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TECHNOLOGY DEVELOPMENT FOR COBALT F-T CATALYSTS RECEIVED

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Prepared for:

U.S. Department of Energy
Pittsburgh Energy Technology Center
PETC Project Manager: Richard E. Tischer
P. O. Box 10940
Pittsburgh, PA 15236-0940

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Submitted by:

Principal Investigator: Alan H. Singleton
Energy International Corporation
135 William Pitt Way
Pittsburgh, PA 15238

March 21, 1996

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EXECUTIVE SUMMARY

The investigation of the effect of certain promoters (Fe, Pd, and Ru) on the deactivation characteristics of Co catalysts during F-T synthesis was continued during this reporting period. All catalysts were tested first at 220°C, then at higher temperatures from 240 to 280°C, while monitoring their deactivation. The choice of these promoters was based on their intrinsic ability to enhance the hydrogenation reactions while slowing down the Boudouard reaction under the conditions used in F-T synthesis. Olefin hydrogenation and CO dissociation reactions were used individually to investigate further the nature of the deactivation process of these catalyst during F-T synthesis. Hydrogenation of isobutene (IB) was carried out in the presence of CO between 120 and 180°C and atmospheric pressure. CO dissociation activities of the catalysts were measured using a pulse technique at 2.5 atm and at temperatures between 180 and 280°C with intermittent H₂ bracketing at 350°C. Promotion with high loadings of Fe or Pd resulted in catalysts with relatively lower activity and higher methane selectivity. The deactivation process and rate for catalysts containing Pd or Fe were similar to those of the non-promoted or Ru-promoted alumina-supported Co catalysts tested previously. The only exception was Co.068 with 1% Pd which had adequate activity and selectivity as well as lower deactivation rate at the various temperatures tested.

Promotion of Co catalyst with Ru doubled the isobutene hydrogenation activity at 120°C and more than tripled it at 180°C. Addition of Fe to CoRu almost completely reversed the effect of Ru and was more pronounced with increasing Fe concentration. The addition of Pd, however, led to a dramatic increase in the hydrogenation activity by more than an order of magnitude compared with the plain Co catalyst and still by a factor of 8 compared with CoRu catalysts. The results of the Boudouard reaction indicate that addition of increasing amounts of Fe to CoRu also gradually

decreased the CO dissociation activity. However, the promotion with 1% Pd instead of Ru showed practically no influence on CO₂ formation. Using 2% Pd, however, reduced the CO dissociation activity by a factor of 2.

During this reporting period, a number of runs were performed in the slurry bubble column reactor in order to evaluate the effect of certain promoters (Fe and Pd) on the deactivation characteristics of Co catalysts during F-T synthesis. The reaction was performed under standard conditions followed by high temperatures up to 300°C in order to evaluate the catalyst resistance to deactivation. The results indicate that the addition of Fe to cobalt catalysts can prevent their fast deactivation at high temperature. However, this promoter results in low overall activity catalysts with high selectivities for methane.

Another aging run was carried out successfully for ca. 850 h using Co/Al₂O₃ as the second catalyst selected for its low methane selectivity and adequate activity in the SBCR system. The reaction was carried out at 220°C and very little deactivation was observed under these conditions.

A series of four SBCR runs was made with an iron catalyst supplied by DOE/PETC that had been used in the F-T Run II at LaPorte, Texas, in 1995. The F-T synthesis was carried out under similar or close to conditions used at Laporte in order to evaluate the catalyst performance and see whether some of the problems encountered during the Laporte run could have been predicted from a bench scale reactor run.

Finally, four Co catalysts were run in a one liter autoclave at the Center for Applied Energy Research of the University of Kentucky, Lexington, Kentucky. Their performance in the CSTR was comparable to that observed previously in the SBCR.

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I. 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.

II. 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 H₂/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 pretreatment 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 pretreatment 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, pretreatment, and performance (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.

III. 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.

IV. SUMMARY OF WORK ACCOMPLISHED THIS QUARTER

TPR experiments using reduction with H_2 up to $900^\circ C$ were carried out on the modified, alumina-supported Co catalysts in order to investigate the effect of the various promoters or modifiers (Ru, Pd, and Fe) on cobalt reducibility and extent of reduction.

The investigation of the effect of certain promoters (Fe, Pd, and Ru) on the deactivation characteristics of Co catalysts during F-T synthesis was continued during this reporting period. All catalysts were tested first at $220^\circ C$, then at higher temperatures from 240 to $280^\circ C$, while monitoring their deactivation.

The investigation of the deactivation characteristics of a selected number of Co catalysts using olefin hydrogenation and Boudouard reaction was completed during this period. Hydrogenation of isobutene (IB) was carried out in the presence of CO between 120 and $180^\circ C$ and atmospheric pressure. CO dissociation activities of the catalysts were measured using a pulse technique at 2.5 atm and at temperatures between 180 and $280^\circ C$ with intermittent H_2 bracketing at $350^\circ C$.

During this reporting period, a total of 9 runs were performed in the slurry bubble column reactor. Out of these 9 runs, 3 runs were carried out to evaluate the effect of certain promoters (Fe and Pd) on the deactivation characteristics of Co catalysts during F-T synthesis. The reaction was performed under standard conditions followed by high temperatures up to $300^\circ C$ in

order to evaluate the catalyst resistance to deactivation. One SBCR run was carried out with a Co catalyst on alumina support that had been H_2 reduced and wax coated to evaluate this procedure for possible scale up for commercial applications. Another aging run was carried out successfully for ca. 850 h using a Co/Al_2O_3 .

A series of four SBCR runs was made with an iron catalyst supplied by DOE/PETC that had been used in the F-T Run II at Laporte, Texas. The F-T synthesis was carried out under similar or close to conditions used at Laporte in order to evaluate the catalyst performance and see whether some of the problem encountered during the Laporte run could have been predicted from a bench scale reactor run.

Four Co catalysts were run in a one liter autoclave at the Center for Applied Energy Research of the University of Kentucky, Lexington, Kentucky. Their performance in the CSTR was compared to the results obtained previously in the SBCR.

V. 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)

A list of all the catalysts formulated so far within Subtask 1.2 is given in Table 1 on page 19 with their compositions. No new catalysts were formulated or prepared during this period.

A list of all the catalysts formulated so far within Subtask 1.3 is given in Table 2 on page

25 with their composition.

c. Catalyst Characterization (Subtask 1.6)

Physical Properties

Table 3 on page 26 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.

Static Hydrogen Chemisorption

An updated summary of the properties of the Co catalysts as determined by H₂ chemisorption is given in Table 4 on page 30.

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 a previous quarterly report. All the TPR results obtained so far are summarized in Table 4 on page 30.

Figure 1 shows TPR traces obtained for the modified, alumina-supported Co catalysts during reduction with H₂ up to 900°C. The traces for the non-promoted and Ru only promoted catalysts (Co.005 and Co.053) are included for comparison purposes. Briefly, Ru was concluded to act as a reduction promoter by enhancing the reducibility at lower temperatures (note the shift of the reduction maxima by 100°C to lower temperatures), thereby increasing the total reducibility as well as the number of exposed metal atoms (see Table 4). In the TPR traces of Pd promoted Co catalysts (Co.067, Co.068) two low temperature reduction peaks at 70°C and at 164°C for Co.067 (137°C for Co.068) were observed. Additionally an intense peak at 370°C with expressed

tailing at higher temperatures was observed for Co.067. With higher Pd loading, the high temperature tailing was transformed into a broad reduction peak at 550°C extending beyond 700°C. In parallel, the peak at 70°C gained intensity whereas the second low temperature peak lost some intensity and was shifted somewhat to lower temperature. The total reducibility of the catalysts (<900°C) decreased with increasing Pd loading and was always lower than that of the Ru promoted ones. CoRuFe catalysts (Co.066 and CoW.10) exhibited one intense reduction peak at ca. 330°C. Additionally, the catalyst containing 10 wt% Fe exhibited a shoulder at 470°C. Although a low temperature shoulder at around 200°C was observed for Co.066, a separate low temperature peak as was the case with Ru or Pd promoted samples was not observed. With increasing Fe content the reducibility of the catalysts up to 900°C decreased.

B. TASK 2: CATALYST TESTING

a. Subtask 2.1 - Fixed Bed Reaction Studies:

The investigation of the effect of certain promoters (Fe, Pd, and Ru) on the deactivation characteristics of Co catalysts during F-T synthesis was continued during this reporting period using Co.068, Co.069 and CoW.10. For this purpose, the reaction was initiated at the standard reaction temperature of 220°C (The standard reaction conditions and procedure used for testing most catalysts were described in previous quarterly reports) and allowed to proceed for ca. 20 h to reach steady-state. After dilution of the reactant stream with Ar ($H_2/CO/Ar = 2/1/1$), the temperature was increased to 280°C or another desired temperature over a period of 2.5 h and CO hydrogenation was continued at this new temperature for another 20-40 h. The performances of all these catalysts (highlighted in Table 5) at steady state are compared in Table 5 on page 34 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 A.

As indicated in the previous quarterly report, the deactivation process and rate for catalysts containing Pd or Fe (Co.066-Co.068) were similar to those of the alumina-supported catalysts tested previously (Co.005 and Co.053), and none of the promoters helped to slow down the rate of carbon formation at high temperatures above 240°C. In addition, promotion with high loadings of Fe or Pd resulted in catalysts with relatively lower activity and higher methane selectivity. All these catalysts were tested as indicated, first at 220°C than at 280°C, while monitoring their deactivation. The only exception was Co.068 with 1% Pd which had adequate activity and selectivity as well as lower deactivation rate at the various temperatures tested (240, 260 and 280°C). Figures 2-14 illustrate the effect of temperature and time-on-stream on CO conversion and rates of total hydrocarbon and C6+ formation for the various catalysts tested.

Co.069 with high Ru loading (2 wt%) did not show any improvement in performance over the catalysts with lower Ru loadings (0.5 wt%).

The investigation of the deactivation characteristics of a selected number of Co catalysts using olefin hydrogenation and Boudouard reaction was completed during this period. Hydrogenation of isobutene (IB) was carried out in the presence of CO between 120 and 180°C and atmospheric pressure. The reactant feed consisted of 7.1% IB, 28.3% H₂, 1% CO, with helium being the balance. The catalysts were reduced *in situ* in flowing hydrogen at 350°C for 10 h prior to reaction. After helium purge for 30 min, reaction was initiated at 120°C. In order to

limit the impact of deactivation, only two samples were taken at every temperature after 5 and 15 min on-stream and the catalyst was bracketed with H_2 for 30 min while raising the temperature. After having obtained data at the highest desired reaction temperature of 180°C, the catalysts were cooled to 120°C under H_2 and the hydrogenation activity was measured again. This procedure ensured that cumulative deposition of carbonaceous species on the surface did not occur since all catalysts gave identical hydrogenation rates at 120°C before and after determination of activation energies. Analysis of the reaction products was carried out with an on-line GC equipped with a packed column (0.19% picric acid on Carbosphere) and FID. Under our reaction conditions, no products other than isobutene, isobutane and methane were detected with all catalysts.

The results of the determination of the hydrogenation activity of the catalysts studied are compiled in Table 6 on page 40. During hydrogenation of isobutene in the presence of CO, isobutane was the only reaction product observed up to 160°C reaction temperature. At 180°C small amounts of methane were formed (<1%) which judging from the lack of other reaction products did not originate from hydrogenation of isobutene but rather from onsetting methanation of some dissociated CO. In the absence of CO, all catalysts showed complete conversion of isobutene to isobutane at 120°C. Promotion of Co catalyst with Ru doubled the hydrogenation activity at 120°C and more than tripled it at 180°C. Addition of Fe to CoRu almost completely reversed the effect of Ru as can be seen by the comparable values for Co.005 and Co.066 catalysts and was more expressed with increasing Fe concentration (CoW.10). The addition of Pd (Co.067, Co068), however, led to a dramatic increase in the hydrogenation activity by more than an order of magnitude compared with the plain Co catalyst and still by a factor of 8 compared with CoRu catalysts (Co.053 and Co.069). The apparent energies of activation measured for all the catalysts

were in the range of 90 kJ/mol and varied only subtly by about 7 kJ/mol suggesting a similar reaction pathway on all catalysts.

