



The preparation of a nickel oxide desulfurization catalyst
by Robert J Fischbach

A THESIS Submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree
of Master of Science in Chemical Engineering
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Abstract:

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ABSTRACT

The purpose of this investigation was to find the optimum conditions for the preparation of an active nickel oxide desulfurization catalyst.

The various catalyst samples were prepared by precipitating nickel carbonate from solutions of nickel sulfate and sodium carbonate. A few samples were prepared from nickel sulfate and calcium hydroxide.

The various catalyst samples were tested in a comparison unit under the same conditions of temperature, hydrogen rate, and oil rate. The activity of the catalysts was based on the grams of sulfur removed per gram of nickel.

A study was made of catalyst activity with respect to precipitation and digestion conditions, entrained salt, time and temperature of calcining, and the effect of oven drying. The most active catalyst was obtained when the precipitation and digestion were carried out at the boiling point, and the precipitate was washed free of entrained salt. Oven-dried catalysts showed more activity than those which were calcined.

INTRODUCTION

The ever-increasing demand for petroleum products has caused a serious depletion of the high grade crude stocks. This has forced the oil refineries to utilize the lower grade, high-sulfur crudes, such as those found in the Rocky Mountain area, West Texas, and California. Recent surveys showed that both the absolute and relative volumes of high sulfur crude oils produced in the United States, has increased considerably over the last several years (7).

The utilization of these higher sulfur crudes has presented the problem of desulfurization. The sulfur may be present as elemental sulfur, hydrogen sulfide, mercaptans, sulfides and polysulfides, thiophenes, and thiophanes. Various methods such as the Unisol process and the Solutizer process, are quite effective in eliminating mercaptan sulfur from gasolines, but the higher boiling thiophenic sulfur, more commonly found in the fuel oil fractions, is not appreciably affected by these treatments. Thiophenes and thiophanes can be removed only by catalytic decomposition in the presence of hydrogen (2).

Sulfur in kerosenes and gas oil stocks gives rise to objectionable odor, corrosion, poor color stability, and is responsible for acrid fumes on burning. Stocks of high sulfur content are difficult to crack catalytically, because all or most of the cracking catalysts now in commercial use are poisoned by sulfur (2).

Compounds of metals such as cobalt, molybdenum, and nickel have long been recognized as efficient hydrogenation catalysts, and various patents

have been procured for the use of these catalysts in desulfurizing certain petroleum fractions. Patents pertaining to the use of nickel oxide as a desulfurizing catalyst in the refining of hydrocarbon distillates, have been described by M. H. Gwynn (4) (5).

The purpose of this investigation was to find a method for the preparation of a nickel oxide desulfurization catalyst. The preparation of such a catalyst is a complex problem because of the many variables that appear to affect the catalyst activity.

The word "catalyst" as used in this investigation is a little erroneous because it has been found that nickel oxide, when used as a desulfurization agent, behaves both as a true catalyst, converting the sulfur in the oil to hydrogen sulfide, and as a reagent, by combining with the sulfur to form nickel sulfide. The nickel oxide used in this investigation has been referred to as a catalyst, but it should be understood that it behaves both as a catalyst and reagent.

The general procedure for making the various samples was to precipitate nickel carbonate from a mixture of nickel sulfate and sodium carbonate, according to the following reaction:



A study was made of catalyst activity with respect to time and temperature of precipitation, time and temperature of digestion, effect of entrained salt, and time and temperature of calcining. When the nickel carbonate was calcined, it was probably converted to nickel oxide with a subsequent loss of carbon dioxide.

APPARATUS AND EQUIPMENT

The various catalysts were tested for activity in the comparison unit. A diagram of this unit may be seen in Figure 1. The comparison unit, or comparator, as it will henceforth be referred to, was designed so that different catalysts could be tested at the same operating conditions, and their relative activity determined.

The main body of the comparator was made from a piece of 25 mm pyrex glass tubing, about 15 inches long. The top of the tubing was fitted with the female portion of a 29/42 ground glass taper joint. Connected to the bottom of the unit was a water-cooled condenser on to which was sealed the male portion of a 35/25 ground glass ball joint. The condenser, fittings, and glass tubing were welded, as shown in Figure 1, to form a solid unit about 36 inches long.

Heat was supplied to the unit by a nichrome wire heating coil which was covered with 1/8 inch porcelain fish spines. The heat input to the unit was controlled by a 110-volt variac, which could be manually adjusted to attain the desired temperature. The heating coil was wound around the entire length of a 1 1/2 inch standard iron pipe, about 12 inches long, which was placed around the unit. This arrangement enabled the unit to be disassembled for repairs without disrupting the heating coil.

A thermowell was inserted into the glass unit just below the iron pipe. The thermowell consisted of a piece of 6 mm pyrex glass tubing, sealed on one end, and projecting vertically into the catalyst bed for a distance of approximately 4 inches.

Inserted into the thermowell was an iron-constantan thermocouple. The lead wires were also of iron and constantan, and were connected to a Leeds and Northrup potentiometer, which was calibrated directly in degrees Centigrade.

The iron pipe was wound with asbestos tape, and the entire unit was covered with a thick layer of magnesia insulation.

The comparator unit was connected by means of the ball joint to an oil reservoir and exhaust system. The exhaust outlet was placed immediately below the female portion of the ball joint. The exhaust gas passed through an ice condenser, and from there to a cadmium chloride bubbler, which removed the hydrogen sulfide from the waste gas.

The oil reservoir consisted of a 500 ml calibrated separatory funnel. The outlet of the reservoir was connected to a Merkle-Korff type bellows pump, which pumped the oil continuously from the reservoir to the top of the unit. A three-way stopcock was located between the pump and the reservoir, and served as a means to withdraw an oil sample for analysis.

Hydrogen was introduced above the oil inlet, and was regulated by a needle valve. The quantity of hydrogen which passed through the unit was determined by a mercury manometer and orifice, previously calibrated by a wet-test gas meter.

The hydrogen and oil inlets were connected to the male portion of the ground glass taper joint. The oil line was made from 1/8 inch stainless steel tubing.

MATERIALS AND PROCEDURE

The oil used in this investigation was a straight-run, light colored fuel oil, refined at the Husky Oil Company in Cody, Wyoming. The average molecular weight was about 222, and the sulfur content varied from 2.09 to 2.20 percent by weight. The A. S. T. M. distillation data for this oil is presented in Table I.

