	1	1	1	1	1
	Calculate	3.958	10239	140	300	51.0806	0.7	2834.65	1470.3065	0	12528	5598.7	1	1	1	1	1	1	1
77	Train	3.958	9650	120	306	50.6107	0.7	1941.65	1764.6714	0	17040	4862.7	1	1	1	1	1	1	1
	Calculate	3.958	9650	120	306	50.6107	0.7	1941.65	1764.6714	0	17040	4862.7	1	1	1	1	1	0.9996	1
78	Train	3.958	8045	119	269	35.5602	1.1	150.65	322.9485	0	7190	2067.7	1	1	1	1	1	1	1
	Calculate	3.958	8045	119	269	35.5602	1.1	150.65	322.9485	0	7190	2067.7	1	1	1	1	1	1	1
79	Train	3.958	8600	119	269	35.5602	1.1	168.65	322.9358	0	6540	2096.7	1	1	1	1	1	1	1
	Calculate	3.958	8600	119	269	35.5602	1.1	168.65	322.9358	0	6540	2096.7	1	1	1	1	1	1	1
80	Train	3.958	9459	119	269	35.5602	1.1	294.65	323.0053	0	7520	2248.7	1	1	1	1	1	1	1
	Calculate	3.958	9459	119	269	35.5602	1.1	294.65	323.0053	0	7520	2248.7	1	1	1	1	1	1	1
81	Train	3.958	7900	119	269	35.5602	1.1	202.65	323.012	0	8300	2094.7	1	1	1	1	1	1	1
	Calculate	3.958	7900	119	269	35.5602	1.1	202.65	323.012	0	8300	2094.7	1	1	1	1	1	1	1
82	Train	3.958	8560	115	262	36.5523	1.122	204.65	336.7797	0	11800	2400.7	1	1	1	1	1	1	1
	Calculate	3.958	8560	115	262	36.5523	1.122	204.65	336.7797	0	11800	2400.7	1	1	1	1	1	1	1
83	Train	3.958	12249	105	245	47.8409	0.7	1439.65	941.5064	0	2496	3543.7	1	1	1	1	1	1	1
	Calculate	3.958	12249	105	245	47.8409	0.7	1439.65	941.5064	0	2496	3543.7	1	1	1	1	1	1	0.9813
84	Train	3.958	10984	140	316	49.678	0.7	2504.65	990.8027	0	14352	5491.7	1	1	1	1	1	1	1
	Calculate	3.958	10984	140	316	49.678	0.7	2504.65	990.8027	0	14352	5491.7	1	1	1	1	1	1	1
85	Train	3.958	11305	136	330	50.1431	0.7	2964.65	1068.4046	0	8976	5729.7	1	1	1	1	1	1	1
	Calculate	3.958	11305	136	330	50.1431	0.7	2964.65	1068.4046	0	8976	5729.7	1	1	1	1	1	1	1
86	Train	3.958	11290	124	311	49.9103	0.7	1763.65	965.2972	0	7521	3852.7	1	1	1	1	1	1	1
	Calculate	3.958	11290	124	311	49.9103	0.7	1763.65	965.2972	0	7521	3852.7	1	1	1	1	1	1	1
87	Train	3.958	11929	140	310	51.0806	0.7	1194.65	1340.3263	0	10296	3423.7	1	1	1	1	1	1	1
	Calculate	3.958	11929	140	310	51.0806	0.7	1194.65	1340.3263	0	10296	3423.7	1	1	1	1	1	0.9992	0.9948
88	Train	3.958	14330	138	320	43.6238	0.7	664.65	1024.8288	0	3504	1872.7	0	1	1	0	0	0	0
	Calculate	3.958	14330	138	320	43.6238	0.7	664.65	1024.8288	0	3504	1872.7	0	0.9992	0.9992	0.0018	0	0.0019	0.0003
89	Train	3.958	12152	148	336	56.6649	0.72	1184.65	3511.7953	0	13056	4625.7	1	1	1	1	0	0	0
	Calculate	3.958	12152	148	336	56.6649	0.72	1184.65	3511.7953	0	13056	4625.7	0.9985	1	1	0.9981	0.0006	0	0.0119
90	Train	3.958	12171	133	334	48.5254	0.72	834.65	1810.1949	0	11496	3217.7	1	1	1	1	0	0	1
	Calculate	3.958	12171	133	334	48.5254	0.72	834.65	1810.1949	0	11496	3217.7	0.9892	1	1	1	0	0	0.9936
91	Train	3.958	9928	120	345	56.6649	0.72	3804.65	4059.9343	0	4872	5300.7	1	1	1	1	1	1	1
	Calculate	3.958	9928	120	345	56.6649	0.72	3804.65	4059.9343	0	4872	5300.7	1	1	1	1	1	1	1
92	Train	3.958	9928	120	350	57.4186	0.72	3604.65	3922.0047	0	6744	5239.7	1	1	1	1	1	1	1
	Calculate	3.958	9928	120	350	57.4186	0.72	3604.65	3922.0047	0	6744	5239.7	1	1	1	1	1	1	1
93	Train	3.958	9930	120	345	47.8409	0.72	814.65	1597.2984	0	11845	2887.7	1	1	1	1	0	0	1
	Calculate	3.958	9930	120	345	47.8409	0.72	814.65	1597.2984	0	11845	2887.7	1	1	1	1	0	0	1
94	Train	3.958	10336	140	342	52.0279	0.72	1164.65	3335.3746	0	14697	4562.7	1	1	1	1	0	0	1
	Calculate	3.958	10336	140	342	52.0279	0.72	1164.65	3335.3746	0	14697	4562.7	1	1	1	1	0.0003	0	0.9977

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No.	Data type	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)	D&R (M) 20%	H&B 20%	F&B 20%	M&B 20%	B&B 20%	Ork 20%	D&R (O) 20%
95	Train	3.958	10158	133	320	54.9295	0.72	3864.65	3139.5349	0	11352	5492.7	0	0	0	0	0	1	1
	Calculate	3.958	10158	133	320	54.9295	0.72	3864.65	3139.5349	0	11352	5492.7	1	1	1	1	1	1	1
96	Train	3.958	10158	134	320	53.9522	0.72	2694.65	3064.7383	0	11616	5493.7	1	1	1	1	1	1	1
	Calculate	3.958	10158	134	320	53.9522	0.72	2694.65	3064.7383	0	11616	5493.7	1	1	1	1	1	1	1
97	Train	3.958	11400	140	342	50.3766	0.7	1914.65	776.4824	0	13896	5000.7	1	1	1	1	1	1	1
	Calculate	3.958	11400	140	342	50.3766	0.7	1914.65	776.4824	0	13896	5000.7	1	1	1	1	1	0.9997	1
98	Train	3.958	10945	130	320	52.0279	0.72	844.65	3153.8367	0	8171	2770.7	1	1	1	1	0	0	0
	Calculate	3.958	10945	130	320	52.0279	0.72	844.65	3153.8367	0	8171	2770.7	0.9987	1	1	1	0.0114	0.011	0.0317
99	Train	3.958	10356	128	320	59.975	0.716	4274.65	2707.0278	0	8936	6632.7	1	1	1	1	1	1	1
	Calculate	3.958	10356	128	320	59.975	0.716	4274.65	2707.0278	0	8936	6632.7	1	1	1	1	1	1	1
100	Train	3.958	10661	125	332	60.7554	0.715	4048.65	2921.411	0	8958	6483.7	1	1	1	1	1	1	1
	Calculate	3.958	10661	125	332	60.7554	0.715	4048.65	2921.411	0	8958	6483.7	1	1	1	1	1	1	1
101	Train	3.958	10059	140	310	67.52	0.702	4431.65	3698.4536	0	9312	6905.7	1	1	1	1	1	1	1
	Calculate	3.958	10059	140	310	67.52	0.702	4431.65	3698.4536	0	9312	6905.7	1	1	1	1	1	1	1
102	Train	3.958	10059	125	334	71.5129	0.49	4336.65	3687.6006	0	9936	6870.7	1	1	1	1	1	1	1
	Calculate	3.958	10059	125	334	71.5129	0.49	4336.65	3687.6006	0	9936	6870.7	1	1	1	1	1	1	1
103	Train	3.958	6233.9	195	235.4	37.31	0.75	771.7	516.6	0	11111	1977	1	1	1	1	1	1	1
	Calculate	3.958	6233.9	195	235.4	37.31	0.75	771.7	516.6	0	11111	1977	1	1	1	1	1	1	1
104	Train	3.958	6250.3	128	234.9	36.33	0.75	384.7	589.6	0	2845	1201.3	0	1	1	1	1	1	1
	Calculate	3.958	6250.3	128	234.9	36.33	0.75	384.7	589.6	0	2845	1201.3	1	1	0.9998	1	1	1	1
105	Train	4.892	10171.1	80.6	190.4	16.7	0.7	235.2	509.8	0	5222.6	4581.7	0	0	0	0	0	0	0
	Calculate	4.892	10171.1	80.6	190.4	16.7	0.7	235.2	509.8	0	5222.6	4581.7	0	0.0001	0	0	0	0	0.0016
106	Train	4.892	10847	157	348	69.7802	0.72	2177.7	5525.8	0	10080	4149.7	1	1	1	1	1	1	1
	Calculate	4.892	10847	157	348	69.7802	0.72	2177.7	5525.8	0	10080	4149.7	1	1	1	1	1	1	0.9989
107	Train	4.892	10838	140	342	66.6793	0.7	3364.7	3091.8	0	9024	5318.7	1	1	1	1	1	1	1
	Calculate	4.892	10838	140	342	66.6793	0.7	3364.7	3091.8	0	9024	5318.7	1	1	1	1	1	1	1
108	Train	4.892	10826.8	117.5	224.6	8.3	1.705	223.297	146.163	0.3	522.05	4758.93	1	1	1	1	1	1	1
	Calculate	4.892	10826.8	117.5	224.6	8.3	1.705	223.297	146.163	0.3	522.05	4758.93	1	1	1	1	1	1	1
109	Train	4.892	10826.8	134.6	228.2	8.3	1.705	209.074	146.163	0.15	930.89	4763.19	1	1	1	1	1	1	1
	Calculate	4.892	10826.8	134.6	228.2	8.3	1.705	209.074	146.163	0.15	930.89	4763.19	1	1	1	1	1	1	1
110	Train	4.892	10498.7	68	194	9	1.567	99.56	129.232	0.2	44.03	4164.4	1	1	1	1	1	1	1
	Calculate	4.892	10498.7	68	194	9	1.567	99.56	129.232	0.2	44.03	4164.4	1	1	1	1	1	1	1
111	Train	4.892	10170.6	80.6	190.4	11.8	0.938	220.45	168.736	0.1	144.67	4566.92	1	1	1	1	1	1	1
	Calculate	4.892	10170.6	80.6	190.4	11.8	0.938	220.45	168.736	0.1	144.67	4566.92	1	1	0.9997	1	1	0.9996	0.9624
112	Train	4.892	10170.6	104	222.8	12.5	1.268	570.33	211.625	0.1	761.07	4521.4	1	1	1	1	1	1	1
	Calculate	4.892	10170.6	104	222.8	12.5	1.268	570.33	211.625	0.1	761.07	4521.4	1	1	1	1	1	1	1
113	Train	4.892	10170.6	136.4	226.4	12.5	1.268	590.24	211.625	0	1100.72	4554.12	1	1	1	1	1	1	1
	Calculate	4.892	10170.6	136.4	226.4	12.5	1.268	590.24	211.625	0	1100.72	4554.12	1	1	1	1	1	1	0.9995
114	Train	4.892	7647.64	138.2	188.6	16.7	0.708	605.89	512.415	0	5222.43	3062.15	1	1	0	1	1	0	1
	Calculate	4.892	7647.64	138.2	188.6	16.7	0.708	605.89	512.415	0	5222.43	3062.15	0.9947	0.9975	0.0032	1	0.9937	0.0009	0.9955
115	Train	6.184	7877	115	262	36.5523	1.122	240.7	336.8254	0	18900	2325.7	1	1	1	1	1	1	1
	Calculate	6.184	7877	115	262	36.5523	1.122	240.7	336.8254	0	18900	2325.7	1	1	1	1	0.9999	1	1
116	Train	6.184	7388	115	262	36.5523	1.122	263.7	336.791	0	26800	2432.7	1	1	1	1	1	1	1
	Calculate	6.184	7388	115	262	36.5523	1.122	263.7	336.791	0	26800	2432.7	1	1	1	1	0.9997	1	1
117	Train	6.184	8379	115	262	36.5523	1.122	234.7	336.7949	0	15600	2209.7	1	1	1	1	1	1	1
	Calculate	6.184	8379	115	262	36.5523	1.122	234.7	336.7949	0	15600	2209.7	1	1	1	1	0.9999	0.9999	1
118	Train	6.184	8255	115	262	36.5523	1.122	260.7	336.7925	0	10600	2296.7	1	1	1	1	1	1	1
	Calculate	6.184	8255	115	262	36.5523	1.122	260.7	336.7925	0	10600	2296.7	1	1	1	1	1	0.9999	1

No.	Data type	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)	D&R (M) 20%	H&B 20%	F&B 20%	M&B 20%	B&B 20%	Ork 20%	D&R (O) 20%
119	Train	6.184	9180	115	262	36.5523	1.122	266.7	336.7884	0	23540	2239.7	1	1	1	1	1	1	1
	Calculate	6.184	9180	115	262	36.5523	1.122	266.7	336.7884	0	23540	2239.7	1	1	1	1	0.9999	1	1
120	Train	6.184	9199	115	262	36.5523	1.122	263.7	336.7794	0	20990	2214.7	1	1	1	1	1	1	1
	Calculate	6.184	9199	115	262	36.5523	1.122	263.7	336.7794	0	20990	2214.7	1	1	1	1	0.9999	1	1
121	Train	6.184	7746	115	262	36.5523	1.122	314.7	336.8182	0	24200	2467.7	1	1	1	1	1	1	1
	Calculate	6.184	7746	115	262	36.5523	1.122	314.7	336.8182	0	24200	2467.7	1	1	1	1	0.9999	1	1
122	Train	6.184	7596	119	269	35.5602	1.1	321.7	323.0159	0	15120	2630.7	1	1	1	1	1	1	1
	Calculate	6.184	7596	119	269	35.5602	1.1	321.7	323.0159	0	15120	2630.7	1	1	1	1	0.9999	0.9967	1
123	Train	6.184	6899	119	269	35.5602	1.1	229.7	322.9873	0	19750	2083.7	1	1	1	1	1	1	1
	Calculate	6.184	6899	119	269	35.5602	1.1	229.7	322.9873	0	19750	2083.7	1	1	1	1	0.9986	1	1
124	Train	6.184	9599	119	269	35.5602	1.1	214.7	323.0047	0	6390	2145.7	1	1	1	1	1	1	1
	Calculate	6.184	9599	119	269	35.5602	1.1	214.7	323.0047	0	6390	2145.7	1	1	1	1	1	1	1
125	Train	6.184	7093	119	269	35.5602	1.1	227.7	323.0146	0	12340	1960.7	1	1	1	1	1	1	1
	Calculate	6.184	7093	119	269	35.5602	1.1	227.7	323.0146	0	12340	1960.7	1	1	1	1	0.9998	0.9967	1
126	Train	6.184	8674	119	269	35.5602	1.1	295.7	322.9775	0	17800	2368.7	1	1	1	1	1	1	1
	Calculate	6.184	8674	119	269	35.5602	1.1	295.7	322.9775	0	17800	2368.7	1	1	1	1	0.9996	0.9999	1
127	Train	6.184	7901	119	269	35.5602	1.1	300.7	322.96	0	12500	2043.7	1	1	1	1	1	1	1
	Calculate	6.184	7901	119	269	35.5602	1.1	300.7	322.96	0	12500	2043.7	1	1	1	1	0.9999	0.9983	1
128	Train	6.184	7999	119	269	35.5602	1.1	387.7	323.0052	0	21656	2502.7	1	1	1	1	1	1	1
	Calculate	6.184	7999	119	269	35.5602	1.1	387.7	323.0052	0	21656	2502.7	1	1	1	1	0.9998	1	1
129	Train	6.184	8169	115	262	36.5523	1.122	291.7	336.7803	0	27270	2295.7	1	1	1	1	1	1	1
	Calculate	6.184	8169	115	262	36.5523	1.122	291.7	336.7803	0	27270	2295.7	1	1	1	1	0.9994	1	1
130	Train	6.184	9714	115	262	36.5523	1.122	319.7	336.8182	0	11000	2322.7	1	1	1	1	1	1	1
	Calculate	6.184	9714	115	262	36.5523	1.122	319.7	336.8182	0	11000	2322.7	1	1	1	1	1	1	1
131	Train	6.184	7891	115	262	36.5523	1.122	397.7	336.8502	0	6540	2392.7	1	1	1	1	1	1	1
	Calculate	6.184	7891	115	262	36.5523	1.122	397.7	336.8502	0	6540	2392.7	1	1	1	1	1	1	1
132	Train	6.184	7799	115	262	36.5523	1.122	263.7	336.7993	0	23370	2212.7	1	1	1	1	1	1	1
	Calculate	6.184	7799	115	262	36.5523	1.122	263.7	336.7993	0	23370	2212.7	1	1	1	1	0.9999	1	1
133	Train	6.184	7133	115	262	36.5523	1.122	402.7	336.8293	0	12300	2491.7	1	1	1	1	1	1	1
	Calculate	6.184	7133	115	262	36.5523	1.122	402.7	336.8293	0	12300	2491.7	1	1	1	1	1	0.9998	1
134	Validate	1.995	9620	75	189	54	0.752	1455	3393	0	480	3365	1	1	0	1	1	1	1
	Calculate	1.995	9620	75	189	54	0.752	1455	3393	0	480	3365	1	0.8824	1	1	1	1	1
135	Validate	1.995	6570	75	189	42	0.8225	665	1245	0	138	2555	0	0	0	0	1	0	0
	Calculate	1.995	6570	75	189	42	0.8225	665	1245	0	138	2555	1	0.0002	0	1	1	1	1
136	Validate	1.995	3346.6	86	172.4	15.6	0.72	356.1	889.2	4.4	101.6228	1505.3	0	0	0	1	1	0	1
	Calculate	1.995	3346.6	86	172.4	15.6	0.72	356.1	889.2	4.4	101.6228	1505.3	0	0	0	0	0.9991	0.9999	0.8437
137	Validate	2.441	6500	75	189	36.2	0.8225	455	906	0	106	1635	1	1	0	0	0	0	0
	Calculate	2.441	6500	75	189	36.2	0.8225	455	906	0	106	1635	1	0.9754	0.0001	1	1	1	1
138	Validate	2.441	8038.4	92.1	167	40.3	0.75	1387.2	942.2	0	191.9	3588.9	1	1	1	1	1	1	1
	Calculate	2.441	8038.4	92.1	167	40.3	0.75	1387.2	942.2	0	191.9	3588.9	1	1	1	1	1	1	1
139	Validate	2.441	8759.8	104	198.5	25	0.571	113.8	383.7	0	353.487	2804.7	0	0	0	0	0	0	1
	Calculate	2.441	8759.8	104	198.5	25	0.571	113.8	383.7	0	353.487	2804.7	0	0.0062	0	0.0005	0.191	0.2212	0.9417
140	Validate	2.441	8038.1	92.12	167	40.3	0.75	1372.5	947	0	191.84	3574.2	1	1	1	1	1	1	1
	Calculate	2.441	8038.1	92.12	167	40.3	0.75	1372.5	947	0	191.84	3574.2	1	1	1	1	1	1	1
141	Validate	2.441	4445.7	104	185	14.48	0.6	289.2	283.3	24	172.064	1988.9	0	1	0	1	1	1	1
	Calculate	2.441	4445.7	104	185	14.48	0.6	289.2	283.3	24	172.064	1988.9	0.974	1	0	1	0.9991	0.6719	1
142	Validate	2.441	8465	90	200	37	0.7	294.9	252.7	50	148.5	3355.6	1	1	1	1	1	1	1
	Calculate	2.441	8465	90	200	37	0.7	294.9	252.7	50	148.5	3355.6	1	1	1	1	1	1	1

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No.	Data type	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)	D&R (M) 20%	H&B 20%	F&B 20%	M&B 20%	B&B 20%	Ork 20%	D&R (O) 20%
143	Validate	2.441	5249.6	90	264	37	0.65	441.4	606.4	0	44	1974.6	0	1	0	1	1	1	1
	Calculate	2.441	5249.6	90	264	37	0.65	441.4	606.4	0	44	1974.6	0.029	0.7473	0	0.9999	1	1	1
144	Validate	2.992	4355	126	150	12.9	0.75	264.65	185	0	855	1714.7	1	1	1	1	1	1	1
	Calculate	2.992	4355	126	150	12.9	0.75	264.65	185	0	855	1714.7	0.9999	1	0.2619	1	1	1	0.9025
145	Validate	2.992	4487	126	150	14.1	0.75	594.65	962	0	1905	1314.7	1	0	1	1	0	1	1
	Calculate	2.992	4487	126	150	14.1	0.75	594.65	962	0	1905	1314.7	0.9999	0.0114	1	1	0.0609	1	0.8073
146	Validate	2.992	4240	126	150	15.6	0.75	714.7	957.4	0	1165	1564.7	1	0	1	1	1	1	0
	Calculate	2.992	4240	126	150	15.6	0.75	714.7	957.4	0	1165	1564.7	1	0.9228	1	1	1	1	0.9576
147	Validate	2.992	7647.64	104	185	31.3	0.92	1587.26	920.43	0	534.63	3850.09	1	1	1	1	1	1	1
	Calculate	2.992	7647.64	104	185	31.3	0.92	1587.26	920.43	0	534.63	3850.09	1	1	1	1	1	1	1
148	Validate	2.992	4521.2	195	237	39.25	0.75	989.7	6081	0	1555	1490	1	1	1	1	1	0	1
	Calculate	2.992	4521.2	195	237	39.25	0.75	989.7	6081	0	1555	1490	1	0.0403	0.914	0	0.9994	1	0.9898
149	Validate	2.992	6512.8	150	236	38.72	0.75	374.7	589.6	0	2306	1099.7	0	1	1	1	0	1	1
	Calculate	2.992	6512.8	150	236	38.72	0.75	374.7	589.6	0	2306	1099.7	1	0.9934	0.9999	1	1	1	0.9997
150	Validate	2.992	5006.1	195	237	39.25	0.75	1164.7	5317.4	35.5	655.32	1631.7	1	1	1	1	1	0	1
	Calculate	2.992	5006.1	195	237	39.25	0.75	1164.7	5317.4	35.5	655.32	1631.7	1	0.9766	1	0.0163	1	1	0.9717
151	Validate	3.958	10049	140	337	51.7902	0.7	1289.65	1286.6915	0	16080	4281.7	1	1	1	1	1	1	1
	Calculate	3.958	10049	140	337	51.7902	0.7	1289.65	1286.6915	0	16080	4281.7	1	1	1	1	0.9999	0.5517	1
152	Validate	3.958	8715	119	269	35.5602	1.1	213.65	323.1173	0	2284	2211.7	1	1	1	1	1	1	1
	Calculate	3.958	8715	119	269	35.5602	1.1	213.65	323.1173	0	2284	2211.7	1	1	1	1	1	1	1
153	Validate	3.958	11248	137	337	57.4186	0.72	2599.65	4823.4127	0	10080	5303.7	1	1	1	1	0	1	1
	Calculate	3.958	11248	137	337	57.4186	0.72	2599.65	4823.4127	0	10080	5303.7	1	1	1	0.9995	0.9993	0.8853	0.0221
154	Validate	3.958	12916	120	271	49.678	0.7	2664.65	1146.3675	0	9360	4958.7	1	1	1	1	1	1	1
	Calculate	3.958	12916	120	271	49.678	0.7	2664.65	1146.3675	0	9360	4958.7	1	1	1	1	1	1	0.9236
155	Validate	3.958	10318	132	320	49.4463	0.7	2749.65	1156.6265	0	9960	5214.7	1	1	1	1	1	1	1
	Calculate	3.958	10318	132	320	49.4463	0.7	2749.65	1156.6265	0	9960	5214.7	1	1	1	1	1	1	1
156	Validate	3.958	10202	140	304	48.5254	0.7	1838.65	455.2469	0	6480	3957.7	0	0	0	0	0	0	0
	Calculate	3.958	10202	140	304	48.5254	0.7	1838.65	455.2469	0	6480	3957.7	1	1	1	1	1	1	1
157	Validate	3.958	10661	108	260	49.4463	0.702	1134.65	2674.0205	0	2629	2178.7	1	1	1	1	0	0	1
	Calculate	3.958	10661	108	260	49.4463	0.702	1134.65	2674.0205	0	2629	2178.7	1	1	1	1	1	1	0.9523
158	Validate	3.958	6234.9	195	235.4	37.31	0.75	794.7	471.7	0	10367	2013	1	1	1	1	1	1	1
	Calculate	3.958	6234.9	195	235.4	37.31	0.75	794.7	471.7	0	10367	2013	1	1	1	1	1	1	1
159	Validate	3.958	6447.2	195	235.4	37.31	0.75	591.7	516.6	0	3356	1546.5	1	1	1	1	1	1	1
	Calculate	3.958	6447.2	195	235.4	37.31	0.75	591.7	516.6	0	3356	1546.5	1	1	1	1	1	1	0.9997
160	Validate	3.958	6501.8	126.3	238.1	37.6	0.75	464.7	550.3	0	2436.5	1385.7	0	1	1	1	1	1	1
	Calculate	3.958	6501.8	126.3	238.1	37.6	0.75	464.7	550.3	0	2436.5	1385.7	1	1	0.9995	1	1	1	1
161	Validate	4.892	10498.7	89.6	195.8	9	1.567	164.984	129.232	0.5	924.6	4473.05	1	1	1	1	1	1	1
	Calculate	4.892	10498.7	89.6	195.8	9	1.567	164.984	129.232	0.5	924.6	4473.05	1	1	1	1	1	1	1
162	Validate	6.184	8543	115	262	36.5523	1.122	248.7	336.7857	0	19600	2238.7	1	1	1	1	1	1	1
	Calculate	6.184	8543	115	262	36.5523	1.122	248.7	336.7857	0	19600	2238.7	1	1	1	1	0.9999	1	1
163	Validate	6.184	7500	119	269	35.5602	1.1	193.7	322.9901	0	7090	1964.7	1	1	0	1	1	1	1
	Calculate	6.184	7500	119	269	35.5602	1.1	193.7	322.9901	0	7090	1964.7	1	1	1	1	1	1	1
164	Validate	6.184	7349	119	269	35.5602	1.1	215.7	323.0034	0	14650	2039.7	1	1	1	1	1	1	1
	Calculate	6.184	7349	119	269	35.5602	1.1	215.7	323.0034	0	14650	2039.7	1	1	1	1	0.9993	0.9991	1
165	Validate	6.184	8045	119	269	35.5602	1.1	256.7	322.987	0	15400	2232.7	1	1	1	1	1	1	1
	Calculate	6.184	8045	119	269	35.5602	1.1	256.7	322.987	0	15400	2232.7	1	1	1	1	0.9995	0.9993	1
166	Validate	6.184	10003	115	262	36.5523	1.122	314.7	336.8082	0	7770	2260.7	1	1	1	1	1	1	1
	Calculate	6.184	10003	115	262	36.5523	1.122	314.7	336.8082	0	7770	2260.7	1	1	1	1	1	1	1