CO dissociation activities of the catalysts were measured using a pulse technique. A 1/4" stainless steel U-tube was used as reactor in which a 1/8" tube and a 1/8" thermocouple were inserted to reduce the void volume. Using an Altamira AMI-1 system, 500 μ l pulses of CO in 72 cc/min He were contacted with 50-150 mg of the reduced catalyst at 2.5 atm and at temperatures between 180 and 280°C with intermittent H₂ bracketing at 350°C. The amount of catalyst used was adjusted to obtain approximately one monolayer coverage by one CO pulse with respect to the number of metal atoms exposed on the surface. The reactor effluent was continuously fed through a 3 ft Porapak-Q column which ensured separation of CO and CO₂. Detection was carried out with an on-line TCD. The rates of CO dissociation were calculated from the conversion of CO to CO₂ per pulse, assuming a contact time of the complete CO pulse with the catalyst according to the residence time of the pulse.

Table 7 on page 41 shows the results for the Boudouard reaction on modified Co catalysts. Since the rate of conversion decreased for subsequent CO pulses without intermediate H₂ bracketing only the first pulse was used for the calculation of rates. Although the accuracy of the data was generally satisfactory for Co catalyst the intrinsic low activity caused problems in determining the rate. Therefore, the rate was determined by averaging 5 CO pulses at each temperature between 240 and 260°C and extrapolating the value to the desired reaction temperature of 220°C using the Arrhenius equation. The data for Co catalyst, thus represent activities for a partially deactivated catalyst and exhibit a greater error due to the extrapolation. This may also explain the ca. 20 fold difference between the plain Co catalyst and the Ru

promoted ones. Based on this and the results for CoRu catalysts, the rate of CO₂ formation seems to correlate well with the amount of metal atoms exposed on the catalyst surface. Addition of increasing amounts of Fe to CoRu also gradually decreased the CO dissociation activity. The promotion with 1% Pd instead of Ru showed practically no influence on CO₂ formation. Using 2% Pd, however, reduced the CO dissociation activity by a factor of 2. The apparent energies of activation were around 106 kJ/mol $\pm$ 10 kJ/mol for all catalysts. This again suggests identical elementary pathways for CO₂ formation on all catalysts investigated.

b. Subtask 2.2 - Slurry Bubble Column Testing (SBCR)

1. Run Chronology

During this reporting period a total of 9 runs were performed in the SBCR's, Runs M3-48 through 53, plus Run 55 and M4-37,38. A chronology of the experimental runs performed in the two slurry bubble column reactors - M3 and M4 - is given in Appendix B. All comparisons of CO conversion and CH₄ selectivities discussed in this chronology were obtained from results obtained at the initial startup conditions -- 240°C temperature, 450 psi pressure, and 2/1 H₂/CO feed gas ratio.

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 2 to 50 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 were prepared to compare catalyst activities for Runs 3 to 38 in M4-SBCR at the same run conditions (see Tables VII, VIII, IX, and X in Appendix C). A summary of all runs using catalysts made by Calsicat is given in Table XI, Appendix C.

Four catalysts were sent to the Center for Applied Energy Research of the University of

Kentucky at Lexington, Kentucky, and have been run in their one liter autoclave. The complete run results have been tabulated and are included in Appendix D along with a flow diagram of the autoclave system.

2. Discussion of Results

(a) Miscellaneous Runs Made to Evaluate the Effects of Higher Temperatures on Selected Catalysts

One run was made with a catalyst containing 10% Co, 10% Fe, and 0.5% Ru on alumina support (see Run 48 in M3-SBCR in Table 8 on page 42). The CO conversion at startup conditions (240°C) was low, 8.5%, with a CH₄ selectivity of 10.8%, and THC production rate of 0.39 gm C₁+ / gm cat / hr. The CO conversion jumped considerably after each temperature, but decreased to a lower level after 24 hours (see Figure 14). The THC production rate increased correspondingly with each temperature change (see Figure 15), while the CH₄ selectivity greatly increased with temperature (see Figure 16). The CO conversion dropped to 2.6% when the temperature was lowered to 240°C. This catalyst showed low resistance to deactivation at higher temperatures.

A second run was made with a catalyst containing 20% Co and 1% Pd on alumina support. The CO conversion was higher (26.7%) at startup conditions than the previous catalyst (see Run 49 in M3-SBCR in Table 8). The CO conversion and THC production rate peaked at 280°C and began to drop at 300°C (see Figures 17 and 18). The CH₄ selectivity continued to increase significantly, up to 60%, with temperature (Figure 19). The conversion dropped to 3.8% when returned to 240°C. This catalyst also showed low resistance to deactivation at higher temperatures.

A third run was made at these higher temperatures with a catalyst containing 15% Co, 5% Fe, and 0.5% Ru on alumina (see Run 50 in Table 8). The CO conversion at startup conditions was

21.1% with a CH₄ selectivity of 11.3%, which are both in the range expected for a 15% Co catalyst. The CO conversion and THC production rate peaked at 280°C and began to drop at 300°C (see Figures 20 and 21). The CH₄ selectivity increased at each temperature level and peaked at 42% at 300°C (see Figure 22). The CO conversion dropped to 3.2% when the reaction temperature was lowered to 240°C.

These catalysts are typical of other cobalt catalysts which have good initial catalytic activity, but deactivate fairly rapidly at reaction temperatures of 240°C and higher due to carbon or coke formation. Addition of Fe does not appear to help reduce the activity loss.

(b) Tests Made to Test the Laporte F-T Iron Catalyst in the SBCR

Four runs were made with an iron catalyst that was used in the F-T Run II at Laporte, Texas. The startup conditions and activation procedure for this iron catalyst are given in Table 9 on page 43.

The first run, Run 51, was reduced in-situ as prescribed and the run conditions were changed to the baseline conditions: 175 psi pressure, 270°C reaction temperature, and a total gas feed space velocity of 3,335 sl/hr/Kg-Fe (see Table 10 on page 45). After 24 hours on-stream, the reactor temperature was raised to 300°C, the pressure to 600 psi (maximum pressure achievable in the SBCR), and the gas space velocity to 15,517 sl/hr/Kg-Fe. After 5 hours at these run conditions, the bottom reactor temperature rose to 437°C. Within 2 hours, the reactor plugged near the bottom just above the inlet filter. The run was terminated and the reactor was cleaned out.

A second run, Run 52, was charged and the catalyst was reduced in-situ the same as the previous run. Several run periods were made in which the temperature was raised from 270°C to 280°C, 290°C, and 300°C at 450 psi pressure and a total gas rate of 900 SLH with a H₂/CO ratio of 2/1 (see Table 11 on page 46). The reactor pressure was raised to 600 psi and then the H₂/CO ratio

was changed to 1/1. Within 2 hours, the temperature in the top section that contains the internal filter began to increase rapidly. The reactor heaters were turned off and the syngas flow was stopped, but the temperature increased above 350°C and the reactor plugged in the top section. The unit was shut down and cleaned out again.

A third run, Run 53, was charged and started the same as the previous two runs (see Table 12 on page 47). The base case conditions were the same as the previous two runs except the H₂/CO feed ratio was 1/1. Several run periods were made in which the temperature was raised from 270°C to 280°C, 290°C, and 300°C at 450 psi pressure and total gas rate of 900 SLH with the 1/1 H₂/CO ratio. The H₂/CO ratio was lowered to 0.7/1 and the reactor pressure was raised to 600 psi. Over a period of 4 hours, the reactor temperature gradually increased until it reached 360°C at which time the reactor plugged again in the top section near the internal filter.

The fourth run, Run 55, was charged with the same iron catalyst and reduced in-situ the same as the preceeding three runs. A total of four run periods were completed when the reactor plugged after the reaction conditions had been raised to 300°C and 500 psi (see Table 13 on page 48).

Synfluid was not fed continuously during any of the above four runs. Some synfluid was added daily to try to maintain the liquid slurry height in the reactor. Since there is no way to remove the heat of reaction except by changing the gas feed rates, there was little we could do to stop the reactor temperature from running away once it got started, particularly during the time the unit was unattended. It is obvious to us now that the heat removal capabilities of our unit had been exceeded, and the operation requires a technician on duty whenever the more severe operating conditions are reached so proper actions can be taken to prevent plugging of the reactor.

Table 14 on page 49 compares the most pertinent data obtain during the above iron catalyst

runs and the results obtained in Laporte with the same catalyst.

(c) Subtask 4.1 - Low Methane Catalyst Aging Studies

Run No. 37 was started in the M4-SBCR on August 14th with a charge of 25.0 gm of Catalyst No. Co.005. This catalyst is a base case catalyst containing 20% Co on an alumina support with no promoters. A complete summary of all the run conditions and results is given in Table 15 on page 50. Also, the CO conversion, THC production rate, and CH₄ selectivity vs. hours into run are plotted in Figures 23, 24, and 25.

The CO conversion at 215°C was too low, 8.0%, so the reaction temperature was raised to 220°C where the CO conversion leveled out at 14.4%. The THC production rate averaged 0.42 gm C₁+/gm cat/hr and the CH₄ selectivity was approximately 4.0%. The synfluid flow rate was stopped after 446 hours on stream. The CO conversion had decreased to 12.5% at this time, and the THC rate dropped to 0.36 gm C₁+/gm cat/hr while the CH₄ selectivity had increased to 5.0%.

At 449 hours, the N₂ feed rate was lowered from 62% to 40% of the total gas feed rate and the H₂ and CO feed rates were increased at a 2/1 ratio while maintaining the same total gas feed rate. The CO conversion dropped to 8.6%, but the THC production rate increased to 0.41 gm/gm/hr, and the CH₄ selectivity jumped to 10.4%. These conditions were held for 240 hours and the CO conversion dropped to 7.6%, the THC production rate to 0.36 gm/gm/hr while the CH₄ selectivity averaged 10.8%. The higher concentration of CO plus H₂ in the reactor tends to increase the CH₄ production rate.

At 663 hours on stream, the H₂/CO ratio was changed to 1.5/1 while maintaining the same total gas feed rate. The CO conversion dropped to 5.6%, THC production rate to 0.32 gm/gm/hr, and the CH₄ selectivity dropped to 8.4%.

The N₂ feed rate was lowered from 40% to 33% while maintaining the same total feed gas rate at 687 hours on stream. The CO conversion dropped again to 4.8%, the THC rate went down to 0.29 gm/gm/hr while the CH₄ selectivity rose up to 10.3%. The synfluid feed was restarted at 735 hours on stream. The CO conversion rose to 5.6%, the THC went up to 0.35 gm/gm/hr, and the CH₄ selectivity dropped to 8.6%. There is some beneficial effect of adding synfluid continuously during the operation. As seen above, reducing the N₂ concentration in the feed gas results in increased CH₄ selectivity.

At 759 hours the reaction conditions were returned to the initial conditions for Period 3. The CO conversion averaged 10.4%, the THC was 0.31 gm/gm/hr, and the CH₄ selectivity dropped to 4.7%. This was a loss of about 28% of the initial catalyst activity after 806 hours on stream.

The run was extended for one more day to check the catalyst activity at 33% N₂ feed rate at a 1.5/1 H₂/CO feed ratio. The CO conversion returned to about the same value, 4.5% vs. 4.8%, the THC to 0.28 gm/gm/hr vs. 0.29, and the CH₄ selectivities were similar, 9.7% vs. 10.3%. This run was shut down on September 18th after 830 hours of successful operation.

