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SULFUR RESISTANT METHANATION CATALYST

MASTER

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OBJECTIVE

The objective of this program was to study catalyst compositions in an effort to develop a sulfur resistant methanation catalyst for the methanation stage of a coal to SNG process.

In the processes to convert coal to a substitute natural gas the coal is first gasified by the reaction of coal with oxygen and steam at high temperature and moderate to high pressure to produce a synthesis gas consisting primarily of methane, hydrogen, carbon monoxide and carbon dioxide. The gas produced is a low BTU gas and carbon monoxide shift conversion is proposed to adjust the H_2 to CO ratio for subsequent hydrogenation of carbon monoxide to methane to produce a high BTU substitute natural gas.

Practically all of the methanation schemes will employ nickel catalyst for methanation. Since all coals contain some sulfur, a major disadvantage to the nickel catalysts are their susceptibility to sulfur poisoning. An operational upset could result in the premature loss of a catalyst charge.

The development of a sulfur tolerant or sulfur resistant catalyst would eliminate the loss of catalyst and could result in more flexibility and reduced operating cost in the sulfur adsorbent system. A study of catalyst compositions was conducted to determine if a sulfur resistant methanation catalyst could be developed that would offer these process advantages.

SCOPE OF WORK

In order to study catalyst composition a series of experimental catalysts were prepared and tested with a feed gas containing H_2S which is typical of the current methanation schemes for this process. These catalysts consisted of a metal, metal oxide or metal sulfide, or a combination of metals on various supports.

In all, approximately fifty catalysts were prepared (Tasks 1 - 4, see Table I) consisting of (1) a single metal oxide on an alumina support, (2) metal oxide combinations on an alumina support, (3) selected metal oxide compositions on a silica support or a magnesium silicate support, and (4) variations in metal oxide ratios or method of preparation on selected metal oxide combinations. These catalyst samples were characterized both chemically and physically by obtaining such properties as metal oxide content, surface area and crush strength.

The catalysts were pretreated by reducing or sulfiding and tested (Task 5) with a feed gas composition and at conditions typical of the various methanation schemes. On each test the operating conditions and analyses of the inlet and outlet gas composition were recorded.

As the work progressed, it became apparent that a catalyst with an acceptable low temperature methanation activity had not yet been discovered. Therefore, the life test (Task 6) was deleted and the time was used for additional screening work.

TABLE I

Task 1	Preparation of single metal oxide catalysts on alumina support.
Task 2	Preparation of metal oxide combination catalysts on alumina support.
Task 3	Preparation of catalysts of selected metal oxide combinations from Tasks 1 and 2 on SiO_2 and MgSiO_3 support.
Task 4	Preparation of catalysts varying the metal ratios and/or method of preparation on selected combinations from Tasks 1, 2, or 3.
Task 5	Activity testing of catalysts from Tasks 1 - 4 at typical conditions for SNG methanation with H_2S in the feed gas.
Task 6	Three month life test on the most promising catalyst.

SUMMARY

The purpose of this work was to develop a catalyst which would methanate a gasified-coal stream without prior sulfur removal. Fifty-eight activity tests have been completed on forty-nine different catalyst compositions which were studied as sulfur-resistant methanation catalysts.

As shown by the data tabulated in this report, most of the base-metal catalytically-active, transition elements were used to prepare the catalysts. Included were the elements potassium, vanadium, chromium, manganese, iron, cobalt, nickel, molybdenum, ruthenium, tungsten, and platinum. These metals were combined or used singly with carriers such as alumina, silica, chromium oxide, magnesium oxide, magnesium silicate, and magnesium aluminate to provide the test catalysts for this work. In addition, a number of catalysts of identical chemical composition were prepared by several formulation methods. It is probable that many of these catalysts would be suitable for other catalyst applications as well.

Test conditions, including temperature, gas composition, and steam levels were varied during the course of the work and computer data processing was used to analyze the test results.

Two catalysts, namely nickel and chromium on magnesium silicate and nickel and chromium on magnesium aluminate, converted all of the carbon monoxide and part of the carbon dioxide to methane at 500°F when reduced with only hydrogen and no sulfur in the process gas. This is equivalent to the performance of nickel - SNG type methanation catalysts. After sulfiding, the nickel-chromium on magnesium silicate catalyst retained a 60-80% methanation activity at 1100°F with low steam/gas ratios. This is still a much better performance than the 7-12% methanation activity shown by a typical sulfur-poisoned nickel methanation catalyst. However, after sulfiding the experimental catalysts had very low methanation and significant shift activity at temperatures less than 1100°F.

It is important to note that 60-80% methanation activity has only been achieved when testing at 1100°F. Catalyst activity of this magnitude may be sufficient for the first stage of a multiple-reactor methanation system. However, the production of a high BTU substitute natural gas, compatible with pipeline gas, will require a sulfur-resistant catalyst which can be used in the latter and final stages of a methanation system.

These final stages usually operate at lower temperatures, 500 to 700°F, where the equilibrium for the methanation reaction is more favorable, resulting in minimal carbon monoxide and hydrogen contamination of the product methane. As a result, in order to develop a completely sulfur tolerant methanation system, a catalyst with a high methanation activity at low temperatures must be developed. Thus this work was partially successful in discovering two catalysts which are capable of high temperature methanation in the presence of sulfur, and which are very active at normal temperatures, 500-800°F, in the absence of sulfur. Since a low temperature activity in the presence of sulfur was not obtained, it was recommended this research be abandoned.

Funds budgeted for this two and a half years of work were \$105,244, whereas total contract expenditures amounted to \$73,819 (Figure 1).

CONCLUSIONS

1. The Ni-Cr-MgSiO₃ and Ni-Cr-MgAl₂O₄ catalysts demonstrated the best methanation activity of all sulfided catalysts tested at 1100°F.
2. In the absence of sulfur, after reduction with hydrogen, the low temperature (500°F) methanation activity of these same two catalysts is equivalent to that of conventional nickel methanation catalysts.
3. The work did not result in the development of a catalyst with good activity in the presence of sulfur at low temperatures of 500-800°F.
4. Chromium in the catalyst serves both to improve catalytic activity and to inhibit sulfur pickup.
5. The loss of surface area is independent of the extent of sulfur pickup.
6. Platinum at the 0.1% level does not enhance catalytic activity.
7. Vanadium at the 2% level does not enhance catalytic activity, although it does inhibit sulfur pickup.
8. Lowering the feed gas space velocity does not improve catalytic activity.
9. At lower temperatures, which require high steam levels in the feed gas, catalysts with a silica carrier show less water-gas shift reaction than alumina containing catalysts.
10. None of the catalysts containing alumina as the only support have shown an acceptable activity with sulfur in the feed gas.

EXPERIMENTAL PROCEDURE FOR TASKS 1 AND 2

To prepare the experimental catalyst samples, several methods of catalyst preparation could be used, such as impregnation, compounding or coprecipitation of the carrier with the metal oxides. One of the methods selected for this study was the coprecipitation of a metal salt with an aluminum salt to obtain hydroxides or carbonates of the metal and aluminum. Subsequently the hydroxides or carbonates were calcined to their oxide state and formed into catalysts. This is one method of preparation expected to give the most active catalyst.

Generally the precipitation will involve the precipitation of metal salt solutions with Na_2CO_3 or NH_4OH . Following the precipitation the precipitated metal carbonates or hydroxides are washed to remove excess sodium or ammonium salts.

The samples are then dried and calcined. After calcination the material is ground, mixed with a lubricant and formed into tablets.

As an example, the NiO on alumina catalyst procedure would involve:

1. Premix

Water solutions of a nickel salt and an aluminum salt would be mixed at the corresponding ratio to obtain the correct composition and then diluted to the desired concentration.

2. Na_2CO_3 or NH_4OH

A solution of Na_2CO_3 or NH_4OH would be made up to a specified concentration.

3. Precipitation

The solutions 1 and 2 would be pumped together to obtain a slurried precipitate.

4. Washing

The precipitate would be washed with deionized water to remove excess sodium or ammonium salts.

5. Drying and Calcining

The catalysts would be dried and calcined for 8-16 hours.

6. The sample would then be ground to a fine mesh, mixed with graphite, water added if necessary, and formed into 1/8" x 1/8" tablets.
7. Calcination

The 1/8" x 1/8" catalyst tablets would then be calcined to remove any remaining water.

Each catalyst was characterized for its chemical and physical properties, e.g., percentage metal or metal oxide, crush, density, surface area, pore volume.

EXPERIMENTAL EQUIPMENT FOR TASK 5

In order to test the catalyst preparations, an existing test unit was modified to obtain the desired conditions.

A schematic drawing of this test unit is given in Figure 2, and Figure 3 is a more detailed picture of the reactor itself. This is a dual tube reactor and the tubes are sulfur resistant 3/4" Schedule 80 Inconel 601 alloy which are mounted in a nickel powder heat sink. The feed gas was premixed by partial pressure in vinyl coated steel cylinders to 1800 psig. The gas pressure was stepped down to operating pressure with an Airco gas regulator. The gas was then fed through rotameters to the unit via 1/4" stainless steel tubing. Process steam was supplied by pumping water into a vaporizer. The steam then mixed with the gas in the upper portion of the reactor tubes, which also preheats the gas to the catalyst bed. Very low steam levels were achieved by bubbling the process gas through an in-line saturator.

The reactor temperature is controlled with electrical resistance heaters and Electromax electrical temperature controllers from thermocouples mounted in the heat sink. The resistance heaters are mounted outside the nickel powder heat sink. The purpose of the heat sink is to approach isothermal operation for easier interpretation of catalyst activity.

Exit the catalyst bed the gas was cooled by an indirect water condenser. The gas then passed through knock-out pots where the water was separated. The gas then passed through back pressure regulators and was stepped down to near atmospheric pressure. Exit the regulator the flow was measured with a wet test meter. Sample valves for gas analyses are in line immediately before and after the reactor.

EXPERIMENTAL PROCEDURE FOR TASK 5

Using the test reactor described above, catalysts were loaded to each of the two reactor tubes. Then the catalysts were pretreated by reduction with H_2 or presulfided with H_2S in H_2 at a controlled temperature, pressure, and space velocity. Following pretreatment the catalysts were placed onstream with a feed gas and steam at conditions typical of the methanation stage for an SNG process. The inlet and outlet flow rates and the concentration of CO , CO_2 , CH_4 , H_2 , and H_2S were obtained and recorded.

More specifically, the reactor tubes were loaded with 5 cc's of inert bed support followed by 10 cc's of $1/8'' \times 1/8''$ catalyst samples with the weight of the 10 cc's recorded. The catalyst was then reduced as follows:

Reduction Conditions

Initial 100% H_2 - 700° F
15 Hrs.
50-100 PSIG
2000 S. V.

Revised

0.6% H_2S/H_2 - 700° F
16 Hrs.
50-100 PSIG
2000 S. V.

Following the pretreatment the catalyst was placed onstream by starting the process gas and steam. The test continued until it lined out at one condition. The feed gas composition and conditions of the test were as follows:

Test Conditions

10 cc Catalyst
500 PSIG
700°, 800°, 1050°, 1150°
10,000 S. V.

Gas Compositions

Desired Hot Spot, ° F	Recycle/Feed	Gas Composition*				
		Inlet S/G	% CO	% CO ₂	% H ₂	% CH ₄
-	Feed gas only	.0024	19.4	2.52	67.8	10.3
500-850	2.7/1	.4363	5.32	3.21	27.72	63.75
950	2.1/1	.3582	6.50	3.97	34.40	55.13
1050	1.6/1	.2786	8.08	4.49	41.35	46.07
1150	1.2/1	.2052	10.11	4.61	47.98	37.30

* There is also 1-5 PPM H_2S in the feed.

The reduction process was revised when it was realized that many months would be required for each catalyst to reach an equilibrium or lined-out condition with sulfur in the feed gas, without sulfiding during reduction.

The gas compositions are typical of the Lurgi coal gasification process with gas recycle at the methanator. Catalyst testing has proceeded with various recycle ratio gas compositions, and the data and results show each composition used.

EXPERIMENTAL TEST RESULTS - TASK 1 AND 2 - CATALYST PREPARATION

All of the catalysts in Tasks 1 and 2, which were listed in the contract, were prepared. In addition, several other catalysts, which differed in metal content or preparation method, were made. Research into other metal combinations, metal contents, and preparation methods continued as catalyst testing and analytical results suggested promising possibilities.

Table II lists all of these catalysts and their chemical and physical properties. The variations in crush and density were expected since each metal oxide represents a different electronic structure, different molecular weight and different valence state.

The list of single-metal catalysts tested includes a platinum and a ruthenium catalyst which were tested mainly for comparison. The alternate supports which were tested include silica, magnesium oxide, magnesium silicate, and magnesium aluminate. These were all prepared with nickel and chromium as the active metals, which were found to be the best catalytic elements.

Several catalysts were prepared by different precipitation methods which resulted in the same metal oxide ratios as others which have been listed in Table II. It is interesting to note that, according to the chemical literature, chromium oxide was not reduced at these test conditions, so that catalysts containing it can be considered as iron or nickel on a chromia support.

Most interesting of the analytical results is the sulfur analyses. The discharged catalysts show large percentages of sulfur in most cases; this was expected since catalyst reduction before testing was accomplished with H_2S in hydrogen. However, a comparison of the sulfur content of the used catalysts shows that those containing chromium or vanadium consistently show a lower sulfur content than the earlier catalysts which did not include these elements. Thus, all future catalysts tested were made to include one or both of these elements.

The marked decrease in surface area continued to occur. Initially we thought that the adsorption of sulfur caused the loss of surface area. Later results, however, showed that the surface area decreased significantly even with low sulfur levels on the discharged catalysts. This suggests a physical or mechanistic effect on the surface area which is independent of the amount of sulfur present.

EXPERIMENTAL TEST RESULTS - TASK 5 - CATALYST TESTING

The unit was first checked out with no catalysts loaded. Temperature profiles showed the heat distribution to be adequate. The unit was flushed with large quantities of feed gas and with H_2S in nitrogen to saturate the unit metal with sulfur and keep subsequent sulfur absorption by the unit to the minimum.

The test data is summarized for each test run in Table III. The last two columns show calculations which give an indication of catalyst activity. The percent of bed above the hot spot gives, as a percentage, the bed depth at which the maximum temperature of reaction occurred, as determined by taking a temperature profile. Thus, a value in this column indicates that only that part of the catalyst bed is being used to accomplish the reaction. The percent carbon monoxide conversion is based on the CO gas analyses, corrected by a factor based on the gas volume change caused by reaction.

Since the calculation of carbon monoxide conversion did not take into account whether shift or methanation was occurring, a mathematical method was developed to differentiate between the competing reactions. Calculations by this method are tabulated in Table IV; the method of calculation is presented as a footnote to that table.

The first several test runs served to establish an efficient test procedure, including line-out times and process changes, and check out the operation of all equipment. Test 1 served mainly as a control run (see Table III). The catalysts were reduced with hydrogen and without H_2S , so that the high conversions to methane were evident. The sulfur analyses showed that the catalysts were absorbing all of the sulfur, and this was just beginning to affect the methanation reaction. Thus, a very long line-out time was predicted if this test were continued.

The second test shows the data taken after presulfiding the catalysts. The gas analyses clearly point out the lack of activity. Although the shift reaction was using up carbon monoxide, the methane levels show a nickel or cobalt catalyst would not work.

Tests 3 and 4 were done with manganese and iron catalysts loaded in the reactor. As the calculations show, neither of these catalysts were active enough, although the iron catalyst demonstrated the best methanation activity of any catalysts tested up to this time.

Test 5 results in Table III showed that the chromium catalyst was active for shift and to a much lesser extent for methanation and the Ni-Fe catalyst was essentially inactive. However, the low sulfur retention by

the chromium catalyst in Test 5 offered some hope of finding an active catalyst in Test 6 testing the Ni-Cr and Fe-Cr-K. Thus, although the standard test conditions provided no evidence for methanation activity during Test 6, the catalysts were not discharged. They were tested with a different gas composition representing less methanator gas recycle to result in a temperature rise up to 1050°F.

It was thought that the lower steam content of this gas composition would hinder the shift reaction and promote the methanation reaction. However, there were still only marginal signs of methanation activity from either catalyst and Test 6 was ended.

In Test 7 a Fe-Cr-K-V catalyst was tested with the idea that the chromium and vanadium present might prevent sulfur pickup and allow the iron to methanate. However, the gas analyses for Test 7, Table III, show that the catalysts were again promoting the carbon monoxide shift reaction with essentially no change in the methane content. The lack of activity may have been due to the low surface area of (both of) the Fe-Cr catalysts tested (Table II).

Run 8 tested the CoMo and NiMo catalysts with the lower metals content (see Table II) while Run 9 had the higher metal CoMo and NiMo catalysts. As the table shows, the catalysts with the lower metals content exhibited a significantly greater percent CO conversion. However, the calculations in Table IV reveal that, once again, the carbon monoxide shift reaction accounted for most of the catalyst activity. Significant methanation was not occurring.

The previous single-metal test data suggested that iron or chromium showed relatively better methanation activity. Accordingly, iron-chromium catalysts, one with alumina carrier and one containing only the metal oxides, were tested in Run 10. As the data summary shows, the percent CO conversion increased for both catalysts as the reactor temperature was increased. Moreover, the sulfur analyses showed that the catalysts were losing the sulfur deposited during reduction. This sulfur loss continued with further testing, until the catalysts reached a sulfur equilibrium with the feed gas at 57 hours. However, on reaching sulfur equilibrium no appreciable effect was observed on CO conversion.

Table IV shows the calculations based on the data from Run 10. The conversion to methane was actually not as good for the Fe-Cr catalysts as it was for the single-metal iron catalyst which had a 26.7% average methane conversion. The calculations point out an interesting difference between the two catalysts; the catalyst containing alumina did not shift as much as that containing only the metals. However, this occurred at the expense of leaving more CO unreacted.

The Ni-W and Fe-Mo (which also contained some chromium) catalysts were tested in Run 11. The Ni-W catalyst was essentially inactive. The percent CO conversion increased with temperature for the Fe-Mo catalyst, but the calculations in Table IV show a lot of shift reaction, some methanation, but with a lot of carbon monoxide left unreacted.

The shift reaction predominated during the first part of Run 12, as shown in Table III. Then the steam/gas ratio was lowered several times during the run. This was done to determine the effect of lower steam on the shift reaction, with the idea that less shift reaction would allow more methanation to occur. The results can be seen in the CO component changes, which show that the percent shift was indeed reduced, to 10 - 30%, when a very low steam/gas was used. At the same time, however, the unreacted CO increased, so that the percent methanation did not change significantly.

For Test 13, the nickel catalyst was dipped with vanadium and retested, along with a new Ni-Cr catalyst prepared by a different method. Some minor changes on the test procedure were made for this test. All testing was done at 800°F, the steam to gas was lowered, and the carbon dioxide content was raised in an attempt to inhibit the shift reaction as much as possible and get the best methanation activity. The percent methanation, however, shows that catalyst activities were not improved.

The Ni-Cr and Fe-Cr catalysts were tested in Run 14 with several of the recycle gas compositions, as shown by the data in Table III. The total percent CO conversions were significant in many cases, but most of this was because of the shift reaction. A notable exception is the data acquired at hour 38 for the Fe-Cr catalyst. The calculations in Table IV, based on this data, showed a large 44% conversion of CO to methane. Unfortunately, the catalyst did not maintain this activity.

Test 15 involved Ni-Cr catalysts supported by carriers other than alumina or chromia. The catalyst with magnesium oxide did not perform any better than several other catalyst compositions tested previously, but the calculations showed that the catalyst with magnesium silicate had an improved methanation activity at high temperatures. More than 40% of the carbon monoxide was still unreacted, however.

The catalyst carriers were silica and magnesium aluminate in Test 16. The Ni-Cr-SiO₂ showed a surprisingly low shift conversion at 800°, but shift conversion took over again at the higher temperature. The Ni-Cr-MgAl₂O₄ showed a 36% methanation activity, which occurred at 800° and decreased significantly at 1150°F. Thus, the catalysts with MgSiO₃ or MgAl₂O₄ were the only ones to date which had shown a reproducible improvement in activity.

Test 17 involved a nickel-chromium catalyst prepared by a different method, and a retest of the Ni-Cr-Al₂O₃ catalyst, which was first tested in Run 6. The results were unexciting, although the alumina base catalyst did show a 29% methanation activity at one point.