The catalyst samples that were used in this investigation were prepared at the Husky Refinery in Cody, Wyoming.

The same procedure was used for testing all catalyst samples. About 0.8 gram of pyrex glass wool was placed in the comparator just below the thermowell. This served merely as a catalyst support, and prevented the finely ground catalyst from washing through with the oil vapor. The catalyst to be tested was then weighed, and mixed with 40 grams of 1/8 inch porcelain fish spines. The fish spines prevented the fine particles of catalyst from caking, and plugging the unit. The catalyst and fish spines were intimately mixed with a small portion of oil (previously weighed) and then charged to the comparator. On top of the catalyst bed was placed a layer of 1/4 inch fish spines which served as a preheat section for the oil. An oil charge of 420 grams was weighed and placed in the reservoir. The pump was previously calibrated to deliver 420 grams of oil per hour.

Calibration was accomplished by a trial and error procedure. The pump was allowed to operate for a definite time interval, and the oil was delivered to a weighed beaker. After weighing the oil, the pump was adjusted and again allowed to operate for a given time interval. After a

series of such adjustments, the desired pump rate was obtained.

When the comparator had been charged it was placed in the proper position. All ground glass joints were greased and clamped in place. The unit was then ready for operation.

The variac was turned on, and while the comparator was heating a small amount of hydrogen was allowed to pass through the unit. When the desired temperature had been attained, the pump was turned on and the hydrogen rate was increased to approximately 2.5 standard cubic feet per hour. The oil was vaporized in the preheat section of the comparator and passed through the catalyst bed into the water condenser, where it was returned as a liquid to the reservoir. A small separatory funnel, not pictured in Figure 1, was inserted into the exhaust line to trap entrained liquids not removed by the ice condenser. The excess water in the ice condenser was removed by a siphon.

The unit was allowed to operate for six hours. Oil samples were periodically withdrawn, weighed, and analyzed for sulfur content. At the end of six hours, the pump and heat were turned off, but hydrogen was allowed to pass through the unit for a few additional minutes to remove any oil holdup in the catalyst bed. The entire contents of the comparator were then dumped and weighed. The oil was likewise withdrawn from the reservoir and its weight recorded.

The oil samples that were to be analyzed were given a caustic wash to remove any hydrogen sulfide, and then washed three times with water. The sulfur content of the oil was determined by the conventional lamp-sulfur

method, as described in the A. S. T. M. Manual of Standards (1).

In order to standardize the conditions under which the various catalysts were tested, a temperature of 625 degrees Fahrenheit and a hydrogen rate of about 2.5 standard cubic feet per hour were used for testing each sample. Haas (6) reported that there is a considerable range of temperature, 600-675 degrees Fahrenheit, where the amount of desulfurization is independent of the temperature, and also that the hydrogen rate did not seem to be a critical factor except that high hydrogen rates carried the oil through faster, and thus reduced the contact time.

CALCULATIONS

The sulfur balances for the various runs are included in Table V. The weight of the oil initially charged to the unit was 420 grams, but the value was altered each time a sample was withdrawn. Therefore, the weight of the oil passing through the unit for each time interval (between samples) was corrected to account for the sample that was withdrawn, and also for the oil loss, which was divided as equally as possible among the time intervals. The weight of the oil after correction was obtained by subtracting the sum of the distillation loss and sample weight from the weight of the oil before correction.

The weight of the sulfur after correction was calculated by multiplying the percent sulfur in the sample by the weight of oil after correction. The figure so obtained is the actual weight of the sulfur in the given amount of oil.

The amount of sulfur removed during each time interval was determined by multiplying the weight of oil before correction by the difference between the initial and final percent sulfur for that particular time interval. The sum of these values for each time interval, divided by the weight of catalyst used, was the grams of sulfur removed per gram of catalyst. Knowing the amount of nickel in the sample, the grams of sulfur removed per gram of nickel could readily be calculated.

The space velocity was reported in Table V on a weight basis rather than a volume basis i.e., grams of oil per gram of catalyst per hour.

RESULTS

As previously stated, the purpose of this investigation was to find a method for preparing a nickel oxide desulfurization catalyst. There were a number of variables involved and each will be considered separately.

Effect of Space Velocity

The catalyst samples used in this investigation varied in weight from 1.9 grams to 30.5 grams. The oil rate was held constant at 420 grams per hour for each run; consequently, the space velocity varied accordingly. In order that a series of runs could be compared with respect to catalyst activity (grams of sulfur removed per gram of nickel), a common space velocity had to be arbitrarily chosen and some method devised to compare all the runs on the basis of the same space velocity.

Nickel carbonate is a very hygroscopic material and will absorb varying amounts of water when exposed to air. For this reason, a space velocity based on the weight of catalyst would tend to be misleading because while one sample may have contained a negligible amount of water, another one would have considerable water content. For purposes of comparison, the space velocity was expressed as grams of oil per gram of nickel per hour, rather than the grams of oil per gram of catalyst per hour which was reported in the sulfur balances (Table V). Any foregoing reference to space velocity will be understood to mean grams of oil per gram of nickel per hour. This quantity was determined for each run, merely by dividing 420 grams of oil per hour by the grams of nickel in any particular sample.

It is well to note that the weight of nickel in the samples may be

in slight error because of the complexity and inaccuracy of the nickel analysis. However, any future correction of the nickel content, resulting from an improved analytical procedure, would cause the values to be changed, either all higher or all lower. Such a correction would have little or no effect on the determination of optimum conditions with respect to catalyst activity.

Five series of runs were made (Runs 1-23), which show the relationship between space velocity and catalyst activity. The five different catalysts were divided into samples of different size. The results of these runs have been graphed in Figure 2. It appears that a family of curves is represented, emanating from the origin. Various operational difficulties have caused a few of the points to deviate considerably from their respective curves.

A space velocity of 60 was chosen as a standard by which to compare the various catalyst samples. The procedure for determining the activity on this basis was as follows. The particular sample under question was located on Figure 2, knowing the space velocity and the grams of sulfur removed per gram of nickel. By following the general trend of the family of curves, this point was then transposed to a value of 60 grams of oil per gram of nickel per hour, and the corresponding activity was read on the ordinate. It was assumed that any particular catalyst sample, when located on Figure 2, fell on a curve which fit into the family of curves already represented. The activities of all the samples have been determined on this basis and are presented in Table III, along with the various space

velocities and makeup of the catalyst samples.