(d) Evaluation of Wax Coated Catalyst from Calsicat

Run No. 38 was made in M4-SBCR with a charge of a selected catalyst on alumina support that had been H₂ reduced and wax coated to evaluate this procedure. The catalyst activity was about 90 to 95% of a similar catalyst that had been H₂ reduced in a fluidized bed reactor and charged into the SBCR in a slurry protected under nitrogen (see Runs 33 and 38 in Table XI in Appendix C). The catalyst activity was much higher than three other batches of catalyst that were H₂ reduced and wax coated. Improvements were made in the H₂ reduction procedure. This procedure for reducing and inerting the catalyst would make it easier and more economical for charging large batches of catalyst

into a large commercial reactor.

3. Catalyst Recovery Analyses

The catalysts charged for all runs, except Runs 28, 30, and 33 in M3 and Runs 4, 20, and 29 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 16 on page 51. The charge weights are in the H_2 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 16. 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 16.

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 the M4-SBCR in Table 16).

Eleven 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 16). 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.

Subtask 2.3 - CSTR Testing

Four catalysts that had been sent to the Center for Applied Energy Research of the University of Kentucky at Lexington, Kentucky have been run in a one liter autoclave. A comparison of performance of these cobalt catalysts in the SBCR and CSTR is given in Tables 17 and 18 on pages 55-56. The complete selectivity and rate data are given in four tables in Appendix D.

The highest total flow rate which could be achieved in the CSTR was 5 Sl/min, i.e., one third of that used as a standard flow rate in the SBCR. Lower flow rates as low as 90 l/min were also tested in order to achieve maximum conversion (up to 99% CO conversion with CAL.13). A comparison of the data from both the CSTR and the SBCR (Tables 17-18) indicate that the CO conversion rates obtained with all the catalysts are within experimental error similar. These results indicate that the reaction in the SBCR was not mass transfer limited.

VI. PLANS FOR THE NEXT REPORTING PERIOD

Additional runs will be made in the SBCR in order to complete the evaluation of all the catalysts formulated for this project. The writing of the final report will be continued.

VII. ASSESSMENT OF PROSPECTS FOR FUTURE PROGRESS

The technical approach which has 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%	0.00	0.00	γ -alumina	Base Catalyst	P
Co.005A	20%	0.4% Ru	0.00	γ -alumina	Ru added to calcined Co.005 by IW impreg.	P
Co.006	12%	0.75% Re	0.00	Titania	U.S. Pat. 4,794,009	P
Co.007	20%	0.00	0.00	Titania	Base Catalyst	P
Co.008	20%	0.00	0.00	Silica	UK Pat. Appl. GB 2 125 062 A (Kneaded with excess liquid)	P
Co.009	20%	0.5% Ru	0.00	γ -alumina	Ru-Promoted Catalyst (use Ru Chloride, single-step aqueous IW)	P
Co.010	20%	0.00	0.00	γ -alumina	Base Catalyst (non-calcined)	P
Co.010A	20%	0.4% Ru	0.00	γ -alumina	Ru added to dried Co.010 by IW impreg.	P
Co.011	20%	0.00	0.00	Silica	UK Pat. Appl. GB 2 125 062 A (Kneaded)	P
Co.012	20%	0.00	0.00	Silica	Base Catalyst (Inc. Wetness)	P
Co.013	20%	0.00	0.00	Titania	Base Catalyst like Co.007, but all aqueous	P
Co.014	12%	0.5% Ru	0.00	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

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

CAT. NO.	wt% Co	wt% M	wt% Prom.	Support	Basis	Prepared
Co.016	20%	0.43% Ru	1% La ₂ O ₃	γ -Alumina	Similar to Co.015, but calcined after Co impregnation	P
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	0.00	γ -Alumina	Ru-Promoted Catalyst (single-step, aqueous IW)	P
Co.019	20%	0.5% Ru	0.00	Silica	Ru-Promoted Catalyst (single-step, aqueous IW)	P
Co.020	0.00	0.5% Ru	0.00	γ -Alumina	Ru Base Catalyst	P
Co.020A	20%	0.4% Ru	0.00	γ -Alumina	Co added to dried Co.020 by IW impreg.	P
Co.020B	20%	0.4% Ru	0.00	γ -Alumina	Co added to reduced Co.020 by IW impreg.	P
Co.020C	20%	0.4% Ru	0.00	γ -Alumina	Co added to calcined Co.020 by IW impreg.	P
Co.021	20%	0.00	0.7% Zr	Silica	U.K. Pat. Appl. GB 2 125 062 A (single-step, aqueous kneaded)	P
Co.022	20%	0.00	0.7% Zr	Silica	U.K. Pat. Appl. GB 2 125 062 A (aqueous, multiple-steps, kneaded Co pre-impregnation, IW Zr)	P
Co.023	20%	0.00	1.4% Zr	Silica	U.K. Pat. Appl. GB 2 125 062 A (aqueous, multiple-steps, kneaded Co pre-impregnation, IW Zr)	P
Co.024	20%	0.00	8.5% Zr	Silica	Eur. Pat. Appl. 0 167 215 A2 (non-aqueous, IW, multiple-steps, Zr pre-impregnation)	P
Co.025	20%	0.00	8.5% Zr	Silica	Similar to Co.024 but aqueous Zr pre-impregnation	P

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

CAT. NO.	wt% Co	wt% M	wt% Prom.	Support	Basis	Prepared
Co.026	20%	0.00	0.00	Silica (Davison Grade 59)	Similar to Co.012 but different grade silica	P
Co.027	20%	0.5% Ru	0.00	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
Co.030	20%	0.00	0.1% Zr	γ -alumina	Zr-Promoted Catalyst (single-step aqueous IW)	P
Co.031	20%	0.00	1.4% Zr	γ -alumina	Zr-Promoted Catalyst (single-step aqueous IW)	P
Co.032	20%	0.00	8.5% Zr	γ -alumina	Zr-Promoted Catalyst (single-step aqueous IW)	P
Co.033	20%	0.00	8.5% Zr	γ -alumina	Multiple-steps, aqueous IW, Co pre-impregnation	P
Co.034	20%	0.00	8.5% Zr	γ -alumina	Multiple-steps, aqueous IW, Zr pre-impregnation	P
Co.035	20%	0.00	8.5% Zr	Silica	Zr-Promoted Catalyst (single-step aqueous, kneaded)	P
Co.036	20%	0.00	8.5% Zr	Silica	Multiple-steps, aq. Co pre-impreg. by kneading, aqueous IW Zr impreg.	P
Co.037	12%	0.00	0.00	Titania	Similar to Co.013, but TiO ₂ mainly anatase	P
Co.038	12%	0.5% Ru	0.00	Titania	Similar to Co.014, but TiO ₂ mainly anatase	P
Co.039	12%	0.00	0.00	Titania	Similar to Co.007, but only 12% Co	P
Co.040	12%	0.00	0.00	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

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

CAT. NO.	wt% Co	wt% M	wt% Prom.	Support	Basis	Prepared
Co.042	0.00	0.00	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%	0.00	15% Zr	Silica	Similar to Co.025, but 15% Zr	P
Co.045	20%	0.00	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	-
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	0.00	0.5% Ru	0.00	Titania (R)		P
Co.052	0.00	0.5% Ru	0.00	Titania (A)		P
Co.053	20%	0.5% Ru	0.00	γ -alumina	Similar to Co.018 (New Batch)	P
Co.054	20%	0.00	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%	0.00	8.5% La ₂ O ₃	Silica	Similar to Co.025, but La instead of Zr	P
Co.057	20%	1% Re	1% La ₂ O ₃	Silica	Similar to Co.055, but with SiO ₂ support	P
Co.058	20%	0.00	1% La ₂ O ₃	γ -alumina	Similar to Co.055, but without Re (one-step impreg.)	P
Co.059	20%	0.00	1% La ₂ O ₃	γ -alumina	Similar to Co.015, but without Re (two-step impreg.)	P
Co.060	30%	0.00	0.00	γ -alumina	Similar to Co.005, but with 30% Co	P
Co.061	30%	0.5% Ru	0.00	γ -alumina	Similar to Co.053, but with 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.062	30%	0.5% Ru	1.5% K	γ -alumina	Similar to Co.029, but with 1.5% K	P
Co.063	20%	0.00	8.5% La	γ -alumina	Multiple-steps, aqueous IW, La pre-impregnation	P
Co.064	20%	0.5% Ru	8.5% Zr	γ -alumina	Multiple-steps, aqueous IW, Zr pre-impregnation	P
Co.065	20%	0.5% Ru	8.5% Zr 0.3% K	γ -alumina	Multiple-steps, aqueous IW, Zr pre-impregnation	P
Co.066	15%	0.5% Ru, 5.0% Fe	0.00	γ -alumina	Ru- and Fe-Promoted Catalyst (single-step, aqueous IW)	P
Co.067	20%	2.0% Pd	0.00	γ -alumina	Pd-Promoted Catalyst (single-step, aqueous IW)	P
Co.068	20%	1.0% Pd	0.00	γ -alumina	Similar to Co.067, but with 1% Pd	P
Co.069	20%	2.0% Ru	0.00	γ -alumina	Similar to Co.053, but with 2% Ru	P
Co.070	13%	0	0.00	γ -alumina	Similar to Co.005, but with 13% Co	P
CAL.01 (97E-13E)	20%	0.5% Ru	0.00	γ -alumina	Similar to Co.018 (Calsicat Prep.)	P
CAL.02 (97E-16B)	20%	0.5% Ru	0.00	γ -alumina	Similar to CAL.01 (New Batch)	P
CAL.03 (97E-13F)	20%	0.5% Ru	0.00	γ -alumina	Multiple-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 1. List of Co-based FT Catalysts Formulated (contd.)

CAT. NO.	wt% Co	wt% M	wt% Prom.	Support	Basis	Prepared
CAL.09 (97E-69C)	20%	0.5% Ru	0.3% K	γ -alumina	Similar to CAL.05, Reduced and Protected in Soya (51.7% Cat. Conc.)	P
CAL.10 (97E-79A)	20%	0.5% Ru	0.3% K	γ -alumina (Condea)	Similar to CAL.05, but on Condea Al_2O_3	P
CAL.11 (29F-07B)	20%	0.5% Ru	0.3% K	γ -alumina	Similar to CAL.05	P
CAL.12 (29F-05D)	20%	0.5% Ru	0.3% K	γ -alumina	Similar to CAL.05	P
CAL.13 (29F-07E)	20%	0.5% Ru	0.3% K	γ -alumina	Similar to CAL.05	P
Fe.01	0%	30%Fe	1.5%Cu	Silica		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	P
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
CoW.08	30%	5.0% Cu	4.0% Cr	γ -alumina	Similar to CoW.05, but with 30% Co	P
CoW.09	20%	10.0% Cu	8.0% Cr	Silica	similar to CoW.06, but with 10% Cu and 8% Cr	P
CoW.10	10% Co, 10% Fe	0.5% Ru	0	γ -alumina	Single Step, IW	P
CoW.11	10% Co, 10% Fe	0.5% Ru	0.5% K	γ -alumina	Single Step, IW	P
CoW.12	10% Co, 10% Fe	0.5% Ru	0	Silica	Single Step, IW	P
CoW.13	10% Co, 10% Fe	0.5% Ru	0	γ -alumina	Similar to CoW.10 (2nd batch)	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	
Condea Al ₂ O ₃	(as received)	219	0.53	97	77
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				78
Co.005	20Co/A	173	0.34	81	65 86
Co.006	12Co/0.75Re/T	16	-	-	121
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

