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FINAL REPORT

TECHNOLOGY DEVELOPMENT FOR COBALT F-T CATALYSTS

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I. EXECUTIVE SUMMARY

During the 8th quarter, a number of important steps have been taken and conclusions made.

Working with Calsicat on catalyst pretreatment and handling procedure, it was found that initial calcination in air vs. N_2 had little effect on the final catalyst properties. However, stabilizing a pre-reduced K- and Ru-promoted 20% Co/ Al_2O_3 in paraffin wax was not sufficient for loading directly into the SBCR without re-reducing again. The catalyst may have sustained oxidation by oxygen diffusion through the wax or during the loading into the SBCR. It has been noted in the past that Co catalysts cannot be suitably reduced in-situ in the SBCR.

There is some evidence that direct reduction without calcination for some of the Co catalysts produces a more active catalyst. However, catalysts with higher initial activities appear to also be more susceptible to exotherming during startup, especially in gas phase reaction, with a concomitant loss of activity.

The Co catalysts being designed in this study particularly are required to have reasonably high activities and chain growth probabilities. In order to achieve this latter, catalysts must be able to operate at temperatures $< 240^\circ C$. As mentioned above, it has been noted that temperature surges during startup in the fixed-bed reactor lead to lower CO conversions. This effect of temperature on deactivating partially these catalysts has also now been seen in the SBCR.

To date, a potential support material (CuCr/ Al_2O_3) has been formulated which has very good water-gas-shift activity. However, fixed-bed results indicate that, when Co is loaded on this support, the resulting catalyst has both poor WGS activity and poorer F-T activity ($< 50\%$).

When a physical mixture of $\text{Co}/\text{Al}_2\text{O}_3$ and the WGS catalyst $\text{CuCr}/\text{Al}_2\text{O}_3$ is used for reaction in the SBCR some WGS is evident which results in slightly higher activity and methane selectivity. However, the increase in CO_2 production is still not significant. Partly, this is a function of the relatively low temperature being used for F-T synthesis.

II. INTRODUCTION AND BACKGROUND

The goal of this project is the development of a commercially viable, cobalt-based Fischer-Tropsch (F-T) catalyst for use in a slurry bubble column reactor. Cobalt-based catalysts have long been known as being active for F-T synthesis. They typically possess greater activity than iron-based catalysts, historically the predominant catalyst being used commercially for the conversion of syngas based on coal, but possess two disadvantages that somewhat lessen its value: (1) cobalt tends to make more methane than iron does, and (2) cobalt is less versatile with low H_2/CO ratio syngas due to its lack of water-gas shift activity. Therefore, the major objectives of this work are (1) to develop a cobalt-based F-T catalyst with low (<5%) methane selectivity, (2) to develop a cobalt-based F-T catalyst with water-gas shift activity, and (3) to combine both these improvements into one catalyst. It will be demonstrated that these catalysts have the desired activity, selectivity, and life, and can be made reproducibly. Following this experimental work, a design and a cost estimate will be prepared for a plant to produce sufficient quantities of catalyst for scale-up studies.

III. PROJECT DESCRIPTION

The Cobalt Fischer-Tropsch Catalyst Project is divided into five tasks designed to systematically develop catalysts through thorough investigation of influences of various promoters, additives, and supports on minimizing methane selectivity and increasing water-gas-shift activity.

Cobalt has long been known to be an excellent catalyst for the F-T synthesis. Nevertheless, all currently operating F-T plants feeding coal produced syngas use iron catalysts,

in spite of the fact that cobalt-based catalysts have higher activity. Two factors that lower cobalt's value as a F-T catalyst are its poorer selectivity, that is, it produces more methane and its inability to be used with low H_2/CO ratio syngas because of its lack of water-gas shift activity. The broad objective of this proposal is to overcome these deficiencies.

In pursuing F-T catalyst development, there are several aspects that need to be considered. These are catalyst formulation, catalyst pretreatment, and catalyst performance. All of these aspects will be dealt with in this project.

In broad terms, the technical approach that will be used is outlined below.

- a. Conduct a thorough review of the literature on F-T synthesis, both the journal literature and the patent literature. In this review, identify approaches for improving methane selectivity of cobalt-based catalysts, identify additives that have WGS activity, identify catalyst formulation options, and define critical pre-treatment parameters.
- b. Based on the above review, develop a list of catalyst formulations with potential for low methane selectivity and a list of catalyst formulations with potential for promoting the WGS reaction.
- c. Screen these catalysts in a small, fixed-bed reactor. If no catalyst meets the target specifications, go back to step b. Otherwise, run catalysts that meet discrimination criteria in a slurry bubble column reactor.
- d. Once catalysts with low methane selectivity and WGS activity have been identified, develop a catalyst combining both these functions and test as described above.
- e. Having found catalysts that meet the desired criteria for activity and selectivity,

optimize the pre-treatment conditions.

- f. Demonstrate catalyst reproducibility by having a commercial subcontractor prepare multiple batches for testing.
- g. Demonstrate catalyst stability by running aging tests in a slurry bubble column reactor.
- h. Based on above results, prepare a design for a plant to produce demonstration scale batches of catalyst. Develop capital and operating costs of this plant.

The program to carry out the above outlined work will consist of five major tasks:

Task 1 -- Catalyst Development

Task 2 -- Catalyst Testing

Task 3 -- Catalyst Reproducibility Tests

Task 4 -- Catalyst Aging Tests

Task 5 -- Preliminary Design and Cost Estimate for a Demonstration

Scale Catalyst Production Facility

All aspects of the catalyst's role in F-T processing will be addressed, including catalyst preparation, pre-treatment, and performance (i. e. activity, selectivity, and aging). In addition to gathering process data, the catalyst will be subjected to a number of analytical measurements at each stage to see how various treatments have affected the catalyst and its performance.

IV. OBJECTIVES

The objective of this project is to investigate the influence of various promoters, additives, and supports on minimizing the methane selectivity and increasing the water-gas shift (WGS) activity of cobalt (Co) Fischer-Tropsch (F-T) catalysts. The ultimate goal of this investigation is to identify and demonstrate a catalyst preparation procedure that will be scaled up for the reproducible synthesis of commercial quantities of supported Co catalysts with desired activity, selectivity, and lifetime for use in F-T synthesis in three-phase slurry bubble column reactors.

V. SUMMARY OF WORK ACCOMPLISHED THIS QUARTER

Four (4) new catalysts were formulated and prepared during this period under both subtasks 1.2 and 1.3. Five more catalysts were prepared by Calsicat.

The characterization of all the catalysts in order to determine their physical properties (BET surface area, pore volume, pore size diameter, particle size distribution), as well as the cobalt reducibility, extent of reduction, and dispersion) was continued.

Fixed-bed reactor testing of the catalysts was continued. Seven (7) new catalysts have been tested for their F-T synthesis performance. Some catalysts have been re-tested for reproducibility checks.

An investigation of the effect of pre-treatment (i.e. calcination in static air versus flowing air, direct reduction without prior calcination) of a selected number of catalysts upon their performance for F-T synthesis was continued during this period.

A paper comparing the effects of supports and promoters on the performance of Co F-T catalysts, both in fixed-bed and slurry bubble column reactors was presented at the 208th ACS

National Meeting in Washington, D.C., August 21-25, 1994.

Another paper comparing the performance of some of the patented Co F-T catalysts studied under this project was presented at the 11th Annual International Pittsburgh Coal Conference, September 12-15, 1994.

VI. DETAILED DESCRIPTION OF TECHNICAL PROGRESS

A. TASK 1: CATALYST DEVELOPMENT

a. Technology Assessment (Subtask 1.1)

Except for regular updating of the literature with the most recent publications, there was no activity during this period to report in this subtask.

b. Catalyst Formulation (Subtasks 1.2, 1.3, 1.4)

An updated list of all the catalysts formulated so far within Subtask 1.2 (including those catalysts listed in previous quarterly reports) is given in Table 1 with their compositions. The last column of Table 1 indicates whether the catalyst has already been prepared. Of the 64 catalysts listed in Table 1, five (CAL.04-CAL.08) were prepared by Calsicat. Two (2) new Co catalysts (highlighted in Table 1) were formulated and prepared during this period. The detailed formulations of the new catalysts are given in Appendix A.

Co.055, an alumina-supported catalyst, is similar to Co.001, but without K. Co.056, a silica-supported catalyst, is similar to Co.025, but with La instead of Zr as a promoter. Both catalysts were formulated in order to investigate in more details the effects of certain promoters such as La_2O_3 and ZrO_2 which significantly affected the activity of cobalt for F-T synthesis in some of the previous formulations.

CAL.04-CAL.08 were formulated with the same composition as that of Co.047 which was selected as the low methane catalyst for the reproducibility test. The only difference between the various catalysts was in the pretreatment conditions (calcined only, reduced only, calcined and reduced, neutralized in air or in a paraffin wax). They were all prepared in small batches for formulation check and determination of the best pre-treatment to adopt for the

preparation of the larger batches to be used for the reproducibility tests.

Under Subtask 1.3 two catalysts were prepared. One Co catalyst (CoW.07), similar in composition to CoW.06, was prepared by pre-impregnating the silica with Cu-CrO and calcining this support precursor at 750°C, instead of 500°C used for CoW.06, before incorporating the cobalt. One water-gas shift catalyst, WGS.09, similar to WGS.03, a 5%Cu/4%Cr/Al₂O₃, which showed the best activity for water-gas shift, was prepared in a larger quantity in order to mix it with a cobalt catalyst for slurry bubble column testing of water-gas shift activity with F-T synthesis. The list of these catalysts is given in Table 2 with their composition, and the detailed formulations are included in Appendix A.

c. Catalyst Pretreatment (Subtask 1.5)

The investigation of the effects of pretreatment on the catalytic properties of a selected number of catalysts was continued during this period. The effects of calcination in static atmosphere versus flow, and the effect of reduction alone without prior calcination were addressed. The results are included in subtask 2.1 where catalysts calcined under different conditions were tested.

d. Catalyst Characterization (Subtask 1.6)

(1) Physical Properties

Table 3 gives an update on the physical property measurements carried out so far. Nitrogen physisorption at 77 K was used to obtain surface area, pore volume and pore diameter of the calcined catalysts. Average particle size of the catalysts was determined using a Microtrac particle size analyzer.

(2) Static Hydrogen Chemisorption

An updated summary of the properties of the Co catalysts as determined by H₂ chemisorption is given in Table 4. Metal dispersions and particle sizes of CAL.04-CAL.08 were determined by CO chemisorption carried out at Calsicat. Only three catalysts were characterized by static hydrogen chemisorption at the University of Pittsburgh because the system was still down and being repaired during most of this period. Co.005 was rerun for reproducibility check. Co.004 was characterized following two different pretreatments: one after calcination followed by standard reduction and the other after reduction only, without prior calcination. A high dispersion was measured for the latter.

(3) Temperature Programmed Reduction (TPR)

TPR experiments were carried out in an automated Altamira Instruments AMI-1 system. The procedure for these measurements was described in the previous quarterly report. All the TPR results obtained so far are summarized in Table 4.

B. TASK 2: CATALYST TESTING

a. Subtask 2.1 - Fixed Bed Reaction Studies:

(1) F-T Synthesis

The reaction conditions and procedure were described in the previous quarterly report. Seven (7) new catalysts (Co.032-Co.034, Co.055, CAL.04-CAL.06, UOP (F-T catalyst supplied by UOP)) were tested for the first time during this reporting period. Catalysts Co.05, Co.012, and Co.019, were retested to check the reproducibility of reaction results obtained previously for these catalysts. Co.004 (runs #2-5), Co.015 (run #2), Co.016 (run #2) , and Co.055 (run

#1-3) were also retested using different pretreatment procedures.

The performances of all these catalysts (highlighted in Table 5) at steady state are compared in Table 5 with those reported in the previous quarterly report. All the pertinent data (CO conversion, rates, product distributions, chain growth probabilities, Anderson-Schulz-Flory distributions, time-on-stream activity and Arrhenius plots when available) obtained with each run for each catalyst is given in Appendix B.

Co.033 and Co.034 were tested in order to evaluate the effect of Zr promotion on Co/Al₂O₃. The results indicate that Zr enhanced significantly the activity of cobalt for F-T synthesis when it is pre-impregnated on the support.

Co.004 and Co.055 were tested both without and with calcination with air in a flow system prior to the standard reduction and reaction procedures. These catalysts, studied as part of the investigation of the effect of La₂O₃ promotion, had a very high activity, especially when they were directly reduced without prior calcination. The pretreatment environment (air vs. hydrogen) seems, therefore, to play a major role in the activation of these catalysts. Both catalysts, as indicated by the data reported for Co.004, run #2a, and Co.055, run #2, and as experienced with other highly active Co catalysts, were very sensitive to temperature effects during the reaction. Because of their high activity, a temperature surge was observed during startup of these runs, resulting in low activities.

The trial catalysts prepared at Calcat, CAL.04-CAL.06, were all tested using the standard reaction conditions. They gave comparable results, irrespective of the pretreatment conditions used by Calcat for the different catalysts. These results are also in agreement with those obtained with Co.047 which was prepared by PARC.

Catalysts Co.05, Co.012, and Co.019 gave slightly higher activities than obtained previously with the same catalysts. This is most probably due to the much improved analytical procedure used presently.

Co.005 (run #7) was tested in the second fixed-bed reactor system for reproducibility check between two different systems.

Co.015 and Co.016 were retested after calcination with air in a flow system. The data reported previously for these catalysts was obtained with the catalysts calcined in a "static" atmosphere at the University of Pittsburgh. As reported previously, this pretreatment procedure may result in low activity catalysts. The new results obtained for Co.015 and Co.016 calcined in flow show also higher activity than those obtained previously with the catalysts calcined in static air.

CoW.03-CoW.06, the catalysts formulated with a water-gas shift component, were also tested under F-T synthesis conditions and the results are included in Table 5. CoW.03 and CoW.04 had very low activity, while CoW.05 and CoW.06 had 50% lower activity than Co.005, a Co/Al₂O₃ catalyst. In addition, no significant effect on the water-gas shift activity was observed during F-T synthesis.

Co.005b and Co.005c, physical mixtures of an F-T catalyst, Co.005 (Co/Al₂O₃ catalyst), and a water-gas shift catalyst, WGS.03 (CuCr/Al₂O₃), were also tested under standard F-T conditions.

b. Subtask 2.2 Slurry Bubble Column Reactor Testing ("SBCR")

(1) Run Chronology

During this reporting period a total of nine runs were performed in the SBCR's, Run 29

in M3 and Runs 14 to 21 in M4. The following is a chronology of the experimental runs performed in the two SBCR's, M3 and M4. A comparison of the CO conversions and the product selectivities of the methane reduction catalysts at the initial operating conditions (i.e., 240°C temperature, 450 psi pressure, and 2/1 H₂/CO ratio) are listed in Tables 6 and 7. All comparisons of CO conversions and CH₄ selectivities discussed in the following chronology were obtained at the startup conditions.

Run No. 14 in the M4-SBCR was started on July 4th with a charge of 15.0 gm of Catalyst No. Co. 005 plus 5.0 gm of Catalyst No. WGS.03. This was a test run in which a cobalt-alumina based catalyst for methane reduction was mixed with a water gas shift catalyst. The CO conversion was slightly higher than using only Catalyst No. Co.005, 29.3% vs. 27.1%. The CH₄ selectivity was also higher, 10.1% vs. 7.9%. The CO₂ selectivity, however, was increased from 0.8% to 2.0%, an insignificant amount.

Run No. 15 in the M4-SBCR was started on July 18th with a charge of 13.0 gm of Catalyst No. Co.034. This catalyst contained 8.5% Zr on alumina support with no other additives. The CO conversion was the same as Catalyst No. Co.005, the alumina catalyst with no additives, 27.5% vs. 27.1%, but the CH₄ selectivity was higher, 10.4% vs. 7.9%. Adding zirconium to the Co-alumina based catalyst had no beneficial effect on lowering CH₄ production.

Run No. 16 in the M4-SBCR was started on August 1st with a charge of 16.1 gm of Catalyst No. CAL.04. This catalyst was supplied by Calsicat and contained 20% Co, 0.4% Ru, and 0.3%K. The CO conversion was 26.25% and the CH₄ selectivity was 7.1%. The CO conversion was about 2% lower than the same catalyst formulation, Co.047, which was prepared by Pitt.

Run No. 17 in the M4-SBCR was started on August 8th with a charge of 15.0 gm of Catalyst No. CAL.08. This catalyst was also supplied by Calsicat, but it was hydrogen reduced and encapsulated in paraffin wax. The catalyst was mixed with synfluid, heated to 100°C under a nitrogen blanket to make a slurry, and then transferred into the reactor under nitrogen. The CO conversion was only 16.9% with a 5.9% CH₄ selectivity. Some of the loss of catalyst activity may have been due to air diffusing through the wax coating during storage or while handling and charging it to the reactor.

Run No. 18 in the M4-SBCR was started on August 15th with a charge of 15.0 gm of Catalyst No. CAL.07. This was another Calsicat catalyst that was hydrogen reduced and encapsulated in paraffin wax. The catalyst charge amount was adjusted to compensate for the was content. The catalyst charge procedure was the same as that used for Run No. 17. The CO conversion was higher, 20.6%, with a corresponding increase of CH₄ selectivity, 7.3% vs. 7.1%.

Run No. 19 in the M4-SBCR was started on August 22nd with a charge of 15.7 gm of Catalyst No. CAL.05. This catalyst is identical to Catalyst No. CAL.04, except it was calcined in nitrogen instead of in air. The CO conversion was nearly identical to CAL.04, 26.6% vs. 26.3%, and so was the CH₄ selectivity, 7.3% vs. 7.1%.

An electrical storm occurred on August 27th and burned out the sequence board of the 5T.I. Programmable Logic Controller. Startup of Run No. 20 was delayed for one week to make the necessary repairs.

Run No. 20 in the M4-SBCR was started on September 5th with Catalyst No. CAL. 06. This was a Calsicat catalyst that had been hydrogen reduced and then stablized with air. The

purpose of running the stabilized catalyst was to see how much residual activity it may have even though it had been oxidized. The CO conversion was 5.6% at startup conditions and dropped to 3% at 220°C reaction temperature. This demonstrates that a reduced catalyst that has been stabilized with air has some residual activity.

Run No. 29 in the M3-SBCR was started on September 12th with 25.2 gm of Catalyst No. Co. 053. A larger amount of catalyst was charged to study catalyst loading and to obtain a higher CO conversion level. The initial CO conversion was the highest conversion obtained to date, 42.0% with a 16% methane selectivity. During Period 7 of the run, the syngas feed rate was reduced in half with a corresponding increase in nitrogen feed. The CO conversion dropped from 40.8% to 31.5%, which was due mainly to reducing the syngas partial pressure. The reaction conditions were returned to startup conditions, but the CO conversion was only 18.0%. The syngas feed rate was then increased by 50%, but the CO conversion increased only 21.6%. It was decided to end the run at this time and repeat it in the near future.

Run No. 21 in the M4-SBCR was started on September 19th with Catalyst No. Co.004. This catalyst is similar to Catalyst No. Co.002 used in Run 3, M4-SBCR, but was not calcined before hydrogen reduction. The CO conversion was much higher than with the calcined version of this catalyst, 39.3% vs. 29.4%. The CO conversion stayed higher over the entire run and remained higher after 227 hours on stream than with the calcined catalyst, 34.6% vs. 24.2%. The methane selectivity, however, was high, averaging about 16% for both the calcined and uncalcined versions of this catalyst.

Data for Runs 5 to 29 in M3-SBCR and Runs 3 to 21 in M4-SBCR are compiled on Tables I through X found in Appendix C.

A complete summary of all runs made in the M3-SBCR is given in Table I in Appendix C. Four tables of data were prepared in order to compare catalyst activities for Runs 5 to 29 in M3-SBCR at the same run conditions (see Tables, II, III, IV, and V in Appendix C).

A complete summary of all runs made in the M4-SBCR is given in Table VI, Appendix C. Four tables are used to present the comparison of catalyst activities for Runs 3 to 21 in M4-SBCR at the same run conditions (see Tables VII, VIII, IX and X in Appendix C).

(2) Discussion of Results

One test run was made in the M4-SBCR (see Run 14 in Table 6 in which 15.0 gm of Catalyst No. Co. 005 plus 5.0 gm of Catalyst No. WGS.03 were charged as a blend. This was a test run in which a cobalt-alumina based catalyst for methane reduction was mixed with a water gas shift catalyst. The CO conversion was slightly higher than using only Catalyst No. Co.005, 29.3% vs 27.1%. The CH₄ selectivity was slightly higher, 10.1% vs. 7.9%, but the CO₂ selectivity increased from 0.8% to 2.0%, an insignificant amount. A run will be made in the near future in which equal amounts of the same two catalysts will be charged.

One run was made to evaluate the addition of zirconium on an alumina supported catalyst. The CO conversion was similar to that obtained with alumina catalyst with no additives (see Run 15 in Table 6), but the CH₄ selectivity was slightly higher, 10.4% vs. 7.9%. Adding

a high concentration of Zr to the cobalt-alumina based catalyst did not increase the CO conversion nor lower the CH₄ selectivity.

Five samples of catalysts were received from Calsicat to test in the SBCR. Each was prepared to match the Catalyst No. Co. 047 prepared by Pitt: 20 wt% Co, 0.5% wt% Ru, and 0.3 wt% K on gamma-alumina support. Two samples, CAL.04 and CAL.05, were calcined in air and nitrogen, respectively. The third sample, CAL.06, was hydrogen reduced and air stabilized. The last two samples, CAL.07 and CAL.08, are reduced powder immersed in paraffin wax and crushed into granules. CAL.08 was calcined in nitrogen before reduction while CAL.07 was processed with hydrogen during the entire heat treatment.

Catalyst No. CAL.04 yielded a CO conversion that was about 2% lower than the same catalyst Co.047, which was prepared by Pitt (see Runs 16-M4 and 23-M3 in Table 7). The CO conversion and CH₄ selectivity for Catalyst No. CAL.05 were nearly identical, (see Runs 16-M4 and 19-M4 in Table 7). Calcining the catalyst in nitrogen instead of air showed no beneficial effect.

Catalyst No. CAL.08 which had been encapsulated in wax yielded only 16.9% CO conversion with a 5.9% CH₄ selectivity (see Run 17-M4 in Table 7). The second wax encapsulated catalyst, CAL.07, produced a slightly higher CO conversion, 20.6%, with a corresponding increase of CH₄ selectivity to 7.7% (see Run 18-M in Table 7). The loss of catalyst activity may have been due to air diffusing through the wax coating during storage or while handling and charging the catalyst slurry into the reactor. Another wax encapsulated catalyst has been received from Calsicat and will be tested in the near future.

The fifth sample from Calsicat, CAL.06, had been hydrogen reduced and then stabilized with air. The purpose was to see how much residual activity the catalyst would have even though it had been oxidized. The CO conversion was 5.6% at startup conditions and demonstrates that a reduced catalyst that had been stabilized with air has some residual activity (see Run 20-M4 in Table 7).

A larger amount of catalyst, 25.2 gm was charged to M3-SBCR to study catalyst loading and to obtain higher syngas conversion levels. A summary of the CO conversion, production rates, and production selectivities are given in Table 8.

The initial CO conversion was higher due to the larger amount of catalyst charged. CH_4 selectivity was high since this catalyst had no potassium to reduce the CH_4 rate. The CO conversion and production rates and selectivities were typical for this catalyst but at a higher level because of the larger amount of catalyst.

For Period 7, the syngas feed rate was reduced in half with a corresponding increase in nitrogen feed. The CO conversion dropped from 40.8% to 31.5% mainly because of the reduction in the syngas partial pressure. Raising the temperature to 260°C did not change the CO conversion (see Period 8). At this point, it was suspected that the catalyst had been partially deactivated. The reactor was then returned to startup conditions, but the CO conversion was only 18%, see period 9 on Table 8. One last period was made in which the syngas feed rate was increased to 150% of normal flows, but the CO conversion only increased to 21.6%. It is not known at this time why the CO conversion dropped. It is possible that the lead oxide beads

were saturated and lost their ability to remove iron carbonyls from the CO feed gas. This run will be repeated in the near future.

Catalyst No. Co.004 was charged to M4-SBCR but was not calcined before hydrogen reduction. This catalyst was identical to Catalyst No. Co.002 which was calcined. The CO conversion was much higher than the calcined version, 39.3% vs. 29.4% (see Runs 3 and 21 in M4-SBCR in Table 6). The CO conversion stayed higher over the entire run (227 hours). CO conversion of uncalcined catalysts has been observed to decrease faster in the fixed bed reactor studies. The methane selectivity, however, was high, about 16%, for both versions of this catalyst.

In conclusion, several catalysts supplied by Calsicat have been tested in the SBCR's and two samples have produced similar results to those formulated by Pitt. The wax coated catalysts, however, showed lower catalyst activity. Additional samples supplied by Calsicat will be tested as soon as they are received. Adding Zr to the Co-alumina based catalyst had no beneficial effect on lowering CH_4 production. Mixing two catalysts, 1/4 water gas shift catalyst + 3/4 cobalt catalyst, produced only a small amount of water gas shift activity. Running with a catalyst that was uncalcined before hydrogen reduction yielded about a 30% increase in catalyst activity. Finally, the high CO conversion hydrogen reduction yielded about a 30% increase in catalyst activity. Finally, the high CO conversion test run yielded a maximum of only 42% CO conversion. This run will be repeated in the near future.

(3) Catalyst Recovery Analyses

The catalysts charged for all runs, except for Run 20 in M3 and for Run 2 in M4, have been recovered and the particle size distributions have been measured. The charge and recovered weights of all catalysts are given in Table 9. The charge weights are in the H₂ reduced state, while the recovered weights are in the oxidized state. Taking this into account, catalyst recoveries are quite good (greater than 90%). The mean volumetric diameters of both the charged and recovered catalysts with the calculated percent reductions in particle size are also given in Table 9. The particle size at the lower 10% pass-through point of the sample for both the charged and recovered catalysts are also given in Table 9.

A comparison of the mean volume diameters of the total feed and recovered samples shows that most of the alumina supported catalysts exhibited the least amount of particle size attrition (5 to 10%) during the reaction. The silica-supported catalysts showed a 10 to 20% particle size reduction while a titanium-supported catalyst had the highest reduction, 18.2% (see Run 8 in M4-SBCR in Table 9).

Five catalysts prepared by Calsicat have been tested in the SBCR and the particle size reduction was very low, 0.5% for CAL.08 and 1.6% for CAL.05. All these catalysts were prepared on a Vista B gamma-alumina catalyst support which has shown good resistance to attrition in the SBCR's.

If you compare the particle size of each sample of the 10% pass-through point, the increase in the amount of fines found in the recovered catalysts, as indicated by the lower particle size at the 10% point, is nearly proportional to the reduction in particle size obtained

by comparing the mean volume diameters of the charge vs. recovered catalysts (see Table 9).

Since the particle size of the charge catalyst was determined on the catalyst after hydrogen reduction and air oxidation, we know that attrition occurred only during the SBCR reaction.

VII. PLANS FOR THE NEXT REPORTING PERIOD

Several tasks are planned for the next reporting period:

A. The fixed-bed reactor testing of new catalysts will be continued on both reactor systems.

A selected number of catalysts will be tested at high pressure (similar to the conditions used in the slurry bubble column reactor) for direct comparison with the SBCR data.

The fixed-bed reactor testing of the series of Al_2O_3 -supported Co catalysts with a water-gas shift function will be continued.

B. The systematic characterization of all the catalysts will be continued using the following techniques:

- Selective hydrogen chemisorption on the reduced catalysts at 100°C ;
- X-ray diffraction before reduction, after reduction, and after slurry bubble column reaction;
- Temperature programmed reduction (TPR);
- Temperature programmed desorption (TPD).

C. New catalyst formulations will be generated in order to pursue the effect of selectivity promoters. The formulation of new Co F-T catalysts having water-gas shift activity will be continued using different preparation techniques for the incorporation of Co into the most active Al_2O_3 -supported WGS catalysts.

D. The investigation of the effect of pretreatment conditions including calcination and reduction will be continued.

E. In the slurry bubble column we shall:

1. Attempt several high conversion runs with high activity catalysts.
2. Test Calsicat produced catalysts as they are received.
3. Install a chilled water pre-cooling coil in the feed gas line to one of the SBCRs before another high CO compression run is attempted.
4. A new bunch of Catalyst No. Co.053 will be charged to determine the effect of catalyst loading and to obtain high CO conversion levels.
5. A blend of Catalyst No. Co.005 and Catalyst No. WGS.09 will be charged for Run 22 in M4-SBCR to evaluate the water gas shift reaction with 3 times the amount of water gas shift catalyst.
6. Calsicat will produce a catalyst similar to our Catalyst No. Co.047 which contains 20 wt % Co, 0.5 wt % Ru, and 0.3 wt % K on gamma-alumina. This catalyst will be tested in both the fixed bed reactor and the SBCR.

VIII. ASSESSMENT OF PROSPECTS FOR FUTURE PROGRESS

The technical approach which had been proposed remains the same and all the tasks are proceeding within schedule.

Table 1. List of Co-based FT Catalysts Formulated

CAT. NO.	wt% Co	wt% M	wt% Prom.	Support	Basis	Prepared
Co.001	20%	1% Re	1% La ₂ O ₃ 0.13% K	γ-alumina	U.S. Pat. 4,880,763	P
Co.002	20%	0.43% Ru	1% La ₂ O ₃	γ-alumina	U.S. Pat. 4,413,064	P
Co.003	20%	0.5% Ru	1% La ₂ O ₃	γ-alumina	U.S. Pat. 4,413,064	P
Co.004	20%	0.43% Ru	1% La ₂ O ₃	γ-alumina	Reproduce Co.002	P
Co.005	20%	0	0	γ-alumina	Base Catalyst	P
Co.005A	20%	0.4% Ru	0	γ-alumina	Ru added to calcined Co.005 by IW impreg.	P
Co.006	12%	0.75% Re	0	Titania	U.S. Pat. 4,794,009	P
Co.007	20%	0	0	Titania	Base Catalyst	P
Co.008	20%	0	0	Silica	UK Pat. Appl. GB 2 125 062 A (Kneaded with excess liquid)	P
Co.009	20%	0.5% Ru	0	γ-alumina	Ru-Promoted Catalyst (use Ru Chloride, single-step aqueous IW)	P
Co.010	20%	0	0	γ-alumina	Base Catalyst (non-calcined)	P
Co.010A	20%	0.4% Ru	0	γ-alumina	Ru added to dried Co.010 by IW impreg.	P
Co.011	20%	0	0	Silica	UK Pat. Appl. GB 2 125 062 A (Kneaded)	P
Co.012	20%	0	0	Silica	Base Catalyst (Inc. Wetness)	P
Co.013	20%	0	0	Titania	Base Catalyst like Co.007, but all aqueous	P
Co.014	12%	0.5% Ru	0	Titania	Ru-Promoted Catalyst (aqueous IW co- impregnation)	P
Co.015	20%	0.43% Ru	1% La ₂ O ₃	γ-Alumina	Similar to Co.002, but all aqueous	P
Co.016	20%	0.43% Ru	1% La ₂ O ₃	γ-Alumina	Similar to Co.015, but calcined after Co impregnation	P

Table 1. List of Co-based FT Catalysts Formulated (Contd.)

CAT. NO.	wt% Co	wt% M	wt% Prom.	Support	Basis	Prepared
Co.017	20%	0.5% Ru	1% La ₂ O ₃	γ -Alumina	Similar to Co.003, but all aqueous	P
Co.018	20%	0.5% Ru	0	γ -Alumina	Ru-Promoted Catalyst (single-step, aqueous IW)	P
Co.019	20%	0.5% Ru	0	Silica	Ru-Promoted Catalyst (single-step, aqueous IW)	P
Co.020	0	0.5% Ru	0	γ -Alumina	Ru Base Catalyst	P
Co.020A	20%	0.4% Ru	0	γ -Alumina	Co added to dried Co.020 by IW impreg.	P
Co.020B	20%	0.4% Ru	0	γ -Alumina	Co added to reduced Co.020 by IW impreg.	P
Co.020C	20%	0.4% Ru	0	γ -Alumina	Co added to calcined Co.020 by IW impreg.	P
Co.021	20%	0	0.7% Zr	Silica	U.K. Pat. Appl. GB 2 125 062 A (single-step)	P
Co.022	20%	0	0.7% Zr	Silica	U.K. Pat. Appl. GB 2 125 062 A (multiple-steps)	P
Co.023	20%	0	1.4% Zr	Silica	U.K. Pat. Appl. GB 2 125 062 A (multiple-steps)	P
Co.024	20%	0	8.5% Zr	Silica	Eur. Pat. Appl. 0 167 215 A2 (non-aqueous Zr pre-impregnation)	P
Co.025	20%	0	8.5% Zr	Silica	Similar to Co.024 but aqueous Zr pre-impregnation	P
Co.026	20%	0	0	Silica (Davison Grade 59)	Similar to Co.012 but different grade silica	P
Co.027	20%	0.5% Ru	0	Silica (Davison Grade 59)	Similar to Co.019 but different grade silica	P
Co.028	20%	0.5% Ru	0.5% K	γ -alumina	Ru- and K-Promoted Catalyst (single-step IW)	P
Co.029	30%	0.5% Ru	0.5% K	γ -alumina	Similar to Co.028 but 30% Co	P

Table 1. List of Co-based FT Catalysts Formulated (Contd.)

CAT. NO.	wt% Co	wt% M	wt% Prom.	Support	Basis	Prepared
Co.030	20%	0	0.1% Zr	γ -alumina	Zr-Promoted Catalyst (single-step aqueous IW)	P
Co.031	20%	0	1.4% Zr	γ -alumina	Zr-Promoted Catalyst (single-step aqueous IW)	P
Co.032	20%	0	8.5% Zr	γ -alumina	Zr-Promoted Catalyst (aqueous IW co-impregnation)	P
Co.033	20%	0	8.5% Zr	γ -alumina	multiple-steps, aqueous IW, Co pre-impregnation	P
Co.034	20%	0	8.5% Zr	γ -alumina	multiple-steps, aqueous IW, Zr pre-impregnation	P
Co.035	20%	0	8.5% Zr	Silica	Zr-Promoted Catalyst (single-step aqueous, kneaded)	P
Co.036	20%	0	8.5% Zr	Silica	multiple-steps, aq. Co pre-impreg. by kneading, aqueous IW Zr impreg.	P
Co.037	12%	0	0	Titania	Similar to Co.013, but TiO ₂ mainly anatase	P
Co.038	12%	0.5% Ru	0	Titania	Similar to Co.014, but TiO ₂ mainly anatase	P
Co.039	12%	0	0	Titania	Similar to Co.007, but only 12% Co	P
Co.040	12%	0	0	Titania	Similar to Co.013, but only 12% Co	P
Co.041	20%	0.5% Ru	8.5% Zr	Silica	Similar to Co.025, but Ru-promoted	P
Co.042	0	0	8.5% Zr	Silica	Blank Zr-promoted SiO ₂	P
Co.043	20%	0.5% Ru	8.5% Zr 0.5% K	Silica	Similar to Co.041, but K-promoted	P
Co.044	20%	0	15% Zr	Silica	Similar to Co.025, but 15% Zr	P
Co.045	20%	0	4% Zr	Silica	Similar to Co.025, but 4% Zr	P
Co.046	12%	0.75% Re	4% SiO ₂	Titania	Similar to Co.006, but SiO ₂ -promoted	-

Table 1. List of Co-based FT Catalysts Formulated (Contd.)