Method of Adding Solutions

The relationship between activity and the method for adding the solutions, i.e., whether the nickel sulfate should be added to the carbonate solution, or whether the sodium carbonate should be added to the sulfate solution, is not clearly understood as yet. Coykendall (3) reported that the highest activity was obtained when the carbonate was added to the nickel solution.

A definite relationship has been noted in the physical characteristics of the catalyst. When the nickel sulfate solution was added to the carbonate solution, the catalyst was very granular, and could not be extruded into "noodles". When the carbonate solution was added to the nickel solution, the catalyst appeared to be very finely divided, and was readily extrudable.

Effect of Excess Carbonate

A group of catalysts have been prepared to study the effect of adding the carbonate in excess of the stoichiometric quantity. At the time of this writing, these samples had not yet been tested in the comparison unit. Ueno (8) reported that nickel hydrogenation catalysts, prepared by precipitating nickel carbonate from nickel sulfate and sodium carbonate solutions, have the greatest activity when a slight excess of sodium carbonate is used.

Effect of Calcium Hydroxide

The purpose of Runs 24-28 was to test catalyst samples precipitated from nickel sulfate and calcium hydroxide. This type of catalyst appeared to show activity comparable to the nickel carbonate, as seen by the data

of Table III. Samples P-46 and P-47 were precipitated and digested at room temperature, while samples P-50-B and P-51-B were precipitated and digested at a boil. In all cases the lime was added to the nickel solution. The activities of these four samples were very similar, which indicated that the precipitation conditions, when using calcium hydroxide, were not a critical factor. Sample P-36-A was precipitated at room temperature, and digested at a boil, but for this sample the nickel solution was added to the lime. The activity of P-36-A appeared to be slightly greater than that of the other samples prepared from lime. One might conclude that a more active catalyst is obtained when the nickel solution is added to the calcium hydroxide. A more thorough investigation would be required, however, to definitely establish this fact.

All five samples were dried in an oven for 18 hours at about 225°F, after precipitation.

Precipitation and Digestion

Three runs were made (Runs 29-31) to determine the effect of precipitation and digestion conditions on the activity of a nickel carbonate catalyst. Sample P-32 was precipitated at 76°F over a time interval of 72 minutes, and digested at the boiling point for 60 minutes. Sample P-33 was precipitated at the boiling point for 16 minutes and digested at the boiling point for 60 minutes. Sample P-34 was precipitated at the boiling point for 72 minutes, but with no time allowed for digestion. On the basis of grams sulfur removed per gram nickel (based on a space velocity of 60), P-33 showed the greatest activity with a value of 0.340. The activities of P-32 and P-34 were 0.250 and 0.280, respectively. These results indicated that a

greater activity is obtained when the precipitation is carried out at the boiling point with appreciable time allowed for digestion.

The precipitation of nickel carbonate at the boiling point is desirable from another standpoint, also. Nickel carbonate is insoluble in hot water, but is slightly soluble in cold water. If the precipitation and digestion are carried out at the boiling point, the amount of nickel lost in the filtrate will be minimized.

Effect of Entrained Salt

Runs 32, 33, and 34, illustrate the detrimental effect that entrained salt has upon the activity of the catalyst. Samples P-38, P-39-B, and P-40, were washed with 340, 100, and 0 milliliters of water, respectively, following the precipitation. Their respective activities were 0.400, 0.300, and 0.080 grams of sulfur removed per gram of nickel. On the basis of these results, it was concluded that the presence of sodium sulfate, as an entrained salt, is very detrimental to the catalyst activity.

Time and Temperature of Calcining

The effect of the calcining temperature on the activity of the catalyst was studied in Runs 35-45. A large batch of catalyst was prepared and divided into portions containing nearly equal amounts of nickel. The various samples were then calcined in a muffle furnace for 16 hours at temperatures ranging from 250°F to 1070°F. The data obtained from this study has been presented in Table IV. The results were very inconclusive. The activity of the various samples varied from 0.042 to 0.278, but no definite relationship appeared to exist between the activity and the calcining temperature. In many cases, two samples calcined at the same, or

nearly the same temperature, showed very inconsistent activities. Sample C-44, calcined at 1066°F, had the lowest activity with 0.042 grams sulfur removed per gram of nickel. This seemed to substantiate the findings of Coykendall (3), who reported a decrease in activity upon calcining at temperatures in excess of 1000°F. It is possible that at the higher temperatures, the nickel catalyst is sintered, and undergoes structural changes which deactivate it as a desulfurization agent. Further study would be required to definitely ascertain the effect of calcining temperature in the region below 1000°F.

The effect of calcining time was studied in Runs 46-48. Cook 27-1 and Cook 31-2 were calcined for 1½ and 7 hours, respectively, at temperatures of 830°F and 790°F. The small difference in temperature was neglected because the calcining temperature does not appear to be too critical. Cook 29, 30-2 was calcined for 5 hours at 830°F. Cook 27-1 and Cook 29, 30-2 showed similar activities of 0.285 and 0.280, respectively. Cook 31-2 had the least activity with 0.235 grams sulfur removed per gram of nickel. It appears that calcining for longer than 5 hours tends to lower the activity. Although this appears to be true for calcining temperatures of about 800°F, it may not necessarily hold true for lower calcining temperatures.

Oven Drying vs Calcining

A number of runs were made to study the effect of oven drying, at temperatures varying from 230°F down to room temperature. The effect of oven drying followed by calcination at 850°F was also studied.

Runs 49-51 showed the effect of oven temperature on the catalyst activity. Sample P-64-X₁ was dried for 18 hours at 230°F, and showed an

activity of 0.190 grams of sulfur removed per gram of nickel. Samples P-64-X₁₂ and P-64-X₂₄ were both dried at room temperature for 140 hours, but P-64-X₂₄ was afterwards dried for 16 hours at 225°F. The activity of the latter two samples was 0.300. This indicated that a catalyst dried at room temperature tends to have an even greater activity than one which is oven dried at 225°F. However, the activity of P-64-X₂₄ indicated that oven drying is evidently not detrimental to the activity if the precipitate is dried at room temperature previous to the oven drying.

The samples used in Runs 52-54 were oven dried in exactly the same manner as the samples for Runs 49-51, respectively, but after the oven drying these samples were calcined for 8 hours at 850°F. The activities of P-64-X_{11A}, P-64-X₁₄, and P-64-X₂₇ were 0.220, 0.210, and 0.210, respectively, indicating a definite decrease in activity upon calcining in the higher temperature range. It appeared that the most active catalyst was prepared by drying the precipitate at room temperature. However, the calcined samples show an activity comparable to the samples that were oven dried at 225°F.