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.013	20Co/T				
Co.014	12Co/0.5Ru/T	15	0.12	328	111
Co.015	20Co/0.43Ru/ 1La ₂ O ₃ /A	141	-	-	67
Co.016	20Co/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	74
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	87
Co.026	20Co/S(59)	184	-	-	
Co.027	20Co/S(59)	189	-	-	
Co.028	20Co/0.5Ru/0.5K/A	161	0.33	82	80
Co.029	30Co/0.5Ru/0.5K/A	140	-	-	76
Co.031	20Co/1.4Zr/S				75
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	89
Co.036	20Co/8.5Zr/S	209	-	-	
Co.037	12Co/T(A)	38	-	-	
Co.039	12Co/T(R)	13	-	-	
Co.040	12Co/T				130
Co.041	20Co/0.5Ru/8.5Zr/S	214	-	-	-
Co.044	20Co/15Zr/S				92

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.047	20Co/0.5Ru/0.3K/A	162	0.31	78	83
Co.048	20Co/0.5Ru/0.3K/ 8.5Zr/S				82
Co.049	20Co/0.5Ru/0.3K/A				81
Co.053	20Co/0.5Ru/A				75
Co.054	20Co/0.3K/8.5Zr/S				101
Co.055	20Co/1Re/ 1La ₂ O ₃ /A				86
Co.056	20Co/8.5La ₂ O ₃ /S				100
CAL.01	20Co/0.5Ru/A	178	0.34	76	
CAL.02	20Co/0.5Ru/A	158	-	-	74
CAL.03	20Co/0.5Ru/A	158	-	-	
CAL.04	20Co/0.5Ru/0.3K/A	151			72
CAL.05	20Co/0.5Ru/0.3K/A	163			73
CAL.06	20Co/0.5Ru/0.3K/A	162			72
CAL.07	20Co/0.5Ru/0.3K/A	-			
CAL.08	20Co/0.5Ru/0.3K/A	-			63
CAL.09	20Co/0.5Ru/0.3K/A				63
CAL.10	20Co/0.5Ru/0.3K/A	142	-	-	83
CAL.11	20Co/0.5Ru/0.3K/A	177	0.34	76	72
CAL.12	20Co/0.5Ru/0.3K/A	175	0.33	75	73
CAL.13	20Co/0.5Ru/0.3K/A	172	0.33	77	81
WGS.02	5Cu/A	159	-	-	-
WGS.03	5Cu/4Cr/A	190	-	-	-
CoW.01	20Co/5Cu/10Zn/A	121	-	-	-

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)
CoW.02	10Co/5Cu/4Cr/A	137	0.27	79	-
CoW.05	20Co/5Cu/4Cr/A	87	0.26	120	-

Table 4. H₂ Chemisorption^a and TPR Results

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. catal.)	% 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 ^f	(1) 205 (1) 147 (1) 167 (2) 126 (3) 132 (4) 144 (5) 136	185 - - - 116 123 122	6.9 9.6 8.4 11.1 10.6 9.8 10.3	12.1 7.4 8.4 6.3 6.6 7.2 6.8	91 - - 64 55 46 41	
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 ^g	(1) 146 (2) 181 (2) 194	124 - -	11.7 7.8 7.2	8.6 9.1 9.7	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
Co.018Cl ^h					95	

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. catal.)	% Red. ^d (stand. red.)
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		
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	53	1.4		

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. catal.)	% Red. ^d (stand. red.)
Co.041	70	55		4		
Co.043	137	109		8	86	
Co.047	146	-	9.6	7.3		
Co.053 ⁱ	(1) 168 (2) 101 (3) 138	139 76 117	8 14 10	8.4 5.2 6.9	97 82 47	
Co.054					57	
Co.055 ^j	(1) 165 (2) 179 (3) 103 (4) 192	139 163 84 165	8.5 8 14 7	8.3 9.0 5.2 9.6	78 50 76 -	
Co.056					58	
Co.60	65		14.4	2.1		
Co.61	277		7.6	9.2		
Co.66	-		-	-	81	
Co.067	-		-	-	88	
Co.068	-		-	-	76	
Co.069	167		8.0	8.4	98	
CoW.10	-			--	71	
CAL.01	169	-	8.3(5.8°)	4.4°	54	
CAL.02	-	-	(6.3°)	5.1°	55	
CAL.03	-	-	5.7°	4.2°	85	
CAL.04	93		15.1(5.5°)	3.5°		
CAL.05	100		14.1(5.6°)	4.4°		
CAL.06			5.7°	4.2°		
CAL.10			7.2°	3.7°		
CAL.11	171		8.3	8.5		

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. catal.)	% Red. ^d (stand. red.)
CAL.12	146		9.6	7.3		
CAL.13	180		7.8	9.0		

(a) static H₂ chemisorption at 100°C

(b) Est. assuming $H_{tot}/Co_s = 1$, $5.46 \times 10^{-20} \text{ m}^2/Co_s$, 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) (1)=uncalcined; (2)=flow calcined in air and reduced in H₂; (3)=ROR (4)=calcined in He; (5)=calcined in nitrogen

(g) (1)=flow calcined in air; (2)=uncalcined

(h) Co.018Cl = Chlorinated Co.018

(i) (1)=flow calcined in air; (2)=uncalcined; (3)=ROR

(j) (1)=calcined in air; (2)=calcined in nitrogen; (3)=uncalcined; (4)=ROR

Table 5. Summary of Fixed Bed Reactor Data

Catalyst	Run	Prep	CO Conv (%)	Rate g CH ₂ /g cat/h	R-C6+ g CH ₂ /g cat/h	R (CO) mol/mol Co/s	wt% CH ₄	alpha	CO ₂ (%) (CO)	g/g cat/h	E act kcal/mol	Comment
Co.001	4	(1)	2.6	0.116	0.056	6.8E-04	19.6	0.76	0.4	0.061		NSH**
Co.002	4	(2)	6.7	0.258	0.082	1.5E-03	26.1	0.64	0.1	0.012		NS
Co.003	1	(3)	5.5	0.185	0.044	1.1E-03	30.8	0.57			28.9	old startup
Co.004	1	(2) s	4.3	0.291	0.086	1.7E-03	30.4	0.62	0.1	0.025	25.9	NSH
"	2	u	11.2	0.517	0.155	3.0E-03	28.9	0.61	0.1	0.038		NSH
"	2h	u	47.6	0.548	0.211	3.2E-03	21.9	0.64	2.3	0.090		NSH, high conv. study
"	2a	f	3.8	0.177	0.063	1.0E-03	25.5	0.65	0.1	0.024		NSH, calc. after run2, T surge
"	3	u	6.7	0.499	0.153	2.9E-03	27.8	0.61	0.1	0.036		NSH
"	3h	u	27.0	0.506	0.164	3.0E-03	27.3	0.62	0.8	0.048		NSH, high conv. study
"	4	u	1.8	0.427	0.241	2.5E-03	24.0	0.79	0.1	0.078		NSH, 10 atm
"	5	f	4.5	0.288	0.150	1.7E-03	19.4	0.75	0.1	0.03		NSH
"	6	n	6.9	0.466	0.151	2.7E-03	27.8	0.61	0.2	0.044		NSH
"	7	ROR	3.9	0.225	0.072	1.3E-03	28.8	0.61	0.2	0.042		NSH
"	8	He	5.8	0.399	0.144	2.3E-03	27.2	0.66	0.1	0.028		NSH
Co.005	2	(1)	3.3	0.087	0.037	5.1E-04	21.4	0.66	0.1	0.005		NS
"	2a		2.5	0.066	0.021	3.9E-04	25.9	0.59	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	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	0.1	0.013		NSH
"	4		4.0	0.069	0.021	4.0E-04	30.0	0.62	0.2	0.009	25.1	NSH
"	5		3.9	0.171	0.084	1.0E-03	26.8	0.76	0.1	0.018		NSH, 10 atm
"	6		2.1	0.129	0.044	7.6E-04	25.7	0.64	0.1	0.017		NSH
"	7		6.7	0.084	0.040	4.9E-04	18.8	0.70	0.1	0.003		S2
"	8		2.7	0.154	0.067	9.0E-04	22.6	0.71	0.1	0.019		D (1:2), NSH
"	8a		2.5	0.140	0.059	8.4E-04	23.4	0.72	0.1	0.019		Ar added to rxn mix
"	8b		4.2	0.239	0.045	1.4E-03	40.0	0.60	0.1	0.032		Rxn @ 240 °C
"	8c		3.5	0.196	0.026	1.1E-03	49.6	0.59	0.1	0.049		Rxn @ 260 °C
"	8d		2.5	0.140	0.059	8.4E-04	23.4	0.72	0.1	0.019		Rxn @ 280 °C
"	9		1.5	0.082	0.025	4.8E-04	27.7	0.60	0.1	0.014		D (1:4), NSH
"	9a		1.4	0.075	0.020	4.4E-04	29.9	0.61	0.1	0.016		Ar added to rxn mix
"	9b	(1)	1.4	0.078	0.004	4.5E-04	62.9	0.58	0.3	0.055		Rxn @ 280 °C
"	10		1.9	0.106	0.045	6.2E-04	23.0	0.70	0.1	0.016		D (1:2), NSH
"	10a		1.6	0.090	0.024	5.3E-04	25.3	0.68	0.1	0.017		Ar added to rxn mix
"	10b		1.8	0.100	0.005	5.9E-04	48.0	0.65	0.2	0.037		Rxn @ 280 °C
"	10c		0.4	0.024	0.010	2.3E-04	25.9	0.76	0.1	0.013	13.8	at 220 after rxn @280
Co.005a	1	(4a)	3.2	0.227	0.067	1.3E-03	30.0	0.60	0.1	0.034		NSH
Co.005b	1	(1)	2.4	0.040	0.024	2.3E-04	13.9	0.74	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	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	0.1	0.006		NSH
Co.007	1	(5)	3.2	0.024	33	7.0E-03	49.8	0.50	0.2	0.004		NSH
Co.009	1	(1)	4.9	0.346			31.1	0.57	0.1	0.020		NSH
"	2		4.9	0.338			31.1	0.58	0.1	0.026		NSH
Co.010a	1	(4b) s	3.5	0.246	0.076	1.4E-03	29.5	0.62	0.2	0.040		NSH
"	2		4.1	0.262	0.080	1.5E-03	30.0	0.61	0.1	0.022		NSH

Table 5. Summary of Fixed Bed Reactor Data (cont.'d)