Test 18 represented a slight departure from the objective in the testing of platinum on alumina and ruthenium on alumina catalyst preparations. The results from ruthenium were less than expected, but the platinum catalyst showed a 36% low temperature methanation activity.

The data summary for Run 19 shows that the Ni-Cr on MgAl₂O₄ and the Ni-Cr on MgSiO₃ catalysts were tested at 600°, 700°, and 800°F with the 500-850° recycle feed gas (Hours 4-13) and at 900°, 1000°, and 1100° with the 500-1150° recycle feed (Hours 17-69).

The data showed that the catalysts at 1000° or 1100°F were responding to lower steam to gas with an increased methanation activity. This was evident from the gas analyses and calculations, as well as from the temperature profiles, which showed a 50-120°F temperature rise. Therefore, they were tested further, at several temperatures with the raw feed gas composition in order to take advantage of the very low steam to gas ratio which is used with that gas composition. However, there was no evidence of catalyst activity with the raw feed gas, and carbon formation occurred with increased temperature. The catalysts were discharged, and new loadings of the same catalysts were tested.

The test results showed the best methanation activity of any catalysts to date. The Ni-Cr on MgAl₂O₄ demonstrated methanation conversions of 46% and 61% and the Ni-Cr on MgSiO₃ was even more impressive with conversions of 60%, 63%, and 84% both at 1100° and .2 S/G. This is in sharp contrast to all previous test results for which the best CO conversion to methane was 44% with the Fe-Cr catalyst.

Run 19 was continued after reloading the catalysts in order to acquire additional low steam data, as shown in Table III. For both catalysts the lower

steam resulted in an increased methane production and lower hydrogen leakages. As the calculations in Table IV show, the lower steam eliminated the shift reaction, and in fact, promoted a reverse shift, which used up some of the hydrogen. For the last part of the test data was taken at a lower space velocity. We expected this change to cause an increase in the catalyst activity, but the data shows that there was not any effect.

Magnesium silicate tablets were impregnated with platinum and ruthenium and tested in Run 20. The lack of activity was disappointing, and this screening test was ended quickly.

The next three tests were done with normal steam to gas ratios. In Run 21, two new catalyst preparations, Ni on MgAl_2O_4 and on MgSiO_3 , were tested. The data in Table III showed some methanation activity, as evidenced by the methane analyses, but the hydrogen and carbon monoxide analyses indicated a lot of shift reaction, too. Thus, the calculations in Table IV show only a 10-17% methanation activity.

The catalysts tested in Run 22 included one with an alpha alumina impregnated with nickel, in contrast to the earlier catalysts in which the nickel was coprecipitated with an amorphous alumina. The second catalyst tested contained nickel, chromium, and vanadium on MgSiO_3 . The nickel on alumina catalyst was inactive, which demonstrates that alumina carrier of any type is not suitable for this application. The Ni-Cr-V catalyst showed 30-40% methanation activity at 1100° , but this is no more than several other catalysts have demonstrated before.

Catalysts with nickel and vanadium on magnesium silicate and Ni-Cr-V on magnesium aluminate were tested in Run 23. The hot spot location shows that the Ni-V catalyst used the whole catalyst bed for minimal methanation activity. The catalyst with nickel, chromium and vanadium demonstrated some methanation activity during the test (30%), but it was not as good as other previous results.

The catalysts tested in Run 24 contained nickel and vanadium on silica and on magnesium aluminate. As shown by Table III, the test was conducted with normal steam to gas levels and recycle gas compositions. The silica catalyst showed less shift reaction at the lower temperature, but with more steam with the feed gas. This is consistent with the results of test 16, in which the Ni-Cr- SiO_2 catalyst showed less shift

reaction at low temperature, high steam test conditions. This is also in contrast to most of the other catalysts tested, which usually displayed a greater shift reaction tendency at higher steam to gas ratios. Methanation activity was minimal, however.

Another way to compare catalyst activity is by means of the percent shift/percent methanation ratio, which is presented as part of Table V. This is simply the numerical result obtained by dividing the percent CO which undergoes shift by the percent CO which is converted to methane. While it is recognized that any detectable shift reaction will result in a gas which is unsuitable as a pipeline gas substitute, noting which catalysts have the best, i.e., lowest, shift/methanation ratio, for example 1.4 or less, shows that catalysts containing Ni, Cr, and V occur most often. This is encouraging since the emphasis during this work was on catalysts containing nickel and chromium.

The other catalyst tested in Run 24 was nickel and vanadium on magnesium aluminate. Shift activity decreased with higher temperature and lower steam to gas conditions, and an increase in methanation activity was also noted. The testing of this catalyst, moreover, allows us to construct the following short table, which includes data at 1100°F and normal steam to gas from Table V for two series of catalyst preparations:

<u>Catalyst</u>	<u>% CO to CH₄</u>	<u>Shift/Methanation Ratio</u>
Ni-MgSiO ₃	12.5	1.14
Ni-V-MgSiO ₃	9.2	2.59
Ni-Cr-MgSiO ₃	39.0 (61.7 retest)	0.39 (.02 retest)
Ni-Cr-V-MgSiO ₃	37.2	0.38
Ni-MgAl ₂ O ₄ (tabs)	13.6	0.97
Ni-Cr-MgAl ₂ O ₄ (tabs)	11.2 (53.7 retest)	2.57 (.10 retest)
Ni-V-MgAl ₂ O ₄ (approx. 1/2 tabs)	35.8	0.15
Ni-Cr-V-MgAl ₂ O ₄ (all 10-14 mesh granules)	29.7	0.59

We discovered after testing that dipping the magnesium aluminate carrier catalysts with vanadium solution caused a severe loss in crush strength and attrition resistance. Subsequent handling of the dipped tablets therefore caused them to break apart. Catalyst preparation by coprecipitation with vanadium would prevent this. However, the results for the magnesium aluminate catalysts are obscured by the particle size effect on the methanation activity. The calculations for the magnesium silicate catalysts on the other hand, show clearly that the activity was enhanced by chromium in the catalyst, and was not aided by vanadium.

All of the catalysts in Runs 25 and 26 showed minimal methanation activity, but testing of the platinum dipped catalysts provided the following table of calculations, again condensed from Table V:

Catalyst	<u>%CO to CH₄</u>		<u>Shift/Methanation Ratio</u>	
	<u>800°</u>	<u>1100°</u>	<u>800°</u>	<u>1100°</u>
Ni-MgSiO ₃	9.3	12.5	2.19	1.14
Ni-MgSiO ₃ /Pt	12.9	2.5	2.53	4.24
1-1 Ni-Cr	9.8	6.2	4.80	4.68
1-1 Ni-Cr/Pt	6.2	5.1	5.92	4.04

Run 27 tested again the two most promising catalysts, Ni-Cr on MgSiO₃ and on MgAl₂O₄. The test was begun at 700°, in order to test the low temperature activity of the catalysts once again. However, significant methanation activity was evident only at 1100° as before. The saturators were used to achieve very low steam to gas ratios, before the test was ended. Both catalysts responded with elimination of the shift reaction, and the catalyst with MgSiO₃ was the better methanator of the two.

Reduction with clean hydrogen was used with these same catalysts for Run 28. Data from this test shows very clearly what happens as a catalyst is poisoned. As shown by the data and calculations in Tables III and IV, both Ni-Cr on MgSiO₃ and on MgAl₂O₄ were excellent methanators at the beginning of the test, using up all of the carbon monoxide and a significant amount of the carbon dioxide. However, as the test continued, the methanation activity decreased, as shown by the gas analyses and the outlet total gas flow, which increases as the gas contraction caused by methanation becomes less. The progressive increase in shift activity, in unreacted carbon monoxide, and in the percent of bed used to complete the reaction all show very clearly the effects of the sulfur poisoning.

After about 30 hours on stream the methanation activity for both catalysts decreased considerably. The catalysts had been exposed to 0.23 wt. % sulfur at this point. The MgAl_2O_4 catalyst continued this decrease in activity and was not tested further after 73 hours. The MgSiO_3 catalyst was less affected by the sulfur in the feed, but further testing at 800° showed continuing activity decline, dropping to 27% methanation activity after 95 hours on stream. The run was concluded by testing at 1100° , where the Ni-Cr- MgSiO_3 showed the 78% methanation activity which has been found to be typical of this catalyst from previous runs.

Run 29 was the final test completed for this work. The catalysts tested were borides, one consisting of MgSiO_3 tablets impregnated with nickel as nickel boride, the other compounded as MgSiO_3 carrier with nickel boride and chromium boride. The catalysts were tested for low temperature activity and, as shown in Tables III and IV, were found to be inactive. Run 29 was stopped after 10 hours.

FIGURE 1

BAR GRAPH OF PROGRAM TASKS AND EXPENDITURES

E.R.D.A. REACTOR
FLOW SCHEMATIC
CATALYSTS & CHEMICALS UNIT

FIGURE 3

OCR UNIT

NOTE: All figures are in centimeters.

TABLE II

SUMMARY OF CATALYST PREPARATIONS FOR ERDA
CONTRACT E(49-18)-2032

% Metals(s)	% Al ₂ O ₃	Crush	Density	% Na, New	% C, (a) Used	% S New	% S Used	Surface Area (m ² /g)		Pore Vol. (cc/g)		Crystallite Size (Å)	
		(lbs.DWL), New	(lbs./CF), New					New	Used	New	Used	New	Used
71.4% NiO	28.6	15	49	0.038	2.61	.08	14.5	226	58.5	.592	.757	40	
76.7% Co ₂ O ₃	23.3	5	74	.018	1.99	.06	18.7	148	70.6	.479		65	
75.3% Fe ₂ O ₃	24.7	12	81	.17	2.35	.05	6.44	140	24.6	.360	.420	amor.	
74.6% CuO	25.4	17	62	.13		.03		104		.566		55	
69.0% MnO ₂	30.7	10	65	.25	3.03	.02	15.9	45.1	15.9	.505	.383	unid. (b)	
73.1% Cr ₂ O ₃	26.9	9	54	.045	2.21	.06	0.10	255	124	.645			
59.6% NiO) 13.4% Fe ₂ O ₃)	27.0	18	58	.08	2.29	.10	12.7	239	22.9	.732	.646	35 (NiO)	
54.9% NiO) 13.4% Cr ₂ O ₃)	31.7	15	53	.02	3.04	.06	10.2 (5.9)	345	111	.666	.639	35 amor. (Ni ₃ S ₂)	225
55.9% NiO) 18.4% MnO ₂)	25.7	14	44	.2		.08		209		.830			
61.7% NiO) 11.0% CuO)	27.2	17	43	.02		.10		208		.684			
57.3% NiO) 13.9% Co ₂ O ₃)	28.7	17	49	.02	1.71	.13	14.7	188	29.4	.863	.456	unid.	
76% Fe ₂ O ₃) 20% K ₂ CO ₃) 4% Cr ₂ O ₃)	0.0	25	70	-		.15	13.0	6.1	2.6	.256	.202	200 (Fe ₂ O ₃)	225 (Fe ₃ O ₄)
74.5% Fe ₂ O ₃) 20% K ₂ CO ₃) 3.5% V ₂ O ₅) 2% Cr ₂ O ₃)	0.0	25	80	-	1.92	.32	1.21	2.1	3.8	.357	.126	200 (Fe ₂ O ₃)	225 (Fe ₃ O ₄)

(a) Two to three percent graphite added for tableting.

(b) Catalyst shows an unidentifiable XRD phase.

TABLE II

SUMMARY OF CATALYST PREPARATIONS FOR ERDA
CONTRACT E(49-18)-2032

% Metal(s)	% Al ₂ O ₃	Crush	Density	% Na, New	% C, Used	% S		Surface Area (m ² /g)		Pore Vol. (cc/g)		Crystallite Size (Å)	
		(lbs.DWL), New	(lbs./CF), New			New	Used	New	Used	New	Used	New	Used
3.5% CoO) 14 % MoO ₃)	82.5	15	36	.05	.23	.04	3.74	211	178	.888	.507	50 (γ -Al ₂ O ₃)	
3.5% NiO) 14 % MoO ₃)	82.5	15	48	.05	.13	.02	3.72	158	146	.615	.486	45 (γ -Al ₂ O ₃)	
25.7% CoO) 49.3% MoO ₃)	25.0	20	109	-	1.0	.01	.97	34.8	57.6	.157	.191		
25.7% NiO) 49.3% MoO ₃)	25.0	12	82	-	.54	.02	10.3	45.9	63.9	.212	.246		
51.2% Fe ₂ O ₃) 48.8% Cr ₂ O ₃)	-	12	97	-		.09		38.6	25.4	.238			
60.5% Fe ₂ O ₃) 14.5% Cr ₂ O ₃)	25.0	27	74	-		.06	.104	123	62.1	.316			
26.7% Fe ₂ O ₃) 48.3% MoO ₃) 2.3% Cr ₂ O ₃)	22.7	22	83	-		.04		64.5	40.0	.242			
18.4% NiO) 56.6% WO ₃)	25.0	14	85	-		.09		74.0		.303			
66.4% NiO) 33.6% Cr ₂ O ₃) (2/1)	-	4	88	-		.03	6.71	101.0	13.2	.240	.249		

TABLE II

SUMMARY OF CATALYST PREPARATIONS FOR ERDA
CONTRACT E(49-18)-2032

% Metal(s)	% Al ₂ O ₃	Crush	(lbs. / CF) New	% Na, New	% C Used	% S		Surface Area m ² / g)		Pore Vol. (cc/g)		Crystallite Size (Å)	
		(lbs. DWL), New				New	Used	New	Used	New	Used	New	Used
50.5% NiO) 49.5% Cr ₂ O ₃) (1/1)	-	2	68	-		.02	.15	65	5.7	.385	.456		
67.8% Fe ₂ O ₃) 32.2% Cr ₂ O ₃) (2/1)	-	5	83	-		.06	.15	124	29.1				
51% Fe ₂ O ₃) 49% Cr ₂ O ₃) (1/1)	-	5	82	-									
71.4% NiO) - % V ₂ O ₅)	28.6	15	49	.038		.10	8.65	193	14.4				
60.5% Fe ₂ O ₃) 14.5% Cr ₂ O ₃) - % V ₂ O ₅)	25.0	27	74	-		.06							
75.3% Fe ₂ O ₃) 1.76% V ₂ O ₅)	24.7	12	81	.17		.05	4.83	132	35.9	.227			
49.7% NiO) 25.3% Cr ₂ O ₃) 25.0% MgO)	-	6	77			.06	3.2	85.8	49.5	.252	.170		
49.7% NiO) 25.3% Cr ₂ O ₃) 25.0% SiO ₂)	-	9	47			.04	1.2	76.1	97.1	.368	.505		

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[illegible]

TABLE II

[illegible]

منذ سنة ١٩٤٤

[illegible]

Table III
CATALYST TESTING SUMMARY

Run No.	Metal	Time On Stream Hrs.	Inlet T, °F	Pressure PSIG	Dry Inlet S. V. v/v/hr.	S/G		%CO		%CO ₂		%H ₂		%CH ₄		ppm S		% of Bed above Hot Spot	% CO Conversion
						In	Out	In	Out	In	Out	In	Out	In	Out	In	Out		
1	Ni/Al ₂ O ₃	7	519	500	2000	.187	.345	5.25	.040	4.40	2.94	20.34	1.66	70.01	95.36	12.0	0	0.0	99.4
		11	504	500	2000	.036	.140	5.51	.583	4.37	3.56	20.53	3.40	69.59	92.46	11.5	0	25.6	91.3
		15	613	500	2000	.242	.390	5.51	.242	4.37	4.06	20.53	2.11	69.59	93.59	11.5	0	12.8	96.4
		23	614	500	2000	.167	.299	5.27	.084	4.08	3.33	19.30	1.96	71.35	94.63	8.0	0	0.0	98.7
		31	612	500	2000	.402	.573	5.01	.147	4.26	3.85	19.49	2.45	71.24	91.55	8.3	0	12.8	97.6
		37	718	500	2000	.388	.557	4.93	.184	4.42	3.86	19.84	3.01	70.81	92.95	8.4	0.04	0.0	96.9
1	Co/Al ₂ O ₃	7	511	500	2000	.433	.593	5.25	.059	4.40	4.20	20.34	5.86	70.01	85.88	12.0	0	0.0	99.1
		11	510	500	2000	.912	1.06	5.51	.489	4.37	4.94	20.53	12.28	69.59	82.29	11.5	0	0.0	92.0
		15	618	500	2000	.637	.849	5.51	.283	4.37	4.50	20.53	4.02	69.59	91.20	11.5	0	0.0	95.7
		23	622	500	2000	.313	.476	5.27	.043	4.08	3.19	19.30	2.53	71.35	94.24	8.0	0	0.0	99.3
		31	620	500	2000	.230	.355	5.01	.233	4.26	4.11	19.49	3.10	71.24	92.56	8.3	0	0.0	96.1
		37	767	500	2000	.147	.256	4.93	.134	4.42	4.17	19.84	4.19	70.81	91.81	8.4	0	0.0	97.7

TABLE III

CATALYST TESTING SUMMARY

Run No.	Metal	Time on Stream, Hours	Pressure PSIG	Dry Inlet S. V. v/v/hr.	S/G		% CO		% CO ₂		% H ₂		% CH ₄		ppm S		Temp. °F		% of Bed Above Hot Spot	% CO Conversion
					In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out		
2	Ni/Al ₂ O ₃	4	500	10000	.415	.419	5.14	3.88	4.06	4.5	23.91	23.91	67.07	67.71	3.7	6.9	605	611	100	24.5
		8	500	5000	.372	.375	4.83	3.09	4.13	4.83	23.64	23.73	67.31	68.44	2.9	17.2	-	-	-	36.1
		12	500	2000	.489	.475	4.83	2.86	4.13	5.46	23.73	24.65	67.31	67.03	-	-	614	615	60.5	40.0
		17	500	2000	.663	.727	4.79	1.47	3.76	4.33	24.73	20.72	66.72	73.48	5.0	10.0	686	699	21.0	70.9
		23	500	2000	.571	.565	4.80	1.00	3.63	5.40	24.41	23.42	67.16	70.18	2.0	11.0	809	806	0.0	79.4
	Co/Al ₂ O ₃	4	500	10000	.382	.377	5.14	2.19	4.06	5.58	23.91	24.54	66.89	67.69	3.7	9.7	616	621	100	57.0
		8	500	5000	.531	.524	4.83	1.30	4.13	5.90	23.73	24.54	67.31	68.26	2.9	9.2	-	-	-	72.8
		12	500	2000	.252	.255	4.83	1.31	4.13	6.10	23.73	25.12	67.31	67.47	-	-	626	619	0.0	72.3
		17	500	2000	1.48	1.55	4.79	0.90	3.76	4.87	24.73	22.29	66.72	71.94	5	-	712	706	0.0	81.8
		23	500	2000	.530	.518	4.80	.834	3.63	6.09	24.41	24.65	67.16	68.43	2	24.4	813	810	15.1	82.6

TABLE III
CATALYST TESTING SUMMARY

Run No.	Metal	Time on Stream, Hours	Pressure PSIG	Dry Inlet S. V. v/v/hr.	S/G		% CO		% CO ₂		% H ₂		% CH ₄		ppm S		Temp. ° F		% of Bed Above Hot Spot	% CO Conversion
					In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out		
3	Fe/Al ₂ O ₃	4	500	2000	.238	.258	3.01	1.96	3.10	3.08	19.05	16.76	74.84	78.2	10.9	.84	610	620	100	36.7
		9	500	2000	.449	.445	3.21	2.71	2.95	3.28	19.10	19.41	74.74	74.6	10.2	11.1	628	627	50.0	15.3
		28	500	2000	.281	.278	2.92	1.45	2.96	3.74	19.23	19.61	74.89	75.2	-	-	730	718	22.2	50.1
		71	500	2035	.323	.310	4.19	2.72	3.46	4.55	20.43	21.43	71.92	71.3	-	-	720	741	91.7	34.3
	Mn/Al ₂ O ₃	4	500	2148	.039	.080	3.01	2.16	3.10	1.69	19.05	16.57	74.84	79.6	10.9	1.93	616	625	100	30.4
		9	500	2000	.592	.591	3.21	3.05	2.95	2.94	19.1	19.41	74.74	74.6	10.2	14.6	617	631	57.6	4.6
		28	500	2000	0.0	0.0	2.92	3.26	2.96	2.52	19.23	18.33	74.89	75.5	-	-	732	723	27.3	0.0