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No.	Data type	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)	D&R (M) 20%	H&B 20%	F&B 20%	M&B 20%	B&B 20%	Ork 20%	D&R (O) 20%
167	Validate	6.184	8950	115	262	36.5523	1.122	231.7	336.8182	0	15400	2214.7	1	1	1	1	1	1	1
	Calculate	6.184	8950	115	262	36.5523	1.122	231.7	336.8182	0	15400	2214.7	1	1	1	1	0.9999	0.9999	1
168	Test	1.995	7850	75	189	38.8	0.9349	990	1019	0	187	3190	1	1	1	1	1	1	1
	Calculate	1.995	7850	75	189	38.8	0.9349	990	1019	0	187	3190	1	1	1	1	1	1	1
169	Test	1.995	3363	86	168.8	15.6	0.78	199.7	944.7	60.4	42.6096	1485.3	0	0	0	1	1	0	1
	Calculate	1.995	3363	86	168.8	15.6	0.78	199.7	944.7	60.4	42.6096	1485.3	0.0004	0.7035	0.3215	1	0.9998	0.1652	1
170	Test	1.995	3313.6	86	167	15.6	0.67	157	692.8	25	16.05	1458.4	0	0	0	1	1	1	1
	Calculate	1.995	3313.6	86	167	15.6	0.67	157	692.8	25	16.05	1458.4	0	0	0	0.0034	0.9998	0.9558	0.9595
171	Test	2.441	10800	75	189	44.4	0.796	1264	2250	0	60	3835	1	1	0	1	1	1	1
	Calculate	2.441	10800	75	189	44.4	0.796	1264	2250	0	60	3835	1	0.9996	1	1	1	1	1
172	Test	2.441	7054.1	107.6	176	32.8	0.7	1003.2	774.9	0	4075	3236.2	1	1	1	1	1	1	1
	Calculate	2.441	7054.1	107.6	176	32.8	0.7	1003.2	774.9	0	4075	3236.2	1	1	1	1	1	1	1
173	Test	2.441	7578.7	118.94	186.8	19.2	0.708	815	512.4	0	3834.3	3444.7	1	1	1	1	1	1	1
	Calculate	2.441	7578.7	118.94	186.8	19.2	0.708	815	512.4	0	3834.3	3444.7	1	1	1	1	1	0.9987	0.9988
174	Test	2.441	7647.6	107.6	192.2	32.2	0.92	1564.5	858.4	0	2616.56	3955.3	1	1	1	1	1	1	1
	Calculate	2.441	7647.6	107.6	192.2	32.2	0.92	1564.5	858.4	0	2616.56	3955.3	1	1	1	1	1	1	1
175	Test	2.441	8038.1	89.6	167	40.3	0.75	1344.1	947	0	330.84	3508.8	1	1	1	1	1	1	1
	Calculate	2.441	8038.1	89.6	167	40.3	0.75	1344.1	947	0	330.84	3508.8	1	1	1	1	1	1	1
176	Test	2.441	3346.6	86	168	16.6	0.78	192.5	747.8	9	160.251	1448.6	0	0	0	1	0	0	0
	Calculate	2.441	3346.6	86	168	16.6	0.78	192.5	747.8	9	160.251	1448.6	0	0	0	0.0001	1	1	0.1768
177	Test	2.441	6102.7	90	264	37	0.65	228	701.9	0	36	2253.4	0	0	0	1	1	1	1
	Calculate	2.441	6102.7	90	264	37	0.65	228	701.9	0	36	2253.4	0.0013	0.3432	0	1	1	1	1
178	Test	2.764	11303	103.5	237.5	45.5964	0.667	575	2750	0	720	1400	1	1	1	0	0	0	1
	Calculate	2.764	11303	103.5	237.5	45.5964	0.667	575	2750	0	720	1400	0.1162	0	0.0001	0.9019	1	1	0.8842
179	Test	2.992	4240	126	150	15.6	0.75	714.65	957	0	1165	1564.7	1	1	1	1	1	1	1
	Calculate	2.992	4240	126	150	15.6	0.75	714.65	957	0	1165	1564.7	1	0.9232	1	1	1	1	0.9576
180	Test	2.992	4400	126	150	18.6	0.75	414.65	472	0	1040	1364.7	1	1	1	1	1	1	1
	Calculate	2.992	4400	126	150	18.6	0.75	414.65	472	0	1040	1364.7	1	0.9998	1	1	1	1	0.6176
181	Test	2.992	3924	126	150	18.7	0.75	714.65	575	0	1850	1514.7	1	1	1	1	1	1	1
	Calculate	2.992	3924	126	150	18.7	0.75	714.65	575	0	1850	1514.7	1	0.9982	1	1	1	1	0.9469
182	Test	2.992	3182.4	86	158	17.05	0.69	181.8	745	7	267.282	1287.7	0	0	0	1	0	0	0
	Calculate	2.992	3182.4	86	158	17.05	0.69	181.8	745	7	267.282	1287.7	0	0	0	0	1	0.9849	0.0018
183	Test	2.992	5800.8	150	235	38.69	0.75	724.7	1207.2	0	6538	1870.7	1	1	1	1	0	0	1
	Calculate	2.992	5800.8	150	235	38.69	0.75	724.7	1207.2	0	6538	1870.7	1	1	1	1	1	1	1
184	Test	2.992	6496.5	130	236	39	0.75	514.7	387.4	0	4286	1562.6	0	1	1	1	0	1	0
	Calculate	2.992	6496.5	130	236	39	0.75	514.7	387.4	0	4286	1562.6	1	1	1	1	1	1	1
185	Test	2.992	7169.1	160	236	37.62	0.87	202.7	426.7	18	291.1	1754.6	1	1	0	0	0	1	1
	Calculate	2.992	7169.1	160	236	37.62	0.87	202.7	426.7	18	291.1	1754.6	1	1	1	1	1	1	0.9865
186	Test	3.958	10947	145	321	54.4396	0.7	1084.65	1177.4387	0	13368	3686.7	1	1	1	1	1	1	1
	Calculate	3.958	10947	145	321	54.4396	0.7	1084.65	1177.4387	0	13368	3686.7	1	1	1	1	1	0.9981	1
187	Test	3.958	10456	112	270	49.678	0.844	2274.65	1387.7953	0	6096	4223.7	1	1	1	1	1	1	1
	Calculate	3.958	10456	112	270	49.678	0.844	2274.65	1387.7953	0	6096	4223.7	1	1	1	1	1	1	1
188	Test	3.958	10289	119	269	35.5602	1.1	230.65	323.0479	0	7940	2340.7	1	1	1	1	1	1	1
	Calculate	3.958	10289	119	269	35.5602	1.1	230.65	323.0479	0	7940	2340.7	1	1	1	1	1	1	1
189	Test	3.958	12062	138	330	50.1431	0.7	1548.65	1200.4405	0	10896	4216.7	1	1	1	1	1	1	1
	Calculate	3.958	12062	138	330	50.1431	0.7	1548.65	1200.4405	0	10896	4216.7	1	1	1	1	1	0.9995	1
190	Test	3.958	14322	114	260	40.6411	0.7	714.65	531.4885	0	3144	2466.7	0	0	0	0	0	0	0
	Calculate	3.958	14322	114	260	40.6411	0.7	714.65	531.4885	0	3144	2466.7	0.3762	0.9893	1	1	0.0013	0.0304	0.0005

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No.	Data type	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)	D&R (M) 20%	H&B 20%	F&B 20%	M&B 20%	B&B 20%	Ork 20%	D&R (O) 20%
191	Test	3.958	12165	122	310	48.7548	0.7	1589.65	522.9767	0	5832	3631.7	0	0	0	0	0	0	0
	Calculate	3.958	12165	122	310	48.7548	0.7	1589.65	522.9767	0	5832	3631.7	1	1	1	1	1	0.9995	0.9997
192	Test	3.958	9928	120	342	62.3356	0.72	1514.65	3615.5651	0	15342	4761.7	1	1	1	1	0	0	1
	Calculate	3.958	9928	120	342	62.3356	0.72	1514.65	3615.5651	0	15342	4761.7	1	1	1	1	0.8039	0.0165	1
193	Test	3.958	10218	140	310	56.1658	0.806	1128.65	4065.1933	0	11719	3827.7	0	1	0	0	0	0	1
	Calculate	3.958	10218	140	310	56.1658	0.806	1128.65	4065.1933	0	11719	3827.7	1	1	1	1	0.963	0.1207	0.1412
194	Test	3.958	6480	195	235.4	37.31	0.75	719.7	527.8	0	10845	2023	1	1	1	1	1	1	1
	Calculate	3.958	6480	195	235.4	37.31	0.75	719.7	527.8	0	10845	2023	1	1	1	1	1	1	1
195	Test	4.892	10170.6	84.2	192.2	11.8	0.938	524.82	168.736	0.1	836.55	4475.89	1	1	1	1	1	1	1
	Calculate	4.892	10170.6	84.2	192.2	11.8	0.938	524.82	168.736	0.1	836.55	4475.89	1	1	1	1	1	1	0.9904
196	Test	4.892	7647.64	124.88	188.6	17.2	0.708	770.87	512.415	0	4128.01	3328.12	1	1	0	1	1	0	1
	Calculate	4.892	7647.64	124.88	188.6	17.2	0.708	770.87	512.415	0	4128.01	3328.12	1	1	0.4775	1	1	0.7046	0.9985
197	Test	6.184	8103	115	262	36.5523	1.122	334.7	336.7901	0	16200	2437.7	1	1	1	1	1	1	1
	Calculate	6.184	8103	115	262	36.5523	1.122	334.7	336.7901	0	16200	2437.7	1	1	1	1	1	1	1
198	Test	6.184	7480	115	262	36.5523	1.122	275.7	336.7983	0	25205	2296.7	1	1	1	1	1	1	1
	Calculate	6.184	7480	115	262	36.5523	1.122	275.7	336.7983	0	25205	2296.7	1	1	1	1	0.9999	1	1
199	Test	6.184	8349	119	269	35.5602	1.1	219.7	323.0043	0	22235	2153.7	1	1	1	1	1	1	1
	Calculate	6.184	8349	119	269	35.5602	1.1	219.7	323.0043	0	22235	2153.7	1	1	1	1	0.9989	1	1
200	Test	6.184	8166	119	269	35.5602	1.1	219.7	323.0159	0	13860	2143.7	1	1	1	1	1	1	1
	Calculate	6.184	8166	119	269	35.5602	1.1	219.7	323.0159	0	13860	2143.7	1	1	1	1	0.9996	0.9959	1
201	Test	6.184	7900	115	262	36.5523	1.122	332.7	336.8098	0	9780	2340.7	1	1	1	1	1	1	1
	Calculate	6.184	7900	115	262	36.5523	1.122	332.7	336.8098	0	9780	2340.7	1	1	1	1	1	1	1

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APPENDIX C

Results of neural network Model number 14 for Case 2: (10% maximum error)

No.	Data type	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)	D&R (M) 10%	H&B 10%	F&B 10%	M&B 10%	B&B 10%	Ork 10%	D&R (O) 10%
1	Train	1.995	7450	75	189	54	0.752	1645	3393	0	82	3300	0	0	0	1	1	1	1
	Calculate	1.995	7450	75	189	54	0.752	1645	3393	0	82	3300	0.0006	0.0015	0	0.9982	1	1	1
2	Train	1.995	7350	75	189	54	0.752	1635	3393	0	125	3290	0	0	0	0	0	0	0
	Calculate	1.995	7350	75	189	54	0.752	1635	3393	0	125	3290	0	0	0	0	0.0005	0.0004	0
3	Train	1.995	7850	75	189	38.8	0.9349	990	1019	0	187	3190	1	0	0	1	1	1	1
	Calculate	1.995	7850	75	189	38.8	0.9349	990	1019	0	187	3190	0.9989	0.0007	0.0008	0.9997	0.9998	1	1
4	Train	1.995	7800	75	189	42.6	0.84	1261	1747	0	168	3141	1	0	0	1	1	1	1
	Calculate	1.995	7800	75	189	42.6	0.84	1261	1747	0	168	3141	0.9986	0.0009	0.0009	0.9996	0.9998	1	1
5	Train	1.995	8070	75	189	42.6	0.84	1229	1747	0	259.2	3199	0	1	1	0	0	1	0
	Calculate	1.995	8070	75	189	42.6	0.84	1229	1747	0	259.2	3199	0	0.9991	0.9979	0.0017	0	1	0
6	Train	1.995	3000	75	189	41.3	1.048	175	189	0	160.3	1083	1	1	1	1	1	1	1
	Calculate	1.995	3000	75	189	41.3	1.048	175	189	0	160.3	1083	1	1	0.9998	1	1	0.9999	1
7	Train	1.995	4410	75	189	41.3	1.048	105	230	0	392.4	1229	0	1	0	1	1	0	1
	Calculate	1.995	4410	75	189	41.3	1.048	105	230	0	392.4	1229	0.0018	0.9989	0	1	1	0	1
8	Train	1.995	3363	86	168.8	15.6	0.78	199.7	944.7	60.4	42.6096	1485.3	0	0	0	1	1	0	0
	Calculate	1.995	3363	86	168.8	15.6	0.78	199.7	944.7	60.4	42.6096	1485.3	0	0	0	0.9993	1	0	0.0008
9	Train	1.995	3362.9	86	168.8	15.6	0.78	250.6	7029.3	56	14.652	1506.7	0	0	0	0	0	0	0
	Calculate	1.995	3362.9	86	168.8	15.6	0.78	250.6	7029.3	56	14.652	1506.7	0	0	0	0	0	0.0001	0
10	Train	1.995	3395	86	158	15.6	0.62	107.2	2475.1	14	12.986	1513.8	0	0	0	0	0	0	0
	Calculate	1.995	3395	86	158	15.6	0.62	107.2	2475.1	14	12.986	1513.8	0	0	0	0	0	0.0015	0
11	Train	1.995	3313.6	86	167	15.6	0.67	157	692.8	25	16.05	1458.4	0	0	0	1	1	0	0
	Calculate	1.995	3313.6	86	167	15.6	0.67	157	692.8	25	16.05	1458.4	0	0	0	0.9992	1	0	0.0008
12	Train	1.995	3346.6	86	172.4	15.6	0.72	356.1	889.2	4.4	101.6228	1505.3	0	0	0	0	0	0	0
	Calculate	1.995	3346.6	86	172.4	15.6	0.72	356.1	889.2	4.4	101.6228	1505.3	0	0	0	0	0	0.0015	0
13	Train	2.441	9592	75	189	50.8	0.68	2360	3640	0	244.8	4090	1	1	1	1	1	1	1
	Calculate	2.441	9592	75	189	50.8	0.68	2360	3640	0	244.8	4090	1	1	0.9997	1	1	1	1
14	Train	2.441	10683	75	189	47.6	0.742	1784	2151	0	313.2	4315	1	0	0	1	1	1	1
	Calculate	2.441	10683	75	189	47.6	0.742	1784	2151	0	313.2	4315	0.9998	0.0007	0.0004	0.9998	0.9993	1	1
15	Train	2.441	10800	75	189	44.4	0.796	1264	2250	0	60	3835	0	1	0	0	0	1	1
	Calculate	2.441	10800	75	189	44.4	0.796	1264	2250	0	60	3835	0.002	0.9974	0.0025	0.0003	0.0006	0.9981	0.9986
16	Train	2.441	12861.5	90	200	37	0.7	1294.7	3762	0	283	4049.7	0	0	0	0	0	0	0
	Calculate	2.441	12861.5	90	200	37	0.7	1294.7	3762	0	283	4049.7	0.0003	0.0008	0	0	0	0	0.0003
17	Train	2.441	7054.1	107.6	176	32.8	0.7	1003.2	774.9	0	4075	3236.2	1	1	1	1	1	1	1
	Calculate	2.441	7054.1	107.6	176	32.8	0.7	1003.2	774.9	0	4075	3236.2	1	1	1	1	1	1	1
18	Train	2.441	8038.4	92.1	167	40.3	0.75	1387.2	942.2	0	191.9	3588.9	1	1	1	1	1	1	1
	Calculate	2.441	8038.4	92.1	167	40.3	0.75	1387.2	942.2	0	191.9	3588.9	1	1	1	1	1	1	1
19	Train	2.441	10532	93.2	232.1	46	0.71	2270.5	2271.8	0	439.7	4654.2	1	0	0	1	1	1	1
	Calculate	2.441	10532	93.2	232.1	46	0.71	2270.5	2271.8	0	439.7	4654.2	0.9997	0.0008	0.0002	0.9996	0.9999	1	1
20	Train	2.441	8760.3	104	198.5	25	0.57	128.5	381.8	0	353.5	2819.4	0	0	0	0	0	0	1
	Calculate	2.441	8760.3	104	198.5	25	0.57	128.5	381.8	0	353.5	2819.4	0	0	0	0	0	0	0.9997
21	Train	2.441	7578.7	132.8	187.88	19.2	0.708	563.2	512.4	0	4226.75	3294	1	1	1	1	0	1	0
	Calculate	2.441	7578.7	132.8	187.88	19.2	0.708	563.2	512.4	0	4226.75	3294	0.9997	1	1	1	0	1	0.0002
22	Train	2.441	8759.8	104	198.5	25	0.571	113.8	383.7	0	255.366	2762.1	0	0	0	0	1	0	1
	Calculate	2.441	8759.8	104	198.5	25	0.571	113.8	383.7	0	255.366	2762.1	0	0	0	0	0.9998	0	0.9997

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No.	Data type	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)	D&R (M) 10%	H&B 10%	F&B 10%	M&B 10%	B&B 10%	Ork 10%	D&R (O) 10%
23	Train	2.441	8759.8	104	198.5	25	0.571	113.8	383.7	0	353.487	2804.7	0	0	0	0	0	0	0
	Calculate	2.441	8759.8	104	198.5	25	0.571	113.8	383.7	0	353.487	2804.7	0	0	0	0	0	0	0.0004
24	Train	2.441	7053.8	105.8	176	32.8	0.701	896	744.9	0	2203.95	2972.6	0	0	0	0	1	0	1
	Calculate	2.441	7053.8	105.8	176	32.8	0.701	896	744.9	0	2203.95	2972.6	0	0.0003	0.0003	0.0018	0.9986	0	1
25	Train	2.441	7053.8	107.6	176	32.8	0.701	988.5	756.2	0	3607.84	3164.6	1	1	1	1	1	1	1
	Calculate	2.441	7053.8	107.6	176	32.8	0.701	988.5	756.2	0	3607.84	3164.6	1	1	1	1	1	0.9999	1
26	Train	2.441	7053.8	107.6	176	32.8	0.701	988.5	778.8	0	4075.8	3221.5	1	1	1	1	1	1	1
	Calculate	2.441	7053.8	107.6	176	32.8	0.701	988.5	778.8	0	4075.8	3221.5	1	1	1	1	1	1	1
27	Train	2.441	8038.1	89.42	167	40.3	0.75	1308.5	947	0	480.54	3436.2	1	1	1	1	1	1	1
	Calculate	2.441	8038.1	89.42	167	40.3	0.75	1308.5	947	0	480.54	3436.2	1	1	1	1	1	1	1
28	Train	2.441	8038.1	98.6	167	40.3	0.75	1173.4	947	0	1125.88	3227.1	1	1	1	1	1	0	1
	Calculate	2.441	8038.1	98.6	167	40.3	0.75	1173.4	947	0	1125.88	3227.1	0.9985	1	0.9994	1	1	0.0012	1
29	Train	2.441	10531.5	93.2	232.16	46	0.71	2255.7	2283.3	0	439.66	4639.5	1	0	0	1	1	1	1
	Calculate	2.441	10531.5	93.2	232.16	46	0.71	2255.7	2283.3	0	439.66	4639.5	0.9995	0.0004	0.0001	0.9993	0.9998	1	1
30	Train	2.441	3346.6	86	168	16.6	0.78	192.5	747.8	9	160.251	1448.6	0	0	0	0	0	0	0
	Calculate	2.441	3346.6	86	168	16.6	0.78	192.5	747.8	9	160.251	1448.6	0	0	0	0	0.0001	0	0
31	Train	2.441	3379.3	86	172.4	16.67	0.72	225.2	1437.3	1.4	71.978	1512.4	0	0	0	0	0	0	0
	Calculate	2.441	3379.3	86	172.4	16.67	0.72	225.2	1437.3	1.4	71.978	1512.4	0	0	0	0	0	0.0015	0
32	Train	2.441	4445.7	104	185	14.48	0.6	289.2	283.3	24	172.064	1988.9	0	0	0	1	1	0	1
	Calculate	2.441	4445.7	104	185	14.48	0.6	289.2	283.3	24	172.064	1988.9	0	0.0011	0	0.999	1	0	0.9992
33	Train	2.441	8465	90	200	37	0.7	294.9	252.7	50	148.5	3355.6	1	1	1	1	1	1	1
	Calculate	2.441	8465	90	200	37	0.7	294.9	252.7	50	148.5	3355.6	1	1	0.9987	1	1	1	1
34	Train	2.441	10007	90	200	37	0.7	606.4	505.3	10	446.04	3745.3	1	0	0	1	1	1	1
	Calculate	2.441	10007	90	200	37	0.7	606.4	505.3	10	446.04	3745.3	0.9989	0.0007	0.0008	0.9997	0.9998	1	1
35	Train	2.441	6102.7	90	264	37	0.65	228	701.9	0	36	2253.4	0	0	0	1	1	0	0
	Calculate	2.441	6102.7	90	264	37	0.65	228	701.9	0	36	2253.4	0	0	0	0.9994	1	0	0.0008
36	Train	2.441	6102.7	90	264	37	0.65	811.2	2027	0	15	2860.7	0	1	0	1	1	1	0
	Calculate	2.441	6102.7	90	264	37	0.65	811.2	2027	0	15	2860.7	0.0008	0.9998	0	0.9985	0.9993	1	0.001
37	Train	2.764	13477	130	289	52.2662	0.71	2130	3086.3	0	823	6045	0	0	0	0	0	0	0
	Calculate	2.764	13477	130	289	52.2662	0.71	2130	3086.3	0	823	6045	0.0005	0.0013	0	0	0	0	0.0006
38	Train	2.764	10876	139	308	66.6793	0.685	3940	2303.4	0	4272	6729	1	1	1	1	1	1	1
	Calculate	2.764	10876	139	308	66.6793	0.685	3940	2303.4	0	4272	6729	1	1	1	1	1	1	1
39	Train	2.992	3940	126	150	14.6	0.75	164.65	252	0	1300	1014.7	0	0	0	0	0	1	0
	Calculate	2.992	3940	126	150	14.6	0.75	164.65	252	0	1300	1014.7	0	0	0	0.0024	0	0.9968	0
40	Train	2.992	3720	126	150	14.4	0.75	314.65	232	0	1965	1214.7	0	0	1	0	0	0	0
	Calculate	2.992	3720	126	150	14.4	0.75	314.65	232	0	1965	1214.7	0	0	0.9999	0.0007	0	0.001	0.0013
41	Train	2.992	4570	126	150	13.5	0.75	864.65	1500	0	1965	1514.7	1	0	1	1	0	0	0
	Calculate	2.992	4570	126	150	13.5	0.75	864.65	1500	0	1965	1514.7	0.9988	0.0013	1	1	0.0003	1	0.0007
42	Train	2.992	4355	126	150	12.9	0.75	264.65	185	0	855	1714.7	1	1	0	1	1	1	1
	Calculate	2.992	4355	126	150	12.9	0.75	264.65	185	0	855	1714.7	1	1	0.001	1	1	0.9984	0.9987
43	Train	2.992	4670	126	150	13.6	0.75	924.65	1565	0	2320	1664.7	1	0	1	1	0	1	0
	Calculate	2.992	4670	126	150	13.6	0.75	924.65	1565	0	2320	1664.7	0.9987	0.0012	1	1	0.0002	1	0.0007
44	Train	2.992	4575	126	150	18.6	0.75	664.65	858	0	2480	1564.7	1	0	0	1	0	1	1
	Calculate	2.992	4575	126	150	18.6	0.75	664.65	858	0	2480	1564.7	0.9999	0.0003	1	1	0	0.9981	0.9983
45	Train	2.992	4065	126	150	13	0.75	514.65	341	0	1490	1564.7	0	0	1	1	0	1	0
	Calculate	2.992	4065	126	150	13	0.75	514.65	341	0	1490	1564.7	0.0013	0	1	0.9989	0	1	0.0001
46	Train	2.992	3705	126	150	13.6	0.75	514.65	335	0	1310	1464.7	0	0	1	1	0	1	0
	Calculate	2.992	3705	126	150	13.6	0.75	514.65	335	0	1310	1464.7	0.0013	0	1	0.9988	0	1	0.0001

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No.	Data type	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)	D&R (M) 10%	H&B 10%	F&B 10%	M&B 10%	B&B 10%	Ork 10%	D&R (O) 10%
47	Train	2.992	4160	126	150	12.9	0.75	164.65	185	0	1350	1514.7	1	1	0	1	1	0	1
	Calculate	2.992	4160	126	150	12.9	0.75	164.65	185	0	1350	1514.7	1	0.9987	0	1	1	0.001	0.9996
48	Train	2.992	4210	126	150	16	0.75	364.65	222	0	788	1764.7	1	1	0	1	1	0	1
	Calculate	2.992	4210	126	150	16	0.75	364.65	222	0	788	1764.7	0.9996	0.9995	0.0006	1	1	0.0006	1
49	Train	2.992	4487	126	150	14.1	0.75	594.65	962	0	1905	1314.7	0	0	1	1	0	1	0
	Calculate	2.992	4487	126	150	14.1	0.75	594.65	962	0	1905	1314.7	0.001	0	1	0.999	0	1	0.0004
50	Train	2.992	4692	126	150	12.9	0.75	414.65	865	0	1585	1164.7	0	0	0	1	0	1	0
	Calculate	2.992	4692	126	150	12.9	0.75	414.65	865	0	1585	1164.7	0	0	0.0007	0.9989	0.0013	1	0
51	Train	2.992	3924	126	150	18.7	0.75	714.65	575	0	1850	1514.7	0	0	1	1	0	1	0
	Calculate	2.992	3924	126	150	18.7	0.75	714.65	575	0	1850	1514.7	0.0013	0	1	0.9987	0	1	0.0004
52	Train	2.992	4240	126	150	15.6	0.75	714.7	957.4	0	1165	1564.7	0	0	1	0	0	1	0
	Calculate	2.992	4240	126	150	15.6	0.75	714.7	957.4	0	1165	1564.7	0	0	0.9995	0.0009	0	0.9989	0
53	Train	2.992	4175.1	126	150	15.6	0.75	314.7	267.3	0	2700	1514.7	1	0	0	1	1	1	0
	Calculate	2.992	4175.1	126	150	15.6	0.75	314.7	267.3	0	2700	1514.7	0.9998	0.0001	0	1	0.9999	1	0
54	Train	2.992	4210	126	150	16	0.75	364.7	223.3	0	788	1764.7	1	1	0	1	1	0	1
	Calculate	2.992	4210	126	150	16	0.75	364.7	223.3	0	788	1764.7	0.9996	0.9994	0.0006	1	1	0.0006	1
55	Train	2.992	7647.64	104	185	31.3	0.92	1322.71	901.81	0	2654.3	3555.7	1	1	1	1	1	0	1
	Calculate	2.992	7647.64	104	185	31.3	0.92	1322.71	901.81	0	2654.3	3555.7	0.9998	1	0.9999	1	1	0	1
56	Train	2.992	3182.5	86	158	17.05	0.69	250.1	989	14	182.32	1390.2	0	0	0	0	0	0	0
	Calculate	2.992	3182.5	86	158	17.05	0.69	250.1	989	14	182.32	1390.2	0	0	0	0	0	0.0009	0
57	Train	2.992	3346.6	86	158	17.05	0.69	184	1243.2	24	120.004	1465.5	0	0	0	0	0	0	0
	Calculate	2.992	3346.6	86	158	17.05	0.69	184	1243.2	24	120.004	1465.5	0	0	0	0	0.0002	0	0.0001
58	Train	2.992	4101.3	195	237	39.25	0.75	1284.7	3773.3	0	278	1731.1	1	1	0	0	0	1	1
	Calculate	2.992	4101.3	195	237	39.25	0.75	1284.7	3773.3	0	278	1731.1	1	0.9988	0	0.0022	0	0.9981	0.9983
59	Train	2.992	4101.3	195	237	39.25	0.75	724.7	3077	0	548	1056.7	1	1	0	1	1	0	1
	Calculate	2.992	4101.3	195	237	39.25	0.75	724.7	3077	0	548	1056.7	1	0.9992	0.0017	1	0.998	0.0017	1
60	Train	2.992	4521.2	195	237	39.25	0.75	989.7	6081	0	1555	1490	1	1	1	1	0	0	0
	Calculate	2.992	4521.2	195	237	39.25	0.75	989.7	6081	0	1555	1490	0.999	1	0.999	0.9992	0.0017	0	0
61	Train	2.992	4921.5	195	230	37.31	0.75	764.7	381.8	0	7226	1976.5	0	0	0	0	0	0	0
	Calculate	2.992	4921.5	195	230	37.31	0.75	764.7	381.8	0	7226	1976.5	0	0	0	0	0	0.0017	0.0015
62	Train	2.992	6411.1	200	236.5	38.72	0.75	589.7	651.3	0	5809	1937.6	1	1	1	1	0	1	1
	Calculate	2.992	6411.1	200	236.5	38.72	0.75	589.7	651.3	0	5809	1937.6	1	0.999	1	1	0.0012	0.999	0.9993
63	Train	2.992	5800.8	150	235	38.69	0.75	724.7	1207.2	0	6538	1870.7	0	1	0	0	0	0	1
	Calculate	2.992	5800.8	150	235	38.69	0.75	724.7	1207.2	0	6538	1870.7	0.0001	0.9999	0	0	0	0	0.9998
64	Train	2.992	6402	130	236	39	0.75	548.7	746.8	0	943	1568.7	1	0	0	1	1	0	1
	Calculate	2.992	6402	130	236	39	0.75	548.7	746.8	0	943	1568.7	1	0.0006	0	0.9995	1	0	0.9999
65	Train	2.992	6105.7	130	236	39	0.75	554.7	797.3	0	2482	1319.5	1	1	1	1	0	0	1
	Calculate	2.992	6105.7	130	236	39	0.75	554.7	797.3	0	2482	1319.5	0.9984	1	0.9976	0.9977	0.002	0	0.9992
66	Train	2.992	6496.5	130	236	39	0.75	514.7	387.4	0	4286	1562.6	0	0	0	0	0	0	0
	Calculate	2.992	6496.5	130	236	39	0.75	514.7	387.4	0	4286	1562.6	0	0.0007	0.0009	0.0015	0	0	0
67	Train	2.992	6069.8	130	236	38.72	0.75	414.7	555.9	0	6037	1663.7	1	1	1	1	0	0	1
	Calculate	2.992	6069.8	130	236	38.72	0.75	414.7	555.9	0	6037	1663.7	0.9998	1	1	1	0.0001	0	1
68	Train	2.992	6512.8	150	236	38.72	0.75	374.7	589.6	0	2306	1099.7	0	1	1	0	0	0	1
	Calculate	2.992	6512.8	150	236	38.72	0.75	374.7	589.6	0	2306	1099.7	0.001	0.9987	1	0.0002	0	0	0.9985
69	Train	2.992	5006.1	195	237	39.25	0.75	1164.7	5317.4	35.5	655.32	1631.7	1	1	1	1	0	0	1
	Calculate	2.992	5006.1	195	237	39.25	0.75	1164.7	5317.4	35.5	655.32	1631.7	1	0.9998	1	0.9999	0	0	1
70	Train	2.992	6001.7	150	236	38.72	0.75	469.7	589.6	20	5401.6	2030.4	1	1	1	1	1	1	1
	Calculate	2.992	6001.7	150	236	38.72	0.75	469.7	589.6	20	5401.6	2030.4	1	1	1	1	1	1	1