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	CO ₂ (%)	g/g cat/hr	E act. kcal/ mol	Comment
Co.011	2	(6b)	2.9	0.094	0.037	5.5E-04	22.4	0.61	0.3	0.030		NSH
Co.012	1	(1)	3.8	0.083	0.027	4.8E-04	26.3	0.64			22.5	slow CO startup (60 min)
"	2		4.4	0.085	0.030	5.0E-04	29.1	0.64	0.3	0.018		NSH
"	3		2.1	0.081	0.026	4.7E-04	28.6	0.66	0.4	0.049		NSH
"	4		2.5	0.105	0.035	6.2E-04	28.4	0.61	0.4	0.023		NSH
Co.014	1	(1)	1.5	0.028	0.009	2.8E-04	32.3	0.63	0.1	0.003		NSH
"	2		2.6	0.034	0.013	3.3E-04	27.7	0.69	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	0.1	0.011		slow CO startup (120 min)
"	2	f	7.0	0.388	0.135	2.3E-03	26.4	0.64	0.1	0.011		NSH
"	3	u	6.7	0.375	0.123	2.2E-03	28.2	0.63	0.2	0.011		NSH
Co.016	1	(4a) s	5.2	0.161	0.035	9.4E-04	33.6	0.56				slow CO startup (30 min)
"	2	f	5.1	0.291	0.112	1.7E-03	25.1	0.68	0.1	0.01		NSH
Co.017	2	(1) s	4.6	0.139	0.066	8.2E-04	22.0	0.69	0.1	0.012		NS
"	2a	s	3.7	0.111	0.043	6.5E-04	25.9	0.64	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	0.1	0.013		+ H ₂ O (eq. 7.5% CO conv.)
"	3	f	4.9	0.274	0.111	1.6E-03	23.0	0.67	0.2	0.030		NSH, calc. flow air
Co.018	2	s	3.4	0.170	0.068	1.0E-03	27.2	0.69	0.1	0.013		NS
"	2a	s	2.7	0.133	0.041	7.8E-04	33.2	0.64	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	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	0.1	0.022		NSH
"	4	s	3.6	0.340	0.180	2.0E-03	25.4	0.80	0.1	0.041		NSH, 10 atm
"	5	f	7.5	0.470	0.136	2.8E-03	29.0	0.60	0.3	0.055		NSH
Co.018Cl	1	(1)	4.5	0.320	0.075	1.9E-03	33.5	0.57	0.1	0.018		NSH
Co.019	1	(1)s	4.4	0.088	0.047	5.2E-04	15.2	0.74				NS
"	2	s	2.2	0.085	0.046	4.9E-04	18.9	0.73	0.3	0.040		NSH
"	3	f	3.4	0.142	0.071	8.3E-04	19.3	0.72	0.2	0.025		NSH
Co.020a	1	(4) s	4.6	0.343	0.085	2.0E-03	33.5	0.57	0.1	0.024		NSH
"	2		4.4	0.315	0.086	1.8E-03	31.2	0.59	0.1	0.028		NSH
Co.020b	1	(4b) s	4.4	0.311	0.084	1.8E-03	31.7	0.58	0.2	0.051		NSH
Co.020c	1	(4a) s	4.0	0.287	0.083	1.7E-03	30.4	0.60	0.1	0.017		NSH
Co.021	1	(6b)	3.4	0.109	0.032	6.4E-04	27.3	0.62	0.1	0.012	28.2	NSH
"	2		3.6	0.114	0.035	6.7E-04	28.0	0.56	0.1	0.012		NSH
Co.022	1	(6c)	3.8	0.121	0.037	7.1E-04	26.7	0.55	0.1	0.015	30.1	NSH
Co.023	1	(6c)	3.8	0.123	0.038	7.2E-04	28.3	0.56	0.2	0.023	29.5	NSH
Co.024	1	(7)	5.1	0.165	0.047	9.7E-04	32.8	0.62	0.5	0.055		NSH
"	2		5.7	0.182	0.060	1.1E-03	28.7	0.62	0.3	0.035		NSH
Co.025	1	(4)	5.0	0.160	0.062	9.4E-04	23.5	0.63	0.2	0.019	26.9	NSH
"	2		2.0	0.113	0.037	6.6E-04	26.8	0.61				NSH
"	2a		0.7	0.040	0.007	2.3E-04	49.5	0.66				Rxn @ 280 °C
Co.026	1	(1)	4.4	0.129	0.043	5.0E-04	26.9	0.62	0.2	0.022		NSH
"	1h		22.9	0.170	0.072	6.6E-04	22.6	0.67	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	0.2	0.026		NSH
"	1h		17.8	0.180	0.085	7.0E-04	19.4	0.71	1.2	0.011		NSH, high conv. study

Table 5. Summary of Fixed Bed Reactor Data (cont.'d)

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	CO ₂ (%)	g/g cat/hr	E act kcal/ mol	Comment
Co.028	1	(4)	3.8	0.146	0.076	5.7E-04	18.2	0.76	0.2	0.031		NSH
"	2		4.3	0.167	0.105	6.5E-04	14.7	0.80	0.2	0.030	28.4	NSH
"	3		4.5	0.206	0.126	8.0E-04	15.5	0.79	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	0.2	0.026		NSH
Co.031	1	(1)	1.9	0.060	0.022	3.5E-04	26.1	0.64	0.3	0.031		NSH
Co.032	1	(1)	3.3	0.183	0.079	1.1E-03	22.0	0.70	0.1	0.022		NSH
Co.033	1	(1)	1.3	0.073	0.027	4.3E-04	24.1	0.67	0.1	0.020		NSH
Co.034	1	(4)	5.0	0.275	0.107	1.6E-03	24.0	0.67	0.1	0.018		NSH
Co.035	2	(6)	4.6	0.147	0.068	8.6E-04	22.0	0.69	0.2	0.019		NSH
Co.036	2	(6c)	3.9	0.125	0.045	7.3E-04	28.9	0.67	0.1	0.013		NSH
Co.037	1	(4a)	2.7	0.053	0.011	5.2E-04	32.8	0.59				NSH
Co.038	1	(4a)	4.5	0.051	0.018	4.9E-04	25.1	0.68	0.3	0.013	24.2	NSH
Co.039	1	(5)	1.1	0.021	0.004	2.0E-04	57.2	0.64	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	0.2	0.009		NSH
Co.040	1	(4a)	1.9	0.037	0.004	3.7E-04	45.2	0.53	0.2	0.007		NSH
"	2		2.8	0.033	0.004	3.3E-04	44.6	0.46	0.2	0.007		NSH
Co.041	1	(4)	3.5	0.136	0.042	8.0E-04	40.7	0.69	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	0.6	0.048		NSH, 2.5 hr on-stream
"	2		3.7	0.078	0.045	4.6E-04	16.3	0.78	0.5	0.035	35.1	NSH
Co.044	1	(4)	3.1	0.179	0.081	1.0E-03	22.7	0.73	0.3	0.020		NSH
Co.045	1	(4)	2.6	0.161	0.076	9.4E-04	22.2	0.73	0.3	0.022		NSH
Co.047	1	(4)	6.4	0.263	0.128	1.5E-03	21.3	0.73	0.3	0.040	26.6	NSH
Co.048	1	(4)	3.5	0.162	0.094	9.5E-04	16.3	0.77	0.2	0.027	28.0	NSH
Co.049	1	(4)	7.1	0.366	0.153	2.1E-03	23.4	0.69	0.3	0.043		NSH
"	2		6.0	0.388	0.160	2.3E-03	23.3	0.68	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	0.3	0.059		NSH
"	3h	f	44.9	0.457	0.178	2.7E-03	26.5	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	0.2	0.049		NSH
"	1h		28.5	0.417	0.145	2.4E-03	26.8	0.64	1.6	0.081		NSH, high conv. study
"	2	f	6.6	0.433	0.174	2.5E-03	23.4	0.63	0.2	0.052		NSH
"	3		7.8	0.453	0.143	2.7E-03	27.6	0.62	0.1	0.027		NSH
"	3h		31.5	0.457	0.164	2.7E-03	25.4	0.65	0.9	0.044		NSH, high conv. study
"	4	u	6.1	0.426	0.142	2.5E-03	28.3	0.65	0.1	0.030		NSH
"	5	ROR	5.6	0.360	0.118	2.1E-03	27.9	0.64	0.2	0.034		NSH, ROR
"	6	f	8.2	0.485	0.163	2.8E-03	28.9	0.64	0.1	0.030		NSH
"	7	f	9.4	0.552	0.147	3.2E-03	34.3	0.60	0.1	0.044		NSH, Rxn @ 227 °C
"	7a	f	1.7	0.099	0.018	5.8E-04	38.1	0.60	0.2	0.028		Rxn @ 245 °C, T surge 280 °C
"	7b	f	2.0	0.119	0.031	7.0E-04	32.1	0.62	0.1	0.021		cal(5 hr) & red after run 7
"	8	f	7.7	0.450	0.144	2.6E-03	30.3	0.65	0.1	0.036		NSH
"	8a	f	6.3	0.368	0.103	2.2E-03	32.8	0.65	0.1	0.047		Ar added to the rxn mix.
"	8b	f	3.0	0.177	0.037	1.0E-03	37.3	0.65	0.1	0.033		Rxn @ 240 °C, T surge 275 °C
"	9	f	4.3	0.470	0.225	2.8E-03	21.6	0.69	0.2	0.046		D (1:2), NSH
"	9a	f	7.5	0.411	0.067	2.4E-03	46.9	0.62	0.2	0.070		Ar added to the rxn mix.
"	9b	f	11.9	0.647	0.116	3.8E-03	42.7	0.59	0.1	0.046		Rxn @ 240 °C

Table 5. Summary of Fixed Bed Reactor Data (cont.'d)

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	CO ₂ (%)	g/g cat/hr	E-act kcal/ mol	Comment
Co.053	10		5.6	0.304	0.091	1.8E-03	29.2	0.60	0.2	0.008		D(1:2) , NSH
"	10a		11.9	0.647	0.116	3.8E-03	42.7	0.59	0.2	0.046		Rxn @ 240 °C
"	10b		7.5	0.411	0.067	2.4E-03	46.9	0.62	0.4	0.070		Rxn @ 260 °C
"	10c		3.0	0.163	0.035	9.6E-04	38.8	0.69	0.3	0.054		Rxn @ 280 °C
"	11		5.4	0.289	0.102	1.7E-03	26.9	0.64	0.1	0.022		D (1:2) ,NSH
"	11a		3.8	0.205	0.047	1.2E-03	38.7	0.69	0.3	0.060		Rxn @ 280 °C
"	12	f	8.1	0.433	0.145	2.5E-03	26.6	0.60	0.2	0.029		D (1:2) ,NSH
"	12a	f	5.3	0.283	0.063	1.7E-03	39.4	0.69	0.4	0.083		Rxn @ 280 °C
"	12b	f	1.4	0.080	0.054	4.7E-04	20.0	0.78	0.1	0.02		Rxn @ 220
"	13	f	8.3	0.444	0.143	2.6E-03	29.3	0.65	0.2	0.037		Cal(10hr) & red after run 12
"	14		6.7	0.375	0.161	2.2E-03	24.8	0.74	0.1	0.025		Cal(24hr) & red after rxn @EI
Co.054	1	(1)	1.2	0.041	0.023	2.4E-04	17.8	0.79	0.2	0.014		NSH
Co.055	1	(1) f	9.1	0.490	0.159	2.9E-03	28.9	0.63	0.2	0.034		NSH
"	2	u	4.9	0.290	0.105	1.7E-03	25.7	0.65	0.2	0.022		NSH, T surge
"	3	u	11.0	0.611	0.193	3.6E-03	29.4	0.60	0.2	0.033		NSH
"	4	u	5.9	0.380	0.124	2.2E-03	28.3	0.60	0.2	0.047		NSH
"	5	u	6.6	0.409	0.135	2.4E-03	29.6	0.59	0.2	0.030		NSH
"	6	ROR	7.5	0.469	0.145	2.7E-03	30.9	0.63	0.2	0.023		NSH
"	7	n	7.5	0.466	0.119	2.7E-03	33.5	0.60	0.2	0.031		NSH
"	8		6.1	0.344	0.108	2.0E-03	29.7	0.66				NSH
"	8a		0.7	0.037	0.005	2.3E-04	41.2	0.66				Rxn @ 280 °C
Co.056	1	(1)	2.4	0.137	0.054	8.0E-04	23.9	0.69	0.1	0.029		NSH
"	2	u	2.2	0.137	0.054	8.0E-04	23.4	0.68	0.1	0.033		NSH
Co.057	1	(1)	2.8	0.171	0.078	1.0E-03	23.4	0.73	0.1	0.029		NSH
Co.060	1	(2)	3.8	0.244	0.097	1.4E-03	25.0	0.69	0.1	0.023		NSH
Co.061	1	(2)	9.4	0.556	0.188	3.3E-03	29.2	0.67	0.1	0.035		NSH
Co.064	1	(2)	7.1	0.384	0.130	2.2E-03	27.5	0.64	0.1	0.028		NSH
Co.066	1	(1)	1.7	0.100	0.031	7.8E-04	27.7	0.67				NSH
"	1a		0.9	0.050	0.009	3.9E-04	32.9	0.68				Rxn @ 280 °C
Co.067	1	(1)	2.2	0.130	0.045	7.5E-04	25.0	0.67				NSH
"	1a		1.6	0.090	0.010	5.2E-04	46.9	0.61				Rxn @ 280 °C
Co.068	1	(1)	4.0	0.220	0.065	1.3E-03	28.8	0.62				NSH
"	1a		1.7	0.100	0.010	6.8E-04	42.7	0.57				Rxn @ 280 °C
"	2		4.5	0.250	0.066	1.5E-03	31.4	0.61				NSH
"	2a		7.6	0.420	0.038	2.5E-03	50.0	0.46				Rxn @ 240 °C
"	3		5.7	0.300		1.8E-03	30.0	0.63				NSH
"	3a		7.5	0.400		2.4E-03	54.3	0.54				Rxn @ 260 °C
Co.069	1	(1)	5.5	0.310		1.8E-03	29.0	0.66				NSH
CAL.01	1	(1)	4.8	0.181	0.068	1.1E-03	24.4	0.66	0.3	0.036		NSH, temp. surge (startup)
"	2		7.4	0.491	0.142	2.9E-03	28.7	0.61	0.4	0.083		NSH
"	3		2.5	0.164	0.053	9.6E-04	25.6	0.63	0.2	0.052		NSH, HT, re-reduced
"	4		7.3	0.483	0.103	2.8E-03	35.8	0.57	0.2	0.098		NSH, HT, re-calcined