SUMMARY

1. The physical characteristics of a catalyst depend, in part at least, upon the method of adding the precipitating solutions. When the nickel solution is added to the carbonate solution, the catalyst is very granular; when the addition is carbonate to nickel, the catalyst is very finely divided.
2. Nickel hydroxide, prepared by reacting calcium hydroxide and nickel sulfate solutions, showed activity as a desulfurization catalyst comparable to nickel carbonate.
3. A more active catalyst is obtained when the precipitation is carried out at the boiling point with considerable time allowed for digestion.
4. Sodium sulfate, as an entrained salt on the catalyst, greatly reduces the catalyst activity.
5. The effect of calcining temperature on catalyst activity cannot be definitely established from the results of this investigation. The optimum time for calcining is questionable, but a period of five hours or less seems to be indicated.
6. A catalyst dried at room temperature shows more activity than one which is dried at 225°F or calcined at 850°F.

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TABLE I

INSPECTION DATA FOR CHARGE OIL
A.S.T.M. DISTILLATION

Percent Distilled	Temperature OF
First Drop	460
5%	500
10%	518
20%	534
30%	546
40%	556
50%	566
60%	576
70%	586
80%	600
90%	620
End Point	660

Percent recovery: 98%

Barometric pressure: 638 mm Hg

Specific gravity: 0.877 at 60°F

TABLE II

SOLUTIONS USED IN CATALYST PRECIPITATIONS

Solution No.	<u>Nickel Solutions</u>		Specific Gravity
	Ingredients		
	Grams Comm. NiSO ₄	ml H ₂ O	
A	Leeched from spent catalyst with H ₂ SO ₄		1.2529 at 28.9°C
B	858	2994	1.1458 at 24.5°C
C	843	1951	1.2060 at 23.9°C
F	1301	4000	unknown
Y	Anhydrous NiSO ₄ crushed to 14 mesh		---
Z	Same as Y, crushed to 48 mesh		---

Carbonate Solutions

Solution No.	Grams Na ₂ CO ₃ per gram of solution
A	0.1860
E	0.2018
L	0.2631

TABLE III

INGREDIENTS AND ACTIVITY OF CATALYST SAMPLES

Run No.	Catalyst Samples	Nickel Solutions	Carbonate Solutions	Grams of Oil Gram Nickel/hr	Grams of Sulfur Removed per Gram of Nickel (Based on 60 gms oil) Gm Ni/hr
1	W-1	A	A	76.5	---
2	W-2	A	A	58.1	---
3	W-3	A	A	116.9	---
4	W-4	A	A	46.4	---
5	W-5	A	A	69.8	---
6	W-6	A	A	125.0	---
7	W-7	A	A	56.7	---
8	W-8	A	A	90.8	---
9	W-9	A	A	160.2	---
10	W-10	A	A	31.0	---
11	W-11	A	A	98.2	---
12	W-12	A	A	50.8	---
13	P-53-1	A	E	411.5	---
14	P-53-2	A	E	190.0	---
15	P-53-3	A	E	94.8	---
16	P-56-1	Z	E	400.0	---
17	P-56-2	Z	E	203.0	---
18	P-56-3	Z	E	88.9	---
19	P-56-4	Z	E	66.4	---
20	P-56-5	Z	E	57.1	---
21	P-56-6	Z	E	49.9	---
22	P-56-7	Z	E	39.4	---
23	P-56-8	Z	E	31.5	---
24	P-36-A	A	milk of lime	100.6	0.390
25	P-46	A	milk of lime	89.6	0.300
26	P-47	A	milk of lime	91.6	0.310
27	P-50-B	A	milk of lime	59.4	0.280
28	P-51-B	A	milk of lime	91.3	0.300
29	P-32	B	A	63.0	0.250
30	P-33	B	A	62.9	0.340
31	P-34	B	A	63.0	0.280
32	P-38	B	A	101.7	0.400
33	P-39-B	B	A	72.5	0.300
34	P-40	B	A	84.6	0.080
35	C-35	A	A	60.9	0.270
36	C-36	A	A	60.8	0.213
37	C-37	A	A	60.7	0.266
38	C-38	A	A	60.3	0.233

TABLE III (continued)

Run No.	Catalyst Samples	Nickel Solutions	Carbonate Solutions	<u>Grams of Oil</u> Gram Nickel/hr	Grams of Sulfur Removed per Gram of Nickel (Based on <u>60 gms oil</u> gm Ni/hr)
39	C-39	A	A	60.6	0.139
40	C-40	A	A	61.0	0.147
41	C-41	A	A	60.9	0.159
42	C-42	A	A	60.9	0.179
43	C-43	A	A	60.8	0.215
44	C-44	A	A	60.9	0.042
45	C-45	A	A	61.0	0.278
46	Cook 27-1	Y	L	52.6	0.285
47	Cook 31-2	Y	L	55.5	0.235
48	Cook 29,30-2	Harshaw No. 3		70.4	0.280
49	P-64-X ₁	F	L	52.1	0.190
50	P-64-X ₁₂	F	L	59.5	0.300
51	P-64-X ₂₄	F	L	64.9	0.300
52	P-64-X ₁₁ A	F	L	39.0	0.220
53	P-64-X ₁₄	F	L	49.0	0.210
54	P-64-X ₂₇	F	L	104.5	0.210

TABLE IV

CALCINING DATA

Catalyst Sample	Calcine Temperature OF	Grams of Sulfur Removed per Gram of Nickel
C-35	362	0.270
C-36	661	0.213
C-37	850	0.266
C-38	250	0.233
C-39	478	0.139
C-40	423	0.147
C-41	758	0.159
C-42	947	0.179
C-43	550	0.215
C-44	1066	0.042
C-45	955	0.278