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No.	Data type	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)	D&R (M) 10%	H&B 10%	F&B 10%	M&B 10%	B&B 10%	Ork 10%	D&R (O) 10%
71	Train	2.992	7169.1	160	236	37.62	0.87	202.7	426.7	18	291.1	1754.6	1	0	0	0	0	0	1
	Calculate	2.992	7169.1	160	236	37.62	0.87	202.7	426.7	18	291.1	1754.6	0.9988	0	0	0.0011	0	0	1
72	Train	3.958	9746	124	306	51.553	0.7	3314.65	1473.6239	0	15696	6516.7	1	1	1	1	1	1	1
	Calculate	3.958	9746	124	306	51.553	0.7	3314.65	1473.6239	0	15696	6516.7	1	1	1	1	1	1	1
73	Train	3.958	10049	140	337	51.7902	0.7	1289.65	1286.6915	0	16080	4281.7	1	1	1	1	0	1	1
	Calculate	3.958	10049	140	337	51.7902	0.7	1289.65	1286.6915	0	16080	4281.7	1	0.9999	1	1	0	1	1
74	Train	3.958	10947	145	321	54.4396	0.7	1084.65	1177.4387	0	13368	3686.7	1	1	1	1	0	0	1
	Calculate	3.958	10947	145	321	54.4396	0.7	1084.65	1177.4387	0	13368	3686.7	1	1	1	1	0	0	1
75	Train	3.958	10083	130	286	50.1431	0.7	3684.65	1592.6309	0	11616	6509.7	1	1	1	1	1	1	1
	Calculate	3.958	10083	130	286	50.1431	0.7	3684.65	1592.6309	0	11616	6509.7	1	1	1	1	1	1	1
76	Train	3.958	10239	140	300	51.0806	0.7	2814.65	1470.3065	0	12528	5598.7	1	1	1	1	1	1	1
	Calculate	3.958	10239	140	300	51.0806	0.7	2814.65	1470.3065	0	12528	5598.7	1	1	1	1	1	1	1
77	Train	3.958	9650	120	306	50.6107	0.7	1941.65	1764.6714	0	17040	4862.7	1	1	1	1	0	1	1
	Calculate	3.958	9650	120	306	50.6107	0.7	1941.65	1764.6714	0	17040	4862.7	1	1	0.9999	0.9997	0.0003	1	1
78	Train	3.958	8045	119	269	35.5602	1.1	150.65	322.9485	0	7190	2067.7	1	1	1	1	1	1	1
	Calculate	3.958	8045	119	269	35.5602	1.1	150.65	322.9485	0	7190	2067.7	1	1	1	1	1	1	1
79	Train	3.958	8715	119	269	35.5602	1.1	213.65	323.1173	0	2284	2211.7	1	0	0	1	1	1	1
	Calculate	3.958	8715	119	269	35.5602	1.1	213.65	323.1173	0	2284	2211.7	0.9994	0	0	0.9998	1	1	1
80	Train	3.958	8600	119	269	35.5602	1.1	168.65	322.9358	0	6540	2096.7	1	1	1	1	1	1	1
	Calculate	3.958	8600	119	269	35.5602	1.1	168.65	322.9358	0	6540	2096.7	1	1	1	1	1	1	1
81	Train	3.958	10289	119	269	35.5602	1.1	230.65	323.0479	0	7940	2340.7	1	1	1	1	1	1	1
	Calculate	3.958	10289	119	269	35.5602	1.1	230.65	323.0479	0	7940	2340.7	1	1	1	1	1	1	1
82	Train	3.958	7900	119	269	35.5602	1.1	202.65	323.012	0	8300	2094.7	1	1	1	1	0	1	1
	Calculate	3.958	7900	119	269	35.5602	1.1	202.65	323.012	0	8300	2094.7	0.9999	0.9999	1	1	0	1	1
83	Train	3.958	12249	105	245	47.8409	0.7	1439.65	941.5064	0	2496	3543.7	0	1	1	1	1	1	1
	Calculate	3.958	12249	105	245	47.8409	0.7	1439.65	941.5064	0	2496	3543.7	0.0003	1	1	1	1	0.9996	0.9996
84	Train	3.958	11305	136	330	50.1431	0.7	2964.65	1068.4046	0	8976	5729.7	1	1	1	1	1	1	1
	Calculate	3.958	11305	136	330	50.1431	0.7	2964.65	1068.4046	0	8976	5729.7	1	1	1	1	1	1	1
85	Train	3.958	14322	114	260	40.6411	0.7	714.65	531.4885	0	3144	2466.7	0	0	0	0	0	0	0
	Calculate	3.958	14322	114	260	40.6411	0.7	714.65	531.4885	0	3144	2466.7	0.0001	0.0003	0	0	0	0	0.0007
86	Train	3.958	14330	138	320	43.6238	0.7	664.65	1024.8288	0	3504	1872.7	0	0	0	0	0	0	0
	Calculate	3.958	14330	138	320	43.6238	0.7	664.65	1024.8288	0	3504	1872.7	0.0004	0.0012	0	0	0	0	0.0007
87	Train	3.958	12152	148	336	56.6649	0.72	1184.65	3511.7953	0	13056	4625.7	0	1	1	0	0	0	0
	Calculate	3.958	12152	148	336	56.6649	0.72	1184.65	3511.7953	0	13056	4625.7	0	1	0.9999	0	0	0	0
88	Train	3.958	11248	137	337	57.4186	0.72	2599.65	4823.4127	0	10080	5303.7	1	1	1	1	0	0	0
	Calculate	3.958	11248	137	337	57.4186	0.72	2599.65	4823.4127	0	10080	5303.7	1	1	1	1	0.0007	0	0.0018
89	Train	3.958	12165	122	310	48.7548	0.7	1589.65	522.9767	0	5832	3631.7	0	0	0	0	0	0	0
	Calculate	3.958	12165	122	310	48.7548	0.7	1589.65	522.9767	0	5832	3631.7	0	0.0002	0	0	0	0.0002	0
90	Train	3.958	12171	133	334	48.5254	0.72	834.65	1810.1949	0	11496	3217.7	1	1	1	1	0	0	1
	Calculate	3.958	12171	133	334	48.5254	0.72	834.65	1810.1949	0	11496	3217.7	1	1	1	0.9999	0	0	1
91	Train	3.958	12916	120	271	49.678	0.7	2664.65	1146.3675	0	9360	4958.7	0	0	0	0	0	1	0
	Calculate	3.958	12916	120	271	49.678	0.7	2664.65	1146.3675	0	9360	4958.7	0	0	0.0001	0	0	1	0
92	Train	3.958	9928	120	342	62.3356	0.72	1514.65	3615.5651	0	15342	4761.7	0	0	0	0	0	0	1
	Calculate	3.958	9928	120	342	62.3356	0.72	1514.65	3615.5651	0	15342	4761.7	0	0	0	0	0	0	1
93	Train	3.958	9928	120	345	56.6649	0.72	3804.65	4059.9343	0	4872	5300.7	1	1	1	1	1	1	1
	Calculate	3.958	9928	120	345	56.6649	0.72	3804.65	4059.9343	0	4872	5300.7	1	1	1	1	0.9998	1	1
94	Train	3.958	9928	120	350	57.4186	0.72	3604.65	3922.0047	0	6744	5239.7	1	1	1	1	0	1	1
	Calculate	3.958	9928	120	350	57.4186	0.72	3604.65	3922.0047	0	6744	5239.7	1	1	0.9993	1	0.0007	1	1

No.	Data type	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)	D&R (M) 10%	H&B 10%	F&B 10%	M&B 10%	B&B 10%	Ork 10%	D&R (O) 10%
95	Train	3.958	9930	120	345	47.8409	0.72	814.65	1597.2984	0	11845	2887.7	1	1	1	1	0	0	1
	Calculate	3.958	9930	120	345	47.8409	0.72	814.65	1597.2984	0	11845	2887.7	1	1	1	1	0	0	1
96	Train	3.958	10318	132	320	49.4463	0.7	2749.65	1156.6265	0	9960	5214.7	1	1	1	1	1	1	1
	Calculate	3.958	10318	132	320	49.4463	0.7	2749.65	1156.6265	0	9960	5214.7	1	1	1	1	1	1	1
97	Train	3.958	10336	140	342	52.0279	0.72	1164.65	3335.3746	0	14697	4562.7	0	1	0	0	0	0	0
	Calculate	3.958	10336	140	342	52.0279	0.72	1164.65	3335.3746	0	14697	4562.7	0	0.9997	0	0	0	0	0
98	Train	3.958	10158	133	320	54.9295	0.72	3864.65	3139.5349	0	11352	5492.7	0	0	0	0	0	0	0
	Calculate	3.958	10158	133	320	54.9295	0.72	3864.65	3139.5349	0	11352	5492.7	0.0004	0	0	0	0	0.001	0.0008
99	Train	3.958	10218	140	310	56.1658	0.806	1128.65	4065.1933	0	11719	3827.7	0	0	0	0	0	0	0
	Calculate	3.958	10218	140	310	56.1658	0.806	1128.65	4065.1933	0	11719	3827.7	0	0.0015	0.0013	0	0	0	0
100	Train	3.958	11400	140	342	50.3766	0.7	1914.65	776.4824	0	13896	5000.7	1	1	1	1	1	1	1
	Calculate	3.958	11400	140	342	50.3766	0.7	1914.65	776.4824	0	13896	5000.7	1	1	1	1	0.9996	1	1
101	Train	3.958	10945	130	320	52.0279	0.72	844.65	3153.8367	0	8171	2770.7	1	1	1	1	0	0	0
	Calculate	3.958	10945	130	320	52.0279	0.72	844.65	3153.8367	0	8171	2770.7	0.9996	1	1	0.9992	0.001	0.0002	0.0007
102	Train	3.958	10356	128	320	59.975	0.716	4274.65	2707.0278	0	8936	6632.7	1	1	1	1	1	1	1
	Calculate	3.958	10356	128	320	59.975	0.716	4274.65	2707.0278	0	8936	6632.7	1	1	1	1	1	1	1
103	Train	3.958	10059	140	310	67.5155	0.702	4431.65	3698.4536	0	9312	6905.7	1	1	1	1	1	1	1
	Calculate	3.958	10059	140	310	67.5155	0.702	4431.65	3698.4536	0	9312	6905.7	1	1	1	1	1	1	1
104	Train	3.958	10059	125	334	71.5129	0.49	4336.65	3687.6006	0	9936	6870.7	1	1	1	1	1	1	1
	Calculate	3.958	10059	125	334	71.5129	0.49	4336.65	3687.6006	0	9936	6870.7	1	1	0.9999	1	0.9999	1	1
105	Train	3.958	6234.9	195	235.4	37.31	0.75	794.7	471.7	0	10367	2013	0	0	0	0	0	1	0
	Calculate	3.958	6234.9	195	235.4	37.31	0.75	794.7	471.7	0	10367	2013	0	0	0	0	0	0.9999	0
106	Train	3.958	6233.9	195	235.4	37.31	0.75	771.7	516.6	0	11111	1977	0	0	0	0	0	1	0
	Calculate	3.958	6233.9	195	235.4	37.31	0.75	771.7	516.6	0	11111	1977	0	0	0	0	0	0.9998	0
107	Train	4.892	10847	157	348	69.7802	0.72	2177.7	5525.8	0	10080	4149.7	1	1	1	1	1	0	0
	Calculate	4.892	10847	157	348	69.7802	0.72	2177.7	5525.8	0	10080	4149.7	1	1	1	1	0.9974	0.002	0.0002
108	Train	4.892	10826.8	117.5	224.6	8.3	1.705	223.297	146.163	0.3	522.05	4758.93	1	1	1	1	1	1	1
	Calculate	4.892	10826.8	117.5	224.6	8.3	1.705	223.297	146.163	0.3	522.05	4758.93	1	1	1	1	1	1	1
109	Train	4.892	10498.7	68	194	9	1.567	99.56	129.232	0.2	44.03	4164.4	0	0	1	0	0	0	1
	Calculate	4.892	10498.7	68	194	9	1.567	99.56	129.232	0.2	44.03	4164.4	0.0008	0	0.9984	0.0001	0.0012	0.0012	1
110	Train	4.892	10170.6	84.2	192.2	11.8	0.938	524.82	168.736	0.1	836.55	4475.89	1	1	1	1	1	1	1
	Calculate	4.892	10170.6	84.2	192.2	11.8	0.938	524.82	168.736	0.1	836.55	4475.89	1	1	1	1	1	1	1
111	Train	4.892	10170.6	104	222.8	12.5	1.268	570.33	211.625	0.1	761.07	4521.4	1	1	1	1	1	1	1
	Calculate	4.892	10170.6	104	222.8	12.5	1.268	570.33	211.625	0.1	761.07	4521.4	1	1	1	1	1	1	1
112	Train	4.892	10170.6	136.4	226.4	12.5	1.268	590.24	211.625	0	1100.72	4554.12	1	1	1	1	1	1	1
	Calculate	4.892	10170.6	136.4	226.4	12.5	1.268	590.24	211.625	0	1100.72	4554.12	1	0.9999	1	1	1	1	1
113	Train	6.184	7877	115	262	36.5523	1.122	240.7	336.8254	0	18900	2325.7	1	1	1	1	1	1	1
	Calculate	6.184	7877	115	262	36.5523	1.122	240.7	336.8254	0	18900	2325.7	1	1	1	1	1	1	1
114	Train	6.184	7388	115	262	36.5523	1.122	263.7	336.791	0	26800	2432.7	1	1	1	1	1	1	1
	Calculate	6.184	7388	115	262	36.5523	1.122	263.7	336.791	0	26800	2432.7	1	1	1	1	1	1	1
115	Train	6.184	8103	115	262	36.5523	1.122	334.7	336.7901	0	16200	2437.7	1	1	1	1	1	1	1
	Calculate	6.184	8103	115	262	36.5523	1.122	334.7	336.7901	0	16200	2437.7	1	1	1	1	1	1	1
116	Train	6.184	8255	115	262	36.5523	1.122	260.7	336.7925	0	10600	2296.7	1	1	1	1	1	1	1
	Calculate	6.184	8255	115	262	36.5523	1.122	260.7	336.7925	0	10600	2296.7	1	1	1	1	1	1	1
117	Train	6.184	9199	115	262	36.5523	1.122	263.7	336.7794	0	20990	2214.7	1	1	1	1	1	1	1
	Calculate	6.184	9199	115	262	36.5523	1.122	263.7	336.7794	0	20990	2214.7	1	1	1	1	1	1	1
118	Train	6.184	7480	115	262	36.5523	1.122	275.7	336.7983	0	25205	2296.7	1	1	1	1	1	1	1
	Calculate	6.184	7480	115	262	36.5523	1.122	275.7	336.7983	0	25205	2296.7	1	1	1	1	1	1	1

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No.	Data type	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)	D&R (M) 10%	H&B 10%	F&B 10%	M&B 10%	B&B 10%	Ork 10%	D&R (O) 10%
119	Train	6.184	8543	115	262	36.5523	1.122	248.7	336.7857	0	19600	2238.7	1	1	1	1	1	1	1
	Calculate	6.184	8543	115	262	36.5523	1.122	248.7	336.7857	0	19600	2238.7	1	1	1	1	1	1	1
120	Train	6.184	7596	119	269	35.5602	1.1	321.7	323.0159	0	15120	2630.7	1	0	0	0	1	1	0
	Calculate	6.184	7596	119	269	35.5602	1.1	321.7	323.0159	0	15120	2630.7	1	1	1	1	1	1	1
121	Train	6.184	8349	119	269	35.5602	1.1	219.7	323.0043	0	22235	2153.7	1	1	1	1	1	1	1
	Calculate	6.184	8349	119	269	35.5602	1.1	219.7	323.0043	0	22235	2153.7	1	1	1	1	1	1	1
122	Train	6.184	6899	119	269	35.5602	1.1	229.7	322.9873	0	19750	2083.7	1	1	1	1	1	1	1
	Calculate	6.184	6899	119	269	35.5602	1.1	229.7	322.9873	0	19750	2083.7	1	1	1	1	1	1	1
123	Train	6.184	9599	119	269	35.5602	1.1	214.7	323.0047	0	6390	2145.7	1	0	0	1	1	1	1
	Calculate	6.184	9599	119	269	35.5602	1.1	214.7	323.0047	0	6390	2145.7	0.9997	0	0	0.9999	1	1	1
124	Train	6.184	7093	119	269	35.5602	1.1	227.7	323.0146	0	12340	1960.7	1	1	1	1	1	1	1
	Calculate	6.184	7093	119	269	35.5602	1.1	227.7	323.0146	0	12340	1960.7	1	1	1	1	0.9999	1	1
125	Train	6.184	8674	119	269	35.5602	1.1	295.7	322.9775	0	17800	2368.7	1	1	1	1	1	1	1
	Calculate	6.184	8674	119	269	35.5602	1.1	295.7	322.9775	0	17800	2368.7	1	1	1	1	1	1	1
126	Train	6.184	7349	119	269	35.5602	1.1	215.7	323.0034	0	14650	2039.7	1	1	1	1	1	1	1
	Calculate	6.184	7349	119	269	35.5602	1.1	215.7	323.0034	0	14650	2039.7	1	1	1	1	1	1	1
127	Train	6.184	8045	119	269	35.5602	1.1	256.7	322.987	0	15400	2232.7	1	1	1	1	1	1	1
	Calculate	6.184	8045	119	269	35.5602	1.1	256.7	322.987	0	15400	2232.7	1	1	1	1	1	1	1
128	Train	6.184	7901	119	269	35.5602	1.1	300.7	322.96	0	12500	2043.7	0	1	1	1	0	0	1
	Calculate	6.184	7901	119	269	35.5602	1.1	300.7	322.96	0	12500	2043.7	1	0.9999	1	1	0	1	1
129	Train	6.184	7999	119	269	35.5602	1.1	387.7	323.0052	0	21656	2502.7	1	1	1	1	1	1	1
	Calculate	6.184	7999	119	269	35.5602	1.1	387.7	323.0052	0	21656	2502.7	1	1	1	1	1	1	1
130	Train	6.184	8169	115	262	36.5523	1.122	291.7	336.7803	0	27270	2295.7	1	1	1	1	1	1	1
	Calculate	6.184	8169	115	262	36.5523	1.122	291.7	336.7803	0	27270	2295.7	1	1	1	1	1	1	1
131	Train	6.184	10003	115	262	36.5523	1.122	314.7	336.8082	0	7770	2260.7	1	1	1	1	1	1	1
	Calculate	6.184	10003	115	262	36.5523	1.122	314.7	336.8082	0	7770	2260.7	1	1	1	1	1	1	1
132	Train	6.184	7900	115	262	36.5523	1.122	332.7	336.8098	0	9780	2340.7	1	1	1	1	1	1	1
	Calculate	6.184	7900	115	262	36.5523	1.122	332.7	336.8098	0	9780	2340.7	1	1	1	1	1	1	1
133	Train	6.184	7133	115	262	36.5523	1.122	402.7	336.8293	0	12300	2491.7	1	1	1	1	1	1	1
	Calculate	6.184	7133	115	262	36.5523	1.122	402.7	336.8293	0	12300	2491.7	1	1	1	1	1	1	1
134	Validate	1.995	6570	75	189	42	0.8225	665	1245	0	138	2555	0	0	0	0	0	0	0
	Calculate	1.995	6570	75	189	42	0.8225	665	1245	0	138	2555	0.1032	1	0	1	1	0	1
135	Validate	1.995	8000	75	189	42.6	0.84	1221	1747	0	91.2	3251	0	0	1	0	0	0	0
	Calculate	1.995	8000	75	189	42.6	0.84	1221	1747	0	91.2	3251	0	0.997	0.994	0.0034	0	1	0.0002
136	Validate	1.995	8480	75	189	43.9	0.8287	1665	3588	0	131	3260	1	0	0	0	1	1	1
	Calculate	1.995	8480	75	189	43.9	0.8287	1665	3588	0	131	3260	0.0005	0.0125	0	0	0	0.0002	0.0052
137	Validate	1.995	4410	75	189	41.3	1.048	145	192	0	245.3	1419	1	1	1	1	1	1	1
	Calculate	1.995	4410	75	189	41.3	1.048	145	192	0	245.3	1419	0.0504	1	0	1	1	0	1
138	Validate	2.441	6500	75	189	36.2	0.8225	555	906	0	60	2325	0	1	0	0	0	1	1
	Calculate	2.441	6500	75	189	36.2	0.8225	555	906	0	60	2325	0.0935	1	0	1	1	0	1
139	Validate	2.441	12861.5	90	200	37	0.7	1579.2	5160.2	0	188.7	4005.6	0	0	0	0	1	0	1
	Calculate	2.441	12861.5	90	200	37	0.7	1579.2	5160.2	0	188.7	4005.6	0.0003	0.0008	0	0	0	0	0.0003
140	Validate	2.441	12795.9	90	200	37	0.7	1993.1	2650.3	0	364.8	5032.5	0	0	0	0	0	0	0
	Calculate	2.441	12795.9	90	200	37	0.7	1993.1	2650.3	0	364.8	5032.5	0.9994	0.0001	0	0.9795	0.786	1	1
141	Validate	2.441	7647.6	107.6	192.2	32.2	0.92	1564.5	858.4	0	2616.56	3955.3	1	1	1	1	1	1	1
	Calculate	2.441	7647.6	107.6	192.2	32.2	0.92	1564.5	858.4	0	2616.56	3955.3	1	1	1	1	1	0.9987	1
142	Validate	2.441	3346.6	86	167	16.6	0.67	346.1	580.6	23	152.075	1488.1	0	0	0	0	1	0	1
	Calculate	2.441	3346.6	86	167	16.6	0.67	346.1	580.6	23	152.075	1488.1	0	0	0	0.9989	1	0	0.0012

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No.	Data type	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)	D&R (M) 10%	H&B 10%	F&B 10%	M&B 10%	B&B 10%	Ork 10%	D&R (O) 10%
143	Validate	2.441	5249.6	90	264	37	0.65	441.4	606.4	0	44	1974.6	0	1	0	0	0	1	1
	Calculate	2.441	5249.6	90	264	37	0.65	441.4	606.4	0	44	1974.6	0	0	0	1	1	0	0.0015
144	Validate	2.764	13477	135	301	52.985	0.71	1540	2717.4	0	1104	5840	0	0	0	0	0	0	0
	Calculate	2.764	13477	135	301	52.985	0.71	1540	2717.4	0	1104	5840	0.0003	0.0011	0	0	0	0	0.001
145	Validate	2.764	11303	103.5	237.5	45.5964	0.667	575	2750	0	720	1400	0	0	0	0	0	0	0
	Calculate	2.764	11303	103.5	237.5	45.5964	0.667	575	2750	0	720	1400	0.9922	1	0	0.9059	1	0	1
146	Validate	2.992	3825	126	150	15.1	0.75	564.65	765	0	1065	1214.7	0	0	0	0	0	1	0
	Calculate	2.992	3825	126	150	15.1	0.75	564.65	765	0	1065	1214.7	0	0	0.9818	0	0	0	0.0001
147	Validate	2.992	4240	126	150	15.6	0.75	714.65	957	0	1165	1564.7	1	0	0	1	1	1	1
	Calculate	2.992	4240	126	150	15.6	0.75	714.65	957	0	1165	1564.7	0	0	0.9995	0.0009	0	0.9989	0
148	Validate	2.992	4505	126	150	12.5	0.75	264.65	385	0	1040	1364.7	1	0	0	1	1	1	0
	Calculate	2.992	4505	126	150	12.5	0.75	264.65	385	0	1040	1364.7	0	0	0.9659	0.1561	0.9903	0	1
149	Validate	3.958	10947	140	304	51.3165	0.7	2014.65	1129.7872	0	9400	4662.7	1	1	1	1	1	1	1
	Calculate	3.958	10947	140	304	51.3165	0.7	2014.65	1129.7872	0	9400	4662.7	1	0.9999	0.9871	1	0.2625	1	1
150	Validate	3.958	12290	140	305	53.9522	0.7	2141.65	1538.769	0	10008	4645.7	1	1	1	1	1	1	1
	Calculate	3.958	12290	140	305	53.9522	0.7	2141.65	1538.769	0	10008	4645.7	1	1	1	1	0.0001	1	0.9986
151	Validate	3.958	8560	115	262	36.5523	1.122	204.65	336.7797	0	11800	2400.7	1	1	1	1	0	1	1
	Calculate	3.958	8560	115	262	36.5523	1.122	204.65	336.7797	0	11800	2400.7	0.0091	0.061	0.9998	0.0001	0	1	1
152	Validate	3.958	11929	140	310	51.0806	0.7	1194.65	1340.3263	0	10296	3423.7	1	1	1	1	0	0	1
	Calculate	3.958	11929	140	310	51.0806	0.7	1194.65	1340.3263	0	10296	3423.7	0	0.0006	0.0078	0	0	0	0.9999
153	Validate	3.958	10158	134	320	53.9522	0.72	2694.65	3064.7383	0	11616	5493.7	1	1	1	1	1	1	1
	Calculate	3.958	10158	134	320	53.9522	0.72	2694.65	3064.7383	0	11616	5493.7	1	0.9461	0	0.0082	0.0269	1	1
154	Validate	3.958	10202	140	304	48.5254	0.7	1838.65	455.2469	0	6480	3957.7	0	0	0	0	0	0	0
	Calculate	3.958	10202	140	304	48.5254	0.7	1838.65	455.2469	0	6480	3957.7	1	1	1	1	1	1	1
155	Validate	3.958	10661	125	332	60.7554	0.715	4048.65	2921.411	0	8958	6483.7	1	1	1	1	1	1	1
	Calculate	3.958	10661	125	332	60.7554	0.715	4048.65	2921.411	0	8958	6483.7	1	1	1	1	1	1	1
156	Validate	3.958	6480	195	235.4	37.31	0.75	719.7	527.8	0	10845	2023	1	1	1	1	0	1	1
	Calculate	3.958	6480	195	235.4	37.31	0.75	719.7	527.8	0	10845	2023	0	0	0	0	0	0.9998	0
157	Validate	3.958	6447.2	195	235.4	37.31	0.75	591.7	516.6	0	3356	1546.5	0	1	1	1	1	1	1
	Calculate	3.958	6447.2	195	235.4	37.31	0.75	591.7	516.6	0	3356	1546.5	1	0.6409	1	0.9999	0	0.0025	1
158	Validate	4.892	10171.1	80.6	190.4	16.7	0.7	235.2	509.8	0	5222.6	4581.7	0	0	0	0	0	0	0
	Calculate	4.892	10171.1	80.6	190.4	16.7	0.7	235.2	509.8	0	5222.6	4581.7	1	1	1	1	1	1	1
159	Validate	4.892	10838	140	342	66.6793	0.7	3364.7	3091.8	0	9024	5318.7	1	1	1	1	1	1	1
	Calculate	4.892	10838	140	342	66.6793	0.7	3364.7	3091.8	0	9024	5318.7	1	1	1	1	1	1	1
160	Validate	4.892	10498.7	89.6	195.8	9	1.567	164.984	129.232	0.5	924.6	4473.05	1	1	1	1	1	1	1
	Calculate	4.892	10498.7	89.6	195.8	9	1.567	164.984	129.232	0.5	924.6	4473.05	0.2769	0.0748	1	0.6654	0.9999	0	1
161	Validate	4.892	7647.64	138.2	188.6	16.7	0.708	605.89	512.415	0	5222.43	3062.15	1	0	0	0	0	0	1
	Calculate	4.892	7647.64	138.2	188.6	16.7	0.708	605.89	512.415	0	5222.43	3062.15	1	1	0.8236	1	1	1	1
162	Validate	6.184	8379	115	262	36.5523	1.122	234.7	336.7949	0	15600	2209.7	1	0	0	1	1	1	1
	Calculate	6.184	8379	115	262	36.5523	1.122	234.7	336.7949	0	15600	2209.7	1	1	1	1	0.0053	1	1
163	Validate	6.184	9180	115	262	36.5523	1.122	266.7	336.7884	0	23540	2239.7	1	1	1	1	1	1	1
	Calculate	6.184	9180	115	262	36.5523	1.122	266.7	336.7884	0	23540	2239.7	1	1	1	1	1	1	1
164	Validate	6.184	7500	119	269	35.5602	1.1	193.7	322.9901	0	7090	1964.7	0	0	0	1	1	1	1
	Calculate	6.184	7500	119	269	35.5602	1.1	193.7	322.9901	0	7090	1964.7	1	1	0.019	1	1	1	1
165	Validate	6.184	8156	119	269	35.5602	1.1	219.7	323.0159	0	13860	2143.7	1	1	1	1	1	1	1
	Calculate	6.184	8156	119	269	35.5602	1.1	219.7	323.0159	0	13860	2143.7	1	1	1	1	0.0001	1	1
166	Validate	6.184	9714	115	262	36.5523	1.122	319.7	336.8182	0	11000	2322.7	1	1	1	1	1	1	1
	Calculate	6.184	9714	115	262	36.5523	1.122	319.7	336.8182	0	11000	2322.7	1	1	1	1	1	1	0.2133