CAT. NO.	wt% Co	wt% M	wt% Prom.	Support	Basis	Prepared
Co.047	20%	0.5% Ru	0.3% K	γ -alumina	Similar to Co.028, but 0.3% K	P
Co.048	20%	0.5% Ru	8.5% Zr 0.3% K	Silica	Similar to Co.043, but 0.3% K	P
Co.049	20%	0.5% Ru	0.1% K	γ -alumina	Similar to Co.047, but 0.1% K	P
Co.050	20%	0.5% Ru	8.5% Zr 0.1% K	Silica	Similar to Co.048, but 0.1% K	P
Co.051	0	0.5% Ru	0	Titania (R)		P
Co.052	0	0.5% Ru	0	Titania (A)		P
Co.053	20%	0.5% Ru	0	γ -alumina	Similar to Co.018 (New Batch)	P
Co.054	20%	0	8.5% Zr 0.3% K	Silica	Similar to Co.043, but without Ru	P
Co.055	20%	1% Re	1% La ₂ O ₃	γ -alumina	Similar to Co.001, but without K	P
Co.056	20%	0	8.5% La ₂ O ₃	Silica	Similar to Co.025, but La instead of Zr	P
CAL.01 (97E-13E)	20%	0.5% Ru	0	γ -alumina	Similar to Co.018 (Calsicat Prep.)	P
CAL.02 (97E-16B)	20%	0.5% Ru	0	γ -alumina	Similar to CAL.01 (New Batch)	P
CAL.03 (97E-13F)	20%	0.5% Ru	0	γ -alumina	2-step impreg., Similar to CAL.02	P
CAL.04 (97E-50C)	20%	0.5% Ru	0.3% K	γ -alumina	Similar to Co.047 Stand. Calc. in Air	P
CAL.05 (97E-50D)	20%	0.5% Ru	0.3% K	γ -alumina	Similar to Co.047 Stand. Calc. in N ₂	P
CAL.06 (97E-51A)	20%	0.5% Ru	0.3% K	γ -alumina	Similar to Co.047 Red. and Pas. in Air	P
CAL.07 (97E-51B)	20%	0.5% Ru	0.3% K	γ -alumina	Similar to Co.047 Red. and Protected in Paraffin (51.3% Cat. Conc.)	P
CAL.08 (97E-51C)	20%	0.5% Ru	0.3% K	γ -alumina	Similar to Co.047 Calc., Red. and Protected in Paraffin (54.4% Cat. Conc.)	P

Table 2. List of Water-Gas Shift Catalysts and F-T Catalysts with WGS Function

CAT. NO.	wt% Co	wt% M	wt% Prom.	Support	Basis	Prepared
WGS.01	0	5.0% Cu	0	γ -alumina	single-step, aqu. IW	P
WGS.02	0	5.0% Cu	10% Zn	γ -alumina	single-step, aqu. IW	P
WGS.03	0	5.0% Cu	4.0% Cr	γ -alumina	single-step, aqu. IW	P
WGS.04	0	0	4.0% Cr	γ -alumina	single-step, aqu. IW	P
WGS.05	0	0	4.0% Mn	γ -alumina	single-step, aqu. IW	P
WGS.06	0	5.0% Cu	4.0% Mn	γ -alumina	single-step, aqu. IW	P
WGS.07	0	4.0% Fe	0	γ -alumina	single-step, aqu. IW	P
WGS.08	0	4.0% Fe	4.0% Cr	γ -alumina	single-step, aqu. IW	P
WGS.09	0	5.0% Cu	4.0% Cr	γ -alumina	Similar to WGS.03	-
CoW.01	20%	5.0% Cu	10% Zn	γ -alumina	multiple-steps, aqu. IW, Cu,Zn pre-impr.	P
CoW.02	20%	5.0% Cu	4.0% Cr	γ -alumina	multiple-steps, aqu. IW, Cu,Cr pre-impr.	P
CoW.03	10%	5.0% Cu	4.0% Cr	γ -alumina	similar to CoW.02 (10% Co only)	P
CoW.04	10%	10% Cu	8.0% Cr	γ -alumina	similar to CoW.03; 10% Cu and 8% Cr	P
CoW.05	20%	5.0% Cu	4.0% Cr	γ -alumina	similar to CoW.02 with support calcined at 750°C	P
CoW.06	20%	5.0% Cu	4.0% Cr	Silica	multiple-steps, aqu. IW, Cu,Cr pre-impr.	P
CoW.07	20%	5.0% Cu	4.0% Cr	Silica	similar to CoW.06, but with support calcined at 750°C	P

Table 3. Summary of Physical Properties

CATALYST	Composition	BET Surface Area (m ² /g)	Pore Volume (cc/g)	Average Pore Dia. (Å)	Average Part. Size (μm)
Vista-B Al ₂ O ₃	(0-400 mesh)	299	1.69	269	24
Vista-B Al ₂ O ₃	Calcined 500°C	240	0.49	82	
Vista-B Al ₂ O ₃	Calcined 600°C	206	0.49	95	
Vista-B Al ₂ O ₃	Calcined 600°C	174	0.47	109	
Davison SiO ₂	(0-400 mesh)	219	0.51	89	121
Degussa P25 TiO ₂	(as received)	47	0.40	335	6
Degussa P25 TiO ₂	Dried 60°C, Calc. 350°C/16hrs	46	0.48	419	51
Degussa P25 TiO ₂	Dried 60°C, Calc. 650°C/16hrs	12	0.17	573	212
Co.001	20Co/1Re/ 1La ₂ O ₃ /0.13K/A	191	0.31	66	42 40
Co.002	20Co/0.43Ru/ 1La ₂ O ₃ /A	149	0.33	89	74
Co.003	20Co/0.5Ru/ 1La ₂ O ₃ /A	122	0.26	87	77
Co.004	20Co/0.43Ru/ 1La ₂ O ₃ /A				
Co.005	20Co/A	173	0.34	81	65 86
Co.006	12Co/0.75Re/T	16	-	-	
Co.007	20Co/T	11	0.10	372	
Co.008	20Co/S	181	1.06	234	
Co.009	20Co/0.5/A				
Co.010	20Co/A				
Co.011	20Co/S	211	1.07	203	107
Co.012	20Co/S	211	-	-	105
Co.013	20Co/T				
Co.014	12Co/0.5Ru/T	15	0.12	328	
Co.015	20Co/0.43Ru/ 1La ₂ O ₃ /A	141	-	-	67

Table 3. Summary of Physical Properties (contd.)

CATALYST	Composition	BET Surface Area (m ² /g)	Pore Volume (cc/g)	Average Pore Dia. (Å)	Average Part. Size (μm)
Co.016	20CoB/0.43Ru/ 1La ₂ O ₃ /A	116	-	-	79
Co.017	20Co/0.5Ru/ 1La ₂ O ₃ /A	123	-	-	73
Co.018	20Co/0.5Ru/A	158	-	-	69
Co.019	20Co/0.5Ru/S				110
Co.021	20Co/0.7Zr/S	213	1.12	210	
Co.023	20Co/1.4Zr/S	213	-	-	
Co.024	20Co/8.5Zr/S	215	1.08	202	
Co.025	20Co/8.5Zr/S	208	0.97	187	
Co.026	20Co/S(59)	184	-	-	
Co.027	20Co/S(59)	189	-	-	
Co.028	20Co/0.5Ru/0.5K/A	161	0.33	82	
Co.029	30Co/0.5Ru/0.5K/A	140	-	-	
Co.032	20Co/8.5Zr/A	155	0.30	77	
Co.034	20Co/8.5Zr/A	150	0.31	83	
Co.035	20Co/8.5Zr/S	207	1.21	233	
Co.036	20Co/8.5Zr/S	209	-	-	
Co.037	12Co/T(A)	38	-	-	
Co.039	12Co/T(R)	13	-	-	
Co.041	20Co/0.5Ru/8.5Zr/S	214	-	-	-
Co.047	20Co/0.5Ru/0.3K/A	162	0.31-	78	
CAL.01	20Co/0.5Ru/A	178	0.34	76	
CAL.02	20Co/0.5Ru/A	158	-	-	
CAL.03	20Co/0.5Ru/A	158	-	-	
CAL.04	20Co/0.5Ru/0.3K/A	151			
CAL.05	20Co/0.5Ru/0.3K/A	163			
CAL.06	20Co/0.5Ru/0.3K/A	162			
CAL.07	20Co/0.5Ru/0.3K/A	-			

Table 3. Summary of Physical Properties (contd.)

CATALYST	Composition	BET Surface Area (m ² /g)	Pore Volume (cc/g)	Average Pore Dia. (Å)	Average Part. Size (μm)
CAL.08	20Co/0.5Ru/0.3K/A	-			

Table 4. H₂ Chemisorption and TPR Results

Catalyst	H ₂ Chemisorption ^a				H ₂ TPR	
	Total (μ mol H ₂ /g cat)	Irrevers. (μ mol H ₂ /g cat)	Average d_p^b (nm)	% Disp.	%Co Red. ^c (TPR calc. Cat.)	% Red. ^d (stand. red.)
Co.001	174 $\pm$ 5	157 $\pm$ 5		10.2		
Co.002	155	130		9.1		
Co.003	165	140		9.6		
Co.004 ¹ " 2	205 65	185 56		12.1 4		
Co.005	48	42	20	2.8	89	58
Co.005a	129	110	11	7.6	92	84
Co.006	44	32	19	4	80	
Co.007	33	23	36	2.0	78	78
Co.008						
Co.009	133	109	13	7.8	98	
Co.010						
Co.010a	124	100	12.5	7.3	91	89
Co.011	82	70	15.6	4.8	75	75
Co.012	89	74	15	5.2	80	80
Co.013	21	17	79	1.2	97	
Co.014	38	30	21	3.7	79	
Co.015	146	124	11.7	8.6	94	94
Co.016	163	146	10.5	9.6	96	96
Co.017	202	183	8.5	11.9	97	97
Co.018	185	165	9.2	11	97	94

Table 4. H₂ Chemisorption^a and TPR Results (contd.)

Catalyst	H ₂ Chemisorption ^a				TPR	
	Total (μ mol H ₂ /g cat)	Irrev. (μ mol H ₂ /g cat)	Average d_p^b (nm)	% Disp.	%Co Red. ^c (TPR calc. Cat.)	% Red. ^d (stand. red.)
Co.018Cl					95	
Co.019	112	92		6.6		
Co.020						
Co.020a	153	126	10	9.1	88	
Co.020b	134	113	11	7.9	86	
Co.020c	115	100	13	6.8	88	
Co.021	74	50		4.3		
Co.022	141	122		8.3	80	
Co.023	158	136		9.3	81	
Co.024	87	72		5.1	91	
Co.025	93	77		5.5	75	
Co.026						
Co.027						
Co.028	170	148		10		
Co.029	175	155		7		
Co.030						
Co.031	71	51	20	4.2	82	
Co.032	55	39	26	3.2	85	
Co.033	43	32	31	2.5	79	
Co.034	114	91	14	6.7	96	
Co.035	125	115	11	7.2	82	
Co.036	122	98		7.2		

Table 4. H₂ Chemisorption^a and TPR Results (contd.)

Catalyst	H ₂ Chemisorption ^a				TPR	
	Total (μ mol H ₂ /g cat)	Irrev. (μ mol H ₂ /g cat)	Average d_p^b (nm)	% Disp.	%Co Red. ^c (TPR calc. Cat.)	% Red. ^d (stand. red.)
Co.037	21	3	48	2	99	
Co.038	45	35	21	4.3	91	
Co.039	19	16	40	1.8	72	
Co.040	14	11		1.4		
Co.041	70	55		4		
Co.042						
Co.043	137	116		8		
Co.053						
CAL.01	-	-	58 ^e	4.4 ^e		
CAL.02	-	-	63 ^e	5.1 ^e		
CAL.03	-	-	57 ^e	4.2 ^e		
CAL.04			55 ^e			
CAL.05			56 ^e			
CAL.06			57 ^e			
CAL.07			-			
CAL.08			-			

(a) static H₂ chemisorption at 100°C(b) Est. assuming $H_{2,0}/Co_s = 1$, 5.46×10^{-20} m²/Co_s, and $d_p = 5/S_{Co}/\rho$ S_{Co} is based on amt. Co reducible during standard reduction

(c) % Co reducible from TPR of calcined catalysts up to 900°C

(d) % Co reduced after standard reduction procedure

(e) Based on CO chemisorption

(f) Catalyst Co.018-Cl is chlorinated.

Table 5. Summary of Fixed Bed Reaction Results

Catalyst	Run	Prep	CO Conv (%)	Rate g CH ₂ /g cat/hr	R-C6+ g CH ₂ /g cat/hr	R (CO) mol/mol Co/s	wt% CH ₄	alpha	C3-C5 Ole/Par	CO ₂ (%) (CO)	g/g cat/hr	E _{act} kcal/mol	Comment
Co.001	4	(1)	2.6	0.116	0.056	6.8E-04	19.6	0.76	8.61	0.4	0.061		NSH**
Co.002	4	(2)	6.7	0.258	0.082	1.5E-03	26.1	0.64	1.97	0.1	0.012		NS*
Co.003	1	(3)	5.5	0.185	0.044	1.1E-03	30.8	0.57	4.22			28.9	old startup
Co.004	1	(2) s	4.3	0.291	0.086	1.7E-03	30.4	0.62	2.77	0.1	0.025	25.9	NSH
"	2	u	11.2	0.517	0.155	3.0E-03	28.9	0.61	1.02	0.1	0.038		NSH
"	2h	u	47.6	0.548	0.211	3.2E-03	21.9	0.64	0.40	2.3	0.090		NSH, high conv. study
"	2a	f	3.8	0.177	0.063	1.0E-03	25.5	0.65	3.02	0.1	0.024		NSH, calc. after run 2, T surge
"	3	u	6.7	0.499	0.153	2.9E-03	27.8	0.61	1.45	0.1	0.036		NSH
"	3h	u	27.0	0.506	0.164	3.0E-03	27.3	0.62	0.46	0.8	0.048		NSH, high conv. study
"	4	u	1.8	0.427	0.241	2.5E-03	24.0	0.79	2.40	0.1	0.078		NSH, 10 atm
"	5	f	4.5	0.288	0.150	1.7E-03	19.4	0.75	7.84	0.1	0.027		NSH
Co.005	2	(1)	3.3	0.087	0.037	5.1E-04	21.4	0.66	3.40	0.1	0.005		NS
"	2a		2.5	0.066	0.021	3.9E-04	25.9	0.59	4.92	0.1	0.004		CO:H ₂ :Ar = 1:2:2
"	2b		2.4	0.064	0.021	3.7E-04	26.3	0.60	6.22	0.1	0.006		+ H ₂ O (eq. 7.5% CO conv.)
"	3		3.3	0.077	0.024	4.5E-04	28.4	0.62	2.29	0.1	0.013		NSH
"	4		4.0	0.069	0.021	4.0E-04	30.0	0.62	2.16	0.2	0.009	25.1	NSH
"	5		3.9	0.171	0.084	1.0E-03	26.8	0.76	2.59	0.1	0.018		NSH, 10 atm
"	6		2.1	0.129	0.044	7.6E-04	25.7	0.64	5.53	0.1	0.017		NSH
"	7		6.7	0.084	0.040	4.9E-04	18.8	0.70	1.95	0.1	0.003		S2
Co.005a	1	(4a)	3.2	0.227	0.067	1.3E-03	30.0	0.60	3.05	0.1	0.034		NSH
Co.005b	1	(1)	2.4	0.040	0.024	2.3E-04	13.9	0.74	0.55	0.4	0.023		S2, 1/4WGS.03 + 3/4Co.005
Co.005c	1	(1)	5.7	0.071	0.031	4.1E-04	20.3	0.68	0.21	1.8	0.076		S2, 1/2WGS.03 + 1/2Co.005
Co.006	1	(5)	2.7	0.052	0.007	5.1E-04	45.0	0.49	1.90	0.1	0.006		NSH
Co.007	1	(5)	3.2	0.024	0.003	1.4E-04	49.8	0.50	0.72	0.2	0.004		NSH
Co.009	1	(1)	4.9	0.346	0.090	2.0E-03	31.1	0.57	1.69	0.1	0.020		NSH
"	2		4.9	0.338	0.091	2.0E-03	31.1	0.58	1.64	0.1	0.026		NSH
Co.010a	1	(4b) s	3.5	0.246	0.076	1.4E-03	29.5	0.62	2.58	0.2	0.040		NSH
"	2		4.1	0.262	0.080	1.5E-03	30.0	0.61	2.31	0.1	0.022		NSH
Co.011	2	(6b)	2.9	0.094	0.037	5.5E-04	22.4	0.61	4.83	0.3	0.030		slow CO startup (60 min)
Co.012	1		3.8	0.083	0.027	4.8E-04	26.3	0.64	4.40			22.5	slow CO startup (60 min)
"	2		4.4	0.085	0.030	5.0E-04	29.1	0.64	1.93	0.3	0.018		NSH
"	3		2.1	0.081	0.026	4.7E-04	28.6	0.66	3.57	0.4	0.049		NSH
"	4		2.5	0.105	0.035	6.2E-04	28.4	0.61	4.94	0.4	0.023		NSH
Co.014	1	(1)	1.5	0.028	0.009	2.8E-04	32.3	0.63	4.70	0.1	0.003		NSH
"	2		2.6	0.034	0.013	3.3E-04	27.7	0.69	10.8	0.1	0.011	26.0	NSH
Co.015	1	(4) s	6.8	0.211	0.063	1.2E-03	26.7	0.60	3.30	0.1	0.011		slow CO startup (120 min)
"	2	f	7.0	0.388	0.135	2.3E-03	26.4	0.64	1.39	0.1	0.011		NSH
Co.016	1	(4a) s	5.2	0.161	0.035	9.4E-04	33.6	0.56	6.85				slow CO startup (30 min)
"	2	f	5.1	0.291	0.112	1.7E-03	25.1	0.68	2.48	0.1	0.01		NSH

Table 5. Summary of Fixed Bed Reaction Results

(Continued)

Catalyst	Run	Prep	CO Conv (%)	Rate g CH ₂ /g cat/hr	R-C6+ g CH ₂ /g cat/hr	R (Co) mol/mol Co/s	wt% CH ₄	alpha	C3-C5 Ole/Par	CO ₂ (%)	g/g cat/hr	E act kcal/mol	Comment
Co.017	2	(1) s	4.6	0.139	0.066	8.2E-04	22.0	0.69	3.72	0.1	0.012		NS
"	2a	s	3.7	0.111	0.043	6.5E-04	25.9	0.64	4.19	0.1	0.011		CO:H ₂ :Ar = 1:2:2
"	2b	s	3.4	0.102	0.039	6.0E-04	26.9	0.65	4.39	0.1	0.013		+ H ₂ O (eq. 7.5% CO conv.)
Co.018	2	s	3.4	0.170	0.068	1.0E-03	27.2	0.69	2.24	0.1	0.013		NS
"	2a	s	2.7	0.133	0.041	7.8E-04	33.2	0.64	2.52	0.1	0.011		CO:H ₂ :Ar = 1:2:2
"	2b	s	3.0	0.147	0.045	8.6E-04	33.6	0.63	2.41	0.1	0.015		+ H ₂ O (eq. 7.5% CO conv.)
"	3	s	4.1	0.290	0.086	1.7E-03	30.0	0.62	2.34	0.1	0.022		NSH
"	4	s	3.6	0.340	0.180	2.0E-03	25.4	0.80	1.92	0.1	0.041		NSH, 10 atm
"	5	f	7.5	0.470	0.136	2.8E-03	29.0	0.60	1.93	0.3	0.055		NSH
"	6	f	6.5	0.409	0.147	2.4E-03	24.6	0.64	2.42				NSH, S ₂ "
Co.018Cl	1	(1)	4.5	0.320	0.075	1.9E-03	33.5	0.57	1.45	0.1	0.018		NSH
Co.019	1	(1)s	4.4	0.088	0.047	5.2E-04	15.2	0.74	7.61				NS
"	2	s	2.2	0.085	0.046	4.9E-03	18.9	0.73	8.59	0.3	0.040		NSH
"	3	s	3.4	0.142	0.071	8.3E-04	19.3	0.72	6.74	0.2	0.025		NSH
"	3h	f	16.7	0.172	0.091	1.0E-03	18.2	0.74	1.77	1.0	0.034		NSH, high conv. study
Co.020a	1	(4) s	4.6	0.343	0.085	2.0E-03	33.5	0.57	1.70	0.1	0.024		NSH
"	2		4.4	0.315	0.086	1.8E-03	31.2	0.59	1.96	0.1	0.028		NSH
Co.020b	1	(4b) s	4.4	0.311	0.084	1.8E-03	31.7	0.58	1.81	0.2	0.051		NSH
Co.020c	1	(4a) s	4.0	0.287	0.083	1.7E-03	30.4	0.60	2.38	0.1	0.017		NSH
Co.021	1	(6b)	3.4	0.109	0.032	6.4E-04	27.3	0.62	2.78	0.1	0.012	28.2	NSH
"	2		3.6	0.114	0.035	6.7E-04	28.0	0.56	2.69	0.1	0.012		NSH
Co.022	1	(6c)	3.8	0.121	0.037	7.1E-04	26.7	0.55	2.91	0.1	0.015	30.1	NSH
Co.023	1	(6c)	3.8	0.123	0.038	7.2E-04	28.3	0.56	3.18	0.2	0.023	29.5	NSH
Co.024	1	(7)	5.1	0.165	0.047	9.7E-04	32.8	0.62	2.08	0.5	0.055		NSH
"	2		5.7	0.182	0.060	1.1E-03	28.7	0.62	2.25	0.3	0.035		NSH
Co.025	1	(4)	5.0	0.160	0.062	9.4E-04	23.5	0.63	4.13	0.2	0.019	26.9	NSH
Co.026	1	(1)	4.4	0.129	0.043	5.0E-04	26.9	0.62	2.65	0.2	0.022		NSH
"	1h		22.9	0.170	0.072	6.6E-04	22.6	0.67	0.64	1.5	0.037		NSH, high conv. study
Co.027	1	(1)	4.2	0.169	0.068	6.6E-04	23.0	0.65	3.44	0.2	0.026		NSH
"	1h		17.8	0.180	0.085	7.0E-04	19.4	0.71	0.96	1.2	0.011		NSH, high conv. study
Co.028	1	(4)	3.8	0.146	0.076	5.7E-04	18.2	0.76	7.63	0.2	0.031		NSH
"	2		4.3	0.167	0.105	6.5E-04	14.7	0.80	13.2	0.2	0.030	28.4	NSH
"	3		4.5	0.206	0.126	8.0E-04	15.5	0.79	13.4	0.2	0.037		NSH, re-calc. in flow air
Co.029	1	(4)	2.8	0.173	0.105	6.7E-04	15.3	0.79	25.9	0.2	0.026		NSH
Co.031	1	(1)	1.9	0.060	0.022	3.5E-04	26.1	0.64	4.65	0.3	0.031		NSH
Co.032	1	(1)	3.3	0.183	0.079	1.1E-03	22.0	0.70	5.28	0.1	0.022		NSH
Co.033	1	(1)	1.3	0.073	0.027	4.3E-04	24.1	0.67	7.36	0.1	0.020		NSH
Co.034	1	(4)	5.0	0.275	0.107	1.6E-03	24.0	0.67	4.29	0.1	0.018		NSH
Co.035	2	(6)	4.6	0.147	0.068	8.6E-04	22.0	0.69	4.84	0.2	0.019		NSH
Co.036	2	(6c)	3.9	0.125	0.045	7.3E-04	28.9	0.67	4.20	0.1	0.013		NSH
Co.037	1	(4a)	2.7	0.053	0.011	5.2E-04	32.8	0.59	2.82				NSH
Co.038	1	(4a)	4.5	0.051	0.018	4.9E-04	25.1	0.68	4.63	0.3	0.013	24.2	NSH

Table 5. Summary of Fixed Bed Reaction Results

(Continued)

Catalyst	Run	Prep	CO Conv (%)	Rate g CH ₂ / g cat/hr	R-C6+ g CH ₂ / g cat/hr	R(C6) mol/mol Co/s	wt% CH ₄	alpha	C3-C5 Ole/ Par	CO ₂ (%) g/g cat/hr	B act kcal/ mol	Comment	
Co.039	1	(5)	1.1	0.021	0.004	2.0E-04	57.2	0.64	0.84	0.2	0.010	25.6	NSH, cracking in the line
"	2		3.9	0.049	0.007	4.7E-04	42.4	0.48	0.95	0.2	0.009		NSH
Co.040	1	(4a)	1.9	0.037	0.004	3.7E-04	45.2	0.53	1.79	0.2	0.007		NSH
"	2		2.8	0.033	0.004	2.0E-04	44.6	0.46	1.12	0.2	0.007		NSH
Co.041	1	(4)	3.5	0.136	0.042	8.0E-04	40.7	0.69	1.47	0.6	0.079		NSH, cracking in the line
Co.043	1	(4a)	4.6	0.104	0.062	6.1E-04	15.3	0.78	12.1	0.6	0.048		NSH, 2.5 hr on-stream
"	2		3.7	0.078	0.045	4.6E-04	16.3	0.78	7.75	0.5	0.035	35.1	NSH
Co.047	1	(4)	6.4	0.263	0.128	1.5E-03	21.3	0.73	7.20	0.3	0.040	26.6	NSH
Co.048	1	(4)	3.5	0.162	0.094	9.5E-04	16.3	0.77	17.1	0.2	0.027	28.0	NSH
Co.049	1	(4)	7.1	0.366	0.153	2.1E-03	23.4	0.69	5.63	0.3	0.043		NSH
"	2		6.0	0.388	0.160	2.3E-03	23.3	0.68	5.93	0.3	0.056		NSH, re-calcined in flow air
"	3	f	6.7	0.410	0.158	2.4E-03	25.2	0.69	4.64	0.3	0.059		NSH
"	3h	f	44.9	0.457	0.178	2.7E-03	26.5	0.67	0.67	3.8	0.131		NSH,HCS
Co.053	1	(1)	7.0	0.408	0.127	2.4E-03	27.3	0.62	3.07	0.2	0.049		NSH
"	1h		28.5	0.417	0.145	2.4E-03	26.8	0.64	0.79	1.6	0.081		NSH, high conv. study
"	2	f	6.6	0.433	0.174	2.5E-03	23.4	0.63	2.35	0.2	0.052		NSH
"	3		7.8	0.453	0.143	2.7E-03	27.6	0.62	1.67	0.1	0.027		NSH
"	3h		31.5	0.457	0.164	2.7E-03	25.4	0.65	0.52	0.9	0.044		NSH, high conv. study
"	4	u	6.1	0.426	0.142	2.5E-03	28.3	0.65	1.41	0.2	0.030		NSH
Co.054	1	(1)	1.2	0.041	0.023	2.4E-04	17.8	0.79	16.3	0.2	0.014		NSH
Co.055	1	(1) f	9.1	0.490	0.159	2.9E-03	28.9	0.63	1.31	0.2	0.034		NSH
"	2	u	4.9	0.290	0.105	1.7E-03	25.7	0.65	1.49	0.2	0.022		NSH, T serge
"	3	u	11.0	0.611	0.193	3.6E-03	29.4	0.60	1.02	0.2	0.033		NSH
CAL.01	1	(1)	4.8	0.181	0.068	1.1E-03	24.4	0.66	5.86	0.3	0.036		NSH, temp. surge (startup)
"	2		7.4	0.491	0.142	2.9E-03	28.7	0.61	2.06	0.4	0.083		NSH
"	3		2.5	0.164	0.053	9.6E-04	25.6	0.63	4.97	0.2	0.052		NSH, HT, re-reduced
"	4		7.3	0.483	0.103	2.8E-03	35.8	0.57	1.21	0.2	0.098		NSH, HT, re-calcined
CAL.02	1	(1)	6.1	0.379	0.121	2.2E-03	27.3	0.63	3.04	0.2	0.040		NSH
CAL.03	1	(1)	7.3	0.459	0.133	2.7E-03	29.0	0.60	2.59	0.2	0.048		NSH
CAL.04	1	(1)	4.1	0.234	0.123	1.4E-03	19.1	0.71	8.98	0.2	0.026		NSH
CAL.05	1	(1)	4.7	0.274	0.134	1.6E-03	20.8	0.75	6.85	0.2	0.026		NSH
CAL.06	1	(1)	5.8	0.267	0.135	1.6E-03	20.7	0.74	5.50	0.2	0.021		NSH
CoW.01	1	(4a)	1.2	0.016	0.003	9.5E-05	30.2	0.58	3.78	0.2	0.006		NSH, reduced at 230 °C
"	1		0.5	0.007	0.001	3.4E-05	42.1	0.51	0.95	0.1	0.003		NSH, re-reduced at 350 °C
"	2		0.2	0.006	0.000	3.4E-05	40.9	0.51	11.3	0.1	0.006		NSH, reduced at 350 °C
CoW.02	1	(4a)	0.3	0.009	0.002	5.4E-05	25.6	0.60	4.94	0.1	0.008		NSH, reduced at 230 °C
CoW.03	1	(4a)											NSH, negligible activity
CoW.04	1	(4a)											S2, negligible activity
CoW.05	1	(4c)	2.8	0.035	0.006	2.1E-04	33.1	0.55	0.66	0.2	0.008		S2, reduced at 350 °C
"	2	u	4.7	0.058	0.011	3.4E-04	34.8	0.50	0.85	0.2	0.009		S2
CoW.06	1	(4a)	3.3	0.041	0.012	2.4E-04	26.0	0.59	2.21	0.2	0.007		S2, reduced at 250 °C
"	2	u	2.6	0.032	0.004	1.9E-04	39.3	0.46	0.99	0.3	0.012		S2
"	2		17.0	0.207	0.004	1.2E-03	68.7	0.32	0.37	1.7	0.07		S2, rxn. at 280 °C
UOP	1	(1)	7.8	0.298	0.104	1.7E-03	22.6	0.61	1.29	0.2	0.023		NSH

Table 5 - Summary of Fixed Bed Reaction Results

(Continued)

All the reactions are carried out at 220 deg. C , 1 atm , and with $H_2:CO=2$

All the catalysts are reduced and passivated before loading into reactor, then rereduced in-situ

All catalysts are calcined at UPARC (static) : except where specified in prep. column

s : calcined at Pitt, static

f : calcined at Pitt, flow

u : uncalcined

In some cases, "re-calcined" means calcination of the calcined catalyst from UPARC for a longer period

(1) single step, aqueous incipient wetness

(2) Two step impregnation: aqueous incipient wetness of Co + acetone/ethanol impregnation of Ru, La

(3) three step, with calcination after each step, acetone incipient wetness

(4) two step, aqueous incipient wetness, (a) intermediate calcination, (b) intermediate reduction, (c) intermediate calcination 750 °C

(5) single step, acetone impregnation

(6) single step, aqueous kneading, (a) = 150%, (b) = 110% of pore volume

(6c) aqueous kneading for Co, calcined, then aqueous incipient wetness for Zr

(7) Two step impregnation :organic incipient wetness + aqueous incipient wetness

* New startup

** New startup, heated inlet

" was done in the second system

~ Davison Grade 59 Silica, if not specified, S refers Davison Grade 952 Silica

corrected overheated line on 3/6/1994

Cl chlorinated (see Co.018Cl)

Table 6

DATE: 09/30/94

COMPARISON OF CONVERSION AND SELECTIVITY OF
METHANE REDUCTION CATALYSTS AT STARTUP CONDITIONS

Period No.				Temp.	Pres.	H2/CO Ratio							
-----				-----	-----	-----							
1				240 C	450psi	2.0							

Run No	Cat. No	Cat. wt,g	Conv. %	Prod. Rate	Selectivities				Alpha GC	Alpha Liq	Catalyst Prom%	Composit. Metal%	Suppt
---	-----	-----	---	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
M-4 SBCR													
3	Co.002	15.2	29.4	1.42	17.3	2.3	79.4	1.01	0.73	0.82	1.0La	0.43Ru	Al
14	BlendA	20.0	29.3	1.41	10.1	1.6	86.3	2.02	0.77	0.86	5.0Cu	4.0Cr	Al
15	Co.034	13.0	27.5	1.54	10.4	1.6	87.2	0.80	0.78	0.84	8.5Zr	0.0	Al
16	CAL.04	16.1	26.3	1.34	7.1	1.3	90.3	1.38	0.80	0.85	0.3K	0.5Ru	Al
17	CAL.08	15.0	16.9	0.93	5.9	0.8	91.7	1.36	0.82	0.88	0.3K	0.5Ru	Al
18	CAL.07	15.0	20.6	1.03	7.7	1.2	90.0	1.09	0.81	0.88	0.3K	0.5Ru	Al
19	CAL.05	15.7	26.6	1.22	7.3	1.3	90.2	1.19	0.82	0.86	0.3K	0.5Ru	Al
20	CAL.06	15.0	5.6	0.26	3.1	2.1	92.0	2.86	0.80	0.90	0.3K	0.5Ru	Al
21	CO.004	15.9	39.3	1.80	15.2	2.3	81.2	1.38	0.74	0.80	1.0La	0.43Ru	Al

Note: Catalysts for all runs except Run 8 screened thru 150 x 400 mesh.
 Blend A contains 15.0 gm of Cat. No. Co.005 plus 5.0 gm of Cat. No. WGS.03.
 Cat. Nos. CAL.07 and CAL.08 were prereduced and wax coated.
 H₂ to CO ratio for Runs 16 and 17 was 1.76/1.0.
 Cat. No. CAL.06 was H₂ reduced and air stabilized.

Table 7

DATE: 09/30/94

COMPARISON OF CONVERSION AND SELECTIVITY OF
CALSICAT PRODUCED CATALYSTS AT STARTUP CONDITIONS

Period No.	Temp.	Pres.	H ₂ /CO Ratio
-----	-----	-----	-----
1	240 C	450psi	2.0

a) Total flow is ca.15 L/min. STP, or 3 cm/sec linear gas flow.

Flows: N₂-563 SLH, H₂-225 SLH, CO-112.5 SLH

b) Conversion is total CO conversion over the period (%).

c) Conversion and selectivities are calculated using N₂ as an internal standard in the GC analysis of the offgas.

d) Prod. rate: Rate for production of total hydrocarbons C₁+ (kg/kg cat.,hr).

e) Alpha: Based on GC analysis of offgas and liquid product.