TABLE V
SULFUR BALANCES

Run No.	Catalyst	Wt. gms.	Space velocity gms oil gm cat/hr	Time in hrs	Percent sulfur	Wt. oil before correction gms.	Distillation Losses gms.	Weight lost by Sample gms.	Wt. oil after correction gms.	Weight sulfur after correction gms.	Sulfur removed during time interval gms.	Grams sulfur removed per gram Nickel
1	W-1	15.7	26.8	0	2.090	420.0	-	-	420.0	8.78	-	0.161
				1	2.025	420.0	2.0	12.3	405.7	8.22	0.273	
				2	1.973	405.7	2.0	13.3	390.4	7.71	0.171	
				3	1.920	390.4	2.0	13.1	375.3	7.20	0.207	
				4	1.878	375.3	2.0	12.8	360.5	6.76	0.158	
				5	1.851	360.5	2.0	13.2	345.3	6.38	0.097	
				6	1.832	345.3	2.0	13.3	00.0	6.29	0.066	
2	W-2	20.5	20.5	0	2.090	420.0	-	-	420.0	8.78	-	0.149
				1	1.972	420.0	5.7	13.5	400.8	7.90	0.495	
				2	1.932	400.8	5.8	13.0	382.0	7.39	0.160	
				3	1.898	382.0	5.7	12.5	363.8	6.89	0.130	
				4	1.851	363.8	5.7	13.8	344.3	6.37	0.171	
				5	1.817	344.3	5.8	11.9	326.6	5.94	0.117	
				6	1.785	326.6	5.8	12.8	00.0	5.84	0.105	
3	W-3	10.4	40.4	0	2.090	420.0	-	-	420.0	8.78	-	0.108
				1	2.082	420.0	0.9	12.2	406.9	8.48	0.034	
				2	2.048	406.9	1.0	13.2	392.7	8.05	0.138	
				3	2.035	392.7	0.9	11.5	380.3	7.74	0.051	
				4	2.023	380.3	0.9	14.1	365.3	7.40	0.046	
				5	1.998	365.3	1.0	13.9	350.4	7.06	0.091	
				6	1.982	350.4	0.9	14.5	00.0	7.02	0.056	

TABLE V (Continued)

SULFUR BALANCES

Run No.	Catalyst	Wt. gms.	Space velocity gms oil gm cat/hr	Time in hrs	Percent sulfur	Wt. oil before correction gms.	Distillation Losses gms.	Weight lost by Sample gms.	Wt. oil after correction gms.	Weight sulfur after correction gms.	Sulfur removed during time interval gms.	Grams sulfur removed per gram Nickel
4	W-4	25.6	16.4	0	2.090	420.0	-	-	420.0	8.78	-	0.117
				1	1.985	420.0	0.6	13.1	406.3	8.06	0.441	
				2	1.904	406.3	0.6	13.9	391.8	7.46	0.329	
				3	1.872	391.8	0.7	13.7	377.4	7.06	0.125	
				4	1.843	377.4	0.6	13.6	363.2	6.69	0.109	
				5	1.818	363.2	0.6	16.9	345.7	6.27	0.091	
				6	1.802	345.7	0.6	345.1	00.0	6.22	0.055	
5	W-5	17.0	24.7	0	2.090	420.0	-	-	420.0	8.78	-	0.161
				1	1.998	420.0	4.0	15.0	401.0	8.00	0.386	
				2	1.912	401.0	3.9	16.2	380.9	7.29	0.345	
				3	1.885	380.9	4.0	13.3	363.6	6.85	0.103	
				4	1.869	363.6	4.0	13.4	346.2	6.47	0.058	
				5	1.842	346.2	3.9	13.9	328.4	6.05	0.094	
				6	1.820	328.4	4.0	324.4	00.0	5.98	0.072	
6	W-6	9.6	43.7	0	2.090	420.0	-	-	420.0	8.78	-	0.181
				1	2.040	420.0	0.8	13.2	406.0	8.29	0.210	
				2	1.988	406.0	0.7	15.4	389.9	7.75	0.212	
				3	1.975	389.9	0.8	14.6	374.5	7.40	0.050	
				4	1.960	374.5	0.8	14.1	359.6	7.05	0.056	
				5	1.948	359.6	0.7	12.8	346.1	6.75	0.043	
				6	1.920	346.1	0.8	345.3	00.0	6.65	0.097	

TABLE V. (Continued)

SULFUR BALANCES

Run No.	Catalyst	Wt. gms.	Space velocity gms oil gm cat/hr	Time in hrs.	Percent sulfur	Wt. oil before correction gms.	Distillation Losses gms.	Weight lost by Sample gms.	Wt. oil after correction gms.	Weight sulfur after correction gms.	Sulfur removed during time interval gms.	Grams Sulfur removed per gram Nickel
7	W-7	19.8	21.2	0	2.090	420.0	-	-	420.0	8.78	-	0.183
				1	1.945	420.0	1.8	14.9	403.3	7.84	0.609	
				2	1.872	403.3	1.7	16.4	385.2	7.21	0.294	
				3	1.828	385.2	1.8	16.1	367.3	6.71	0.169	
				4	1.791	367.3	1.8	12.8	352.7	6.32	0.136	
				5	1.762	352.7	1.7	14.0	337.0	5.94	0.102	
				6	1.740	337.0	1.8	335.2	00.0	5.86	0.074	
8	W-8	12.6	33.3	0	2.090	420.0	-	-	420.0	8.78	-	0.231
				1	1.988	420.0	1.0	16.1	402.9	8.00	0.428	
				2	1.920	402.9	0.9	13.2	388.8	7.46	0.274	
				3	1.885	388.8	1.0	14.7	373.1	7.03	0.136	
				4	1.855	373.1	1.0	13.5	358.6	6.65	0.112	
				5	1.835	358.6	0.9	15.1	342.6	6.29	0.072	
				6	1.805	342.6	1.0	341.6	00.0	6.19	0.103	
9	W-9	7.4	56.8	0	2.090	420.0	-	-	420.0	8.78	-	0.311
				1	1.990	420.0	1.5	14.7	403.8	8.03	0.420	
				2	1.948	403.8	1.4	12.9	389.5	7.58	0.169	
				3	1.915	389.5	1.4	13.7	374.4	7.18	0.128	
				4	1.898	374.4	1.5	13.3	359.6	6.82	0.064	
				5	1.882	359.6	1.5	15.3	342.8	6.45	0.058	
				6	1.870	342.8	1.4	341.4	00.0	6.42	0.041	

TABLE V (Continued)