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No.	Data type	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)	D&R (M) 10%	H&B 10%	F&B 10%	M&B 10%	B&B 10%	Ork 10%	D&R (O) 10%
167	Validate	6.184	8950	115	262	36.5523	1.122	231.7	336.8182	0	15400	2214.7	1	1	1	1	1	1	1
	Calculate	6.184	8950	115	262	36.5523	1.122	231.7	336.8182	0	15400	2214.7	1	1	1	1	0.9999	1	1
168	Test	1.995	9620	75	189	54	0.752	1455	3393	0	480	3365	0	0	0	0	1	0	0
	Calculate	1.995	9620	75	189	54	0.752	1455	3393	0	480	3365	0	0.0001	0	0	0	0.002	0
169	Test	1.995	6550	75	189	42	0.8225	985	1245	0	167	2665	0	0	0	1	1	1	0
	Calculate	1.995	6550	75	189	42	0.8225	985	1245	0	167	2665	0	0.8348	0	0	1	0.0001	1
170	Test	1.995	3395.7	86	172.4	15.6	0.68	193.8	787.6	51	41.013	1509.9	0	0	0	1	1	0	0
	Calculate	1.995	3395.7	86	172.4	15.6	0.68	193.8	787.6	51	41.013	1509.9	0	0	0	0.9993	1	0	0.0008
171	Test	2.441	6500	75	189	36.2	0.8225	455	906	0	106	1635	1	0	0	0	0	0	0
	Calculate	2.441	6500	75	189	36.2	0.8225	455	906	0	106	1635	0	0	0	0.9993	1	0	0.0008
172	Test	2.441	7579.1	138.9	187.9	19.2	0.71	444.2	509.8	0	6868.7	3264.6	0	0	0	0	0	0	0
	Calculate	2.441	7579.1	138.9	187.9	19.2	0.71	444.2	509.8	0	6868.7	3264.6	0.0004	1	1	1	0.0016	0.9999	0
173	Test	2.441	7578.7	118.94	186.8	19.2	0.708	815	512.4	0	3834.3	3444.7	1	1	1	1	0	1	0
	Calculate	2.441	7578.7	118.94	186.8	19.2	0.708	815	512.4	0	3834.3	3444.7	1	1	1	1	0.9929	1	1
174	Test	2.441	7578.7	138.92	187.88	19.2	0.708	429.5	512.4	0	6868.47	3249.9	0	0	0	0	0	0	0
	Calculate	2.441	7578.7	138.92	187.88	19.2	0.708	429.5	512.4	0	6868.47	3249.9	0.0002	1	1	1	0.0005	0.9999	0
175	Test	2.441	8038.1	92.12	167	40.3	0.75	1372.5	947	0	191.84	3574.2	1	1	1	1	1	1	1
	Calculate	2.441	8038.1	92.12	167	40.3	0.75	1372.5	947	0	191.84	3574.2	1	1	1	1	1	1	1
176	Test	2.441	8038.1	89.6	167	40.3	0.75	1344.1	947	0	330.84	3508.8	1	1	1	1	1	1	1
	Calculate	2.441	8038.1	89.6	167	40.3	0.75	1344.1	947	0	330.84	3508.8	1	1	1	1	1	1	1
177	Test	2.441	10531.5	93.2	232.16	46	0.71	2193.1	2283.3	0	215.74	4640.9	1	0	0	1	1	1	1
	Calculate	2.441	10531.5	93.2	232.16	46	0.71	2193.1	2283.3	0	215.74	4640.9	0.9994	0.0003	0.0001	0.9989	0.9996	1	1
178	Test	2.764	10039	134	320	50.3766	0.7	1620	1116.6	0	10872	6695	1	1	1	1	1	1	1
	Calculate	2.764	10039	134	320	50.3766	0.7	1620	1116.6	0	10872	6695	1	1	1	1	0.9985	1	1
179	Test	2.992	3800	126	150	14.4	0.75	714.65	1430	0	3166	1264.7	0	0	1	0	0	0	0
	Calculate	2.992	3800	126	150	14.4	0.75	714.65	1430	0	3166	1264.7	0.9965	0.0002	1	1	0	1	0.0113
180	Test	2.992	4175	126	150	15.6	0.75	314.65	267	0	2700	1514.7	1	0	0	1	1	1	1
	Calculate	2.992	4175	126	150	15.6	0.75	314.65	267	0	2700	1514.7	0.9998	0.0001	0	1	0.9999	1	0
181	Test	2.992	4400	126	150	18.6	0.75	414.65	472	0	1040	1364.7	0	1	0	1	1	1	0
	Calculate	2.992	4400	126	150	18.6	0.75	414.65	472	0	1040	1364.7	0	0	0	0	0	0	0.0001
182	Test	2.992	4766	126	150	13.3	0.75	264.65	193	0	967	1564.7	0	0	1	0	0	1	0
	Calculate	2.992	4766	126	150	13.3	0.75	264.65	193	0	967	1564.7	1	0.9994	0	1	1	0.4554	0.9955
183	Test	2.992	4691.8	126	150	12.9	0.75	414.7	865.8	0	1585	1164.7	0	0	0	0	0	0	0
	Calculate	2.992	4691.8	126	150	12.9	0.75	414.7	865.8	0	1585	1164.7	0	0	0.0007	0.999	0.0013	1	0
184	Test	2.992	7647.64	104	185	31.3	0.92	1587.26	920.43	0	534.63	3850.09	1	1	1	1	1	1	1
	Calculate	2.992	7647.64	104	185	31.3	0.92	1587.26	920.43	0	534.63	3850.09	0.9999	1	1	1	1	0.1151	1
185	Test	2.992	3182.4	86	158	17.05	0.69	181.8	745	7	267.282	1287.7	0	0	0	0	0	0	0
	Calculate	2.992	3182.4	86	158	17.05	0.69	181.8	745	7	267.282	1287.7	0	0	0	0	0	0.0004	0
186	Test	2.992	3948.5	150	235	38.69	0.75	482.7	1021.9	0	213	1178.7	0	0	0	0	0	1	0
	Calculate	2.992	3948.5	150	235	38.69	0.75	482.7	1021.9	0	213	1178.7	1	0.9989	0.0056	1	0.997	0.0009	1
187	Test	3.958	10456	112	270	49.678	0.844	2274.65	1387.7953	0	6096	4223.7	0	0	0	0	0	1	0
	Calculate	3.958	10456	112	270	49.678	0.844	2274.65	1387.7953	0	6096	4223.7	0.0314	0	0	0	0	1	0.897
188	Test	3.958	9902	119	280	51.3165	0.7	3744.65	1339.1137	0	12456	6570.7	1	1	1	1	1	1	1
	Calculate	3.958	9902	119	280	51.3165	0.7	3744.65	1339.1137	0	12456	6570.7	1	1	1	1	1	1	1
189	Test	3.958	9459	119	269	35.5602	1.1	294.65	323.0053	0	7520	2248.7	1	1	1	1	0	1	1
	Calculate	3.958	9459	119	269	35.5602	1.1	294.65	323.0053	0	7520	2248.7	1	1	1	1	1	1	0.5462
190	Test	3.958	10984	140	316	49.678	0.7	2504.65	990.8027	0	14352	5491.7	1	1	1	1	1	1	1
	Calculate	3.958	10984	140	316	49.678	0.7	2504.65	990.8027	0	14352	5491.7	1	1	1	1	1	1	1

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No.	Data type	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)	D&R (M) 10%	H&B 10%	F&B 10%	M&B 10%	B&B 10%	Ork. 10%	D&R (O) 10%
191	Test	3.958	12062	138	330	50.1431	0.7	1548.65	1200.4405	0	10896	4216.7	1	1	1	1	1	1	1
	Calculate	3.958	12062	138	330	50.1431	0.7	1548.65	1200.4405	0	10896	4216.7	1	1	1	0.9979	0	0	1
192	Test	3.958	11290	124	311	49.9103	0.7	1763.65	965.2972	0	7521	3852.7	0	0	0	0	0	0	0
	Calculate	3.958	11290	124	311	49.9103	0.7	1763.65	965.2972	0	7521	3852.7	0	0	0	0	0	0	0.3634
193	Test	3.958	10661	108	260	49.4463	0.702	1134.65	2674.0205	0	2629	2178.7	1	1	1	1	0	0	1
	Calculate	3.958	10661	108	260	49.4463	0.702	1134.65	2674.0205	0	2629	2178.7	0.0004	0.0011	0	0	0	0	0.0004
194	Test	3.958	6501.8	126.3	238.1	37.6	0.75	464.7	550.3	0	2436.5	1385.7	0	0	0	1	1	1	1
	Calculate	3.958	6501.8	126.3	238.1	37.6	0.75	464.7	550.3	0	2436.5	1385.7	0	0	0	0	0	0	0.9455
195	Test	3.958	6250.3	128	234.9	36.33	0.75	384.7	589.6	0	2845	1201.3	0	0	0	0	0	0	1
	Calculate	3.958	6250.3	128	234.9	36.33	0.75	384.7	589.6	0	2845	1201.3	0.9999	0	0	0.0382	0	0	1
196	Test	4.892	10826.8	134.6	228.2	8.3	1.705	209.074	146.163	0.15	930.89	4763.19	1	1	1	1	1	1	1
	Calculate	4.892	10826.8	134.6	228.2	8.3	1.705	209.074	146.163	0.15	930.89	4763.19	1	1	1	1	1	1	1
197	Test	4.892	10170.6	80.6	190.4	11.8	0.938	220.45	168.736	0.1	144.67	4566.92	1	1	0	1	1	1	1
	Calculate	4.892	10170.6	80.6	190.4	11.8	0.938	220.45	168.736	0.1	144.67	4566.92	0.9995	0.5154	1	0.9899	0.9999	0.9325	1
198	Test	4.892	7647.64	124.88	188.6	17.2	0.708	770.87	512.415	0	4128.01	3328.12	1	0	0	0	0	0	1
	Calculate	4.892	7647.64	124.88	188.6	17.2	0.708	770.87	512.415	0	4128.01	3328.12	1	1	1	1	1	1	1
199	Test	6.184	7746	115	262	36.5523	1.122	314.7	336.8182	0	24200	2467.7	1	1	1	1	1	1	1
	Calculate	6.184	7746	115	262	36.5523	1.122	314.7	336.8182	0	24200	2467.7	1	1	1	1	1	1	1
200	Test	6.184	7891	115	262	36.5523	1.122	397.7	336.8502	0	6540	2392.7	1	1	1	1	1	1	1
	Calculate	6.184	7891	115	262	36.5523	1.122	397.7	336.8502	0	6540	2392.7	1	1	1	1	1	1	1
201	Test	6.184	7799	115	262	36.5523	1.122	263.7	336.7993	0	23370	2212.7	1	1	1	1	1	1	1
	Calculate	6.184	7799	115	262	36.5523	1.122	263.7	336.7993	0	23370	2212.7	1	1	1	1	1	1	1

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APPENDIX D

Results of neural network Model number 10 for Case 3: (best correlation)

No.	Data type	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)	D&R (M)	H&B	F&B	M&B	B&B	Ork	D&R (O)
1	Train	1.995	7450	75	189	54	0.752	1645	3393	0	82	3300	0	0	0	0	1	0	0
	Calculate	1.995	7450	75	189	54	0.752	1645	3393	0	82	3300	0	0	0	0	0.84	0	0.0068
2	Train	1.995	7350	75	189	54	0.752	1635	3393	0	125	3290	0	0	0	0	0	1	0
	Calculate	1.995	7350	75	189	54	0.752	1635	3393	0	125	3290	0	0	0	0	0.0043	0	0.0321
3	Train	1.995	7800	75	189	42.6	0.84	1261	1747	0	168	3141	0	0	0	0	0	1	0
	Calculate	1.995	7800	75	189	42.6	0.84	1261	1747	0	168	3141	0.0311	0	0	0	0.0062	0	0.0149
4	Train	1.995	8070	75	189	42.6	0.84	1229	1747	0	259.2	3199	1	0	0	0	0	0	0
	Calculate	1.995	8070	75	189	42.6	0.84	1229	1747	0	259.2	3199	0.9731	0	0	0	0.0021	0	0.0003
5	Train	1.995	3000	75	189	41.3	1.048	175	189	0	160.3	1083	1	0	0	0	0	0	0
	Calculate	1.995	3000	75	189	41.3	1.048	175	189	0	160.3	1083	0.9836	0	0.001	0	0.009	0	0.0001
6	Train	1.995	3363	86	168.8	15.6	0.78	199.7	944.7	60.4	42.6096	1485.3	0	0	0	1	0	0	0
	Calculate	1.995	3363	86	168.8	15.6	0.78	199.7	944.7	60.4	42.6096	1485.3	0	0	0.0037	0.9989	0	0.0003	0.0016
7	Train	1.995	3362.9	86	168.8	15.6	0.78	250.6	7029.3	56	14.652	1506.7	0	0	0	0	0	0	1
	Calculate	1.995	3362.9	86	168.8	15.6	0.78	250.6	7029.3	56	14.652	1506.7	0	0	0	0.0066	0	0	1
8	Train	1.995	3395	86	158	15.6	0.62	107.2	2475.1	14	12.986	1513.8	0	0	1	0	0	0	0
	Calculate	1.995	3395	86	158	15.6	0.62	107.2	2475.1	14	12.986	1513.8	0	0	0	0.0091	0.0081	0	1
9	Train	1.995	3313.6	86	167	15.6	0.67	157	692.8	25	16.05	1458.4	0	0	0	1	0	0	0
	Calculate	1.995	3313.6	86	167	15.6	0.67	157	692.8	25	16.05	1458.4	0	0	0.0021	0.9981	0	0.0003	0.0004
10	Train	1.995	3346.6	86	172.4	15.6	0.72	356.1	889.2	4.4	101.6228	1505.3	0	0	0	1	0	0	0
	Calculate	1.995	3346.6	86	172.4	15.6	0.72	356.1	889.2	4.4	101.6228	1505.3	0	0	0.0008	0.9907	0	0.0013	0.0007
11	Train	2.441	9592	75	189	50.8	0.68	2360	3640	0	244.8	4090	0	0	0	0	0	0	1
	Calculate	2.441	9592	75	189	50.8	0.68	2360	3640	0	244.8	4090	0	0.0001	0	0	0.0001	0	0.9889
12	Train	2.441	10683	75	189	47.6	0.742	1784	2151	0	313.2	4315	1	0	0	0	0	0	0
	Calculate	2.441	10683	75	189	47.6	0.742	1784	2151	0	313.2	4315	0.9834	0	0	0	0	0	0.0033
13	Train	2.441	10800	75	189	44.4	0.796	1264	2250	0	60	3835	0	0	0	0	0	0	1
	Calculate	2.441	10800	75	189	44.4	0.796	1264	2250	0	60	3835	0	0	0	0	0.0002	0	0.9955
14	Train	2.441	6500	75	189	36.2	0.8225	555	906	0	60	2325	0	0	0	0	0	0	1
	Calculate	2.441	6500	75	189	36.2	0.8225	555	906	0	60	2325	0	0	0.0053	0.0001	0	0	1
15	Train	2.441	12861.5	90	200	37	0.7	1294.7	3762	0	283	4049.7	0	0	0	0	0	0	1
	Calculate	2.441	12861.5	90	200	37	0.7	1294.7	3762	0	283	4049.7	0	0	0	0	0	0	1
16	Train	2.441	7054.1	107.6	176	32.8	0.7	1003.2	774.9	0	4075	3236.2	0	0	0	1	0	0	0
	Calculate	2.441	7054.1	107.6	176	32.8	0.7	1003.2	774.9	0	4075	3236.2	0	0	0.0035	0	0.0019	0.0001	0.0104
17	Train	2.441	8038.4	92.1	167	40.3	0.75	1387.2	942.2	0	191.9	3588.9	0	0	0	0	0	0	1
	Calculate	2.441	8038.4	92.1	167	40.3	0.75	1387.2	942.2	0	191.9	3588.9	0.0001	0	0	0	0	0.0002	0.9655
18	Train	2.441	10532	93.2	232.1	46	0.71	2270.5	2271.8	0	439.7	4654.2	1	0	0	0	0	0	0
	Calculate	2.441	10532	93.2	232.1	46	0.71	2270.5	2271.8	0	439.7	4654.2	1	0	0	0	0.0012	0.0004	0
19	Train	2.441	7579.1	138.9	187.9	19.2	0.71	444.2	509.8	0	6868.7	3264.6	0	0	1	0	0	0	0
	Calculate	2.441	7579.1	138.9	187.9	19.2	0.71	444.2	509.8	0	6868.7	3264.6	0	0.0001	0.9908	0	0	0.001	0.0001
20	Train	2.441	8760.3	104	198.5	25	0.57	128.5	381.8	0	353.5	2819.4	0	0	0	0	0	0	1
	Calculate	2.441	8760.3	104	198.5	25	0.57	128.5	381.8	0	353.5	2819.4	0	0	0	0.0011	0	0	0.9987
21	Train	2.441	7578.7	132.8	187.88	19.2	0.708	563.2	512.4	0	4226.75	3294	0	0	0	0	0	1	0
	Calculate	2.441	7578.7	132.8	187.88	19.2	0.708	563.2	512.4	0	4226.75	3294	0	0	0.0091	0	0	0.9941	0
22	Train	2.441	8759.8	104	198.5	25	0.571	113.8	383.7	0	255.366	2762.1	0	0	0	0	0	0	1
	Calculate	2.441	8759.8	104	198.5	25	0.571	113.8	383.7	0	255.366	2762.1	0	0	0	0.0007	0	0	0.9961

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No.	Data type	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)	D&R (M)	H&B	F&B	M&B	B&B	Or's	D&R (O)
23	Train	2.441	8759.8	104	198.5	25	0.571	113.8	383.7	0	353.487	2804.7	0	0	0	0	0	0	1
	Calculate	2.441	8759.8	104	198.5	25	0.571	113.8	383.7	0	353.487	2804.7	0	0	0	0.0009	0	0	0.9977
24	Train	2.441	7647.6	107.6	192.2	32.2	0.92	1564.5	858.4	0	2616.56	3955.3	0	0	0	0	0	0	1
	Calculate	2.441	7647.6	107.6	192.2	32.2	0.92	1564.5	858.4	0	2616.56	3955.3	0	0	0	0	0	0.0014	0.9966
25	Train	2.441	7053.8	105.8	176	32.8	0.701	896	744.9	0	2209.95	2972.6	0	0	0	0	1	0	0
	Calculate	2.441	7053.8	105.8	176	32.8	0.701	896	744.9	0	2209.95	2972.6	0.0003	0	0.0008	0	0.9841	0	0.001
26	Train	2.441	7053.8	107.6	176	32.8	0.701	988.5	778.8	0	4075.8	3221.5	0	0	0	1	0	0	0
	Calculate	2.441	7053.8	107.6	176	32.8	0.701	988.5	778.8	0	4075.8	3221.5	0	0	0.0062	0	0.0098	0.0001	0.0028
27	Train	2.441	8038.1	89.6	167	40.3	0.75	1344.1	947	0	330.84	3508.8	1	0	0	0	0	0	0
	Calculate	2.441	8038.1	89.6	167	40.3	0.75	1344.1	947	0	330.84	3508.8	0.9651	0.0027	0	0	0	0	0.0472
28	Train	2.441	8038.1	89.42	167	40.3	0.75	1308.5	947	0	480.54	3436.2	0	0	0	0	0	0	1
	Calculate	2.441	8038.1	89.42	167	40.3	0.75	1308.5	947	0	480.54	3436.2	0.0352	0	0	0	0	0	0.9656
29	Train	2.441	8038.1	98.6	167	40.3	0.75	1173.4	947	0	1125.88	3227.1	1	0	0	0	0	0	0
	Calculate	2.441	8038.1	98.6	167	40.3	0.75	1173.4	947	0	1125.88	3227.1	0.9737	0	0	0	0.0045	0	0
30	Train	2.441	10531.5	93.2	232.16	46	0.71	2255.7	2283.3	0	439.66	4639.5	1	0	0	0	0	0	0
	Calculate	2.441	10531.5	93.2	232.16	46	0.71	2255.7	2283.3	0	439.66	4639.5	1	0.0001	0	0	0.0007	0.0002	0
31	Train	2.441	3346.6	86	168	16.6	0.78	192.5	747.8	9	160.251	1448.6	0	0	0	1	0	0	0
	Calculate	2.441	3346.6	86	168	16.6	0.78	192.5	747.8	9	160.251	1448.6	0	0	0	0.9961	0	0.0001	0.0055
32	Train	2.441	3379.3	86	172.4	16.67	0.72	225.2	1437.3	1.4	71.978	1512.4	0	0	0	0	1	0	0
	Calculate	2.441	3379.3	86	172.4	16.67	0.72	225.2	1437.3	1.4	71.978	1512.4	0	0	0	0.0081	0.9905	0	0.0086
33	Train	2.441	4445.7	104	185	14.48	0.6	289.2	283.3	24	172.064	1988.9	0	0	0	1	0	0	0
	Calculate	2.441	4445.7	104	185	14.48	0.6	289.2	283.3	24	172.064	1988.9	0	0	0	1	0	0.0004	0.0041
34	Train	2.441	8465	90	200	37	0.7	294.9	252.7	50	148.5	3355.6	0	0	1	0	0	0	0
	Calculate	2.441	8465	90	200	37	0.7	294.9	252.7	50	148.5	3355.6	0	0	0.9978	0	0	0	0.0073
35	Train	2.441	10007	90	200	37	0.7	606.4	505.3	10	446.04	3745.3	1	0	0	0	0	0	0
	Calculate	2.441	10007	90	200	37	0.7	606.4	505.3	10	446.04	3745.3	0.9999	0	0	0	0	0	0
36	Train	2.441	6102.7	90	264	37	0.65	228	701.9	0	36	2253.4	0	0	0	1	0	0	0
	Calculate	2.441	6102.7	90	264	37	0.65	228	701.9	0	36	2253.4	0	0	0.002	0.9943	0	0.0001	0.0001
37	Train	2.441	6102.7	90	264	37	0.65	811.2	2027	0	15	2860.7	0	0	0	0	1	0	0
	Calculate	2.441	6102.7	90	264	37	0.65	811.2	2027	0	15	2860.7	0.0002	0	0	0	0.9938	0	0.0029
38	Train	2.764	10039	134	320	50.3766	0.7	1620	1116.6	0	10872	6695	0	0	0	0	0	1	0
	Calculate	2.764	10039	134	320	50.3766	0.7	1620	1116.6	0	10872	6695	0	0	0.0011	0	0.0037	0.9977	0.0003
39	Train	2.764	13477	130	289	52.2662	0.71	2130	3086.3	0	823	6045	0	0	0	0	1	0	0
	Calculate	2.764	13477	130	289	52.2662	0.71	2130	3086.3	0	823	6045	0.0062	0	0	0	0.9968	0.0001	0.0001
40	Train	2.764	11303	103.5	237.5	45.5964	0.667	575	2750	0	720	1400	0	0	0	0	0	0	1
	Calculate	2.764	11303	103.5	237.5	45.5964	0.667	575	2750	0	720	1400	0	0	0	0	0.0039	0	1
41	Train	2.764	10876	139	308	66.6793	0.685	3940	2303.4	0	4272	6729	0	0	0	0	1	0	0
	Calculate	2.764	10876	139	308	66.6793	0.685	3940	2303.4	0	4272	6729	0.0171	0	0.0047	0	0.9838	0	0
42	Train	2.992	3940	126	150	14.6	0.75	164.65	252	0	1300	1014.7	0	0	0	0	0	1	0
	Calculate	2.992	3940	126	150	14.6	0.75	164.65	252	0	1300	1014.7	0	0.0018	0.0004	0.0098	0	0.9886	0.0002
43	Train	2.992	3720	126	150	14.4	0.75	314.65	232	0	1965	1214.7	0	0	1	0	0	0	0
	Calculate	2.992	3720	126	150	14.4	0.75	314.65	232	0	1965	1214.7	0	0.0048	0.9918	0	0	0.0118	0
44	Train	2.992	4570	126	150	13.5	0.75	864.65	1500	0	1965	1514.7	0	0	1	0	0	0	0
	Calculate	2.992	4570	126	150	13.5	0.75	864.65	1500	0	1965	1514.7	0.0026	0	0.967	0	0	0.0009	0
45	Train	2.992	4355	126	150	12.9	0.75	264.65	185	0	855	1714.7	0	1	0	0	0	0	0
	Calculate	2.992	4355	126	150	12.9	0.75	264.65	185	0	855	1714.7	0.0033	0.9937	0	0	0	0.0033	0
46	Train	2.992	4670	126	150	13.6	0.75	924.65	1565	0	2320	1664.7	0	0	0	0	0	1	0
	Calculate	2.992	4670	126	150	13.6	0.75	924.65	1565	0	2320	1664.7	0	0	0.0035	0	0	0.9867	0.0038

No.	Data type	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)	D&R (M)	H&B	F&B	M&B	B&B	Ork	D&R (O)
47	Train	2.992	4575	126	150	18.6	0.75	664.65	858	0	2480	1564.7	1	0	0	0	0	0	0
	Calculate	2.992	4575	126	150	18.6	0.75	664.65	858	0	2480	1564.7	0.9931	0	0.0005	0	0	0	0
48	Train	2.992	4065	126	150	13	0.75	514.65	341	0	1490	1564.7	0	0	0	0	0	1	0
	Calculate	2.992	4065	126	150	13	0.75	514.65	341	0	1490	1564.7	0	0.0001	0	0	0	0.9997	0.004
49	Train	2.992	3705	126	150	13.6	0.75	514.65	335	0	1310	1464.7	0	0	0	0	0	1	0
	Calculate	2.992	3705	126	150	13.6	0.75	514.65	335	0	1310	1464.7	0	0.0027	0.0079	0	0	0.993	0.0001
50	Train	2.992	4160	126	150	12.9	0.75	164.65	185	0	1350	1514.7	0	1	0	0	0	0	0
	Calculate	2.992	4160	126	150	12.9	0.75	164.65	185	0	1350	1514.7	0	0.9877	0	0	0	0.0002	0
51	Train	2.992	4487	126	150	14.1	0.75	594.65	962	0	1905	1314.7	0	0	0	1	0	0	0
	Calculate	2.992	4487	126	150	14.1	0.75	594.65	962	0	1905	1314.7	0.0027	0.003	0.0043	0	0	0.0004	0
52	Train	2.992	3924	126	150	18.7	0.75	714.65	575	0	1850	1514.7	0	0	1	0	0	0	0
	Calculate	2.992	3924	126	150	18.7	0.75	714.65	575	0	1850	1514.7	0.0034	0	0.9999	0	0	0.007	0
53	Train	2.992	4240	126	150	15.6	0.75	714.7	957.4	0	1165	1564.7	0	0	1	0	0	0	0
	Calculate	2.992	4240	126	150	15.6	0.75	714.7	957.4	0	1165	1564.7	0.0176	0	0.9965	0	0	0.0012	0
54	Train	2.992	4210	126	150	16	0.75	364.7	223.3	0	788	1764.7	1	0	0	0	0	0	0
	Calculate	2.992	4210	126	150	16	0.75	364.7	223.3	0	788	1764.7	0.9895	0.0092	0	0	0	0.0001	0
55	Train	2.992	7647.64	104	185	31.3	0.92	1322.71	901.81	0	2654.3	3555.7	0	0	0	0	0	0	1
	Calculate	2.992	7647.64	104	185	31.3	0.92	1322.71	901.81	0	2654.3	3555.7	0	0	0	0	0	0.0009	0.9966
56	Train	2.992	3182.5	86	158	17.05	0.69	250.1	989	14	182.32	1390.2	0	0	0	0	1	0	0
	Calculate	2.992	3182.5	86	158	17.05	0.69	250.1	989	14	182.32	1390.2	0	0	0.0004	0	0.9945	0	0.001
57	Train	2.992	3346.6	86	158	17.05	0.69	184	1243.2	24	120.004	1465.5	0	0	0	0	1	0	0
	Calculate	2.992	3346.6	86	158	17.05	0.69	184	1243.2	24	120.004	1465.5	0	0	0.0002	0.0002	0.9979	0	0.0055
58	Train	2.992	4101.3	195	237	39.25	0.75	1284.7	3773.3	0	278	1731.1	1	0	0	0	0	0	0
	Calculate	2.992	4101.3	195	237	39.25	0.75	1284.7	3773.3	0	278	1731.1	1	0.0019	0	0.0001	0.0003	0	0
59	Train	2.992	4101.3	195	237	39.25	0.75	724.7	3077	0	548	1056.7	0	0	0	1	0	0	0
	Calculate	2.992	4101.3	195	237	39.25	0.75	724.7	3077	0	548	1056.7	0.0005	0.0004	0.0001	0.9943	0.0002	0	0.0024
60	Train	2.992	4521.2	195	237	39.25	0.75	989.7	6081	0	1555	1490	0	1	0	0	0	0	0
	Calculate	2.992	4521.2	195	237	39.25	0.75	989.7	6081	0	1555	1490	0.0021	0.9843	0	0.0025	0	0	0
61	Train	2.992	4921.5	195	230	37.31	0.75	764.7	381.8	0	7226	1976.5	0	0	0	0	0	1	0
	Calculate	2.992	4921.5	195	230	37.31	0.75	764.7	381.8	0	7226	1976.5	0.0015	0	0	0	0	0.9999	0.0009
62	Train	2.992	6411.1	200	236.5	38.72	0.75	589.7	651.3	0	5809	1937.6	0	0	0	0	0	0	1
	Calculate	2.992	6411.1	200	236.5	38.72	0.75	589.7	651.3	0	5809	1937.6	0.0001	0	0.0027	0	0	0.0022	0.9854
63	Train	2.992	5800.8	150	235	38.69	0.75	724.7	1207.2	0	6538	1870.7	0	0	0	0	0	0	1
	Calculate	2.992	5800.8	150	235	38.69	0.75	724.7	1207.2	0	6538	1870.7	0	0	0.0025	0	0	0.0023	0.9963
64	Train	2.992	6402	130	236	39	0.75	548.7	746.8	0	943	1568.7	0	0	0	0	1	0	0
	Calculate	2.992	6402	130	236	39	0.75	548.7	746.8	0	943	1568.7	0	0.0121	0	0	0	0.003	0.0002
65	Train	2.992	6105.7	130	236	39	0.75	554.7	797.3	0	2482	1319.5	0	0	0	0	0	0	1
	Calculate	2.992	6105.7	130	236	39	0.75	554.7	797.3	0	2482	1319.5	0	0	0.0047	0.007	0	0.0014	0.9803
66	Train	2.992	6496.5	130	236	39	0.75	514.7	387.4	0	4286	1562.6	0	0	0	0	0	1	0
	Calculate	2.992	6496.5	130	236	39	0.75	514.7	387.4	0	4286	1562.6	0	0	0	0	0	0.9908	0.0143
67	Train	2.992	6069.8	130	236	38.72	0.75	414.7	555.9	0	6037	1663.7	0	0	1	0	0	0	0
	Calculate	2.992	6069.8	130	236	38.72	0.75	414.7	555.9	0	6037	1663.7	0.0095	0	0	0	0	0.0025	0.0099
68	Train	2.992	6512.8	150	236	38.72	0.75	374.7	589.6	0	2306	1099.7	0	1	0	0	0	0	0
	Calculate	2.992	6512.8	150	236	38.72	0.75	374.7	589.6	0	2306	1099.7	0	0.9972	0	0.0067	0	0	0.0053
69	Train	2.992	5006.1	195	237	39.25	0.75	1164.7	5317.4	35.5	655.32	1631.7	1	0	0	0	0	0	0
	Calculate	2.992	5006.1	195	237	39.25	0.75	1164.7	5317.4	35.5	655.32	1631.7	1	0.0124	0	0.0006	0.0027	0	0
70	Train	3.958	9746	124	306	51.553	0.7	3314.65	1473.6239	0	15696	6516.7	0	0	0	0	0	1	0
	Calculate	3.958	9746	124	306	51.553	0.7	3314.65	1473.6239	0	15696	6516.7	0	0	0.0053	0	0.002	0.9967	0.0052