Run No	Cat. No	Cat. wt,g	Conv. %	Prod. Rate	Selectivities				Alpha GC	Alpha Liq	Catalyst Prom%	Composit. Metal%	Suppt
-----	-----	-----	-----	-----	%CH ₄	%C ₂	%C ₃ +	%CO ₂	-----	-----	-----	-----	-----
M-4 SBCR													
10	CAL.02	15.9	34.5	1.58	12.9	2.0	83.9	1.23	0.75	0.81	0.0	0.5Ru	Al
11	CAL.03	15.6	29.7	1.39	13.5	2.1	83.4	1.08	0.74	0.86	0.0	0.5Ru	Al
16	CAL.04	16.1	26.3	1.34	7.1	1.3	90.3	1.38	0.80	0.85	0.3K	0.5Ru	Al
17	CAL.08	15.0	16.9	0.93	5.9	0.8	91.7	1.36	0.82	0.88	0.3K	0.5Ru	Al
18	CAL.07	15.0	20.6	1.03	7.7	1.2	90.0	1.09	0.81	0.88	0.3K	0.5Ru	Al
19	CAL.05	15.7	26.6	1.22	7.3	1.3	90.2	1.19	0.82	0.86	0.3K	0.5Ru	Al
20	CAL.06	15.0	5.6	0.26	3.1	2.1	92.0	2.86	0.80	0.90	0.3K	0.5Ru	Al

M-3 SBCR

12	CO.018	15.6	33.8	1.56	9.7	2.0	86.6	1.68	0.75	0.85	0.0	0.5Ru	Al
23	CO.047	15.8	28.2	1.29	7.7	1.5	89.3	1.47	0.79	0.84	0.3K	0.5Ru	Al

Note: Catalysts for all runs except Runs 17,18,& 20 screened thru 150 x 400 mesh.

Catalyst CAL.04 was calcined in air; Catalyst CAL.05 processed in N₂.

Cat. No. CAL.06 was H₂ reduced and air stabilized before charging.

Cat. Nos. CAL.08 and CAL.07 were prereduced and wax coated. CAL.08 was calcined in N₂ ; CAL.07 was reduced in H₂ without prior calcination. H₂ to CO ratio for Runs 16 and 17 was 1.76/1.

Cat. Nos. Co.018 & Co.047 were prepared by Pitt. Shown for comparison.

Table 8

HIGH SYNGAS CONVERSION TEST: RUN 29-M3

<u>Period No.</u>	<u>Temp.</u> <u>°C</u>	<u>Pressure</u> <u>psi</u>	<u>H₂/CO</u> <u>Ratio</u>	<u>CO Conv.</u> <u>%</u>	<u>Prod.Rate</u> <u>KgC₁+/ Kg, Hr</u>	<u>Selectivities</u>	
						<u>% CH₄</u>	<u>%C₃+</u>
1	240	450	2.0	42.0	1.19	15.8	79.5
2	220	450	2.0	20.5	0.59	5.7	89.0
3	240	450	2.0	39.2	1.13	15.8	79.2
4	240	450	1.0	18.4	0.79	5.3	90.6
5	240	600	1.0	19.7	0.85	4.6	92.9
6	240	600	2.0	40.8	1.17	14.8	81.4
7	240	450	2.0 (1)	31.5	0.45	21.0	72.2
8	260	450	2.0 (1)	31.0	0.44	36.4	52.6
9	240	450	2.0	18.0	0.55	23.0	72.1
10	240	450	2.0 (2)	21.6	0.98	14.4	82.4

Notes:

(1) Feed gas composition: N₂-80%, H₂-13.5%, CO-6.5%(2) Feed gas composition: N₂-40%, H₂-40%, CO-20%All other periods: N₂-60%, H₂-33%, CO-17%

Table 9

SBCR CATALYST EXTRACTIONS

Catalyst No. (Support)	Run No.	Charge		Charge		Recovered		Reduction in Particle Size, %
		(H ₂ Reduced) wt, gm	(Oxidized) wt, gm	Particle Size, mvd, microns	Particle Size at 10% microns	Particle Size, mvd, microns	Particle Size at 10% microns	
Co.001 (Al)	1	14.5	12.63	42.02	24.25	41.06	23.62	2.3
Co.001 (Al)	2	16.5	15.18	42.02	24.25	40.09	22.86	4.6
Co.005 (Al)	3	19.5	18.41	85.66	30.46	64.53	31.27	24.7
Co.002 (Al)	4	20.1	20.4	73.61	32.86	71.19	33.50	3.3
Co.003 (Al)	5	15.1	14.54	76.81	34.40	72.57	34.25	5.5
Co.011 (Si)	6	15.3	16.03	107.09 (1)	53.19	94.02	40.44	12.2
Co.012 (Si)	7	15.8	14.73	105.22 (1)	51.33	101.37	44.44	3.7
Co.015 (Al)	8	15.0	15.52	75.63 (1)	33.15	74.68	32.68	1.3
Co.011 (Si)	9	15.0	15.92	79.88 (2)	48.31	72.44	36.31	9.3
Co.016 (Al)	10	15.5	15.72	64.60 (2)	32.16	64.38	32.78	0.3
Co.017 (Al)	11	15.0	15.09	73.14 (3)	36.29	69.95	35.62	4.4
Co.018 (Al)	12	15.6	16.97	62.89 (3)	32.56	68.16	34.74	--
Co.016 (Al)	13	14.7	13.30	67.69 (3)	35.05	64.79	34.20	4.3
Co.019 (Si)	14	15.2	15.00	92.63 (3)	42.73	84.39	36.52	8.9
Co.005 (Al)	15	14.7	15.30	80.62 (3)	45.07	71.90	36.79	10.8
Co.002 (Al)	16	15.4	14.98	73.61 (3)	32.86	67.62	32.67	8.1
Co.002 (Al)	1 (M4)	15.0	11.00	73.61 (3)	32.86	66.26	35.75	10.0
Co.025 (Si)	17	15.6	14.60	87.19 (3)	47.35	78.31	36.27	10.2
Co.004 (Al)	18	15.0	15.25	78.12 (3)	44.15	66.86	33.83	14.4
Co.021 (Si)	19	15.6	16.06	86.18 (3)	46.54	77.95	35.59	9.55
Co.041 (Si)	20	15.8	17.02	87.48 (3)	49.26	68.74	26.72	17.0
Co.021 (Si)	3 (M4)	15.2	15.1	73.61 (3)	24.46	71.38	32.33	3.03
Co.024 (Al)	4 (M4)	15.4	(4)	--	--	--	--	--
Co.035 (Si)	5 (M4)	15.4	14.08	89.14 (3)	49.29	74.76	31.67	19.2
Co.028 (Al)	6 (M4)	15.4	15.7	80.83 (3)	44.81	71.83	36.34	11.1

(1) Screened through 100x400 mesh screens.
 (3) Screened through 150x400 mesh screens.

(2) Screened through 170x400 mesh screens.
 (4) Did not filter, too waxy

Note: The charge weights are in the hydrogen-reduced state and the recovered weights are in the oxidized state. The particle size is reported as the mean volume diameter (mvd) as measured by a Microtrac particle size analyzer.

Table 9
(Continued)

SBCR CATALYST EXTRACTIONS

Catalyst No. (Support)	Run No.	Charge		Recovered		Charge		Recovered		Reduction in Particle Size, %
		(H ₂ Reduced) wt, gm		(Oxidized) wt, gm		Particle Size, mvd, microns	Particle Size at 10% microns	Particle Size, mvd. microns	Particle Size at 10% microns	
Co.014 (Ti)	21	15.1		15.1		111.70 (1)	32.65	106.66	33.49	4.51
Co.040 (Ti)	22	14.5		8.5		(5)	(5)	130.40	51.40	--
Co.047 (Al)	23	15.8		16.95		83.42 (3)	44.41	76.46	39.02	8.34
Co.049 (Al)	24	15.6		16.54		81.3 (3)	42.39	70.11	35.87	13.8
Co.047 (Al)	25	15.6		16.69		79.36 (3)	41.72	69.09	36.16	12.94
Co.031 (Al)	26	15.9		15.37		75.48 (3)	38.34	68.42	35.39	9.35
Co.029 (Al)	27	15.9		18.28		76.39 (3)	39.56	68.72	36.04	10.04
Co.043 (Si)	7 (M4)	15.4		15.1		(5)	(5)	85.51	40.20	--
Co.006 (Ti)	8 (M4)	15.0		9.09		121.38 (1)	52.80	99.31	38.62	18.2
Co.048 (Si)	9 (M4)	15.4		15.85		82.40 (3)	40.94	70.69	25.53	14.2
CAL.02 (Al)	10 (M4)	15.9		16.42		74.40 (3)	37.79	65.89	34.14	11.44
Co.053 (Al)	12 (M4)	15.9		16.95		82.02 (3)	43.10	69.53	35.76	15.23
Co.054 (Si)	13 (M4)	15.7		17.09		101.17 (3)	57.54	82.37	37.89	18.58
Blend A (Al)	14 (M4)	20.0		14.61		86.23 (3)	46.36	77.43	42.81	10.21
Co.034 (Al)	15 (M4)	13.0		9.52		(5)	(5)	88.26	45.28	--
CAL.04 (Al)	16 (M4)	16.1		21.78		71.54 (3)	36.28	66.50	32.82	7.05
CAL.08 (Al)	17 (M4)	15.0 (6)		14.27		63.12	25.60	62.80	26.03	0.51
CAL.07 (Al)	18 (M4)	14.5 (6)		13.37		--	--	67.02	28.12	--
CAL.05 (Al)	19 (M4)	15.7		5.62		72.75	36.90	71.62	36.55	1.55
CAL.06 (Al)	20 (M4)	15.0		(7)		72.62	37.33	--	--	--
Co.053 (Al)	29 (M3)	25.2		25.8		75.63	40.80	71.09	38.20	6.00
Co.004 (Al)	21 (M4)	15.9		15.04		81.38	41.82	72.88	37.61	10.44

-
- (1) Screened through 100x400 mesh screens.
 (3) Screened through 150x400 mesh screens.
 (5) Insufficient feed sample.
 (6) Wax coated.
 (7) Lost catalyst.

APPENDICES

APPENDIX A

Co Catalyst Formulations

Catalyst Prep #	WGS.09	Date Tech	Jul-13-94	Amount	500.0 g
Compound (%wt)	Cu		Cr	Al ₂ O ₃	
	5		4		

Support	y-Alumina VISTA B	Amount	455.00 g
Particle Size	400 - 0 mesh	Treatment	500°C / 10 hrs
Metal I	Copper (II) Nitrate	Amount	95.03 g
Metal II	Chromium (III) Nitrate	Amount	153.85 g
Promoter		Amount	
Promoter		Amount	
Promoter		Amount	

PROCEDURE			
Preparation	X	Incipient Wetness Ion Exchange	Wet Impregnation Other
Notes	Incipient wetness: aqueous solution Cu + Cr, ca. 1.2 ml/g Dry catalyst precursor in an oven 110°C / 16 hrs		
Calcination	Temperature	500°C	Time 24 hrs
Notes			

WGS.09 5 wt% Cu
 4 wt% Cr
 γ -alumina

Preparation Procedure of Cu-Cr/ γ -alumina

Calcine γ -alumina at 500°C for 10 hrs. Use Vista B alumina. Presieve to >38 microns (400-0 mesh).

Impregnate the support with an aqueous solution of $\text{Cu}(\text{NO}_3)_2 \cdot x\text{H}_2\text{O}$, and $\text{Cr}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$ using appropriate quantities to yield 5 wt% Cu, and 4 wt% Cr and to get incipient wetness (ca. 1.2 ml/g).

Dry the catalyst precursor in an oven for 16 hours at 110°C.

The dried catalyst is then calcined in air by raising its temperature at a heating rate of ca. 1°C/min to 500°C and holding for 24 hours.

Reduction Procedure before Reaction:

Heat the catalyst in inert gas to 120°C at a rate of 1°C/min then start adding hydrogen to give a concentration of 0.5% at the bed inlet. Raise the catalyst bed temperature to 165°C at a rate of ca. 30°C/hr. When the temperature of the bed has reached 165°C increase the hydrogen concentration in the carrier gas to 1.0%. As the reduction proceeds and the temperature rise begins to diminish, the inlet temperature may be raised to 200°C. The inlet hydrogen concentration can then be increased to about 3-5%, provided that the maximum temperature limit of 230°C is not exceeded. When the reduction appears to be complete the inlet temperature should be raised to 230°C and the inlet hydrogen concentration raised to ca. 20%.

Catalyst Handbook 2nd ed. Martyn V. Twigg
J. Catal. 137, 408-422 (1992)

Catalyst Prep #	Co.055	Date Tech	July 12-1994	Amount	200.0 g
Compound (%wt)		Ce	Re	La2O3	Al2O3
		20	1	1	

Support	y-Alumina / Vista-B	Amount	156.00 g
Particle Size	400 - 0 mesh	Treatment	500°C / 10 hr
Cobalt	Cobalt Nitrate	Amount	197.29 g
Metal	Perrhenic Acid	Amount	3.67 g
Promoter	La-Nitrate / Molycorp C5247	Amount	5.31 g
Promoter		Amount	
Promoter		Amount	

PROCEDURE

Preparation	X	Incipient Wetness	Wet Impregnation
		Ion Exchange	Other
Notes	Incipient wetness: aqueous solution - ca. 1.2 ml/g support Dry catalyst precursor in an oven at 115°C / 5 hr		

Calcination	Temperature	300°C	Time	2 hr
Notes	50g of the catalyst precursor are not to be calcined !!			

Co.055: 20 wt% Co
 1 wt% Re (molar ratio of Re/Co = 1/63)
 1 wt% La₂O₃ [patent uses a mixture of RE oxides (66% La₂O₃, 24%
 Nd₂O₃, 8.2% Pr₆O₁₁, 0.7% CeO₂ and 1.1% other
 oxides)(Molycorp 5247)]
 γ-alumina

Based heavily on Eri et al., U.S. Pat. No. 4,880,763 (1989).

Preparation Procedure:

Calcine the γ-alumina at 500°C for 10 hrs. Use Vista B alumina. Presieve to 38-63 microns (400-250 mesh).

Impregnate the support with an aqueous solution of Co nitrate [Co(NO₃)₂·6H₂O], perrhenic acid [HReO₄], lanthanum nitrate, and using an appropriate quantity to get incipient wetness (ca. 1.2 ml/g) with the desired loading of Co.

Dry the catalyst precursor in an oven for 5 hrs at 115°C with moderate stirring.

The dried catalyst is then calcined in air by raising its temperature at a heating rate of ca. 1°C/min to 300°C and holding for 2 hrs.

Reduction Procedure before Reaction:

Reduce the catalyst in a pure hydrogen flow of 3000 cc/g/hr by heating at 1°C/min to 350°C and holding for 10 hrs.

Catalyst Prep #	Co.056	Date Tech	Jul-12-94	Amount	200.0 g
Compound (%wt)	Co	La	SiO ₂		
	20	8.5			

Support	Silica Davison Grade 952	Amount	143.00 g
Particle Size	400 - 250 mesh	Treatment	500°C / 10 hrs
Cobalt	Cobalt Nitrate	Amount	197.29 g
Metal		Amount	
Promoter	La-Nitrate/Molycorp	Amount	105.91 g
Promoter		Amount	
Promoter		Amount	

PROCEDURE			
Preparation	X	Incipient Wetness Ion Exchange	Wet Impregnation Other
Notes	Incipient wetness: aqueous solution of La Dry catalyst precursor in an oven 115°C / 5 hrs with stirring/calcine at 300 °C/2hrs Incipient wetness: aqueous solution of Co with catalyst precursor Dry catalyst precursor in an oven 115°C / 5 hrs with stirring		
Calcination	Temperature	300°C	Time 2 hrs
Notes	50g of the catalyst precursor are not to be calcined !!		

Co.056: 20 wt% Co
 8.5 wt% La
 SiO₂

La-promoted SiO₂-supported catalyst comparable to Co.025 where Zr is replaced by La. One-step impregnation of silica with lanthanum nitrate followed by one-step impregnation with cobalt nitrate solution.

Preparation Procedure:

- # Calcine the SiO₂ at 500°C for 10 hrs. Presieve to >38 microns (400-0 mesh).

Impregnate the support with an aqueous solution of La nitrate using an appropriate quantity to get incipient wetness with the desired loading of La.
- # Dry the La-loaded SiO₂ in an oven for 5 hrs at 115°C with moderate stirring.
- # Calcine the dried support in air by raising its temperature at a heating rate of ca. 1°C/min to 300°C and holding for 2 hrs.

Impregnate the La-loaded silica with an aqueous solution of Co nitrate [Co(NO₃)₂·6H₂O] using an appropriate quantity to get incipient wetness with the desired loading of Co.
- # Dry the catalyst precursor in an oven for 5 hrs at 115°C with moderate stirring.
- # Calcine the dried catalyst in air by raising its temperature at a heating rate of ca. 1°C/min to 300°C and holding for 2 hrs.

Reduction Procedure before Reaction:

Reduce the catalyst in a pure hydrogen flow of 3000 cc/g/hr by heating at 1°C/min to 250°C and holding for 10 hrs.

CoW.07

20 wt% Co

5 wt% Cu

4 wt% Cr

Silica

Cobalt impregnation on calcined Cu-Cr/Silica. Similar to CoW.06, but Cu-Cr/SiO₂ calcined at 750°C.

Preparation Procedure

Calcine silica at 500°C for 10 hrs. Use Davison Grade 952 silica. Presieve to > 38 microns (400-0 mesh).

Impregnate the support with an aqueous solution of Cu(NO₃)₂·xH₂O, and Cr(NO₃)₃·9H₂O using appropriate quantity to get incipient wetness (ca. 1.2 ml/g) with the desired loading of Cu and Cr.

Dry the catalyst precursor in an oven for 16 hours at 110°C.

The dried catalyst precursor is then calcined in air by raising its temperature at a heating rate of ca. 1°C/min to 750°C and holding for 24 hours.

Impregnate the Cu-Cr/SiO₂ with an aqueous solution of Co nitrate [Co(NO₃)₂·6H₂O] using an appropriate quantity to get incipient wetness with the desired loading of Co.

Dry the catalyst precursor in an oven for 5 hrs at 115°C with moderate stirring.

Calcine the dried catalyst in air by raising its temperature at a heating rate of ca. 1°C/min to 300°C and holding for 10 hrs.

Reduction Procedure before Reaction:

Heat the catalyst in inert gas to 120°C at a rate of 1°C/min then start adding hydrogen to give a concentration of 0.5% at the bed inlet. Raise the catalyst bed temperature to 165°C at a rate of ca. 30°C/hr. When the temperature of the bed has reached 160°C increase the hydrogen concentration in the carrier gas to 1.0%. As the reduction proceeds and the temperature rise begins to diminish, the inlet temperature may be raised to 200°C. The inlet hydrogen concentration can then be increased to about 3-5%, provided that the maximum temperature limit of 230°C is not exceeded. When the reduction appears to be complete the inlet temperature should be raised to 230°C and the inlet hydrogen concentration raised to ca. 20%.

APPENDIX B

FIXED BED REACTION DATA

Co.004 - Run #2

Co wt%	NM wt %	Promotor wt%		Support
20	Ru 0.43		La2O3 1.00	Al2O3

SUMMARY REACTION DATA

Reaction Conditions:

P = 1.0 atm

T = 220 °C

H₂/CO = 2

weight of catalyst = 0.244 g

WHSV = 10.54 1/hr

time on stream = 27.5 hrs

CO₂ (g/g cat/hr) = 0.038CO₂ (% of CO) = 0.2

O/P = 1.02

CO conversion (%)	11.2
rate (g CH ₂ /g cat/hr)	0.52
alpha	0.61
C1 (wt%)	28.9
C2 - C4 (wt%)	30.7
C5 - C12 (wt%)	38.6
C13 + (wt%)	1.7

10/13/94

Performance of Co.004

Dates: 07/11/94 - 07/12/94 Run #2

flow rate = 90.0 cc/min, loading= 0.2 g, WHSV = 10.5 l/hr, H₂/CO ratio in feed = 2

time on stream, hr	0.5	3.5	6.5	9.5	12.5	15.5
reaction temperature, °C	220	220	220	220	220	220
pressure, atm	1.0	1.0	1.0	1.0	1.0	1.0
flow, cc/min	90.0	90.0	90.0	90.0	90.0	90.0

C1 - C15 product distribution, weight %

C1	28.82	28.66	28.91	28.87	29.00	28.71
C2	5.34	5.19	5.17	5.13	5.14	5.07
C3	13.23	13.11	13.05	13.02	13.05	12.99
C4	13.52	13.29	13.20	13.18	13.15	13.02
C5	12.08	12.00	11.84	11.85	11.83	11.86
C6	8.90	8.93	8.80	8.88	8.83	8.92
C7	6.59	6.66	6.76	6.79	6.77	6.79
C8	4.20	4.33	4.48	4.50	4.48	4.50
C9	2.59	2.73	2.87	2.85	2.87	2.85
C10	1.85	1.93	1.88	1.87	1.87	1.95
C11	1.07	1.29	1.22	1.21	1.23	1.48
C12	0.71	0.82	0.77	0.85	0.78	0.87
C13	0.48	0.48	0.50	0.46	0.50	0.44
C14	0.34	0.33	0.33	0.30	0.29	0.32
C15	0.29	0.25	0.23	0.23	0.21	0.23
alpha chain growth probability	0.62	0.61	0.60	0.60	0.60	0.60

C1 - C50 estimated total product distribution, weight %

C1	28.4	28.4	28.7	28.7	28.9	28.6
C2 - C4	31.6	31.4	31.2	31.2	31.2	31.0
C5 - C12	38.1	38.5	38.5	38.6	38.5	38.9
C13 - C50	1.9	1.7	1.5	1.5	1.4	1.5

CO conversion, %	15.5	13.5	12.9	12.4	12.1	11.6
rate, g CH ₂ /g cat/hr	0.71	0.62	0.60	0.57	0.56	0.53
CO ₂ formation, %	0.4	0.3	0.3	0.3	0.3	0.3

Performance of Co.004

Dates: 07/11/94 - 07/12/94 Run #2

flow rate = 90.0 cc/min, loading= 0.2 g, WHSV = 10.5 l/hr, H₂/CO ratio in feed = 2

time on stream, hr	18.5	21.5	24.5	27.5	30.5
reaction temperature, °C	220	220	220	220	220
pressure, atm	1.0	1.0	1.0	1.0	1.0
flow, cc/min	90.0	90.0	90.0	90.0	22.5

C1 - C15 product distribution, weight %

C1	29.03	28.99	28.84	29.15	21.94
C2	5.11	5.09	5.06	5.10	4.50
C3	12.99	12.98	12.97	12.95	10.74
C4	13.04	13.02	13.02	12.91	12.93
C5	11.74	11.76	11.78	11.67	12.60
C6	8.80	8.82	8.93	8.72	9.79
C7	6.76	6.81	6.88	6.81	8.43
C8	4.53	4.54	4.55	4.57	5.97
C9	2.94	2.90	2.94	2.92	4.22
C10	1.88	2.01	1.89	2.00	3.10
C11	1.27	1.21	1.33	1.30	2.12
C12	0.81	0.86	0.75	0.87	1.52
C13	0.52	0.46	0.47	0.46	1.02
C14	0.32	0.32	0.33	0.33	0.71
C15	0.24	0.24	0.26	0.26	0.41
alpha chain growth probability	0.61	0.61	0.61	0.61	0.64

C1 - C50 estimated total product distribution, weight %

C1	28.9	28.8	28.6	28.9	21.9
C2 - C4	31.0	30.9	30.8	30.7	28.2
C5 - C12	38.6	38.7	38.9	38.6	47.2
C13 - C50	1.6	1.6	1.7	1.7	2.7

CO conversion, %	11.8	11.5	11.0	11.2	47.6
rate, g CH ₂ /g cat/hr	0.54	0.53	0.51	0.52	0.55
CO ₂ formation, %	0.3	0.2	0.2	0.2	2.3

Schulz-Flory Plot for Co.004 - Run #2
Time on Stream (hrs)

Time-on-Stream Plot for Co.004 - Run #2

Co.004 - Run #2h

Co wt%	NM wt %	Promotor wt%		Support
20	Ru 0.43		La2O3 1.00	Al2O3

SUMMARY REACTION DATA*

Reaction Conditions:

P = 1.0 atm

T = 220 °C

H₂/CO = 2

weight of catalyst = 0.244 g

WHSV = 2.63 1/hr

time on stream = 30.5 hrs

CO₂ (g/g cat/hr) = 0.090CO₂ (% of CO) = 2.3

O/P = 0.40

CO conversion (%)	47.6
rate (g CH ₂ /g cat/hr)	0.55
alpha	0.64
C1 (wt%)	21.9
C2 - C4 (wt%)	28.2
C5 - C12 (wt%)	47.2
C13 + (wt%)	2.7

- High Conversion study

Schulz-Flory Plot for Co.004 - Run #2h
Time on Stream (hrs)

hrs.

Co.004 - Run #2a

Co wt%	NM wt %	Promotor wt%		Support
20	Ru 0.43		La2O3 1.00	Al2O3

SUMMARY REACTION DATA*

Reaction Conditions:

P = 1.0 atm

T = 220 °C

H₂/CO = 2

weight of catalyst = 0.244 g

WHSV = 10.54 1/hr

time on stream = 24.5 hrs

CO₂ (g/g cat/hr) = 0.024CO₂ (% of CO) = 0.2

O/P = 3.02

CO conversion (%)	3.8
rate (g CH ₂ /g cat/hr)	0.18
alpha	0.65
C1 (wt%)	25.5
C2 - C4 (wt%)	28.8
C5 - C12 (wt%)	42.7
C13 + (wt%)	3.0

* calc. and reduced after run#2, with temp. surge to 260 °C

Performance of Co.004

Dates: 07/14/94 - 07/15/94 Run #2a

flow rate = 90.0 cc/min, loading= 0.2 g, WHSV = 10.5 1/hr, H₂/CO ratio in feed = 2

time on stream, hr	0.5	3.5	6.5	9.5	12.5	15.5
reaction temperature, °C	260	220	220	220	220	220
pressure, atm	1.0	1.0	1.0	1.0	1.0	1.0
flow, cc/min	90.0	90.0	90.0	90.0	90.0	90.0
C1 - C15 product distribution, weight %						
C1	90.25	23.38	24.31	24.72	24.83	25.10
C2	2.90	4.85	5.02	5.08	5.09	5.13
C3	1.85	11.84	11.94	11.93	11.85	11.84
C4	1.51	12.53	12.45	12.36	12.23	12.14
C5	1.28	12.77	12.32	12.19	12.04	11.89
C6	0.89	9.99	9.87	9.65	9.57	9.41
C7	0.54	7.71	7.46	7.51	7.42	7.41
C8	0.35	5.42	5.28	5.37	5.29	5.26
C9	0.19	3.76	3.71	3.78	3.76	3.74
C10	0.11	2.72	2.65	2.74	2.70	2.75
C11	0.06	1.70	1.76	1.77	1.86	1.83
C12	0.04	1.19	1.20	1.27	1.25	1.29
C13	0.02	0.84	0.88	0.92	0.92	0.94
C14		0.70	0.63	0.71	0.67	0.74
C15		0.60	0.53		0.50	0.53
alpha chain growth probability	0.55	0.64	0.64	0.65	0.65	0.65
C1 - C50 estimated total product distribution, weight %						
C1	90.2	23.3	24.1	24.4	24.6	24.9
C2 - C4	6.3	29.1	29.2	28.9	28.9	28.8
C5 - C12	3.5	45.1	44.0	43.7	43.5	43.2
C13 - C50	0.1	2.6	2.8	3.0	3.0	3.1
CO conversion, %	35.1	3.9	4.0	4.0	4.0	4.0
rate, g CH ₂ /g cat/hr	1.62	0.18	0.18	0.19	0.18	0.18
CO ₂ formation, %	57.3	0.2	0.2	0.2	0.2	0.2

Performance of Co.004

Dates: 07/14/94 - 07/15/94 Run #2a

flow rate = 90.0 cc/min, loading = 0.2 g, WHSV = 10.5 l/hr, H₂/CO ratio in feed = 2

time on stream, hr	18.5	21.5	24.5
reaction temperature, °C	220	220	220
pressure, atm	1.0	1.0	1.0
flow, cc/min	90.0	90.0	90.0

C1 - C15 product distribution, weight %

C1	25.34	25.55	25.69
C2	5.16	5.20	5.22
C3	11.86	11.85	11.86
C4	12.04	12.00	12.01
C5	11.85	11.73	11.75
C6	9.40	9.27	9.31
C7	7.38	7.30	7.29
C8	5.24	5.22	5.19
C9	3.68	3.69	3.68
C10	2.75	2.75	2.71
C11	1.84	1.86	1.86
C12	1.32	1.40	1.28
C13	0.91	0.92	0.93
C14	0.72	0.73	0.72
C15	0.51	0.54	0.52
alpha chain growth probability	0.65	0.65	0.65

C1 - C50 estimated total product distribution, weight %

C1	25.1	25.4	25.5
C2 - C4	28.8	28.8	28.8
C5 - C12	43.1	42.8	42.7
C13 - C50	3.0	3.0	3.0

CO conversion, %	4.0	4.0	3.8
rate, g CH ₂ /g cat/hr	0.19	0.19	0.18
CO ₂ formation, %	0.2	0.2	0.2

Schulz-Flory Plot for Co.004 - Run #2a

Time on Stream (hrs)

hrs.

Time-on-Stream Plot for Co.004 - Run #2a

Co.004 - Run #3

Co wt%	NM wt %	Promotor wt%		Support
20	Ru 0.43		La2O3 1.00	Al2O3

SUMMARY REACTION DATA

Reaction Conditions:

P = 1.0 atm
 T = 220 °C
 H₂/CO = 2
 weight of catalyst = 0.150 g
 WHSV = 17.17 1/hr
 time on stream = 24.5 hrs

CO₂ (g/g cat/hr) = 0.036
 CO₂ (% of CO) = 0.1
 O/P = 1.45

CO conversion (%)	6.7
rate (g CH ₂ /g cat/hr)	0.50
alpha	0.61
C1 (wt%)	27.8
C2 - C4 (wt%)	30.8
C5 - C12 (wt%)	39.7
C13 + (wt%)	1.7

Performance of Co.004

Dates: 07/18/94 - 07/19/94 Run #3

flow rate = 90.0 cc/min, loading = 0.1 g, WHSV = 17.2 l/hr, H₂/CO ratio in feed = 2

time on stream, hr	0.5	3.5	6.5	9.5	12.5	15.5
reaction temperature, °C	220	220	220	220	220	220
pressure, atm	1.0	1.0	1.0	1.0	1.0	1.0
flow, cc/min	90.0	90.0	90.0	90.0	90.0	90.0

C1 - C15 product distribution, weight %

C1	26.34	27.15	27.26	27.66	27.41	27.68
C2	4.96	5.03	5.02	5.06	5.00	5.03
C3	13.32	13.30	13.17	13.18	13.08	13.07
C4	13.56	13.40	13.22	13.15	13.14	13.05
C5	12.43	12.27	12.20	12.08	12.15	12.07
C6	9.38	9.26	9.12	9.06	9.16	9.09
C7	7.08	7.00	7.16	7.09	7.05	7.06
C8	4.65	4.59	4.73	4.66	4.71	4.69
C9	2.96	2.99	2.98	2.92	2.96	2.99
C10	1.93	1.87	2.02	2.07	2.07	2.06
C11	1.23	1.24	1.26	1.27	1.33	1.30
C12	0.88	0.82	0.79	0.73	0.86	0.86
C13	0.56	0.46	0.46	0.47	0.50	0.49
C14	0.41	0.35	0.35	0.33	0.34	0.33
C15	0.30	0.27	0.25	0.26	0.24	0.25
alpha chain growth probability	0.62	0.61	0.61	0.61	0.61	0.61

C1 - C50 estimated total product distribution, weight %

C1	26.0	26.9	27.0	27.4	27.3	27.5
C2 - C4	31.5	31.4	31.1	31.1	31.1	31.0
C5 - C12	40.5	39.9	40.1	39.8	40.1	39.9
C13 - C50	2.0	1.8	1.7	1.7	1.6	1.6

CO conversion, %	8.4	7.9	7.4	7.4	6.9	6.9
rate, g CH ₂ /g cat/hr	0.63	0.59	0.56	0.55	0.52	0.52
CO ₂ formation, %	0.2	0.2	0.2	0.2	0.2	0.2

Performance of Co.004

Dates: 07/18/94 - 07/19/94 Run #3

flow rate = 90.0 cc/min, loading= 0.1 g, WHSV = 17.2 1/hr, H₂/CO ratio in feed = 2

time on stream, hr	18.5	21.5	24.5	27.5
reaction temperature, °C	220	220	220	220
pressure, atm	1.0	1.0	1.0	1.0
flow, cc/min	90.0	90.0	90.0	22.5

C1 - C15 product distribution, weight %

C1	27.72	27.90	27.96	27.57
C2	5.03	5.05	5.05	5.14
C3	13.07	13.09	13.03	11.63
C4	13.03	13.03	12.94	13.01
C5	12.05	12.05	11.98	12.04
C6	9.11	9.09	9.05	9.03
C7	7.06	7.03	7.01	7.33
C8	4.73	4.68	4.69	4.97
C9	3.03	2.97	2.98	3.32
C10	2.10	2.06	2.07	2.14
C11	1.24	1.26	1.35	1.58
C12	0.79	0.79	0.83	0.98
C13	0.49	0.45	0.48	0.67
C14	0.32	0.32	0.33	0.47
C15	0.24	0.24	0.25	0.12
alpha chain growth probability	0.61	0.61	0.61	0.62

C1 - C50 estimated total product distribution, weight %

C1	27.5	27.7	27.8	27.3
C2 - C4	30.9	31.0	30.8	29.5
C5 - C12	40.0	39.8	39.7	41.0
C13 - C50	1.6	1.6	1.7	2.1

CO conversion, %	6.8	6.7	6.7	27.0
rate, g CH ₂ /g cat/hr	0.51	0.50	0.50	0.51
CO ₂ formation, %	0.1	0.1	0.1	0.8

Schulz-Flory Plot for Co.004 - Run #3
Time on Stream (hrs)

Time-on-Stream Plot for Co.004 - Run #3

Co.004 - Run #3h

Co wt%	NM wt %	Promotor wt%		Support
20	Ru 0.43		La2O3 1.00	Al2O3

SUMMARY REACTION DATA*

Reaction Conditions:

P = 1.0 atm
 T = 220 °C
 H₂/CO = 2
 weight of catalyst = 0.150 g
 WHSV = 4.29 1/hr
 time on stream = 27.5 hrs

CO₂ (g/g cat/hr) = 0.048
 CO₂ (% of CO) = 0.8
 O/P = 0.46

CO conversion (%)	27.0
rate (g CH ₂ /g cat/hr)	0.51
alpha	0.62
C1 (wt%)	27.3
C2 - C4 (wt%)	29.5
C5 - C12 (wt%)	41.0
C13 + (wt%)	2.1

* High conversion study

Schulz-Flory Plot for Co.004 - Run #3h
Time on Stream (hrs)

hrs.