SULFUR BALANCES

Run No.	Catalyst	Wt. gms.	Space velocity gms oil gm cat/hr	Time in hrs.	Percent sulfur	Wt. oil before correction gms.	Distillation Losses gms.	Weight lost by Sample gms.	Wt. oil after correction gms.	Weight sulfur after correction gms.	Sulfur removed during time interval gms.	Grams sulfur removed per gram Nickel
10	W-10	20.1	20.9	0	2.090	420.0	-	-	420.0	8.78	-	0.155
				1	1.792	420.0	7.4	14.4	398.2	7.14	1.250	
				2	1.690	398.2	7.4	14.7	376.1	6.36	0.406	
				3	1.622	376.1	7.3	14.8	354.0	5.75	0.256	
				4	1.590	354.0	7.4	15.8	330.8	5.26	0.113	
				5	1.545	330.8	7.3	15.3	308.2	4.76	0.149	
				6	1.532	308.2	7.4	300.8	00.0	4.72	0.040	
11	W-11	6.5	64.6	0	2.090	420.0	-	-	420.0	8.78	-	0.341
				1	1.946	420.0	2.3	13.8	403.9	7.85	0.605	
				2	1.830	403.9	2.3	11.6	390.0	7.14	0.468	
				3	1.782	390.0	2.3	12.1	375.6	6.69	0.187	
				4	1.748	375.6	2.3	12.0	361.3	6.31	0.128	
				5	1.725	361.3	2.3	12.4	346.6	5.98	0.083	
				6	1.698	346.6	2.3	344.3	00.0	5.88	0.094	
12	W-12	12.3	34.2	0	2.090	420.0	-	-	420.0	8.78	-	0.208
				1	1.832	420.0	3.3	13.5	403.2	7.38	1.082	
				2	1.755	403.2	3.3	12.8	387.1	6.79	0.310	
				3	1.722	387.1	3.4	12.7	371.0	6.39	0.128	
				4	1.690	371.0	3.4	12.9	354.7	5.99	0.119	
				5	1.664	354.7	3.3	14.4	337.0	5.61	0.092	
				6	1.640	337.0	3.4	336.6	00.0	5.52	0.081	

TABLE V (Continued)

SULFUR BALANCES

Run No.	Catalyst	Wt. gms.	Space velocity gms oil gm cat/hr	Time in hrs	Percent sulfur	Wt. oil before correction gms.	Distillation Losses gms.	Weight lost by Sample gms.	Wt. oil after correction gms.	Weight sulfur after correction gms.	Sulfur removed during time interval gms.	Grams Sulfur removed per gram Nickel
13	P-53-1	1.9	221.0	0	2.140	420.0	-	-	420.0	8.98	-	0.514
				1	2.060	420.0	4.7	13.5	401.8	8.27	0.336	
				2	2.050	401.8	4.8	12.6	384.4	7.90	0.040	
				4	2.020	384.4	4.8	12.9	366.7	7.40	0.115	
				6	2.015	366.7	4.8	361.9	00.0	7.38	0.018	
14	P-53-2	4.1	102.5	0	2.140	420.0	-	-	420.0	8.98	-	0.424
				1	2.000	420.0	3.3	11.8	404.9	8.10	0.588	
				2	1.970	404.9	3.4	9.7	391.8	7.71	0.121	
				4	1.936	391.8	3.4	15.1	373.3	7.23	0.134	
				6	1.918	373.3	3.3	370.0	00.0	7.15	0.067	
15	P-53-3	8.3	50.6	0	2.140	420.0	-	-	420.0	8.98	-	0.350
				1	2.010	420.0	4.7	11.6	403.7	8.10	0.546	
				2	1.905	403.7	4.8	12.1	386.8	7.36	0.423	
				4	1.782	386.8	4.7	12.8	369.3	6.58	0.475	
				6	1.764	369.3	4.8	364.5	00.0	6.51	0.067	
16	P-56-1	2.0	210	0	2.200	420.0	-	-	420.0	9.24	-	0.573
				1	2.083	420.0	6.0	16.2	397.8	8.30	0.491	
				2	2.075	397.8	6.1	16.1	375.6	7.78	0.032	
				4	2.060	375.6	6.1	17.8	351.7	7.24	0.056	
				6	2.050	351.7	6.1	345.6	00.0	7.20	0.035	

TABLE V (Continued)

SULFUR BALANCES

Run No.	Catalyst	Wt. gms.	Space velocity gms oil gm cat/hr	Time in hrs	Percent sulfur	Wt. oil before correction gms.	Distillation Losses gms.	Weight lost by Sample gms.	Wt. oil after correction gms.	Weight sulfur after correction gms.	Sulfur removed during time interval gms.	Grams Sulfur removed per gram Nickel
17	P-56-2	4.1	102	0	2.200	420.0	-	-	420.0	9.24	-	0.655
				1	1.978	420.0	2.0	16.7	401.3	7.94	0.932	
				2	1.935	401.3	1.9	14.6	384.8	7.45	0.173	
				4	1.890	384.8	2.0	14.4	368.4	6.96	0.173	
				6	1.852	368.4	2.0	366.4	00.0	6.84	0.140	
18	P-56-3	8.8	47.7	0	2.200	420.0	-	-	420.0	9.24	-	0.391
				1	1.883	420.0	1.4	16.0	402.6	7.58	1.330	
				2	1.788	402.6	1.4	16.2	385.0	6.88	0.382	
				4	1.765	385.0	1.4	14.1	369.5	6.51	0.088	
				6	1.754	369.5	1.4	368.1	00.0	6.48	0.041	
19	P-56-4	11.7	35.9	0	2.140	420.0	-	-	420.0	8.98	-	0.294
				1	1.870	420.0	4.0	14.0	402.0	7.52	1.133	
				2	1.780	402.0	4.0	13.0	385.0	6.85	0.362	
				4	1.713	385.0	4.0	17.5	365.5	6.23	0.258	
				6	1.682	365.5	4.0	359.5	00.0	6.11	0.113	
20	P-56-5	13.9	30.2	0	2.200	420.0	-	-	420.0	9.24	-	0.316
				1	1.931	420.0	3.9	14.1	402.0	7.77	1.130	
				2	1.795	402.0	3.8	14.7	383.5	6.89	0.547	
				4	1.678	383.5	3.9	14.1	365.5	6.12	0.449	
				6	1.624	365.5	3.9	361.6	00.0	5.94	0.197	

TABLE V (Continued)