Table III
CATALYST TESTING SUMMARY

Run No.	Metal	Time On Stream Hrs.	Pressure PSIG	Dry Inlet S. V. v/v/hr.	S/G		% CO		% CO ₂		% H ₂		% CH ₄		ppm S		Temp., °F		% of Bed above Hot Spot	% CO Conversion
					In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out		
4	Mn/Al ₂ O ₃	21	500	10,000	.421	.427	4.50	4.41	3.95	3.93	21.12	21.76	70.43	69.90	5.6	4.5	594	607	100	3.7
		24	500	10,000	.406	.372	4.50	4.51	3.95	3.98	21.12	22.46	70.43	69.05	-	-	602	607	57.1	0
		51	500	10,000	.381	.386	6.15	5.70	5.11	5.35	19.44	20.30	69.3	68.65	2.9	6.1	705	706	28.6	5.8
		55	500	10,000	.412	-	6.16	5.42	5.12	5.34	20.02	20.07	68.7	69.17	3.5	-	705	701	28.6	-
		59	500	10,000	.420	.461	6.16	4.13	5.12	6.20	20.02	21.14	68.7	68.53	-	-	815	818	57.1	43.7
		64	500	10,000	-	.379	5.80	3.52	4.47	5.82	22.88	24.34	66.85	66.32	2.6	32.7	815	815	42.9	-
4	Fe/Al ₂ O ₃	21	500	10,000	.410	.277	4.50	3.98	3.95	4.31	21.12	22.13	70.43	69.58	5.6	28.1	601	610	100	0
		24	500	10,000	.389	.311	4.50	3.82	3.95	4.27	21.12	22.64	70.43	69.27	-	-	605	611	40	15.9
		51	500	10,000	.389	.302	6.15	3.67	5.11	6.64	19.44	21.67	69.3	68.02	2.9	29.3	716	714	40	39.3
		55	500	10,000	.398	.342	6.16	3.63	5.12	6.61	20.02	21.60	68.7	68.16	3.5	-	716	709	27.5	48.0
		59	500	10,000	-	.342	6.16	1.56	5.12	7.70	20.02	22.60	68.7	68.14	-	-	825	823	40	79.2
		64	500	10,000	.379	.254	5.80	1.69	4.47	6.83	22.88	25.24	66.85	66.24	2.6	47.8	821	822	40	69.2

Table III
CATALYST TESTING SUMMARY

Run No.	Metal	Time On Stream Hrs.	Pressure PSIG	Dry Inlet S.V. v/v/hr.	S/G		% CO		% CO ₂		% H ₂		% CH ₄		ppm S		Temp., °F		% of Bed above Hot Spot	% CO Conversion
					In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out		
5	Cr/Al ₂ O ₃	5	500	10,000	.382	.361	-	-	4.39	4.69	22.94	23.02	-	-	6.4	10.1	598	595	44.4	-
		22	500	10,000	.377	.549	5.51	5.06	3.59	3.85	25.23	25.47	65.67	65.62	4.9	9.8	604	609	44.4	4.1
		29	500	10,000	.365	.371	5.60	3.68	3.64	4.89	22.35	23.43	68.41	68.00	1.7	4.8	701	-	16.7	33.3
		34	500	10,000	-	.337	5.16	3.63	4.03	5.06	22.35	23.29	68.46	68.02	.94	2.6	699	706	72.2	-
		53	500	10,000	.404	.577	5.16	2.05	3.81	5.90	22.51	24.59	68.52	67.46	.36	1.3	809	798	0	71.6
		56	500	4,000	.954	1.23	5.16	2.14	3.81	5.94	22.51	24.34	8.52	67.58	.36	5.6	804	-	-	69.1
5	Ni/Fe/ Al ₂ O ₃	5	500	10,000	.374	.514	-	-	4.39	4.54	22.94	22.93	-	-	6.4	53.1	592	594	78.9	-
		22	500	10,000	.420	.581	5.51	5.24	3.59	3.69	25.23	25.45	65.67	65.62	4.9	26.8	595	606	92.1	0
		29	500	10,000	.344	.350	5.60	5.22	3.64	3.96	22.35	22.47	68.41	68.35	1.7	10.9	695	-	0	6.9
		34	500	10,000	.366	.388	5.16	4.75	4.03	4.37	22.35	22.81	68.46	68.07	.94	6.62	697	704	100.0	10.9
		53	500	10,000	.382	.360	5.16	4.13	3.81	4.59	22.51	23.14	68.52	68.14	.36	4.39	801	801	39.5	18.2
		56	500	3,000	1.27	.859	5.16	3.99	3.81	4.68	22.51	23.06	68.52	68.27	.36	10.95	803	-	-	0

Table III
CATALYST TESTING SUMMARY

Run No.	Metal	Time On Stream Hrs.	Pressure PSIG	Dry Inlet S.V. v/v/hr.	S/G		% CO		% CO ₂		% H ₂		% CH ₄		ppm S		Temp., °F		% of Bed above Hot Spot	% CO Conversion
					In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out		
6	Fe/Cr/ K	6	500	10,000	-	.566	5.35	5.12	3.65	3.75	21.38	21.22	69.62	69.91	0	20.7	596	591	0	-
		23	500	10,000	.388	.484	6.17	5.71	3.90	4.03	24.93	24.99	65.00	65.27	1.3	24.8	605	608	53.8	22.5
		28	500	10,000	.420	.450	6.17	3.89	3.90	4.24	24.93	20.97	65.00	70.9	.54	48.4	704	702	15.4	42.3
		31	500	10,000	.420	.454	5.26	-	3.68	4.15	21.79	23.00	69.27	-	1.3	34.5	708	710	53.8	-
		50	500	10,000	.388	.379	4.96	2.52	3.34	5.23	20.50	21.75	71.2	70.5	1.4	25.8	811	802	0	49.6
		52	500	10,000	.434	.448	5.26	2.29	3.81	5.86	20.59	22.57	70.34	69.28	1.1	23.5	-	796	-	61.3
		55	500	10,000	.255	.198	6.96	4.28	4.40	5.72	37.01	37.10	51.63	52.9	4.8	62.7	-	784	-	39.2
		61	500	10,000	.275	.211	7.14	4.75	4.48	6.48	30.89	39.09	57.49	49.68	2.6	88.1	787	789	41.0	33.5
6	Ni/Cr/ Al ₂ O ₃	6	500	10,000	.385	.349	5.35	4.36	3.65	4.32	21.38	21.59	69.62	69.73	0	7.9	600	599	39.5	16.0
		23	500	10,000	.420	.375	6.17	4.71	3.90	4.62	24.93	25.17	65.00	65.5	1.3	1.7	607	613	65.8	17.6
		28	500	10,000	.433	.361	6.17	3.41	3.90	4.68	24.93	21.5	65.00	70.41	.54	5.2	707	707	26.3	42.2
		31	500	10,000	.420	.385	5.26	-	3.68	4.38	21.79	23.66	69.27	-	1.3	2.6	711	714	78.9	-
		50	500	10,000	.385	.347	4.96	2.83	3.34	4.93	20.50	21.62	71.2	70.62	1.4	5.7	809	807	13.2	40.6
		52	500	10,000	.442	.395	5.26	2.90	3.81	5.53	20.59	22.52	70.34	69.05	1.1	.47	-	803	-	47.8
		55	500	10,000	.279	.249	6.96	4.40	4.40	6.13	37.01	37.06	51.63	52.41	4.8	23.8	-	790	-	36.9
		61	500	10,000	.271	.020	7.14	7.61	4.48	3.80	30.89	36.88	57.49	51.71	2.6	72.2	783	789	100.0	0

TABLE III
CATALYST TESTING SUMMARY

Run No.	Metal	Time On Stream Hrs.	Pressure PSIG	Dry Inlet S. V. v/v/hr.	S/G		% CO		% CO ₂		% H ₂		% CH ₄		ppm S		Temperature °F		% of Bed above Hot Spot	% CO Conversion
					In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out		
7	Fe/Cr K/V	24	500	10,000	.423	.433	3.54	3.22	4.47	5.00	25.34	26.08	66.65	65.7	9.9	33.1	609	608	63.0	11.9
		30	500	10,000	.402	.390	3.54	2.88	4.47	5.43	25.34	26.32	66.65	65.37	10.4	118	-	700	-	20.1
		47	500	10,000	.550	.542	6.19	4.86	5.84	6.78	24.26	24.85	63.71	63.51	7.9	67.9	704	700	0.0	20.0
		50	500	10,000	.370	.333	3.52	1.63	5.68	7.18	26.11	27.46	64.69	63.73	4.7	38.7	804	797	19.6	53.4
		56	500	10,000	.351	.334	3.42	1.77	5.89	7.67	24.43	27.03	66.26	63.53	3.2	39.8	805	797	19.6	50.6
	Ni/Co/ Al ₂ O ₃	24	500	10,000	.405	.784	3.54	3.41	4.47	4.72	25.34	25.88	66.65	65.99	9.9	0	588	601	69.4	8.0
		30	500	10,000	.401	.501	3.54	3.27	4.47	4.97	25.34	26.08	66.65	65.68	10.4	56.2	-	700	-	22.7
		47	500	10,000	.568	.564	6.19	5.36	5.84	6.40	24.26	24.74	63.71	63.50	7.9	20.4	689	703	69.4	7.8
		50	500	10,000	.459	.399	3.52	2.86	5.68	6.02	26.11	26.09	64.69	65.03	4.7	35.0	801	801	7.8	5.2
		56	500	10,000	.354	.353	3.42	2.91	5.89	6.51	24.43	26.69	66.26	63.89	3.2	35.4	801	800	41.7	12.0

Table III
CATALYST TESTING SUMMARY

Run No.	Metal	Time On Stream Hrs.	Pressure PSIG	Dry Inlet S.V. v/v/hr.	S/G		% CO		% CO ₂		% H ₂		% CH ₄		ppm S		Temp., °F		% of Bed above Hot Spot	% CO Conversion
					In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out		
8	Co/Mo/Al ₂ O ₃ (low metals)	9	500	10,000	.400	.283	3.64	1.80	5.71	6.91	24.84	25.99	65.81	65.30	.1	.05	608	597	36.6	49.8
		25	500	10,000	.454	.340	3.28	2.14	3.41	5.16	23.58	25.32	69.73	67.38	1.4	59.0	614	607	36.6	33.2
		27	500	10,000	.383	.296	3.40	1.06	3.87	6.40	24.64	25.09	68.09	67.45	5.9	20.6	713	718	48.8	68.6
		31	500	10,000	.419	.347	3.40	.552	3.86	6.92	24.48	27.32	68.26	65.21	2.2	39.9	830	819	24.4	83.1
		33	500	10,000	.409	.342	3.40	.686	3.86	6.57	24.48	28.94	68.26	63.80	2.2	49.9	829	824	24.4	78.6
		36	500	10,000	.278	.168	7.21	2.60	2.59	-	37.6	39.66	52.6	-	-	-	801	798	36.6	62.7
		53	500	10,000	.290	.175	6.61	2.48	2.59	6.61	37.94	41.26	52.86	49.65	-	-	805	799	36.6	60.4
		57	500	10,000	.267	.108	8.0	3.78	4.16	7.01	42.48	45.12	45.36	44.09	-	-	797	793	24.4	50.5
		68	500	10,000	.300	.147	5.30	2.38	-	-	43.44	45.53	-	-	6.1	20.4	-	-	-	53.4
	Ni/Mo/Al ₂ O ₃ (low metals)	9	500	10,000	.395	.393	3.64	.223	5.71	7.73	24.84	27.00	65.81	65.05	.1	.09	615	603	36.6	93.7
		25	500	10,000	.387	.331	3.28	.585	3.41	6.37	23.58	27.99	69.73	65.06	1.4	40.0	616	612	36.6	81.1
		27	500	10,000	.370	.300	3.40	.400	3.87	6.51	24.64	28.03	68.09	65.06	5.9	25.2	715	722	36.6	87.7
		31	500	10,000	.436	.344	3.40	.485	3.86	6.21	24.48	25.83	68.26	67.48	2.2	6.1	832	822	24.4	85.5
		33	500	10,000	.423	.351	3.40	.523	3.86	6.93	24.48	29.01	68.26	63.54	2.2	24.0	829	826	36.6	83.6
		36	500	10,000	.277	.179	7.21	2.34	2.59	-	37.6	40.43	52.60	-	-	-	800	802	36.6	66.0
		53	500	10,000	.281	.0087	6.61	7.07	2.59	2.27	37.94	36.90	52.86	53.76	-	-	786	793	73.2	-5.2
		57	500	10,000	.260	.167	8.0	3.78	4.16	6.97	42.48	45.57	45.36	43.68	-	-	794	799	48.8	50.1
		68	500	10,000	.296	.243	5.30	2.44	-	-	43.44	40.61	-	-	6.1	10.1	-	-	-	56.2

Table III
CATALYST TESTING SUMMARY

Run No.	Metal	Time On Stream Hrs.	Pressure PSIG	Dry Inlet S.V. v/v/hr.	S/G		% CO		% CO ₂		% H ₂		% CH ₄		ppm S		Temp., °F		% of Bed above Hot Spot	% CO Conversion
					In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out		
9 Co/Mo/Al ₂ O ₃ (high metals)		5	500	10,000	.420	.317	3.97	3.75	4.84	4.78	24.11	24.02	67.08	67.45	2.2	5.4	601	602	23.3	5.7
		10	500	10,000	.398	.422	6.18	6.16	4.83	4.99	24.26	24.05	64.73	64.80	0.7	.6	598	595	0.0	0.6
		30	500	10,000	.430	.406	2.74	2.63	4.38	4.58	25.13	25.09	67.75	67.70	-	-	705	708	69.8	4.1
		34	500	10,000	.458	.521	2.74	2.56	4.38	4.65	25.13	25.05	67.75	67.74	2.8	7.4	702	702	23.3	6.7
		52	500	10,000	.410	.425	3.48	3.26	4.39	5.05	24.26	26.81	67.87	64.88	0.3	36.9	808	810	23.3	3.1
		54	500	10,000	.458	.462	2.56	2.14	3.73	3.69	25.11	24.47	68.60	69.70	4.3	49.2	805	807	23.3	17.1
Ni/Mo/Al ₂ O ₃ (high metals)		5	500	10,000	.393	.370	3.97	2.36	4.84	7.10	24.11	25.78	67.08	64.76	2.2	0	606	613	51.3	39.2
		10	500	10,000	.397	.451	6.18	4.23	4.83	6.61	24.26	25.62	64.73	63.54	0.7	0	594	603	64.1	30.3
		30	500	10,000	.414	.409	2.74	1.52	4.38	6.25	25.13	26.46	67.75	65.77	-	-	706	715	76.9	43.5
		34	500	10,000	.460	.579	2.74	1.45	4.38	6.29	25.13	26.43	67.75	65.83	2.8	2.8	706	709	25.6	46.1
		52	500	10,000	.427	.389	3.48	1.49	4.39	6.99	24.26	28.17	67.87	63.35	0.3	3.3	817	820	38.5	54.9
		54	500	10,000	.439	.400	2.56	.814	3.73	5.30	25.11	26.60	68.60	67.29	4.3	24.1	813	817	25.6	67.6

Table III
CATALYST TESTING SUMMARY

Run No.	Metal	Time On Stream Hrs.	Pressure PSIG	Dry Inlet S.V. v/v/hr.	S/G		% CO		%CO ₂		% H ₂		% CH ₄		ppm S		Temp., °F		% of Bed above Hot Spot	% CO Conversion
					In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out		
10	Fe/Cr/ Al ₂ O ₃	4	500	10,000	.397	.423	5.74	4.96	3.77	4.42	25.46	26.16	65.03	64.46	3.5	85.8	602	610	97.1	12.8
		7	500	10,000	.393	.356	3.99	2.63	3.66	5.66	25.75	27.41	66.60	64.30	1.8	158	720	715	38.2	32.6
		12	500	10,000	.406	.402	3.99	2.51	3.66	5.99	25.75	27.87	66.60	63.63	1.8	-	722	722	52.9	35.2
		29	500	10,000	.439	.438	5.31	1.64	4.58	7.75	24.10	27.34	66.01	63.27	5.4	95.3	817	818	67.6	67.7
		33	500	10,000	.439	.378	5.31	1.16	4.58	7.95	24.10	27.37	66.01	63.52	5.4	85.6	828	816	0.0	77.2
		39	500	10,000	.414	.363	5.26	1.39	3.81	7.39	25.18	28.53	65.75	62.69	2.5	37.0	830	816	38.2	72.3
		57	500	10,000	.373	.303	4.92	1.20	3.59	7.00	24.89	27.90	66.60	63.9	3.0	3.2	832	822	38.2	74.6
		63	500	10,000	.436	.325	4.67	1.28	3.79	7.34	23.45	26.85	68.09	64.53	5.0	2.7	829	820	38.2	71.3
		81	500	10,000	.384	.370	7.69	2.68	4.74	7.60	24.93	27.45	62.64	62.27	3.0	2.3	826	816	0.0	63.9
		85	500	10,000	.505	.429	7.36	2.68	3.73	6.98	23.35	26.32	65.56	64.02	5.6	3.7	828	822	52.9	62.1
		91	500	10,000	.414	.372	7.72	2.88	3.91	6.98	23.27	26.38	65.10	63.76	4.3	1.3	829	-	0.0	61.1
		108	500	10,000	.414	.383	5.31	2.17	3.98	6.24	20.31	23.21	70.40	68.38	8.2	5.5	820	821	38.2	57.6
		112	500	10,000	.414	.388	5.31	2.09	3.98	6.14	20.31	22.98	70.40	68.79	8.2	4.0	818	811	23.5	59.3
		132	500	10,000	.397	.383	5.34	2.49	3.89	5.89	24.94	26.87	65.83	64.75	2.0	4.2	824	817	23.5	52.1
		139	500	10,000	.414	.414	5.38	1.44	3.66	6.36	22.73	25.29	68.23	66.91	-	-	919	909	23.5	72.3
10	Fe/Cr	4	500	10,000	.410	.383	5.74	4.59	3.77	4.77	25.46	26.62	65.03	64.02	3.5	85.3	600	610	83.3	18.8
		7	500	10,000	.420	.304	3.99	1.15	3.66	6.96	25.75	28.90	66.60	62.99	1.8	14	725	717	23.8	69.9
		12	500	10,000	.414	.350	3.99	.966	3.66	7.43	25.75	29.19	66.60	62.41	1.8	-	723	724	23.8	74.6
		29	500	10,000	.430	.329	5.31	.744	4.58	8.58	24.10	28.03	66.01	62.65	5.4	73.5	843	815	23.8	85.2
		33	500	10,000	.444	.323	5.31	.759	4.58	8.38	24.10	27.84	66.01	63.02	5.4	67.6	832	809	11.9	85.0
		39	500	10,000	.422	.302	5.26	.688	3.81	8.27	25.18	29.90	65.75	61.14	2.5	59.0	827	812	23.8	86.0
		57	500	10,000	.398	.284	4.92	.753	3.59	7.56	24.89	28.54	66.60	63.15	3.0	3.4	828	815	23.8	83.9
		63	500	10,000	.444	.309	4.67	.684	3.79	8.07	23.45	27.69	68.09	63.56	5.0	5.6	830	816	23.8	84.5
		81	500	10,000	.398	.311	7.69	1.54	4.74	8.19	24.93	28.19	62.64	62.08	3.0	2.8	828	810	11.9	79.1
		85	500	10,000	.458	.308	7.36	1.32	3.73	7.94	23.35	27.57	65.56	63.17	5.6	4.0	828	815	23.8	81.0
		91	500	10,000	.446	.325	7.72	1.33	3.91	7.93	23.27	26.71	65.10	64.03	4.3	5.4	829	-	23.8	82.0
		108	500	10,000	.430	.343	5.31	.960	3.98	6.95	20.31	24.11	70.40	67.98	8.2	4.4	820	816	35.7	81.0
		112	500	10,000	.430	.311	5.31	.960	3.98	7.01	20.31	23.67	70.40	68.36	8.2	3.0	820	805	11.9	81.1
		132	500	10,000	.430	.322	5.34	1.22	3.89	6.73	24.94	27.62	65.83	64.43	2.0	4.4	825	813	11.9	76.3
		139	500	10,000	.430	.312	5.38	1.24	3.66	6.54	22.73	25.49	68.23	66.73	-	-	920	910	11.9	76.1