Co.004 - Run #4

Co wt%	NM wt %	Promotor wt%		Support
20	Ru 0.43		La ₂ O ₃ 1.00	Al ₂ O ₃

SUMMARY REACTION DATA*

Reaction Conditions:

P = 10.0 atm

T = 220 °C

H₂/CO = 2

weight of catalyst = 0.049 g

WHSV = 52.91 1/hr

time on stream = 24.5 hrs

CO₂ (g/g cat/hr) = 0.078CO₂ (% of CO) = 0.1

O/P = 2.40

CO conversion (%)	1.8
rate (g CH ₂ /g cat/hr)	0.43
alpha	0.79
C1 (wt%)	24.0
C2 - C4 (wt%)	14.8
C5 - C12 (wt%)	41.7
C13 + (wt%)	19.5

* High pressure run

Performance of Co.004

Dates: 08/04/94 - 08/05/94 Run #4

flow rate = 110.0 cc/min, loading = 0.0 g, WHSV = 52.9 1/hr, H₂/CO ratio in feed = 2

time on stream, hr	0.5	3.5	6.5	9.5	12.5	15.5
reaction temperature, °C	220	220	220	220	220	220
pressure, atm	10.0	10.0	10.0	10.0	10.0	10.0
flow, cc/min	110.0	110.0	110.0	110.0	110.0	110.0

C1 - C15 product distribution, weight %

C1	21.23	23.30	23.42	23.09	21.94	23.88
C2	3.77	3.99	3.94	3.75	3.45	3.65
C3	7.72	8.14	7.92	7.72	7.38	7.88
C4	13.85	7.81	7.57	7.57	7.33	7.88
C5	8.33	8.79	8.53	8.58	8.35	9.00
C6	7.41	7.87	7.64	7.71	7.52	8.18
C7	6.87	7.62	7.48	7.52	7.41	7.85
C8	6.30	7.03	6.94	7.06	7.11	7.48
C9	5.68	6.57	6.43	6.53	6.70	7.03
C10	4.96	6.01	6.00	6.06	6.28	6.42
C11	4.43	5.15	5.46	5.25	6.28	5.89
C12	3.77	4.31	4.60	4.54	5.78	4.87
C13	3.13	3.41	4.06	4.62	4.47	
C14	2.52					
C15						
alpha chain growth probability	0.76	0.77	0.78	0.78	0.81	0.78

C1 - C50 estimated total product distribution, weight %

C1	19.2	20.0	19.8	19.7	16.9	19.3
C2 - C4	22.9	17.1	16.4	16.2	14.0	15.7
C5 - C12	43.4	45.8	44.9	45.5	42.9	45.7
C13 - C50	14.5	17.1	18.8	18.6	26.2	19.4

CO conversion, %	2.0	1.8	1.8	1.8	2.0	1.7
rate, g CH ₂ /g cat/hr	0.46	0.42	0.43	0.41	0.46	0.41
CO ₂ formation, %	0.1	0.1	0.1	0.1	0.1	0.1

Performance of Co.004

Dates: 08/04/94 - 08/05/94 Run #4

flow rate = 110.0 cc/min, loading = 0.0 g, WHSV = 52.9 l/hr, H₂/CO ratio in feed = 2

time on stream, hr	18.5	21.5	24.5
reaction temperature, °C	220	220	220
pressure, atm	10.0	10.0	10.0
flow, cc/min	110.0	110.0	110.0

C1 - C15 product distribution, weight %

C1	24.11	26.31	29.81
C2	3.46	3.58	3.93
C3	7.57	7.43	7.37
C4	7.61	7.32	7.07
C5	8.73	8.40	8.02
C6	7.83	7.57	7.12
C7	7.71	7.37	7.11
C8	7.36	6.82	6.66
C9	6.90	6.56	6.46
C10	6.67	6.20	6.22
C11	6.42	6.48	5.53
C12	5.64	5.96	4.70
C13			
C14			
C15			
alpha chain growth probability	0.80	0.81	0.79

C1 - C50 estimated total product distribution, weight %

C1	18.2	19.3	24.0
C2 - C4	14.1	13.4	14.8
C5 - C12	43.3	40.7	41.7
C13 - C50	24.3	26.6	19.5

CO conversion, %	1.9	2.1	1.8
rate, g CH ₂ /g cat/hr	0.44	0.49	0.43
CO ₂ formation, %	0.1	0.1	0.1

Schulz-Flory Plot for Co.004 - Run #4 (hp)
Time on Stream (hrs)

hrs.

Time-on-Stream Plot for Co.004 - Run #4 (hp)

Co.004 - Run #5

Co wt%	NM wt %	Promotor wt%		Support
20	Ru 0.43		La2O3 1.00	Al2O3

SUMMARY REACTION DATA

Reaction Conditions:

P = 1.0 atm

T = 220 °C

H₂/CO = 2

weight of catalyst = 0.177 g

WHSV = 14.54 1/hr

time on stream = 24.5 hrs

CO₂ (g/g cat/hr) = 0.027CO₂ (% of CO) = 0.1

O/P = 7.84

CO conversion (%)	4.5
rate (g CH ₂ /g cat/hr)	0.29
alpha	0.75
C1 (wt%)	19.4
C2 - C4 (wt%)	20.3
C5 - C12 (wt%)	48.6
C13 + (wt%)	11.6

Performance of Co.004

Dates: 08/08/94 - 08/09/94 Run #5

flow rate = 90.0 cc/min, loading = 0.2 g, WHSV = 14.5 1/hr, H₂/CO ratio in feed = 2

time on stream, hr	0.5	3.5	6.5	9.5	12.5	21.5
reaction temperature, °C	220	220	220	220	220	220
pressure, atm	1.0	1.0	1.0	1.0	1.0	1.0
flow, cc/min	90.0	90.0	90.0	90.0	90.0	90.0

C1 - C15 product distribution, weight %

C1	19.54	20.17	20.29	20.44	20.40	20.52
C2	3.77	3.89	3.92	3.95	3.95	3.98
C3	9.13	8.78	8.66	8.62	8.57	8.57
C4	10.31	9.51	9.35	9.27	9.18	9.16
C5	11.44	10.63	10.46	10.27	10.27	10.18
C6	10.08	8.99	8.94	8.76	8.89	8.71
C7	8.78	8.62	8.54	8.50	8.38	8.41
C8	6.96	7.07	7.05	7.03	7.02	7.06
C9	5.51	5.79	5.84	5.78	5.75	5.89
C10	4.44	4.78	4.79	4.76	4.77	4.83
C11	3.45	3.79	3.80	3.92	3.89	3.93
C12	2.63	2.98	2.99	2.98	3.11	3.13
C13	1.95	2.18	2.27	2.38	2.35	2.38
C14	1.38	1.74	1.84	1.93	1.91	1.84
C15	0.64	1.07	1.27	1.42	1.54	1.42
alpha chain growth probability	0.71	0.73	0.74	0.74	0.74	0.74

C1 - C50 estimated total product distribution, weight %

C1	19.0	19.3	19.3	19.4	19.4	19.6
C2 - C4	22.6	21.2	20.9	20.7	20.6	20.8
C5 - C12	51.2	49.9	49.6	49.1	49.2	49.3
C13 - C50	7.2	9.6	10.2	10.8	10.8	10.3

CO conversion, %	5.5	5.1	4.7	4.8	4.5	4.4
rate, g CH ₂ /g cat/hr	0.35	0.32	0.30	0.31	0.29	0.28
CO ₂ formation, %	0.1	0.1	0.1	0.1	0.1	0.1

Performance of Co.004

Dates: 08/08/94 - 08/09/94 Run #5

flow rate = 90.0 cc/min, loading= 0.2 g, WHSV = 14.5 l/hr, H₂/CO ratio in feed = 2

time on stream, hr	24.5
reaction temperature, °C	220
pressure, atm	1.0
flow, cc/min	90.0

C1 - C15 product distribution, weight %

C1	20.64
C2	3.99
C3	8.54
C4	9.05
C5	10.05
C6	8.63
C7	8.30
C8	6.99
C9	5.79
C10	4.86
C11	4.01
C12	3.15
C13	2.38
C14	2.04
C15	1.59

alpha	chain growth probability	0.75
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C1 - C50 estimated total product distribution, weight %

C1	19.4
C2 - C4	20.3
C5 - C12	48.6
C13 - C50	11.6

CO conversion, %	4.5
rate, g CH ₂ /g cat/hr	0.29
CO ₂ formation, %	0.1

Schulz-Flory Plot for Co.004 - Run #5

Time on Stream (hrs)

hrs.

Time-on-Stream Plot for Co.004 - Run #5

Co.005 - Run #6

Co wt%	NM wt %	Promotor wt%		Support
20				Al ₂ O ₃

SUMMARY REACTION DATA

Reaction Conditions:

P = 1.0 atm
 T = 220 °C
 H₂/CO = 2
 weight of catalyst = 0.186 g
 WHSV = 13.80 1/hr
 time on stream = 27.5 hrs

CO₂ (g/g cat/hr) = 0.017
 CO₂ (% of CO) = 0.1
 O/P = 5.53

CO conversion (%)	2.1
rate (g CH ₂ /g cat/hr)	0.13
alpha	0.64
C1 (wt%)	25.7
C2 - C4 (wt%)	29.5
C5 - C12 (wt%)	42.2
C13 + (wt%)	2.6

Performance of Co.005

Dates: 08/19/94 - 08/20/94 Run #6

flow rate = 90.0 cc/min, loading = 0.2 g, WHSV = 13.8 l/hr, H₂/CO ratio in feed = 2

time on stream, hr	0.5	3.5	6.5	9.5	12.5	15.5
reaction temperature, °C	220	220	220	220	220	220
pressure, atm	1.0	1.0	1.0	1.0	1.0	1.0
flow, cc/min	90.0	90.0	90.0	90.0	90.0	90.0

C1 - C15 product distribution, weight %

C1	22.93	23.94	24.62	25.28	25.00	25.03
C2	4.80	4.91	5.02	5.11	5.03	5.01
C3	12.33	12.23	12.29	12.44	12.16	12.08
C4	13.07	12.76	12.75	12.84	12.62	12.49
C5	13.18	12.81	12.68	12.82	12.64	12.57
C6	9.01	8.66	8.29	7.06	8.30	8.53
C7	7.70	7.61	7.61	7.71	7.56	7.63
C8	5.39	5.31	5.28	5.40	5.25	5.30
C9	3.77	3.97	3.71	3.75	4.00	3.79
C10	2.56	2.60	2.73	2.65	2.69	2.82
C11	1.92	1.78	1.72	1.80	1.69	1.73
C12	1.30	1.26	1.41	1.22	1.21	1.16
C13	0.82	0.87	0.78	0.77	0.77	0.78
C14	0.82	0.74	0.62	0.62	0.60	0.59
C15	0.39	0.55	0.48	0.52	0.49	0.50
alpha chain growth probability	0.64	0.66	0.65	0.65	0.65	0.65

C1 - C50 estimated total product distribution, weight %

C1	22.8	23.4	24.2	24.7	24.5	24.5
C2 - C4	30.1	29.2	29.6	29.7	29.2	29.0
C5 - C12	44.4	43.7	43.0	42.1	43.0	43.2
C13 - C50	2.6	3.6	3.2	3.4	3.2	3.3

CO conversion, %	2.4	2.4	2.3	2.3	2.3	2.3
rate, g CH ₂ /g cat/hr	0.15	0.15	0.14	0.14	0.14	0.14
CO ₂ formation, %	0.1	0.1	0.1	0.1	0.1	0.1

Performance of Co.005

Dates: 08/19/94 - 08/20/94 Run #6

flow rate = 90.0 cc/min, loading = 0.2 g, WHSV = 13.8 l/hr, H₂/CO ratio in feed = 2

time on stream, hr	18.5	21.5	24.5	27.5
reaction temperature, °C	220	220	220	220
pressure, atm	1.0	1.0	1.0	1.0
flow, cc/min	90.0	90.0	90.0	90.0

C1 - C15 product distribution, weight %

C1	25.19	25.17	26.02	25.93
C2	5.04	5.01	5.18	5.16
C3	12.03	11.95	12.27	12.16
C4	12.36	12.27	12.37	12.39
C5	12.41	12.39	12.46	12.53
C6	8.78	8.99	7.42	7.48
C7	7.59	7.58	7.62	7.64
C8	5.28	5.31	5.32	5.35
C9	3.71	3.75	3.77	3.81
C10	2.88	2.74	2.75	2.79
C11	1.71	1.71	1.74	1.76
C12	1.23	1.21	1.23	1.23
C13	0.76	0.81	0.80	0.79
C14	0.57	0.60	0.57	0.59
C15	0.46	0.50	0.49	0.40
alpha chain growth probability	0.65	0.65	0.65	0.64

C1 - C50 estimated total product distribution, weight %

C1	24.8	24.7	25.6	25.7
C2 - C4	28.9	28.7	29.3	29.5
C5 - C12	43.2	43.4	42.0	42.2
C13 - C50	3.0	3.3	3.2	2.6

CO conversion, %	2.3	2.3	2.2	2.1
rate, g CH ₂ /g cat/hr	0.14	0.14	0.13	0.13
CO ₂ formation, %	0.1	0.1	0.1	0.1

Schulz-Flory Plot for Co.005 - Run #6
Time on Stream (hrs)

Time-on-Stream Plot for Co.005 - Run #6

Co.005 S2 - Run #7

Co wt%	NM wt %	Promotor wt%		Support
20				Al ₂ O ₃

SUMMARY REACTION DATA*

Reaction Conditions:

P = 1.0 atm

T = 220 °C

H₂/CO = 2

weight of catalyst = 0.300 g

WHSV = 2.86 1/hr

time on stream = 21.0 hrs

CO₂ (g/g cat/hr) = 0.003CO₂ (% of CO) = 0.1

O/P = 1.95

CO conversion (%)	6.7
rate (g CH ₂ /g cat/hr)	0.08
alpha	0.70
C1 (wt%)	18.8
C2 - C4 (wt%)	23.4
C5 - C12 (wt%)	50.9
C13 + (wt%)	6.8

* Reaction studied in system 2

Performance of Co.005 S2

Dates: 08/06/94 - 08/07/94 Run #7

flow rate = 30.0 cc/min, loading = 0.3 g, WHSV = 2.9 l/hr, H₂/CO ratio in feed = 2

time on stream, hr	0.5	3.5	6.0	21.0
reaction temperature, °C	220	220	220	220
pressure, atm	1.0	1.0	1.0	1.0
flow, cc/min	30.0	30.0	30.0	30.0

C1 - C15 product distribution, weight %

C1	17.44	19.77	20.61	19.28
C2	2.95	3.34	3.35	3.13
C3	9.88	10.75	10.70	9.81
C4	11.23	12.04	11.70	10.99
C5	12.12	12.79	12.43	11.99
C6	10.48	11.13	10.70	12.20
C7	7.61	8.18	7.53	7.78
C8	6.03	6.57	6.05	6.06
C9	4.60	4.79	4.55	4.90
C10	3.91	4.09	3.88	3.93
C11	2.93	2.82	2.53	2.93
C12	2.28	1.87	2.01	2.28
C13	1.72	1.02	1.23	1.53
C14	1.59	0.30	0.88	1.32
C15	1.51	0.28	0.73	1.10
alpha chain growth probability	0.71	0.68	0.69	0.70

C1 - C50 estimated total product distribution, weight %

C1	17.7	19.2	20.2	18.8
C2 - C4	24.4	25.4	25.3	23.4
C5 - C12	50.8	50.5	48.9	50.9
C13 - C50	7.1	4.9	5.6	6.8

CO conversion, %	8.2	7.8	7.0	6.7
rate, g CH ₂ /g cat/hr	0.10	0.10	0.09	0.08
CO ₂ formation, %	0.2	0.1	0.1	0.1

Performance of Co.005 S2

Dates: 08/06/94 - 08/07/94 Run #7

flow rate = 30.0 cc/min, loading= 0.3 g, WHSV = 2.9 l/hr, H₂/CO ratio in feed = 2

time on stream, hr
reaction temperature, °C
pressure, atm
flow, cc/min

C1 - C15 product distribution, weight %

C1

C2

C3

C4

C5

C6

C7

C8

C9

C10

C11

C12

C13

C14

C15

alpha chain growth probability

C1 - C50 estimated total product distribution, weight %

C1

C2 - C4

C5 - C12

C13 - C50

CO conversion, %
rate, g CH₂/g cat/hr
CO₂ formation, %

Schulz-Flory Plot for Co.005 (S2) - Run #7
Time on Stream (hrs)

hrs.

Time-on-Stream Plot for Co.005 - Run #7 S2

Co.005b - Run #1

Co wt%		Promotor wt%		Support
20		WGS.03 25		Al ₂ O ₃

SUMMARY REACTION DATA

Reaction Conditions:

P = 1.0 atm

T = 220 °C

H₂/CO = 2

weight of catalyst = 0.225 g

WHSV = 3.81 1/hr

time on stream = 24.0 hrs

CO₂ (g/g cat/hr) = 0.023CO₂ (% of CO) = 0.4

O/P = 0.61

CO conversion (%)	2.2
rate (g CH ₂ /g cat/hr)	0.04
alpha	0.32
C1 (wt%)	19.5
C2 - C4 (wt%)	24.7
C5 - C12 (wt%)	55.8
C13 + (wt%)	0.0

Performance of Co.005b

Dates: 08/08/94 - 08/09/94 Run #1

flow rate = 30.0 cc/min, loading= 0.23 g, WHSV = 3.8 1/hr, H₂/CO ratio in feed = 2

time on stream, hr	0.5	3.5	6.0	18.0	21.0	
reaction temperature, °C	220	220	220	220	220	
pressure, atm	1.0	1.0	1.0	1.0	1.0	
flow, cc/min	30.0	30.0	30.0	30.0	30.0	

C1 - C15 product distribution, weight %

C1	13.50	14.69	14.04	14.29	14.82	17.26
C2	2.83	2.90	2.70	2.70	2.73	3.26
C3	7.36	7.54	7.17	7.23	7.39	8.56
C4	9.33	9.24	8.85	8.66	8.69	10.06
C5	11.08	11.25	10.86	10.43	10.83	11.80
C6	17.80	18.37	17.24	23.52	17.45	12.08
C7	8.34	7.69	7.89	7.81	8.43	8.60
C8	6.62	7.21	6.59	6.79	6.90	6.89
C9	5.65	5.27	5.57	5.39	5.88	5.68
C10	4.60	4.18	4.80	4.15	4.86	4.35
C11	3.76	3.48	3.73	3.42	3.74	3.90
C12	3.05	3.06	2.32	1.95	3.08	3.14
C13	2.66	2.03	2.21	1.88	3.02	1.61
C14	1.68	1.66	1.78	1.77	2.18	1.43
C15	1.72	1.43	1.62			1.38
alpha chain growth probability	0.48	0.47	0.46	0.39	0.35	0.32

C1 - C50 estimated total product distribution, weight %

C1	15.4	16.6	16.3	15.7	16.8	19.5
C2 - C4	22.3	22.2	21.8	20.4	21.4	24.7
C5 - C12	62.2	61.2	61.8	63.9	61.8	55.8
C13 - C50	0.2	0.1	0.1	0.0	0.0	0.0

CO conversion, %	3.1	2.7	2.4	2.0	2.0	2.2
rate, g CH ₂ /g cat/hr	0.05	0.04	0.04	0.03	0.03	0.04
CO ₂ formation, %	1.5	0.9	0.7	0.5	0.4	0.4

Schulz-Flory Plot for Co.005b (S2) - Run 1
Time on Stream (hrs)

hrs.

Co.005c - Run #1

Co wt%		Promotor wt%		Support
20		WGS.03 50		Al ₂ O ₃

SUMMARY REACTION DATA

Reaction Conditions:

P = 1.0 atm

T = 220 °C

H₂/CO = 2

weight of catalyst = 0.300 g

WHSV = 2.86 1/hr

time on stream = 28.0 hrs

CO₂ (g/g cat/hr) = 0.076CO₂ (% of CO) = 1.8

O/P = 0.21

CO conversion (%)	5.1
rate (g CH ₂ /g cat/hr)	0.06
alpha	0.39
C1 (wt%)	22.3
C2 - C4 (wt%)	27.7
C5 - C12 (wt%)	50.1
C13 + (wt%)	0.0

Performance of Co.005c

Dates: 09/02/94 - 09/03/94 Run #1

flow rate = 30.0 cc/min, loading = 0.30 g, WHSV = 2.9 1/hr, H₂/CO ratio in feed = 2

time on stream, hr	0.5	3.5	22.5	28.0	21.0
reaction temperature, °C	220	220	220	220	220
pressure, atm	1.0	1.0	1.0	1.0	1.0
flow, cc/min	30.0	30.0	30.0	30.0	30.0

C1 - C15 product distribution, weight %

C1	15.10	15.69	21.21	20.44
C2	3.42	3.69	4.47	4.56
C3	7.92	9.27	10.66	9.70
C4	10.09	10.89	11.81	11.15
C5	11.82	12.37	13.01	12.36
C6	11.98	12.93	10.80	11.27
C7	8.47	8.45	8.63	9.73
C8	6.72	6.43	5.72	5.76
C9	5.40	5.15	4.02	4.11
C10	4.01	3.74	2.96	2.67
C11	3.46	3.24	2.15	2.37
C12	2.95	3.02	1.64	1.65
C13	2.55	2.41	1.40	1.32
C14	2.08	1.57	0.93	0.83
C15	2.20	1.14	0.59	1.38

alpha	chain growth probability	0.48	0.47	0.46	0.39
	C-/C=[C3-C5]	56571	7.40	5.20	4.80

C1 - C50 estimated total product distribution, weight %

C1	17.7	17.6	22.7	22.3
C2 - C4	25.1	26.8	28.8	27.7
C5 - C12	57.1	55.5	48.5	50.1
C13 - C50	0.2	0.1	0.1	0.0

CO conversion, %	3.6	3.9	5.7	5.1
rate, g CH ₂ /g cat/hr	0.05	0.05	0.07	0.06
CO ₂ formation, %	3.9		2.6	1.8

Co.012 - Run #4

Co wt%	NM wt %	Promotor wt%		Support
20				SiO ₂

SUMMARY REACTION DATA

Reaction Conditions:

P = 1.0 atm

T = 220 °C

H₂/CO = 2

weight of catalyst = 0.266 g

WHSV = 9.66 1/hr

time on stream = 27.5 hrs

CO₂ (g/g cat/hr) = 0.023CO₂ (% of CO) = 0.2

O/P = 4.94

CO conversion (%)	2.5
rate (g CH ₂ /g cat/hr)	0.11
alpha	0.61
C1 (wt%)	28.4
C2 - C4 (wt%)	28.1
C5 - C12 (wt%)	41.9
C13 + (wt%)	1.6

Performance of Co.012

Dates: 07/29/94 - 07/30/94 Run #4

flow rate = 90.0 cc/min, loading = 0.3 g, WHSV = 9.7 1/hr, H₂/CO ratio in feed = 2

time on stream, hr	0.5	3.5	6.5	9.5	12.5	15.5
reaction temperature, °C	220	220	220	220	220	220
pressure, atm	1.0	1.0	1.0	1.0	1.0	1.0
flow, cc/min	90.0	90.0	90.0	90.0	90.0	90.0

C1 - C15 product distribution, weight %

C1	26.89	28.51	29.37	29.95	29.87	29.79
C2	5.35	5.48	5.62	5.69	5.67	5.66
C3	11.61	11.17	11.27	11.36	11.31	11.39
C4	11.74	10.98	11.00	11.01	10.97	11.11
C5	11.94	11.28	11.23	11.18	11.16	11.25
C6	8.11	9.21	9.24	9.01	9.09	9.06
C7	7.82	7.88	7.68	7.30	7.50	7.53
C8	5.53	5.40	5.31	5.22	5.26	5.21
C9	3.96	3.80	3.67	3.70	3.63	3.55
C10	2.64	2.65	2.56	2.53	2.59	2.56
C11	1.92	1.61	1.53	1.48	1.43	1.46
C12	1.15	0.98	0.96	0.94	0.95	0.89
C13	0.79	0.62	0.56	0.61	0.57	0.53
C14	0.56	0.43				
C15						
alpha chain growth probability	0.64	0.62	0.62	0.62	0.62	0.61

C1 - C50 estimated total product distribution, weight %

C1	26.7	28.4	29.2	29.6	29.6	29.6
C2 - C4	28.5	27.5	27.7	27.8	27.7	28.0
C5 - C12	42.4	42.3	41.5	40.8	41.0	40.9
C13 - C50	2.4	1.8	1.6	1.8	1.7	1.5

CO conversion, %	3.1	2.8	2.6	2.6	2.6	2.5
rate, g CH ₂ /g cat/hr	0.13	0.12	0.11	0.11	0.11	0.11
CO ₂ formation, %	0.2	0.2	0.2	0.2	0.2	0.2

Performance of Co.012

Dates: 07/29/94 - 07/30/94 Run #4

flow rate = 90.0 cc/min, loading= 0.3 g, WHSV = 9.7 1/hr, H₂/CO ratio in feed = 2

time on stream, hr	18.5	21.5	24.5	27.5	30.5
reaction temperature, °C	220	220	220	220	220
pressure, atm	1.0	1.0	1.0	1.0	1.0
flow, cc/min	90.0	90.0	90.0	90.0	90.0

C1 - C15 product distribution, weight %

C1	29.53	28.89	29.44	28.67	28.62
C2	5.56	5.54	5.65	5.53	5.53
C3	11.41	11.36	11.59	11.39	11.39
C4	11.15	11.32	11.47	11.35	11.34
C5	11.29	11.63	11.75	11.66	11.62
C6	9.13	9.43	7.98	9.45	9.38
C7	7.57	7.54	7.69	7.67	7.67
C8	5.20	5.28	5.28	5.27	5.27
C9	3.60	3.65	3.64	3.60	3.70
C10	2.59	2.51	2.59	2.51	2.55
C11	1.48	1.44	1.45	1.41	1.48
C12	0.94	0.88	0.90	0.92	0.90
C13	0.53	0.53	0.55	0.55	0.54
C14					
C15					
alpha chain growth probability	0.61	0.61	0.61	0.61	0.61

C1 - C50 estimated total product distribution, weight %

C1	29.4	28.7	29.2	28.4	28.4
C2 - C4	28.0	28.0	28.5	28.1	28.1
C5 - C12	41.2	41.8	40.7	41.9	41.9
C13 - C50	1.5	1.5	1.6	1.6	1.6

CO conversion, %	2.6	2.5	2.5	2.5	2.5
rate, g CH ₂ /g cat/hr	0.11	0.11	0.10	0.11	0.11
CO ₂ formation, %	0.2	0.1	0.2	0.2	0.2

Schulz-Flory Plot for Co.012 - Run #4

Time on Stream (hrs)

hrs.

Time-on-Stream Plot for Co.012 - Run #4

CO.015 - Run #2

Co wt%	NM wt %	Promotor wt%		Support
20	Ru 0.43		La2O3 1.00	Al2O3

SUMMARY REACTION DATA

Reaction Conditions:

P = 1.0 atm

T = 220 °C

H₂/CO = 2

weight of catalyst = 0.204 g

WHSV = 12.63 1/hr

time on stream = 24.5 hrs

CO₂ (g/g cat/hr) = 0.025CO₂ (% of CO) = 0.1

O/P = 1.39

CO conversion (%)	7.0
rate (g CH ₂ /g cat/hr)	0.39
alpha	0.64
C1 (wt%)	26.4
C2 - C4 (wt%)	28.4
C5 - C12 (wt%)	42.3
C13 + (wt%)	3.0

Performance of CO.015

Dates: 09/19/94 - 09/20/94 Run #2

flow rate = 90.0 cc/min, loading = 0.2 g, WHSV = 12.6 1/hr, H₂/CO ratio in feed = 2

time on stream, hr	0.5	3.5	6.5	9.5	12.5	15.5
reaction temperature, °C	220	220	220	220	220	220
pressure, atm	1.0	1.0	1.0	1.0	1.0	1.0
flow, cc/min	90.0	90.0	90.0	90.0	90.0	90.0

C1 - C15 product distribution, weight %

C1	26.54	27.62	26.41	28.28	26.68	26.80
C2	4.25	4.93	4.67	4.99	4.68	4.69
C3	12.55	12.81	12.15	12.76	12.01	11.97
C4	13.08	13.00	12.69	12.68	12.48	12.41
C5	12.31	11.55	12.13	10.76	12.05	11.90
C6	9.16	9.02	9.29	5.87	9.23	9.12
C7	7.33	7.01	7.44	7.94	7.51	7.48
C8	4.96	4.56	5.13	5.51	5.14	5.16
C9	3.30	3.24	3.45	3.79	3.48	3.52
C10	2.23	2.13	2.31	2.48	2.39	2.46
C11	1.62	1.54	1.65	1.86	1.66	1.70
C12	1.02	0.94	0.97	1.22	1.12	1.07
C13	0.69	0.68	0.72	0.75	0.66	0.73
C14	0.55	0.55	0.52	0.63	0.51	0.55
C15	0.42	0.44	0.45	0.47	0.42	0.46
alpha chain growth probability	0.64	0.64	0.64	0.65	0.64	0.64

C1 - C50 estimated total product distribution, weight %

C1	26.1	27.1	25.9	27.9	26.3	26.3
C2 - C4	29.4	30.1	28.9	30.0	28.7	28.5
C5 - C12	41.8	39.9	42.2	39.1	42.3	42.2
C13 - C50	2.7	2.9	3.0	3.1	2.7	3.0

CO conversion, %	9.3	7.7	7.9	6.3	7.4	7.2
rate, g CH ₂ /g cat/hr	0.51	0.42	0.44	0.35	0.41	0.40
CO ₂ formation, %	0.2	0.2	0.2	0.3	0.2	0.1

Performance of CO.015

Dates: 09/19/94 - 09/20/94 Run #2

flow rate = 90.0 cc/min, loading= 0.2 g, WHSV = 12.6 l/hr, H₂/CO ratio in feed = 2

time on stream, hr	18.5	21.5	24.5
reaction temperature, °C	220	220	220
pressure, atm	1.0	1.0	1.0
flow, cc/min	90.0	90.0	90.0

C1 - C15 product distribution, weight %

C1	25.85	26.30	26.85
C2	4.52	4.59	4.69
C3	11.50	11.67	11.89
C4	11.84	11.94	12.27
C5	11.36	11.30	11.87
C6	8.74	8.27	9.20
C7	8.39	8.33	7.47
C8	5.83	5.78	5.21
C9	4.02	3.96	3.47
C10	2.76	2.75	2.48
C11	1.96	1.90	1.75
C12	1.20	1.23	1.14
C13	0.84	0.80	0.69
C14	0.63	0.67	0.55
C15	0.55	0.51	0.45
alpha chain growth probability	0.66	0.65	0.64

C1 - C50 estimated total product distribution, weight %

C1	25.3	25.8	26.4
C2 - C4	27.2	27.7	28.4
C5 - C12	43.9	43.1	42.3
C13 - C50	3.6	3.4	3.0

CO conversion, %	7.7	7.2	7.0
rate, g CH ₂ /g cat/hr	0.42	0.40	0.39
CO ₂ formation, %	0.1	0.2	0.1

Schulz-Flory Plot for Co.015 - Run #2
Time on Stream (hrs)

Time-on-Stream Plot for Co.015 - Run #2

Co.016 - Run #2

Co wt%	NM wt %	Promotor wt%		Support
20	Ru 0.43		La2O3 1.00	Al2O3

SUMMARY REACTION DATA

Reaction Conditions:

P = 1.0 atm

T = 220 °C

H₂/CO = 2

weight of catalyst = 0.197 g

WHSV = 13.05 1/hr

time on stream = 27.5 hrs

CO₂ (g/g cat/hr) = 0.024CO₂ (% of CO) = 0.1

O/P = 2.48

CO conversion (%)	5.1
rate (g CH ₂ /g cat/hr)	0.29
alpha	0.68
C1 (wt%)	25.1
C2 - C4 (wt%)	26.6
C5 - C12 (wt%)	43.7
C13 + (wt%)	4.7

Performance of Co.016

Dates: 09/29/94 - 09/30/94 Run #2

flow rate = 90.0 cc/min, loading= 0.2 g, WHSV = 13.1 1/hr, H₂/CO ratio in feed = 2

time on stream, hr	0.5	3.5	6.5	9.5	12.5	15.5
reaction temperature, °C	220	220	220	220	220	220
pressure, atm	1.0	1.0	1.0	1.0	1.0	1.0
flow, cc/min	90.0	90.0	90.0	90.0	90.0	90.0

C1 - C15 product distribution, weight %

C1	38.10	23.78	24.85	24.88	25.24	28.28
C2	6.05	4.42	4.60	4.57	4.63	5.20
C3	14.71	11.42	11.62	11.35	11.40	12.62
C4	11.48	11.83	11.97	11.64	11.68	12.62
C5	9.58	11.64	11.41	11.53	11.68	11.85
C6	0.07	9.15	8.34	7.89	9.20	4.36
C7	6.95	8.65	8.58	8.64	12.99	7.68
C8	4.61	5.98	5.94	6.14	3.83	5.49
C9	3.09	4.18	4.15	4.29	2.71	3.94
C10	1.98	2.89	2.85	2.93	1.85	2.76
C11	1.34	2.00	1.96	2.06	1.25	1.91
C12	0.84	1.44	1.35	1.45	1.25	1.21
C13	0.70	1.25	1.12	1.08	0.92	0.87
C14	0.41	0.85	0.84	0.90	0.75	0.73
C15	0.09	0.53	0.44	0.65	0.62	0.47
alpha chain growth probability	0.56	0.65	0.64	0.67	0.67	0.65

C1 - C50 estimated total product distribution, weight %

C1	38.7	23.5	24.7	24.3	24.4	27.9
C2 - C4	32.8	27.4	28.1	26.9	26.8	30.1
C5 - C12	27.9	45.6	44.3	44.5	44.7	38.9
C13 - C50	0.6	3.5	2.9	4.3	4.0	3.1

CO conversion, %	0.9	6.3	5.8	5.9	5.6	4.7
rate, g CH ₂ /g cat/hr	0.05	0.36	0.33	0.34	0.32	0.27
CO ₂ formation, %	0.2	0.2	0.2	0.1	0.1	0.2

Performance of Co.016

Dates: 09/29/94 - 09/30/94 Run #2

flow rate = 90.0 cc/min, loading = 0.2 g, WHSV = 13.1 l/hr, H₂/CO ratio in feed = 2

time on stream, hr	18.5	21.5	24.5	27.5
reaction temperature, °C	220	220	220	220
pressure, atm	1.0	1.0	1.0	1.0
flow, cc/min	90.0	90.0	90.0	90.0

C1 - C15 product distribution, weight %

C1	34.21	25.92	26.24	25.86
C2	6.02	4.75	4.81	4.74
C3	13.99	11.45	11.51	11.26
C4	12.77	11.67	11.68	11.42
C5	9.69	11.62	11.54	11.52
C6	3.22	9.29	9.06	9.04
C7	6.30	7.57	7.60	7.67
C8	4.46	5.41	5.41	5.59
C9	3.17	3.92	3.92	4.03
C10	2.21	2.75	2.79	2.91
C11	1.51	1.84	1.86	2.05
C12	1.03	1.42	1.24	1.46
C13	0.68	0.96	0.94	0.95
C14	0.41	0.78	0.75	0.78
C15	0.34	0.64	0.65	0.71
alpha chain growth probability	0.63	0.67	0.67	0.68

C1 - C50 estimated total product distribution, weight %

C1	33.9	25.2	25.5	25.1
C2 - C4	32.5	27.1	27.2	26.6
C5 - C12	31.4	43.4	43.1	43.7
C13 - C50	2.2	4.2	4.2	4.7

CO conversion, %	2.2	5.3	5.2	5.1
rate, g CH ₂ /g cat/hr	0.12	0.30	0.29	0.29
CO ₂ formation, %	0.3	0.1	0.1	0.1

Schulz-Flory Plot for Co.016 - Run #2
Time on Stream (hrs)