SULFUR BALANCES

Run No.	Catalyst	Wt. gms.	Space velocity $\frac{\text{gms oil}}{\text{gm cat/hr}}$	Time in hrs.	Percent sulfur	Wt. oil before correction gms.	Distillation Losses gms.	Weight lost by Sample gms.	Wt. oil after correction gms.	Weight sulfur after correction gms.	Sulfur removed during time interval gms.	Grams sulfur removed per gram Nickel
21	P-56-6	15.9	26.4	0	2.200	420.0	-	-	420.0	9.24	-	0.312
				1	1.768	420.0	3.5	14.5	402.0	7.11	1.815	
				2	1.594	402.0	3.5	15.5	383.0	6.10	0.700	
				4	1.555	383.0	3.5	15.5	364.0	5.66	0.149	
				6	-	-	-	-	-	-	-	
22	P-56-7	19.9	21.1	0	2.200	420.0	-	-	420.0	9.24	-	0.284
				1	1.712	420.0	9.2	14.6	396.2	6.78	2.045	
				2	1.616	396.2	9.3	19.7	367.2	5.93	0.380	
				4	1.509	367.2	9.2	21.1	336.9	5.07	0.392	
				6	1.448	336.9	9.2	327.7	00.0	4.87	0.206	
23	P-56-8	24.8	16.9	0	2.200	420.0	-	-	420.0	9.24	-	0.238
				1	1.752	420.0	10.5	15.0	394.5	6.91	1.880	
				2	1.588	394.5	10.6	15.3	368.6	5.85	0.647	
				4	1.474	368.6	10.5	14.8	343.3	5.06	0.420	
				6	1.410	343.3	10.5	332.8	00.0	4.84	0.220	
24	P-36-A	22.1	17.8	0	2.200	420.0	-	-	420.0	9.24	-	0.477
				1	1.939	420.0	5.6	16.7	397.7	7.70	1.097	
				2	1.878	397.7	5.6	17.6	374.5	7.04	0.242	
				4	1.760	374.5	5.7	16.1	352.7	6.21	0.441	
				6	1.700	352.7	5.7	347.0	00.0	6.00	0.212	

TABLE V (Continued)

Sulfur Balances

Run No.	Catalyst	Wt. gms.	Space velocity gms oil gm cat/hr	Time in hrs	Percent sulfur	Wt. oil before correction gms.	Distillation Losses gms.	Weight lost by Sample gms.	Wt. oil after correction gms.	Weight sulfur after correction gms.	Sulfur removed during time interval gms.	Grams Sulfur removed per gram Nickel
25	P-46	20.0	21.0	0	2.200	420.0	-	-	420.0	9.24	-	0.353
				1	1.969	420.0	3.6	13.4	403.0	7.93	0.970	
				2	1.900	403.0	3.6	14.4	385.0	7.32	0.278	
				4	1.832	385.0	3.7	17.4	363.9	6.66	0.262	
				6	1.790	363.9	3.7	360.2	00.0	6.51	0.153	
				6	1.790	363.9	3.7	360.2	00.0	6.51	0.153	
26	P-47	20.0	21.0	0	2.200	420.0	-	-	420.0	9.24	-	0.372
				1	1.910	420.0	2.8	14.7	402.5	7.69	1.219	
				2	1.875	402.5	2.8	15.7	384.0	7.20	0.141	
				4	1.826	384.0	2.8	16.7	364.5	6.65	0.188	
				6	1.782	364.5	2.8	361.7	00.0	6.50	0.161	
				6	1.782	364.5	2.8	361.7	00.0	6.50	0.161	
27	P-50-B	30.5	13.8	0	2.200	420.0	-	-	420.0	9.24	-	0.280
				1	1.898	420.0	2.9	15.3	401.8	7.62	1.270	
				2	1.820	401.8	2.9	15.8	383.1	6.96	0.314	
				4	1.747	383.1	3.0	20.0	360.1	6.28	0.280	
				6	1.708	360.1	3.0	357.1	00.0	6.15	0.140	
				6	1.708	360.1	3.0	357.1	00.0	6.15	0.140	
28	P-51-B	20.0	21.0	0	2.200	420.0	-	-	420.0	9.24	-	0.365
				1	1.969	420.0	3.4	15.2	401.4	7.90	0.970	
				2	1.892	401.4	3.3	15.7	382.4	7.24	0.309	
				4	1.832	382.4	3.4	17.8	361.2	6.61	0.230	
				6	1.785	361.2	3.4	357.8	00.0	6.45	0.170	
				6	1.785	361.2	3.4	357.8	00.0	6.45	0.170	

TABLE V (Continued)

SULFUR BALANCES

Run No.	Catalyst	Wt. gms.	Space velocity $\frac{\text{gas oil}}{\text{gm cat/hr}}$	Time in hrs	Percent sulfur	Wt. oil before correction gms.	Distillation Losses gms.	Weight lost by Sample gms.	Wt. oil after correction gms.	Weight sulfur after correction gms.	Sulfur removed during time interval gms.	Grams Sulfur removed per gram Nickel
29	P-32	12.9	32.6	0	2.200	420.0	-	-	420.0	9.24	-	0.260
				1	1.986	420.0	2.3	15.8	401.9	7.98	0.899	
				2	1.882	401.9	2.3	15.3	384.3	7.24	0.418	
				4	1.808	384.3	2.3	16.3	365.7	6.60	0.284	
				6	1.773	365.7	2.3	363.4	00.0	6.48	0.128	
30	P-33	12.7	33.0	0	2.200	420.0	-	-	420.0	9.24	-	0.347
				1	1.892	420.0	1.6	17.3	401.1	7.60	1.292	
				2	1.770	401.1	1.6	16.9	382.6	6.77	0.490	
				4	1.674	382.6	1.7	15.5	365.4	6.11	0.368	
				6	1.628	365.4	1.7	363.7	00.0	5.94	0.168	
31	P-34	12.8	32.8	0	2.200	420.0	-	-	420.0	9.24	-	0.284
				1	1.960	420.0	0.9	16.3	402.8	7.89	1.009	
				2	1.866	402.8	1.0	13.9	387.9	7.24	0.378	
				4	1.782	387.9	1.0	15.2	371.7	6.63	0.326	
				6	1.734	371.7	1.0	370.7	00.0	6.44	0.178	
32	P-38	7.4	53.1	0	2.200	420.0	-	-	420.0	9.24	-	0.522
				1	1.947	420.0	2.4	15.1	402.5	7.83	1.062	
				2	1.832	402.5	2.4	15.1	385.0	7.05	0.463	
				4	1.728	385.0	2.4	17.6	365.0	6.30	0.400	
				6	1.663	365.0	2.4	362.6	00.0	6.06	0.237	