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No.	Data type	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)	D&R (M)	H&B	F&B	M&B	B&B	Ork	D&R (O)
71	Train	3.958	10049	140	337	51.7902	0.7	1289.65	1286.6915	0	16080	4281.7	0	0	1	0	0	0	0
	Calculate	3.958	10049	140	337	51.7902	0.7	1289.65	1286.6915	0	16080	4281.7	0	0.0033	0	0	0.0022	0.0038	0.0032
72	Train	3.958	10947	145	321	54.4396	0.7	1084.65	1177.4387	0	13368	3686.7	0	0	0	0	0	0	1
	Calculate	3.958	10947	145	321	54.4396	0.7	1084.65	1177.4387	0	13368	3686.7	0	0.0043	0	0	0	0	0.9985
73	Train	3.958	10083	130	286	50.1431	0.7	3684.65	1592.6309	0	11616	6509.7	0	0	1	0	0	0	0
	Calculate	3.958	10083	130	286	50.1431	0.7	3684.65	1592.6309	0	11616	6509.7	0	0	0.9891	0	0	0.006	0.0039
74	Train	3.958	10239	140	300	51.0806	0.7	2814.65	1470.3065	0	12528	5598.7	0	0	1	0	0	0	0
	Calculate	3.958	10239	140	300	51.0806	0.7	2814.65	1470.3065	0	12528	5598.7	0	0	0.9937	0	0.0001	0.0069	0.0001
75	Train	3.958	9650	120	306	50.6107	0.7	1941.65	1764.6714	0	17040	4862.7	0	0	0	0	0	0	1
	Calculate	3.958	9650	120	306	50.6107	0.7	1941.65	1764.6714	0	17040	4862.7	0	0.0093	0	0	0	0.0027	0.9964
76	Train	3.958	8045	119	269	35.5602	1.1	150.65	322.9485	0	7190	2067.7	0	0	0	1	0	0	0
	Calculate	3.958	8045	119	269	35.5602	1.1	150.65	322.9485	0	7190	2067.7	0	0.0055	0.0017	0.9955	0.0001	0	0
77	Train	3.958	8715	119	269	35.5602	1.1	213.65	323.1173	0	2284	2211.7	0	0	0	1	0	0	0
	Calculate	3.958	8715	119	269	35.5602	1.1	213.65	323.1173	0	2284	2211.7	0	0.0003	0.0003	0.9905	0.0046	0	0
78	Train	3.958	8600	119	269	35.5602	1.1	168.65	322.9358	0	6540	2096.7	0	0	0	1	0	0	0
	Calculate	3.958	8600	119	269	35.5602	1.1	168.65	322.9358	0	6540	2096.7	0	0	0.0223	0.9861	0.0021	0	0
79	Train	3.958	9459	119	269	35.5602	1.1	294.65	323.0053	0	7520	2248.7	0	0	1	0	0	0	0
	Calculate	3.958	9459	119	269	35.5602	1.1	294.65	323.0053	0	7520	2248.7	0	0	0.9848	0.0001	0.0002	0	0.0042
80	Train	3.958	10289	119	269	35.5602	1.1	230.65	323.0479	0	7940	2340.7	0	0	0	0	0	0	1
	Calculate	3.958	10289	119	269	35.5602	1.1	230.65	323.0479	0	7940	2340.7	0	0	0.0051	0.0025	0	0	0.9931
81	Train	3.958	7900	119	269	35.5602	1.1	202.65	323.012	0	8300	2094.7	0	0	1	0	0	0	0
	Calculate	3.958	7900	119	269	35.5602	1.1	202.65	323.012	0	8300	2094.7	0	0	0.9881	0.0116	0.0001	0	0
82	Train	3.958	12249	105	245	47.8409	0.7	1439.65	941.5064	0	2496	3543.7	0	0	0	0	0	1	0
	Calculate	3.958	12249	105	245	47.8409	0.7	1439.65	941.5064	0	2496	3543.7	0	0	0.003	0	0	0.9942	0.006
83	Train	3.958	12062	138	330	50.1431	0.7	1548.65	1200.4405	0	10896	4216.7	0	0	0	0	0	1	0
	Calculate	3.958	12062	138	330	50.1431	0.7	1548.65	1200.4405	0	10896	4216.7	0.0001	0	0	0	0	0.9974	0.0174
84	Train	3.958	11305	136	330	50.1431	0.7	2964.65	1068.4046	0	8976	5729.7	0	0	0	0	0	0	1
	Calculate	3.958	11305	136	330	50.1431	0.7	2964.65	1068.4046	0	8976	5729.7	0	0	0.0028	0	0	0.0101	0.9978
85	Train	3.958	14322	114	260	40.6411	0.7	714.65	531.4885	0	3144	2466.7	0	0	0	0	0	1	0
	Calculate	3.958	14322	114	260	40.6411	0.7	714.65	531.4885	0	3144	2466.7	0	0	0	0	0	1	0.0013
86	Train	3.958	14330	138	320	43.6238	0.7	664.65	1024.8288	0	3504	1872.7	0	0	1	0	0	0	0
	Calculate	3.958	14330	138	320	43.6238	0.7	664.65	1024.8288	0	3504	1872.7	0.0004	0	0.99	0	0.0001	0	0.0001
87	Train	3.958	11248	137	337	57.4186	0.72	2599.65	4823.4127	0	10080	5303.7	0	1	0	0	0	0	0
	Calculate	3.958	11248	137	337	57.4186	0.72	2599.65	4823.4127	0	10080	5303.7	0	0.9987	0	0	0.001	0	0.0034
88	Train	3.958	12165	122	310	48.7548	0.7	1589.65	522.9767	0	5832	3631.7	0	0	0	0	0	1	0
	Calculate	3.958	12165	122	310	48.7548	0.7	1589.65	522.9767	0	5832	3631.7	0.0001	0	0	0	0	0.9973	0.0002
89	Train	3.958	12171	133	334	48.5254	0.72	834.65	1810.1949	0	11496	3217.7	0	1	0	0	0	0	0
	Calculate	3.958	12171	133	334	48.5254	0.72	834.65	1810.1949	0	11496	3217.7	0.0007	0.9921	0	0.0011	0	0	0
90	Train	3.958	12916	120	271	49.678	0.7	2664.65	1146.3675	0	9360	4958.7	0	0	0	0	0	1	0
	Calculate	3.958	12916	120	271	49.678	0.7	2664.65	1146.3675	0	9360	4958.7	0	0	0.0003	0	0	0.9965	0.0091
91	Train	3.958	9928	120	342	62.3356	0.72	1514.65	3615.5651	0	15342	4761.7	0	0	0	0	0	0	1
	Calculate	3.958	9928	120	342	62.3356	0.72	1514.65	3615.5651	0	15342	4761.7	0	0.005	0	0	0	0	0.9928
92	Train	3.958	9928	120	345	56.6649	0.72	3804.65	4059.9343	0	4872	5300.7	0	0	0	0	0	0	1
	Calculate	3.958	9928	120	345	56.6649	0.72	3804.65	4059.9343	0	4872	5300.7	0	0.001	0.0006	0	0.0059	0.0001	0.9987
93	Train	3.958	9928	120	350	57.4186	0.72	3604.65	3922.0047	0	6744	5239.7	0	0	0	0	0	0	1
	Calculate	3.958	9928	120	350	57.4186	0.72	3604.65	3922.0047	0	6744	5239.7	0	0.0001	0.0014	0	0.0001	0.0012	1
94	Train	3.958	9930	120	345	47.8409	0.72	814.65	1597.2984	0	11845	2887.7	0	1	0	0	0	0	0
	Calculate	3.958	9930	120	345	47.8409	0.72	814.65	1597.2984	0	11845	2887.7	0.0098	0.9918	0	0.0052	0	0	0

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No.	Data type	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)	D&R (M)	H&B	F&B	M&B	B&B	Ork	D&R (O)
95	Train	3.958	10318	132	320	49.4463	0.7	2749.65	1156.6265	0	9960	5214.7	0	0	0	0	0	1	0
	Calculate	3.958	10318	132	320	49.4463	0.7	2749.65	1156.6265	0	9960	5214.7	0.0001	0	0.0001	0	0.0002	0.9858	0.0156
96	Train	3.958	10336	140	342	52.0279	0.72	1164.65	3335.3746	0	14697	4562.7	0	1	0	0	0	0	0
	Calculate	3.958	10336	140	342	52.0279	0.72	1164.65	3335.3746	0	14697	4562.7	0	0.9995	0	0.0123	0	0	0.0072
97	Train	3.958	10158	133	320	54.9295	0.72	3864.65	3139.5349	0	11352	5492.7	0	0	0	0	0	1	0
	Calculate	3.958	10158	133	320	54.9295	0.72	3864.65	3139.5349	0	11352	5492.7	0	0	0	0	0.0166	0.9992	0.0078
98	Train	3.958	10218	140	310	56.1658	0.806	1128.65	4065.1933	0	11719	3827.7	0	0	0	0	0	0	1
	Calculate	3.958	10218	140	310	56.1658	0.806	1128.65	4065.1933	0	11719	3827.7	0	0.0076	0	0	0.0023	0	0.9999
99	Train	3.958	11400	140	342	50.3766	0.7	1914.65	776.4824	0	13896	5000.7	0	0	0	0	0	1	0
	Calculate	3.958	11400	140	342	50.3766	0.7	1914.65	776.4824	0	13896	5000.7	0.0056	0	0	0	0.0027	1	0.0013
100	Train	3.958	10945	130	320	52.0279	0.72	844.65	3153.8367	0	8171	2770.7	0	1	0	0	0	0	0
	Calculate	3.958	10945	130	320	52.0279	0.72	844.65	3153.8367	0	8171	2770.7	0.0003	0.9912	0	0.0027	0	0	0.0005
101	Train	3.958	10356	128	320	59.975	0.716	4274.65	2707.0278	0	8936	6632.7	0	0	1	0	0	0	0
	Calculate	3.958	10356	128	320	59.975	0.716	4274.65	2707.0278	0	8936	6632.7	0	0	0.997	0	0.0039	0.0006	0
102	Train	3.958	10059	140	310	67.5155	0.702	4431.65	3698.4536	0	9312	6905.7	1	0	0	0	0	0	0
	Calculate	3.958	10059	140	310	67.5155	0.702	4431.65	3698.4536	0	9312	6905.7	1	0.0057	0	0	0.0197	0	0
103	Train	3.958	10059	125	334	71.5129	0.49	4336.65	3687.6006	0	9936	6870.7	0	0	0	0	1	0	0
	Calculate	3.958	10059	125	334	71.5129	0.49	4336.65	3687.6006	0	9936	6870.7	0.0001	0.0029	0	0	0.9954	0	0.0009
104	Train	3.958	6234.9	195	235.4	37.31	0.75	794.7	471.7	0	10367	2013	0	0	0	0	0	1	0
	Calculate	3.958	6234.9	195	235.4	37.31	0.75	794.7	471.7	0	10367	2013	0.0017	0	0	0	0	0.9998	0.0012
105	Train	3.958	6233.9	195	235.4	37.31	0.75	771.7	516.6	0	11111	1977	0	0	0	0	0	1	0
	Calculate	3.958	6233.9	195	235.4	37.31	0.75	771.7	516.6	0	11111	1977	0.0014	0	0	0	0	0.9991	0.0035
106	Train	4.892	10171.1	80.6	190.4	16.7	0.7	235.2	509.8	0	5222.6	4581.7	0	0	0	0	0	0	1
	Calculate	4.892	10171.1	80.6	190.4	16.7	0.7	235.2	509.8	0	5222.6	4581.7	0	0	0	0.0004	0	0.0003	0.9913
107	Train	4.892	10847	157	348	69.7802	0.72	2177.7	5525.8	0	10080	4149.7	0	0	0	0	1	0	0
	Calculate	4.892	10847	157	348	69.7802	0.72	2177.7	5525.8	0	10080	4149.7	0	0.0122	0	0	0.9979	0	0.0032
108	Train	4.892	10826.8	117.5	224.6	8.3	1.705	223.297	146.163	0.3	522.05	4758.93	0	0	0	1	0	0	0
	Calculate	4.892	10826.8	117.5	224.6	8.3	1.705	223.297	146.163	0.3	522.05	4758.93	0.0032	0	0	0.9965	0	0	0.0007
109	Train	4.892	10498.7	68	194	9	1.567	99.56	129.232	0.2	44.03	4164.4	0	0	1	0	0	0	0
	Calculate	4.892	10498.7	68	194	9	1.567	99.56	129.232	0.2	44.03	4164.4	0.0036	0	0.9983	0.0046	0	0	0.0006
110	Train	4.892	10170.6	84.2	192.2	11.8	0.938	524.82	168.736	0.1	836.55	4475.89	0	0	1	0	0	0	0
	Calculate	4.892	10170.6	84.2	192.2	11.8	0.938	524.82	168.736	0.1	836.55	4475.89	0.0037	0	0.992	0	0	0	0.0057
111	Train	4.892	10170.6	104	222.8	12.5	1.268	570.33	211.625	0.1	761.07	4521.4	1	0	0	0	0	0	0
	Calculate	4.892	10170.6	104	222.8	12.5	1.268	570.33	211.625	0.1	761.07	4521.4	0.9968	0	0	0.0078	0	0	0
112	Train	4.892	10170.6	136.4	226.4	12.5	1.268	590.24	211.625	0	1100.72	4554.12	0	0	0	0	0	0	1
	Calculate	4.892	10170.6	136.4	226.4	12.5	1.268	590.24	211.625	0	1100.72	4554.12	0	0	0	0.0008	0	0.0122	0.9864
113	Train	6.184	7877	115	262	36.5523	1.122	240.7	336.8254	0	18900	2325.7	0	0	0	0	1	0	0
	Calculate	6.184	7877	115	262	36.5523	1.122	240.7	336.8254	0	18900	2325.7	0.0008	0	0	0.0015	0.9874	0	0
114	Train	6.184	7388	115	262	36.5523	1.122	263.7	336.791	0	26800	2432.7	0	0	0	0	0	1	0
	Calculate	6.184	7388	115	262	36.5523	1.122	263.7	336.791	0	26800	2432.7	0	0	0	0.0003	0	0.9996	0
115	Train	6.184	8103	115	262	36.5523	1.122	334.7	336.7901	0	16200	2437.7	1	0	0	0	0	0	0
	Calculate	6.184	8103	115	262	36.5523	1.122	334.7	336.7901	0	16200	2437.7	0.9845	0	0	0.0006	0.0043	0	0
116	Train	6.184	8255	115	262	36.5523	1.122	260.7	336.7925	0	10600	2296.7	0	0	0	0	1	0	0
	Calculate	6.184	8255	115	262	36.5523	1.122	260.7	336.7925	0	10600	2296.7	0	0	0.0059	0.0001	0.9934	0	0
117	Train	6.184	9199	115	262	36.5523	1.122	263.7	336.7794	0	20990	2214.7	0	0	0	1	0	0	0
	Calculate	6.184	9199	115	262	36.5523	1.122	263.7	336.7794	0	20990	2214.7	0.0001	0	0	0.9883	0	0	0.0057
118	Train	6.184	7746	115	262	36.5523	1.122	314.7	336.8182	0	24200	2467.7	0	0	0	0	0	1	0
	Calculate	6.184	7746	115	262	36.5523	1.122	314.7	336.8182	0	24200	2467.7	0.0047	0	0	0.0043	0.0001	0.9899	0

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No.	Data type	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)	D&R (M)	H&B	F&B	M&B	B&B	Ork	D&R (O)
119	Train	6.184	7480	115	262	36.5523	1.122	275.7	336.7983	0	25205	2296.7	1	0	0	0	0	0	0
	Calculate	6.184	7480	115	262	36.5523	1.122	275.7	336.7983	0	25205	2296.7	0.9913	0.0001	0	0.0152	0	0.0116	0
120	Train	6.184	7596	119	269	35.5602	1.1	321.7	323.0159	0	15120	2630.7	0	0	0	0	0	1	0
	Calculate	6.184	7596	119	269	35.5602	1.1	321.7	323.0159	0	15120	2630.7	0	0	0.0027	0	0.0057	0.9934	0.0041
121	Train	6.184	8349	119	269	35.5602	1.1	219.7	323.0043	0	22235	2153.7	1	0	0	0	0	0	0
	Calculate	6.184	8349	119	269	35.5602	1.1	219.7	323.0043	0	22235	2153.7	0.9909	0.0049	0	0.0013	0.0024	0	0
122	Train	6.184	6899	119	269	35.5602	1.1	229.7	322.9873	0	19750	2083.7	0	0	0	1	0	0	0
	Calculate	6.184	6899	119	269	35.5602	1.1	229.7	322.9873	0	19750	2083.7	0	0.004	0	0.9847	0	0.0038	0
123	Train	6.184	9599	119	269	35.5602	1.1	214.7	323.0047	0	6390	2145.7	0	0	0	0	1	0	0
	Calculate	6.184	9599	119	269	35.5602	1.1	214.7	323.0047	0	6390	2145.7	0.0001	0	0.0001	0.0193	0.9996	0	0
124	Train	6.184	7093	119	269	35.5602	1.1	227.7	323.0146	0	12340	1960.7	0	0	0	1	0	0	0
	Calculate	6.184	7093	119	269	35.5602	1.1	227.7	323.0146	0	12340	1960.7	0	0.0004	0.0016	1	0.0001	0.0026	0
125	Train	6.184	8674	119	269	35.5602	1.1	295.7	322.9775	0	17800	2368.7	1	0	0	0	0	0	0
	Calculate	6.184	8674	119	269	35.5602	1.1	295.7	322.9775	0	17800	2368.7	0.9964	0	0	0.0004	0.0004	0	0
126	Train	6.184	7349	119	269	35.5602	1.1	215.7	323.0034	0	14650	2039.7	0	0	0	1	0	0	0
	Calculate	6.184	7349	119	269	35.5602	1.1	215.7	323.0034	0	14650	2039.7	0	0	0.0008	0.9998	0.0018	0.0001	0
127	Train	6.184	8045	119	269	35.5602	1.1	256.7	322.987	0	15400	2232.7	0	0	0	0	1	0	0
	Calculate	6.184	8045	119	269	35.5602	1.1	256.7	322.987	0	15400	2232.7	0.0167	0	0.0023	0.0004	0.9924	0	0
128	Train	6.184	7901	119	269	35.5602	1.1	300.7	322.96	0	12500	2043.7	0	0	1	0	0	0	0
	Calculate	6.184	7901	119	269	35.5602	1.1	300.7	322.96	0	12500	2043.7	0	0	0.9831	0.001	0.0145	0	0
129	Train	6.184	8169	115	262	36.5523	1.122	291.7	336.7803	0	27270	2295.7	0	0	0	1	0	0	0
	Calculate	6.184	8169	115	262	36.5523	1.122	291.7	336.7803	0	27270	2295.7	0	0.0008	0	0.9938	0	0	0.0026
130	Train	6.184	10003	115	262	36.5523	1.122	314.7	336.8082	0	7770	2260.7	0	0	0	1	0	0	0
	Calculate	6.184	10003	115	262	36.5523	1.122	314.7	336.8082	0	7770	2260.7	0	0	0	0.9883	0.011	0	0.0047
131	Train	6.184	7900	115	262	36.5523	1.122	332.7	336.8098	0	9780	2340.7	0	0	1	0	0	0	0
	Calculate	6.184	7900	115	262	36.5523	1.122	332.7	336.8098	0	9780	2340.7	0	0	0.9982	0.0046	0.0087	0	0.0001
132	Train	6.184	7799	115	262	36.5523	1.122	263.7	336.7993	0	23370	2212.7	0	1	0	0	0	0	0
	Calculate	6.184	7799	115	262	36.5523	1.122	263.7	336.7993	0	23370	2212.7	0.003	0	0	0.0047	0.0089	0	0
133	Train	6.184	7133	115	262	36.5523	1.122	402.7	336.8293	0	12300	2491.7	0	0	0	1	0	0	0
	Calculate	6.184	7133	115	262	36.5523	1.122	402.7	336.8293	0	12300	2491.7	0	0.0001	0.0092	0.9933	0.0001	0.0041	0
134	Validate	1.995	7850	75	189	38.8	0.9349	990	1019	0	187	3190	1	0	0	0	0	0	0
	Calculate	1.995	7850	75	189	38.8	0.9349	990	1019	0	187	3190	0.7227	0	0	0	0	0	0.0032
135	Validate	1.995	6550	75	189	42	0.8225	985	1245	0	167	2665	0	0	0	1	0	0	0
	Calculate	1.995	6550	75	189	42	0.8225	985	1245	0	167	2665	0	0	0.0178	0	0	0	0.9985
136	Validate	1.995	6570	75	189	42	0.8225	665	1245	0	138	2555	0	0	0	0	1	0	0
	Calculate	1.995	6570	75	189	42	0.8225	665	1245	0	138	2555	0	0	0.0178	0	0	0	0.9992
137	Validate	1.995	8000	75	189	42.6	0.84	1221	1747	0	91.2	3251	0	0	1	0	0	0	0
	Calculate	1.995	8000	75	189	42.6	0.84	1221	1747	0	91.2	3251	0.9594	0	0	0	0.0026	0	0.0004
138	Validate	1.995	8480	75	189	43.9	0.8287	1665	3588	0	131	3260	0	0	0	0	0	0	1
	Calculate	1.995	8480	75	189	43.9	0.8287	1665	3588	0	131	3260	0	0	0	0	0.7386	0	0.9998
139	Validate	1.995	4410	75	189	41.3	1.048	145	192	0	245.3	1419	0	1	0	0	0	0	0
	Calculate	1.995	4410	75	189	41.3	1.048	145	192	0	245.3	1419	0.9831	0	0.001	0	0.0086	0	0.0001
140	Validate	1.995	4410	75	189	41.3	1.048	105	230	0	392.4	1229	0	0	0	0	0	0	1
	Calculate	1.995	4410	75	189	41.3	1.048	105	230	0	392.4	1229	0.981	0	0.0011	0	0.0093	0	0.0001
141	Validate	2.441	7053.8	107.6	176	32.8	0.701	988.5	756.2	0	3607.84	3164.6	0	0	0	0	0	0	1
	Calculate	2.441	7053.8	107.6	176	32.8	0.701	988.5	756.2	0	3607.84	3164.6	0.0002	0	0.0048	0	0.0919	0	0.0006
142	Validate	2.441	5249.6	90	264	37	0.65	441.4	606.4	0	44	1974.6	0	0	0	0	0	0	1
	Calculate	2.441	5249.6	90	264	37	0.65	441.4	606.4	0	44	1974.6	0	0	0.0019	0.9896	0	0.0001	0.0001

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No.	Data type	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)	D&R (M)	H&B	F&B	M&B	B&B	Ork	D&R (O)
143	Validate	2.764	13477	135	301	52.985	0.71	1540	2717.4	0	1104	5840	0	0	0	0	0	1	0
	Calculate	2.764	13477	135	301	52.985	0.71	1540	2717.4	0	1104	5840	0	0.0003	0	0	0.9624	0	0.9977
144	Validate	2.992	3825	126	150	15.1	0.75	564.65	765	0	1065	1214.7	0	0	0	0	0	1	0
	Calculate	2.992	3825	126	150	15.1	0.75	564.65	765	0	1065	1214.7	0	0.0002	0.9931	0	0	0.0066	0
145	Validate	2.992	4210	126	150	16	0.75	364.65	222	0	788	1764.7	1	0	0	0	0	0	0
	Calculate	2.992	4210	126	150	16	0.75	364.65	222	0	788	1764.7	0.9891	0.0092	0	0	0	0.0001	0
146	Validate	2.992	4505	126	150	12.5	0.75	264.65	385	0	1040	1364.7	0	0	0	1	0	0	0
	Calculate	2.992	4505	126	150	12.5	0.75	264.65	385	0	1040	1364.7	0	0.955	0	0.0132	0	0.0043	0
147	Validate	2.992	4692	126	150	12.9	0.75	414.65	865	0	1585	1164.7	0	0	0	0	0	1	0
	Calculate	2.992	4692	126	150	12.9	0.75	414.65	865	0	1585	1164.7	0	0.552	0	0	0	0.0523	0
148	Validate	2.992	4175.1	126	150	15.6	0.75	314.7	267.3	0	2700	1514.7	0	0	0	1	0	0	0
	Calculate	2.992	4175.1	126	150	15.6	0.75	314.7	267.3	0	2700	1514.7	0.6422	0.0025	0.0002	0	0	0.0001	0
149	Validate	2.992	4691.8	126	150	12.9	0.75	414.7	865.8	0	1585	1164.7	0	0	0	1	0	0	0
	Calculate	2.992	4691.8	126	150	12.9	0.75	414.7	865.8	0	1585	1164.7	0	0.5511	0	0	0	0.0525	0
150	Validate	2.992	7647.64	104	185	31.3	0.92	1587.26	920.43	0	534.63	3850.09	1	0	0	0	0	0	0
	Calculate	2.992	7647.64	104	185	31.3	0.92	1587.26	920.45	0	534.63	3850.09	0	0	0	0	0	0.0012	0.9916
151	Validate	2.992	3948.5	150	235	38.69	0.75	482.7	1021.9	0	213	1178.7	0	0	0	0	0	1	0
	Calculate	2.992	3948.5	150	235	38.69	0.75	482.7	1021.9	0	213	1178.7	0	0.0001	0.1413	0.4066	0	0.0001	0.0537
152	Validate	2.992	6001.7	150	236	38.72	0.75	469.7	589.6	20	5401.6	2030.4	0	0	0	0	0	1	0
	Calculate	2.992	6001.7	150	236	38.72	0.75	469.7	589.6	20	5401.6	2030.4	0.0001	0	0	0	0	0.9997	0.0016
153	Validate	2.992	7169.1	160	236	37.62	0.87	202.7	426.7	18	291.1	1754.6	1	0	0	0	0	0	0
	Calculate	2.992	7169.1	160	236	37.62	0.87	202.7	426.7	18	291.1	1754.6	0	0.0311	0.0001	0	0	0.9427	0
154	Validate	3.958	10947	140	304	51.3165	0.7	2014.65	1129.7872	0	9400	4662.7	0	0	0	0	0	0	1
	Calculate	3.958	10947	140	304	51.3165	0.7	2014.65	1129.7872	0	9400	4662.7	0	0	0.0372	0	0	0.8383	0.0003
155	Validate	3.958	8560	115	262	36.5523	1.122	204.65	336.7797	0	11800	2400.7	0	0	1	0	0	0	0
	Calculate	3.958	8560	115	262	36.5523	1.122	204.65	336.7797	0	11800	2400.7	0	0	0.985	0	0	0	0.0041
156	Validate	3.958	10984	140	316	49.678	0.7	2504.65	990.8027	0	14352	5491.7	0	0	0	0	0	1	0
	Calculate	3.958	10984	140	316	49.678	0.7	2504.65	990.8027	0	14352	5491.7	0	0	0	0	0	1	0.2114
157	Validate	3.958	11929	140	310	51.0806	0.7	1194.65	1340.3263	0	10296	3423.7	0	0	0	0	0	0	1
	Calculate	3.958	11929	140	310	51.0806	0.7	1194.65	1340.3263	0	10296	3423.7	0	0.0002	0	0	0	0.008	0.9785
158	Validate	3.958	12152	148	336	56.6649	0.72	1184.65	3511.7953	0	13056	4625.7	0	1	0	0	0	0	0
	Calculate	3.958	12152	148	336	56.6649	0.72	1184.65	3511.7953	0	13056	4625.7	0	0.9848	0	0.0006	0	0	0.9994
159	Validate	3.958	6480	195	235.4	37.31	0.75	719.7	527.8	0	10845	2023	0	0	1	0	0	0	0
	Calculate	3.958	6480	195	235.4	37.31	0.75	719.7	527.8	0	10845	2023	0.0006	0	0.0001	0	0	0.9267	0.0941
160	Validate	3.958	6447.2	195	235.4	37.31	0.75	591.7	516.6	0	3356	1546.5	0	0	0	0	0	0	1
	Calculate	3.958	6447.2	195	235.4	37.31	0.75	591.7	516.6	0	3356	1546.5	0	0.0002	0	0	0	1	0
161	Validate	4.892	7647.64	138.2	188.6	16.7	0.708	605.89	512.415	0	5222.43	3062.15	0	0	0	0	0	0	1
	Calculate	4.892	7647.64	138.2	188.6	16.7	0.708	605.89	512.415	0	5222.43	3062.15	0	0	0.1778	0	0	0.089	0.0983
162	Validate	6.184	8379	115	262	36.5523	1.122	234.7	336.7949	0	15600	2209.7	0	0	0	0	1	0	0
	Calculate	6.184	8379	115	262	36.5523	1.122	234.7	336.7949	0	15600	2209.7	0.0004	0	0.0004	0.0002	0.9916	0	0
163	Validate	6.184	9180	115	262	36.5523	1.122	266.7	336.7884	0	23540	2239.7	0	0	0	1	0	0	0
	Calculate	6.184	9180	115	262	36.5523	1.122	266.7	336.7884	0	23540	2239.7	0	0.0001	0	0.9923	0	0	0.1719
164	Validate	6.184	8543	115	262	36.5523	1.122	248.7	336.7857	0	19600	2238.7	0	0	0	1	0	0	0
	Calculate	6.184	8543	115	262	36.5523	1.122	248.7	336.7857	0	19600	2238.7	0.1186	0	0	0.0018	0.0008	0	0
165	Validate	6.184	7500	119	269	35.5602	1.1	193.7	322.9901	0	7090	1964.7	0	0	0	0	0	0	1
	Calculate	6.184	7500	119	269	35.5602	1.1	193.7	322.9901	0	7090	1964.7	0	0	0.9068	1	0.0044	0	0.0004
166	Validate	6.184	7999	119	269	35.5602	1.1	387.7	323.0052	0	21656	2502.7	1	0	0	0	0	0	0
	Calculate	6.184	7999	119	269	35.5602	1.1	387.7	323.0052	0	21656	2502.7	0.2496	0	0	0	0.9772	0.8934	0