Time-on-Stream Plot for Co.016 - Run #2

Co.019 - Run #3

Co wt%	NM wt %	Promotor wt%		Support
20	Ru 0.50			SiO ₂

SUMMARY REACTION DATA

Reaction Conditions:

P = 1.0 atm

T = 220 °C

H₂/CO = 2

weight of catalyst = 0.273 g

WHSV = 9.43 1/hr

time on stream = 24.5 hrs

CO₂ (g/g cat/hr) = 0.025CO₂ (% of CO) = 0.2

O/P = 6.74

CO conversion (%)	3.4
rate (g CH ₂ /g cat/hr)	0.14
alpha	0.72
C1 (wt%)	19.3
C2 - C4 (wt%)	21.6
C5 - C12 (wt%)	50.4
C13 + (wt%)	8.7

Performance of Co.019

Dates: 07/05/94 - 07/06/94 Run #3

flow rate = 90.0 cc/min, loading = 0.3 g, WHSV = 9.4 l/hr, H₂/CO ratio in feed = 2

time on stream, hr	0.5	3.5	6.5	9.5	12.5	15.5
reaction temperature, °C	220	220	220	220	220	220
pressure, atm	1.0	1.0	1.0	1.0	1.0	1.0
flow, cc/min	90.0	90.0	90.0	90.0	90.0	90.0

C1 - C15 product distribution, weight %

C1	20.39	21.73	21.65	21.62	21.22	20.65
C2	4.18	4.41	4.41	4.44	4.40	4.32
C3	9.54	9.50	9.35	9.31	9.17	8.96
C4	10.44	10.23	10.07	9.98	9.86	9.52
C5	11.51	11.19	10.98	10.98	10.98	10.81
C6	10.24	10.15	9.99	9.25	9.42	9.31
C7	8.72	8.68	8.64	8.71	8.34	8.75
C8	6.64	6.63	6.68	6.86	6.90	7.02
C9	4.88	5.08	5.21	5.34	5.45	5.58
C10	3.61	3.93	4.09	4.16	4.31	4.42
C11	3.01	2.68	2.80	3.08	3.12	3.29
C12	2.19	1.89	2.21	2.29	2.42	2.51
C13	1.80	1.48	1.53	1.60	1.85	1.95
C14	1.50	1.36	1.38	1.35	1.46	1.63
C15	1.35	1.08	1.00	1.04	1.11	1.29
alpha chain growth probability	0.72	0.71	0.71	0.71	0.71	0.73

C1 - C50 estimated total product distribution, weight %

C1	19.2	20.8	20.9	20.9	20.5	19.7
C2 - C4	22.7	23.1	23.1	23.0	22.7	21.8
C5 - C12	49.0	48.9	49.2	49.0	49.3	49.6
C13 - C50	9.1	7.3	6.8	7.1	7.6	8.9

CO conversion, %	4.7	4.2	4.0	3.9	3.7	3.7
rate, g CH ₂ /g cat/hr	0.20	0.17	0.16	0.16	0.15	0.15
CO ₂ formation, %	0.3	0.2	0.2	0.2	0.2	0.2

Performance of Co.019

Dates: 07/05/94 - 07/06/94 Run #3

flow rate = 90.0 cc/min, loading = 0.3 g, WHSV = 9.4 1/hr, H₂/CO ratio in feed = 2

time on stream, hr	18.5	21.5	24.5	29.5	32.5
reaction temperature, °C	220	220	220	220	220
pressure, atm	1.0	1.0	1.0	1.0	1.0
flow, cc/min	90.0	90.0	90.0	22.5	22.5

C1 - C15 product distribution, weight %

C1	20.51	21.52	20.01	19.33	15.23
C2	4.31	4.51	4.27	3.64	2.94
C3	8.92	9.31	8.77	8.59	6.86
C4	9.43	9.63	9.37	9.39	8.03
C5	10.69	10.77	10.68	10.31	9.57
C6	9.23	9.20	9.51	9.52	9.34
C7	8.76	8.63	8.80	8.67	8.78
C8	7.07	6.90	7.14	7.18	7.76
C9	5.59	5.38	5.63	5.97	6.80
C10	4.51	4.20	4.56	4.80	5.96
C11	3.50	3.24	3.61	3.79	5.19
C12	2.60	2.48	2.72	3.12	4.50
C13	2.03	1.75	2.04	2.29	3.45
C14	1.61	1.42	1.63	1.83	3.06
C15	1.25	1.06	1.25	1.58	2.51
alpha chain growth probability	0.72	0.71	0.72	0.74	0.79

C1 - C50 estimated total product distribution, weight %

C1	19.7	20.9	19.3	18.2	13.7
C2 - C4	21.8	22.8	21.6	20.4	16.0
C5 - C12	49.8	49.0	50.4	50.3	51.4
C13 - C50	8.7	7.3	8.7	11.1	18.9

CO conversion, %	3.8	4.1	3.4	16.7	8.8
rate, g CH ₂ /g cat/hr	0.16	0.17	0.14	0.17	0.09
CO ₂ formation, %	0.2	0.2	0.2	1.0	0.5

Schulz-Flory Plot for Co.019 - Run #3
Time on Stream (hrs)

Time-on-Stream Plot for Co.019 - Run #3

Co.019 - Run #3h

Co wt%	NM wt %	Promotor wt%		Support
20	Ru 0.50			SiO ₂

SUMMARY REACTION DATA*

Reaction Conditions:

P = 1.0 atm
 T = 220 °C
 H₂/CO = 2
 weight of catalyst = 0.273 g
 WHSV = 2.36 1/hr
 time on stream = 29.5 hrs

CO₂ (g/g cat/hr) = 0.034
 CO₂ (% of CO) = 1.0
 O/P = 1.77

CO conversion (%)	16.7
rate (g CH ₂ /g cat/hr)	0.17
alpha	0.74
C1 (wt%)	18.2
C2 - C4 (wt%)	20.4
C5 - C12 (wt%)	50.3
C13 + (wt%)	11.1

* High conversion study

Schulz-Flory Plot for Co.019 - Run #3h
Time on Stream (hrs)

Co.032 - Run #1

Co wt%	NM wt %	Promotor wt%		Support
20			Zr 8.50	Al ₂ O ₃

SUMMARY REACTION DATA

Reaction Conditions:

P = 1.0 atm

T = 220 °C

H₂/CO = 2

weight of catalyst = 0.200 g

WHSV = 12.86 1/hr

time on stream = 27.1 hrs

CO₂ (g/g cat/hr) = 0.022CO₂ (% of CO) = 0.1

O/P = 5.28

CO conversion (%)	3.3
rate (g CH ₂ /g cat/hr)	0.18
alpha	0.70
C1 (wt%)	22.0
C2 - C4 (wt%)	24.9
C5 - C12 (wt%)	46.8
C13 + (wt%)	6.3

Performance of Co.032

Dates: 09/14/94 - 09/15/94 Run #1

flow rate = 90.0 cc/min, loading = 0.2 g, WHSV = 12.9 l/hr, H₂/CO ratio in feed = 2

time on stream, hr	0.1	3.1	6.1	9.1	12.1	15.1
reaction temperature, °C	220	220	220	220	220	220
pressure, atm	1.0	1.0	1.0	1.0	1.0	1.0
flow, cc/min	90.0	90.0	90.0	90.0	90.0	90.0

C1 - C15 product distribution, weight %

C1	20.50	20.57	20.98	21.50	21.65	21.91
C2	4.09	4.04	4.09	4.19	4.23	4.31
C3	11.07	10.29	10.16	10.27	10.21	10.25
C4	12.48	11.50	11.24	11.21	11.06	11.09
C5	12.49	12.37	12.05	12.00	11.84	11.92
C6	8.40	9.18	9.82	9.09	9.09	9.25
C7	8.33	8.54	8.40	8.46	8.48	8.01
C8	6.23	6.37	6.32	6.41	6.40	6.32
C9	4.74	4.82	4.79	4.81	4.80	4.85
C10	3.70	3.74	3.71	3.77	3.79	3.75
C11	2.69	2.66	2.83	2.69	2.74	2.62
C12	2.03	2.17	2.04	1.98	1.98	2.01
C13	1.53	1.47	1.41	1.47	1.50	1.54
C14	1.10	1.25	1.19	1.21	1.29	1.24
C15	0.61	1.02	0.95	0.94	0.94	0.92
alpha chain growth probability	0.67	0.70	0.70	0.70	0.70	0.70

C1 - C50 estimated total product distribution, weight %

C1	20.5	19.8	20.3	20.8	21.0	21.3
C2 - C4	27.6	24.8	24.7	24.8	24.7	24.9
C5 - C12	47.8	48.5	48.7	48.1	48.0	47.7
C13 - C50	4.1	6.9	6.4	6.3	6.3	6.2

CO conversion, %	3.5	3.8	3.7	3.6	3.5	3.3
rate, g CH ₂ /g cat/hr	0.20	0.21	0.21	0.20	0.20	0.19
CO ₂ formation, %	0.2	0.1	0.1	0.1	0.1	0.1

10/12/94

Performance of Co.032

Dates: 09/14/94 - 09/15/94 Run #1

flow rate = 90.0 cc/min, loading = 0.2 g, WHSV = 12.9 1/hr, H₂/CO ratio in feed = 2

time on stream, hr	18.1	21.1	24.1	27.1
reaction temperature, °C	220	220	220	220
pressure, atm	1.0	1.0	1.0	1.0
flow, cc/min	90.0	90.0	90.0	90.0

C1 - C15 product distribution, weight %

C1	22.06	21.81	21.69	22.71
C2	4.36	4.33	4.34	4.54
C3	10.29	10.10	9.98	10.32
C4	10.90	10.68	10.55	10.84
C5	11.60	11.33	11.90	11.47
C6	8.93	8.68	8.76	8.77
C7	8.28	8.73	8.44	8.24
C8	6.20	6.56	6.41	6.20
C9	4.78	5.01	4.87	4.74
C10	3.75	3.90	3.83	3.75
C11	2.70	2.72	2.76	2.69
C12	2.35	2.16	2.53	2.05
C13	1.52	1.62	1.54	1.51
C14	1.30	1.35	1.39	1.25
C15	0.98	1.02	1.02	0.94
alpha chain growth probability	0.70	0.71	0.70	0.70

C1 - C50 estimated total product distribution, weight %

C1	21.4	21.0	21.0	22.0
C2 - C4	24.8	24.2	24.1	24.9
C5 - C12	47.3	47.8	48.0	46.8
C13 - C50	6.6	6.9	6.9	6.3

CO conversion, %	3.5	3.4	3.4	3.3
rate, g CH ₂ /g cat/hr	0.20	0.19	0.19	0.18
CO ₂ formation, %	0.1	0.1	0.1	0.1

Schulz-Flory Plot for Co.032 - Run #1
Time on Stream (hrs)

Time-on-Stream Plot for Co.032 - Run #1

Co.033 - Run #1

Co wt%	NM wt %	Promotor wt%		Support
20			Zr 8.50	Al ₂ O ₃

SUMMARY REACTION DATA

Reaction Conditions:

P = 1.0 atm

T = 217 °C

H₂/CO = 2

weight of catalyst = 0.194 g

WHSV = 13.27 1/hr

time on stream = 30.5 hrs

CO₂ (g/g cat/hr) = 0.020CO₂ (% of CO) = 0.1

O/P = 7.36

CO conversion (%)	1.3
rate (g CH ₂ /g cat/hr)	0.07
alpha	0.67
C1 (wt%)	24.1
C2 - C4 (wt%)	28.1
C5 - C12 (wt%)	44.0
C13 + (wt%)	3.8

Performance of Co.033

Dates: 08/29/94 - 08/30/94 Run #1

flow rate = 90.0 cc/min, loading = 0.2 g, WHSV = 13.3 1/hr, H₂/CO ratio in feed = 2

time on stream, hr	0.5	24.5	27.5	30.5
reaction temperature, °C	217	217	217	217
pressure, atm	1.0	1.0	1.0	1.0
flow, cc/min	90.0	90.0	90.0	90.0

C1 - C15 product distribution, weight %

C1	22.02	23.36	24.68	24.50
C2	5.01	5.03	5.29	5.26
C3	12.12	11.00	11.53	11.44
C4	13.26	20.38	11.91	11.80
C5	13.98	11.11	12.49	12.53
C6	5.00	4.69	6.06	6.46
C7	8.42	7.46	8.33	8.35
C8	5.92	5.38	6.15	6.18
C9	4.10	3.85	4.35	4.38
C10	2.92	2.57	3.08	2.99
C11	2.06	1.88	2.15	2.22
C12	1.73	1.42	1.44	1.33
C13	1.55	0.97	1.11	1.11
C14	1.19	0.68	0.84	0.87
C15	0.72	0.23	0.60	0.58
alpha chain growth probability	0.67	0.61	0.67	0.67

C1 - C50 estimated total product distribution, weight %

C1	21.6	23.7	24.3	24.1
C2 - C4	29.7	37.0	28.2	28.1
C5 - C12	44.0	37.7	43.5	44.0
C13 - C50	4.7	1.6	4.0	3.8

CO conversion, %	1.5	1.2	1.3	1.3
rate, g CH ₂ /g cat/hr	0.09	0.07	0.08	0.07
CO ₂ formation, %	0.1	0.1	0.1	0.1

Schulz-Flory Plot for Co.033 - Run #1
Time on Stream (hrs)

hrs.

Time-on-Stream Plot for Co.033 - Run #1

Co.034 - Run #1

Co wt%	NM wt %	Promotor wt%		Support
20			Zr 8.50	Al ₂ O ₃

SUMMARY REACTION DATA

Reaction Conditions:

P = 1.0 atm

T = 220 °C

H₂/CO = 2

weight of catalyst = 0.203 g

WHSV = 12.67 1/hr

time on stream = 30.0 hrs

CO₂ (g/g cat/hr) = 0.018CO₂ (% of CO) = 0.1

O/P = 4.29

CO conversion (%)	5.0
rate (g CH ₂ /g cat/hr)	0.27
alpha	0.67
C1 (wt%)	24.0
C2 - C4 (wt%)	26.7
C5 - C12 (wt%)	45.3
C13 + (wt%)	4.0

Performance of Co.034

Dates: 08/26/94 - 08/27/94 Run #1

flow rate = 90.0 cc/min, loading = 0.2 g, WHSV = 12.7 l/hr, H₂/CO ratio in feed = 2

time on stream, hr	0.5	3.0	6.0	9.0	12.0	15.0
reaction temperature, °C	220	220	220	220	220	220
pressure, atm	1.0	1.0	1.0	1.0	1.0	1.0
flow, cc/min	90.0	90.0	90.0	90.0	90.0	90.0

C1 - C15 product distribution, weight %

C1	21.45	22.14	22.28	23.63	22.97	23.08
C2	3.98	4.03	4.02	4.24	4.10	4.12
C3	11.70	11.49	11.23	11.67	11.16	11.07
C4	12.75	12.29	12.06	12.43	11.78	11.61
C5	12.86	12.44	12.40	12.80	12.08	11.95
C6	9.66	9.65	10.01	10.33	9.74	9.49
C7	8.22	8.08	8.20	8.50	8.11	8.11
C8	5.88	5.94	6.02	6.33	5.99	6.02
C9	4.19	4.28	4.40	0.03	4.39	4.43
C10	3.02	3.08	3.16	3.37	3.25	3.29
C11	2.13	2.45	2.23	2.38	2.28	2.48
C12	1.61	1.60	1.53	1.64	1.60	1.78
C13	1.07	1.02	1.05	1.12	1.07	1.10
C14	0.87	0.83	0.79	0.88	0.83	0.88
C15	0.61	0.68	0.61	0.65	0.63	0.58
alpha chain growth probability	0.66	0.67	0.67	0.67	0.67	0.66

C1 - C50 estimated total product distribution, weight %

C1	21.1	21.6	21.9	23.2	22.5	22.9
C2 - C4	27.9	27.2	26.8	27.8	26.5	26.6
C5 - C12	47.0	46.7	47.3	44.7	46.7	46.7
C13 - C50	4.0	4.5	4.1	4.3	4.2	3.9

CO conversion, %	6.0	6.0	5.6	5.2	5.4	5.2
rate, g CH ₂ /g cat/hr	0.33	0.33	0.31	0.29	0.30	0.29
CO ₂ formation, %	0.1	0.1	0.1	0.1	0.1	0.1

Performance of Co.034

Dates: 08/26/94 - 08/27/94 Run #1

flow rate = 90.0 cc/min, loading = 0.2 g, WHSV = 12.7 1/hr, H₂/CO ratio in feed = 2

time on stream, hr	18.0	21.0	24.0	27.0	30.0
reaction temperature, °C	220	220	220	220	220
pressure, atm	1.0	1.0	1.0	1.0	1.0
flow, cc/min	90.0	90.0	90.0	90.0	90.0

C1 - C15 product distribution, weight %

C1	23.30	23.38	23.60	23.78	24.19
C2	4.14	4.15	4.19	4.22	4.29
C3	11.07	11.01	11.05	11.05	11.19
C4	11.51	11.43	11.45	11.38	11.48
C5	11.87	11.78	11.85	11.67	11.81
C6	9.62	9.51	9.67	9.21	7.99
C7	8.08	8.12	8.11	8.04	8.16
C8	5.99	6.00	5.98	5.97	6.08
C9	4.39	4.46	4.38	4.37	4.48
C10	3.29	3.32	3.27	3.31	3.40
C11	2.48	2.45	2.29	2.52	2.49
C12	1.68	1.71	1.60	1.76	1.74
C13	1.09	1.18	1.06	1.22	1.14
C14	0.91	0.92	0.93	0.91	0.98
C15	0.58	0.57	0.57	0.58	0.60
alpha chain growth probability	0.66	0.66	0.66	0.67	0.67

C1 - C50 estimated total product distribution, weight %

C1	23.1	23.2	23.3	23.6	24.0
C2 - C4	26.5	26.4	26.4	26.5	26.7
C5 - C12	46.6	46.6	46.5	46.0	45.3
C13 - C50	3.9	3.8	3.8	3.9	4.0

CO conversion, %	5.3	5.2	5.1	5.0	5.0
rate, g CH ₂ /g cat/hr	0.29	0.29	0.28	0.28	0.27
CO ₂ formation, %	0.1	0.1	0.1	0.1	0.1

Schulz-Flory Plot for Co.034 - Run #1
Time on Stream (hrs)

Time-on-Stream Plot for Co.034 - Run #1

Co.055 - Run #1

Co wt%	NM wt %	Promotor wt%		Support
20	Re 1.00		La2O3 1.00	Al2O3

SUMMARY REACTION DATA**Reaction Conditions:**

P = 1.0 atm

T = 220 °C

H₂/CO = 2

weight of catalyst = 0.208 g

WHSV = 12.36 1/hr

time on stream = 21.3 hrs

CO₂ (g/g cat/hr) = 0.034CO₂ (% of CO) = 0.2

O/P = 1.31

CO conversion (%)	9.1
rate (g CH ₂ /g cat/hr)	0.49
alpha	0.63
C1 (wt%)	28.9
C2 - C4 (wt%)	28.8
C5 - C12 (wt%)	40.0
C13 + (wt%)	2.2

Performance of Co.055

Dates: 09/01/94 - 09/02/94 Run #1

flow rate = 90.0 cc/min, loading = 0.2 g, WHSV = 12.4 1/hr, H₂/CO ratio in feed = 2

time on stream, hr	0.3	3.3	6.3	9.3	12.3	21.3
reaction temperature, °C	220	220	220	220	220	220
pressure, atm	1.0	1.0	1.0	1.0	1.0	1.0
flow, cc/min	90.0	90.0	90.0	90.0	90.0	90.0

C1 - C15 product distribution, weight %

C1	27.41	28.60	28.58	30.85	29.60	29.05
C2	4.66	4.75	4.69	5.02	4.79	4.65
C3	12.79	12.74	12.57	13.35	12.75	12.29
C4	13.03	11.14	12.64	7.77	12.70	12.04
C5	11.97	11.82	11.73	12.11	11.74	11.04
C6	8.71	8.86	7.94	7.83	6.82	6.39
C7	7.01	7.19	7.12	7.46	7.09	8.03
C8	4.79	5.03	5.01	5.27	5.00	5.65
C9	3.28	3.38	3.43	3.57	3.37	3.84
C10	2.13	2.17	2.21	2.36	2.23	2.58
C11	1.51	1.59	1.60	1.72	1.58	1.80
C12	1.04	1.04	0.94	1.11	1.00	1.10
C13	0.75	0.74	0.61	0.75	0.58	0.71
C14	0.55	0.56	0.44	0.47	0.40	0.50
C15	0.38	0.38	0.49	0.37	0.33	0.34
alpha chain growth probability	0.63	0.63	0.65	0.63	0.63	0.63

C1 - C50 estimated total product distribution, weight %

C1	27.1	28.3	27.8	30.6	29.3	28.9
C2 - C4	30.1	28.3	29.1	25.9	30.0	28.8
C5 - C12	40.3	40.9	39.8	41.1	38.5	40.0
C13 - C50	2.5	2.5	3.2	2.4	2.2	2.2

CO conversion, %	11.7	10.8	10.1	9.0	8.9	9.1
rate, g CH ₂ /g cat/hr	0.63	0.59	0.55	0.49	0.48	0.49
CO ₂ formation, %	0.3	0.2	0.2	0.2	0.2	0.2

Performance of Co.055

Dates: 09/01/94 - 09/02/94 Run #1

flow rate = 90.0 cc/min, loading = 0.2 g, WHSV = 12.4 1/hr, H₂/CO ratio in feed = 2

time on stream, hr	24.3
reaction temperature, °C	220
pressure, atm	1.0
flow, cc/min	90.0

C1 - C15 product distribution, weight %

C1	29.10
C2	4.65
C3	12.17
C4	11.87
C5	10.90
C6	6.55
C7	7.94
C8	5.58
C9	3.88
C10	2.74
C11	1.85
C12	1.24
C13	0.73
C14	0.46
C15	0.34
alpha chain growth probability	0.63

C1 - C50 estimated total product distribution, weight %

C1	29.0
C2 - C4	28.6
C5 - C12	40.1
C13 - C50	2.3

CO conversion, %	9.4
rate, g CH ₂ /g cat/hr	0.51
CO ₂ formation, %	0.1

Schulz-Flory Plot for Co.055 - Run #1
Time on Stream (hrs)

hrs.

Time-on-Stream Plot for Co.055 - Run #1

Co.055 - Run #2

Co wt%	NM wt %	Promotor wt%		Support
20	Re 1.00		La ₂ O ₃ 1.00	Al ₂ O ₃

SUMMARY REACTION DATA

Reaction Conditions:

P = 1.0 atm

T = 220 °C

H₂/CO = 2

weight of catalyst = 0.191 g

WHSV = 13.46 1/hr

time on stream = 24.1 hrs

CO₂ (g/g cat/hr) = 0.022CO₂ (% of CO) = 0.1

O/P = 1.49

CO conversion (%)	4.9
rate (g CH ₂ /g cat/hr)	0.29
alpha	0.65
C1 (wt%)	25.7
C2 - C4 (wt%)	27.6
C5 - C12 (wt%)	43.3
C13 + (wt%)	3.4

- * Catalyst is directly reduced without calcination
- * Temperature surge during startup

Performance of Co.055

Dates: 09/07/94 - 09/08/94 Run #2

flow rate = 90.0 cc/min, loading = 0.2 g, WHSV = 13.5 l/hr, H₂/CO ratio in feed = 2

time on stream, hr	0.1	3.1	6.1	9.1	12.1	15.1
reaction temperature, °C	220	220	220	220	220	220
pressure, atm	1.0	1.0	1.0	1.0	1.0	1.0
flow, cc/min	90.0	90.0	90.0	90.0	90.0	90.0

C1 - C15 product distribution, weight %

C1	24.41	23.88	25.48	25.63	25.93	26.11
C2	4.22	4.08	4.32	4.33	4.37	4.38
C3	11.89	11.40	11.73	11.65	11.71	11.71
C4	12.82	12.39	12.45	12.34	12.33	12.25
C5	12.55	12.35	12.19	12.11	12.00	11.98
C6	9.71	9.74	9.45	9.47	9.09	9.22
C7	7.76	8.04	7.74	7.78	7.73	7.68
C8	5.33	5.66	5.43	5.46	5.46	5.45
C9	3.65	4.01	3.78	3.76	3.83	3.75
C10	2.43	2.71	2.50	2.53	2.63	2.55
C11	1.78	1.97	1.79	1.82	1.80	1.84
C12	1.25	1.32	1.17	1.18	1.22	1.14
C13	0.94	1.04	0.83	0.78	0.78	0.75
C14	0.63	0.83	0.65	0.64	0.64	0.65
C15	0.63	0.58	0.49	0.54	0.48	0.54
alpha chain growth probability	0.66	0.66	0.65	0.65	0.65	0.66

C1 - C50 estimated total product distribution, weight %

C1	23.7	23.4	25.0	25.0	25.5	25.5
C2 - C4	28.0	27.3	28.0	27.7	27.9	27.7
C5 - C12	44.2	45.5	43.8	43.8	43.4	43.3
C13 - C50	4.1	3.8	3.2	3.5	3.2	3.6

CO conversion, %	6.3	5.2	5.6	5.5	5.3	5.3
rate, g CH ₂ /g cat/hr	0.37	0.30	0.33	0.32	0.31	0.31
CO ₂ formation, %	0.1	0.1	0.1	0.1	0.1	0.1

Performance of Co.055

Dates: 09/07/94 - 09/08/94 Run #2

flow rate = 90.0 cc/min, loading = 0.2 g, WHSV = 13.5 l/hr, H₂/CO ratio in feed = 2

time on stream, hr	18.1	21.1	24.1
reaction temperature, °C	220	220	220
pressure, atm	1.0	1.0	1.0
flow, cc/min	90.0	90.0	90.0

C1 - C15 product distribution, weight %

C1	26.38	26.58	26.13
C2	4.41	4.44	4.35
C3	11.78	11.82	11.61
C4	12.26	12.28	12.08
C5	11.90	11.84	11.83
C6	8.94	8.86	9.14
C7	7.65	7.61	7.65
C8	5.46	5.38	5.38
C9	3.73	3.79	3.81
C10	2.56	2.47	2.63
C11	1.73	1.84	2.17
C12	1.24	1.12	1.30
C13	0.81	0.82	0.76
C14	0.67	0.67	0.64
C15	0.47	0.48	0.51
alpha chain growth probability	0.65	0.65	0.65

C1 - C50 estimated total product distribution, weight %

C1	26.0	26.1	25.7
C2 - C4	28.0	28.1	27.6
C5 - C12	42.9	42.6	43.3
C13 - C50	3.1	3.2	3.4

CO conversion, %	5.1	5.0	4.9
rate, g CH ₂ /g cat/hr	0.30	0.29	0.29
CO ₂ formation, %	0.1	0.1	0.1

Schulz-Flory Plot for Co.055 - Run #2
Time on Stream (hrs)

Time-on-Stream Plot for Co.055 - Run #3

Schulz-Flory Plot for Co.055 - Run #3
Time on Stream (hrs)

co.055 - Run #3

Co wt%	NM wt %	Promotor wt%		Support
20	Re 1.00		La2O3 1.00	Al2O3

SUMMARY REACTION DATA

Reaction Conditions:

P = 1.0 atm

T = 220 °C

H₂/CO = 2

weight of catalyst = 0.203 g

WHSV = 12.70 1/hr

time on stream = 21.5 hrs

CO₂ (g/g cat/hr) = 0.033CO₂ (% of CO) = 0.2

O/P = 1.02

CO conversion (%)	11.0
rate (g CH ₂ /g cat/hr)	0.61
alpha	0.60
C1 (wt%)	29.4
C2 - C4 (wt%)	29.3
C5 - C12 (wt%)	39.1
C13 + (wt%)	2.2

* Catalyst is reduced without calcination

Performance of co.055

Dates: 09/12/94 - 09/13/94 Run #3

flow rate = 90.0 cc/min, loading = 0.2 g, WHSV = 12.7 1/hr, H₂/CO ratio in feed = 2

time on stream, hr	0.5	3.5	6.5	9.5	12.5	15.5
reaction temperature, °C	220	220	220	220	220	220
pressure, atm	1.0	1.0	1.0	1.0	1.0	1.0
flow, cc/min	90.0	90.0	90.0	90.0	90.0	90.0

C1 - C15 product distribution, weight %

C1	30.11	29.21	29.16	30.15	29.80	29.95
C2	5.08	4.82	4.77	4.89	4.81	4.81
C3	10.36	12.59	12.42	12.63	12.45	12.50
C4	13.16	12.68	12.57	12.57	12.44	12.43
C5	11.74	11.44	11.30	11.09	11.25	11.24
C6	8.37	8.33	8.27	7.53	8.23	8.30
C7	7.49	7.35	7.22	7.16	7.19	7.16
C8	4.83	4.80	4.82	4.79	4.89	4.85
C9	3.06	3.19	3.37	3.15	3.21	3.16
C10	2.10	1.91	2.15	2.23	2.01	1.99
C11	1.43	1.34	1.69	1.65	1.45	1.42
C12	0.87	0.97	0.89	0.89	0.99	0.96
C13	0.66	0.61	0.59	0.63	0.57	0.51
C14	0.51	0.45	0.43	0.39	0.40	0.42
C15	0.24	0.32	0.35	0.27	0.31	0.30
alpha chain growth probability	0.58	0.60	0.60	0.59	0.59	0.59

C1 - C50 estimated total product distribution, weight %

C1	30.0	28.8	28.7	29.9	29.4	29.5
C2 - C4	28.5	29.6	29.3	29.9	29.3	29.3
C5 - C12	39.9	39.5	39.7	38.4	39.2	39.1
C13 - C50	1.6	2.1	2.3	1.8	2.0	2.0

CO conversion, %	13.7	12.6	12.3	11.5	11.4	11.1
rate, g CH ₂ /g cat/hr	0.76	0.70	0.68	0.64	0.63	0.62
CO ₂ formation, %	0.2	0.2	0.2	0.2	0.2	0.2

Performance of co.055

Dates: 09/12/94 - 09/13/94 Run #3

flow rate = 90.0 cc/min, loading= 0.2 g, WHSV = 12.7 1/hr, H₂/CO ratio in feed = 2

time on stream, hr	18.5	21.5	24.5
reaction temperature, °C	220	220	220
pressure, atm	1.0	1.0	1.0
flow, cc/min	90.0	90.0	90.0

C1 - C15 product distribution, weight %

C1	29.89	29.91	29.93
C2	4.81	4.80	4.79
C3	12.49	12.55	12.55
C4	12.37	12.43	12.46
C5	11.12	11.21	11.23
C6	8.09	8.15	8.24
C7	7.19	7.20	7.19
C8	4.81	4.82	4.83
C9	3.21	3.18	3.17
C10	2.11	2.03	2.02
C11	1.75	1.40	1.42
C12	0.94	1.02	0.96
C13	0.51	0.55	0.52
C14	0.40	0.42	0.39
C15	0.32	0.33	0.32
alpha chain growth probability	0.60	0.60	0.60

C1 - C50 estimated total product distribution, weight %

C1	29.5	29.4	29.5
C2 - C4	29.3	29.3	29.3
C5 - C12	39.1	39.1	39.1
C13 - C50	2.1	2.2	2.1

CO conversion, %	11.3	11.0	10.7
rate, g CH ₂ /g cat/hr	0.63	0.61	0.60
CO ₂ formation, %	0.2	0.2	0.2

CAL.04 - Run #1

Co wt%	NM wt %	Promotor wt%		Support
20	Ru 0.50	K 0.30		Al ₂ O ₃

SUMMARY REACTION DATA

Reaction Conditions:

P = 1.0 atm

T = 220 °C

H₂/CO = 2

weight of catalyst = 0.195 g

WHSV = 13.19 1/hr

time on stream = 29.0 hrs

CO₂ (g/g cat/hr) = 0.026

CO₂ (% of CO) = 0.1

O/P = 8.98

CO conversion (%)	4.1
rate (g CH ₂ /g cat/hr)	0.23
alpha	0.71
C1 (wt%)	19.1
C2 - C4 (wt%)	20.0
C5 - C12 (wt%)	50.6
C13 + (wt%)	10.2

Performance of CAL.04

Dates: 08/01/94 - 08/02/94 Run #1

flow rate = 90.0 cc/min, loading = 0.2 g, WHSV = 13.2 l/hr, H₂/CO ratio in feed = 2

time on stream, hr	0.5	3.5	6.5	9.5	12.5	15.5
reaction temperature, °C	220	220	220	220	220	220
pressure, atm	1.0	1.0	1.0	1.0	1.0	1.0
flow, cc/min	90.0	90.0	90.0	90.0	90.0	90.0

C1 - C15 product distribution, weight %

C1	19.57	19.50	19.66	19.92	20.11	20.00
C2	3.75	3.75	3.81	3.87	3.90	3.89
C3	8.94	8.42	8.35	8.38	8.40	8.32
C4	9.99	9.26	9.12	9.06	9.08	9.00
C5	10.98	10.42	10.35	10.16	10.11	10.13
C6	9.84	8.98	9.21	8.97	8.96	9.02
C7	8.57	8.60	8.50	8.44	8.37	8.43
C8	6.91	7.12	7.11	7.08	7.05	7.07
C9	5.50	5.89	5.87	5.91	5.82	5.89
C10	4.44	4.90	4.84	4.98	4.88	4.92
C11	3.47	3.88	3.96	4.01	3.90	3.93
C12	2.81	3.27	3.13	2.92	3.07	3.18
C13	2.07	2.43	2.45	2.53	2.50	2.51
C14	1.74	2.00	2.03	2.11	2.24	2.02
C15	1.42	1.59	1.61	1.65	1.62	1.69
alpha chain growth probability	0.69	0.71	0.71	0.71	0.72	0.71

C1 - C50 estimated total product distribution, weight %

C1	18.7	18.5	18.7	18.8	18.8	19.0
C2 - C4	21.7	20.4	20.2	20.1	20.0	20.2
C5 - C12	51.1	51.1	51.0	50.5	50.0	50.7
C13 - C50	8.4	10.0	10.2	10.6	11.3	10.2

CO conversion, %	6.5	5.2	4.7	4.8	4.7	4.3
rate, g CH ₂ /g cat/hr	0.37	0.30	0.27	0.28	0.27	0.25
CO ₂ formation, %	0.1	0.1	0.1	0.1	0.1	0.1

Performance of CAL.04

Dates: 08/01/94 - 08/02/94 Run #1

flow rate = 90.0 cc/min, loading= 0.2 g, WHSV = 13.2 l/hr, H₂/CO ratio in feed = 2

time on stream, hr	23.0	26.0	29.0
reaction temperature, °C	220	220	220
pressure, atm	1.0	1.0	1.0
flow, cc/min	90.0	90.0	90.0

C1 - C15 product distribution, weight %

C1	19.97	20.24	20.13
C2	3.89	3.94	3.93
C3	8.23	8.33	8.26
C4	8.86	8.91	8.86
C5	9.91	10.13	10.21
C6	8.83	9.03	8.88
C7	8.29	8.39	8.45
C8	7.02	7.03	7.09
C9	5.73	5.84	5.89
C10	4.88	4.85	4.92
C11	3.96	3.93	4.02
C12	4.24	3.11	3.21
C13	2.50	2.45	2.45
C14	1.99	2.12	2.03
C15	1.69	1.71	1.67
alpha chain growth probability	0.71	0.71	0.71