TABLE III
CATALYST TESTING SUMMARY

Run No.	Metal	Time On Stream Hrs.	Pressure PSIG	Dry Inlet S.V. v/v/hr.	S/G		% CO		% CO ₂		% H ₂		% CH ₄		ppm S		Temp., °F		% of Bed above Hot Spot	% CO Conversion
					In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out		
11	Ni/W / Al ₂ O ₃	3	500	10,000	.444	.356	5.38	4.72	3.69	3.97	22.88	23.29	68.05	68.02	7.6	71.5	603	605	54.5	11.8
		21	500	10,000	.398	.316	8.00	7.47	3.93	4.15	24.72	24.72	63.35	63.66	1.0	7.7	601	-	24.2	6.6
		25	500	10,000	.446	.349	8.00	6.84	3.93	4.40	24.72	24.85	63.35	63.91	1.0	275.3	708	714	84.8	14.4
		46	500	10,000	.430	.345	4.74	3.96	3.39	3.88	21.60	21.73	70.27	70.43	0.7	369.2	814	814	24.2	16.3
		51	500	10,000	.414	.313	4.74	3.84	3.39	3.88	21.60	21.58	70.27	70.70	0.7	78.4	814	818	84.8	19.0
	Fe/Cr/Mo / Al ₂ O ₃	3	500	10,000	.427	.414	5.38	4.22	3.69	4.25	22.88	23.43	68.05	68.10	7.6	152.0	606	608	30.8	21.0
		21	500	10,000	.384	.299	8.00	6.53	3.93	4.58	24.72	25.14	63.35	63.75	1.0	302.2	608	-	30.8	17.9
		25	500	10,000	.414	.322	8.00	4.50	3.93	5.62	24.72	26.04	63.35	63.84	1.0	547.6	713	718	56.4	42.7
		46	500	10,000	.426	.357	4.74	1.84	3.39	5.38	21.60	23.03	70.27	69.75	0.7	416.7	825	820	17.9	60.5
		51	500	10,000	.410	.308	4.74	1.81	3.39	5.42	21.60	23.12	70.27	69.65	0.7	67.3	822	824	30.8	61.1

TABLE III
CATALYST TESTING SUMMARY

Run No.	Metal	Time On Stream hrs.	Pressure PSIG	Dry Inlet S.V. v/v/hr.	S/G		%CO		%CO ₂		%H ₂		%CH ₄		ppmS		Temp., °F		% of Bed above Hot Spot	% CO Conversion
					In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out		
12	Fe/V/ Al ₂ O ₃	9	500	10,000	.458	.358	5.20	3.76	4.05	4.80	24.44	24.86	66.31	66.58	8.2	20.3	598	594	0.0	27.3
		16	500	10,000	.431	.342	5.16	1.59	3.89	6.28	25.82	27.31	65.13	64.82	2.5	59.3	706	-	67.6	68.6
		23	500	10,000	.420	.270	4.82	1.39	3.99	6.43	24.43	26.78	66.76	65.40	3.6	95.0	812	811	40.5	70.2
		31	500	10,000	.414	.288	4.73	1.43	3.53	5.93	28.96	30.72	62.78	61.92	3.8	78.5	811	810	40.5	69.0
		37	500	10,000	.440	.314	4.95	1.57	3.58	6.08	29.06	31.26	62.41	61.09	3.8	75.6	810	806	27.0	67.3
		44	500	10,000	.261	.232	4.53	1.34	3.52	5.96	21.68	23.95	70.27	68.75	3.5	102.0	-	-	-	69.5
		50	500	10,000	.280	.244	4.55	1.50	3.62	5.77	23.22	26.68	68.61	66.05	2.6	57.0	-	-	-	65.5
		56	500	10,000	.274	.188	4.46	1.40	3.57	5.86	22.17	24.49	69.80	68.25	-	-	-	-	-	67.6
	Ni/Mn / Al ₂ O ₃	59	500	10,000	.242	.114	4.88	2.68	3.59	4.96	21.21	22.74	70.32	69.62	1.4	49.7	-	-	-	44.0
		62	500	10,000	.189	.151	4.53	1.82	3.27	4.69	25.24	25.80	66.96	67.69	4.3	47.9	-	-	-	59.5
		68	500	10,000	-	1.74	4.48	3.74	3.30	3.83	26.34	25.64	65.88	66.79	4.2	106.9	-	-	-	17.3
		9	500	10,000	.414	.386	5.20	4.17	4.05	3.88	24.44	24.94	66.31	67.01	8.2	70.5	591	597	57.6	19.3
		16	500	10,000	.406	.334	5.16	2.88	3.89	5.41	25.82	25.84	65.13	65.87	2.5	23.3	704	-	57.6	44.2
		23	500	10,000	.414	.386	4.82	2.08	3.99	5.87	24.43	26.47	66.76	65.58	3.6	47.8	814	816	42.4	55.6
		31	500	10,000	.398	.409	4.73	2.24	3.53	5.41	28.96	30.18	62.78	62.17	3.8	45.5	810	813	72.7	51.8
		37	500	10,000	.423	.353	4.95	2.51	3.58	5.36	29.06	30.47	62.41	61.66	3.8	24.0	809	812	57.6	48.3
		44	500	10,000	.277	.181	4.53	2.58	3.52	5.09	21.68	23.05	70.27	69.28	3.5	48.5	-	-	-	42.0
		50	500	10,000	.287	.302	4.55	2.30	3.62	5.27	23.22	25.60	68.61	66.83	2.6	14.7	-	-	-	47.8
		56	500	10,000	.280	.214	4.46	2.22	3.57	5.09	22.17	23.56	69.80	69.13	-	-	-	-	-	49.3
		59	500	10,000	.248	.128	4.88	3.57	3.59	4.34	21.21	-	70.32	-	1.4	17.4	-	-	-	-
		62	500	10,000	.156	.113	4.53	3.53	3.27	3.52	25.24	24.77	66.96	68.18	4.3	19.3	-	-	-	22.6
		68	500	10,000	.159	.155	4.48	2.98	3.30	4.27	26.34	26.20	65.88	66.55	4.2	29.1	-	-	-	33.6

TABLE III
CATALYST TESTING SUMMARY

Run No.	Metal	Time On Stream Hrs.	Pressure PSIG	Dry Inlet S. V. v/v/hr.	S/G		% CO		% CO ₂		% H ₂		% CH ₄		ppm S		Temp., °F		% of Bed above Hot Spot	% CO Conversion
					In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out		
13	2Ni/1Cr	3	500	10,000	.404	.313	4.26	1.59	3.08	4.32	25.70	30.21	66.96	63.88	-	-	825	830	51.2	39.7
		21	500	10,000	.424	.303	4.69	2.07	3.45	5.26	22.44	24.78	69.42	67.89	3.3	34.9	-	-	-	54.5
		27	500	10,000	.446	.322	4.22	1.98	3.17	4.81	-	-	-	-	3.9	38.0	-	-	-	-
		31	500	10,000	.118	.134	3.82	2.11	3.32	4.45	25.20	26.52	67.66	66.92	3.9	27.9	-	-	-	43.7
		35	500	10,000	.122	.142	3.89	2.28	3.55	4.79	22.44	24.68	70.12	68.25	6.4	31.8	-	-	-	39.6
		40	500	10,000	.109	.134	3.54	2.24	3.54	4.71	23.54	24.55	69.38	68.50	4.8	21.1	-	-	-	35.9
		43	500	10,000	.105	.140	2.34	1.51	8.91	8.96	22.38	22.15	66.37	67.38	4.6	17.3	-	-	-	35.7
		59	500	10,000	.112	.188	3.64	2.57	8.81	9.49	21.87	22.36	65.68	65.58	4.6	16.4	806	801	39.0	29.0
		81	500	10,000	.137	.193	4.35	3.81	19.86	20.15	22.23	22.77	53.56	53.27	-	15.7	-	-	-	11.8
		85	500	10,000	-	.190	4.42	3.54	20.12	19.96	21.88	22.37	53.58	54.13	-	15.1	-	-	-	19.4
		88	500	10,000	-	.210	4.80	4.07	19.95	20.38	21.94	21.85	53.31	53.70	-	-	-	-	-	9.2
	Ni/V/ Al ₂ O ₃	3	500	10,000	.417	.372	4.26	1.90	3.08	4.07	25.70	30.36	66.96	63.67	-	-	829	833	47.4	52.4
		21	500	10,000	.413	.378	4.69	2.24	3.45	5.09	22.44	24.39	69.42	68.28	3.3	33.6	-	-	-	51.0
		27	500	10,000	.434	.411	4.22	2.29	3.17	4.45	-	-	-	-	3.9	29.0	-	-	-	-
		31	500	10,000	.125	.096	3.82	2.64	3.32	4.08	25.20	25.95	67.66	67.33	3.9	22.3	-	-	-	45.2
		35	500	10,000	.128	.082	3.89	3.35	3.55	4.29	22.44	23.51	70.12	68.85	6.4	21.1	-	-	-	12.7
		40	500	10,000	.125	.087	3.54	2.86	3.54	4.20	23.54	23.80	69.38	69.14	4.8	20.7	-	-	-	18.9
		43	500	10,000	.132	.122	2.34	1.66	8.91	8.92	22.38	21.08	66.37	68.34	4.6	17.5	-	-	-	30.2
		59	500	10,000	.112	.122	3.64	2.93	8.81	9.27	21.87	22.06	65.68	65.74	4.6	17.6	810	804	34.2	19.3
		81	500	10,000	.175	.144	4.35	3.82	19.86	19.52	22.23	-	53.56	-	-	15.4	-	-	-	-
		85	500	10,000	-	.171	4.42	3.90	20.12	19.87	21.88	22.08	53.58	54.15	-	14.3	-	-	-	11.5
		88	500	10,000	-	.198	4.80	4.32	19.95	20.36	21.94	21.81	53.31	53.51	-	-	-	-	-	10.1

Table III
CATALYST TESTING SUMMARY

Run No.	Metal	Time On Stream Hrs.	Pressure PSIG	Dry Inlet S. V. v/v/hr.	S/G		% CO		% CO ₂		% H ₂		% CH ₄		ppm S		Temp., °F		% of Bed above Hot Spot	% CO Conversion
					In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out		
14	1Ni/1Cr	6	500	10,000	.424	.345	5.26	2.41	2.32	4.64	24.46	26.77	67.96	66.18	-	-	800	-	-	52.7
		12	500	10,000	.425	.363	4.89	2.38	2.37	4.49	-	-	-	-	-	-	-	-	-	-
		16	500	10,000	.380	.295	5.25	1.32	2.42	5.12	25.18	27.19	67.15	66.37	-	-	-	-	-	74.2
		21	500	10,000	.399	.246	4.33	1.31	3.45	5.95	24.64	26.86	67.58	65.88	-	-	-	-	-	68.8
		27	500	10,000	.422	.270	4.63	1.18	3.48	6.14	24.82	26.90	67.07	65.78	-	-	-	-	-	73.8
		(1050° (32	500	10,000	.318	.222	9.30	4.33	4.12	7.48	38.14	40.48	48.44	47.71	-	-	1049	-	-	51.6
		Gas Comp)(38	500	10,000	.299	.237	9.42	4.66	4.20	7.33	38.12	39.93	48.26	48.08	-	-	-	-	-	49.0
		(41	500	10,000	.299	.244	8.80	4.21	4.23	6.88	38.74	39.80	48.23	49.11	-	-	-	-	-	51.3
		(48	500	10,000	.219	.177	10.09	6.81	3.93	5.32	47.94	46.99	38.04	40.88	3.0	100.4	1148	-	0.0	33.7
		(1150° (53	500	10,000	.206	.182	9.84	6.71	4.31	5.44	48.08	49.92	37.77	37.93	2.7	23.2	1141	1152	23.7	29.7
		Gas Comp)(58	500	10,000	.206	.185	9.91	5.82	4.53	6.30	48.53	48.06	37.03	39.82	-	-	-	-	-	41.8
	1Fe/1Cr	6	500	10,000	.434	.397	5.26	1.05	2.32	5.58	24.46	27.81	67.96	65.56	-	-	800	-	-	79.1
		12	500	10,000	.446	.380	4.89	.883	2.37	5.73	-	-	-	-	-	-	-	-	-	-
		16	500	10,000	.446	.402	5.25	.991	2.42	5.30	25.18	27.50	67.15	66.21	-	-	-	-	-	80.5
		21	500	10,000	.434	.324	4.33	1.10	3.45	6.13	24.64	26.78	67.58	65.99	-	-	-	-	-	73.9
		27	500	10,000	.432	.301	4.63	.960	3.48	6.23	24.82	27.06	67.07	65.75	-	-	-	-	-	78.6
		(1050° (32	500	10,000	.319	.242	9.30	4.37	4.12	7.42	38.14	40.48	48.44	47.73	-	-	1050	-	-	51.2
		Gas Comp)(38	500	10,000	.315	.192	9.42	6.64	4.20	4.11	38.12	29.43	48.26	59.82	-	-	-	-	-	38.2
		(41	500	10,000	.315	.296	8.80	3.09	4.23	7.33	38.74	40.78	48.23	48.80	-	-	-	-	-	63.7
		(48	500	10,000	.227	.161	10.09	7.34	3.93	5.56	47.94	48.82	38.04	38.28	3.0	8.3	1143	-	28.6	26.0
		(1150° (53	500	10,000	.220	.152	9.84	5.94	4.31	5.61	48.08	49.47	37.77	38.98	2.7	4.9	1145	1142	16.7	38.0
		Gas Comp)(58	500	10,000	.211	.191	9.91	6.04	4.53	6.65	48.53	49.58	37.03	37.73	-	-	-	-	-	37.8

Table III
CATALYST TESTING SUMMARY

Run No.	Metal	Time On Stream Hrs.	Pressure PSIG	Dry Inlet S.V. v/v/hr.	S/G		% CO		% CO ₂		% H ₂		% CH ₄		ppm S		Temp., °F		% of Bed above Hot Spot	% CO Conversion
					In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out		
15	Ni-Cr-MgO	5	500	10,000	.276	.220	5.60	2.78	4.72	7.09	23.34	25.99	66.34	64.14	-	-	-	-	-	48.6
		9	500	10,000	.276	.231	5.79	1.44	4.79	7.68	23.53	26.29	65.89	64.59	-	-	-	-	-	74.2
		15	500	10,000	.276	.263	5.85	1.67	4.65	7.60	23.80	26.59	65.70	64.14	4.3	33.4	-	-	-	70.4
	(1150° Gas Comp)	18	500	10,000	.654	.537	10.06	3.91	4.54	7.85	48.00	49.34	37.40	38.90	-	-	1148	1161	48.8	60.1
		23	500	10,000	.339	.252	10.03	6.03	4.52	7.41	47.76	49.60	31.68	30.48	-	-	1095	1092	25.6	36.7
		28	500	10,000	.323	.179	3.53	2.18	3.60	5.66	26.46	28.88	65.17	61.50	-	-	807	809	48.8	35.6
		33	500	10,000	.326	.244	5.05	1.80	3.93	6.01	25.50	27.43	62.00	61.19	-	-	806	812	72.1	63.3
	Ni-Cr-MgSiO ₃	5	500	10,000	.346	.256	5.60	1.83	4.72	7.81	23.34	-	66.34	-	-	-	-	-	-	-
		9	500	10,000	.335	.295	5.79	2.42	4.79	7.01	23.53	25.35	65.89	65.22	-	-	-	-	-	57.2
		15	500	10,000	.337	.335	5.85	2.56	4.65	6.89	23.80	25.94	65.70	64.61	4.3	29.5	-	-	-	55.0
		18	500	10,000	.301	.445	10.06	5.03	4.54	6.15	48.00	42.97	37.40	45.85	-	-	1174	1226	71.0	54.4
		23	500	10,000	.318	.338	10.03	4.74	4.52	6.78	47.76	46.95	31.68	36.35	-	-	1104	1122	71.0	54.4
	(1150° Gas Comp)	28	500	10,000	.316	.332	3.53	2.75	3.60	4.38	26.46	27.42	65.17	61.42	-	-	807	806	18.4	17.8
		33	500	10,000	.318	.301	5.05	3.65	3.93	4.85	25.50	26.21	62.00	65.38	-	-	808	810	57.9	30.6

Table III
CATALYST TESTING SUMMARY

CATALYST TESTING SUMMARY																				
Run No.	Metal	Time On Stream Hrs.	Pressure PSIG	Dry Inlet S.V. v/v/hr.	S/G		% CO		%CO ₂		% H ₂		% CH ₄		ppm S		Temp., °F		% of Bed above	% CO
					In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	Hot Spot	Conversion
16	Ni-Cr-	3	500	10,000	.284	.160	4.69	3.56	3.97	4.58	25.11	25.52	56.16	63.79	-	-	807	800	-	31.6
	SiO ₂	7	500	10,000	.295	.198	5.38	4.08	3.72	4.42	25.42	25.61	64.68	74.06	-	-	-	-	-	32.2
	(1150°	(14	500	10,000	-	.553	11.11	5.67	4.63	8.02	43.80	45.34	33.34	33.01	-	-	1104	1116	-	46.4
	Gas Comp)	(18	500	10,000	-	.354	11.61	5.86	4.74	7.56	43.39	43.60	37.77	37.77	-	-	-	-	-	46.6
	Ni-Cr-	3	500	10,000	.315	.258	4.69	1.27	3.97	6.32	25.11	27.08	56.16	62.60	-	-	815	814	-	75.0
	MgAl ₂ O ₄	7	500	10,000	.311	.222	5.38	1.35	3.72	5.88	25.42	27.07	64.68	67.34	-	-	-	-	-	75.2
	(1150°	(14	500	10,000	.307	.245	11.11	6.53	4.63	7.66	43.80	44.89	33.34	33.28	-	-	1112	1119	-	39.2
	Gas Comp)	(18	500	10,000	.329	.197	11.61	6.47	4.74	7.51	43.39	44.11	37.77	36.93	-	-	-	-	-	40.8
17	Ni-Cr	5	500	10,000	.282	.188	5.12	2.17	3.36	5.65	24.18	25.69	67.34	66.49	-	-	811	805	45.0	56.8
	(1150°	(9	500	10,000	.307	.211	10.81	6.99	4.71	6.83	42.88	43.11	37.77	37.84	-	-	1122	1112	32.5	33.3
	Gas Comp)	(12	500	10,000	.267	.239	10.23	5.20	4.44	6.59	50.74	52.44	38.19	30.91	-	-	1112	1108	45.0	37.1
	Ni-Cr-	5	500	10,000	.313	.284	5.12	2.06	3.36	5.59	24.18	25.74	67.34	66.49	-	-	813	808	32.5	58.9
	Al ₂ O ₃	(9	500	10,000	.341	.282	10.81	5.46	4.71	7.37	42.88	41.18	37.77	37.44	-	-	1131	1139	57.5	46.5
	(1150°	(12	500	10,000	.294	.217	10.23	4.98	4.44	5.89	50.74	48.88	38.19	38.30	-	-	1132	1137	57.5	47.7
	Gas Comp)																			
18	Pt-	4	500	10,000	.326	.334	4.87	1.34	3.45	4.92	24.57	25.80	64.17	62.87	-	-	-	-	-	71.1
	Al ₂ O ₃	(7	500	10,000	.318	.228	12.66	9.66	4.44	5.60	50.01	54.40	30.96	32.22	-	-	1113	1110	34.9	22.8
	Ru-	4	500	10,000	.335	.247	4.87	3.18	3.45	4.46	24.57	25.68	64.17	63.26	-	-	-	-	-	33.2
	Al ₂ O ₃	(7	500	10,000	.345	.479	12.66	7.31	4.44	6.97	50.01	55.87	30.96	31.77	-	-	1112	1100	56.1	39.7