TABLE V (Continued)

SULFUR BALANCES

Run No.	Catalyst	Wt. gms.	Space velocity $\frac{\text{gms oil}}{\text{gm cat/hr}}$	Time in hrs.	Percent sulfur	Wt. oil before correction gms.	Distillation losses gms.	Weight lost by Sample gms.	Wt. oil after correction gms.	Weight sulfur after correction gms.	Sulfur removed during time interval gms.	Grams sulfur removed per gram Nickel				
33	P-39-B	10.4	37.8	0	2.200	420.0	-	-	420.0	9.24	-	0.328				
				1	1.952	420.0	2.2	15.9	401.9	7.85	1.040					
				2	1.864	401.9	2.2	15.6	384.1	7.16	0.354					
				4	1.780	384.1	2.3	15.3	366.5	6.50	0.322					
				6	1.728	366.5	2.3	364.2	00.0	6.31	0.191					
				34	P-40	14.0	28.1	0	2.200	420.0	-	-	420.0	9.24	-	0.088
				1				2.105	420.0	6.1	15.8	398.1	8.38	0.399		
2	2.100	398.1	6.1	14.6				377.4	7.92	0.020						
4	2.100	377.4	6.2	16.1				355.1	7.45	0.000						
6	2.095	355.1	6.2	348.9				00.0	7.43	0.018						
35	C-35	13.7	30.6	0	2.090	420.0	-	-	420.0	8.78	-	0.270				
				1	1.845	420.0	1.7	13.3	405.0	7.46	1.029					
				2	1.731	405.0	1.7	13.8	389.5	6.75	0.461					
				3	1.653	389.5	1.7	12.8	375.0	6.20	0.304					
				4	1.641	375.0	1.6	11.8	361.6	5.94	0.045					
				5	1.608	361.6	1.7	15.1	344.8	5.54	0.012					
				6	1.570	344.8	1.7	343.1	00.0	5.41	0.013					

TABLE V (Continued)

SULFUR BALANCES

Run No.	Catalyst	Wt. gms.	Space velocity gms oil gm cat/hr	Time in hrs	Percent sulfur	Wt. oil before correction gms.	Distillation Losses gms.	Weight lost by sample gms.	Wt. oil after correction gms.	Weight sulfur after correction gms.	Sulfur removed during time interval gms.	Grams Sulfur removed per gram Nickel
36	C-36	10.9	38.6	0	2.090	420.0	-	-	420.0	8.78	-	0.213
				1	1.938	420.0	1.7	13.8	404.5	7.84	0.639	
				2	1.876	404.5	1.7	13.8	389.0	7.30	0.251	
				3	1.800	389.0	1.6	12.5	374.9	6.75	0.296	
				4	1.768	374.9	1.7	15.0	358.2	6.34	0.120	
				5	1.748	358.2	1.7	13.1	343.4	6.00	0.072	
				6	1.720	343.4	1.7	341.7	00.0	5.90	0.096	
37	C-37	10.5	40.0	0	2.090	420.0	-	-	420.0	8.78	-	0.266
				1	1.875	420.0	1.4	12.9	405.7	7.61	0.904	
				2	1.800	405.7	1.3	12.9	391.5	7.05	0.304	
				3	1.744	391.5	1.3	12.9	377.3	6.59	0.220	
				4	1.690	377.3	1.4	13.1	362.8	6.14	0.204	
				5	1.665	362.8	1.4	13.4	348.0	5.80	0.091	
				6	1.632	348.0	1.3	346.7	00.0	5.69	0.115	
38	C-38	14.6	28.8	0	2.090	420.0	-	-	420.0	8.78	-	0.233
				1	1.942	420.0	0.5	11.9	407.6	7.92	0.622	
				2	1.855	407.6	0.5	11.6	395.5	7.34	0.354	
				3	1.805	395.5	0.6	12.2	382.7	6.92	0.198	
				4	1.751	382.7	0.5	13.6	368.6	6.46	0.206	
				5	1.718	368.6	0.5	12.9	355.2	6.10	0.122	
				6	1.685	355.2	0.5	354.7	00.0	5.98	0.117	

TABLE V (Continued)

SULFUR BALANCES

Run No.	Catalyst	Wt. gms.	Space velocity $\frac{\text{gms oil}}{\text{gm cat/hr}}$	Time in hrs.	Percent sulfur	Wt. oil before correction gms.	Distillation Losses gms.	Weight lost by Sample gms.	Wt. oil after correction gms.	Weight sulfur after correction gms.	Sulfur removed during time interval gms.	Grams Sulfur removed per gram Nickel
39	C-39	11.7	35.9	0	2.090	420.0	-	-	420.0	8.78	-	0.139
				1	1.962	420.0	2.5	13.3	404.2	7.94	0.537	
				2	1.925	404.2	2.5	13.4	388.3	7.48	0.149	
				3	1.895	388.3	2.6	13.0	372.7	7.06	0.116	
				4	1.888	372.7	2.5	13.8	356.4	6.73	0.026	
				5	1.872	356.4	2.6	14.2	339.6	6.36	0.057	
				6	1.861	339.6	2.5	337.1	00.0	6.32	0.037	
40	C-40	12.4	33.8	0	2.090	420.0	-	-	420.0	8.78	-	0.147
				1	2.010	420.0	3.0	12.8	404.2	8.12	0.336	
				2	1.920	404.2	3.0	13.9	387.3	7.43	0.274	
				3	1.871	387.3	2.9	12.4	372.0	6.96	0.190	
				4	1.850	372.0	3.0	13.0	356.0	6.59	0.078	
				5	1.835	356.0	3.0	13.4	339.6	6.22	0.053	
				6	1.812	339.6	3.0	336.6	00.0	6.15	0.078	
41	C-41	10.8	38.9	0	2.090	420.0	-	-	420.0	8.78	-	0.159
				1	2.020	420.0	9.2	12.4	398.4	8.05	0.294	
				2	1.975	398.4	9.1	11.6	377.7	7.45	0.179	
				3	1.928	377.7	9.2	12.0	356.5	6.86	0.177	
				4	1.895	356.5	9.2	14.1	333.2	6.31	0.118	
				5	1.852	333.2	9.1	15.0	309.1	5.72	0.143	
				6	1.815	309.1	9.1	300.0	00.0	5.61	0.114	