Table 5. Summary of Fixed Bed Reactor Data (cont.'d)

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	CO ₂ (%)	g/g cat/hr	E act kcal/ mol	Comment
CAL.02	1	(1)	6.1	0.379	0.121	2.2E-03	27.3	0.63	0.2	0.040		NSH
CAL.03	1	(1)	7.3	0.459	0.133	2.7E-03	29.0	0.60	0.2	0.048		NSH
CAL.04	1	(1)	4.1	0.234	0.123	1.4E-03	19.1	0.71	0.2	0.026		NSH
CAL.05	1	(1)	4.7	0.274	0.134	1.6E-03	20.8	0.75	0.2	0.026		NSH
CAL.06	1	(1)	5.8	0.267	0.135	1.6E-03	20.7	0.74	0.2	0.021		NSH
CAL. 10	1	(1)	3.5	0.196	0.097	1.1E-03	23.5	0.74	0.2	0.05		NSH
CAL.11	1	(1)	5.2	0.281	0.147	1.6E-03	20.0	0.75	0.2	0.029		NSH
CAL.12	1	(1)	5.2	0.288	0.143	1.7E-03	21.6	0.73	0.2	0.035		NSH
CAL.13	1	(1)	4.6	0.258	0.142	1.5E-03	18.0	0.77	0.2	0.024		NSH
CoW.01	1	(4a)	1.2	0.016	0.003	9.5E-05	30.2	0.58	0.2	0.006		NSH, reduced at 230 °C
"	1		0.5	0.007	0.001	3.4E-05	42.1	0.51	0.1	0.003		NSH, re-reduced at 350 °C
"	2		0.2	0.006	0.000	3.4E-05	40.9	0.51	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	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	0.2	0.008		S2, reduced at 350 °C
"	2	u	4.7	0.058	0.011	3.4E-04	34.8	0.50	0.2	0.009		S2
"	3	(4c)	0.8	0.020	0.005	1.2E-04	32.8	0.64				NSH
"	3a	(4c)	3.5	0.100	0.008	6.0E-04	54.2	0.58				Rxn @ 280°C
CoW.06	1	(4a)	3.3	0.041	0.012	2.4E-04	26.0	0.59	0.2	0.007		S2, reduced at 250 °C
"	2	u	2.6	0.032	0.004	1.9E-04	39.3	0.46	0.3	0.012		S2
CoW.06	2		17.0	0.207	0.004	1.2E-03	68.7	0.32	1.7	0.07		S2, rxn. at 280 °C
CoW.10	1	?	1.2	0.070	0.021	8.2E-04	31.8	0.67				NSH
"	1a	?	0.9	0.050	0.010	5.9E-04	36.6	0.66				Rxn @ 280°C
UOP	1	(1)	7.8	0.298	0.104	1.7E-03	22.6	0.61	0.2	0.023		NSH

Table 5. Summary of Fixed Bed Reactor Data (cont.'d)

Reaction Conditions: $T = 220^{\circ}\text{C}$, $\text{H}_2:\text{CO} = 2, 1 \text{ atm}$

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

n : Nitrogen calcined

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

NS New startup

NSH New startup, heated inlet

S2 was done in the second system

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

corrected overheated line on 3/6/1994

D (x:y) Catalyst bed dilution with x parts cat. and y parts -alumina

Co.018Cl Chlorinated Co.018

Table 6. Results of Hydrogenation of Isobutene in the Presence of CO^a

Catalyst	Rate ^b 120°C ($\mu\text{mol/g s}$)	TOF 120°C ($10^{-3}/\text{s}$)	Rate 180°C ($\mu\text{mol/g s}$)	TOF 180°C ($10^{-3}/\text{s}$)	E _a (kJ/mol)
Co.005	0.031	0.33	0.86	9.1	82
Co.053	0.068	0.20	3.1	9.3	94
Co.069	0.075	0.19	3.2	8.2	97
Co.067	0.543	-	14.6	-	83
Co.068	0.550	-	18.9	-	89
Co.066	0.046	-	1.4	-	85
CoW.10	0.040	-	1.2	-	87

a reaction conditions: H₂:IB:CO=4:1:0.14, P_{tot}=1 atm, P_{IB}=0.07 atm, WHSV = 28-35 h⁻¹, helium balance.

b initial data (taken after 5 min on-stream).

Table 7. Results of Boudouard Reaction Using 500 μl Pulses of CO^{a}

Catalyst	Rate 220°C ($\mu\text{mol/g}\cdot\text{s}$)	TOF 220°C (1/s)	Rate 260°C ($\mu\text{mol/g}\cdot\text{s}$)	TOF 260°C (1/s)	Ea (kJ/mol)
Co.005	3.2 ^h	-	30.6	0.34	123 ^b
Co.053	52.8	0.16	227.8	0.68	94 ^c
Co.069	61.1	0.18	-	-	-
Co.067	25.0	-	-	-	102 ^c
Co.068	52.8	-	100.0	-	110 ^e
Co.066	19.4	-	-	-	117 ^f
Co.W10	8.3	-	-	-	105 ^g

- a reaction conditions: 500 μl CO pulse size, $P_{\text{tot}}=2.5$ atm, 50-150 mg catalyst, 72 cc/min He.
b determined on a partially deactivated catalyst by average of 5 pulses at every temperature (240 - 280°C).
c determined between 190 and 220°C.
d determined between 220 and 240°C (two points only).
e determined between 210 and 230°C.
f determined between 210 and 250°C.
g determined between 220 and 250°C.
h obtained by extrapolation using the Arrhenius relationship due to immeasurably low conversion.

Table 8

SUMMARY OF M3 SBCR RUN RESULTS

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

Conversion is total CO conversion over the period (Z).

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

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

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 C5-18,Z	Comments
												ZCH4	ZC2	ZC3+	ZCO2			C3	C4		
48	Cow.13	15.5	1	23	38	240	450	2.0	20	8.5	0.39	10.9	8.1	76.9	4.30	0.74	0.89	4.00	3.00	21.0	G.C.Calib
48	Cow.13	15.5	2	47	62	260	450	2.0	20	20.0	0.90	19.9	5.0	68.5	6.61	0.64	--	2.56	1.74	--	
48	Cow.13	15.5	3	71	86	279	450	2.0	20	25.7	1.11	34.5	6.0	48.1	11.4	0.48	--	2.17	1.52	--	
48	Cow.13	15.5	4	95	110	300	450	2.0	20	28.0	1.12	41.2	7.4	32.0	19.4	0.35	--	2.22	1.61	--	
48	Cow.13	15.5	5	117	133	240	450	2.0	20	2.62	0.12	12.3	18.6	62.9	6.2	0.66	--	5.00	3.50	--	
49	Co.068	15.5	1	23	39	242	450	2.0	20	26.7	1.26	18.9	4.6	75.3	1.19	0.68	0.77	0.52	0.34	20.3	
49	Co.068	15.5	2	47	62	259	450	2.0	20	34.5	1.62	35.3	6.4	55.0	3.38	0.54	--	0.35	0.27	--	
49	Co.068	15.5	3	71	86	278	450	2.0	20	34.6	1.61	53.2	7.5	33.0	6.30	0.34	--	0.59	0.46	--	
49	Co.068	15.5	4	102	110	299	450	2.0	20	28.4	1.31	63.2	8.4	20.3	8.11	--	--	1.07	0.81	--	
49	Co.068	15.5	5	114	116	241	450	2.0	20	3.8	0.18	34.8	16.7	45.8	2.65	0.55	--	2.57	1.60	--	
50	Co.066	15.5	1	23	38	240	450	2.0	20	21.1	0.99	11.3	3.5	83.6	1.58	0.72	0.81	3.19	1.94	--	
50	Co.066	15.5	2	47	62	260	450	2.0	20	36.1	1.66	21.6	4.2	70.1	4.09	0.64	--	1.72	1.13	--	
50	Co.066	15.5	3	71	86	279	450	2.0	20	36.9	1.66	37.6	6.2	48.1	8.10	0.47	--	2.01	1.37	--	
50	Co.066	15.5	4	95	110	299	450	2.0	20	31.1	1.35	40.7	7.9	39.7	11.7	0.37	--	3.35	2.27	--	
50	Co.066	15.5	5	119	133	239	450	2.0	20	3.7	0.17	15.1	17.0	64.6	3.31	0.67	--	7.00	12.00	--	

Table 9

START-UP CONDITIONS AND ACTIVATION PROCEDURE FOR IRON F-T CATALYSTS

Start-up conditions:

- Catalyst Composition: 86.6 wt% Fe₂O₃, 12.5 wt% CuO, and 0.05 K₂O
- 29 wt% slurry
- Start-up medium: Synfluid

Activation Procedure:

- Pressure = 75 psig
- Heat up to 220°C (428°F) under 100% N₂
- Space velocity = 2,000 sl/hr-kg Fe
- Switch to 75% CO / 25% N₂ at 220°C
- Heat up to 270°C (518°F) at 17°C (30°F) / hr
- Monitor CO₂ concentration in effluent and cumulative CO₂ production

- ACTIVATION CHEMISTRY

- Stop activation after 12 hr on-stream at 270°C (the carbiding should have leveled off by that time with CO₂ concentrations in the effluent of 1-2%. The carbiding should be about 90-95% complete based on Fe₃C₂ formation)
- Start H₂ blending at about 100% of theoretical activation
- Slowly blend H₂ at activation conditions to reach H₂/CO = 0.7
- Change to F-T conditions (see Table)

Table 9
(Continued)

(TENTATIVE) F-T RUN PLAN

Period No.	Description	Space Velocity (sl/hr kg-Fe)	Reactor Pressure (psig)	Teator Temperature (°C)	Days On-Stream
1	Activation	2000	75	270	1
2	Base Line	2400	175	270	2
3	High Prod.	11700*	750*	300	2
4	High Lin. Vel.	11700*	500	300	2
5	Return to B. L.	2400	175	270	2

*750 psi or maximum pressure achievable on the SBCR

Table 10

SUMMARY OF M3 SBCR RUN RESULTS USING LaPorte IRON CATALYST

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

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

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

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

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

Cat.	Cat.	Per Time	Time	Temp	Pres	H2:	Synfl	Conv.	Prod.	Selectivities				Alpha	Alpha	Olefin/Paraf	Olefins	Comments		
No	wt,g	No	Start	Stop	C	psi	CO	cc/hr	%	Rate	%CH4	%C2	%C3+	%CO2	GC	Liq	C3	C4	C6-C18,%	
C3950	58.0	1	1	16	270	77	0.0	0	--	0.58	--	--	100	--	--	--	--	--	--	Cat Reduct
C3950	58.0	2	27	64	270	174	0.7	0	17.4	0.04	9.3	7.2	32.4	51.1	0.40	--	1.11	1.13	--	
C3950	58.0	3	65	70	300	600	0.7	0	--	--	--	--	--	--	--	--	--	--	--	Rx Plugged

Feed Gas Rates

Per N2	H2	CO	Total
No	SLH	SLH	SLH
1	14	0	52
2	48	29	41
3	86	139	198
			423

Table 11

SUMMARY OF M3 SBCR RUN RESULTS USING LaPorte IRON CATALYST

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 (Z).