Table II
CATALYST TESTING SUMMARY

Run No.	Metal	Time On Stream Hrs.	Pressure PSIG	Dry Inlet S. V. v/v/hr.	S/G		% CO		% CO ₂		% H ₂		% CH ₄		Temperature, °F			% of Bed above Hot Spot	% CO Conversion
					In	Out	In	Out	In	Out	In	Out	In	Out	In	Hot Spot	Out		
19	Ni/Cr/ MgAl ₂ O ₄	4	500	10,000	.458	.367	4.36	1.78	3.40	5.14	25.84	28.03	58.34	57.20	612	615	599	29.7	57.9
		8	500	10,000	.447	.348	3.95	.703	3.35	5.83	26.40	27.79	63.75	62.55	718	723	703	29.7	81.7
		13	500	10,000	.458	.356	3.89	.712	3.35	5.77	26.55	28.75	64.05	60.72	818	822	804	29.7	80.6
		17	500	10,000	.267	.168	8.86	4.88	4.37	6.94	48.27	48.89	32.01	29.24	918	920	897	29.7	39.3
		21	500	10,000	.217	.147	10.45	5.05	4.42	7.46	52.89	55.39	33.17	29.82	918	922	905	43.2	45.2
		25	500	10,000	.202	.111	8.00	4.43	4.18	6.05	52.70	53.73	34.29	32.04	915	916	895	16.2	39.5
		41	500	10,000	.207	.151	10.65	6.34	4.20	7.03	46.85	47.89	35.96	35.31	1025	1041	1007	29.7	37.9
		48	500	10,000	.187	.161	9.03	5.81	4.03	5.70	50.60	50.17	30.53	35.99	1035	1055	1011	56.8	41.0
		65	500	10,000	.199	.207	10.16	4.74	4.18	6.08	45.89	39.04	45.73	56.55	1187	1223	1136	29.7	58.4
		69	500	10,000	.199	.283	9.22	4.16	3.99	4.26	48.91	39.09	40.36	51.20	1180	1291	1130	29.7	59.5
	Ni/Cr/ MgSiO ₃	75	500	10,000	0	.0022	18.37	18.37	2.48	2.48	68.50	69.53	10.0	10.0	509	510	510	-	-
		80	500	10,000	0	-	-	-	-	-	No Reaction		-	-	665	666	661	-	-
		85	500	10,000	0	-	-	-	-	-	No Reaction		-	-	757	753	767	-	-
		92	500	10,000	0	.0039	17.56	19.12	2.05	1.94	-	-	30.55	30.39	926	937	914	29.7	-
		4	500	10,000	.447	.527	4.36	3.55	3.40	4.04	25.84	27.24	58.34	59.78	603	606	603	48.6	20.1
		8	500	10,000	.447	.457	3.95	2.26	3.35	4.69	26.40	27.02	63.75	66.91	711	714	709	48.6	45.0
		13	500	10,000	.443	.457	3.89	1.62	3.35	5.18	26.55	28.19	64.05	61.11	812	815	809	35.1	56.3
		17	500	10,000	.226	.118	8.86	7.08	4.37	3.93	48.27	43.10	32.01	41.36	955	1034	976	48.6	31.0
		21	500	10,000	.280	.267	10.45	5.02	4.42	7.20	52.89	55.06	33.17	30.30	913	920	903	35.1	45.7
		25	500	10,000	.198	.137	8.00	5.51	4.18	5.03	52.70	52.69	34.29	32.27	913	920	905	48.6	25.2
		41	500	10,000	.200	.147	10.65	7.33	4.20	3.99	46.85	34.90	35.96	49.65	1060	1159	1113	62.2	42.6
		48	500	10,000	.192	.097	9.03	4.64	4.03	3.07	50.60	36.59	30.53	53.97	1199	1248	1059	21.6	63.7
		65	500	10,000	.415	.210	10.16	6.02	4.18	6.48	45.89	40.57	45.73	78.66	1147	1201	1156	35.1	61.0
		69	500	10,000	.224	.305	9.22	3.48	3.99	4.30	48.91	38.64	40.36	48.71	1140	1260	1160	35.1	64.2
		75	500	10,000	0	.0024	18.37	18.37	2.48	2.48	68.51	69.52	10.0	10.0	511	512	512	-	-
		80	500	10,000	0	-	-	-	-	-	No Reaction		-	-	670	670	-	-	-
		85	500	10,000	0	-	-	-	-	-	No Reaction		-	-	757	756	-	-	-
		92	500	10,000	0	.0066	17.56	19.90	2.05	1.96	-	-	30.55	29.52	935	930	921	48.6	-

TABLE III
CATALYST TESTING SUMMARY

Run No.	Metal	Time On Stream Hrs.	Pressure PSIG	Dry Inlet	S/G		%CO		%CO ₂		% H ₂		% CH ₄		ppm S		Temp., °F		% Bed above Hot Spot	% CO Conv.	
				S. V. v/v/hr.	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	Spot		
19 (cont'd)	Ni/Cr/ MgSiO ₃	5	500	10,000	.247	.133	9.22	6.12	3.45	4.11	39.78	34.58	41.84	55.13	-	-	1067	-	-	44.6	
		10	500	10,000	.232	.120	9.63	7.16	3.36	4.58	40.55	40.60	40.31	55.81	5.0	112.3	1013	1035	77.8	41.3	
		14	500	10,000	.075	.054	11.89	5.34	4.49	4.49	47.81	37.36	35.81	52.81	-	-	1249	1125	36.1	62.6	
		19	500	10,000	.081	.111	12.29	7.52	4.44	4.97	46.89	40.50	36.38	47.01	-	-	1044	1056	63.9	45.4	
		25	500	5,000	.074	.138	12.38	5.79	4.06	4.54	46.42	35.32	37.17	54.35	-	-	1152	-	36.1	61.2	
		30	500	5,000	.034	.131	12.11	5.36	4.63	4.85	47.11	35.18	36.15	54.61	-	-	1152	-	50.0	63.9	
	Ni/Cr/ MgAl ₂ O ₄	5	500	10,000	.173	.078	9.22	10.16	3.45	4.59	39.78	39.59	41.84	60.57	-	-	1012	-	-	20.3	
		10	500	10,000	.215	.074	9.63	6.80	3.36	5.15	40.55	42.66	40.31	41.12	5.0	122.6	1012	1016	57.5	29.1	
		14	500	10,000	.093	.021	11.89	6.99	4.49	4.30	47.81	41.75	35.81	46.96	-	-	1209	1142	32.5	47.3	
		19	500	10,000	.081	.065	12.29	11.09	4.44	4.30	46.89	45.84	36.38	36.38	-	-	1011	1118	57.5	11.5	
		25	500	5,000	.144	.094	12.38	8.28	4.06	4.31	46.42	38.68	37.17	48.73	-	-	1136	1115	45.0	41.5	
		30	500	5,000	.049	.079	12.11	7.25	4.63	4.81	47.11	37.77	36.15	50.17	-	-	1138	1124	57.5	49.1	
	20	Pt/MgSiO ₃	3	500	10,000	.426	.087	5.22	5.30	3.09	3.07	26.69	28.09	65.00	63.54	-	-	808	811	100.0	0.0
			13	500	10,000	.395	.615	5.12	2.88	3.46	4.98	25.07	27.42	66.35	64.72	5.5	9.8	810	819	77.5	41.9
18			500	10,000	.206	.070	12.01	12.05	4.69	4.08	47.70	49.57	35.60	34.30	-	-	1102	1107	52.5	0.0	
22			500	10,000	-	-	10.85	9.38	4.68	6.07	44.97	45.75	39.50	38.80	-	-	-	-	55.0	12.3	
Ru/MgSiO ₃		3	500	10,000	.375	.274	5.22	4.82	3.09	2.66	26.69	29.93	65.00	62.59	-	-	812	816	20.5	3.4	
		7	500	10,000	.375	.300	5.32	5.07	3.84	3.67	23.32	25.73	67.52	65.53	-	-	-	818	71.8	1.6	
		13	500	10,000	.375	.276	5.12	4.92	3.46	3.47	25.07	26.50	66.35	65.11	5.5	3.0	817	819	33.3	2.0	
		18	500	10,000	.190	.149	12.01	10.89	4.69	4.90	47.70	49.94	35.60	34.27	-	-	1109	-	59.0	5.3	
		22	500	10,000	-	-	10.85	11.03	4.68	4.96	44.97	48.93	39.50	35.08	-	-	-	-	-	0.0	

TABLE III
CATALYST TESTING SUMMARY

Run No.	Metal	Time On Stream Hrs.	Pressure PSIG	Dry Inlet	S/G		%CO		%CO ₂		% H ₂		% CH ₄		ppm S		Temp., °F		% of Bed above Hot Spot	% CO Conv.	
				S. V. v/v/hr.	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out			
21	Ni/ MgAl ₂ O ₄	19	500	10,000	.419	.219	5.27	2.04	4.13	6.33	23.26	26.93	67.34	64.70	--	--	815	817	45.2	59.3	
		25	500	10,000	.419	.213	5.30	2.07	4.18	6.22	25.35	27.77	65.17	63.94	--	--	--	--	--	59.6	
		30	500	10,000	.252	.140	11.64	8.97	4.35	5.48	49.31	50.29	34.70	35.26	5.31	1025	--	--	--	21.4	
		34	500	10,000	.252	.177	11.87	7.85	4.33	6.06	48.93	50.15	34.87	35.94	--	--	--	--	--	32.2	
	Ni/ MgSiO ₃	19	500	10,000	.428	.422	5.27	3.81	4.13	5.10	23.26	24.73	67.34	66.36	--	--	812	812	29.4	26.3	
		25	500	10,000	.428	.452	5.30	3.48	4.18	5.16	25.35	26.83	65.17	64.53	--	--	--	--	--	33.0	
		30	500	10,000	.196	.234	11.64	7.27	4.35	6.69	49.31	51.77	34.70	34.27	5.3	713	--	--	--	34.5	
		34	500	10,000	.196	.234	11.87	9.50	4.33	4.94	48.93	49.39	34.87	36.17	--	--	--	--	--	19.2	
	22	Ni/Al ₂ O ₃	3	500	10,000	.385	.308	5.38	4.35	3.67	3.77	25.79	30.04	65.16	61.84	--	--	809	806	41.0	14.2
			7	500	10,000	.385	.282	5.51	5.19	3.49	3.68	27.55	28.74	63.45	62.39	--	--	--	--	--	4.2
			31	500	10,000	.183	.185	11.51	10.00	4.50	5.67	49.67	50.24	34.32	34.09	--	--	1110	1113	41.0	12.1
			36	500	10,000	.183	.185	11.59	9.24	4.48	5.92	48.38	50.35	35.55	34.49	7.1	57.6	1110	1105	35.0	17.1
Ni/Cr/V/ MgSiO ₃		3	500	10,000	.416	.388	5.38	1.25	3.67	6.29	25.79	32.36	65.16	60.10	--	--	821	814	10.0	74.5	
		7	500	10,000	.416	.403	5.51	1.25	3.49	6.19	27.55	31.79	63.45	60.77	--	--	--	--	--	75.9	
		31	500	10,000	.180	.265	11.51	5.89	4.50	6.49	49.67	44.23	34.32	43.39	--	--	1184	1142	47.5	53.8	
		36	500	10,000	.188	.257	11.59	6.16	4.48	6.66	48.38	46.24	35.55	40.94	7.1	77.3	1187	1133	15.4	49.0	

TABLE III
CATALYST TESTING SUMMARY

No. Run	Metal	Time On Stream Hrs.	Pressure PSIG	Dry Inlet S.V. v/v/hr.	S/G		% CO		% CO ₂		% H ₂		% CH ₄		ppm S		Temp., °F		% of Bed above Hot Spot	% CO Conversion
					In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out		
23	Ni/V/ MgSiO ₃	3	500	10,000	-	.216	5.18	3.50	3.64	4.76	26.66	28.95	64.52	62.79	-	-	824	833	78.4	30.3
		9	500	10,000	.438	.275	5.14	2.97	3.58	5.22	27.27	29.03	64.01	62.78	-	-	835	852	100	40.8
		13	500	10,000	.224	.276	11.39	6.98	4.41	6.52	49.38	53.00	34.82	33.50	-	-	1125	1131	100	34.0
		18	500	10,000	.208	.294	11.31	7.48	4.46	7.03	49.23	50.72	35.00	34.77	-	-	1121	1131	100	31.9
	Ni/Cr/V MgAl ₂ O ₄	3	500	10,000	-	.249	5.18	1.14	3.64	6.31	26.66	30.57	64.52	61.98	-	-	841	839	32.4	76.8
		9	500	10,000	.391	.328	5.14	0.43	3.58	6.77	27.27	30.77	64.01	62.03	-	-	847	856	100	91.2
		13	500	10,000	.236	.238	11.39	5.95	4.41	6.56	49.38	48.79	34.82	38.70	-	-	1184	1151	17.6	48.4
		18	500	10,000	.225	.241	11.31	6.38	4.46	6.63	49.23	46.95	35.00	40.04	-	-	1206	1145	2.9	46.0

CATALYST TESTING SUMMARY

Run No.	Metal	Time On	Pressure	Inlet	S/G		% CO		% CO ₂		% H ₂		% CH ₄		ppm S		Temp., °F		% of Bed	% CO	
		Stream		S. V.	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	above	Conversion	
		Hrs.	PSIG	v/v/hr.															Hot Spot		
24	Ni/V/ SiO ₂	5	500	10,000	.415	.332	4.92	4.60	3.54	3.80	22.74	23.40	68.80	68.20	-	-	811	817	75.0	5.7	
		8	500	10,000	.216	.107	10.81	7.11	4.47	5.85	49.90	50.68	34.82	36.35	-	-	1163	1115	19.4	33.2	
		11	500	10,000	.217	.228	11.18	7.33	4.62	6.14	49.43	52.41	34.77	34.12	-	-	-	-	-	30.3	
	Ni/V/ MgAl ₂ O ₄	5	500	10,000	.423	.276	4.92	1.87	3.54	5.74	22.74	25.56	68.80	66.83	-	-	820	823	31.0	60.6	
		8	500	10,000	.196	.152	10.81	6.79	4.47	5.43	49.90	49.08	34.82	38.70	-	-	1182	1111	19.0	38.2	
		11		10,000	.183	.138	11.18	6.73	4.62	5.21	49.43	45.95	34.77	42.11	-	-	-	-	-	43.7	
	25	Ni/Mn/ MgSiO ₃	3	500	10,000	.381	-	4.69	1.72	3.58	5.51	26.87	33.81	64.86	58.96	-	-	810	805	21.1	59.5
			8	500	10,000	.215	.137	10.98	13.18	4.64	2.77	49.41	47.13	34.97	36.92	-	-	1099	1099	34.2	0
		Ni/Pt/ MgSiO ₃	3	500	10,000	.382	-	4.69	2.40	3.58	4.79	26.87	31.42	64.86	61.39	-	-	808	808	39.0	45.4
8			500	10,000	.221	.182	10.98	9.38	4.64	5.70	49.41	50.30	34.97	34.62	-	-	1107	1100	2.4	13.0	
26	1-1 Ni-Cr /Pt	7	500	10,000	.378	-	5.07	2.83	3.58	5.32	26.35	27.97	65.00	63.88	15.1	51.4	816	818	82.5	42.9	
		11	500	10,000	.167	.202	11.17	7.99	5.01	7.03	48.07	50.03	35.75	34.95	-	-	1116	1118	68.6	25.7	
	Ni/Pt/SiO ₂	7	500	10,000	.353	-	5.07	4.86	3.58	3.79	26.35	26.99	65.00	64.36	15.1	62.5	810	802	32.4	3.3	
		11	500	10,000	.207	.184	11.17	10.03	5.01	5.46	48.07	49.27	35.75	35.24	-	-	-	-	-	8.1	

Table III
CATALYST TESTING SUMMARY

Run No.	Metal	Time On Stream Hrs.	Pressure PSIG	Dry Inlet S. V. v/v/hr.	S/G		Mole % H ₂		Mole % CO		Mole % CO ₂		Mole % CH ₄		ppm S		Temp., °F		% of Bed above Hot Spot	% CO Conversion
					In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out		
27	Ni-Cr-MgSiO ₃	5	500	10,000	.335	.262	21.26	20.73	4.79	2.68	3.86	5.37	70.09	71.22	-	-	709	719	62.1	44.4
		9	500	10,000	.374	.318	22.93	23.20	4.92	2.49	3.65	5.27	68.50	69.04	-	-	711	705	35.1	49.2
		14	500	10,000	.182	.113	22.53	25.44	4.88	2.90	3.64	4.96	68.95	66.70	-	-	718	713	48.6	38.3
		20	500	10,000	.265	.236	51.25	46.00	9.88	5.38	4.29	5.68	34.58	42.94	-	-	1180	1113	21.6	50.8
		27	500	10,000	.253	.219	51.05	46.30	9.88	6.45	4.33	5.15	34.74	42.10	-	-	1164	1117	48.6	40.5
		32	500	10,000	.045	.096	50.97	39.92	9.93	5.95	4.24	3.55	34.86	50.58	-	-	1243	1125	35.1	51.1
		40	500	10,000	.075	.178	52.95	35.21	10.18	4.03	3.97	3.70	32.90	57.06	-	-	1295	1124	21.6	71.3
	Ni-Cr-MgAl ₂ O ₄	5	500	10,000	.352	.258	21.26	27.97	4.79	1.05	3.86	6.54	70.09	64.44	-	-	714	718	55.3	76.0
		9	500	10,000	.410	.280	22.93	24.94	4.92	0.96	3.65	6.23	68.50	67.83	-	-	716	708	28.9	80.0
		14	500	10,000	.227	.208	22.53	25.80	4.88	1.05	3.64	6.19	68.95	66.96	-	-	723	720	42.1	77.5
		20	500	10,000	.258	.232	51.25	51.16	9.88	6.36	4.29	6.53	34.58	35.95	-	-	1119	1104	42.1	35.7
		27	500	10,000	.254	.246	51.05	49.90	9.88	7.13	4.33	5.67	34.74	37.30	-	-	1125	1107	42.1	29.5
		32	500	10,000	.049	.037	50.97	45.44	9.93	8.77	4.24	3.12	34.86	42.67	-	-	1141	1122	42.1	20.6
		40	500	10,000	.060	.098	52.95	39.03	10.18	6.73	3.97	3.73	32.90	50.51	-	-	1212	1110	42.1	49.0

Table III
CATALYST TESTING SUMMARY

Run No.	Metal	Time On Stream Hrs.	Pressure PSIG	Dry Inlet S. V. v/v/hr.	S/G		Mole % H ₂		Mole % CO		Mole % CO ₂		Mole % CH ₄		ppm S		Temp., °F		% of Bed above Hot Spot	% CO Conversion
					In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out		
28	Ni-Cr-MgSiO ₃	5	500	10,000	.448	.586	22.14	-4.83	4.22	.0016	3.99	2.76	69.65	102.07	-	-	646	526	13.2	99.97
		8	500	10,000	.418	.973	26.53	10.08	4.76	NIL	4.24	3.61	64.47	86.25	-	-	661	-	13.2	100.0
		15	500	10,000	.406	.485	26.53	4.24	4.82	.0008	4.40	4.15	64.25	91.60	0.54	2.1	665	-	13.2	99.99
		20.5	500	10,000	.406	.504	24.21	3.63	5.03	.0053	4.34	3.69	66.42	92.67	0.38	0.39	661	534	13.2	99.92
		26.5	500	10,000	.390	.670	25.66	3.68	5.52	.0206	4.55	5.08	64.27	91.22	5.8	1.2	649	552	26.3	99.7
		31.5	500	10,000	.406	.247	22.69	17.01	5.63	.105	4.61	6.02	67.07	76.87	-	-	604	528	26.3	98.3
		48.5	500	10,000	.414	.793	26.90	6.73	4.46	.120	3.81	3.66	64.83	89.49	-	-	596	531	39.5	97.9
		54.5	500	10,000	.398	.601	25.05	10.71	4.60	.240	3.86	4.35	66.49	84.70	-	-	552	537	52.6	95.6
		59	500	10,000	.406	.302	25.75	7.44	4.94	.127	4.34	4.23	64.97	88.20	-	-	593	544	39.5	97.9
		65	500	10,000	.381	.296	26.36	8.10	4.85	.156	4.31	3.98	64.48	87.76	6.0	0.32	614	536	39.5	97.4
		70	500	10,000	.415	.866	28.10	20.30	4.80	.529	3.87	4.99	63.23	74.18	-	-	737	729	39.5	90.1
		73	500	10,000	.386	.357	22.08	18.13	4.91	.455	3.96	5.22	69.05	76.20	-	-	855	829	39.5	91.2
		87	500	10,000	.415	.503	22.73	19.24	4.66	1.09	4.01	5.86	68.60	73.81	-	-	815	822	65.8	77.6
		92	500	10,000	.403	.448	22.68	20.98	4.80	1.20	4.15	5.95	68.37	71.87	-	-	812	823	52.6	75.5
		95	500	10,000	.397	.325	22.65	24.53	5.02	1.60	3.84	5.74	68.49	68.13	-	-	809	824	65.8	67.3
		101	500	10,000	.227	.303	51.57	38.23	10.40	3.79	4.76	5.34	33.27	52.64	-	-	1268	1153	26.3	71.4
		106	500	10,000	.212	.327	51.36	37.74	10.38	3.69	4.81	5.31	33.45	53.26	4.4	20.5	1254	-	13.2	72.2