C1 - C50 estimated total product distribution, weight %

C1	19.2	19.1	19.1
C2 - C4	20.2	20.0	20.0
C5 - C12	50.4	50.3	50.6
C13 - C50	10.2	10.7	10.2

CO conversion, %	4.2	4.1	4.1
rate, g CH ₂ /g cat/hr	0.24	0.23	0.23
CO ₂ formation, %	0.1	0.1	0.1

Schulz-Flory Plot for CAL.04 - Run #1
Time on Stream (hrs)

Time-on-Stream Plot for CAL.04 - Run #1

CAL.05 - Run #1

Co wt%	NM wt %	Promotor wt%		Support
20	Ru 0.50	K 0.30		Al ₂ O ₃

SUMMARY REACTION DATA

Reaction Conditions:

P = 1.0 atm

T = 219 °C

H₂/CO = 2

weight of catalyst = 0.192 g

WHSV = 13.37 1/hr

time on stream = 24.5 hrs

CO₂ (g/g cat/hr) = 0.026

CO₂ (% of CO) = 0.1

O/P = 6.85

CO conversion (%)	4.7
rate (g CH ₂ /g cat/hr)	0.27
alpha	0.75
C1 (wt%)	20.8
C2 - C4 (wt%)	21.5
C5 - C12 (wt%)	46.1
C13 + (wt%)	11.6

Performance of CAL.05
 Dates: 08/16/94 - 08/17/94 Run #1

flow rate = 90.0 cc/min, loading = 0.2 g, WHSV = 13.4 l/hr, H₂/CO ratio in feed = 2

time on stream, hr	0.5	3.5	6.5	9.5	12.5	15.5
reaction temperature, °C	217	219	219	219	219	219
pressure, atm	1.0	1.0	1.0	1.0	1.0	1.0
flow, cc/min	90.0	90.0	90.0	90.0	90.0	90.0

C1 - C15 product distribution, weight %

C1	19.27	19.88	20.68	20.63	20.67	20.71
C2	3.61	3.71	3.86	3.85	3.87	3.88
C3	8.92	8.55	8.68	8.53	8.50	8.45
C4	10.36	9.66	9.58	9.35	9.26	9.09
C5	11.57	10.80	10.70	10.44	10.42	10.32
C6	10.16	9.76	8.55	8.89	8.73	8.93
C7	8.73	8.65	8.69	8.54	8.60	8.53
C8	6.96	6.96	7.06	6.97	7.05	7.01
C9	5.43	5.57	5.72	5.72	5.81	5.78
C10	4.25	4.73	4.63	4.70	4.78	4.76
C11	3.33	3.59	3.71	3.74	3.80	3.83
C12	2.48	2.93	2.95	3.18	3.04	3.14
C13	1.92	2.09	2.16	2.37	2.21	2.26
C14	1.66	1.74	1.72	1.77	1.83	1.85
C15	1.33	1.39	1.31	1.32	1.42	1.46
alpha chain growth probability	0.72	0.73	0.73	0.73	0.74	0.74

C1 - C50 estimated total product distribution, weight %

C1	18.3	19.0	19.9	20.0	19.8	19.8
C2 - C4	21.8	20.9	21.3	21.0	20.7	20.4
C5 - C12	50.8	50.4	49.6	49.7	49.5	49.5
C13 - C50	9.1	9.7	9.2	9.3	10.0	10.3

CO conversion, %	6.4	6.0	5.6	5.6	5.4	5.3
rate, g CH ₂ /g cat/hr	0.37	0.35	0.33	0.33	0.31	0.31
CO ₂ formation, %	0.2	0.1	0.2	0.2	0.1	0.1

Performance of CAL.05

Dates: 08/16/94 - 08/17/94 Run #1

flow rate = 90.0 cc/min, loading= 0.2 g, WHSV = 13.4 l/hr, H₂/CO ratio in feed = 2

time on stream, hr	18.5	21.5	24.5
reaction temperature, °C	219	219	219
pressure, atm	1.0	1.0	1.0
flow, cc/min	90.0	90.0	90.0

C1 - C15 product distribution, weight %

C1	21.01	20.77	21.97
C2	3.93	3.89	4.12
C3	8.53	8.41	8.87
C4	9.21	9.13	9.67
C5	10.23	10.17	10.76
C6	8.59	8.54	3.38
C7	8.47	8.48	8.95
C8	7.00	6.99	7.40
C9	5.77	5.80	6.12
C10	4.73	4.80	5.06
C11	3.84	3.94	4.16
C12	3.12	3.28	3.37
C13	2.27	2.35	2.49
C14	1.88	1.93	2.07
C15	1.43	1.52	1.62
alpha chain growth probability	0.74	0.74	0.75

C1 - C50 estimated total product distribution, weight %

C1	20.1	19.8	20.8
C2 - C4	20.7	20.4	21.5
C5 - C12	49.0	49.0	46.1
C13 - C50	10.1	10.8	11.6

CO conversion, %	5.2	5.0	4.7
rate, g CH ₂ /g cat/hr	0.30	0.29	0.27
CO ₂ formation, %	0.1	0.1	0.1

Schulz-Flory Plot for CAL.05 - Run #1
Time on Stream (hrs)

Time-on-Stream Plot for CAL.05 - Run #1

CAL.06 - Run #1

Co wt%	NM wt %	Promotor wt%		Support
20	Ru 0.50	K 0.30		Al ₂ O ₃

SUMMARY REACTION DATA

Reaction Conditions:

P = 1.0 atm

T = 220 °C

H₂/CO = 2

weight of catalyst = 0.246 g

WHSV = 10.47 1/hr

time on stream = 27.5 hrs

CO₂ (g/g cat/hr) = 0.021

CO₂ (% of CO) = 0.1

O/P = 5.50

CO conversion (%)	5.8
rate (g CH ₂ /g cat/hr)	0.27
alpha	0.74
C1 (wt%)	20.7
C2 - C4 (wt%)	20.9
C5 - C12 (wt%)	47.9
C13 + (wt%)	10.5

Performance of CAL.06

Dates: 07/27/94 - 07/28/94 Run #1

flow rate = 90.0 cc/min, loading = 0.2 g, WHSV = 10.5 l/hr, H₂/CO ratio in feed = 2

time on stream, hr	0.5	3.5	6.5	9.5	12.5	15.5
reaction temperature, °C	220	220	220	220	220	220
pressure, atm	1.0	1.0	1.0	1.0	1.0	1.0
flow, cc/min	90.0	90.0	90.0	90.0	90.0	90.0

C1 - C15 product distribution, weight %

C1	20.50	20.91	21.17	21.15	21.35	21.30
C2	3.80	3.84	3.89	3.89	3.93	3.93
C3	9.22	8.83	8.75	8.66	8.66	8.61
C4	10.29	9.66	9.49	9.43	9.40	9.34
C5	11.21	10.61	10.40	10.28	10.21	10.21
C6	9.90	9.53	9.36	9.28	8.70	8.74
C7	8.50	8.35	8.36	8.30	8.32	8.30
C8	6.73	6.80	6.78	6.76	6.77	6.78
C9	5.23	5.51	5.52	5.53	5.56	5.57
C10	4.13	4.51	4.50	4.55	4.59	4.66
C11	3.20	3.46	3.64	3.71	3.77	3.75
C12	2.54	2.78	2.82	3.06	3.18	3.14
C13	1.84	2.13	2.17	2.23	2.25	2.27
C14	1.58	1.68	1.78	1.79	1.87	1.86
C15	1.32	1.39	1.38	1.38	1.44	1.54
alpha chain growth probability	0.71	0.73	0.73	0.74	0.74	0.74

C1 - C50 estimated total product distribution, weight %

C1	20.0	20.1	20.3	20.3	20.5	20.4
C2 - C4	22.7	21.4	21.2	21.0	21.1	21.0
C5 - C12	49.9	49.3	49.0	48.8	48.4	48.5
C13 - C50	7.4	9.2	9.5	9.9	10.1	10.2

CO conversion, %	7.9	7.2	6.9	6.5	6.4	6.1
rate, g CH ₂ /g cat/hr	0.36	0.33	0.32	0.30	0.29	0.28
CO ₂ formation, %	0.2	0.2	0.2	0.1	0.1	0.1

Performance of CAL.06

Dates: 07/27/94 - 07/28/94 Run #1

flow rate = 90.0 cc/min, loading = 0.2 g, WHSV = 10.5 1/hr, H₂/CO ratio in feed = 2

time on stream, hr	18.5	21.5	24.5	27.5
reaction temperature, °C	220	220	220	220
pressure, atm	1.0	1.0	1.0	1.0
flow, cc/min	90.0	90.0	90.0	90.0

C1 - C15 product distribution, weight %

C1	21.47	21.37	21.50	21.63
C2	3.96	3.95	3.97	4.00
C3	8.63	8.56	8.58	8.59
C4	9.33	9.25	9.21	9.21
C5	10.12	10.14	10.02	10.03
C6	8.64	8.72	8.58	8.52
C7	8.17	8.22	8.25	8.18
C8	6.75	6.77	6.86	6.76
C9	5.59	5.60	5.66	5.55
C10	4.63	4.66	4.60	4.62
C11	3.75	3.95	3.71	3.85
C12	3.21	3.27	3.28	3.15
C13	2.30	2.20	2.29	2.31
C14	1.98	1.88	2.01	1.95
C15	1.45	1.47	1.48	1.65
alpha chain growth probability	0.74	0.74	0.74	0.74

C1 - C50 estimated total product distribution, weight %

C1	20.5	20.6	20.6	20.7
C2 - C4	21.0	21.0	20.8	20.9
C5 - C12	48.1	48.5	48.2	47.9
C13 - C50	10.4	9.8	10.4	10.5

CO conversion, %	6.1	5.8	5.9	5.8
rate, g CH ₂ /g cat/hr	0.28	0.26	0.27	0.27
CO ₂ formation, %	0.1	0.1	0.1	0.1

Schulz-Flory Plot for CAL.05 - Run #1
Time on Stream (hrs)

Time-on-Stream Plot for CAL.06 - Run #1

UOP - Run #1

Co wt%	NM wt %	Promotor wt%		Support
#REF!	#REF! #REF!	#REF! #REF!	#REF! #REF!	#REF!

SUMMARY REACTION DATA

Reaction Conditions:

P = 1.0 atm

T = 220 °C

H₂/CO = 2

weight of catalyst = 0.293 g

WHSV = 8.77 1/hr

time on stream = 24.5 hrs

CO₂ (g/g cat/hr) = 0.023CO₂ (% of CO) = 0.2

O/P = 1.29

CO conversion (%)	7.8
rate (g CH ₂ /g cat/hr)	0.30
alpha	0.61
C1 (wt%)	22.6
C2 - C4 (wt%)	30.9
C5 - C12 (wt%)	44.7
C13 + (wt%)	1.9

Performance of UOP

Dates: 07/07/94 - 07/08/94 Run #1

flow rate = 90.0 cc/min, loading= 0.3 g, WHSV = 8.8 1/hr, H₂/CO ratio in feed = 2

time on stream, hr	0.5	3.5	6.5	9.5	12.5	15.5
reaction temperature, °C	220	220	220	220	220	220
pressure, atm	1.0	1.0	1.0	1.0	1.0	1.0
flow, cc/min	90.0	90.0	90.0	90.0	90.0	90.0

C1 - C15 product distribution, weight %

C1	25.00	23.37	22.86	23.03	22.65	22.66
C2	4.98	4.69	4.61	4.65	4.57	4.56
C3	13.42	13.17	13.02	13.12	13.01	12.99
C4	13.74	13.62	13.51	13.60	13.59	13.55
C5	12.62	12.83	12.86	12.87	13.01	12.98
C6	9.44	9.83	9.90	9.93	10.10	10.06
C7	7.47	7.65	7.77	7.85	7.93	7.92
C8	4.86	5.07	5.31	5.32	5.46	5.43
C9	3.24	3.32	3.56	3.50	3.49	3.54
C10	2.05	2.38	2.53	2.29	2.44	2.38
C11	1.44	1.66	1.78	1.65	1.53	1.56
C12	0.82	1.16	1.03	0.94	0.85	1.01
C13	0.49	0.62	0.59	0.58	0.69	0.68
C14	0.30	0.35	0.36	0.38	0.38	0.36
C15	0.13	0.27	0.32	0.29	0.30	0.30
alpha chain growth probability	0.57	0.61	0.62	0.61	0.62	0.62

C1 - C50 estimated total product distribution, weight %

C1	25.2	23.3	22.7	22.9	22.5	22.5
C2 - C4	32.4	31.4	30.9	31.2	30.9	30.9
C5 - C12	41.5	43.4	44.3	44.0	44.6	44.6
C13 - C50	0.9	1.8	2.1	1.9	2.0	2.0

CO conversion, %	12.7	10.1	9.4	9.1	8.4	8.3
rate, g CH ₂ /g cat/hr	0.49	0.39	0.36	0.35	0.32	0.32
CO ₂ formation, %	0.3	0.2	0.2	0.2	0.2	0.2

Performance of UOP

Dates: 07/07/94 - 07/08/94 Run #1

flow rate = 90.0 cc/min, loading = 0.3 g, WHSV = 8.8 1/hr, H₂/CO ratio in feed = 2

time on stream, hr	18.5	21.4	24.5	27.5
reaction temperature, °C	220	220	220	220
pressure, atm	1.0	1.0	1.0	1.0
flow, cc/min	90.0	90.0	90.0	22.5

C1 - C15 product distribution, weight %

C1	22.62	22.58	22.62	20.79
C2	4.54	4.53	4.52	4.29
C3	12.98	12.93	12.91	11.14
C4	13.56	13.50	13.47	12.87
C5	13.02	12.96	12.92	12.88
C6	10.14	10.06	10.03	10.45
C7	7.98	7.95	7.87	8.69
C8	5.42	5.47	5.40	6.16
C9	3.48	3.58	3.52	4.21
C10	2.39	2.50	2.51	3.01
C11	1.57	1.64	1.94	2.08
C12	0.94	1.02	1.00	1.42
C13	0.63	0.63	0.62	0.89
C14	0.43	0.38	0.41	0.66
C15	0.29	0.28	0.28	0.45
alpha chain growth probability	0.61	0.61	0.61	0.64

C1 - C50 estimated total product distribution, weight %

C1	22.5	22.5	22.6	20.6
C2 - C4	30.9	30.8	30.9	28.1
C5 - C12	44.7	44.8	44.7	48.3
C13 - C50	1.9	1.9	1.9	3.0

CO conversion, %	8.1	7.9	7.8	36.1
rate, g CH ₂ /g cat/hr	0.31	0.30	0.30	0.35
CO ₂ formation, %	0.2	0.2	0.2	0.9

Schulz-Flory Plot for UOP - Run #1
Time on Stream (hrs)

Time-on-Stream Plot for UOP - Run #1

CoW.05 - Run #1

Co wt%	NM wt %	Promotor wt%		Support
20	Cu 5.00	Cr 4.00		Al ₂ O ₃

SUMMARY REACTION DATA

Reaction Conditions:

P = 1.0 atm

T = 220 °C

H₂/CO = 2

weight of catalyst = 0.300 g

WHSV = 2.86 1/hr

time on stream = 24.0 hrs

CO₂ (g/g cat/hr) = 0.008CO₂ (% of CO) = 0.2

O/P = 0.66

CO conversion (%)	2.8
rate (g CH ₂ /g cat/hr)	0.04
alpha	0.55
C1 (wt%)	33.1
C2 - C4 (wt%)	38.2
C5 - C12 (wt%)	28.2
C13 + (wt%)	0.6

Performance of CoW.05

Dates: 08/30/94 - 01/00/00 Run #1

flow rate = 30.0 cc/min, loading= 0.3 g, WHSV = 2.9 1/hr, H₂/CO ratio in feed = 2

time on stream, hr	0.5	3.0	6.0	24.0	27.0
reaction temperature, °C	220	220	220	220	220
pressure, atm	1.0	1.0	1.0	1.0	1.0
flow, cc/min	30.0	30.0	30.0	30.0	30.0

C1 - C15 product distribution, weight %

C1	35.91	33.56	33.43	32.99	32.52
C2	7.66	7.16	7.19	7.32	7.30
C3	17.42	16.24	16.18	17.46	17.55
C4	14.49	14.26	14.16	13.29	13.32
C5	9.31	10.80	11.13	11.56	11.62
C6	5.99	7.20	7.55	7.48	7.52
C7	3.81	4.29	4.21	4.10	4.27
C8	1.83	2.48	2.35	2.15	2.12
C9	1.43	1.69	1.46	1.27	1.30
C10	0.99	0.67	0.61	0.56	0.58
C11	0.49	0.48	0.43	0.47	0.48
C12	0.36	0.40	0.36	0.39	0.41
C13	0.30	0.30	0.29	0.36	0.38
C14		0.27	0.25	0.37	0.38
C15		0.21	0.20	0.25	0.26
alpha chain growth probability	0.54	0.55	0.54	0.55	0.55

C1 - C50 estimated total product distribution, weight %

C1	35.8	33.6	33.5	33.1	32.6
C2 - C4	39.4	37.7	37.6	38.2	38.3
C5 - C12	24.3	28.2	28.4	28.2	28.6
C13 - C50	0.5	0.6	0.5	0.6	0.6

CO conversion, %	3.2	3.2	3.1	2.8	2.8
rate, g CH ₂ /g cat/hr	0.04	0.04	0.04	0.04	0.04
CO ₂ formation, %	0.5	0.3	0.2	0.2	0.2

Cow05 - Run #2

(Uncalcined)

Co wt%		Promotor wt%		Support
20	Cu 5%	Cr 4		Al ₂ O ₃

SUMMARY REACTION DATA

Reaction Conditions:

P = 1.0 atm

T = 220 °C

H₂/CO = 2

weight of catalyst = 0.300 g

WHSV = 2.86 1/hr

time on stream = 27.7 hrs

CO₂ (g/g cat/hr) = 0.009CO₂ (% of CO) = 0.2

O/P = 0.85

CO conversion (%)	4.7
rate (g CH ₂ /g cat/hr)	0.06
alpha	0.50
C1 (wt%)	34.8
C2 - C4 (wt%)	35.1
C5 - C12 (wt%)	29.8
C13 + (wt%)	0.2

Performance of Cow05

Dates: 09/06/94 - 09/07/94 Run #2

flow rate = 30.0 cc/min, loading = 0.30 g, WHSV = 2.9 l/hr, H₂/CO ratio in feed = 2

time on stream, hr	0.5	3.0	4.5	22.0	27.7
reaction temperature, °C	220	220	220	220	220
pressure, atm	1.0	1.0	1.0	1.0	1.0
flow, cc/min	30.0	30.0	30.0	30.0	30.0

C1 - C15 product distribution, weight %

C1	32.87	33.36	32.57	36.02	34.78
C2	6.04	6.10	5.86	6.34	6.20
C3	15.11	15.39	14.64	15.60	15.27
C4	14.95	14.27	13.48	13.54	13.59
C5	12.26	12.07	11.53	11.34	11.38
C6	8.32	7.95	12.34	8.31	7.69
C7	4.73	4.90	4.19	4.37	4.91
C8	2.50	2.49	2.35	2.21	2.77
C9	1.04	1.46	1.36	1.23	1.61
C10	0.74	0.63	0.62	0.38	0.82
C11	0.42	0.51	0.31	0.32	0.33
C12	0.35	0.28	0.26	0.20	0.21
C13	0.27	0.21	0.20	0.13	0.13
C14	0.22	0.19	0.17		0.14
C15	0.19	0.19	0.15		0.16
alpha chain growth probability	0.54	0.53	0.52	0.50	0.50

C1 - C50 estimated total product distribution, weight %

C1	32.9	33.4	32.6	36.0	34.8
C2 - C4	36.1	35.8	34.0	35.4	35.1
C5 - C12	30.5	30.3	33.1	28.4	29.8
C13 - C50	0.5	0.4	0.3	0.2	0.2

CO conversion, %	6.0	5.6	5.5	4.8	4.7
rate, g CH ₂ /g cat/hr	0.07	0.07	0.07	0.06	0.06
CO ₂ formation, %	0.7	0.4	0.3	0.3	0.2

CoW.06 - Run #1

Co wt%	NM wt %	Promotor wt%		Support
20	Cu 5.00	Cr 4.00		SiO ₂

SUMMARY REACTION DATA

Reaction Conditions:

P = 1.0 atm

T = 220 °C

H₂/CO = 2

weight of catalyst = 0.300 g

WHSV = 2.86 1/hr

time on stream = 24.0 hrs

CO₂ (g/g cat/hr) = 0.007CO₂ (% of CO) = 0.2

O/P = 2.21

CO conversion (%)	3.3
rate (g CH ₂ /g cat/hr)	0.04
alpha	0.59
C1 (wt%)	26.0
C2 - C4 (wt%)	33.2
C5 - C12 (wt%)	39.7
C13 + (wt%)	1.1

Performance of CoW.06

Dates: 09/01/94 - 09/02/94 Run #1

flow rate = 30.0 cc/min, loading = 0.3 g, WHSV = 2.9 l/hr, H₂/CO ratio in feed = 2

time on stream, hr	0.5	3.0	4.5	24.0
reaction temperature, °C	220	220	220	220
pressure, atm	1.0	1.0	1.0	1.0
flow, cc/min	30.0	30.0	30.0	30.0

C1 - C15 product distribution, weight %

C1	23.10	24.99	25.94	26.08
C2	5.62	6.21	6.18	6.29
C3	13.54	14.89	14.36	13.96
C4	13.99	14.75	13.94	13.05
C5	13.19	13.64	13.88	12.46
C6	10.63	10.33	10.32	12.30
C7	5.97	5.53	5.52	5.46
C8	4.21	3.19	3.31	3.57
C9	3.07	2.58	2.66	2.79
C10	2.24	1.60	1.62	1.67
C11	1.58	0.98	0.97	1.04
C12	0.86	0.61	0.62	0.64
C13	0.63	0.49	0.49	0.48
C14	0.54	0.21	0.20	0.20
C15	0.46			
alpha chain growth probability	0.62	0.59	0.59	0.59

C1 - C50 estimated total product distribution, weight %

C1	23.2	24.9	25.8	26.0
C2 - C4	33.4	35.7	34.4	33.2
C5 - C12	41.7	38.3	38.7	39.7
C13 - C50	1.7	1.1	1.1	1.1

CO conversion, %	5.1	4.3	4.0	3.3
rate, g CH ₂ /g cat/hr	0.06	0.05	0.05	0.04
CO ₂ formation, %	0.4	0.2	0.2	0.2

CoW06 - Run #2

Co wt%	NM wt %	Promotor wt%		Support
20	Cu 5.00	Cr 4.00		SiO ₂

SUMMARY REACTION DATA

Reaction Conditions:

P = 1.0 atm

T = 220 °C

H₂/CO = 2

weight of catalyst = 0.300 g

WHSV = 2.86 1/hr

time on stream = 24.0 hrs

CO₂ (g/g cat/hr) = 0.012CO₂ (% of CO) = 0.3

O/P = 0.99

CO conversion (%)	2.6
rate (g CH ₂ /g cat/hr)	0.03
alpha	0.46
C1 (wt%)	39.3
C2 - C4 (wt%)	39.3
C5 - C12 (wt%)	21.4
C13 + (wt%)	0.1

Performance of CoW06

Dates: 09/09/94 - 09/12/94 Run #2

flow rate = 30.0 cc/min, loading = 0.3 g, WHSV = 2.9 1/hr, H₂/CO ratio in feed = 2

time on stream, hr	0.5	3.0	24.0	27.5	30.0	44.5
reaction temperature, °C	220	220	220	240	260	280
pressure, atm	1.0	1.0	1.0	1.0	1.0	1.0
flow, cc/min	30.0	30.0	30.0	30.0	30.0	30.0

C1 - C15 product distribution, weight %

C1	36.49	37.08	39.14	49.15	62.36	68.75
C2	8.54	8.70	9.10	10.04	10.87	11.05
C3	16.83	16.92	16.95	15.74	12.02	10.59
C4	13.35	13.76	13.10	10.92	7.48	5.27
C5	10.34	10.18	9.80	7.01	3.95	2.48
C6	6.32	6.66	5.86	4.06	1.93	1.12
C7	3.62	2.92	2.96	1.75	0.78	0.41
C8	1.86	1.56	1.52	0.74	0.38	0.25
C9	1.08	0.93	0.61	0.28	0.14	0.06
C10	0.46	0.36	0.33	0.12	0.04	0.02
C11	0.32	0.30	0.25	0.09	0.03	
C12	0.24	0.29	0.13	0.07	0.02	
C13	0.23	0.17	0.17	0.04		
C14	0.16	0.16	0.08			
C15	0.15					
alpha chain growth probability	0.48	0.47	0.46	0.39	0.35	0.32

C1 - C50 estimated total product distribution, weight %

C1	36.7	37.3	39.3	49.2	62.4	68.7
C2 - C4	39.0	39.6	39.3	36.7	30.4	26.9
C5 - C12	24.2	23.0	21.4	14.0	7.2	4.3
C13 - C50	0.1	0.1	0.1	0.0	0.0	0.0

CO conversion, %	3.3	3.1	2.6	6.9	16.6	16.6
rate, g CH ₂ /g cat/hr	0.04	0.04	0.03	0.09	0.21	0.21
CO ₂ formation, %	0.4	0.3	0.3	0.4	1.1	1.7

CoW06 - Run #2

Co wt%	NM wt %	Promotor wt%		Support
20	Cu 5.00	Cr 4.00		SiO2

SUMMARY REACTION DATA*

Reaction Conditions:

P = 1.0 atm

T = 280 °C

H₂/CO = 2

weight of catalyst = 0.300 g

WHSV = 2.86 1/hr

time on stream = 44.5 hrs

CO₂ (g/g cat/hr) = 0.073CO₂ (% of CO) = 1.7

O/P = 0.37

CO conversion (%)	16.6
rate (g CH ₂ /g cat/hr)	0.21
alpha	0.32
C1 (wt%)	68.7
C2 - C4 (wt%)	26.9
C5 - C12 (wt%)	4.3
C13 + (wt%)	0.0

* Reaction at 280 deg C.

APPENDIX C

SLURRY BUBBLE COLUMN REACTOR DATA

Table I

SUMMARY OF M3 SBCR RUN RESULTS

a)Unless otherwise noted, total flow is ca.15 L/min. STP, or 3 cm/sec linear gas flow.

b)Conversion is total CO conversion over the period (%).

c)Conversion and selectivities are calculated using N2 as an internal standard in the GC analysis of the offgas.

d)Prod. rate: Rate for production of total hydrocarbons,C1+ (kg/kg cat.,hr).

e)Alpha: Based on GC analysis of offgas and liquid product.

Run No	Cat. No	Cat. wt,g	Per No	Time Start	Time Stop	Temp C	Pres psi	H2: CO	Synfl cc/hr	Conv. %	Prod. Rate	Selectivities				Alpha GC	Alpha Liq	Olefin/Paraf		Olefins C6-18,%	Comments
												%CH4	%C2	%C3+	%CO2			C3	C4		
2	CO.001	16.5	1	162	177	225	450	2.0	20	15.9	0.70	2.3	0.8	96.4	0.53	0.98	0.88	5.00	2.27	25.2	
2	CO.001	16.5	2	202	228	200	450	2.0	20	3.9	0.17	0.0	0.0	99.9	0.00	0.81	0.91	0.00	0.00	21.7	
2	CO.001	16.5	3	254	280	240	450	2.0	20	30.9	1.36	11.7	1.8	85.5	1.04	0.87	0.77	2.63	1.64	22.4	
2	CO.001	16.5	4	302	323	225	450	1.2	20	9.9	0.59	0.7	0.3	98.4	0.67	0.76	0.90	0.00	7.14	29.4	
2	CO.001	16.5	5	350	372	225	450	2.0	20	15.3	0.68	6.0	1.0	92.5	0.49	0.84	0.88	4.00	2.70	23.1	
2	CO.001	16.5	6	398	420	225	300	2.0	20	12.5	0.55	6.1	1.1	92.2	0.63	0.79	0.86	4.35	2.86	21.7	
2	CO.001	16.5	7	446	468	240	300	2.0	20	22.9	1.02	16.5	0.8	81.5	1.16	0.71	0.79	3.03	1.79	22.4	
2	CO.001	16.5	8	494	516	240	600	2.0	20	29.9	1.33	12.6	1.6	85.0	0.84	0.76	0.82	2.63	1.69	22.4	
2	CO.001	16.5	9	517	540	240	600	2.0	0	29.5	1.31	12.0	1.7	85.3	0.96	0.76	--	2.50	1.56	22.4	
2	CO.001	16.5	9	541	564	240	600	2.0	0	28.4	1.26	10.4	1.7	87.1	0.89	0.77	--	3.03	1.72	--	
2	CO.001	16.5	9	565	588	240	600	2.0	0	27.9	1.27	11.1	1.7	86.2	0.93	0.76	--	3.03	1.72	--	
2	CO.001	16.5	9	589	612	240	600	2.0	0	27.0	1.20	10.7	1.7	86.7	0.89	0.76	0.82	2.78	2.00	--	
2	CO.001	16.5	10	637	660	240	600	2.0	20	26.4	1.17	11.0	1.7	86.4	0.85	0.77	0.83	2.86	1.96	22.4	G.C.Calib
2	CO.001	16.5	11	684	706	225	450	2.0	20	11.6	0.51	5.4	1.0	93.0	0.61	0.81	0.87	5.26	3.45	23.8	
3	CO.005	19.5	1	12	36	240	450	2.0	20	33.2	1.23	5.6	1.6	91.8	1.06	0.80	0.81	2.04	1.27	23.1	G.C.Calib
3	CO.005	19.5	2	60	84	220	450	2.0	20	15.0	0.56	2.9	0.6	96.2	0.24	0.86	0.87	4.55	3.23	21.7	
3	CO.005	19.5	3	108	132	240	450	1.2	20	18.5	0.94	6.9	1.0	91.3	0.85	0.81	--	5.88	3.85	26.6	
3	CO.005	19.5	4	156	179	240	450	2.0	20	29.6	1.11	11.5	1.8	85.8	0.91	0.76	0.78	2.22	1.39	21.7	
4	CO.002	20.1	1	37	59	240	450	2.0	20	36.1	1.32	22.9	3.2	72.4	1.51	0.66	0.77	0.65	0.31	16.8	
4	CO.002	20.1	2	85	106	220	450	2.0	20	16.6	0.60	3.8	1.1	94.7	0.35	0.84	0.88	2.44	0.89	--	
4	CO.002	20.1	3	133	149	210	600	1.0	20	5.2	0.28	0.0	0.0	99.1	0.87	0.89	0.94	0.00	0.00	--	Power Fail
5	CO.003	15.1	1	15	35	240	450	2.0	20	31.7	1.53	16.7	2.4	79.8	1.16	0.71	--	1.30	0.60	18.2	G.C.Calib
5	CO.003	15.1	2	61	83	220	450	2.0	20	13.2	0.63	5.1	1.0	93.4	0.51	0.82	0.90	4.55	1.89	--	
5	CO.003	15.1	3	88	107	240	450	2.0	20	28.4	1.37	15.1	2.4	81.4	1.11	0.75	--	1.45	0.97	--	
5	CO.003	15.1	4	133	155	240	450	1.0	20	13.1	0.95	4.2	1.2	93.3	1.24	0.83	0.88	6.67	3.70	--	
5	CO.003	15.1	5	181	203	240	600	1.0	20	13.4	0.97	3.9	1.1	93.7	1.30	0.81	--	5.26	3.45	30.1	
5	CO.003	15.1	6	217	227	240	450	2.0	20	25.4	1.23	14.9	2.4	81.7	1.03	0.73	--	1.89	1.19	--	
6	CO.011	15.3	1	13	35	240	450	2.0	20	14.3	0.67	7.6	1.6	89.4	1.42	0.78	0.83	4.17	2.57	21.7	
6	CO.011	15.3	2	61	83	220	450	2.0	20	5.1	0.23	0.0	0.0	97.2	2.78	0.87	0.82	--	--	--	
6	CO.011	15.3	3	88	107	240	450	2.0	20	13.5	0.63	5.4	1.7	91.1	1.86	0.79	--	4.00	2.83	--	
6	CO.011	15.3	4	133	155	240	450	1.0	20	6.3	0.44	0.4	1.0	95.5	3.05	0.82	0.88	--	--	--	
6	CO.011	15.3	5	181	203	240	600	1.0	20	6.7	0.46	0.2	0.9	96.0	2.91	0.84	0.89	12.00	3.67	27.3	G.C.Calib
6	CO.011	15.3	6	217	226	240	450	2.0	20	12.0	0.57	5.9	1.8	90.4	1.91	0.78	--	4.40	2.43	--	

Table I
(Continued)

SUMMARY OF M3 SBCR RUN RESULTS

a) Unless otherwise noted, total flow is ca. 15 L/min. STP, or 3 cm/sec linear gas flow.

b) Conversion is total CO conversion over the period (%).

c) Conversion and selectivities are calculated using N₂ as an internal standard in the GC analysis of the offgas.

d) Prod. rate: Rate for production of total hydrocarbons, C₁+ (kg/kg cat., hr).

e) Alpha: Based on GC analysis of offgas and liquid product.