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No.	Data type	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)	D&R (M)	H&B	F&B	M&B	B&B	Ork	D&R (O)
167	Validate	6.184	8950	115	262	36.5523	1.122	231.7	336.8182	0	15400	2214.7	1	0	0	0	0	0	0
	Calculate	6.184	8950	115	262	36.5523	1.122	231.7	336.8182	0	15400	2214.7	0	0	0	0.0067	0.006	0	0
168	Test	1.995	9620	75	189	54	0.752	1455	3393	0	480	3365	0	0	0	0	1	0	0
	Calculate	1.995	9620	75	189	54	0.752	1455	3393	0	480	3365	0	0.0542	0	0	0.3767	0	0.9999
169	Test	1.995	3395.7	86	172.4	15.6	0.68	193.8	787.6	51	41.013	1509.9	0	0	0	1	0	0	0
	Calculate	1.995	3395.7	86	172.4	15.6	0.68	193.8	787.6	51	41.013	1509.9	0	0	0.0018	0.9986	0	0.0003	0.0005
170	Test	2.441	6500	75	189	36.2	0.8225	455	906	0	106	1635	1	0	0	0	0	0	0
	Calculate	2.441	6500	75	189	36.2	0.8225	455	906	0	106	1635	0	0	0.0003	0.0006	0.0087	0	1
171	Test	2.441	12861.5	90	200	37	0.7	1579.2	5160.2	0	188.7	4005.6	0	0	0	0	1	0	0
	Calculate	2.441	12861.5	90	200	37	0.7	1579.2	5160.2	0	188.7	4005.6	0	0	0	0	0	0	1
172	Test	2.441	12795.9	90	200	37	0.7	1993.1	2650.3	0	364.8	5032.5	0	0	0	0	0	0	1
	Calculate	2.441	12795.9	90	200	37	0.7	1993.1	2650.3	0	364.8	5032.5	0.8982	0.0016	0	0	0	0	0.1116
173	Test	2.441	7578.7	118.94	186.8	19.2	0.708	815	512.4	0	3834.3	3444.7	0	0	0	0	0	1	0
	Calculate	2.441	7578.7	118.94	186.8	19.2	0.708	815	512.4	0	3834.3	3444.7	0	0	0.0001	0	0	0.9999	0.2751
174	Test	2.441	7578.7	138.92	187.88	19.2	0.708	429.5	512.4	0	6868.47	3249.9	0	0	1	0	0	0	0
	Calculate	2.441	7578.7	138.92	187.88	19.2	0.708	429.5	512.4	0	6868.47	3249.9	0	0.0002	0.9937	0	0	0.0005	0.0001
175	Test	2.441	8038.1	92.12	167	40.3	0.75	1372.5	947	0	191.84	3574.2	0	0	0	0	0	0	1
	Calculate	2.441	8038.1	92.12	167	40.3	0.75	1372.5	947	0	191.84	3574.2	0.0013	0	0	0	0	0	0.8864
176	Test	2.441	10531.5	93.2	232.16	46	0.71	2193.1	2283.3	0	215.74	4640.9	0	0	0	1	0	0	0
	Calculate	2.441	10531.5	93.2	232.16	46	0.71	2193.1	2283.3	0	215.74	4640.9	1	0.0003	0	0	0.0003	0.0001	0
177	Test	2.441	3346.6	86	167	16.6	0.67	346.1	580.6	23	152.075	1488.1	0	0	0	0	1	0	0
	Calculate	2.441	3346.6	86	167	16.6	0.67	346.1	580.6	23	152.075	1488.1	0	0	0.0027	0.9996	0	0	0.0344
178	Test	2.992	3800	126	150	14.4	0.75	714.65	1430	0	3166	1264.7	0	0	1	0	0	0	0
	Calculate	2.992	3800	126	150	14.4	0.75	714.65	1430	0	3166	1264.7	0.0003	0	0.999	0	0	0.0002	0
179	Test	2.992	4240	126	150	15.6	0.75	714.65	957	0	1165	1564.7	0	0	0	1	0	0	0
	Calculate	2.992	4240	126	150	15.6	0.75	714.65	957	0	1165	1564.7	0.0175	0	0.9965	0	0	0.0012	0
180	Test	2.992	4175	126	150	15.6	0.75	314.65	267	0	2700	1514.7	0	0	0	1	0	0	0
	Calculate	2.992	4175	126	150	15.6	0.75	314.65	267	0	2700	1514.7	0.6413	0.0025	0.0002	0	0	0.0001	0
181	Test	2.992	4400	126	150	18.6	0.75	414.65	472	0	1040	1364.7	0	1	0	0	0	0	0
	Calculate	2.992	4400	126	150	18.6	0.75	414.65	472	0	1040	1364.7	0.8652	0	0.0467	0	0	0	0
182	Test	2.992	4766	126	150	13.3	0.75	264.65	193	0	967	1564.7	0	0	0	0	0	1	0
	Calculate	2.992	4766	126	150	13.3	0.75	264.65	193	0	967	1564.7	0	0.8113	0	0.0015	0	0.0001	0
183	Test	2.992	3182.4	86	158	17.05	0.69	181.8	745	7	267.282	1287.7	0	0	0	1	0	0	0
	Calculate	2.992	3182.4	86	158	17.05	0.69	181.8	745	7	267.282	1287.7	0	0	0	0.0018	0.8971	0	0.0004
184	Test	3.958	10456	112	270	49.678	0.844	2274.65	1387.7953	0	6096	4223.7	0	0	0	0	0	1	0
	Calculate	3.958	10456	112	270	49.678	0.844	2274.65	1387.7953	0	6096	4223.7	0	0	0.0005	0	0	0.6438	0.0389
185	Test	3.958	12290	140	305	53.9522	0.7	2141.65	1538.769	0	10008	4645.7	0	0	0	0	0	1	0
	Calculate	3.958	12290	140	305	53.9522	0.7	2141.65	1538.769	0	10008	4645.7	0	0	0	0	0	0.9998	0.0119
186	Test	3.958	9902	119	280	51.3165	0.7	3744.65	1339.1137	0	12456	6570.7	0	0	1	0	0	0	0
	Calculate	3.958	9902	119	280	51.3165	0.7	3744.65	1339.1137	0	12456	6570.7	0	0	0.0176	0	0	0.0384	0.9918
187	Test	3.958	11290	124	311	49.9103	0.7	1763.65	965.2972	0	7521	3852.7	0	0	0	0	0	1	0
	Calculate	3.958	11290	124	311	49.9103	0.7	1763.65	965.2972	0	7521	3852.7	0.0005	0	0	0	0	1	0.4158
188	Test	3.958	10158	134	320	53.9522	0.72	2694.65	3064.7383	0	11616	5493.7	0	0	0	0	0	1	0
	Calculate	3.958	10158	134	320	53.9522	0.72	2694.65	3064.7383	0	11616	5493.7	0	0.0099	0	0	0.0009	0.0463	0.9244
189	Test	3.958	10202	140	304	48.5254	0.7	1838.65	455.2469	0	6480	3957.7	0	0	1	0	0	0	0
	Calculate	3.958	10202	140	304	48.5254	0.7	1838.65	455.2469	0	6480	3957.7	0	0	0	0	0	0.9916	0.9697
190	Test	3.958	10661	125	332	60.7554	0.715	4048.65	2921.411	0	8958	6483.7	0	0	0	0	0	0	1
	Calculate	3.958	10661	125	332	60.7554	0.715	4048.65	2921.411	0	8958	6483.7	0.0002	0	0.0014	0	0.3575	0.8699	0

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No.	Data type	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)	D&R (M)	H&B	F&B	M&B	B&B	Ork	D&R (O)
191	Test	3.958	10661	108	260	49.4463	0.702	1134.65	2674.0205	0	2629	2178.7	0	0	1	0	0	0	0
	Calculate	3.958	10661	108	260	49.4463	0.702	1134.65	2674.0205	0	2629	2178.7	0	0	0	0	0.992	0	0.9998
192	Test	3.958	6501.8	126.3	238.1	37.6	0.75	464.7	550.3	0	2436.5	1385.7	0	0	0	0	0	0	1
	Calculate	3.958	6501.8	126.3	238.1	37.6	0.75	464.7	550.3	0	2436.5	1385.7	0	0	0.0003	0.9531	0	0	0
193	Test	3.958	6250.3	128	234.9	36.33	0.75	384.7	589.6	0	2845	1201.3	0	0	0	0	0	0	1
	Calculate	3.958	6250.3	128	234.9	36.33	0.75	384.7	589.6	0	2845	1201.3	0	0	0.0086	0.9841	0	0.0001	0.0001
194	Test	4.892	10838	140	342	66.6793	0.7	3364.7	3091.8	0	9024	5318.7	0	0	0	0	1	0	0
	Calculate	4.892	10838	140	342	66.6793	0.7	3364.7	3091.8	0	9024	5318.7	0	0.0037	0	0	0.9998	0	0.0357
195	Test	4.892	10826.8	134.6	228.2	8.3	1.705	209.074	146.163	0.15	930.89	4763.19	0	0	0	1	0	0	0
	Calculate	4.892	10826.8	134.6	228.2	8.3	1.705	209.074	146.163	0.15	930.89	4763.19	0	0	0	1	0	0	0.0959
196	Test	4.892	10498.7	89.6	195.8	9	1.567	164.984	129.232	0.5	924.6	4473.05	0	0	0	0	0	0	1
	Calculate	4.892	10498.7	89.6	195.8	9	1.567	164.984	129.232	0.5	924.6	4473.05	1	0	0.0003	0	0	0	0
197	Test	4.892	10170.6	80.6	190.4	11.8	0.938	220.45	168.736	0.1	144.67	4566.92	0	0	0	0	1	0	0
	Calculate	4.892	10170.6	80.6	190.4	11.8	0.938	220.45	168.736	0.1	144.67	4566.92	0.0111	0	0.04	0	0	0	0.0358
198	Test	4.892	7647.64	124.88	188.6	17.2	0.708	770.87	512.415	0	4128.01	3328.12	0	0	0	0	0	0	1
	Calculate	4.892	7647.64	124.88	188.6	17.2	0.708	770.87	512.415	0	4128.01	3328.12	0	0	0.9938	0	0	0.0014	0.0024
199	Test	6.184	8166	119	269	35.5602	1.1	219.7	323.0159	0	13860	2143.7	0	0	0	1	0	0	0
	Calculate	6.184	8166	119	269	35.5602	1.1	219.7	323.0159	0	13860	2143.7	0.0001	0	0.0299	0.0001	0.9923	0	0
200	Test	6.184	9714	115	262	36.5523	1.122	319.7	336.8182	0	11000	2322.7	0	0	0	0	1	0	0
	Calculate	6.184	9714	115	262	36.5523	1.122	319.7	336.8182	0	11000	2322.7	0	0	0	0.2297	0	0	0.0067
201	Test	6.184	7891	115	262	36.5523	1.122	397.7	336.8502	0	6540	2392.7	0	0	0	0	0	1	0
	Calculate	6.184	7891	115	262	36.5523	1.122	397.7	336.8502	0	6540	2392.7	0	0	0.9855	0.9849	0.1196	0	0.0005

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APPENDIX E

Results of neural network Model number 9 for Case 4: (percentage error)

No.	Data type	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)	D&R (M)	H&B	F&B	M&B	B&B	Ork	D&R (O)
1	Train	1.995	7450	75	189	54	0.752	1645	3393	0	82	3300	14.0303	22.8485	22.8485	7.0909	1.4242	6.2424	9.5758
	Calculate	1.995	7450	75	189	54	0.752	1645	3393	0	82	3300	15.4202	23.4488	23.4972	16.0836	6.778	8.9641	10.6423
2	Train	1.995	7350	75	189	54	0.752	1635	3393	0	125	3290	16.9301	23.5866	23.5866	23.3435	12.604	11.1246	11.7021
	Calculate	1.995	7350	75	189	54	0.752	1635	3393	0	125	3290	18.8695	26.7895	26.2353	18.6613	7.5749	11.0239	13.1081
3	Train	1.995	8070	75	189	42.6	0.84	1229	1747	0	259.2	3199	1.0903	15.1854	15.1857	7.4858	7.2588	11.6211	7.3617
	Calculate	1.995	8070	75	189	42.6	0.84	1229	1747	0	259.2	3199	5.6623	15.8485	15.0166	6.1573	8.3242	10.996	6.3245
4	Train	1.995	3000	75	189	41.3	1.048	175	189	0	160.3	1083	0.1847	3.2318	5.7248	5.3555	4.8015	3.0471	2.1237
	Calculate	1.995	3000	75	189	41.3	1.048	175	189	0	160.3	1083	1.2245	0.5057	4.7242	5.8631	4.9163	1.0984	2.4159
5	Train	1.995	3363	86	168.8	15.6	0.78	199.7	944.7	60.4	42.6096	1485.3	42.2339	39.7428	60.3447	2.4036	7.8974	26.5468	15.5053
	Calculate	1.995	3363	86	168.8	15.6	0.78	199.7	944.7	60.4	42.6096	1485.3	42.5057	40.1195	60.5047	2.2086	7.7832	26.6445	15.2092
6	Train	1.995	3395.7	86	172.4	15.6	0.68	193.8	787.6	51	41.013	1509.9	44.5659	39.2013	62.9777	0.8014	4.1658	24.0347	15.0937
	Calculate	1.995	3395.7	86	172.4	15.6	0.68	193.8	787.6	51	41.013	1509.9	44.1075	39.2367	63.2212	2.2818	4.6517	23.9087	15.385
7	Train	1.995	3362.9	86	168.8	15.6	0.78	250.6	7029.3	56	14.652	1506.7	65.8857	59.3814	78.7615	40.0013	41.196	50.3551	37.4795
	Calculate	1.995	3362.9	86	168.8	15.6	0.78	250.6	7029.3	56	14.652	1506.7	66.2593	59.499	78.385	40.0899	41.2185	50.4059	37.6023
8	Train	1.995	3395	86	158	15.6	0.62	107.2	2475.1	14	12.986	1513.8	71.2644	72.1892	90.4875	47.6153	48.3419	37.7064	30.6381
	Calculate	1.995	3395	86	158	15.6	0.62	107.2	2475.1	14	12.986	1513.8	69.905	71.7754	88.867	49.8391	48.2717	38.1143	30.4132
9	Train	1.995	3313.6	86	167	15.6	0.67	157	692.8	25	16.05	1458.4	45.8996	23.2035	74.2183	0.2331	0.3703	12.0954	12.0954
	Calculate	1.995	3313.6	86	167	15.6	0.67	157	692.8	25	16.05	1458.4	45.4894	23.8368	74.0762	1.6064	1.0584	12.2472	11.6342
10	Train	2.441	9592	75	189	50.8	0.68	2360	3640	0	244.8	4090	0.5379	8.2641	8.2641	7.0171	0.4156	1.2714	0.1956
	Calculate	2.441	9592	75	189	50.8	0.68	2360	3640	0	244.8	4090	1.5806	8.5524	9.1386	3.3521	1.8487	1.7312	2.3579
11	Train	2.441	10683	75	189	47.6	0.742	1784	2151	0	313.2	4315	4.9363	14.438	14.438	8.343	8.2039	7.6941	8.1808
	Calculate	2.441	10683	75	189	47.6	0.742	1784	2151	0	313.2	4315	3.9776	12.249	17.215	9.0566	7.8697	7.9451	8.2158
12	Train	2.441	10800	75	189	44.4	0.796	1264	2250	0	60	3835	8.4735	4.5424	18.7625	12.6827	12.0644	4.5424	0.3789
	Calculate	2.441	10800	75	189	44.4	0.796	1264	2250	0	60	3835	2.9923	7.0785	18.328	12.1998	12.2483	4.8	0.7349
13	Train	2.441	6500	75	189	36.2	0.8225	555	906	0	60	2325	18.1505	4.3011	36.3871	14.4516	16.3441	4.3011	0.043
	Calculate	2.441	6500	75	189	36.2	0.8225	555	906	0	60	2325	13.8184	3.8527	36.7117	15.8143	15.3554	6.8486	2.7532
14	Train	2.441	6500	75	189	36.2	0.8225	455	906	0	106	1635	4.6483	14.8012	24.526	50.3364	55.1682	30.948	24.4037
	Calculate	2.441	6500	75	189	36.2	0.8225	455	906	0	106	1635	9.5542	13.7996	24.5506	47.6621	55.7809	31.1876	23.7856
15	Train	2.441	12861.5	90	200	37	0.7	1294.7	3762	0	283	4049.7	22.5128	31.6986	36.5632	20.8089	16.2654	29.822	14.7344
	Calculate	2.441	12861.5	90	200	37	0.7	1294.7	3762	0	283	4049.7	21.8954	32.2616	35.684	21.5634	15.9602	30.2862	14.8901
16	Train	2.441	7054.1	107.6	176	32.8	0.7	1003.2	774.9	0	4075	3236.2	0.7478	1.0877	1.9529	0.7169	9.3258	4.085	2.3423
	Calculate	2.441	7054.1	107.6	176	32.8	0.7	1003.2	774.9	0	4075	3236.2	1.3467	2.9305	2.763	1.8308	5.9312	3.9537	2.4976
17	Train	2.441	8038.4	92.1	167	40.3	0.75	1387.2	942.2	0	191.9	3588.9	1.8362	0.443	6.1551	3.4579	3.4857	1.3124	0.1644
	Calculate	2.441	8038.4	92.1	167	40.3	0.75	1387.2	942.2	0	191.9	3588.9	1.9061	2.6218	3.8763	2.8185	1.5098	3.1667	1.4514
18	Train	2.441	10532	93.2	232.1	46	0.71	2270.5	2271.8	0	439.7	4654.2	3.3131	10.5324	10.5324	6.6435	6.0633	7.8252	6.3856
	Calculate	2.441	10532	93.2	232.1	46	0.71	2270.5	2271.8	0	439.7	4654.2	2.5442	10.9687	9.2603	4.7085	3.5874	6.7021	5.7177
19	Train	2.441	7579.1	138.9	187.9	19.2	0.71	444.2	509.8	0	6868.7	3264.6	36.5251	35.0242	27.8258	36.5251	55.3023	34.1359	44.2749
	Calculate	2.441	7579.1	138.9	187.9	19.2	0.71	444.2	509.8	0	6868.7	3264.6	35.6576	33.0248	26.4018	36.3859	52.6503	33.6592	44.922
20	Train	2.441	8760.3	104	198.5	25	0.57	128.5	381.8	0	353.5	2819.4	20.1248	35.3763	51.5854	25.1614	20.3022	26.119	9.8744
	Calculate	2.441	8760.3	104	198.5	25	0.57	128.5	381.8	0	353.5	2819.4	23.0802	35.8675	52.9717	30.4702	21.2377	27.1869	9.0516
21	Train	2.441	7578.7	138.92	187.88	19.2	0.708	429.5	512.4	0	6868.47	3249.9	36.8042	34.9888	28.0039	36.8042	55.9125	34.4041	44.6198
	Calculate	2.441	7578.7	138.92	187.88	19.2	0.708	429.5	512.4	0	6868.47	3249.9	36.6968	34.7144	27.1708	37.5886	52.954	34.2805	45.0753
22	Train	2.441	8759.8	104	198.5	25	0.571	113.8	383.7	0	255.366	2762.1	26.5052	35.7373	54.3101	28.7861	7.3169	17.3455	5.1808
	Calculate	2.441	8759.8	104	198.5	25	0.571	113.8	383.7	0	255.366	2762.1	24.8734	37.6752	56.6321	28.9565	16.5588	24.924	9.9408

No.	Data type	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)	D&R (M)	H&B	F&B	M&B	B&B	Ork	D&R (O)
23	Train	2.441	8759.8	104	198.5	25	0.571	113.8	383.7	0	353.487	2804.7	22.0237	36.7847	54.7189	26.8371	21.6315	28.1563	11.2205
	Calculate	2.441	8759.8	104	198.5	25	0.571	113.8	383.7	0	353.487	2804.7	23.1669	36.021	53.6835	30.7596	20.9771	26.4667	9.0317
24	Train	2.441	7647.6	107.6	192.2	32.2	0.92	1564.5	858.4	0	2616.56	3955.3	1.4234	1.5751	1.7521	1.4234	1.3577	6.5305	0.3717
	Calculate	2.441	7647.6	107.6	192.2	32.2	0.92	1564.5	858.4	0	2616.56	3955.3	0.9974	1.7727	1.4884	0.3543	1.8488	8.1568	0.7614
25	Train	2.441	7053.8	105.8	176	32.8	0.701	896	744.9	0	2203.95	2972.6	11.1216	13.0054	13.9474	11.7271	4.6289	19.0617	8.3967
	Calculate	2.441	7053.8	105.8	176	32.8	0.701	896	744.9	0	2203.95	2972.6	10.2997	13.2668	14.4187	10.6384	7.9441	18.9556	8.556
26	Train	2.441	7053.8	107.6	176	32.8	0.701	988.5	778.8	0	4075.8	3221.5	0.9157	1.2572	2.1884	0.9157	9.39	4.2992	2.1574
	Calculate	2.441	7053.8	107.6	176	32.8	0.701	988.5	778.8	0	4075.8	3221.5	1.4278	3.0133	2.9028	1.944	6.2498	4.0112	2.6363
27	Train	2.441	8038.1	89.6	167	40.3	0.75	1344.1	947	0	330.84	3508.8	0.6042	5.9223	6.2642	2.9298	2.8728	1.8753	0.9918
	Calculate	2.441	8038.1	89.6	167	40.3	0.75	1344.1	947	0	330.84	3508.8	1.8506	3.2378	4.2753	2.8998	1.8306	3.7398	1.7203
28	Train	2.441	8038.1	89.42	167	40.3	0.75	1308.5	947	0	480.54	3436.2	1.9149	5.8553	6.1172	3.0324	2.8578	4.924	1.2281
	Calculate	2.441	8038.1	89.42	167	40.3	0.75	1308.5	947	0	480.54	3436.2	1.9369	3.8965	4.5573	2.995	2.2466	4.8136	1.9095
29	Train	2.441	8038.1	98.6	167	40.3	0.75	1173.4	947	0	1125.88	3227.1	1.5215	6.6964	6.7584	4.6512	1.9243	16.6744	2.2342
	Calculate	2.441	8038.1	98.6	167	40.3	0.75	1173.4	947	0	1125.88	3227.1	3.909	8.8622	6.398	4.446	4.6599	14.8989	2.0957
30	Train	2.441	10531.5	93.2	232.16	46	0.71	2193.1	2283.3	0	215.74	4640.9	7.1516	12.4954	12.4954	0.0194	4.1781	3.0576	6.3975
	Calculate	2.441	10531.5	93.2	232.16	46	0.71	2193.1	2283.3	0	215.74	4640.9	3.4666	11.9877	12.2887	4.2201	2.427	6.2218	7.0984
31	Train	2.441	3346.6	86	167	16.6	0.67	346.1	580.6	23	152.075	1488.1	31.9938	29.373	45.7026	12.2908	0.0739	19.6963	8.0707
	Calculate	2.441	3346.6	86	167	16.6	0.67	346.1	580.6	23	152.075	1488.1	32.7554	28.9108	46.5875	10.8658	3.8903	19.265	8.7027
32	Train	2.441	3346.6	86	168	16.6	0.78	192.5	747.8	9	160.251	1448.6	56.8549	47.8117	72.8704	18.8182	23.7195	46.7762	29.3801
	Calculate	2.441	3346.6	86	168	16.6	0.78	192.5	747.8	9	160.251	1448.6	57.5465	47.0541	71.8501	18.8545	23.5006	48.4136	29.347
33	Train	2.441	3379.3	86	172.4	16.67	0.72	225.2	1437.3	1.4	71.978	1512.4	59.799	57.9476	77.7837	21.9783	20.722	45.8477	29.6482
	Calculate	2.441	3379.3	86	172.4	16.67	0.72	225.2	1437.3	1.4	71.978	1512.4	60.6985	58.3869	79.7625	21.3869	21.7199	44.5063	30
34	Train	2.441	4445.7	104	185	14.48	0.6	289.2	283.3	24	172.064	1988.9	21.263	16.1848	32.7769	2.6195	2.71	11.8105	7.2352
	Calculate	2.441	4445.7	104	185	14.48	0.6	289.2	283.3	24	172.064	1988.9	21.6298	15.5092	33.7235	0.7678	0.4761	11.96	7.4047
35	Train	2.441	8465	90	200	37	0.7	294.9	252.7	50	148.5	3355.6	1.5318	0.8463	0.8225	0.9357	2.6344	2.3066	2.1576
	Calculate	2.441	8465	90	200	37	0.7	294.9	252.7	50	148.5	3355.6	1.391	0.8964	1.4429	0.1105	0.371	3.2821	0.0893
36	Train	2.441	10007	90	200	37	0.7	606.4	505.3	10	446.04	3745.3	1.1828	10.1541	10.5546	5.8019	5.6684	8.0981	4.4936
	Calculate	2.441	10007	90	200	37	0.7	606.4	505.3	10	446.04	3745.3	6.2063	11.1935	8.2607	3.2635	7.1656	6.0809	3.2571
37	Train	2.441	6002.7	90	264	37	0.65	228	701.9	0	36	2253.4	42.3595	27.1479	69.8709	0.1646	0.1691	11.598	17.455
	Calculate	2.441	6002.7	90	264	37	0.65	228	701.9	0	36	2253.4	41.8453	27.9844	69.1529	0.4324	0.0899	11.5301	17.7915
38	Train	2.441	6002.7	90	264	37	0.65	811.2	2027	0	15	2860.7	34.9509	8.0022	54.8194	1.2878	1.2864	8.0022	13.4296
	Calculate	2.441	6002.7	90	264	37	0.65	811.2	2027	0	15	2860.7	36.4193	7.0428	54.6637	0.8208	0.0916	8.0088	12.9888
39	Train	2.764	10039	134	320	50.3766	0.7	1620	1116.6	0	10872	6695	2.2853	2.2853	2.4645	2.2853	3.4951	1.7028	2.1658
	Calculate	2.764	10039	134	320	50.3766	0.7	1620	1116.6	0	10872	6695	1.6818	0.5028	1.6467	2.3438	3.5589	1.4943	2.688
40	Train	2.764	13477	135	301	52.985	0.71	1540	2717.4	0	1104	5840	48.5445	50.6849	51.1473	48.5103	43.613	40.5651	49.0411
	Calculate	2.764	13477	135	301	52.985	0.71	1540	2717.4	0	1104	5840	49.2426	52.0428	52.9536	45.5639	45.3878	40.4681	46.1205
41	Train	2.764	13477	130	289	52.2662	0.71	2130	3086.3	0	823	6045	36.3772	40.0331	40.0331	37.2374	34.4251	34.938	37.2208
	Calculate	2.764	13477	130	289	52.2662	0.71	2130	3086.3	0	823	6045	36.681	39.5504	39.8933	38.0658	33.7298	35.1799	38.0808
42	Train	2.764	10876	139	308	66.6793	0.685	3940	2303.4	0	4272	6729	1.709	1.6347	1.7685	1.709	0.5944	2.4075	1.5604
	Calculate	2.764	10876	139	308	66.6793	0.685	3940	2303.4	0	4272	6729	1.5499	0.5012	1.4103	1.5339	1.2718	1.2527	1.0927
43	Train	2.992	3940	126	150	14.6	0.75	164.65	252	0	1300	1014.7	28.7671	32.2361	16.192	15.1473	18.4291	4.8586	30.4228
	Calculate	2.992	3940	126	150	14.6	0.75	164.65	252	0	1300	1014.7	32.2872	31.8636	12.7301	16.1654	18.3274	8.2113	30.2883
44	Train	2.992	3800	126	150	14.4	0.75	714.65	1430	0	3166	1264.7	20.7243	45.2281	3.9614	20.8271	48.8416	16.7391	23.8476
	Calculate	2.992	3800	126	150	14.4	0.75	714.65	1430	0	3166	1264.7	15.1369	45.5321	3.8919	20.7706	47.5024	17.4727	25.8314
45	Train	2.992	3720	126	150	14.4	0.75	314.65	232	0	1965	1214.7	30.8471	32.6747	2.2639	17.0659	21.0587	13.526	30.0486
	Calculate	2.992	3720	126	150	14.4	0.75	314.65	232	0	1965	1214.7	29.3128	31.4513	8.4616	13.5251	19.1857	6.0228	27.3214
46	Train	2.992	4570	126	150	13.5	0.75	864.65	1500	0	1965	1514.7	8.741	36.3372	3.3604	8.2194	26.7116	10.101	18.063
	Calculate	2.992	4570	126	150	13.5	0.75	864.65	1500	0	1965	1514.7	9.2696	36.1691	3.8223	8.1128	27.9548	8.8433	15.9357