Table III
CATALYST TESTING SUMMARY

Run No.	Metal	Time On Stream Hrs.	Pressure PSIG	Dry Inlet S. V. v/v/hr.	S/G		Mole % H ₂		Mole % CO		Mole % CO ₂		Mole % CH ₄		ppm S		Temp., °F		% of Bed above Hot Spot	% CO Conversion
					In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out		
28	Ni-Cr-MgAl ₂ O ₄	5	500	10,000	.445	.539	22.14	3.87	4.22	.0056	3.99	3.05	69.65	93.07	-	-	672	523	19.5	99.89
		8	500	10,000	.371	.278	26.53	7.27	4.76	.0045	4.24	3.40	64.47	89.33	-	-	703	-	19.5	99.93
		15	500	10,000	.413	.446	26.53	4.91	4.82	.0258	4.40	4.12	64.25	90.94	0.94	Nil	663	-	31.7	99.59
		20.5	500	10,000	.397	.619	24.21	8.29	5.03	.0705	4.34	4.31	66.42	87.33	0.38	.83	627	552	43.9	98.84
		26.5	500	10,000	.397	.583	25.66	7.27	5.52	.148	4.55	5.71	64.27	86.87	5.8	.72	607	571	43.9	97.85
		31.5	500	10,000	.409	.495	22.69	21.87	5.63	.720	4.61	7.22	67.07	70.19	-	-	528	532	56.1	87.34
		48.5	500	10,000	.413	.437	26.90	26.47	4.46	1.12	3.81	6.07	64.83	66.34	-	-	516	518	68.3	75.0
		54.5	500	10,000	.387	.423	25.05	25.63	4.60	1.32	3.86	6.10	66.49	66.95	-	-	513	514	68.3	71.1
		59	500	10,000	.395	.342	25.75	27.87	4.94	1.21	4.34	6.99	64.97	63.93	-	-	519	516	68.3	74.8
		65	500	10,000	.387	.402	26.36	26.58	4.85	1.67	4.31	6.78	64.48	64.97	6.0	.63	518	498	56.1	65.5
		70	500	10,000	.360	.432	28.10	26.79	4.80	.570	3.87	5.90	63.23	66.74	-	-	727	722	68.3	88.3
		73	500	10,000	.438	.218	22.08	25.51	4.91	.692	3.96	6.71	69.05	67.09	-	-	821	806	56.1	85.3

Table III
CATALYST TESTING SUMMARY

Run No.	Metal	Time On Stream Hrs.	Pressure PSIG	Dry Inlet S. V. v/v/hr.	S/G		Mole % H ₂		Mole % CO		Mole % CO ₂		Mole % CH ₄		ppm S		Temp., °F		% of Bed above Hot Spot	% CO Conversion
					In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out		
29	NiB/	4	500	10,000	.385	.236	24.92	26.30	4.73	4.58	3.81	3.65	66.54	65.47	-	-	726	729	71.4	1.4
	MgSiO ₃	10	500	10,000	.395	.337	24.92	27.37	4.73	4.54	3.81	3.80	66.54	64.29	-	-	824	821	47.6	0.8
	NiB/CrB/	4	500	10,000	.447	.285	24.92	26.22	4.73	4.03	3.81	4.09	66.54	65.66	-	-	728	730	48.8	13.3
	MgSiO ₃	10	500	10,000	.456	.241	24.92	27.25	4.73	2.73	3.81	5.34	66.54	64.68	-	-	829	826	36.6	40.4

TABLE IV
CARBON MONOXIDE CHANGES AT 800° F

Run	Catalyst	Mole % H ₂		Mole % CO		Mole % CO ₂		Mole % CH ₄		(a.) Flow Outlet, l/hr.	(b.) Δ Moles CO ₂	(c.) Δ Moles CH ₄	(d.) % CO Shift	(e.) % CO to CH ₄	(f.) % CO Unreacted
		In	Out	In	Out	In	Out	In	Out						
2	Ni	20.49	21.67	5.77	4.61	3.89	4.39	69.9	69.3	101.51	.566	.444	9.8	7.7	81.1
	Co	20.49	23.03	5.77	2.68	3.89	5.95	69.9	68.34	103.30	2.26	.695	39.1	12.0	48.0
4	Mn	20.02	21.14	6.16	4.13	5.12	6.20	68.7	68.53	101.42	1.168	.803	19.0	13.0	68.0
		22.88	24.34	5.80	3.52	4.47	5.82	66.85	66.32	101.93	1.46	.750	25.2	12.9	61.9
	Fe	20.02	22.60	6.16	1.56	5.12	7.70	68.7	68.14	103.33	2.84	1.71	46.0	27.8	26.2
		22.88	25.24	5.80	1.69	4.47	6.83	66.85	66.24	103.16	2.58	1.48	44.4	25.5	30.1
5	Cr	22.51	24.59	5.16	2.05	3.81	5.90	68.52	67.46	102.76	2.25	.801	43.6	15.5	40.8
		22.51	24.34	5.16	2.14	3.81	5.94	68.52	67.58	102.42	2.27	.695	44.1	13.5	42.5
	Ni/Fe	22.51	23.14	5.16	4.13	3.81	4.59	68.52	68.14	100.82	.818	.178	15.8	3.5	80.7
		22.51	23.06	5.16	3.99	3.81	4.68	68.52	68.27	101.42	.936	.720	18.1	13.9	78.4
6	Fe/Cr/ K	20.50	21.75	4.96	2.52	3.34	5.23	71.20	70.50	101.60	1.97	.426	39.7	8.6	51.6
		20.59	22.57	5.26	2.29	3.81	5.86	70.34	69.28	102.56	2.20	.712	41.8	13.5	44.7
		37.01	37.10	6.96	4.28	4.40	5.72	51.63	52.9	100.14	1.33	1.35	19.1	19.4	61.6
	Cr/Ni	30.89	39.09	7.14	4.75	4.48	6.48	57.49	49.68	113.46	2.87	-1.122	40.2	-15.7	75.5
		20.50	21.62	4.96	2.83	3.34	4.93	71.20	70.62	101.43	1.66	.429	33.5	8.6	57.9
		20.59	22.52	5.26	2.90	3.81	5.53	70.34	69.05	102.49	1.86	.430	35.4	8.2	56.5
		37.01	37.06	6.96	4.40	4.40	6.13	51.63	52.41	100.08	1.73	.822	24.9	11.8	63.3
		30.89	36.88	7.14	7.61	4.48	3.80	57.49	51.71	109.49	-.319	-.873	-4.5	-12.2	116.7
7	Fe/Cr	26.11	27.46	3.52	1.63	5.68	7.18	64.69	63.73	101.86	1.63	.225	46.4	6.4	47.2
	K/V	24.43	27.03	3.42	1.77	5.89	7.67	66.26	63.53	103.56	2.05	-.468	60.0	-13.7	53.6
	Ni/Co	26.11	26.09	3.52	2.86	5.68	6.02	64.69	65.03	99.97	.338	.320	9.6	9.1	81.2
		24.43	26.69	3.42	2.91	5.89	6.51	66.26	63.89	103.08	.821	-.400	24.0	-11.7	87.7

(a.) Outlet flow = inlet flow x carbon factor, where inlet flow = 100 l/hr. (assumed); carbon factor = $\frac{\text{carbon in}}{\text{carbon out}} = \frac{100 - \% \text{ H}_2 \text{ in}}{100 - \% \text{ H}_2 \text{ out}}$

(b.) Δ moles CO₂ = mole % CO₂ out x outlet flow - mole % CO₂ in x inlet flow

(c.) Δ moles CH₄ = mole % CH₄ out x outlet flow - mole % CH₄ in x inlet flow

(d.) % CO shift = $\frac{\Delta \text{ moles CO}_2}{\text{mole \% CO in}} \times 100$

(e.) % CO to CH₄ = $\frac{\Delta \text{ moles CH}_4}{\text{mole \% CO in}} \times 100$

(f.) % CO unreacted = $\frac{\text{mole \% CO out} \times \text{outlet flow}}{\text{mole \% CO in} \times \text{inlet flow}} \times 100$

TABLE IV
CARBON MONOXIDE CHANGES AT 800° F

Run No.	Catalyst	Mole % H ₂		Mole % CO		Mole % CO ₂		Mole % CH ₄		Flow Outlet, l/hr.	Δ Moles	Δ Moles	% CO Shift	% CO to CH ₄	% CO Unreacted
		In	Out	In	Out	In	Out	In	Out		CO ₂	CH ₄			
8	CoMo	24.48	27.32	3.40	.552	3.86	6.92	68.26	65.21	103.91	3.33	-.502	97.9	-14.8	16.9
		24.48	28.94	3.40	.686	3.86	6.57	68.26	63.80	106.28	3.12	-.456	91.8	-13.4	21.4
	(1050° Gas Comp.)	37.6	39.66	7.21	2.60	2.51	-	52.60	-	103.41	-	-	-	-	-
		37.94	41.26	6.61	2.48	2.59	6.61	52.86	49.65	105.65	4.39	-.404	66.5	-6.1	39.6
		42.48	45.12	8.0	3.78	4.16	7.01	45.36	44.09	104.81	3.19	.851	39.8	10.6	49.5
	NiMo	24.48	25.83	3.40	.485	3.86	6.21	68.26	67.48	101.82	2.46	.448	72.4	13.2	14.5
		24.48	29.01	3.40	.523	3.86	6.93	68.26	63.54	106.38	3.51	-.665	103.3	-19.6	16.4
	(1050° Gas Comp.)	37.6	40.43	7.21	2.34	2.59	-	52.60	-	104.75	-	-	-	-	-
		37.94	36.90	6.61	7.07	2.59	2.27	52.86	53.76	98.35	-.357	.0139	-5.41	0.211	105.20
		42.48	45.57	8.0	3.78	4.16	6.97	45.36	43.68	105.68	3.21	.800	40.1	10.0	49.9
9	CoMo	24.26	26.81	3.48	3.26	4.39	5.05	67.87	64.88	103.48	.836	-.730	24.0	-21.0	96.9
		25.11	24.47	2.56	2.14	3.73	3.69	68.60	69.70	99.15	-.071	.509	-2.8	19.9	82.9
	NiMo	24.26	28.17	3.48	1.49	4.39	6.99	67.87	63.35	105.44	2.98	-1.072	85.6	-30.8	45.1
		25.11	26.60	2.56	.814	3.73	5.30	68.60	67.29	102.03	1.68	-.056	65.5	2.2	32.4
10	Fe/Cr	24.10	28.03	5.31	.744	4.58	8.58	66.01	62.65	105.46	4.47	.0611	84.2	1.2	14.8
		24.10	27.84	5.31	.759	4.58	8.38	66.01	63.02	105.18	4.23	.276	79.7	5.2	15.0
		25.18	29.90	5.26	.688	3.81	8.27	65.75	61.14	106.73	5.02	-.493	95.4	-9.4	14.0
		24.89	28.54	4.92	.753	3.59	7.56	66.60	63.15	105.11	2.21	-.224	88.5	-4.6	16.1
		23.45	27.69	4.67	.684	3.79	8.07	68.09	63.56	105.86	4.75	-.803	101.8	-17.2	15.5
		24.93	28.19	7.69	1.54	4.74	8.19	62.64	62.08	104.54	3.82	2.26	49.7	29.4	20.9
		23.35	27.57	7.36	1.32	3.73	7.94	65.56	63.17	105.83	4.67	1.29	63.5	17.5	19.0
		23.27	26.71	7.72	1.33	3.91	7.93	65.10	64.03	104.69	4.39	1.94	56.9	25.1	18.0
		20.31	24.11	5.31	.960	3.98	6.95	70.40	67.98	105.01	3.32	.984	62.5	18.5	19.0
		20.31	23.67	5.31	.960	3.98	7.01	70.40	68.36	104.40	3.34	.969	62.9	18.3	18.9
		24.94	27.62	5.34	1.22	3.89	6.73	65.83	64.43	103.70	3.09	.986	57.9	18.5	23.7
		22.73	25.49	5.38	1.24	3.66	6.54	68.23	66.73	103.70	3.12	.972	58.0	18.1	23.9

TABLE IV
CARBON MONOXIDE CHANGES AT 800°F

Run	Catalyst	Mole % H ₂		Mole % CO		Mole % CO ₂		Mole % CH ₄		Outlet, l/hr.	Moles CO ₂	Moles CH ₄	% CO Shift	% CO to CH ₄	% CO Unreacted	
		In	Out	In	Out	In	Out	In	Out							
10	Fe/Cr/ Al ₂ O ₃	24.10	27.34	5.31	1.64	4.58	7.75	66.01	63.27	104.46	3.52	.0813	66.2	1.53	32.3	
		24.10	27.37	5.31	1.16	4.58	7.95	66.01	63.52	104.50	3.73	.370	70.2	6.96	22.8	
		25.18	28.53	5.26	1.39	3.81	7.39	65.75	62.69	104.69	3.93	-.122	74.6	-2.31	27.7	
		24.89	27.90	4.92	1.20	3.59	7.00	66.60	63.9	104.17	3.70	-.032	75.2	-.657	25.4	
		23.45	26.85	4.67	1.28	3.79	7.34	68.09	64.53	104.65	3.89	-.561	83.3	-12.0	28.7	
		24.93	27.45	7.69	2.68	4.74	7.60	62.64	62.27	103.47	3.12	1.79	40.6	23.3	36.1	
		23.35	26.32	7.36	2.68	3.73	6.98	65.56	64.02	104.03	3.53	1.04	48.0	14.1	37.9	
		23.27	26.38	7.72	2.88	3.91	6.98	65.10	63.76	104.22	3.36	1.35	43.6	17.5	38.9	
		20.31	23.21	5.31	2.17	3.98	6.24	70.40	68.38	103.78	2.50	.562	47.0	10.6	42.4	
		20.31	22.98	5.31	2.09	3.98	6.14	70.40	68.79	103.47	2.37	.775	44.7	14.6	40.7	
		24.94	26.87	5.34	2.49	3.89	5.89	65.83	64.75	102.64	2.15	.629	40.4	11.8	47.9	
		22.73	25.29	5.38	1.44	3.66	6.36	68.23	66.91	103.43	2.92	.973	54.2	18.1	27.7	
11	W/Ni	21.60	21.73	4.74	3.96	3.39	3.88	70.27	70.43	100.17	.496	.277	10.5	5.8	83.7	
		21.60	21.58	4.74	3.84	3.39	3.88	70.27	70.70	99.97	.489	.412	10.3	8.7	81.0	
	Fe/Mo	21.60	23.03	4.74	1.84	3.39	5.38	70.27	69.75	101.86	2.09	.776	44.1	16.4	39.5	
		21.60	23.12	4.74	1.81	3.39	5.42	70.27	69.65	101.98	2.14	.757	45.1	16.0	38.9	
	12	Ni/Mn	24.43	26.47	4.82	2.08	3.99	5.87	66.76	65.58	102.77	2.04	.639	42.4	13.3	44.4
			28.96	30.18	4.73	2.24	3.53	5.41	62.78	62.17	101.75	1.97	.476	41.7	10.1	48.2
29.06			30.47	4.95	2.51	3.58	5.36	62.41	61.66	102.03	1.89	.500	38.2	10.1	51.7	
(.27 S/G)		21.68	23.05	4.53	2.58	3.52	5.09	70.27	69.28	101.78	1.66	.243	36.7	5.4	57.9	
		23.22	25.60	4.55	2.30	3.62	5.27	68.61	66.83	103.20	1.82	.359	40.0	7.9	52.2	
		22.17	23.56	4.46	2.22	3.57	5.09	69.80	69.13	101.82	1.61	.587	36.2	13.2	50.7	
(.25 S/G)		21.21	-	4.88	3.57	3.59	4.34	70.32	-	-	-	-	-	-	-	
		(.16 S/G)	25.24	24.77	4.53	3.53	3.27	3.52	66.96	68.18	99.38	.228	.794	5.0	17.5	77.4
			26.34	26.20	4.48	2.98	3.30	4.27	65.88	66.55	99.81	.962	.544	21.5	12.1	66.4
		Fe/V	24.43	26.78	4.82	1.39	3.99	6.43	66.76	65.40	103.21	2.65	.739	54.9	15.3	29.8
	28.96		30.72	4.73	1.43	3.53	5.93	62.78	61.92	102.54	2.55	.713	53.9	15.1	31.0	
	29.06		31.26	4.95	1.57	3.58	6.08	62.41	61.09	103.20	2.69	.635	54.4	12.8	32.7	
	(.28 S/G)	21.68	23.95	4.53	1.34	3.52	5.96	70.27	68.75	102.98	2.62	.532	57.8	11.7	30.5	
		23.22	26.68	4.55	1.50	3.62	5.77	68.61	66.05	104.72	2.42	.557	53.2	12.2	34.5	
		22.17	24.49	4.46	1.40	3.57	5.86	69.80	68.25	103.07	2.47	.547	55.4	12.3	32.4	
	(.24 S/G)	21.21	22.74	4.88	2.68	3.59	4.96	70.32	69.62	101.98	1.47	.679	30.1	13.9	50.8	
		(.19 S/G)	25.24	25.80	4.53	1.82	3.27	4.69	66.96	67.69	100.75	1.46	1.24	32.1	27.4	40.5

TABLE IV
CARBON MONOXIDE CHANGES AT 800° F

Run	Catalyst	Mole % H ₂		Mole % CO		Mole % CO ₂		Mole % CH ₄		Flow Outlet, l/hr.	Δ Moles CO ₂	Δ Moles CH ₄	% CO Shift	% CO to CH ₄	% CO Unreacted
		In	Out	In	Out	In	Out	In	Out						
13	Ni/V (.12 S/G)	25.70	30.36	4.26	1.90	3.08	4.07	66.96	63.67	106.69	1.26	.971	29.6	22.8	47.6
		22.44	24.39	4.69	2.24	3.45	5.09	69.42	68.28	102.58	1.77	.621	37.8	13.2	49.0
		25.20	25.95	3.82	2.64	3.32	4.08	67.66	67.33	101.01	.801	.352	21.0	9.2	69.8
		22.44	23.51	3.89	3.35	3.55	4.29	70.12	68.85	101.40	.800	-.307	20.6	-7.9	87.3
		23.54	23.80	3.54	2.86	3.54	4.20	69.38	69.14	100.34	.674	-.004	19.0	-0.12	81.1
		22.38	21.08	2.34	1.66	8.91	8.92	66.37	68.34	98.35	-.137	.844	-5.9	36.1	69.8
		21.87	22.06	3.64	2.93	8.81	9.27	65.68	65.74	100.24	.483	.229	13.3	6.0	80.7
		21.28	22.08	4.42	3.90	20.12	19.87	54.18	54.15	101.03	-.046	.526	-1.0	11.9	89.1
		21.94	21.81	4.80	4.32	19.95	20.36	53.31	53.51	99.83	.376	.111	7.8	2.3	89.9
	2Ni/1Cr (.12 S/G)	25.70	30.21	4.26	1.59	3.08	4.32	66.96	63.88	106.46	1.52	1.05	35.7	24.6	39.7
		22.44	24.78	4.69	2.07	3.45	5.26	69.42	67.89	103.11	1.97	.582	42.1	12.4	45.5
		25.20	26.52	3.82	2.11	3.32	4.45	67.66	66.92	101.80	1.21	.462	31.7	12.1	56.2
		22.44	24.68	3.89	2.28	3.55	4.79	70.12	68.25	102.97	1.38	.159	35.5	4.1	60.4
		23.54	24.55	3.54	2.24	3.54	4.71	69.38	68.50	101.34	1.23	.037	34.8	1.0	64.1
		22.38	22.15	2.34	1.51	8.91	8.96	66.37	67.38	99.70	.024	.811	1.0	34.7	64.3
		21.87	22.36	3.64	2.57	8.81	9.49	65.68	65.58	100.63	.740	.314	20.3	8.6	71.0
		22.23	22.77	4.35	3.81	19.86	20.15	53.56	53.27	100.70	.431	.082	9.9	1.9	88.2
		21.88	22.37	4.42	3.54	20.12	19.96	53.58	54.13	100.63	-.034	.891	-.77	20.2	80.6
		21.94	21.85	4.80	4.07	19.95	20.38	53.31	53.70	99.88	.406	.328	8.5	6.8	84.7