Run No	Cat. No	Cat. wt, g	Per No	Time Start	Time Stop	Temp C	Pres psi	H ₂ CO	Synfl cc/hr	Conv. %	Prod. Rate	Selectivities				Alpha GC	Alpha Liq	Olefin/Paraf		Olefins C ₆ -18, %	Comments
												%CH ₄	%C ₂	%C ₃ +	%CO ₂			C ₃	C ₄		
7	CO.012	15.8	1	14	36	240	450	2.0	20	13.9	0.63	6.1	1.5	90.6	1.74	0.80	0.89	4.00	2.57	17.5	
7	CO.012	15.8	2	62	84	220	450	2.0	20	5.1	0.23	0.0	0.2	97.8	2.02	0.89	0.90	--	2.50	--	
7	CO.012	15.8	3	88	92	240	450	2.0	20	13.1	0.59	6.1	1.7	90.4	1.75	0.80	--	5.00	2.25	--	Power Fail
7	CO.012	15.8	4	134	156	240	450	1.0	20	3.9	0.26	4.8	2.3	86.3	6.64	0.70	0.85	16.00	3.50	--	
7	CO.012	15.8	5	182	204	240	600	1.0	20	4.3	0.28	0.1	2.1	91.6	9.29	0.75	0.82	8.50	3.50	30.8	
7	CO.012	15.8	6	218	227	240	450	2.0	20	7.2	0.32	7.3	3.2	85.1	4.45	0.70	--	5.00	3.17	--	
8	CO.015	15.0	1	14	35	240	450	2.0	20	28.3	1.37	12.7	2.0	84.1	1.24	0.76	0.80	1.61	1.07	19.6	G.C. Calib
8	CO.015	15.0	2	61	83	220	450	2.0	20	11.5	0.56	4.4	1.0	93.9	0.80	0.81	0.89	3.60	2.14	--	
8	CO.015	15.0	3	97	106	240	450	2.0	20	26.4	1.28	13.2	2.1	83.5	1.12	0.75	--	1.69	1.20	--	
8	CO.015	15.0	4	133	155	240	450	1.0	20	11.5	0.83	4.8	1.2	92.5	1.53	0.80	0.85	5.60	3.29	--	
8	CO.015	15.0	5	181	191	240	600	1.0	20	12.4	0.90	4.9	0.8	93.6	0.73	0.84	0.85	5.20	3.14	30.8	Power Fail
9	CO.011	15.0	1	13	35	240	450	2.0	20	18.5	0.89	8.8	1.7	88.8	0.77	0.78	0.83	3.18	1.85	20.3	G.C. Calib
9	CO.011	15.0	2	61	82	220	450	2.0	20	6.3	0.31	0.0	1.0	98.6	0.41	0.88	0.93	12.00	1.80	--	
9	CO.011	15.0	3	97	107	240	450	2.0	20	16.6	0.80	8.4	2.1	88.7	0.81	0.77	--	3.30	2.00	--	
9	CO.011	15.0	4	133	155	240	450	1.0	20	8.0	0.58	1.3	1.3	96.3	1.16	0.82	0.87	7.00	2.83	--	
9	CO.011	15.0	5	181	203	240	600	1.0	20	8.7	0.63	1.4	1.1	96.4	1.05	0.83	0.87	5.00	2.67	30.5	
9	CO.011	15.0	6	228	229	240	450	2.0	20	14.7	0.71	7.9	2.2	89.1	0.85	0.78	--	3.78	1.67	--	Power Fail
11	CO.017	15.0	1	9	31	240	450	2.0	20	27.2	1.32	11.2	1.8	85.9	1.14	0.77	0.80	2.09	1.20	30.8	
11	CO.017	15.0	2	55	79	220	450	2.0	20	11.4	0.55	5.0	0.0	94.8	0.22	0.88	0.90	5.00	3.20	--	
11	CO.017	15.0	3	81	103	240	450	2.0	20	25.9	1.26	11.7	1.6	85.6	1.14	0.77	--	1.95	1.26	--	
11	CO.017	15.0	4	129	151	240	450	1.0	20	11.6	0.84	5.0	0.0	93.9	1.19	0.82	0.86	25.0	2.88	--	
11	CO.017	15.0	5	177	199	240	600	1.0	20	11.6	0.84	4.2	0.0	94.7	1.17	0.86	0.86	24.0	1.63	21.0	G.C. Calib
11	CO.017	15.0	6	213	221	240	450	2.0	20	24.3	1.20	12.1	1.4	86.4	0.08	0.78	--	2.47	1.64	--	
12	CO.018	15.6	1	13	35	240	450	2.0	20	33.8	1.56	9.7	2.0	86.6	1.68	0.75	0.85	1.81	1.13	21.0	G.C. Calib
12	CO.018	15.6	2	61	80	220	450	2.0	20	12.6	0.59	2.8	0.0	97.1	0.08	0.90	0.88	--	--	--	
12	CO.018	15.6	3	97	107	240	450	2.0	20	27.9	1.30	9.4	1.9	87.7	1.03	0.75	--	2.65	2.17	--	
12	CO.018	15.6	4	133	155	240	450	1.0	20	12.4	0.86	3.3	0.0	95.0	1.67	0.80	0.86	--	--	--	
12	CO.018	15.6	5	181	203	240	600	1.0	20	13.0	0.90	3.2	0.0	94.9	1.86	0.80	0.85	--	--	38.5	
12	CO.018	15.6	6	217	226	240	450	2.0	20	26.4	1.22	10.1	1.4	86.8	1.74	0.73	--	2.89	2.05	--	

Table I
(Continued)

SUMMARY OF M3 SBCR RUN RESULTS

a)Unless otherwise noted, total flow is ca.15 L/min. STP, or 3 cm/sec linear gas flow.

b)Conversion is total CO conversion over the period (%).

c)Conversion and selectivities are calculated using N2 as an internal standard in the GC analysis of the offgas.

d)Prod. rate: Rate for production of total hydrocarbons, C1+ (kg/kg cat.,hr).

e)Alpha: Based on GC analysis of offgas and liquid product.

Run No	Cat. No	Cat. wt,g	Per No	Time Start	Time Stop	Temp C	Pres psi	H2: CO	Synfl cc/hr	Conv. %	Prod. Rate	Selectivities				Alpha GC	Alpha Liq	Olefin/Paraf		Olefins C6-18,%	Comments
No	No	wt,g	No	Start	Stop	C	psi	CO	cc/hr	%	Rate	%CH4	%C2	%C3+	%CO2	GC	Liq	C3	C4	C6-18,%	
13	CO.016	14.7	1	16	35	240	450	2.0	20	26.4	1.31	8.3	1.7	89.3	0.68	0.78	0.81	2.00	1.41	21.7	G.C.Calib
13	CO.016	14.7	2	65	83	220	450	2.0	20	9.7	0.48	0.0	0.99	9	0.00	0.91	0.88	--	--	--	TCD weak.
13	CO.016	14.7	3	89	105	240	450	2.0	20	25.2	1.25	9.2	1.7	88.6	0.51	0.78	--	2.10	1.41	--	CH4 peaks
13	CO.016	14.7	4	134	155	240	450	1.0	20	10.9	0.81	1.2	0.7	97.7	0.32	0.84	0.86	--	--	--	are lower
13	CO.016	14.7	5	181	203	240	600	1.0	20	11.4	0.85	0.0	0.4	99.3	0.25	0.92	0.86	--	--	32.2	than
13	CO.016	14.7	6	210	226	240	450	2.0	20	22.7	1.12	3.8	1.9	93.7	0.46	0.79	--	2.37	1.41	--	expected.
14	CO.019	15.2	1	14	35	240	450	2.0	20	13.9	0.66	0.4	1.7	97.2	0.70	0.80	0.86	5.33	2.67	26.6	G.C.Calib
14	CO.019	15.2	2	66	83	220	450	2.0	20	3.8	0.18	0.0	1.7	96.7	1.56	0.88	--	--	--	--	New TCD
14	CO.019	15.2	3	88	105	240	450	2.0	20	12.2	0.57	0.0	2.0	96.3	1.67	0.80	--	5.60	3.80	--	
14	CO.019	15.2	4	133	155	240	450	1.0	20	--	--	--	--	--	0.85	--	--	--	--	--	Repair G.C
14	CO.019	15.2	5	169	178	240	600	1.0	20	5.9	0.41	0.0	1.5	96.1	2.42	0.80	--	8.50	13.00	--	Valve Leak
14	CO.019	15.2	6	193	203	240	450	2.0	20	10.2	0.48	0.8	2.2	95.0	1.96	0.79	--	4.80	3.40	--	CH4 peaks
14	CO.019	15.2	7	217	226	240	450	1.0	20	5.1	0.36	0.0	1.6	95.4	3.09	0.80	--	--	--	--	undetected
15	CO.005	14.7	1	25	35	240	450	2.0	20	27.1	1.34	7.9	1.6	89.7	0.82	0.79	0.82	2.30	1.38	23.1	G.C.Calib
15	CO.005	14.7	2	62	83	220	450	2.0	20	10.7	0.53	0.0	0.9	98.4	0.70	0.83	0.88	4.25	3.25	--	
15	CO.005	14.7	3	86	105	240	450	2.0	20	25.3	1.25	7.6	1.8	89.6	1.01	0.78	--	2.42	1.50	--	
15	CO.005	14.7	4	134	155	240	450	1.0	20	11.6	0.85	0.0	1.1	97.5	1.37	0.82	0.85	7.00	4.60	--	
15	CO.005	14.7	5	182	203	240	600	1.0	20	12.3	0.90	0.0	1.0	97.7	1.33	0.83	0.85	7.00	4.40	--	
15	CO.005	14.7	6	210	226	240	450	2.0	20	23.0	1.13	5.9	1.8	91.4	0.99	0.78	--	3.20	2.00	--	
16	CO.002	15.4	1	14	35	240	450	2.0	20	30.1	1.42	12.5	2.5	83.9	1.09	0.75	0.80	1.00	0.66	17.5	
16	CO.002	15.4	2	67	83	220	450	2.0	20	12.8	0.60	4.2	1.3	93.9	0.65	0.80	0.86	2.57	1.63	--	G.C.Calib
16	CO.002	15.4	3	91	107	240	450	2.0	20	28.2	1.34	17.3	2.9	78.8	0.99	0.71	--	0.93	0.65	--	
16	CO.002	15.4	4	136	155	240	450	1.0	20	12.6	0.89	4.4	1.6	92.8	1.21	0.79	0.84	4.43	2.88	--	
16	CO.002	15.4	5	182	198	240	600	1.0	20	13.1	0.92	3.6	1.4	93.9	1.12	0.81	0.84	4.29	2.75	25.2	
16	CO.002	15.4	6	209	227	240	450	2.0	20	25.6	1.22	17.4	3.1	78.7	0.83	0.71	--	1.00	0.66	--	
17	CO.025	15.6	1	21	35	240	450	2.0	20	26.6	1.24	10.7	2.1	86.4	0.82	0.76	0.82	2.25	1.47	21.7	G.C.Calib
17	CO.025	15.6	2	62	83	220	450	2.0	20	8.4	0.39	0.0	1.1	96.9	1.94	0.82	0.92	6.50	3.00	--	
17	CO.025	15.6	3	90	107	240	450	2.0	20	21.5	1.00	9.0	2.0	88.0	1.03	0.77	--	2.64	1.64	--	
17	CO.025	15.6	4	134	155	240	450	1.0	20	10.3	0.71	0.8	1.2	96.7	1.30	0.82	0.93	7.67	4.25	--	
17	CO.025	15.6	5	181	203	240	600	1.0	20	11.7	0.81	1.3	1.1	96.5	1.12	0.83	0.88	8.00	4.25	32.9	
17	CO.025	15.6	6	217	226	240	450	2.0	20	19.9	0.93	9.3	2.2	87.7	0.91	0.76	--	2.92	1.85	--	
18	CO.004	15.0	1	20	39	240	450	2.0	20	33.9	1.64	15.3	2.4	80.9	1.37	0.74	0.79	1.17	0.78	20.3	Repair G.C
18	CO.004	15.0	2	66	87	220	450	2.0	20	15.1	0.73	4.1	1.6	94.0	0.29	0.81	0.85	3.83	2.25	--	
18	CO.004	15.0	3	92	111	240	450	2.0	20	32.7	1.59	15.7	2.6	80.2	1.49	0.73	--	1.20	0.80	--	
18	CO.004	15.0	4	138	159	240	450	1.0	20	14.7	1.06	4.1	1.2	93.2	1.44	0.80	0.83	6.17	3.75	--	
18	CO.004	15.0	5	186	207	240	600	1.0	20	15.0	1.09	3.6	1.1	94.1	1.18	0.82	0.83	5.67	4.00	33.6	
18	CO.004	15.0	6	214	230	240	450	2.0	20	28.4	1.38	14.9	2.5	86.5	1.13	0.73	--	1.58	1.03	--	

Table I
(Continued)

SUMMARY OF M3 SBCR RUN RESULTS

a)Unless otherwise noted, total flow is ca.15 L/min. STP, or 3 cm/sec linear gas flow.

b)Conversion is total CO conversion over the period (%).

c)Conversion and selectivities are calculated using N2 as an internal standard in the GC analysis of the offgas.

d)Prod. rate: Rate for production of total hydrocarbons, C1+ (kg/kg cat.,hr).

e)Alpha: Based on GC analysis of offgas and liquid product.

Run No	Cat. No	Cat. wt,g	Per No	Time Start	Time Stop	Temp C	Pres psi	H2: CO	Synfl cc/hr	Conv. %	Prod. Rate	Selectivities				Alpha GC	Alpha Liq	Olefin/Paraf		Olefins C6-18,%	Comments
No	No		No									%CH4	%C2	%C3+	%CO2			C3	C4		
19	CO.021	15.6	1	16	35	240	450	2.0	20	23.2	1.08	9.4	2.0	88.0	0.73	0.77	0.82	2.56	1.54	20.3	
19	CO.021	15.6	2	62	83	220	450	2.0	20	8.3	0.38	0.0	1.3	98.2	0.51	0.82	0.88	4.33	3.33	--	
19	CO.021	15.6	3	90	107	240	450	2.0	20	21.8	1.02	10.2	2.2	86.7	0.95	0.76	--	2.50	1.53	--	
19	CO.021	15.6	4	134	155	240	450	1.0	20	9.9	0.69	1.7	1.6	95.5	1.41	0.81	0.83	6.00	3.80	--	
19	CO.021	15.6	5	182	203	240	600	1.0	20	11.5	0.80	1.8	1.2	95.8	1.16	0.83	0.85	6.50	3.80	30.8	
19	CO.021	15.6	6	210	226	240	450	2.0	20	19.9	0.93	9.6	2.3	87.2	0.95	0.76	--	2.31	1.38	--	
20	CO.041	15.8	1	17	37	240	450	2.0	20	25.3	1.16	11.0	2.1	86.0	0.88	0.76	0.84	2.94	1.61	20.3	
20	CO.041	15.8	2	66	75	220	450	2.0	20	9.1	0.41	0.0	1.5	97.8	0.65	0.82	0.91	8.00	2.75	--	
20	CO.041	15.8	3	90	109	240	450	2.0	20	26.3	1.21	9.5	1.9	87.8	0.82	0.78	--	2.81	1.71	--	
20	CO.041	15.8	4	136	148	240	450	1.0	20	12.7	0.88	1.9	1.2	95.9	0.95	0.83	0.86	9.00	4.20	--	
20	CO.041	15.8	5	169	178	240	600	1.0	20	13.2	0.91	2.0	1.0	96.1	0.93	0.84	--	7.00	3.50	--	
20	CO.041	15.8	6	193	203	240	450	2.0	20	24.6	1.13	9.4	1.8	87.9	0.92	0.78	--	2.93	1.75	--	
21	CO.014	15.1	1	24	38	240	450	2.0	20	8.5	0.40	8.3	3.5	85.8	2.43	0.74	0.83	2.75	1.67	17.5	G.C.Calib
21	CO.014	15.1	2	68	86	220	450	2.0	20	3.2	0.15	0.0	2.3	93.4	4.31	0.76	0.86	3.50	3.00	--	
21	CO.014	15.1	3	93	110	240	450	2.0	20	7.1	0.34	8.7	3.0	85.9	2.46	0.71	--	3.00	2.00	--	
21	CO.014	15.1	4	138	157	240	450	1.0	20	2.2	0.15	0.0	2.8	89.3	7.92	0.67	0.84	9.00	4.00	--	
21	CO.014	15.1	5	186	206	240	600	1.0	20	2.1	0.15	0.0	2.6	94.8	2.68	0.71	0.81	4.50	3.50	--	
22	CO.040	14.5	1	19	32	240	450	2.0	20	1.8	0.09	0.0	4.0	94.1	1.89	0.71	0.82	2.50	2.00	--	G.C.Calib
22	CO.040	14.5	2	43	63	220	450	2.0	20	0.7	0.03	0.0	0.7	97.1	2.17	0.91	--	1.00	2.00	--	Shut down
23	CO.047	15.8	1	21	39	240	450	2.0	20	28.2	1.29	7.7	1.5	89.3	1.47	0.79	0.84	3.14	1.69	24.5	
23	CO.047	15.8	2			220	450	2.0	20	--	--	--	--	--	--	--	--	--	--	--	Repair G.C
23	CO.047	15.8	3	94	111	240	450	2.0	20	25.6	1.17	8.9	1.5	88.2	1.38	0.78	--	3.15	2.00	--	
23	CO.047	15.8	4	141	159	240	450	1.0	20	11.9	0.81	2.9	0.9	94.1	2.13	0.82	0.88	7.33	4.75	--	
23	CO.047	15.8	5	187	207	240	600	1.0	20	11.8	0.81	2.6	0.8	94.6	2.01	0.82	0.87	7.00	3.60	--	
23	CO.047	15.8	6	215	226	240	450	2.0	20	24.0	1.10	10.7	1.9	85.7	1.71	0.75	--	3.54	2.13	--	
24	CO.049	15.6	1	19	39	240	450	2.0	20	30.6	1.41	10.9	1.8	85.7	1.66	0.76	0.82	2.09	1.30	14.0	
24	CO.049	15.6	2	71	87	220	450	2.0	20	12.0	1.07	2.7	0.9	95.3	1.09	0.81	0.95	4.25	3.25	--	
24	CO.049	15.6	3	95	111	240	450	2.0	20	29.5	1.37	9.5	1.6	87.6	1.30	0.78	--	2.32	1.40	--	
24	CO.049	15.6	4	139	159	240	450	1.0	20	12.6	0.87	3.1	1.0	94.1	1.80	0.81	0.86	8.33	4.20	--	
24	CO.049	15.6	5	187	207	240	600	1.0	20	13.4	0.93	2.6	0.9	94.8	1.68	0.82	0.88	8.33	4.20	37.8	
24	CO.049	15.6	6	211	231	240	450	2.0	20	24.9	1.16	10.4	1.7	86.5	1.36	0.76	--	2.75	1.75	--	
25	CO.047	15.6	1	19	33	240	450	2.0	20	28.1	1.30	8.8	1.6	88.1	1.50	0.78	0.85	2.93	1.88	25.9	Repeat R23
25	CO.047	15.6	2	55	69	220	450	2.0	20	7.4	0.34	1.5	1.2	96.3	1.02	0.76	0.89	3.00	4.67	--	
25	CO.047	15.6	3	93	159	240	450	2.0	20	25.6	1.19	8.9	1.6	87.9	1.48	0.77	--	3.14	2.00	--	
25	CO.047	15.6	4	143	159	240	450	1.0	20	10.8	0.75	3.0	1.0	94.2	1.84	0.81	0.94	8.00	4.75	--	
25	CO.047	15.6	5	189	207	240	600	1.0	20	12.4	0.86	2.2	0.8	95.6	1.39	0.83	0.86	7.33	4.50	36.4	
25	CO.047	15.6	6	215	231	240	450	2.0	20	23.2	1.08	9.6	1.7	87.4	1.28	0.77	--	3.50	2.07	--	
26	CO.031	15.9	1	19	39	240	450	2.0	20	30.9	1.41	12.1	1.9	84.9	1.12	0.75	0.83	1.83	1.14	22.4	
26	CO.031	15.9	2	67	87	220	450	2.0	20	13.6	0.62	3.9	0.9	94.6	0.49	0.80	0.85	4.20	2.67	--	
26	CO.031	15.9	3	93	111	240	450	2.0	20	29.5	1.35	12.2	2.1	84.6	1.15	0.75	--	1.97	1.25	--	
26	CO.031	15.9	4	141	159	240	450	1.0	20	12.9	0.88	3.6	1.1	94.3	1.11	0.80	0.88	7.75	4.00	--	
26	CO.031	15.9	5	189	207	240	600	1.0	20	13.9	0.95	3.5	1.0	94.4	1.12	0.81	0.85	6.80	3.71	30.1	
26	CO.031	15.9	6	221	230	240	450	2.0	20	26.6	1.22	12.0	2.2	84.9	0.96	0.74	--	2.30	1.43	--	

Table I
(Continued)

SUMMARY OF M3 SBCR RUN RESULTS

a) Unless otherwise noted, total flow is ca.15 L/min. STP, or 3 cm/sec linear gas flow.

b) Conversion is total CO conversion over the period (%).

c) Conversion and selectivities are calculated using H₂ as an internal standard in the GC analysis of the offgas.

d) Prod. rate: Rate for production of total hydrocarbons, C₁+ (kg/kg cat., hr).

e) Alpha: Based on GC analysis of offgas and liquid product.

Run No	Cat. No	Cat. wt, g	Per No	Time Start	Time Stop	Temp C	Pres psi	H ₂ : CO	Synfl cc/hr	Conv. %	Prod. Rate	Selectivities				Alpha GC	Alpha Liq	Olefin/Paraf		Olefins C6-18, %	Comments
No	No		No									%CH ₄	%C ₂	%C ₃ +	%CO ₂			C ₃	C ₄		
27	CO.029	15.9	1	23	39	240	450	2.0	20	28.3	1.27	8.3	1.6	87.9	2.21	0.77	0.84	3.40	2.20	27.3	
27	CO.029	15.9	2	71	87	220	450	2.0	20	9.5	0.43	1.7	1.1	96.0	1.23	0.80	0.89	5.67	3.00	--	
27	CO.029	15.9	3	99	111	240	450	2.0	20	25.7	1.16	7.7	1.6	88.8	1.86	0.78	--	4.00	2.36	--	
27	CO.029	15.9	4	150	159	240	450	1.0	20	12.0	0.82	1.9	0.9	95.4	1.88	0.83	0.90	8.33	4.75	--	
27	CO.029	15.9	5	191	207	240	600	1.0	20	12.1	0.82	1.7	0.9	95.6	1.75	0.83	0.89	7.67	4.75	39.9	
27	CO.029	15.9	6	222	230	240	450	2.0	20	23.7	1.08	8.2	1.7	88.5	1.60	0.78	--	3.92	2.67	--	
28	CO.01	15.0	1	19	36	240	450	2.0	20	1.1	0.05	0.0	12.	83.9	4.23	0.58	--	3.33	2.50	--	Shut down
29	CO.053	25.2	1	21	39	240	450	2.0	20	42.0	1.19	15.8	2.3	79.5	2.42	0.73	--	1.00	0.67	17.5	
29	CO.053	25.2	2	71	87	220	450	2.0	20	20.5	0.59	5.7	4.8	89.0	0.50	0.79	0.84	3.38	2.10	--	
29	CO.053	25.2	3	95	111	240	450	2.0	20	39.2	1.13	15.8	2.9	79.2	2.09	0.72	--	1.11	0.74	--	
29	CO.053	25.2	4	143	159	240	450	1.0	20	18.4	0.79	5.3	2.6	90.6	1.52	0.80	0.84	5.86	3.56	--	
29	CO.053	25.2	5	191	207	240	600	1.0	20	19.7	0.85	4.6	1.2	92.9	1.34	0.82	--	5.71	3.44	33.6	
29	CO.053	25.2	6	239	255	240	600	2.0	20	40.8	1.17	14.8	2.1	81.4	1.68	0.75	0.80	1.10	0.74	--	
29	CO.053	25.2	7	303	304	240	450	2.0	20	31.5	0.45	21.0	3.9	72.2	2.93	0.63	--	1.34	0.97	--	G.C.Repair
29	CO.053	25.2	8	332	351	260	450	2.0	20	31.0	0.44	36.4	5.3	52.6	5.74	0.52	--	2.60	1.75	--	
29	CO.053	25.2	9	375	376	240	450	2.0	20	18.0	0.55	23.0	3.5	72.1	1.46	0.66	--	3.21	2.05	--	
29	CO.053	25.2	10	415	423	240	450	2.0	20	21.6	0.98	14.4	2.5	82.4	0.82	0.72	--	2.87	1.79	--	G.C.Repair

Table II

DATE: 09/30/94

M3 SBCR RUN RESULTS

COMPARISON OF CATALYST ACTIVITY AT SIMILAR RUN CONDITIONS

Period No.	Temp.	Pres.	H2/CO Ratio
-----	-----	-----	-----
1	240 C	450psi	2.0

a) Total flow is ca.15 L/min. STP, or 3 cm/sec linear gas flow.

Flows: N2-563 SLH, H2-225 SLH, CO-112.5 SLH

b) Conversion is total CO conversion over the period (%).

c) Conversion and selectivities are calculated using N2 as an internal standard in the GC analysis of the offgas.

d) Prod. rate: Rate for production of total hydrocarbons, C1+ (kg/kg cat.,hr)

e) Alpha: Based on GC analysis of offgas and liquid product.

Run No	Cat. No	Cat. wt,g	Conv. %	Prod. Rate	Selectivities				Alpha GC	Alpha Liq	Olefin/Paraf		Olefins C6-18,%
					%C1	%C2	%C3+	%CO2			C3	C4	
5	CO.003	15.1	31.7	1.53	16.7	2.4	79.8	1.2	0.71	--	1.30	0.60	18.2
6	CO.011	15.3	14.3	0.67	7.6	1.6	89.4	1.4	0.78	0.83	4.17	2.57	21.7
7	CO.012	15.8	13.9	0.63	6.1	1.5	90.6	1.7	0.80	0.89	4.00	2.57	17.5
8	CO.015	15.0	28.3	1.37	12.7	2.0	84.1	1.2	0.76	0.80	1.61	1.07	19.6
9	CO.011	15.0	18.5	0.89	8.8	1.7	88.8	0.8	0.78	0.83	3.18	1.85	20.3
11	CO.017	15.0	27.2	1.32	11.2	1.8	85.9	1.1	0.77	0.80	2.09	1.20	30.8
12	CO.018	15.6	33.8	1.56	9.7	2.0	86.6	1.7	0.75	0.85	1.81	1.13	21.0
13	CO.016	14.7	26.4	1.31	(1)	1.7	89.3	0.7	0.78	0.81	2.00	1.41	21.7
14	CO.019	15.2	13.9	0.66	(2)	1.7	97.2	0.7	0.80	0.86	5.33	2.67	26.6
15	CO.005	14.7	27.1	1.34	7.9	1.6	89.7	0.8	0.79	0.82	2.30	1.38	23.1
16	CO.002	15.4	30.1	1.42	12.5	2.5	83.9	1.1	0.75	0.80	1.00	0.66	17.5
17	CO.025	15.6	26.6	1.24	10.7	2.1	86.4	0.8	0.76	0.82	2.25	1.47	21.7
18	CO.004	15.0	33.9	1.64	15.3	2.4	80.9	1.4	0.74	0.79	1.17	0.78	20.3
19	CO.021	15.6	23.2	1.08	9.4	2.0	88.0	0.7	0.77	0.82	2.56	1.54	20.3
20	CO.041	15.8	25.3	1.16	11.0	2.1	86.0	0.9	0.76	0.84	2.94	1.61	20.3
21	CO.014	15.1	8.5	0.40	8.3	3.5	85.8	2.4	0.74	0.83	2.75	1.67	17.5
22	CO.040	14.5	1.8	0.09	0.0	4.0	94.1	1.9	0.71	0.82	2.50	2.00	--
23	CO.047	15.8	28.2	1.29	7.7	1.5	89.3	1.5	0.79	0.84	3.14	1.69	24.5
24	CO.049	15.6	30.6	1.41	10.9	1.8	85.7	1.7	0.76	0.82	2.09	1.30	14.0
25	CO.047	15.6	28.1	1.30	8.8	1.6	88.1	1.5	0.78	0.85	2.93	1.88	25.9
26	CO.031	15.9	30.9	1.41	12.1	1.9	84.9	1.1	0.75	0.83	1.83	1.14	22.4
27	CO.029	15.9	28.3	1.27	8.3	1.6	87.9	2.2	0.77	0.84	3.40	2.20	27.3
28	COW.01	15.0	1.1	0.05	0.0	12.	83.9	4.2	0.58	--	3.33	2.50	--
29	CO.053	25.2	42.0	1.19	15.8	2.3	79.5	2.4	0.73	--	1.00	0.67	17.5

Note: Catalyst Run 9 screened thru 170 x 400 mesh.

Catalysts For Runs 11 thru 20, and 23 thru 28
screened thru 150 x 400 mesh.

Catalysts for Runs 21 and 22 screened thru 100 x 400 mesh.

(1) Weak TCD filaments in G.C. CH4 peaks smaller than expected.

(2) Internal valve in G.C. leaked. CH4 peak undetected.

Table III

DATE: 09/30/94

M3 SBCR RUN RESULTS

COMPARISON OF CATALYST ACTIVITY AT SIMILAR RUN CONDITIONS

Period No.	Temp.	Pres.	H2/CO Ratio
-----	-----	-----	-----
2	220 C	450psi	2.0

a) Total flow is ca.15 L/min. STP, or 3 cm/sec linear gas flow.

Flows: N2-563 SLH, H2-225 SLH, CO-112.5 SLH

b) Conversion is total CO conversion over the period (%).

c) Conversion and selectivities are calculated using N2 as an internal standard in the GC analysis of the offgas.

d) Prod. rate: Rate for production of total hydrocarbons, C1+ (kg/kg cat.,hr)

e) Alpha: Based on GC analysis of offgas and liquid product.

Run No	Cat. No	Cat. wt,g	Conv. %	Prod. Rate	Selectivities				Alpha GC	Alpha Liq	Olefin/Paraf		Olefin C6-18,
					%CH4	%C2	%C3+	%CO2			C3	C4	
5	CO.003	15.1	13.2	0.63	5.1	1.0	93.4	0.5	0.82	0.90	4.55	1.89	--
6	CO.011	15.3	5.1	0.23	0.0	0.0	97.2	2.8	0.87	0.82	--	--	--
7	CO.012	15.8	5.1	0.23	0.0	0.2	97.8	2.0	0.89	0.90	--	2.50	--
8	CO.015	15.0	11.5	0.56	4.4	1.0	93.9	0.8	0.81	0.89	3.60	2.14	--
9	CO.011	15.0	6.3	0.31	0.0	1.0	98.6	0.4	0.88	0.93	12.00	1.80	--
11	CO.017	15.0	11.4	0.55	5.0	0.0	94.8	0.2	0.88	0.90	5.00	3.20	--
12	CO.018	15.6	12.6	0.59	2.8	0.0	97.1	0.1	0.90	0.88	--	--	--
13	CO.016	14.7	9.7	0.48	(1)	0.1	99.9	0.0	0.91	0.88	--	--	--
14	CO.019	15.2	3.8	0.18	(2)	1.7	96.7	1.6	0.88	--	--	--	--
15	CO.005	14.7	10.7	0.53	0.0	0.9	98.4	0.7	0.83	0.88	4.25	3.25	--
16	CO.002	15.4	12.8	0.60	4.2	1.3	93.9	0.7	0.80	0.86	2.57	1.63	--
17	CO.025	15.6	8.4	0.39	0.0	1.1	96.9	1.9	0.82	0.92	6.50	3.00	--
18	CO.004	15.0	15.1	0.73	4.1	1.6	94.0	0.3	0.81	0.85	3.83	2.25	--
19	CO.021	15.6	8.3	0.38	0.0	1.3	98.2	0.5	0.82	0.88	4.33	3.33	--
20	CO.041	15.8	9.1	0.41	0.0	1.5	97.8	0.7	0.82	0.91	8.00	2.75	--
21	CO.014	15.1	3.2	0.15	0.0	2.3	85.8	4.3	0.76	0.86	3.50	3.00	--
22	CO.040	14.5	0.7	0.35	0.0	0.7	97.1	2.2	0.91	--	1.00	2.00	--
23	CO.047	15.8	---	---	(3)	---	---	---	---	---	---	---	--
24	CO.049	15.6	12.0	1.07	2.7	0.9	95.3	1.1	0.81	0.95	4.25	3.25	--
25	CO.047	15.6	7.4	0.34	1.5	1.2	96.3	1.0	0.76	0.89	3.00	4.67	--
26	CO.031	15.9	13.6	0.62	3.9	0.9	94.6	0.5	0.80	0.85	4.20	2.67	--
27	CO.029	15.9	9.5	0.43	1.7	1.1	96.0	1.2	0.80	0.89	5.67	3.00	--
29	CO.053	25.2	20.5	0.59	5.7	4.8	89.0	0.5	0.79	0.84	3.38	2.10	--

Note: Catalyst Run 9 screened thru 170 x 400 mesh.

Catalysts for Runs 11 thru 27 (except Runs 21 and 22) screened through 150 x 400 mesh.

Catalysts for Runs 21 and 22 screened thru 100 x 400.

(1) Weak TCD filaments in G.C. CH4 peaks smaller than expected.

(2) Internal valve in G.C. leaked. CH4 peak undetected.

(3) Replaced dual column restrictor valve.

Table IV

DATE: 09/30/94

M3 SBCR RUN RESULTS

COMPARISON OF CATALYST ACTIVITY AT SIMILAR RUN CONDITIONS

Period No.	Temp.	Pres.	H2/CO Ratio
-----	-----	-----	-----
4	240 C	450psi	1.0

a) Total flow is ca.15 L/min. STP, or 3 cm/sec linear gas flow.

Flows: N2-562 SLH, H2-119 SLH, CO-119 SLH

b) Conversion is total CO conversion over the period (%).

c) Conversion and selectivities are calculated using N2 as an internal standard in the GC analysis of the offgas.

d) Prod. rate: Rate for production of total hydrocarbons, C1+ (kg/kg cat.,hr)

e) Alpha: Based on GC analysis of offgas and liquid product.

Run No	Cat. No	Cat. wt,g	Conv. %	Prod. Rate	Selectivities				Alpha GC	Alpha Liq	Olefin/Paraf		Olefin C6-18,
					%CH4	%C2	%C3+	%CO2			C3	C4	
5	CO.003	15.1	13.1	0.95	4.2	1.2	93.3	1.2	0.83	0.88	6.67	3.70	--
6	CO.011	15.3	6.3	0.44	0.4	1.0	95.5	3.1	0.82	0.88	--	--	--
7	CO.012	15.8	3.9	0.26	4.8	2.3	86.3	6.6	0.70	0.85	16.00	3.50	--
8	CO.015	15.0	11.5	0.83	4.8	1.2	92.5	1.5	0.80	0.85	5.60	3.29	--
9	CO.011	15.0	8.0	0.58	1.3	1.3	96.3	1.2	0.82	0.87	7.00	2.83	--
11	CO.017	15.0	11.6	0.84	5.0	0.0	93.9	1.2	0.82	0.86	25.00	2.88	--
12	CO.018	15.6	12.4	0.86	3.3	0.0	95.0	1.7	0.80	0.86	--	--	--
13	CO.016	14.7	10.9	0.81	(1)	0.8	97.7	0.3	0.84	0.86	--	--	--
14	CO.019	15.2	--	--	(2)	--	--	--	0.80	--	--	--	--
15	CO.005	14.7	11.6	0.85	0.0	1.1	97.5	1.4	0.82	0.85	7.00	4.60	--
16	CO.002	15.4	12.6	0.89	4.4	1.6	92.8	1.2	0.79	0.84	4.43	2.88	--
17	CO.025	15.6	10.3	0.71	0.8	1.2	96.7	1.3	0.82	0.93	7.67	4.25	--
18	CO.004	15.0	14.7	1.06	4.1	1.2	93.2	1.4	0.80	0.83	6.17	3.75	--
19	CO.021	15.6	9.9	0.69	1.7	1.4	95.5	1.4	0.81	0.83	6.00	3.80	--
20	CO.041	15.8	12.7	0.88	1.9	1.2	95.9	1.0	0.83	0.86	9.00	4.20	--
21	CO.014	15.1	2.2	0.15	0.0	2.8	89.3	7.9	0.67	0.84	9.00	4.00	--
23	CO.047	15.8	11.9	0.81	2.9	0.9	94.1	2.1	0.82	0.88	7.33	4.75	--
24	CO.049	15.6	12.6	0.87	3.1	1.0	94.1	1.8	0.81	0.86	8.33	4.20	--
25	CO.047	15.6	10.8	0.75	3.0	1.0	94.2	1.8	0.81	0.90	8.00	4.75	--
26	CO.031	15.9	12.9	0.88	3.6	1.1	94.3	1.1	0.80	0.88	7.75	4.00	--
27	CO.029	15.9	12.0	0.82	1.9	0.9	95.4	1.9	0.83	0.90	8.33	4.75	--
29	CO.053	25.2	18.4	0.79	5.3	2.6	90.6	1.5	0.80	0.84	5.86	3.56	--

Note: Catalyst Run 9 screened thru 170 x 400 mesh.