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No.	Data type	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)	D&R (M)	H&B	F&B	M&B	B&B	Ork	D&R (O)
47	Train	2.992	4175	126	150	15.6	0.75	314.65	267	0	2700	1514.7	8.3581	18.0036	13.0191	0.9837	5.209	4.3639	9.9624
	Calculate	2.992	4175	126	150	15.6	0.75	314.65	267	0	2700	1514.7	7.8366	14.9783	8.0423	3.2607	7.8676	6.8899	8.4083
48	Train	2.992	4355	126	150	12.9	0.75	264.65	185	0	855	1714.7	3.2251	2.5952	17.1225	4.6014	3.1726	9.8326	4.2223
	Calculate	2.992	4355	126	150	12.9	0.75	264.65	185	0	855	1714.7	2.9567	2.4884	19.4985	5.0665	3.1969	9.6389	2.1568
49	Train	2.992	4670	126	150	13.6	0.75	924.65	1565	0	2320	1664.7	4.1209	32.0598	4.6735	5.1541	24.7192	3.4421	12.3205
	Calculate	2.992	4670	126	150	13.6	0.75	924.65	1565	0	2320	1664.7	7.0785	29.5238	2.9598	5.5416	24.1648	5.3402	11.2497
50	Train	2.992	4575	126	150	18.6	0.75	664.65	858	0	2480	1564.7	0.0256	14.1497	10.9542	1.0162	11.9256	7.8418	5.8669
	Calculate	2.992	4575	126	150	18.6	0.75	664.65	858	0	2480	1564.7	5.0455	14.511	3.0801	2.3065	11.4531	2.1656	5.5465
51	Train	2.992	4400	126	150	18.6	0.75	414.65	472	0	1040	1364.7	16.8242	3.4586	16.3919	5.3418	6.7048	8.6246	16.3772
	Calculate	2.992	4400	126	150	18.6	0.75	414.65	472	0	1040	1364.7	9.3443	8.6574	13.6026	6.5695	6.5869	11.4406	14.2506
52	Train	2.992	4065	126	150	13	0.75	514.65	341	0	1490	1564.7	17.6839	17.5241	5.8158	7.9504	10.4621	3.9305	17.3899
	Calculate	2.992	4065	126	150	13	0.75	514.65	341	0	1490	1564.7	11.8406	14.7069	9.4561	7.2004	9.6868	7.3401	14.3038
53	Train	2.992	3705	126	150	13.6	0.75	514.65	335	0	1310	1464.7	17.6828	15.8121	5.1819	8.8619	11.2446	4.8611	17.2254
	Calculate	2.992	3705	126	150	13.6	0.75	514.65	335	0	1310	1464.7	18.8226	16.8119	8.4826	12.3043	13.2339	5.0412	20.8775
54	Train	2.992	4160	126	150	12.9	0.75	164.65	185	0	1350	1514.7	2.0532	1.5383	26.322	7.1235	4.0602	12.3523	2.8587
	Calculate	2.992	4160	126	150	12.9	0.75	164.65	185	0	1350	1514.7	6.2536	6.5633	22.4343	6.4262	4.7467	11.6513	4.2728
55	Train	2.992	4487	126	150	14.1	0.75	594.65	962	0	1905	1314.7	11.1356	37.7805	9.5383	7.9029	23.8762	8.2376	17.89
	Calculate	2.992	4487	126	150	14.1	0.75	594.65	962	0	1905	1314.7	13.7822	38.8143	5.4412	7.7421	24.6801	8.3211	19.5044
56	Train	2.992	3924	126	150	18.7	0.75	714.65	575	0	1850	1514.7	15.2439	18.3733	0.6404	9.289	13.4482	3.0831	18.9476
	Calculate	2.992	3924	126	150	18.7	0.75	714.65	575	0	1850	1514.7	15.9736	20.2855	6.5924	9.1169	15.0993	4.7939	17.7844
57	Train	2.992	4240	126	150	15.6	0.75	714.7	957.4	0	1165	1564.7	16.7636	20.3426	4.7741	11.523	13.2485	7.3688	20.5982
	Calculate	2.992	4240	126	150	15.6	0.75	714.7	957.4	0	1165	1564.7	15.3963	19.8253	7.4436	10.057	12.1116	5.0647	20.3073
58	Train	2.992	4210	126	150	16	0.75	364.7	223.3	0	788	1764.7	1.683	4.913	15.3397	6.3864	5.8197	11.373	3.417
	Calculate	2.992	4210	126	150	16	0.75	364.7	223.3	0	788	1764.7	3.2096	1.7021	15.8838	5.9419	3.1801	9.3902	4.1441
59	Train	2.992	7647.64	104	185	31.3	0.92	1322.71	901.81	0	2654.3	3555.7	5.082	5.7007	5.8132	5.1382	2.1571	13.9129	1.9321
	Calculate	2.992	7647.64	104	185	31.3	0.92	1322.71	901.81	0	2654.3	3555.7	6.1872	3.2551	7.1225	3.0484	3.549	13.6264	3.0435
60	Train	2.992	3182.5	86	158	17.05	0.69	250.1	989	14	182.32	1390.2	53.6757	50.223	70.6517	21.9537	13.6096	48.137	27.5644
	Calculate	2.992	3182.5	86	158	17.05	0.69	250.1	989	14	182.32	1390.2	54.7757	50.5616	70.0102	21.8152	14.955	49.3743	26.4602
61	Train	2.992	3182.4	86	158	17.05	0.69	181.8	745	7	267.282	1287.7	56.5116	48.9788	73.5963	17.9933	22.8858	52.9393	29.9526
	Calculate	2.992	3182.4	86	158	17.05	0.69	181.8	745	7	267.282	1287.7	55.0707	50.2509	73.8142	18.9123	23.091	52.4434	30.4557
62	Train	2.992	3346.6	86	158	17.05	0.69	184	1243.2	24	120.004	1465.5	63.9031	60.2184	80.4845	28.2839	22.825	57.9666	36.5404
	Calculate	2.992	3346.6	86	158	17.05	0.69	184	1243.2	24	120.004	1465.5	63.701	59.2697	80.0416	28.8777	22.756	57.9571	37.2912
63	Train	2.992	4101.3	195	237	39.25	0.75	1284.7	3773.3	0	278	1731.1	2.0854	7.8621	11.3281	39.911	15.3602	4.7311	3.4025
	Calculate	2.992	4101.3	195	237	39.25	0.75	1284.7	3773.3	0	278	1731.1	4.1575	0.2933	9.5524	39.2512	15.5476	5.4876	4.399
64	Train	2.992	4521.2	195	237	39.25	0.75	989.7	6081	0	1555	1490	2.1477	0.8725	2.4161	2.1477	14.9664	31.6779	15.4362
	Calculate	2.992	4521.2	195	237	39.25	0.75	989.7	6081	0	1555	1490	1.1944	0.2252	2.0799	2.4006	14.8999	31.7913	15.4409
65	Train	2.992	4921.5	195	230	37.31	0.75	764.7	381.8	0	7226	1976.5	19.6054	14.2929	13.9894	14.4447	19.8077	12.6739	16.6709
	Calculate	2.992	4921.5	195	230	37.31	0.75	764.7	381.8	0	7226	1976.5	19.1214	13.539	15.7474	14.011	19.7175	12.622	17.2438
66	Train	2.992	6411.1	200	236.5	38.72	0.75	589.7	651.3	0	5809	1937.6	2.2502	2.8179	3.0244	1.9922	13.2845	2.2915	0.8567
	Calculate	2.992	6411.1	200	236.5	38.72	0.75	589.7	651.3	0	5809	1937.6	1.5715	1.4412	1.5415	1.8304	12.9349	2.8946	2.3569
67	Train	2.992	6402	130	236	39	0.75	548.7	746.8	0	943	1568.7	8.3062	23.1211	23.376	2.0845	1.2558	12.794	7.8855
	Calculate	2.992	6402	130	236	39	0.75	548.7	746.8	0	943	1568.7	10.9448	21.4075	23.4035	2.5649	2.2893	13.0819	7.6906
68	Train	2.992	6105.7	130	236	39	0.75	554.7	797.3	0	2482	1319.5	8.7533	2.6904	4.8882	4.0546	15.6499	12.9973	0.5684
	Calculate	2.992	6105.7	130	236	39	0.75	554.7	797.3	0	2482	1319.5	4.3147	4.5267	5.962	3.7429	15.084	12.9475	2.1299
69	Train	2.992	6496.5	130	236	39	0.75	514.7	387.4	0	4286	1562.6	22.8721	16.7285	16.4085	18.7764	26.8399	15.1926	21.7842
	Calculate	2.992	6496.5	130	236	39	0.75	514.7	387.4	0	4286	1562.6	24.0906	17.6375	14.8906	16.5044	26.9411	15.3873	22.6964
70	Train	2.992	6069.8	130	236	38.72	0.75	414.7	555.9	0	6037	1663.7	5.1872	4.4058	4.2255	5.5479	24.2411	10.5368	6.5697
	Calculate	2.992	6069.8	130	236	38.72	0.75	414.7	555.9	0	6037	1663.7	6.5139	3.3881	5.2345	5.4815	24.4261	9.7678	6.676

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No.	Data type	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)	D&R (M)	H&B	F&B	M&B	B&B	Ork	D&R (O)
71	Train	2.992	6512.8	150	236	38.72	0.75	374.7	589.6	0	2306	1099.7	25.4888	0.2091	2.9735	12.758	22.5789	18.1231	6.2108
	Calculate	2.992	6512.8	150	236	38.72	0.75	374.7	589.6	0	2306	1099.7	26.1825	2.7699	4.098	12.2983	22.4546	18.1628	4.9536
72	Train	2.992	5006.1	195	237	39.25	0.75	1164.7	5317.4	35.5	655.32	1631.7	0.1655	2.0406	5.5586	1.146	10.8047	25.5133	0.4719
	Calculate	2.992	5006.1	195	237	39.25	0.75	1164.7	5317.4	35.5	655.32	1631.7	0.2778	0.2052	0.394	1.2603	10.8633	25.4828	0.0444
73	Train	3.958	10049	140	337	51.7902	0.7	1289.65	1286.6915	0	16080	4281.7	0.5675	0.4975	0.334	0.5675	11.8948	5.0517	0.8338
	Calculate	3.958	10049	140	337	51.7902	0.7	1289.65	1286.6915	0	16080	4281.7	1.4744	1.2388	1.9058	1.4135	12.1992	4.2018	1.5202
74	Train	3.958	10947	145	321	54.4396	0.7	1084.65	1177.4387	0	13368	3686.7	6.2468	6.1383	5.9755	6.2468	18.4528	12.7295	5.0262
	Calculate	3.958	10947	145	321	54.4396	0.7	1084.65	1177.4387	0	13368	3686.7	5.7787	5.4423	4.8253	6.1612	18.2696	13.0243	5.5631
75	Train	3.958	10083	130	286	50.1431	0.7	3684.65	1592.6309	0	11616	6509.7	0.3887	0.4808	0.3272	0.3887	1.5101	0.5484	0.6191
	Calculate	3.958	10083	130	286	50.1431	0.7	3684.65	1592.6309	0	11616	6509.7	0.5316	0.4212	0.5888	0.1872	0.8959	0.8943	0.1856
76	Train	3.958	9902	119	280	51.3165	0.7	3744.65	1339.1137	0	12456	6570.7	2.0896	2.1048	2.0287	2.0896	2.2418	2.1048	2.1657
	Calculate	3.958	9902	119	280	51.3165	0.7	3744.65	1339.1137	0	12456	6570.7	0.7924	0.6251	0.7365	0.1996	1.1232	2.0551	0.2195
77	Train	3.958	10239	140	300	51.0806	0.7	2834.65	1470.3065	0	12528	5598.7	0.952	1.0413	0.8627	0.952	3.8813	0.9056	1.4343
	Calculate	3.958	10239	140	300	51.0806	0.7	2834.65	1470.3065	0	12528	5598.7	1.7179	1.2224	1.9505	1.7684	5.0777	1.1524	1.3623
78	Train	3.958	9650	120	306	50.6107	0.7	1941.65	1764.6714	0	17040	4862.7	7.3272	7.43	7.1286	7.3272	19.008	7.2038	5.209
	Calculate	3.958	9650	120	306	50.6107	0.7	1941.65	1764.6714	0	17040	4862.7	6.9769	5.9648	7.7966	6.4206	20.1665	8.244	5.0449
79	Train	3.958	8045	119	269	35.5602	1.1	150.65	322.9485	0	7190	2067.7	3.013	4.048	5.3538	0.8077	8.4297	4.4639	2.9356
	Calculate	3.958	8045	119	269	35.5602	1.1	150.65	322.9485	0	7190	2067.7	5.846	3.6554	5.2137	3.0796	8.5106	5.1399	3.2894
80	Train	3.958	8715	119	269	35.5602	1.1	213.65	323.1173	0	2284	2211.7	8.2425	10.9735	11.29	0.1492	0.6918	4.7791	1.5237
	Calculate	3.958	8715	119	269	35.5602	1.1	213.65	323.1173	0	2284	2211.7	8.1263	9.0156	10.352	1.2974	1.2279	4.1092	2.4186
81	Train	3.958	8600	119	269	35.5602	1.1	168.65	322.9358	0	6540	2096.7	4.0683	4.3258	5.4705	0.3672	7.3592	3.4483	2.1319
	Calculate	3.958	8600	119	269	35.5602	1.1	168.65	322.9358	0	6540	2096.7	6.8709	4.5293	5.9831	3.0566	6.896	5.0903	4.0588
82	Train	3.958	9459	119	269	35.5602	1.1	294.65	323.0053	0	7520	2248.7	9.7078	5.9279	5.7945	7.7956	12.6873	8.3293	8.6405
	Calculate	3.958	9459	119	269	35.5602	1.1	294.65	323.0053	0	7520	2248.7	7.7252	4.9544	6.1583	4.156	10.2119	5.5853	6.3389
83	Train	3.958	10289	119	269	35.5602	1.1	230.65	323.0479	0	7940	2340.7	1.209	2.2515	2.5932	0.4571	5.9939	1.2945	0.1581
	Calculate	3.958	10289	119	269	35.5602	1.1	230.65	323.0479	0	7940	2340.7	3.5347	2.317	3.0726	1.6278	7.8475	3.1366	2.8463
84	Train	3.958	7900	119	269	35.5602	1.1	202.65	323.012	0	8300	2094.7	6.3637	2.2581	1.6375	4.4064	12.2356	7.6526	4.1199
	Calculate	3.958	7900	119	269	35.5602	1.1	202.65	323.012	0	8300	2094.7	5.7212	3.467	5.081	3.9336	12.653	5.6459	3.9713
85	Train	3.958	12249	105	245	47.8409	0.7	1439.65	941.5064	0	2496	3543.7	10.9857	6.2449	6.0756	7.543	8.2484	3.4512	9.1232
	Calculate	3.958	12249	105	245	47.8409	0.7	1439.65	941.5064	0	2496	3543.7	9.8955	7.1594	7.6886	8.1855	7.2173	4.4469	9.1485
86	Train	3.958	12062	138	330	50.1431	0.7	1548.65	1200.4405	0	10896	4216.7	3.645	3.6687	3.811	3.645	3.849	1.0601	2.7201
	Calculate	3.958	12062	138	330	50.1431	0.7	1548.65	1200.4405	0	10896	4216.7	3.4703	2.6588	3.472	4.3619	4.3453	1.559	4.3384
87	Train	3.958	11306	136	330	50.1431	0.7	2964.65	1068.4046	0	8976	5729.7	0.2391	0.2042	0.2915	0.2391	0.075	0.5358	0.0471
	Calculate	3.958	11306	136	330	50.1431	0.7	2964.65	1068.4046	0	8976	5729.7	0.8217	0.3829	0.8589	0.7969	1.325	0.3749	0.5274
88	Train	3.958	14322	114	260	40.6411	0.7	714.65	531.4885	0	3144	2466.7	44.8089	32.6469	32.4442	37.39	38.89	30.9442	38.5657
	Calculate	3.958	14322	114	260	40.6411	0.7	714.65	531.4885	0	3144	2466.7	45.6356	33.0825	33.1877	37.3734	39.7649	31.4453	38.9322
89	Train	3.958	14330	138	320	43.6238	0.7	664.65	1024.8288	0	3504	1872.7	45.7254	18.1182	16.8367	33.9777	44.5506	60.5703	27.4096
	Calculate	3.958	14330	138	320	43.6238	0.7	664.65	1024.8288	0	3504	1872.7	46.3156	18.1729	17.4279	34.1236	44.2654	58.8107	28.0052
90	Train	3.958	12165	122	310	48.7548	0.7	1589.65	522.9767	0	5832	3631.7	24.735	24.5422	24.4321	24.5422	24.8176	24.1017	24.7625
	Calculate	3.958	12165	122	310	48.7548	0.7	1589.65	522.9767	0	5832	3631.7	25.372	26.0007	22.3278	25.4549	24.5547	24.2191	24.9596
91	Train	3.958	9928	120	342	62.3356	0.72	1514.65	3615.5651	0	15342	4761.7	16.009	12.8799	15.694	16.009	39.173	22.2673	8.7511
	Calculate	3.958	9928	120	342	62.3356	0.72	1514.65	3615.5651	0	15342	4761.7	16.1255	12.7595	17.334	16.2831	39.5832	21.9485	9.5316
92	Train	3.958	9928	120	345	56.6649	0.72	3804.65	4059.9343	0	4872	5300.7	3.2882	3.2316	3.2316	3.2882	7.2877	5.1748	2.5336
	Calculate	3.958	9928	120	345	56.6649	0.72	3804.65	4059.9343	0	4872	5300.7	1.1121	0.9906	1.937	4.1068	7.3325	4.5136	2.2379
93	Train	3.958	9928	120	350	57.4186	0.72	3604.65	3922.0047	0	6744	5239.7	4.7579	4.7007	4.6816	4.7579	10.7124	6.3038	2.6585
	Calculate	3.958	9928	120	350	57.4186	0.72	3604.65	3922.0047	0	6744	5239.7	1.3471	2.1311	2.7068	4.3583	10.6399	6.9427	4.0426
94	Train	3.958	9930	120	345	47.8409	0.72	814.65	1597.2984	0	11845	2887.7	3.1271	1.0493	2.7461	3.1271	24.8745	26.1904	7.2965
	Calculate	3.958	9930	120	345	47.8409	0.72	814.65	1597.2984	0	11845	2887.7	2.4842	1.6592	2.2634	4.8136	24.543	26.3648	5.7022

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No.	Data type	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)	D&R (M)	H&B	F&B	M&B	B&B	Ork	D&R (O)
95	Train	3.958	10318	132	320	49.4463	0.7	2749.65	1156.6265	0	9960	5214.7	3.8219	3.8602	3.7452	3.8219	4.8574	2.5371	4.2821
	Calculate	3.958	10318	132	320	49.4463	0.7	2749.65	1156.6265	0	9960	5214.7	3.3106	2.5576	4.1931	3.3793	6.8386	2.8316	3.3468
96	Train	3.958	10336	140	342	52.0279	0.72	1164.65	3335.3746	0	14697	4562.7	13.8799	9.0801	13.4854	13.8799	39.1939	28.0601	18.031
	Calculate	3.958	10336	140	342	52.0279	0.72	1164.65	3335.3746	0	14697	4562.7	13.0153	10.0444	13.2835	14.2822	39.1642	28.2102	18.4028
97	Train	3.958	10158	133	320	54.9295	0.72	3864.65	3139.5349	0	11352	5492.7	20.6875	20.7057	20.5782	20.6875	27.9334	16.5183	19.5405
	Calculate	3.958	10158	133	320	54.9295	0.72	3864.65	3139.5349	0	11352	5492.7	20.7467	21.0065	19.4945	21.0329	27.5674	16.4089	20.3372
98	Train	3.958	10158	134	320	53.9522	0.72	2694.65	3064.7383	0	11616	5493.7	1.2141	1.3051	1.3415	1.2141	9.7803	0.6244	6.4565
	Calculate	3.958	10158	134	320	53.9522	0.72	2694.65	3064.7383	0	11616	5493.7	2.179	1.9928	3.1134	3.5445	7.5322	1.8579	3.363
99	Train	3.958	10218	140	310	56.1658	0.806	1128.65	4065.1933	0	11719	3827.7	22.6324	17.5118	22.2144	22.6324	49.7505	38.9346	17.4178
	Calculate	3.958	10218	140	310	56.1658	0.806	1128.65	4065.1933	0	11719	3827.7	21.7833	17.2528	23.3098	22.7805	48.8842	39.5454	17.4689
100	Train	3.958	11400	140	342	50.3766	0.7	1914.65	776.4824	0	13896	5000.7	3.1056	3.1656	3.0056	3.3056	4.4654	2.1257	3.5855
	Calculate	3.958	11400	140	342	50.3766	0.7	1914.65	776.4824	0	13896	5000.7	1.5629	1.3589	2.2577	1.9998	5.4672	0.8867	2.4914
101	Train	3.958	10945	130	320	52.0279	0.72	844.65	3153.8367	0	8171	2770.7	6.8683	2.5373	6.5074	6.8683	34.226	48.8793	23.4129
	Calculate	3.958	10945	130	320	52.0279	0.72	844.65	3153.8367	0	8171	2770.7	8.9775	1.9552	7.4768	5.3875	34.8597	47.8859	23.41
102	Train	3.958	10356	128	320	59.975	0.716	4274.65	2707.0278	0	8936	6632.7	0.9544	1.0147	0.9091	0.9544	2.7334	1.1564	1.1504
	Calculate	3.958	10356	128	320	59.975	0.716	4274.65	2707.0278	0	8936	6632.7	1.5853	0.6671	1.2111	0.5574	1.2767	2.3072	0.495
103	Train	3.958	10661	125	332	60.7554	0.715	4048.65	2921.411	0	8958	6483.7	0.3964	0.3655	0.4581	0.3964	2.5186	3.1109	0.2884
	Calculate	3.958	10661	125	332	60.7554	0.715	4048.65	2921.411	0	8958	6483.7	1.7655	0.6607	1.3861	0.8004	1.393	2.1371	0.6736
104	Train	3.958	10059	140	310	67.5155	0.702	4431.65	3698.4536	0	9312	6905.7	0.6907	0.9369	1.0528	0.9803	2.495	4.0792	1.2265
	Calculate	3.958	10059	140	310	67.5155	0.702	4431.65	3698.4536	0	9312	6905.7	2.6223	0.9261	1.6953	0.8975	1.6688	3.6901	0.7664
105	Train	3.958	10069	125	334	71.5129	0.49	4336.65	3687.6006	0	9936	6870.7	4.6822	4.8277	4.8423	4.6822	0.4847	6.6034	5.0897
	Calculate	3.958	10069	125	334	71.5129	0.49	4336.65	3687.6006	0	9936	6870.7	4.3354	1.3203	3.129	4.6066	3.2368	7.1876	4.1838
106	Train	3.958	6234.9	195	235.4	37.31	0.75	794.7	471.7	0	10367	2013	12.0715	11.1773	10.8793	11.6742	18.2812	9.7367	14.6547
	Calculate	3.958	6234.9	195	235.4	37.31	0.75	794.7	471.7	0	10367	2013	13.5426	11.9118	11.9612	11.9966	16.8041	9.9714	14.3473
107	Train	3.958	6233.9	195	235.4	37.31	0.75	771.7	516.6	0	11111	1977	10.8245	10.4704	10.2681	11.128	19.828	9.8128	14.1123
	Calculate	3.958	6233.9	195	235.4	37.31	0.75	771.7	516.6	0	11111	1977	11.0963	9.9475	8.8123	11.3536	20.7353	8.6029	13.7375
108	Train	3.958	6501.8	126.3	238.1	37.6	0.75	464.7	550.3	0	2436.5	1385.7	23.3312	11.164	11.164	7.3104	8.465	3.7743	2.7639
	Calculate	3.958	6501.8	126.3	238.1	37.6	0.75	464.7	550.3	0	2436.5	1385.7	23.1039	10.0949	9.3772	8.1996	6.8019	5.5118	5.2897
109	Train	4.892	10171.1	80.6	190.4	16.7	0.7	235.2	509.8	0	5222.6	4581.7	35.5698	37.9924	54.8421	42.2049	38.0361	54.0564	34.784
	Calculate	4.892	10171.1	80.6	190.4	16.7	0.7	235.2	509.8	0	5222.6	4581.7	36.0761	37.8237	54.4245	42.0447	38.269	53.7059	34.7961
110	Train	4.892	10847	157	348	69.7802	0.72	2177.7	5525.8	0	10080	4149.7	6.8954	6.7169	7.2369	6.3853	5.4876	6.7916	17.0005
	Calculate	4.892	10847	157	348	69.7802	0.72	2177.7	5525.8	0	10080	4149.7	5.7682	6.192	10.4491	6.5093	5.5058	6.837	16.8561
111	Train	4.892	10826.8	117.5	224.6	8.3	1.705	223.297	146.163	0.3	522.05	4758.93	6.4496	4.8946	9.2023	2.6042	2.8773	4.8946	4.7055
	Calculate	4.892	10826.8	117.5	224.6	8.3	1.705	223.297	146.163	0.3	522.05	4758.93	6.2082	6.443	8.6893	3.6405	3.1513	3.9242	2.8707
112	Train	4.892	10498.7	68	194	9	1.567	99.56	129.232	0.2	44.03	4164.4	10.1719	11.2525	3.9526	11.3966	12.069	11.2525	8.1068
	Calculate	4.892	10498.7	68	194	9	1.567	99.56	129.232	0.2	44.03	4164.4	9.6493	10.0939	6.8709	11.472	12.7229	11.3947	8.9999
113	Train	4.892	10170.6	80.6	190.4	11.8	0.938	220.45	168.736	0.1	144.67	4566.92	9.3919	4.4214	15.4572	3.1295	3.02	4.4214	5.56
	Calculate	4.892	10170.6	80.6	190.4	11.8	0.938	220.45	168.736	0.1	144.67	4566.92	9.3712	5.0074	14.7509	4.407	2.7696	5.6556	5.191
114	Train	4.892	10170.6	84.2	192.2	11.8	0.938	524.82	168.736	0.1	836.55	4475.89	2.0803	3.5548	0.8019	5.722	5.2305	3.5548	2.7952
	Calculate	4.892	10170.6	84.2	192.2	11.8	0.938	524.82	168.736	0.1	836.55	4475.89	2.476	1.422	4.3892	3.7577	1.3749	1.6396	2.7088
115	Train	4.892	10170.6	104	222.8	12.5	1.268	570.33	211.625	0.1	761.07	4521.4	0.1902	1.1634	1.5349	2.8885	2.4019	1.1634	1.0307
	Calculate	4.892	10170.6	104	222.8	12.5	1.268	570.33	211.625	0.1	761.07	4521.4	1.3789	1.8618	5.0591	1.5055	0.8724	1.2934	1.2087
116	Train	4.892	10170.6	136.4	226.4	12.5	1.268	590.24	211.625	0	1100.72	4554.12	1.3201	0.5955	3.0548	0.5735	0.3707	0.5955	0.1563
	Calculate	4.892	10170.6	136.4	226.4	12.5	1.268	590.24	211.625	0	1100.72	4554.12	0.1262	0.5994	1.0284	0.1236	0.2906	0.2795	0.1563
117	Train	6.184	7877	115	262	36.5523	1.122	240.7	336.8254	0	18900	2325.7	1.75	7.5117	7.6837	4.2439	0.8729	0.9159	5.1038
	Calculate	6.184	7877	115	262	36.5523	1.122	240.7	336.8254	0	18900	2325.7	1.5956	4.6911	4.6983	1.077	3.0176	2.809	2.7952
118	Train	6.184	8103	115	262	36.5523	1.122	334.7	336.7901	0	16200	2437.7	0.6687	3.9669	4.0489	1.7927	0.7917	1.325	1.4645
	Calculate	6.184	8103	115	262	36.5523	1.122	334.7	336.7901	0	16200	2437.7	2.5942	6.4344	6.2675	1.7712	3.0465	3.8083	3.336