TABLE IV
CARBON MONOXIDE CHANGES

Run	Catalyst	Mole % H ₂		Mole % CO		Mole % CO ₂		Mole % CH ₄		Flow (a)	Δ (b)	Δ (c)	% (d)	% (e)	% (f)
		In	Out	In	Out	In	Out	In	Out	Outlet, l/hr.	Moles CO ₂	Moles CH ₄	CO Shift	CO to CH ₄	CO Unreacted
14	1Ni/1Cr (900°)	24.46	26.77	5.26	2.41	2.32	4.64	67.97	66.18	103.15	2.47	.308	46.9	5.8	47.3
		25.18	27.19	5.25	1.32	2.42	5.12	67.15	66.37	102.76	2.84	1.05	54.1	20.0	25.8
		24.64	26.86	4.33	1.31	3.45	5.95	67.58	65.88	103.04	2.68	.300	61.9	6.9	31.2
		24.82	26.90	4.63	1.18	3.48	6.14	67.07	65.78	102.85	2.83	.582	61.2	12.6	26.2
		(38.14	40.48	9.30	4.33	4.12	7.48	48.44	47.71	103.93	3.65	1.146	39.3	12.3	48.4
	(1050°	(38.12	39.93	9.42	4.66	4.20	7.33	48.26	48.08	103.01	3.35	1.269	35.6	13.5	51.0
	Gas Comp)	(38.74	39.80	8.80	4.21	4.23	6.88	48.23	49.11	101.76	2.77	1.745	31.5	19.8	48.7
	(1150°	(47.94	46.99	10.09	6.81	3.93	5.32	38.04	40.88	98.21	1.29	2.11	12.8	20.9	66.3
		(48.08	49.92	9.84	6.71	4.31	5.44	37.77	37.93	103.67	1.33	1.55	13.5	15.8	70.7
		Gas Comp)	(48.53	48.06	9.91	5.82	4.53	37.03	39.82	99.10	1.71	2.43	17.3	24.5	58.2
	2Fe/1Cr (900°)	24.46	27.81	5.26	1.05	2.32	5.58	67.96	65.56	104.64	3.52	.642	66.9	12.2	20.9
		25.18	27.50	5.25	.991	2.42	5.30	67.15	66.21	103.20	3.05	1.09	58.1	20.7	19.5
		24.64	26.78	4.33	1.10	3.45	6.13	67.58	65.99	102.92	2.86	.339	66.0	7.8	26.1
		24.82	27.06	4.63	.960	3.48	6.23	67.07	65.75	103.07	2.94	.699	63.5	15.1	21.4
		(38.14	40.48	9.30	4.37	4.12	7.42	48.44	47.73	103.93	3.59	1.166	38.6	12.5	48.8
	(1050°	(38.12	29.43	9.42	6.64	4.20	4.11	48.26	59.82	87.69	-.596	4.19	-6.3	44.5	61.8
	Gas Comp)	(38.74	40.78	8.80	3.09	4.23	7.33	48.23	48.80	103.44	3.35	2.25	38.1	25.6	36.3
	(1150°	(47.94	48.82	10.09	7.34	3.93	5.56	38.04	38.28	101.72	1.73	.898	17.1	8.9	74.0
		(48.08	49.47	9.84	5.94	4.31	5.61	37.77	38.98	102.75	1.45	2.28	14.8	23.2	62.0
		Gas Comp)	(48.53	49.58	9.91	6.04	4.53	37.03	37.73	102.08	2.26	1.49	22.8	15.0	62.2

CARBON MONOXIDE CHANGES

Run	Catalyst	Mole % H ₂		Mole % CO		Mole % CO ₂		Mole % CH ₄		Flow Outlet, l/hr.	Δ	Δ	%	%	%
		In	Out	In	Out	In	Out	In	Out		Moles CO ₂	Moles CH ₄	CO Shift	CO to CH ₄	CO Unreacted
15	1Ni/1Cr on MgO (1150° Gas Comp)	23.34	25.99	5.60	2.78	4.72	7.09	66.34	64.14	103.58	2.62	.097	46.9	1.7	51.4
		23.53	26.29	5.79	1.44	4.79	7.68	65.89	64.59	103.74	3.18	1.12	56.7	19.3	25.8
		23.80	26.59	5.85	1.67	4.65	7.60	65.70	64.14	103.80	3.24	.878	55.4	15.0	29.6
		48.00	49.34	10.06	3.91	4.54	7.85	37.40	38.90	102.65	3.52	2.53	35.0	25.1	39.9
		47.76	49.60	10.03	6.03	4.52	7.41	31.68	30.48	105.26	3.28	.403	32.7	4.0	63.3
		26.46	28.88	3.53	2.18	3.60	5.66	65.17	61.50	104.27	2.33	-1.04	65.2	-29.6	64.4
		25.50	27.43	5.05	1.80	3.93	6.01	62.00	61.19	102.87	2.25	.946	44.6	18.7	36.7
	1Ni/1Cr on MgSiO ₃ (1150° Gas Comp)	23.53	25.35	5.79	2.42	4.79	7.01	65.89	65.22	102.44	2.39	.920	41.3	15.9	42.8
		23.80	25.94	5.85	2.56	4.65	6.89	65.70	64.61	102.44	2.41	.485	41.3	8.3	44.8
		48.00	42.97	10.06	5.03	4.54	6.15	37.40	45.85	91.18	1.07	4.41	10.6	43.8	45.6
		47.76	46.95	10.03	4.74	4.52	6.78	31.68	31.35	96.57	2.03	3.42	20.2	34.1	45.6
		26.46	27.42	3.53	2.75	3.60	4.38	65.17	61.42	105.47	1.02	-.390	28.9	-11.0	82.2
		25.50	26.21	5.05	3.65	3.93	4.85	62.00	65.38	96.07	.720	.814	14.4	16.1	69.4

TABLE IV
CARBON MONOXIDE CHANGES

Run	Catalyst	Mole % H ₂		Mole % CO		Mole % CO ₂		Mole % CH ₄		Flow Outlet, l/hr.	Moles CO ₂	Moles CH ₄	% CO Shift	% CO to CH ₄	% CO Unreacted
		In	Out	In	Out	In	Out	In	Out						
16	Ni/Cr/SiO ₂ (1150° gas comp.)	25.11	25.52	4.69	3.56	3.97	4.58	56.16	63.79	90.12	1.157	1.32	3.4	28.2	68.4
		25.42	25.61	5.38	4.08	3.72	4.42	64.68	74.06	89.37	1.230	1.50	4.3	28.0	67.8
		43.80	45.34	11.11	5.67	4.63	8.02	33.34	33.01	105.10	3.80	1.35	34.2	12.2	53.6
		43.39	43.60	11.61	5.86	4.74	7.56	37.77	37.77	105.72	3.25	2.16	28.0	18.6	53.4
	Ni/Cr/MgAl ₂ O ₄ (1150° gas comp.)	25.11	27.08	4.69	1.27	3.97	6.32	56.16	62.60	92.30	1.87	1.65	39.8	35.2	25.0
		25.42	27.07	5.38	1.35	3.72	5.88	64.68	67.34	98.94	2.10	1.95	39.0	36.2	24.8
		43.80	44.89	11.11	6.53	4.63	7.66	33.34	33.28	103.39	3.29	1.07	29.6	9.6	60.8
		43.39	44.11	11.61	6.47	4.74	7.51	37.77	36.93	106.31	3.24	1.49	27.9	12.8	59.2
17	Ni/Cr (1150° gas comp.)	24.18	25.69	5.12	2.17	3.36	5.65	67.34	66.49	102.03	2.40	.501	47.0	9.8	43.2
		42.88	43.11	10.81	6.99	4.71	6.83	37.77	37.84	103.16	2.34	1.26	21.6	11.7	66.7
		50.74	52.44	10.23	5.20	4.44	6.59	38.19	30.91	123.79	3.72	.075	36.4	.73	62.9
	Ni/Cr/Al ₂ O ₃ (1150° gas comp.)	24.18	25.74	5.12	2.06	3.36	5.59	67.34	66.61	102.10	2.35	.669	45.8	13.1	41.1
		42.88	41.18	10.81	5.46	4.71	7.37	37.77	37.44	106.01	3.10	1.92	28.7	17.8	53.5
		50.74	48.88	10.23	4.98	4.44	5.89	38.19	38.30	107.50	1.89	2.98	18.5	29.2	52.3
18	Pt/Al ₂ O ₃	24.57	25.80	4.87	1.34	3.45	4.92	64.17	62.87	104.86	1.71	1.76	35.1	36.1	28.9
		50.01	54.40	12.66	9.66	4.44	5.60	30.96	32.22	101.22	1.23	1.65	9.7	13.1	77.2
	Ru/Al ₂ O ₃	24.57	25.68	4.87	3.18	3.45	4.46	64.17	63.26	102.24	1.11	.509	22.8	10.4	66.8
		50.01	55.87	12.66	7.31	4.44	6.97	30.96	31.77	104.36	2.83	2.20	22.4	17.4	57.7

TABLE IV.
CARBON MONOXIDE CHANGES

Run	Catalyst	Temp °F	Mole % H ₂		Mole % CO		Mole % CO ₂		Mole % CH ₄		Flow Outlet, l/hr.	Δ Moles CO ₂	Δ Moles CH ₄	% CO Shift	% CO to CH ₄	% CO Unreacted	
			In	Out	In	Out	In	Out	In	Out							
19	Ni/Cr/ Mg/A ₂ O ₄	600	25.84	28.03	4.36	1.78	3.40	5.14	58.34	57.20	103.09	1.90	.626	43.5	14.4	42.1	
		700	26.40	27.79	3.95	.703	3.35	5.83	63.75	62.55	102.85	2.65	.581	67.0	14.7	18.3	
		800	26.55	28.75	3.89	.712	3.35	5.77	64.05	60.72	106.08	2.77	.364	71.2	9.3	19.4	
		900	48.27	48.89	8.86	4.88	4.37	6.94	32.01	29.24	110.18	3.28	.207	37.0	2.3	60.7	
		900	52.89	55.39	10.45	5.05	4.42	7.46	33.17	29.82	113.49	4.05	.672	38.7	6.4	54.8	
		900	52.70	53.73	8.00	4.43	4.18	6.05	34.29	32.04	109.29	2.43	.726	30.4	9.1	60.5	
		1000	46.85	47.89	10.65	6.34	4.20	7.03	35.96	35.31	104.38	3.14	.895	29.5	8.4	62.1	
		1000	50.60	50.17	9.03	5.81	4.03	5.70	30.53	35.99	91.77	1.20	2.50	13.2	27.7	59.0	
		1100	45.89	39.04	10.16	4.74	4.18	6.08	45.73	56.55	89.16	1.24	4.69	12.2	46.2	41.6	
		1100	48.91	39.09	9.22	4.16	3.99	4.26	40.36	51.20	89.85	-.162	5.64	-1.8	61.2	40.5	
		500	68.50	69.53	18.37	18.37	2.48	2.48	10.0	10.0	No Reaction						
		670	No Reaction														
		750	No Reaction														
		910	-	-	17.56	19.12	2.05	1.94	30.55	30.39							
	Ni/Cr/ MgSiO ₃	600	25.84	27.24	4.36	3.55	3.40	4.04	58.34	59.78	98.11	.564	.313	12.9	7.2	80.0	
		700	26.40	27.02	3.95	2.26	3.35	4.69	63.75	66.91	96.20	1.16	.614	29.4	15.6	55.0	
		800	26.55	28.19	3.89	1.62	3.35	5.18	64.05	61.11	104.98	2.09	.102	53.7	2.6	43.7	
		900	48.27	43.10	8.86	7.08	4.37	3.93	32.01	41.36	86.39	-.975	3.72	-11.0	42.0	69.0	
		900	52.89	55.06	10.45	5.02	4.42	7.20	33.17	30.30	112.98	3.71	1.06	35.5	10.2	54.3	
		900	52.70	52.69	8.00	5.51	4.18	5.03	34.29	32.27	108.55	1.28	.739	16.0	9.2	74.8	
		1000	46.85	34.90	10.65	7.33	4.20	3.99	35.96	49.65	83.34	-.875	5.42	-8.2	50.9	57.4	
		1000	50.60	36.59	9.03	4.64	4.03	3.07	30.53	53.97	70.67	-1.86	7.61	-20.6	84.3	36.3	
		1100	45.89	40.57	10.16	6.02	4.18	6.48	45.73	78.66	65.90	.090	6.10	0.89	60.1	39.0	
		1100	48.91	38.64	9.22	3.48	3.99	4.30	40.36	48.71	94.83	.088	5.83	0.95	63.3	35.8	
		500	68.50	69.52	18.37	18.37	2.48	2.48	10.0	10.0	No Reaction						
		670	No Reaction														
		750	No Reaction														
		910	-	-	17.56	19.90	2.05	1.96	30.55	29.52							

TABLE IV
CARBON MONOXIDE CHANGES AT 800-1100° F

Run	Catalyst	Temp., ° F	Mole % H ₂		Mole % CO		Mole % CO ₂		Mole % CH ₄		Flow Outlet, l/hr.	Δ	Δ	%	%	CO Unreacted
			In	Out	In	Out	In	Out	In	Out		Moles CO ₂	Moles CH ₄	CO Shift	CO to CH ₄	
19 (cont'd)	Ni/Cr/MgSiO ₃	1000	39.78	34.58	9.22	6.12	3.45	4.11	41.84	55.13	83.4	-.0223	4.14	-.24	44.9	55.4
		1000	40.55	40.60	9.63	7.16	3.36	4.58	40.31	55.81	78.9	.254	3.73	2.6	38.7	58.7
		1100	47.81	37.36	11.89	5.34	4.49	4.49	35.81	52.81	83.3	-.749	8.19	-6.3	68.9	37.4
		1000	46.89	40.50	12.29	7.52	4.44	4.97	36.38	47.01	89.3	.004	5.58	-.03	45.4	54.6
	(5000 SV)	1100	46.42	35.32	12.38	5.79	4.06	4.54	37.17	54.35	41.4	-.297	7.88	-2.4	63.6	38.8
	(5000 SV)	1100	47.11	35.18	12.11	5.36	4.63	4.85	36.15	54.61	40.8	-.672	8.41	-5.6	69.4	36.1
19 (cont'd)	Ni/Cr/ MgAl ₂ O ₄	1000	39.78	39.59	9.22	10.16	3.45	4.59	41.84	60.57	72.4	-.128	2.00	-1.39	21.6	79.7
		1000	40.55	42.66	9.63	6.80	3.36	5.15	40.31	41.12	100.4	1.81	0.99	19.9	10.3	70.9
		1100	47.81	41.75	11.89	6.99	4.49	4.30	35.81	46.96	89.6	0.64	6.26	-5.4	52.7	52.7
		1000	46.89	45.84	12.29	11.09	4.44	4.30	36.38	38.77	98.1	-.22	1.64	-1.8	13.3	88.5
	(5000 SV)	1100	46.42	38.68	12.38	8.28	4.06	4.31	37.17	48.73	43.7	-.29	5.43	-2.4	43.9	58.5
	(5000 SV)	1100	47.11	37.77	12.11	7.25	4.63	4.81	36.15	50.17	42.5	-.54	6.49	-4.5	53.6	50.9

TABLE IV
CARBON MONOXIDE CHANGES AT 800-1100°F

Run	Catalyst	Temp., °F	Mole % H ₂		Mole % CO		Mole % CO ₂		Mole % CH ₄		Flow Outlet, l/hr.	Δ	Δ	%	%	CO
			In	Out	In	Out	In	Out	In	Out		Moles CO ₂	Moles CH ₄	CO Shift	CO to CH ₄	
20	Pt/MgSiO ₃	800	26.69	28.09	5.22	5.30	3.09	3.07	65.00	63.54	101.9	.04	-.22	.76	-4.3	103.5
		800	25.07	27.42	5.12	2.88	3.46	4.98	66.35	64.72	103.2	1.7	.47	32.8	9.1	58.1
		1100	47.70	49.57	12.01	12.05	4.69	4.08	35.60	34.30	103.7	-.46	-.28	-3.8	-.23	104.1
		1100	44.97	45.75	10.85	9.38	4.68	6.07	39.50	38.80	101.4	1.5	-.14	13.6	-1.3	87.7
	Ru/MgSiO ₃	800	26.69	29.93	5.22	4.82	3.09	2.66	65.00	62.59	104.6	-.31	.48	-5.9	9.3	96.6
		800	23.32	25.73	5.32	5.07	3.84	3.67	67.52	65.53	103.2	-.05	.14	-.96	2.5	98.4
		800	25.07	26.50	5.12	4.92	3.46	3.47	66.35	65.11	101.7	.07	-.11	1.4	-2.1	100.7
		1100	47.70	49.94	12.01	10.89	4.69	4.90	35.60	34.27	104.4	.43	.20	3.6	1.7	94.7
		1100	44.97	48.93	10.85	11.03	4.68	4.96	39.50	35.08	107.8	.66	-1.7	6.1	-15.7	109.5

TABLE IV
CARBON MONOXIDE CHANGES AT 800-1100°F

Run	Catalyst	Temp., °F	Mole % H ₂		Mole % CO		Mole % CO ₂		Mole % CH ₄		Flow Outlet, l/hr.	Δ	Δ	%	%	CO Unreacted
			In	Out	In	Out	In	Out	In	Out		Moles CO ₂	Moles CH ₄	CO Shift	CO to CH ₄	
21	Ni/MgAl ₂ O ₄	800	23.26	26.93	5.27	2.04	4.13	6.33	67.34	64.70	105.0	2.5	.61	47.7	11.6	40.7
		800	25.35	27.77	5.30	2.07	4.18	6.22	65.17	63.94	103.4	2.2	.91	42.4	17.2	40.4
		1100	49.31	50.29	11.64	8.97	4.35	5.48	34.70	35.26	102.0	1.2	1.3	10.6	10.8	78.6
		1100	48.93	50.15	11.87	7.85	4.33	6.06	34.87	35.94	102.4	1.9	1.9	15.8	16.4	67.8
	Ni/MgSiO ₃	800	23.26	24.73	5.27	3.81	4.13	5.10	67.34	66.36	102.0	1.1	.32	20.3	6.0	73.7
		800	25.35	26.83	5.30	3.48	4.18	5.16	65.17	64.53	102.0	1.1	.67	20.5	12.6	67.0
		1100	49.31	51.77	11.64	7.27	4.35	6.69	34.70	34.27	105.1	2.7	1.3	23.0	11.3	65.6
		1100	48.93	49.39	11.87	9.50	4.33	4.94	34.87	36.17	100.9	.65	1.6	5.5	13.7	80.8
	Ni/Al ₂ O ₃	800	25.79	30.04	5.38	4.35	3.67	3.77	65.16	61.84	106.1	.33	.44	6.1	8.1	85.8
		800	27.55	28.74	5.51	5.19	3.49	3.68	63.45	62.39	101.7	.25	.02	4.6	.33	95.8
		1100	49.67	50.24	11.51	10.0	4.50	5.67	34.32	34.09	101.1	1.2	.16	10.7	1.4	87.9
		1100	48.38	50.35	11.59	9.24	4.48	5.92	35.55	34.49	104.0	1.7	.31	14.5	2.7	82.9
22	Ni/Cr/V/ MgSiO ₃	800	25.79	32.36	5.38	1.25	3.67	6.29	65.16	60.10	109.7	3.2	.78	60.1	14.5	25.5
		800	27.55	31.79	5.51	1.25	3.49	6.19	63.45	60.77	106.2	3.1	1.1	56.0	19.9	24.1
		1100	49.67	44.23	11.51	5.89	4.50	6.49	34.32	43.39	90.2	1.4	4.8	11.8	42.0	46.2
		1100	48.38	48.38	11.59	6.16	4.48	6.66	35.55	40.94	96.0	1.9	3.8	16.5	32.4	51.0