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	Comments
No	No		No									ZCH4	ZC2	ZC3+	ZCO2			C3	C4	C6-C18,Z	
52	C3950	58.0	2	25	36	271	450	2.0	0	19.0	0.16	33.4	8.6	23.3	34.8	0.44	--	0.28	0.06	--	
52	C3950	58.0	3	49	62	276	450	2.0	0	29.2	0.24	28.7	12.9	21.9	36.5	0.39	--	0.30	0.28	--	
52	C3950	58.0	4	69	86	279	450	2.0	0	29.4	0.25	23.5	14.4	26.6	35.6	0.45	--	0.38	0.32	--	
52	C3950	58.0	5	96	110	288	450	2.0	0	35.8	0.29	26.5	14.1	21.4	38.0	0.37	--	0.38	0.33	--	
52	C3950	58.0	6	126	134	299	450	2.0	0	92.3	0.76	48.7	9.3	2.14	39.9	--	--	0.39	0.36	--	
52	C3950	58.0	7	138	158	304	600	2.0	0	97.8	0.82	47.8	6.0	8.0	38.2	0.16	--	0.21	0.22	--	
52	C3950	58.0	8	164	165	310	600	1.0	0	98.4	1.44	31.6	--	42.6	25.8	0.65	--	0.12	0.15	--	Rx.Plugged

Feed Gas Rates

Per No	N2 SLH	H2 SLH	CO SLH	Total SLH
2	563	225	112	900
3	563	225	112	900
4	563	225	112	900
5	563	225	112	900
6	563	225	112	900
7	563	225	112	900
8	562	169	169	900

Table 12

SUMMARY OF M3 SBGR RUN RESULTS USING LaPorte IRON CATALYST

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

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

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

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

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

Run	Cat.	Per	Time	Time	Temp	Pres	H2:	Synfl	Conv.	Prod.	Selectivities				Alpha	Alpha	Olefin/Paraf	Olefins	Comments	
No	wt, g	No	Start	Stop	C	psi	CO	cc/hr	%	Rate	XC4	XC2	XC3+	XCO2	GC	Liq	C3	C4	C6-C18, %	
3	C3950	58.0	2	28	42	268	450	1.0	0	13.5	0.14	12.7	11.8	30.0	45.5	0.18	--	0.88	0.78	--
3	C3950	58.0	3	52	66	270	450	1.0	0	21.9	0.23	12.9	10.9	30.9	45.6	0.34	--	0.67	0.59	--
3	C3950	58.0	4	76	90	280	450	1.0	0	25.7	0.27	15.7	11.4	26.2	46.7	0.12	--	0.56	0.50	--
3	C3950	58.0	5	100	114	290	450	1.0	0	25.4	0.27	17.1	11.9	24.5	46.5	0.04	--	0.60	0.55	--
3	C3950	58.0	6	124	138	298	450	1.0	0	28.5	0.29	17.6	11.8	24.0	46.7	--	--	0.72	0.64	--
3	C3950	58.0	7	148	159	300	450	0.7	0	27.2	0.33	11.9	9.7	30.7	47.7	0.37	--	1.16	1.00	--
3	C3950	58.0	8	170	172	302	600	0.7	0	29.4	0.35	11.8	9.5	30.5	48.3	0.40	--	0.79	0.72	-- Rx.Plugged

Feed Gas Rates

Per No	N2 SLH	H2 SLH	CO SLH	Total SLH
2	562	169	169	900
3	562	169	169	900
4	562	169	169	900
5	562	169	169	900
6	562	169	169	900
7	560	140	200	900
8	560	140	200	900

Table 13

SUMMARY OF M3 SBCR RUN RESULTS USING LaPorte IRON CATALYST

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

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

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

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

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

Cat. No	Cat. wt, g	Per No	Time Start	Time Stop	Temp C	Pres psi	H ₂ : Synfl CO	Conv. %	Prod. Rate	Selectivities					Alpha GC	Alpha Liq	Olefin C ₃	Paraf C ₄	Olefins C ₆ -C ₁₈ , %	Comments
5 C3950	43.0	1	1	15	270	75	0.0	0	--	--	--	--	--	--	--	--	--	--	--	Cat Reduct
5 C3950	43.0	2	26	38	270	175	0.7	0	18.7	0.27	9.5	7.0	34.5	49.1	0.44	--	0.92	0.78	--	
5 C3950	43.0	3	50	58	270	175	0.7	0	28.1	0.21	8.8	6.7	35.9	48.6	0.48	--	0.66	0.59	--	
5 C3950	43.0	4	74	86	300	175	0.7	0	35.5	0.26	12.4	8.1	30.8	48.6	0.41	--	0.90	0.96	--	
5 C3950	43.0	5	97	98	295	500	0.7	0	65.1	1.31	18.7	9.1	21.2	51.0	0.27	--	0.90	0.73	--	Rx Plugged

Feed Gas Rates

Per No	N ₂ SLH	H ₂ SLH	CO SLH	Total SLH
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1	16	0	42	58
2	40	130	185	355
3	22	65	93	180
4	22	65	93	180
5	250	180	260	690

Table 14. Catalyst Performance Comparison: LaPorte vs. EI Runs

Reactor Run No. Period No.	AFDU AF- R12.1	AFDU AF- R12.2	AFDU AF- R12.4	AFDU AF- R12.5	EI 51 2	EI 52 2	EI 52 6	EI 52 7	EI 52 8	EI 53 3	EI 53 6	EI 53 7	EI 53 8	EI 55 2
CONDITIONS														
Slurry Conc. (%)	25	23	15	13.8	18	18	18	18	18	18	18	18	18	14
Temp. (°C)	270	302	303	270	270	271	299	304	310	268	300	300	302	270
Pressure (psi)	175	750	500	175	174	450	450	600	600	450	450	450	600	175
Inlet H ₂ /CO ratio	0.7	0.7	0.7	0.7	0.7	2	2	2	1	1	1	0.7	0.7	0.7
SV (sl/h kg-Fe)	2534	12266	18682	3665	3335	15517	15517	15517	15517	15517	15517	15517	15517	13340
Catal. loading (lbs)	445	445	?	?	58 g	58 g	58 g	58 g	58 g	58 g	58 g	58 g	58 g	43g
Lin. Vel. (cm/s)	5.8	7.3	11	5.5	1.0	3.1	3.3	2.5	2.5	3.1	3.3	3.3	3.3	3.0
Time-on-stream (h)	9	33	13	12	37	11	134	158	165	42	138	159	172	26
ACTIVITY														
CO conv. (%)	84.7	54.2	15.6	10	17.4	19.0	92.3	97.8	98.4	13.5	28.5	27.2	29.4	18.7
g HC/h g-Fe	0.424	1.405	0.875	0.106	0.065	0.262	1.246	1.344	2.361	0.229	0.475	0.541	0.574	0.27
SELECTIVITY														
HC (CO₂ free)														
CH ₄ (mol% C)	13.40	11.80	5.55	3.87	19.0	51.2	61.3	77.3	42.6	23.3	32.9	22.7	22.8	18.6
C ₂ "	12.19	12.39	9.16	8.24	14.7	13.2	11.7	9.7	-	21.7	22.1	18.6	18.3	13.7
C ₃ + "	74.41	75.81	85.29	87.89	66.3	35.7	27.0	13.0	57.4	55.0	45.0	58.7	58.9	67.6
α (gas phase)	-	-	0.68	-	0.40	0.44	-	0.16	0.65	0.18	-	0.37	0.40	0.44
CO ₂ (mol%)	44.9	43.7	20.0	22.4	51.1	34.8	39.9	38.2	25.8	45.5	46.7	47.7	48.3	49.1

LaPorte Catalyst: 86.6 wt% Fe₂O₃, 12.5 wt% CuO, and 0.05 wt% K₂O (61 wt% Fe)

Activation Procedure: P = 75 psig; Heat up to 220°C under 100% N₂; SV = 2,000 sl/hr-kg Fe; Switch to 75% CO/25% N₂; Heat up to 270°C at 17°C/hr; Time = ca. 12 hrs.