No.	Data type	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)	D&R (M)	H&B	F&B	M&B	B&B	Ork	D&R (O)
119	Train	6.184	8255	115	262	36.5523	1.122	260.7	336.7925	0	10600	2296.7	2.582	8.9128	8.9999	2.9912	1.1625	1.6241	4.0798
	Calculate	6.184	8255	115	262	36.5523	1.122	260.7	336.7925	0	10600	2296.7	9.1905	8.5595	6.6402	5.1994	5.7888	6.8724	5.2574
120	Train	6.184	7746	115	262	36.5523	1.122	314.7	336.8182	0	24200	2467.7	1.2846	3.1487	3.2703	1.8519	2.2004	0.1906	1.3251
	Calculate	6.184	7746	115	262	36.5523	1.122	314.7	336.8182	0	24200	2467.7	0.7943	2.0941	2.6739	0.6029	4.6589	2.0477	1.5445
121	Train	6.184	7480	115	262	36.5523	1.122	275.7	336.7983	0	25205	2296.7	1.0319	2.9912	3.209	1.5109	4.0624	1.1086	1.2932
	Calculate	6.184	7480	115	262	36.5523	1.122	275.7	336.7983	0	25205	2296.7	0.5935	1.566	2.1682	0.457	4.8093	1.8418	1.0998
122	Train	6.184	7596	119	269	35.5602	1.1	321.7	323.0159	0	15120	2630.7	8.0093	13.5591	13.6352	11.0123	8.6555	7.8192	10.9365
	Calculate	6.184	7596	119	269	35.5602	1.1	321.7	323.0159	0	15120	2630.7	4.0307	7.2361	8.1289	2.4839	3.1291	5.1543	3.1289
123	Train	6.184	7093	119	269	35.5602	1.1	227.7	323.0146	0	12340	1960.7	7.3086	7.533	7.686	0.2703	3.5855	7.3086	2.0758
	Calculate	6.184	7093	119	269	35.5602	1.1	227.7	323.0146	0	12340	1960.7	5.4908	6.8913	6.8097	3.5731	4.3831	6.562	3.8535
124	Train	6.184	8166	119	269	35.5602	1.1	219.7	323.0159	0	13860	2143.7	4.9587	7.3564	7.4964	0.8257	3.1394	6.1249	2.9715
	Calculate	6.184	8066	119	269	35.5602	1.1	219.7	323.0159	0	13860	2143.7	3.3699	5.8363	5.7664	1.7034	2.561	3.9146	2.7171
125	Train	6.184	8674	119	269	35.5602	1.1	295.7	322.9775	0	17800	2368.7	0.6037	4.6734	4.8001	2.0982	1.4058	1.5325	2.056
	Calculate	6.184	8674	119	269	35.5602	1.1	295.7	322.9775	0	17800	2368.7	2.1892	5.6863	5.1967	1.0144	2.1052	2.6221	3.094
126	Train	6.184	7349	119	269	35.5602	1.1	215.7	323.0034	0	14650	2039.7	4.7213	7.7806	7.9767	3.1129	3.4466	6.5353	3.5152
	Calculate	6.184	7349	119	269	35.5602	1.1	215.7	323.0034	0	14650	2039.7	2.5439	5.5387	5.923	1.6367	2.7421	4.2673	2.4837
127	Train	6.184	8045	119	269	35.5602	1.1	256.7	322.987	0	15400	2232.7	2.2529	6.3466	6.5257	2.0021	1.8946	3.507	2.9426
	Calculate	6.184	8045	119	269	35.5602	1.1	256.7	322.987	0	15400	2232.7	2.7018	6.0546	6.1272	1.4658	2.3639	3.7154	2.7621
128	Train	6.184	7999	119	269	35.5602	1.1	387.7	323.0052	0	21656	2502.7	0.1478	2.3455	2.4254	1.3465	1.4904	0.3476	0.3876
	Calculate	6.184	7999	119	269	35.5602	1.1	387.7	323.0052	0	21656	2502.7	1.2677	4.2946	4.5557	0.8699	3.0909	2.7221	2.5527
129	Train	6.184	8169	115	262	36.5523	1.122	291.7	336.7803	0	27270	2295.7	0.4922	0.6403	0.8146	0.4487	5.9372	2.1475	0.8843
	Calculate	6.184	8169	115	262	36.5523	1.122	291.7	336.7803	0	27270	2295.7	0.4497	1.0063	1.3729	0.2856	4.9852	1.1485	0.729
130	Train	6.184	9714	115	262	36.5523	1.122	319.7	336.8182	0	11000	2322.7	3.1128	4.8521	4.9382	1.1926	0.3573	2.0364	1.1926
	Calculate	6.184	9714	115	262	36.5523	1.122	319.7	336.8182	0	11000	2322.7	4.3379	6.2954	4.8078	1.8694	2.5171	3.3995	3.4067
131	Train	6.184	7900	115	262	36.5523	1.122	332.7	336.8098	0	9780	2340.7	18.0835	8.0373	7.9113	11.4444	12.0861	13.7356	11.5525
	Calculate	6.184	7900	115	262	36.5523	1.122	332.7	336.8098	0	9780	2340.7	14.0092	10.5617	8.174	8.656	7.3658	9.2126	7.6539
132	Train	6.184	7799	115	262	36.5523	1.122	263.7	336.7993	0	23370	2212.7	2.0925	0.7999	0.9807	1.1434	6.9734	4.4877	1.053
	Calculate	6.184	7799	115	262	36.5523	1.122	263.7	336.7993	0	23370	2212.7	0.8055	2.2451	2.7776	0.5441	3.7443	1.9473	1.5887
133	Train	6.184	7133	115	262	36.5523	1.122	402.7	336.8293	0	12300	2491.7	2.6608	1.9946	2.0348	0.2288	1.1358	2.0588	0.4134
	Calculate	6.184	7133	115	262	36.5523	1.122	402.7	336.8293	0	12300	2491.7	6.045	7.3729	8.287	4.8529	4.4349	5.8492	4.4475
134	Validate	1.995	9620	75	189	54	0.752	1455	3393	0	480	3365	19.4948	19.1382	21.367	18.3952	9.5394	17.1174	17.0282
	Calculate	1.995	9620	75	189	54	0.752	1455	3393	0	480	3365	1.4301	2.8353	6.7492	1.8738	2.2283	1.0721	0.4562
135	Validate	1.995	7800	75	189	42.6	0.84	1261	1747	0	168	3141	7.9592	18.0516	18.0516	9.7421	7.5135	7.3225	7.5135
	Calculate	1.995	7800	75	189	42.6	0.84	1261	1747	0	168	3141	5.5888	16.1863	13.8062	6.8781	8.3685	9.6562	6.9121
136	Validate	1.995	4410	75	189	41.3	1.048	105	230	0	392.4	1229	12.1237	7.0789	11.8796	6.0212	6.7535	13.4255	5.6143
	Calculate	1.995	4410	75	189	41.3	1.048	105	230	0	392.4	1229	0.8489	0.6689	4.3917	2.9388	12.0822	0.814	1.0819
137	Validate	1.995	3346.6	86	172.4	15.6	0.72	356.1	889.2	4.4	101.6228	1505.3	41.2742	33.1695	58.5465	11.2469	12.5091	26.3934	17.0265
	Calculate	1.995	3346.6	86	172.4	15.6	0.72	356.1	889.2	4.4	101.6228	1505.3	59.7852	36.1101	74.1498	8.5939	6.8863	13.0147	35.9105
138	Validate	2.441	12861.5	90	200	37	0.7	1579.2	5360.2	0	188.7	4005.6	17.3158	24.7553	29.3988	29.299	2.3367	14.6944	4.5337
	Calculate	2.441	12861.5	90	200	37	0.7	1579.2	5160.2	0	188.7	4005.6	66.9916	69.9083	72.272	49.0594	47.8714	47.4017	47.1398
139	Validate	2.441	12795.9	90	200	37	0.7	1993.1	2650.3	0	364.8	5032.5	15.1118	24.8485	25.3055	16.9598	13.6612	23.0999	13.2837
	Calculate	2.441	12795.9	90	200	37	0.7	1993.1	2650.3	0	364.8	5032.5	1.7855	3.5192	4.4813	9.0595	29.4085	6.0623	1.5892
140	Validate	2.441	7578.7	132.8	187.88	19.2	0.708	563.2	512.4	0	4226.75	3294	1.5179	8.5914	5.4341	1.609	15.847	0.7286	11.2325
	Calculate	2.441	7578.7	132.8	187.88	19.2	0.708	563.2	512.4	0	4226.75	3294	39.4114	21.0284	40.9728	41.4468	48.2437	29.0242	43.3435
141	Validate	2.441	7053.8	107.6	176	32.8	0.701	988.5	756.2	0	3607.84	3164.6	3.1473	3.4633	4.2849	3.0209	6.2062	6.1809	0.2338
	Calculate	2.441	7053.8	107.6	176	32.8	0.701	988.5	756.2	0	3607.84	3164.6	2.0509	4.0495	3.8721	2.8046	6.2219	5.5286	3.0899
142	Validate	2.441	10531.5	93.2	232.16	46	0.71	2255.7	2283.3	0	439.66	4639.5	3.481	10.8309	10.8309	6.8003	6.1968	8.0073	6.5632
	Calculate	2.441	10531.5	93.2	232.16	46	0.71	2255.7	2283.3	0	439.66	4639.5	2.6566	11.5156	9.8125	4.6089	3.4453	6.8507	5.9018

No.	Data type	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)	D&R (M)	H&B	F&B	M&B	B&B	Ork	D&R (O)
143	Validate	2.764	11303	103.5	237.5	45.5964	0.667	575	2750	0	720	1400	18.7857	12.5	12.7857	14.2857	38.2143	47.8571	11.5714
	Calculate	2.764	11303	103.5	237.5	45.5964	0.667	575	2750	0	720	1400	41.5105	3.1721	50.2124	12.7162	0.3011	15.0923	21.0392
144	Validate	2.992	4766	126	150	13.3	0.75	264.65	193	0	967	1564.7	18.5083	15.8944	2.9782	10.3215	11.5613	1.6936	22.4835
	Calculate	2.992	4766	126	150	13.3	0.75	264.65	193	0	967	1564.7	3.5618	4.5661	19.5864	2.8226	2.758	12.6487	3.3464
145	Validate	2.992	4175.1	126	150	15.6	0.75	314.7	267.3	0	2700	1514.7	8.9985	19.3636	11.9958	0.2443	5.9616	2.753	11.4412
	Calculate	2.992	4175.1	126	150	15.6	0.75	314.7	267.3	0	2700	1514.7	7.8382	14.9836	8.0417	3.2612	7.8691	6.8891	8.4105
146	Validate	2.992	4101.3	195	237	39.25	0.75	724.7	3077	0	548	1056.7	1.3911	3.8516	14.5453	0.634	5.1386	15.5484	1.4858
	Calculate	2.992	4101.3	195	237	39.25	0.75	724.7	3077	0	548	1056.7	2.8767	0.2177	4.7711	23.8193	6.6617	6.6338	1.1339
147	Validate	2.992	5800.8	150	235	38.69	0.75	724.7	1207.2	0	6538	1870.7	12.0971	9.4243	11.2418	12.0971	34.6555	22.7883	3.3838
	Calculate	2.992	5800.8	150	235	38.69	0.75	724.7	1207.2	0	6538	1870.7	2.6454	2.2403	3.6216	4.0178	26.0499	9.3096	3.2762
148	Validate	2.992	7169.1	160	236	37.62	0.87	202.7	426.7	18	291.1	1754.6	3.3854	18.386	23.9143	35.1875	27.4365	14.613	9.5406
	Calculate	2.992	7169.1	160	236	37.62	0.87	202.7	426.7	18	291.1	1754.6	61.3575	22.8505	15.3518	3.6062	0.6789	1.711	16.914
149	Validate	3.958	9746	124	306	51.553	0.7	3314.65	1473.6239	0	15696	6516.7	1.4471	1.5698	1.3703	1.4471	3.1657	0.3269	1.6926
	Calculate	3.958	9746	124	306	51.553	0.7	3314.65	1473.6239	0	15696	6516.7	0.5651	1.0163	0.7547	0.1974	2.111	2.204	0.2907
150	Validate	3.958	10456	112	270	49.678	0.844	2274.65	1387.7953	0	6096	4223.7	10.898	10.898	10.8033	10.898	12.6027	9.2407	11.703
	Calculate	3.958	10456	112	270	49.678	0.844	2274.65	1387.7953	0	6096	4223.7	21.5876	9.48	17.2518	7.2432	8.4092	36.6398	5.6024
151	Validate	3.958	10984	140	316	49.678	0.7	2504.65	990.8027	0	14352	5491.7	3.7384	3.8112	3.6473	3.7384	4.9948	2.7186	4.1026
	Calculate	3.958	10984	140	316	49.678	0.7	2504.65	990.8027	0	14352	5491.7	1.9655	1.4073	2.6264	3.7783	8.8419	0.7617	2.549
152	Validate	3.958	11248	137	337	57.4186	0.72	2599.65	4823.4127	0	10080	5303.7	6.4163	5.8129	6.2466	6.4163	22.9896	13.0343	11.8728
	Calculate	3.958	11248	137	337	57.4186	0.72	2599.65	4823.4127	0	10080	5303.7	44.3692	32.5925	48.8383	46.3184	34.5334	19.6135	31.5538
153	Validate	3.958	12171	133	334	48.5254	0.72	834.65	1810.1949	0	11496	3217.7	7.0019	4.5467	6.5979	7.0019	29.8443	29.2227	9.4073
	Calculate	3.958	12171	133	334	48.5254	0.72	834.65	1810.1949	0	11496	3217.7	2.1256	1.3896	2.0526	4.2128	33.949	29.9799	3.5158
154	Validate	3.958	12916	120	271	49.678	0.7	2664.65	1146.3675	0	9360	4958.7	10.3313	10.3717	10.2507	10.3313	11.3195	9.1617	10.7548
	Calculate	3.958	12916	120	271	49.678	0.7	2664.65	1146.3675	0	9360	4958.7	6.9619	1.978	4.7101	3.8469	4.3623	3.0398	2.4758
155	Validate	3.958	10202	140	304	48.5254	0.7	1838.65	455.2469	0	6480	3957.7	24.1092	24.0238	24.0157	24.1092	24.1188	24.0238	24.1196
	Calculate	3.958	10202	140	304	48.5254	0.7	1838.65	455.2469	0	6480	3957.7	33.6278	33.1927	38.3606	8.4807	4.5387	12.5502	26.9448
156	Validate	3.958	10661	108	260	49.4463	0.702	1134.65	2674.0205	0	2629	2178.7	3.4103	1.8956	1.5468	5.0168	21.5863	42.5621	4.2365
	Calculate	3.958	10661	108	260	49.4463	0.702	1134.65	2674.0205	0	2629	2178.7	46.1163	38.3395	48.9581	34.6287	46.6625	52.0549	47.3627
157	Validate	3.958	6250.3	128	234.9	36.33	0.75	384.7	589.6	0	2845	1201.3	28.8604	11.5958	12.8444	11.2129	13.5437	13.1274	2.8053
	Calculate	3.958	6250.3	128	234.9	36.33	0.75	384.7	589.6	0	2845	1201.3	16.1257	3.7599	4.2892	7.8139	12.8108	5.6111	2.2726
158	Validate	4.892	10826.8	134.6	228.2	8.3	1.705	209.074	146.163	0.15	930.89	4763.19	7.499	7.8769	9.9763	3.72	4.2448	6.2393	5.2946
	Calculate	4.892	10826.8	134.6	228.2	8.3	1.705	209.074	146.163	0.15	930.89	4763.19	2.579	4.6841	5.5248	1.3079	1.7276	2.1145	1.3796
159	Validate	4.892	10498.7	89.6	195.8	9	1.567	164.984	129.232	0.5	924.6	4473.05	6.0574	3.1064	2.2814	7.7341	8.6507	7.4435	1.1167
	Calculate	4.892	10498.7	89.6	195.8	9	1.567	164.984	129.232	0.5	924.6	4473.05	5.3191	4.3966	6.2074	5.862	5.4976	3.4702	3.773
160	Validate	4.892	7647.64	124.88	188.6	17.2	0.708	770.87	512.415	0	4128.01	3328.12	7.9961	16.9201	20.706	14.8168	13.5848	24.7022	5.0815
	Calculate	4.892	7647.64	124.88	188.6	17.2	0.708	770.87	512.415	0	4128.01	3328.12	1.3479	6.1812	5.1728	1.2173	0.64	4.3378	6.9393
161	Validate	6.184	7388	115	262	36.5523	1.122	263.7	336.791	0	26800	2432.7	1.5497	2.9884	3.194	1.673	3.8764	1.04	1.5908
	Calculate	6.184	7388	115	262	36.5523	1.122	263.7	336.791	0	26800	2432.7	0.5023	1.1933	1.6547	0.3906	6.0706	1.5559	0.8355
162	Validate	6.184	9199	115	262	36.5523	1.122	263.7	336.7794	0	20990	2214.7	1.4133	2.4247	2.6053	0.1671	5.4319	3.9418	0.3025
	Calculate	6.184	9199	115	262	36.5523	1.122	263.7	336.7794	0	20990	2214.7	1.1824	2.9796	2.6956	0.463	2.1185	1.3253	2.1747
163	Validate	6.184	8349	119	269	35.5602	1.1	219.7	323.0043	0	22235	2153.7	0.6175	4.0256	4.3507	1.2862	5.725	3.9142	2.3077
	Calculate	6.184	8349	119	269	35.5602	1.1	219.7	323.0043	0	22235	2153.7	0.9064	2.6013	2.7764	0.3903	2.1229	1.4844	1.5998
164	Validate	6.184	6899	119	269	35.5602	1.1	229.7	322.9873	0	19750	2083.7	2.414	4.5928	4.8327	0.7055	5.0535	5.4854	2.0012
	Calculate	6.184	6899	119	269	35.5602	1.1	229.7	322.9873	0	19750	2083.7	0.817	3.6251	4.2999	0.6481	2.2467	2.9119	1.5986
165	Validate	6.184	9599	119	269	35.5602	1.1	214.7	323.0047	0	6390	2145.7	8.6359	12.0567	12.1965	1.1977	0.6851	1.9714	2.3629
	Calculate	6.184	9599	119	269	35.5602	1.1	214.7	323.0047	0	6390	2145.7	24.7017	17.6177	6.7917	7.9994	8.5815	18.4715	11.0613
166	Validate	6.184	7901	119	269	35.5602	1.1	300.7	322.96	0	12500	2043.7	14.6939	5.0056	4.9078	9.5562	11.9538	14.2536	9.1648
	Calculate	6.184	7901	119	269	35.5602	1.1	300.7	322.96	0	12500	2043.7	4.4536	6.8158	6.7093	2.6168	3.3446	5.3486	3.3273

No.	Data type	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)	D&R (M)	H&B	F&B	M&B	B&B	Ork	D&R (O)
167	Validate	6.184	10003	115	262	36.5523	1.122	314.7	336.8082	0	7770	2260.7	7.2677	3.2601	3.3928	1.4288	1.8711	3.1097	1.6057
	Calculate	6.184	10003	115	262	36.5523	1.122	314.7	336.8082	0	7770	2260.7	11.0686	11.2063	5.6424	4.1761	4.8895	7.7567	6.7633
168	Test	1.995	7850	75	189	38.8	0.9349	990	1019	0	187	3190	4.4201	13.4169	13.4169	6.8652	7.4608	6.9592	5.5172
	Calculate	1.995	7850	75	189	38.8	0.9349	990	1019	0	187	3190	2.6658	9.9526	10.8785	1.2916	2.3496	9.6613	1.9949
169	Test	1.995	6550	75	189	42	0.8225	985	1245	0	167	2665	12.9081	21.9887	21.9887	8.3677	9.9062	9.0807	10.2064
	Calculate	1.995	6550	75	189	42	0.8225	985	1245	0	167	2665	21.1593	29.3591	31.924	25.5425	13.4364	19.5379	20.0612
170	Test	1.995	6570	75	189	42	0.8225	665	1245	0	138	2555	29.6282	41.9178	42.7006	22.1526	15.5773	23.0137	23.4051
	Calculate	1.995	6570	75	189	42	0.8225	665	1245	0	138	2555	42.4798	24.9665	60.78	30.4442	13.0515	32.3793	16.5023
171	Test	1.995	8000	75	189	42.6	0.84	1221	1747	0	91.2	3251	10.12	11.8118	4.614	21.1935	19.3171	15.4722	12.7345
	Calculate	1.995	8000	75	189	42.6	0.84	1221	1747	0	91.2	3251	6.6022	13.5518	17.044	5.2311	4.5991	7.8421	5.5322
172	Test	1.995	8480	75	189	43.9	0.8287	1665	3588	0	133	3260	4.6012	13.681	13.681	13.4663	1.411	1.4417	1.0736
	Calculate	1.995	8480	75	189	43.9	0.8287	1665	3588	0	133	3260	5.9184	8.0984	5.3605	5.3965	8.0223	0.4642	1.1977
173	Test	1.995	4410	75	189	41.3	1.048	145	192	0	245.3	1419	6.6244	0.2819	0.5638	5.9901	6.0606	4.6512	6.7653
	Calculate	1.995	4410	75	189	41.3	1.048	145	192	0	245.3	1419	0.6487	0.5207	4.1492	2.5792	7.5359	0.5536	0.6086
174	Test	2.441	7578.7	118.94	186.8	19.2	0.708	815	512.4	0	3834.3	3444.7	2.4472	9.5596	2.6911	2.6214	33.1593	0.9377	11.9981
	Calculate	2.441	7578.7	118.94	186.8	19.2	0.708	815	512.4	0	3834.3	3444.7	15.3717	5.0427	14.2563	17.2974	37.4572	15.0911	29.7144
175	Test	2.441	8038.1	92.12	167	40.3	0.75	1372.5	947	0	191.84	3574.2	2.104	0.6211	6.5805	3.6596	3.4357	1.1695	0.3693
	Calculate	2.441	8038.1	92.12	167	40.3	0.75	1372.5	947	0	191.84	3574.2	2.008	2.7868	4.0826	2.9306	1.5402	3.2723	1.5032
176	Test	2.441	5249.6	90	264	37	0.65	441.4	606.4	0	44	1974.6	21.4605	2.7312	41.3238	11.7391	11.6869	2.7312	2.1832
	Calculate	2.441	5249.6	90	264	37	0.65	441.4	606.4	0	44	1974.6	14.8311	7.6523	39.0435	0.4974	0.6413	44.8965	30.3426
177	Test	2.992	3825	126	150	15.1	0.75	564.65	765	0	1065	1214.7	15.2136	25.3725	10.4388	13.6906	16.2098	4.0833	22.7793
	Calculate	2.992	3825	126	150	15.1	0.75	564.65	765	0	1065	1214.7	25.2167	28.5527	6.5877	17.3689	22.0536	4.5118	28.8947
178	Test	2.992	4240	126	150	15.6	0.75	714.65	957	0	1165	1564.7	1.9173	12.4752	17.0959	0.7414	4.723	6.6466	7.5222
	Calculate	2.992	4240	126	150	15.6	0.75	714.65	957	0	1165	1564.7	15.3924	19.8184	7.4441	10.0546	12.1102	5.0646	20.3022
179	Test	2.992	4210	126	150	16	0.75	364.65	222	0	788	1764.7	1.3713	6.1767	15.9461	7.1287	6.6414	12.172	3.0147
	Calculate	2.992	4210	126	150	16	0.75	364.65	222	0	788	1764.7	3.2076	1.7014	15.8826	5.935	3.1789	9.3957	4.1394
180	Test	2.992	4505	126	150	12.5	0.75	264.65	385	0	1040	1364.7	4.4698	10.266	29.8381	0.7035	3.0117	8.6979	12.3544
	Calculate	2.992	4505	126	150	12.5	0.75	264.65	385	0	1040	1364.7	10.8107	15.4373	21.427	5.4865	5.1261	15.1664	11.9655
181	Test	2.992	4692	126	150	12.9	0.75	414.65	865	0	1585	1164.7	10.2602	39.2376	19.842	6.2505	22.5723	4.6793	19.7562
	Calculate	2.992	4692	126	150	12.9	0.75	414.65	865	0	1585	1164.7	15.5841	47.2167	8.451	7.2406	23.6468	15.5197	23.8714
182	Test	2.992	4691.8	126	150	12.9	0.75	414.7	865.8	0	1585	1164.7	16.5965	41.8396	17.8329	13.5915	29.0461	16.7683	31.1067
	Calculate	2.992	4691.8	126	150	12.9	0.75	414.7	865.8	0	1585	1164.7	15.5913	47.2398	8.4532	7.2454	23.6596	15.54	23.8864
183	Test	2.992	7647.64	104	185	31.3	0.92	1587.26	920.43	0	534.63	3850.09	0.1795	4.0802	4.4957	3.1711	3.0932	2.8075	0.314
	Calculate	2.992	7647.64	104	185	31.3	0.92	1587.26	920.43	0	534.63	3850.09	2.7003	0.7063	2.8481	0.9222	0.5565	3.9012	0.6003
184	Test	2.992	3948.5	150	235	38.69	0.75	482.7	1021.9	0	213	1178.7	19.9118	39.34	40.6125	25.8166	17.7569	7.8646	10.834
	Calculate	2.992	3948.5	150	235	38.69	0.75	482.7	1021.9	0	213	1178.7	49.7935	1.779	47.8428	39.9144	6.5132	30.8515	17.3397
185	Test	2.992	6001.7	150	236	38.72	0.75	469.7	589.6	20	5401.6	2030.4	6.5209	7.1119	7.2104	6.3239	8.0083	3.221	4.3538
	Calculate	2.992	6001.7	150	236	38.72	0.75	469.7	589.6	20	5401.6	2030.4	57.1471	11.7926	13.6379	16.1365	10.7347	6.9266	21.3512
186	Test	3.958	10947	140	304	51.3165	0.7	2014.65	1129.7872	0	9400	4662.7	0.7228	0.7228	0.83	0.7228	2.194	1.7308	0.3067
	Calculate	3.958	10947	140	304	51.3165	0.7	2014.65	1129.7872	0	9400	4662.7	7.5013	3.1832	7.2648	5.5477	4.397	1.1505	6.7049
187	Test	3.958	12290	140	305	53.9522	0.7	2141.65	1538.769	0	10008	4645.7	2.7402	2.7617	2.611	2.7402	8.4013	2.3742	3.5581
	Calculate	3.958	12290	140	305	53.9522	0.7	2141.65	1538.769	0	10008	4645.7	11.7695	3.854	9.9639	9.653	3.2179	0.6949	10.8335
188	Test	3.958	8560	115	262	36.5523	1.122	204.65	336.7797	0	11800	2400.7	4.7195	4.2196	4.053	4.8861	12.6338	7.0105	5.011
	Calculate	3.958	8560	115	262	36.5523	1.122	204.65	336.7797	0	11800	2400.7	3.0101	1.6335	2.5016	2.7322	20.8633	3.8028	2.3506
189	Test	3.958	11290	124	311	49.9103	0.7	1763.65	965.2972	0	7521	3852.7	10.8054	10.7016	10.5978	10.7535	13.4269	10.2603	12.207
	Calculate	3.958	11290	124	311	49.9103	0.7	1763.65	965.2972	0	7521	3852.7	37.7555	34.5786	39.7852	18.6792	10.3688	20.1152	31.9363
190	Test	3.958	11929	140	310	51.0806	0.7	1194.65	1340.3263	0	10296	3423.7	2.141	1.9657	1.8781	2.141	15.6059	13.4292	0.7974
	Calculate	3.958	11929	140	310	51.0806	0.7	1194.65	1340.3263	0	10296	3423.7	4.9022	6.112	4.486	15.4359	27.5288	18.5105	4.783

No.	Data type	Tubing diameter (inches)	Tubing depth (feet)	WHT (°F)	BHT (°F)	Oil gravity (°API)	Gas specific gravity (air=1)	WHP (psia)	GOR (scf/bbl)	Water cut (%)	Oil flow rate (stb/day)	Measured BHP (psia)	D&R (M)	H&B	F&B	M&B	B&B	Ork	D&R (O)
191	Test	3.958	12152	148	336	56.6649	0.72	1184.65	3511.7953	0	13056	4625.7	10.1671	5.6273	9.8212	10.1671	34.4013	23.6786	20.7255
	Calculate	3.958	12152	148	336	56.6649	0.72	1184.65	3511.7953	0	13056	4625.7	44.5477	20.9797	42.3853	48.5697	51.2945	38.0356	45.5492
192	Test	3.958	6480	195	235.4	37.31	0.75	719.7	527.8	0	10845	2023	6.4261	5.8824	5.7341	6.7721	16.1147	6.0801	9.4909
	Calculate	3.958	6480	195	235.4	37.31	0.75	719.7	527.8	0	10845	2023	8.5488	7.2958	7.1685	9.0394	19.1501	7.5574	11.6257
193	Test	3.958	6447.2	195	235.4	37.31	0.75	591.7	516.6	0	3356	1546.5	13.676	5.7226	5.7226	3.1361	4.5587	2.5542	2.1662
	Calculate	3.958	6447.2	195	235.4	37.31	0.75	591.7	516.6	0	3356	1546.5	30.8064	5.3653	14.0316	10.339	2.361	3.3767	4.6512
194	Test	4.892	10838	140	342	66.6793	0.7	3364.7	3091.8	0	9024	5318.7	3.4162	3.4727	3.4727	3.4162	0.2388	4.0967	2.8522
	Calculate	4.892	10838	140	342	66.6793	0.7	3364.7	3091.8	0	9024	5318.7	14.153	4.4305	14.0228	8.0495	4.4944	10.7102	6.1748
195	Test	4.892	7647.64	138.2	188.6	16.7	0.708	605.89	512.415	0	5222.43	3062.15	9.8999	15.9414	24.2689	16.6272	13.6228	25.9344	6.3077
	Calculate	4.892	7647.64	138.2	188.6	16.7	0.708	605.89	512.415	0	5222.43	3062.15	0.4122	4.1602	2.1979	0.1907	0.4347	1.897	2.1741
196	Test	6.184	8379	115	262	36.5523	1.122	234.7	336.7949	0	15600	2209.7	1.4346	10.1688	10.3046	5.4623	0.8463	1.0092	6.7747
	Calculate	6.184	8379	115	262	36.5523	1.122	234.7	336.7949	0	15600	2209.7	2.2747	5.3165	4.9113	1.3209	2.5802	3.0056	2.865
197	Test	6.184	9180	115	262	36.5523	1.122	266.7	336.7884	0	23540	2239.7	1.2189	1.2368	1.46	0.4152	6.3535	3.496	0.4599
	Calculate	6.184	9180	115	262	36.5523	1.122	266.7	336.7884	0	23540	2239.7	0.7366	1.7265	1.7668	0.2785	2.3555	0.953	1.2473
198	Test	6.184	8543	115	262	36.5523	1.122	248.7	336.7857	0	19600	2238.7	1.1301	3.9621	4.1408	1.014	4.2569	4.0336	1.5947
	Calculate	6.184	8543	115	262	36.5523	1.122	248.7	336.7857	0	19600	2238.7	1.5811	4.2562	3.9737	0.8284	2.6538	2.1073	2.9094
199	Test	6.184	7500	119	269	35.5602	1.1	193.7	322.9901	0	7090	1964.7	14.4195	10.6225	10.7752	2.4584	3.1201	8.1081	0.3716
	Calculate	6.184	7500	119	269	35.5602	1.1	193.7	322.9901	0	7090	1964.7	39.1124	18.0262	9.6579	22.2282	14.1405	22.4609	20.1774
200	Test	6.184	7891	115	262	36.5523	1.122	397.7	336.8502	0	6540	2392.7	5.3203	1.9936	2.1189	0.932	1.0992	0.5977	1.3499
	Calculate	6.184	7891	115	262	36.5523	1.122	397.7	336.8502	0	6540	2392.7	38.5482	17.5491	10.8101	25.0268	13.1773	17.2158	21.4163
201	Test	6.184	8950	115	262	36.5523	1.122	231.7	336.8182	0	15400	2214.7	1.5487	7.3464	7.4818	2.5602	1.9551	3.7612	3.8696
	Calculate	6.184	8950	115	262	36.5523	1.122	231.7	336.8182	0	15400	2214.7	2.1981	4.9059	4.2711	1.0766	2.1621	2.4791	2.8015

Vitae

Ruttapone Chanlongsawaitkul was born on February 15, 1979 in Nakonratchasima, Thailand. He received his B.Eng. in Mechanical Engineering from the Faculty of Engineering, Thammasat University in 2000. He has been a graduate student in the Master's Degree Program in Petroleum Engineering of the Department of Mining and Petroleum Engineering, Chulalongkorn University since 2006.