Catalysts for Runs 11 thru 20 and Run 27 (except Runs 21 and 22) screened thru 150 x 400 mesh.

Catalysts for Runs 21 and 22 screened thru 100 x 400 mesh.

(1) Weak TCD filaments in G.C. CH4 peaks smaller than expected.

(2) Internal valve in G.C. leaked. CH4 peak undetected.

Table V

DATE: 09/30/94

M3 SBCR RUN RESULTS

COMPARISON OF CATALYST ACTIVITY AT SIMILAR RUN CONDITIONS

Period No.	Temp.	Pres.	H2/CO Ratio
-----	-----	-----	-----
5	240 C	600psi	1.0

a) Total flow is ca.15 L/min. STP, or 3 cm/sec linear gas flow.

Flows: N2-562 SLH, H2-119 SLH, CO-119 SLH

b) Conversion is total CO conversion over the period (%).

c) Conversion and selectivities are calculated using N2 as an internal standard in the GC analysis of the offgas.

d) Prod. rate: Rate for production of total hydrocarbons, C1+ (kg/kg cat.,hr)

e) Alpha: Based on GC analysis of offgas and liquid product.

Run No	Cat. No	Cat. wt,g	Conv. %	Prod. Rate	Selectivities				Alpha GC	Alpha Liq	Olefin/Paraf			Olefin C6-18,%
---	---	---	---	---	%CH4	%C2	%C3+	%CO2	---	---	C3	C4	---	---
5	CO.003	15.1	13.4	0.97	3.9	1.1	93.7	1.3	0.81	--	5.26	3.45		30.1
6	CO.011	15.3	6.7	0.46	0.2	0.9	96.0	2.9	0.84	0.89	12.00	3.67		27.3
7	CO.012	15.8	4.3	0.28	0.1	2.1	91.6	6.3	0.75	0.82	8.50	3.50		--
8	CO.015	15.0	12.4	0.90	4.9	0.8	93.6	0.7	0.84	0.85	5.20	3.14		30.8
9	CO.011	15.0	8.7	0.63	1.4	1.1	96.4	1.1	0.83	0.87	5.00	2.67		30.5
11	CO.017	15.0	11.6	0.84	4.2	0.0	94.7	1.2	0.86	0.86	24.00	1.63		21.0
12	CO.018	15.6	13.0	0.90	3.2	0.0	94.9	1.9	0.80	0.85	--	--		38.5
13	CO.016	14.7	11.4	0.85	(1)	0.5	99.2	0.3	0.92	0.86	--	--		32.2
14	CO.019	15.2	5.9	0.41	(2)	1.5	96.1	2.4	0.80	--	--	--		--
15	CO.005	14.7	23.0	0.90	0.0	1.0	97.7	1.3	0.83	0.85	7.00	4.40		36.4
16	CO.002	15.4	13.1	0.92	3.6	1.4	93.9	1.1	0.81	0.84	4.29	2.75		25.2
17	CO.025	15.6	19.9	0.81	9.3	1.1	96.5	1.1	0.83	0.88	8.00	4.25		32.9
18	CO.004	15.0	15.0	1.09	3.6	1.1	94.1	1.2	0.82	0.83	5.67	4.00		33.6
19	CO.021	15.6	11.5	0.80	1.8	1.2	95.8	1.2	0.83	0.85	6.50	3.80		30.8
20	CO.041	15.8	13.2	0.91	2.0	1.0	96.1	0.9	0.84	0.87	7.00	3.50		31.5
21	Co.014	15.1	2.1	0.15	0.0	2.6	94.8	2.7	0.71	0.81	4.50	3.50		23.1
23	CO.047	15.8	11.8	0.80	2.6	0.8	94.6	2.0	0.82	0.87	7.00	3.60		38.5
24	CO.049	15.6	13.4	0.92	2.6	0.9	94.8	1.7	0.82	0.88	8.33	4.20		37.8
25	CO.047	15.6	12.4	0.86	2.2	0.8	95.6	1.3	0.83	0.86	7.33	4.50		36.4
26	CO.031	15.9	13.9	0.95	3.5	1.0	94.4	1.1	0.81	0.85	6.80	3.71		30.1
27	CO.029	15.9	12.1	0.82	1.7	0.9	95.6	1.8	0.83	0.89	7.67	4.75		39.9
29	CO.053	25.2	19.7	0.85	4.6	1.2	92.9	1.34	0.82	0.85	5.71	3.44		33.6

Note: Catalyst Run 9 screened thru 170 x 400 mesh.

Catalysts for Runs 11 thru 27 (except Runs 21 and 22) screened thru 150 x 400 mesh.

Catalyst for Run 21 screened thru 100 x 400 mesh.

- (1) Weak TCD filaments in G.C. CH4 peaks smaller than expected.
 (2) Internal valve in G.C. leaked. CH4 peak undetected.

Table VI

SUMMARY OF M4 SBCR RUN RESULTS

a) Unless otherwise noted, total flow is ca. 15 L/min. STP, or 3 cm/sec linear gas flow.

b) Conversion is total CO conversion over the period (%).

c) Conversion and selectivities are calculated using N₂ as an internal standard in the GC analysis of the offgas.

d) Prod. rate: Rate for production of total hydrocarbons, C₁+ (kg/kg cat., hr).

e) Alpha: Based on GC analysis of offgas and liquid product.

Run No	Cat. No	Per wt, g	Time No	Time Start	Time Stop	Temp C	Pres psi	H ₂ : CO	Synfl cc/hr	Conv. %	Prod. Rate	Selectivities %CH ₄	%C ₂	%C ₃ +	%CO ₂	Alpha GC	Alpha Liq	Olefin/Paraf C ₃	C ₄	Olefins C ₆ -18, %	Comments
3	CO.002	15.2	1	25	35	240	450	2.0	20	29.4	1.42	17.3	2.2	79.4	1.01	0.73	0.82	0.91	0.60	17.5	
3	CO.002	15.2	2	73	83	220	450	2.0	20	11.8	0.56	4.7	1.0	93.7	0.59	0.81	0.90	2.71	1.63	--	G.C. Calib
3	CO.002	15.2	3	97	107	240	450	2.0	20	26.4	1.28	16.0	3.1	80.1	0.88	0.73	--	0.98	0.66	--	
3	CO.002	15.2	4	145	155	240	450	1.0	20	11.6	0.83	3.9	2.4	92.8	0.84	0.81	0.87	4.29	3.14	--	G.C. Calib
3	CO.002	15.2	5	182	203	240	600	1.0	20	12.9	0.92	4.0	1.5	93.5	0.91	0.81	0.82	4.29	2.75	24.5	
3	CO.002	15.2	6	217	226	240	450	2.0	20	24.2	1.17	17.1	3.1	79.0	0.83	0.71	--	1.03	0.70	--	
4	CO.024	15.4	1	20	37	240	450	2.0	20	25.5	1.21	8.6	2.0	89.0	0.43	0.79	0.84	2.93	1.93	21.7	
4	CO.024	15.4	2	68	85	220	450	2.0	0	9.5	0.45	0.0	2.1	97.6	0.27	0.83	0.91	5.33	4.00	--	No Synfl
4	CO.024	15.4	3	92	109	240	450	2.0	0	23.7	1.13	9.5	2.1	88.0	0.45	0.77	--	2.81	1.88	--	
4	CO.024	15.4	4	140	157	240	450	1.0	0	10.3	0.73	0.5	1.6	97.2	0.71	0.83	0.87	8.33	4.75	--	
4	CO.024	15.4	5	188	205	240	600	1.0	0	11.3	0.80	0.9	1.5	97.0	0.65	0.83	0.87	6.50	3.80	36.4	
4	CO.024	15.4	6	212	229	240	450	2.0	0	21.5	1.02	9.3	2.3	87.9	0.50	0.76	--	2.93	2.07	--	
5	CO.035	15.4	1	16	37	240	450	2.0	20	24.8	1.18	8.5	2.1	89.0	0.47	0.78	0.84	3.13	1.94	23.1	
5	CO.035	15.4	2	68	85	220	450	2.0	20	8.8	0.42	0.0	2.3	97.4	0.31	0.82	--	5.33	4.00	--	
5	CO.035	15.4	3	99	109	240	450	2.0	20	23.5	1.11	8.7	2.1	88.6	0.61	0.77	--	3.07	1.94	--	
5	CO.035	15.4	4	136	157	240	450	1.0	20	10.4	0.73	0.9	0.0	98.4	0.65	--	0.83	--	--	--	G.C. Calib
5	CO.035	15.4	5	184	205	240	600	1.0	20	10.7	0.76	0.7	1.4	97.1	0.75	0.84	0.88	6.25	4.50	27.3	
5	CO.035	15.4	6	212	228	240	450	2.0	20	19.4	0.92	7.8	2.3	89.4	0.56	0.79	--	3.08	1.77	--	
6	CO.028	15.4	1	23	40	240	450	2.0	20	21.2	1.00	6.1	1.6	91.3	1.01	0.81	0.83	4.86	3.00	28.7	
6	CO.028	15.4	2	67	88	220	450	2.0	20	6.6	0.31	0.0	1.9	97.4	0.72	0.83	0.90	5.50	4.00	--	
6	CO.028	15.4	3	95	112	240	450	2.0	20	20.1	0.94	5.8	1.6	91.6	1.02	0.81	--	4.25	2.67	--	
6	CO.028	15.4	4	139	160	240	450	1.0	20	9.2	0.65	0.0	1.3	97.3	1.46	0.85	0.88	9.50	3.75	--	
6	CO.028	15.4	5	189	208	240	600	1.0	20	9.5	0.67	0.0	1.1	97.5	1.36	0.85	0.88	6.00	3.50	40.6	
6	CO.028	15.4	6	213	232	240	450	2.0	20	18.0	0.84	5.7	1.6	91.5	1.12	0.80	--	4.57	2.88	--	
7	CO.043	15.4	1	18	39	240	450	2.0	20	13.0	0.61	3.7	1.8	93.4	1.06	0.79	0.85	5.60	3.17	27.3	
7	CO.043	15.4	2	53	63	220	450	2.0	20	4.3	0.20	0.0	1.4	96.3	2.25	0.81	0.91	4.00	3.00	--	
7	CO.043	15.4	3	94	111	240	450	2.0	20	12.3	0.58	3.0	1.5	93.9	1.58	0.80	--	5.00	2.83	--	
7	CO.043	15.4	4	138	159	240	450	1.0	20	5.2	0.37	0.0	0.0	99.4	0.64	0.83	0.89	7.00	5.00	--	
7	CO.043	15.4	5	191	207	240	600	1.0	20	5.9	0.41	0.0	2.2	94.8	2.99	0.82	0.89	6.00	3.75	30.1	G.C. Calib
7	CO.043	15.4	6	215	231	240	450	2.0	20	10.2	0.47	4.7	2.1	91.4	1.79	0.78	--	5.50	3.20	--	Repair G.C
8	CO.006	15.0	1	19	40	240	450	2.0	20	2.7	0.13	0.1	0.2	98.8	1.75	0.67	0.85	3.33	2.33	16.1	Shut down

Table VI
(Continued)

SUMMARY OF M4 SBCR RUN RESULTS

a)Unless otherwise noted, total flow is ca.15 L/min. STP, or 3 cm/sec linear gas flow.

b)Conversion is total CO conversion over the period (%).

c)Conversion and selectivities are calculated using N2 as an internal standard in the GC analysis of the offgas.

d)Prod. rate: Rate for production of total hydrocarbons, C1+ (kg/kg cat.,hr).

e)Alpha: Based on GC analysis of offgas and liquid product.

Run No	Cat. No	Per wt,g	Time No	Time Start	Time Stop	Temp C	Pres psi	H2: CO	Synfl cc/hr	Conv. %	Prod. Rate	Selectivities				Alpha GC	Alpha Liq	Olefin/Paraf		Olefins C6-18,%	Comments
No	No	wt,g	No	Start	Stop	C	psi	CO	cc/hr	%	Rate	%CH4	%C2	%C3+	%CO2	GC	Liq	C3	C4	C6-18,%	
9	CO.048	15.4	1	19	40	240	450	2.0	12	19.1	0.90	9.9	1.6	87.4	1.05	0.77	0.88	3.60	2.09	20.3	
9	CO.048	15.4	2	70	84	220	450	2.0	12	6.1	0.28	1.8	1.0	95.2	1.93	0.80	0.91	3.67	3.00	--	
9	CO.048	15.4	3	93	111	240	450	2.0	20	17.8	0.84	10.1	1.7	86.9	1.33	0.77	--	3.30	2.10	--	
9	CO.048	15.4	4	139	159	240	450	1.0	20	8.2	0.57	2.3	1.0	93.8	2.98	0.82	0.90	8.50	4.33	--	
9	CO.048	15.4	5	189	207	240	600	1.0	20	11.9	0.83	2.7	0.9	94.4	1.93	0.84	0.89	5.75	3.20	14.0	
9	CO.048	15.4	6	217	226	240	450	2.0	20	24.2	1.17	17.1	3.1	79.0	0.83	0.71	--	1.03	0.70	--	
10	CAL.02	15.9	1	19	40	240	450	2.0	20	34.5	1.58	12.9	2.0	83.9	1.23	0.75	0.84	1.66	1.06	21.0	
10	CAL.02	15.9	2	69	88	220	450	2.0	20	14.9	0.68	4.6	0.9	94.0	0.47	0.81	0.88	4.40	2.29	--	
10	CAL.02	15.9	3	91	112	240	450	2.0	20	34.2	1.57	12.6	2.0	84.4	1.00	0.75	--	1.71	1.06	--	
10	CAL.02	15.9	4	139	160	240	450	1.0	20	14.6	1.00	4.6	1.1	93.3	0.97	0.80	0.88	7.20	4.00	--	
10	CAL.02	15.9	5	187	201	240	600	1.0	20	16.4	1.12	4.2	1.0	94.0	0.89	0.82	0.86	5.83	3.86	35.7	
10	CAL.02	15.9	6	215	230	240	450	2.0	20	30.9	1.42	13.3	2.1	83.7	0.90	0.74	--	1.90	1.21	--	
11	CAL.03	15.6	1	19	40	240	450	2.0	20	29.7	1.39	13.5	2.1	83.4	1.08	0.74	0.86	1.65	1.03	18.2	ShutDown
12	CO.053	15.9	1	22	40	240	450	2.0	20	34.2	1.56	12.6	2.0	84.2	1.23	0.75	0.83	1.60	1.00	24.5	
12	CO.053	15.9	2	69	88	220	450	2.0	20	14.4	0.66	4.3	1.0	94.3	0.48	0.81	0.89	4.20	2.67	--	
12	CO.053	15.9	3	93	112	240	450	2.0	20	34.0	1.56	13.4	2.2	83.2	1.21	0.74	--	1.50	0.94	--	
12	CO.053	15.9	4	150	152	240	450	1.0	20	13.3	0.91	4.3	1.2	93.3	1.18	0.80	0.89	6.60	3.71	--	
12	CO.053	15.9	5	189	208	240	600	1.0	20	15.6	1.06	4.0	0.9	94.0	1.01	0.82	0.87	5.50	3.57	32.2	
12	CO.053	15.9	6	223	231	240	450	2.0	20	29.8	1.37	12.8	2.0	84.3	0.94	0.75	--	1.89	1.10	--	
13	CO.054	15.7	1	23	40	240	450	2.0	20	10.4	0.48	4.7	1.8	92.3	1.17	0.78	0.86	5.75	4.00	25.9	
13	CO.054	15.7	2	71	88	220	450	2.0	20	0.2	0.01	0.0	19.	60.8	19.5	0.33	0.94	8.00	5.00	--	
13	CO.054	15.7	3	102	112	240	450	2.0	20	10.6	0.49	4.5	1.5	92.8	1.23	0.79	--	5.50	3.75	--	
13	CO.054	15.7	4	143	160	240	450	1.0	20	5.2	0.36	0.0	1.2	97.0	1.85	0.83	0.95	6.00	4.50	--	
13	CO.054	15.7	5	191	208	240	600	1.0	20	5.0	0.34	0.0	1.3	96.9	1.78	0.82	0.93	6.50	3.33	30.8	
13	CO.054	15.7	6	223	230	240	450	2.0	20	8.8	0.40	4.7	2.0	91.7	1.54	0.78	--	5.00	3.50	--	
14	BlendA	20.0	1	25	39	240	450	2.0	20	29.3	1.41	10.1	1.6	86.3	2.02	0.77	0.86	2.23	1.35	23.1	
14	BlendA	20.0	2	69	87	220	450	2.0	20	12.4	0.60	4.3	0.9	93.9	0.95	0.81	0.91	3.80	2.33	--	
14	BlendA	20.0	3	93	111	240	450	2.0	20	27.5	1.33	10.5	1.7	86.4	1.44	0.76	--	2.09	1.32	--	
14	BlendA	20.0	4	143	158	240	450	1.0	20	12.7	0.91	3.4	1.0	94.0	1.61	0.81	0.86	7.50	3.83	--	
14	BlendA	20.0	5	191	207	240	600	1.0	20	14.1	1.02	3.7	1.0	93.8	1.45	0.82	0.89	6.40	3.43	32.9	
14	BlendA	20.0	6	215	231	240	450	2.0	20	27.0	1.29	11.5	1.9	85.5	1.12	0.76	--	2.04	1.30	--	

Table VI
(Continued)

SUMMARY OF M4 SBCR RUN RESULTS

a) Unless otherwise noted, total flow is ca.15 L/min. STP, or 3 cm/sec linear gas flow.

b) Conversion is total CO conversion over the period (%).

c) Conversion and selectivities are calculated using N₂ as an internal standard in the GC analysis of the offgas.

d) Prod. rate: Rate for production of total hydrocarbons, C₁+ (kg/kg cat., hr).

e) Alpha: Based on GC analysis of offgas and liquid product.

Run No	Cat. No	Cat. wt, g	Per No	Time Start	Time Stop	Temp C	Pres psi	H ₂ : CO	Synfl cc/hr	Conv. %	Prod. Rate	Selectivities %CH ₄	%C ₂	%C ₃ +	%CO ₂	Alpha GC	Alpha Liq	Olefin/Paraf C ₃	C ₄	Olefins C ₆₋₁₈ , %	Comments
15	CO.034	13.0	1	21	39	240	450	2.0	20	27.5	1.54	10.4	1.6	87.2	0.80	0.78	0.84	2.21	1.40	21.0	G.C. Calib
15	CO.034	13.0	2	45	87	220	450	2.0	20	11.0	0.61	4.0	0.9	94.5	0.59	0.82	0.90	4.00	3.00	--	
15	CO.034	13.0	3	95	111	240	450	2.0	20	26.6	1.49	11.5	1.9	85.9	0.82	0.76	--	2.10	1.33	--	
15	CO.034	13.0	4	141	159	240	450	1.0	20	11.2	0.94	3.9	1.0	94.0	1.02	0.82	0.87	8.33	4.00	--	
15	CO.034	13.0	5	189	207	240	600	1.0	20	11.8	0.99	3.9	1.1	94.0	1.03	0.83		5.75	3.80	37.8	
15	CO.034	13.0	6	215	231	240	450	2.0	20	21.6	1.19	10.9	1.9	86.3	0.87	0.76	--	3.33	2.15	--	
16	CAL.04	16.1	1	21	39	240	450	1.8	20	26.3	1.34	7.1	1.3	90.3	1.38	0.80	0.85	4.80	3.18	32.9	H ₂ /CO:
16	CAL.04	16.1	2	54	163	220	450	1.8	20	8.4	0.42	2.6	1.0	94.1	2.31	0.80	0.88	5.00	4.00	--	1.76/1.0
17	CAL.08	15.0	1	21	39	240	450	1.8	20	16.9	0.93	5.9	1.0	91.7	1.36	0.82	0.88	5.20	3.33	28.7	H ₂ /CO:
17	CAL.08	15.0	2	47	62	220	450	1.8	20	5.4	0.28	0.1	0.8	96.9	2.23	0.83	--	4.00	3.00	--	1.76/1.0
18	CAL.07	15.0	1	21	39	240	450	2.0	20	20.6	1.03	7.7	1.2	90.0	1.09	0.81	0.88	5.00	3.00	32.2	
18	CAL.07	15.0	2	47	62	220	450	2.0	20	6.7	0.33	1.8	1.4	95.0	1.81	0.84	--	4.00	3.00	--	
19	CAL.05	15.7	1	23	39	240	450	2.0	20	26.6	1.22	7.3	1.3	90.2	1.19	0.82	0.86	4.11	2.70	18.2	G.C. Calib
19	CAL.05	15.7	2	47	62	220	450	2.0	20	9.0	0.41	2.3	1.4	94.8	1.56	0.84	--	5.50	3.00	--	
20	CAL.06	15.0	1	15	30	240	450	2.0	20	5.6	0.26	3.1	2.1	92.0	2.86	0.80	0.90	4.50	3.50	30.8	G.C. Calib
20	CAL.06	15.0	2	55	63	240	450	2.0	20	3.5	0.16	0.0	3.3	92.8	3.87	0.80	0.85	3.00	2.50	--	
20	CAL.06	15.0	3	103	110	240	450	2.0	20	1.7	0.08	0.0	3.3	89.5	7.22	0.80	--	1.50	3.00	--	Cat. Loss
21	CO.004	15.9	1	23	40	240	450	2.0	20	39.3	1.80	15.2	2.3	81.2	1.38	0.74	0.89	1.16	0.73	23.1	
21	CO.004	15.9	2	71	88	220	450	2.0	20	16.1	0.74	8.1	1.2	90.2	0.48	0.78	0.87	3.38	2.22	--	
21	CO.004	15.9	3	105	110	240	450	2.0	20	37.6	1.47	16.4	2.3	80.2	1.20	0.73	--	1.10	0.70	--	
21	CO.004	15.9	4	136	138	240	450	1.0	20	14.9	1.02	7.4	1.4	89.9	1.29	0.77	0.84	4.67	2.82	--	
21	CO.004	15.9	5	166	184	240	600	1.0	20	18.4	1.26	6.1	1.1	91.9	0.94	0.81	0.84	5.25	2.91	--	G.C. Repair
21	CO.004	15.9	6	199	207	240	600	2.0	20	39.0	1.80	14.2	1.9	83.0	0.91	0.78	0.82	0.85	0.77	--	
21	CO.004	15.9	7	212	214	240	450	2.0	20	34.6	1.59	15.8	2.3	81.0	1.00	0.76	--	0.86	0.81	--	G.C. Repair

Table VII

DATE: 09/30/94

M4 SBCR RUN RESULTS

COMPARISON OF CATALYST ACTIVITY AT SIMILAR RUN CONDITIONS

Period No.	Temp.	Pres.	H2/CO Ratio
-----	-----	-----	-----
1	240 C	450psi	2.0

a) Total flow is ca.15 L/min. STP, or 3 cm/sec linear gas flow.

Flows: N2-563 SLH, H2-225 SLH, CO-112.5 SLH

b) Conversion is total CO conversion over the period (%).

c) Conversion and selectivities are calculated using N2 as an internal standard in the GC analysis of the offgas.

d) Prod. rate: Rate for production of total hydrocarbons C1+ (kg/kg cat., hr).

e) Alpha: Based on GC analysis of offgas and liquid product.

Run No	Cat. No	Cat. wt, g	Conv. %	Prod. Rate	Selectivities				Alpha GC	Alpha Liq	Olefin C3	Paraf C4	Olefin C6-18, %
---	---	---	---	---	---	---	---	---	---	---	---	---	---
3	CO.002	15.2	29.4	1.42	17.3	2.3	79.4	1.01	0.73	0.82	0.91	0.60	17.5
4	CO.024	15.4	25.5	1.21	8.6	2.0	89.0	0.43	0.79	0.84	2.93	1.93	21.7
5	CO.035	15.4	24.8	1.18	8.5	2.1	89.0	0.47	0.78	0.84	3.13	1.94	23.1
6	CO.028	15.4	21.2	1.00	6.1	1.6	91.3	1.01	0.81	0.83	4.86	3.00	28.7
7	CO.043	15.4	13.0	0.61	3.7	1.8	93.4	1.06	0.79	0.85	5.60	3.17	27.3
8	CO.006	15.0	2.7	0.25	0.1	0.2	98.8	1.75	0.67	0.85	3.33	2.33	16.1
9	CO.048	15.4	19.1	0.90	9.9	1.6	87.4	1.05	0.77	0.88	3.60	2.09	20.3
10	CAL.02	15.9	34.5	1.58	12.9	2.0	83.9	1.23	0.75	0.81	1.66	1.06	21.0
11	CAL.03	15.6	29.7	1.39	13.5	2.1	83.4	1.08	0.74	0.86	1.65	1.03	18.2
12	CO.053	15.9	34.2	1.56	12.6	2.0	84.2	1.23	0.75	0.83	1.60	1.00	24.5
13	CO.054	15.7	10.4	0.48	4.7	1.8	92.3	1.17	0.78	0.86	5.75	4.00	25.9
14	BlendA	20.0	29.3	1.41	10.1	1.6	86.3	2.02	0.77	0.86	2.23	1.35	23.1
15	CO.034	13.0	27.5	1.54	10.4	1.6	87.2	0.80	0.78	0.84	2.21	1.40	21.0
16	CAL.04	16.1	26.3	1.34	7.1	1.3	90.3	1.38	0.80	0.85	4.80	3.18	32.9
17	CAL.08	15.0	16.9	0.93	5.9	1.0	91.7	1.36	0.82	0.88	5.20	3.33	28.7
18	CAL.07	15.0	20.6	1.03	7.7	1.2	90.0	1.09	0.81	0.88	5.00	3.00	32.2
19	CAL.05	15.7	26.6	1.22	7.3	1.3	90.2	1.19	0.82	0.86	4.11	3.00	28.7
20	CAL.06	15.0	5.6	0.26	3.1	2.1	92.0	2.86	0.80	0.90	4.50	3.50	30.8
21	CO.004	15.9	39.3	1.80	15.2	2.3	81.2	1.38	0.74	0.80	1.16	0.73	23.1

Note: Catalysts for Runs 3 thru 15 (except 8) screened through 150 x 400 mesh.

Catalyst for Run 8 screened thru 100 x 400 mesh.

Cat. Nos. CAL.08 and CAL.07 were prereduced and coated with wax.

H2 to CO ratio for Runs 16 and 17 was 1.76/1.0.

Cat. No. CAL.06 was H2 reduced and air stabilized.

Table VIII

DATE: 09/30/94

M4 SBCR RUN RESULTS

COMPARISON OF CATALYST ACTIVITY AT SIMILAR RUN CONDITIONS

Period No.	Temp.	Pres.	H2/CO Ratio
-----	-----	-----	-----
2	220 C	450psi	2.0

a) Total flow is ca.15 L/min. STP, or 3 cm/sec linear gas flow.

Flows: N2-563 SLH, H2-225 SLH, CO-112.5 SLH

b) Conversion is total CO conversion over the period (%).

c) Conversion and selectivities are calculated using N2 as an internal standard in the GC analysis of the offgas.

d) Prod. rate: Rate for production of total hydrocarbons C1+ (kg/kg cat., hr).

e) Alpha: Based on GC analysis of offgas and liquid product.

Run No	Cat. No	Cat. wt, g	Conv. %	Prod. Rate	Selectivities				Alpha GC	Alpha Liq	Olefin/Paraf		Olefin C6-18, %
					%CH4	%C2	%C3+	%CO2			C3	C4	
3	CO.002	15.2	11.8	0.56	4.7	1.0	93.7	0.59	0.81	0.90	2.71	1.63	--
4	CO.024	15.4	9.5	0.45	0.0	2.1	97.6	0.27	0.83	0.91	5.33	4.00	--
5	CO.035	15.4	8.8	0.42	0.0	2.3	97.4	0.31	0.82	--	5.33	4.00	--
6	CO.028	15.4	6.6	0.31	0.0	1.9	97.4	0.72	0.83	0.90	5.50	4.00	--
7	CO.043	15.4	4.3	0.20	0.0	1.4	96.3	2.25	0.81	0.91	4.00	3.00	--
9	CO.048	15.4	6.1	0.28	1.8	1.0	95.2	1.93	0.80	0.91	3.67	3.00	--
10	CAL.02	15.9	14.9	0.68	4.6	0.9	94.0	0.47	0.81	0.88	4.40	2.29	--
12	CO.053	15.9	14.4	0.66	4.3	1.0	94.3	0.48	0.81	0.89	4.20	2.67	--
13	CO.054	15.7	0.2	0.01	0.0	20.	60.8	19.5	0.33	0.94	8.00	5.00	--
14	Blend A	20.0	12.4	0.60	4.3	0.9	93.9	0.95	0.81	0.91	3.80	2.33	--
15	CO.034	13.0	11.0	0.61	4.0	0.9	94.5	0.59	0.82	0.90	4.00	3.00	--
16	CAL.04	16.1	8.4	0.42	2.6	1.0	94.1	2.31	0.80	0.88	5.00	4.00	--
17	CAL.08	15.0	5.4	0.28	0.1	0.8	96.9	2.23	0.83	--	4.00	3.00	--
18	CAL.07	15.0	6.7	0.33	1.8	1.4	95.0	1.81	0.85	--	4.00	3.00	--
19	CAL.05	15.7	9.0	0.41	2.3	1.4	94.8	1.56	0.84	--	5.50	3.00	--
20	CAL.06	15.0	3.5	0.16	0.0	3.3	92.8	3.87	0.80	0.85	3.00	2.50	--
21	CO.004	15.9	16.1	0.74	8.1	1.2	90.2	0.48	0.78	0.86	3.38	2.22	--

Note: Catalysts for Runs 3 through 15 screened thru 150 x 400 mesh.

Blend A contains 15.0 gm of Cat. No. CO.005 plus 5.0 gm of Cat. No. WGS.03.

Cat. NOS. CAL.08 and CAL.07 were prereduced and wax coated.

H2 to CO for Runs 16 and 17 was 1.76/1.0.

Cat. No. CAL.06 was H2 reduced and air stabilized before charging.

Table IX

DATE: 09/30/94

M4 SBCR RUN RESULTS

COMPARISON OF CATALYST ACTIVITY AT SIMILAR RUN CONDITIONS

Period No.	Temp.	Pres.	H2/CO Ratio
-----	-----	-----	-----
4	240 C	450psi	1.0

a) Total flow is ca.15 L/min. STP, or 3 cm/sec linear gas flow.

Flows: N2-562 SLH, H2-119 SLH, CO-119 SLH

b) Conversion is total CO conversion over the period (%).

c) Conversion and selectivities are calculated using N2 as an internal standard in the GC analysis of the offgas.

d) Prod. rate: Rate for production of total hydrocarbons C1+ (kg/kg cat.,hr).

e) Alpha: Based on GC analysis of offgas and liquid product.

Run No	Cat. No	Cat. wt,g	Conv. %	Prod. Rate	Selectivities				Alpha GC	Alpha Liq	Olefin/Paraf		Olefin C6-18,%
---	---	---	---	---	%CH4	%C2	%C3+	%CO2	---	---	C3	C4	---
3	CO.002	15.2	11.6	0.83	3.9	2.4	92.8	0.84	0.81	0.87	4.29	3.14	--
4	CO.024	15.4	10.3	0.73	0.5	1.6	97.2	0.71	0.83	0.87	8.33	4.75	--
5	CO.035	15.4	10.4	0.73	0.9	0.0	98.4	0.65	--	0.83	--	--	--
6	CO.028	15.4	9.2	0.65	0.0	1.3	97.3	1.46	0.85	0.88	9.50	3.75	--
7	CO.043	15.4	5.2	0.37	0.0	0.0	99.4	0.64	0.83	0.89	7.00	5.00	--
9	CO.048	15.4	8.2	0.57	2.3	1.0	93.8	3.00	0.82	0.90	8.50	4.33	--
10	CAL.02	15.9	14.6	1.00	4.6	1.0	93.3	0.97	0.80	0.88	7.20	4.00	--
12	CO.053	15.9	13.3	0.91	4.3	1.2	93.3	1.18	0.80	0.89	6.60	3.71	--
13	CO.054	15.7	5.2	0.36	0.0	1.2	97.0	1.85	0.83	0.95	6.00	4.50	--
14	BlendA	20.0	12.7	0.91	3.4	1.0	94.0	1.61	0.81	0.86	7.50	3.83	--
15	CO.034	13.0	11.2	0.94	3.9	1.0	94.0	1.02	0.82	0.87	8.33	4.00	--
21	CO.004	15.9	14.9	1.02	7.4	1.4	89.9	1.29	0.77	0.84	4.67	2.82	--

Note: Catalysts for Runs 3 through 21 screened thru 150 x 400 mesh.

Table X

DATE: 09/30/94

M4 SBCR RUN RESULTS

COMPARISON OF CATALYST ACTIVITY AT SIMILAR RUN CONDITIONS

Period No.	Temp.	Pres.	H2/CO Ratio
-----	-----	-----	-----
5	240 C	600psi	1.0

a) Total flow is ca.15 L/min. STP, or 3 cm/sec linear gas flow.

b) Conversion is total CO conversion over the period (%).

Flows: N2-562 SLH, H2-119 SLH, CO-119 SLH

c) Conversion and selectivities are calculated using N2 as an internal standard in the GC analysis of the offgas.

d) Prod. rate: Rate for production of total hydrocarbons C1+ (kg/kg cat.,hr).

e) Alpha: Based on GC analysis of offgas and liquid product.

Run No	Cat. No	Cat. wt,g	Conv. %	Prod. Rate	Selectivities				Alpha GC	Alpha Liq	Olefin/Paraf		Olefin C6-18,%
---	---	---	---	---	%CH4	%C2	%C3+	%CO2	---	---	C3	C4	---
3	CO.002	15.2	12.9	0.92	4.0	1.5	93.5	0.91	0.81	0.82	4.29	2.75	24.5
4	CO.024	15.4	11.3	0.80	0.9	1.5	97.0	0.65	0.83	0.87	6.50	3.80	36.4
5	CO.035	15.4	10.7	0.76	0.7	1.4	97.1	0.75	0.84	0.88	6.25	4.50	27.3
6	CO.028	15.4	9.5	0.67	0.0	1.1	97.5	1.36	0.85	0.88	6.00	3.50	40.6
7	CO.043	15.4	5.9	0.41	0.0	2.2	94.8	2.99	0.82	0.89	6.00	3.75	30.1
9	CO.048	15.4	11.9	0.83	2.7	0.9	94.4	1.93	0.84	0.89	5.75	3.20	14.0
10	CAL.02	15.9	16.4	1.12	4.2	1.0	94.0	0.89	0.82	0.86	5.83	3.86	35.7
12	CO.053	15.9	15.6	1.06	4.0	0.9	94.0	1.0	0.82	0.87	5.50	3.57	32.2
13	CO.054	15.7	5.0	0.34	0.0	1.3	96.9	1.78	0.82	0.93	6.50	3.33	30.8
14	BlendA	20.0	14.1	1.02	3.7	1.0	93.8	1.45	0.82	0.89	6.40	3.43	32.9
15	CO.034	13.0	11.8	0.99	3.9	1.1	94.0	1.03	0.83	0.87	5.75	3.80	37.8
21	CO.004	15.9	18.4	1.26	6.1	1.1	91.9	0.94	0.81	0.84	5.25	2.91	32.2

Note: Catalysts for Runs 3 through 21 screened thru 150 x 400 mesh.