TABLE IV
CARBON MONOXIDE CHANGES AT 800-1100°F

Run	Catalyst	Temp., °F	Mole % H ₂		Mole % CO		Mole % CO ₂		Mole % CH ₄		Flow Outlet, l/hr.	Δ	Δ	%	%	CO
			In	Out	In	Out	In	Out	In	Out		Moles CO ₂	Moles CH ₄	CO Shift	CO to CH ₄	
23	Ni/V/ MgSiO ₃	800	26.66	28.95	5.18	3.50	3.64	4.76	64.52	62.79	103.2	1.3	.29	24.6	5.7	69.7
		800	27.27	29.03	5.14	2.97	3.58	5.22	64.01	62.78	102.5	1.8	.33	34.4	6.4	59.2
		1100	49.38	53.00	11.39	6.98	4.41	6.52	34.82	33.50	107.7	2.6	1.3	22.9	11.1	66.0
		1100	49.23	50.72	11.31	7.48	4.46	7.03	35.00	34.77	103.0	2.8	.82	24.6	7.3	68.1
	Ni/Cr/V MgAl ₂ O ₄	800	26.66	30.57	5.18	1.14	3.64	6.31	64.52	61.98	105.6	3.0	.95	58.4	18.3	23.2
		800	27.27	30.77	5.14	0.43	3.58	6.77	64.01	62.03	105.1	3.5	1.2	68.7	22.5	8.8
		1100	49.38	48.79	11.39	5.95	4.41	6.56	34.82	38.70	98.8	2.1	3.4	18.2	30.1	51.6
		1100	49.23	46.95	11.31	6.38	4.46	6.63	35.00	40.04	95.7	1.9	3.3	16.7	29.3	54.0

TABLE IV
CARBON MONOXIDE CHANGES AT 800-1100°F

No. Run	Catalyst	Temp. °F	Mole% H ₂		Mole % CO		Mole % CO ₂		Mole % CH ₄		Flow Outlet, l/hr.	Moles CO ₂	Moles CH ₄	% CO Shift	% CO to CO CH ₄ Unreacted	
			In	Out	In	Out	In	Out	In	Out						
24	Ni/V/SiO ₂	800	22.74	23.40	4.92	4.60	3.54	3.80	58.80	68.20	100.9	.29	-.01	6.0	-.25	94.3
		1100	49.90	50.68	10.81	7.11	4.47	5.85	34.82	36.36	101.6	1.5	2.1	13.6	19.5	66.8
		1100	49.43	52.41	11.18	7.33	4.62	6.14	34.77	34.12	106.3	1.9	1.5	17.0	13.3	69.7
	Ni/V/ MgAl ₂ O ₄	800	22.74	25.56	4.92	1.87	3.54	5.74	68.80	66.83	103.8	2.4	.56	49.1	11.4	39.4
		1100	49.90	49.08	10.81	6.79	4.47	5.43	34.82	38.70	98.4	.87	3.3	8.1	30.1	61.8
		1100	49.43	45.95	11.18	6.73	4.62	5.21	34.77	42.11	93.6	.25	4.6	2.3	41.4	56.3
	Ni/Mn/ MgSiO ₃	800	26.87	33.81	4.69	1.72	3.58	5.51	64.86	58.96	110.5	2.5	.28	53.5	6.0	40.5
		1100	49.41	47.13	10.98	13.18	4.64	2.77	34.97	36.92	95.7	-2.0	.36	-18.1	3.3	114.9
	Ni/Pt/ MgSiO ₃	800	26.87	31.42	4.69	2.40	3.58	4.79	64.86	61.39	106.6	1.5	.60	32.6	12.9	54.6
		1100	49.41	50.30	10.98	9.38	4.64	5.70	34.97	34.62	101.8	1.2	.27	10.6	2.5	87.0
26	1-1 Ni-Cr/ Pt	800	26.35	27.97	5.07	2.83	3.58	5.32	65.00	63.88	102.2	1.9	.32	36.7	6.2	57.1
		1100	48.07	50.03	11.17	7.99	5.01	7.03	35.75	34.95	103.9	2.3	.57	20.6	5.1	74.3
	Ni/Pt/ SiO ₂	800	26.35	26.99	5.07	4.86	3.58	3.79	65.00	64.36	100.9	.24	-.08	4.8	-1.5	96.7
		1100	48.07	49.27	11.17	10.03	5.01	5.46	35.75	35.24	102.4	.58	.32	5.2	2.9	91.9

TABLE IV
CARBON MONOXIDE CHANGES AT 800-1100°F

Run	Catalyst	Temp. °F	Mole % H ₂		Mole % CO		Mole % CO ₂		Mole % CH ₄		Flow Outlet, l/hr.	Δ Moles CO ₂	Δ Moles CH ₄	% CO Shift	% CO to CH ₄	% CO Unreacted
			In	Out	In	Out	In	Out	In	Out						
27	Ni-Cr- MgSiO ₃	700	21.26	20.73	4.79	2.68	3.86	5.37	70.09	71.22	99.31	1.47	.654	30.8	13.6	55.6
		700	22.93	23.20	4.92	2.49	3.65	5.27	68.50	69.04	100.4	1.64	.783	33.3	15.9	50.8
		700	22.53	25.44	4.88	2.90	3.64	4.96	68.95	66.70	103.9	1.51	.353	31.0	7.2	61.7
		1100	51.25	46.00	9.88	5.38	4.29	5.68	34.58	42.94	90.3	.838	4.19	8.4	42.4	49.2
		1100	51.05	46.30	9.88	6.45	4.33	5.15	34.74	42.10	91.2	.364	3.64	3.7	36.8	59.5
		1100	50.97	39.92	9.93	5.95	4.24	3.55	34.86	50.58	81.6	-1.34	6.42	-13.5	64.6	48.9
		1100	52.95	35.21	10.18	4.03	3.97	3.70	32.90	57.06	72.6	-1.28	8.54	-12.6	83.9	28.7
	Ni-Cr- MgAl ₂ O ₄	700	21.20	27.97	4.79	1.05	3.86	6.54	70.09	64.44	109.3	3.29	.353	68.7	7.4	24.0
		700	22.93	24.94	4.92	0.96	3.65	6.27	68.50	67.83	102.7	2.79	1.15	56.7	23.3	20.0
		700	22.53	25.80	4.88	1.05	3.64	6.19	68.95	66.96	104.4	2.83	.953	58.0	19.5	22.5
		1100	51.25	51.16	9.88	6.36	4.29	6.53	34.58	35.95	99.8	2.23	1.30	22.6	13.2	64.3
		1100	51.05	49.90	9.88	7.13	4.33	5.67	34.74	37.30	97.7	1.20	1.70	12.2	17.2	70.5
		1100	50.97	45.44	9.93	8.77	4.24	3.12	34.86	42.67	89.9	-1.44	3.49	-14.5	35.1	79.4
		1100	52.95	39.03	10.18	6.73	3.97	3.73	32.90	50.51	77.2	-1.09	6.08	-10.7	59.7	51.0

TABLE IV
CARBON MONOXIDE CHANGES AT 800- 1100° F

Run	Catalyst	Temp. °F	Mole % H ₂		Mole % CO		Mole % CO ₂		Mole % CH ₄		Flow Outlet, l/hr.	Δ Moles CO ₂	Δ Moles CH ₄	% CO Shift	% CO to CH ₄	% CO Unreacted
			In	Out	In	Out	In	Out	In	Out						
28	Ni-Cr- MgSiO ₃	500	22.14	-4.83	4.22	.0016	3.99	2.76	69.65	102.07	74.3	-1.94	6.16	-46.0	145.9	.03
		500	26.53	10.08	4.76	Nil	4.24	3.67	64.47	86.25	81.7	-1.24	6.00	-26.1	126.1	0
		500	26.53	4.24	4.82	.0008	4.40	4.15	64.25	91.60	76.7	-1.22	6.04	-25.2	125.2	.01
		500	24.21	3.63	5.03	.0053	4.34	3.69	66.42	92.67	78.6	-1.40	6.46	-28.6	125.5	.08
		500	25.66	3.68	5.52	.0206	4.55	5.08	64.27	91.22	77.2	-.63	6.13	-11.4	111.1	.29
		500	22.69	17.01	5.63	.105	4.61	6.02	67.07	76.87	93.2	1.00	4.53	17.7	80.5	1.7
		500	26.90	6.73	4.46	.120	3.81	3.66	64.83	89.49	78.4	-.94	5.31	-21.1	119.0	2.1
		500	25.05	10.71	4.60	.240	3.86	4.35	66.49	84.70	83.9	-.21	4.61	-4.5	100.2	4.4
		500	25.75	7.44	4.94	.127	4.34	4.23	64.97	88.20	80.2	-.95	5.78	-19.2	117.1	2.1
		500	26.36	8.10	4.85	.156	4.31	3.98	64.48	87.76	80.1	-1.12	5.85	-23.1	120.5	2.6
		700	28.10	20.30	4.80	.529	3.87	4.99	63.23	74.18	90.2	.63	3.69	13.2	76.9	9.9
		800	22.08	18.13	4.91	.455	3.96	5.22	69.05	76.20	95.2	1.01	3.47	20.5	70.7	8.8
		800	22.73	19.24	4.66	1.09	4.01	5.86	68.60	73.81	95.7	1.60	2.02	34.3	43.4	22.4
		800	22.68	20.98	4.80	1.20	4.15	5.95	68.37	71.87	97.8	1.67	1.95	34.8	40.7	24.5
		800	22.65	24.53	5.02	1.60	3.84	4.74	68.49	68.13	102.5	2.04	1.34	40.7	26.6	32.7
		1100	51.57	38.23	10.40	3.79	4.76	5.34	33.27	52.64	78.4	-.57	8.00	-5.5	76.9	28.6
		1100	51.36	37.74	10.38	3.69	4.81	5.31	33.45	53.26	78.1	-.66	8.16	-6.4	78.6	27.8

TABLE IV
CARBON MONOXIDE CHANGES AT 800 - 1100° F

Run	Catalyst	Temp. °F	Mole % H ₂		Mole % CO		Mole % CO ₂		Mole % CH ₄		Flow Outlet, l/hr.	Δ Moles CO ₂	Δ Moles CH ₄	% CO Shift	% CO to CH ₄	% CO Unreacted
			In	Out	In	Out	In	Out	In	Out						
28	Ni-Cr- MgAl ₂ O ₄	500	22.14	3.87	4.22	.0056	3.99	3.05	69.65	93.07	81.0	-1.52	5.74	-36.0	135.9	.11
		500	26.53	7.27	4.76	.0045	4.24	3.40	64.47	89.33	79.2	-1.55	6.30	-32.5	132.4	.07
		500	26.53	4.91	4.82	.0258	4.40	4.12	64.25	90.94	77.3	-1.22	6.02	-25.2	124.8	.41
		500	24.21	8.29	5.03	.0705	4.34	4.31	66.42	87.33	82.6	-.778	5.75	-15.5	114.3	1.2
		500	25.66	7.27	5.52	.148	4.55	5.71	64.27	86.87	80.2	-.027	5.37	.501	97.3	2.1
		500	22.69	21.87	5.63	.720	4.61	7.22	67.07	70.19	99.0	2.53	2.38	45.0	42.3	12.7
		500	26.90	26.47	4.46	1.12	3.81	6.07	64.83	66.34	99.4	2.22	1.12	49.9	25.2	25.0
		500	25.05	25.63	4.60	1.32	3.86	6.10	66.49	66.95	100.8	2.29	.98	49.7	21.4	28.9
		500	25.75	27.87	4.94	1.21	4.34	6.99	64.97	63.93	102.9	2.86	.84	57.8	17.0	25.2
		500	26.36	26.58	4.85	1.67	4.31	6.78	64.48	64.97	100.3	2.49	.68	51.3	14.1	34.5
		700	28.10	26.79	4.80	.570	3.87	5.90	63.23	66.74	98.2	1.92	2.32	40.1	48.2	11.7
		800	22.08	25.51	4.91	.692	3.96	6.71	69.05	67.09	104.6	3.06	1.13	62.3	23.0	14.7

TABLE IV
CARBON MONOXIDE CHANGES AT 800-1100° F

Run	Catalyst	Temp. °F	Mole % H ₂		Mole % CO		Mole % CO ₂		Mole % CH ₄		Flow Outlet, l/hr.	Δ Moles CO ₂	Δ Moles CH ₄	% CO Shift	% CO to CH ₄	% CO Unreacted
			In	Out	In	Out	In	Out	In	Out						
29	NiB/ MgSiO ₃	700	24.92	26.30	4.73	4.58	3.81	3.65	66.54	65.47	101.9	-.092	.156	-1.9	3.3	98.6
		800	24.92	27.37	4.73	4.58	3.81	3.80	66.54	64.29	103.4	.118	-.08	2.5	-1.7	99.2
	NiB/ CrB/ MgSiO ₃	700	24.92	26.22	4.73	4.03	3.81	4.09	66.54	65.66	101.8	.352	.277	7.4	5.9	86.7
		800	24.92	27.25	4.73	2.73	3.81	5.34	66.54	64.68	103.2	1.70	.212	36.0	4.5	59.6

TABLE V

Average % Carbon Monoxide Reaction at 800° F and 1150° F*

Run	Catalyst	Inlet Steam/Gas	% CO Shift	% CO to CH ₄	% CO Unreacted	Shift/Methanation Ratio
2	Ni/Al ₂ O ₃	.425	9.8	7.7	81.1	1.27
	Co/Al ₂ O ₃	.403	39.1	12.0	48.0	3.26
4	Mn/Al ₂ O ₃	.420	22.1	12.9	65.0	1.71
	Fe/Al ₂ O ₃	.379	45.2	26.7	28.2	1.69
5	Cr/Al ₂ O ₃	.404	43.6	15.5	40.8	2.81
	Ni/Fe/Al ₂ O ₃	.382	15.8	3.5	80.7	4.51
6	Fe/Cr/K	.359	33.5	13.8	52.6	2.43
	Ni/Cr/Al ₂ O ₃	.367	31.3	9.5	59.2	3.29
7	Fe/Cr/K/V	.370	46.4	6.4	47.2	7.25
	Ni/Co/Al ₂ O ₃	.459	9.6	9.1	81.2	1.05
8	Co/Mo(low)/Al ₂ O ₃	.414	94.9	-14.1	19.2	-
	Ni/Mo(low)/Al ₂ O ₃	.436	72.4	13.2	14.5	5.48
9	Co/Mo(high)/Al ₂ O ₃	.458	-2.8	19.9	82.9	-
	Ni/Mo(high)/Al ₂ O ₃	.439	65.5	2.2	32.4	29.77
10	Fe/Cr	.433	63.9	16.7	24.3	3.83
	Fe/Cr/Al ₂ O ₃	.424	50.5	13.2	36.3	3.83
11	Ni/W/Al ₂ O ₃	.422	10.4	7.3	82.4	1.42
	Fe/Mo/Cr/Al ₂ O ₃	.418	44.6	16.2	39.2	2.75
12	Ni/Mn/Al ₂ O ₃	.412	40.8	11.2	48.1	3.64
		.273	37.6	8.8	53.6	4.27
		.158	13.3	14.8	71.9	0.90
	Fe/V/Al ₂ O ₃	.425	54.4	14.4	31.2	3.78
		.264	49.1	12.5	37.1	3.93
		.189	32.1	27.4	40.5	1.17
13	2Ni/1Cr	.425	38.9	18.5	42.6	2.10
		.113	24.7	12.1	63.2	2.04
		.137	9.2	9.6	84.5	.96
	Ni/V/Al ₂ O ₃	.421	33.7	18.0	48.3	1.87
		.124	18.5	17.1	77.7	1.08
		.175	3.4	7.1	89.5	.48
14	1Ni/1Cr	.410	56.0	11.3	32.6	4.96
		.305	35.5	15.2	49.4	2.34
		*.210	18.2	15.7	66.1	1.16
	2Fe/1Cr	.438	63.6	14.0	22.0	4.54
		.316	23.5	27.5	49.0	.85
		*.219	14.5	20.4	65.1	.71
15	Ni/Cr/MgO	.276	53.0	12.0	35.6	4.42
		*.497	33.9	14.6	51.6	2.32
		.325	54.9	- 5.5	50.6	-
	Ni/Cr/MgSiO ₃	.330	31.5	7.3	59.8	4.32
		*.310	15.4	39.0	45.6	.39
16	Ni/Cr/SiO ₂	.290	3.9	28.1	68.1	.14
		*	31.1	15.4	53.5	2.02
	Ni/Cr/MgAl ₂ O ₄	.313	39.4	35.7	24.9	1.10
		*.318	28.8	11.2	60.0	2.57

TABLE V

Average % Carbon Monoxide Reaction at 800° F and 1150° F*

Run	Catalyst	Inlet Steam/Gas	% CO Shift	% CO to CH ₄	% CO Unreacted	Shift/Methanation Ratio
17	1Ni/1Cr	.282	47.0	9.8	43.2	4.80
		*.287	29.0	6.2	64.3	4.68
	Ni/Cr/Al ₂ O ₃	.313	45.8	13.1	41.1	3.50
		*.318	23.6	23.5	52.9	1.00
18	Pt/Al ₂ O ₃	.326	35.1	36.1	28.9	.97
		*.318	9.7	13.1	77.2	.74
	Ru/Al ₂ O ₃	.335	22.8	10.4	66.8	2.19
		*.345	22.4	17.4	57.7	1.28
19	Ni/Cr/MgSiO ₃	.443	53.7	2.6	43.7	20.65
		*.320	0.93	61.7	37.4	.02
		*.061	-4.8	67.3	37.4	-
	Ni/Cr/MgAl ₂ O ₄	.458	9.3	9.3	19.4	7.66
		*.199	5.2	53.7	41.1	.10
		*.095	-4.1	50.1	54.0	-
20	Pt/MgSiO ₃	.411	16.8	2.4	80.8	7.00
		*.206	4.9	-0.8	95.9	-
	Ru/MgSiO ₃	.375	-1.8	3.2	98.6	-
		*.190	4.9	-7.0	102.1	-
21	Ni/MgAl ₂ O ₄	.419	45.1	14.4	40.6	3.13
		*.252	13.2	13.6	73.2	.97
	Ni/MgSiO ₃	.428	20.4	9.3	70.4	2.19
		*.196	14.3	12.5	73.2	1.14
22	Ni/Al ₂ O ₃	.385	5.4	3.9	90.8	1.38
		*.183	12.6	2.1	85.4	6.00
	Ni/Cr/V/MgSiO ₃	.416	58.0	17.2	24.8	3.37
		*.184	14.2	37.2	48.6	.38
23	Ni/V/MgSiO ₃	.438	29.5	6.1	64.5	4.84
		*.216	23.8	9.2	67.1	2.59
	Ni/Cr/V/MgAl ₂ O ₄	.391	63.6	20.4	16.0	3.12
		*.230	17.5	29.7	52.8	.59
24	Ni/V/SiO ₂	.415	6.0	- .3	94.3	-
		*.217	15.3	16.4	68.3	.93
	Ni/V/MgAl ₂ O ₄	.423	49.1	11.4	39.4	4.31
		*.189	5.2	35.8	59.1	.15
25	Ni/Mn/MgSiO ₃	.381	53.5	6.0	40.5	8.92
		*.215	-18.1	3.3	114.9	-
	Ni/Pt/MgSiO ₃	.382	32.6	12.9	54.6	2.53
		*.221	10.6	2.5	87.0	4.24
26	1-1 Ni-Cr/Pt	.378	36.7	6.2	57.1	5.92
		*.167	20.6	5.1	74.3	4.04
	Ni/Pt/SiO ₂	.353	4.8	-1.5	96.7	-
		*.207	5.2	2.9	91.9	1.79

TABLE V

Average % Carbon Monoxide Reaction at 800°F and 1150°F*

Run	Catalyst	Inlet Steam/Gas	% CO Shift	% CO to CH ₄	% CO Unreacted	Shift/Methanation Ratio
27	Ni/Cr/ MgSiO ₃	.355	32.1	14.8	53.2	2.17
		* .259	6.1	39.6	54.4	0.15
		* .060	-13.1	74.3	38.8	-
	Ni/Cr/ MgAl ₂ O ₄	.381	62.7	15.4	22.0	4.08
		* .256	17.4	15.2	67.4	1.14
		* .055	-12.6	47.4	65.2	-
28	Ni/Cr/ MgSiO ₃	.400	32.6	45.4	22.1	.72
		* .220	6.0	77.8	28.2	.08
	Ni/Cr/ MgAl ₂ O ₄	.438	62.3	23.0	14.7	2.71
29	NiB/ MgSiO ₃	.390	0.3	0.8	98.9	.38
	NiB/CrB MgSiO ₃	.452	21.7	5.2	73.2	4.17