SUMMARY OF M4 SBCR COBALT ONLY CATALYST AGING RUN

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

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

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

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

)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		
37	C0.005	25.0	1	1	18	216	450	2.0	20	8.1	0.23	0	--	--	--	--	--	--	--	--	--
37	C0.005	25.0	2	20	38	221	450	2.0	20	12.5	0.36	1.5	3.9	93.9	0.71	0.90	0.89	--	--	26.6	
37	C0.005	25.0	3	41	62	221	450	2.0	20	14.4	0.42	2.9	--	96.5	0.60	0.91	--	--	--	--	Repair G.C
37	C0.005	25.0	4	65	86	221	450	2.0	20	14.9	0.43	3.4	5.0	91.1	0.49	0.88	--	6.33	--	--	
37	C0.005	25.0	5	89	110	221	450	2.0	20	14.4	0.42	3.6	9.0	86.8	0.60	0.85	--	6.67	7.50	--	
37	C0.005	25.0	6	113	134	221	450	2.0	20	14.1	0.41	3.8	8.0	87.7	0.58	0.85	--	5.00	15.00	--	
37	C0.005	25.0	7	137	158	222	450	2.0	20	14.8	0.43	4.4	6.6	88.5	0.55	0.82	0.90	5.50	3.20	23.1	
37	C0.005	25.0	8	165	182	221	450	2.0	20	14.1	0.41	4.3	5.3	89.9	0.50	0.80	--	5.50	4.25	--	
37	C0.005	25.0	9	185	206	220	450	2.0	20	13.3	0.39	3.9	3.6	92.0	0.53	0.79	--	5.25	3.20	--	
37	C0.005	25.0	10	209	230	221	450	2.0	20	13.6	0.39	5.1	3.2	91.3	0.51	0.78	--	5.50	2.67	--	
37	C0.005	25.0	11	233	254	221	450	2.0	20	13.5	0.39	4.7	3.6	91.2	0.48	0.78	0.89	4.60	3.20	22.4	
37	C0.005	25.0	12	257	278	221	450	2.0	20	13.3	0.39	4.5	3.1	91.9	0.49	0.78	--	4.40	2.67	--	
37	C0.005	25.0	13	281	302	221	450	2.0	20	13.1	0.38	4.7	3.3	91.5	0.49	0.78	--	4.40	2.67	--	
37	C0.005	25.0	14	305	326	221	450	2.0	20	12.7	0.37	4.9	4.1	90.5	0.52	0.78	--	4.40	2.67	--	
37	C0.005	25.0	15	329	350	221	450	2.0	20	12.4	0.36	4.9	3.9	90.6	0.54	0.77	--	4.60	2.67	--	
37	C0.005	25.0	16	353	374	221	450	2.0	0	12.5	0.36	5.2	3.8	90.5	0.54	0.77	0.83	4.60	2.67	--	Stop Syn F
37	C0.005	25.0	17	377	397	221	450	2.0	0	12.5	0.36	5.1	3.3	90.9	0.56	0.77	--	4.60	2.67	--	
37	C0.005	25.0	18	401	422	221	450	2.0	0	12.9	0.37	5.3	3.9	90.4	0.42	0.77	0.87	4.80	2.83	--	
37	C0.005	25.0	19	425	446	221	450	2.0	0	12.3	0.36	5.1	3.1	91.6	0.44	0.77	--	4.60	2.83	--	
37	C0.005	25.0	20	449	470	221	450	2.0	0	8.6	0.41	10.4	2.5	86.7	0.37	0.72	--	4.14	2.63	--	
37	C0.005	25.0	21	473	494	221	450	2.0	0	9.1	0.43	10.5	2.6	86.5	0.37	0.74	--	4.43	2.63	25.2	
37	C0.005	25.0	22	497	518	221	450	2.0	0	8.9	0.42	10.8	2.8	85.9	0.45	0.73	0.86	4.43	2.63	--	
37	C0.005	25.0	23	521	542	221	450	2.0	0	8.7	0.41	10.9	2.7	85.9	0.50	0.73	--	4.43	2.63	--	
37	C0.005	25.0	24	545	554	221	450	2.0	0	8.5	0.41	10.9	3.2	85.3	0.50	0.72	--	4.43	3.00	--	
37	C0.005	25.0	25	574	590	221	450	2.0	0	8.1	0.38	10.9	3.5	84.9	0.55	0.72	--	4.29	2.86	--	
37	C0.005	25.0	26	593	614	221	450	2.0	0	7.9	0.37	10.8	3.5	85.1	0.54	0.72	--	4.14	2.86	--	
37	C0.005	25.0	27	617	638	220	450	2.0	0	7.6	0.36	10.8	3.1	85.6	0.57	0.72	0.86	4.00	2.71	--	
37	C0.005	25.0	28	641	662	220	450	2.0	0	7.6	0.36	10.8	2.6	85.9	0.54	0.72	--	4.00	2.71	--	
37	C0.005	25.0	29	674	686	221	450	1.5	0	5.6	0.32	8.4	2.6	88.2	0.78	0.73	--	5.00	2.83	--	
37	C0.005	25.0	30	698	710	221	450	1.5	0	4.8	0.29	10.3	3.0	85.9	0.81	0.71	0.85	5.00	3.40	--	
37	C0.005	25.0	31	731	734	215	450	1.5	0	3.2	0.19	8.3	4.5	85.1	2.03	0.70		4.50	12.00	--	
37	C0.005	25.0	32	742	758	221	450	1.5	20	5.6	0.35	8.6	3.1	87.6	0.71	0.75		4.80	3.20	--	Add Syn F1
37	C0.005	25.0	33	774	782	220	450	2.0	20	10.4	0.31	4.7	3.0	91.6	0.70	0.75		4.40	2.50	--	
37	C0.005	25.0	34	785	806	220	450	2.0	20	10.3	0.29	4.7	2.9	91.6	0.70	0.75		3.67	2.50	--	
37	C0.005	25.0	35	813	830	220	450	1.5	20	4.5	0.28	9.7	3.3	86.2	0.82	0.72		4.60	3.20	--	

Feed Gas Rates

Per No	N2 SLH	H2 SLH	CO SLH	Total SLH
1	563	225	112	900
20	360	360	180	900
29	360	324	216	900
30	300	360	240	900
33	563	225	112	900
35	300	360	240	900

SBCR CATALYST EXTRACTIONS

Catalyst No. (Support)	Run No.	Charge		Recovered (Oxidized) wt, gm	Charge		Recovered		Reduction in Particle Size, %
		(H ₂ Reduced) wt, gm	Particle Size, mvd, microns		Particle Size at 10 μ microns	Particle Size, mvd, microns	Particle Size at 10 μ microns		
Co.001 (Al)	1	14.5	42.02	12.63	24.25	41.06	23.62	2.3	
Co.001 (Al)	2	16.5	42.02	15.10	24.25	40.09	22.86	4.6	
Co.005 (Al)	3	19.5	85.66	18.41	30.46	64.53	31.27	24.7	
Co.002 (Al)	4	20.1	73.61	20.4	32.86	71.19	33.50	3.3	
Co.003 (Al)	5	15.1	76.81	14.54	34.40	72.57	34.25	5.5	
Co.011 (Si)	6	15.3	107.09 (1)	16.03	53.19	94.02	40.44	12.2	
Co.012 (Si)	7	15.8	105.22 (1)	14.73	51.33	101.37	44.44	3.7	
Co.015 (Al)	8	15.0	75.63 (1)	15.52	33.15	74.68	32.68	1.3	
Co.011 (Si)	9	15.0	79.80 (2)	15.92	48.31	72.44	36.31	9.3	
Co.016 (Al)	10	15.5	64.60 (2)	15.72	32.16	64.38	32.78	0.3	
Co.017 (Al)	11	15.0	73.14 (3)	15.09	36.29	69.95	35.62	4.4	
Co.018 (Al)	12	15.6	62.89 (3)	16.97	32.56	68.16	34.74	--	
Co.016 (Al)	13	14.7	67.69 (3)	13.30	35.05	64.79	34.20	4.3	
Co.019 (Si)	14	15.2	92.63 (3)	15.00	42.73	84.39	36.52	8.9	
Co.005 (Al)	15	14.7	80.62 (3)	15.30	45.07	71.90	36.79	10.8	
Co.002 (Al)	16	15.4	73.61 (3)	14.98	32.86	67.62	32.67	8.1	
Co.002 (Al)	1 (M4)	15.0	73.61 (3)	11.00	32.86	66.26	35.75	10.0	
Co.025 (Si)	17	15.6	87.19 (3)	14.60	47.35	78.31	36.27	10.2	
Co.004 (Al)	18	15.0	78.12 (3)	15.25	44.15	66.86	33.83	14.4	
Co.021 (Si)	19	15.6	86.18 (3)	16.06	46.54	77.95	35.59	9.55	
Co.041 (Si)	20	15.8	87.48 (3)	17.02	49.26	68.74	26.72	17.0	
Co.021 (Si)	3 (M4)	15.2	73.61 (3)	15.1	24.46	71.38	32.33	3.03	
Co.024 (Al)	4 (M4)	15.4	--	(4)	--	--	--	--	
Co.035 (Si)	5 (M4)	15.4	89.14 (3)	14.08	49.29	74.76	31.67	19.2	
Co.028 (Al)	6 (M4)	15.4	80.83 (3)	15.7	44.01	71.03	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 16
(Continued)

SBCR CATALYST EXTRACTIONS

Catalyst No. (Support)	Run No.	Charge		Recovered (Oxidized) wt, gm	Charge		Recovered		Reduction in Particle Size, %
		(H ₂ Reduced) 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)	80.26	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.

(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	
Blend B (Al)	22 (M4)	30.5	31.75	77.85	43.10	73.74	38.80	5.28
CAL.09 (Al)	23 (M4)	30.0 (6)	14.34	63.12	25.60	62.10	26.32	1.62
Co.053-3 (Al)	24 (M4)	28.5	27.85	75.63	40.80	70.69	35.03	6.53
Co.055 (Al)	31 (M3)	15.0	14.67	85.58	46.27	74.56	39.00	12.88
Co.056 (Si)	25 (M4)	15.0	14.93	99.93	54.62	88.48	43.26	11.46
Co.044 (Si)	32 (M3)	16.4	17.01	92 15	49.30	84.92	40.21	7.85
CAL.10 (Al)	26 (M4)	15.6	14.63	83.05	47.11	81.12	45.87	2.32
Co.053-4 (Al)	33 (M4)	31.4	31.9	84.09	44.40	73.50	37.10	12.6
Co.050 (Al)	27 (M4)	14.6	10.62	(5)	(5)	91.37	44.07	--
Co.060 (Al)	34 (M3)	15.6	15.8	87.45	47.08	80.89	43.42	7.50
Co.041 (Si)	35 (M3)	26.0	24.23	87.48	49.26	80.63	31.75	7.83
Co.057 (Si)	28 (M4)	15.8	14.64	98.85	55.78	82.94	36.71	16.10
Co.032 (Al)	36 (M3)	15.9	14.66	78.22	43.34	78.55	36.02	9.81
Co.045 (Si)	37 (M3)	15.9	15.67	95.67	53.59	68.84	22.06	28.04
Co.061 (Si)	29 (M4)	45 4	10	--	--	(7)	(7)	--
Co.011 (Si)	30 (M4)	15.9	15.82	83.99	40.60	54.04	13.72	35 66
Co.003 (Al)	50% Solids	135	130	78.93	39.94	73.02	36.97	7.49
CAL.12 (Al)	31 (M4)	15.9	11.86	72.75	38.67	72.85	40.91	0
CAL.11 (Al)	32 (M4)	15 9	17.87	71.92	38.83	69.91	36.68	2.8
Co.058 (Al)	38 (M3)	15.9	15.29	85.69	45.95	78.99	42 90	7.82
Co.064 (Al)	39 (M3)	15.9	14.86	83.74	44.86	70.37	35.17	16.0

(5) Insufficient feed sample

(6) Wax coated

(7) Lost catalyst

Table 16
(Continued)

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.063 (Al)	40 (M3)	15.0	12.02	88.99	48.36	80.70	44.32	9.32
Co.062 (Al)	41 (M3)	15.0	14.48	82.85	44.80	72.90	38.55	12.0
Co.065 (Al)	42 (M3)	15.9	17.24	83.08	44.17	71.81	37.63	13.6
CoW.12 (Si)	43 (M3)	9.1	9.44	(5)	(5)	105.95	49.99	--
CoW.11 (Al)	44 (M3)	15.6	15.24	80.32	42.03	66.93	34.40	16.7
CAL.13 (Al)	33 (M4)	15.9	14.45 (8)	80.60	43.53	104.15	59.24	--
Fe.01 (Si)	45 (M3)	15.9	15.96	84.91	46.55	78.01	39.01	8.1
CoW.05	46 (M3)	15.7	14.14	79.45	42.54	76.03	39.88	4.3
CAL.13 (Al)	35 (M4)	25.0	27.0	80.66	43.53	74.18	36.16	8.0
Co.070 (Al)	47 (M3)	15.6	17.0	85.64	45.59	78.41	40.91	8.4
CoW.13 (Al)	48 (M3)	15.5	16.0	74.45	39.00	71.64	37.84	3.8
Co.068 (Al)	49 (M3)	15.5	18.0	80.05	42.27	118.58	62.82	48.1 (9)
Co.066 (Al)	50 (M3)	15.5	16.0	77.19	39.49	72.28	37.48	6.4
Co.005 (Al)	37 (M4)	25.0	28.0	84.71	46.56	75.47	37.56	19.3

(5) Insufficient feed sample.

(8) Catalyst was rinsed with solvent only,
not Soxhlet extracted.

(9) Particle size increased.

Table 17. Performance of Co Catalysts in CSTR and SBCR

(AT 240°C)

CATALYST	ACTIVITY		SELECTIVITY (mol% C converted)	
	CO Conversion (%)	Rate (g CH ₂ /g cat/hr)	CH ₄	C ₃ +
CST REACTOR RESULTS^a				
Co.005 (20Co/Al ₂ O ₃)	61.1	1.33	6.6	92.2
Co.053 (20Co0.5Ru/Al ₂ O ₃)	64.7	1.39	9.9	88.8
Co.041 (20Co0.5Ru8.5Zr/Al ₂ O ₃)	59.6	1.30	8.5	89.7
CAL.13 (20Co/0.5Ru0.3KAl ₂ O ₃)	73.3	1.69	4.1	95.4
SBC REACTOR RESULTS^b				
Co.005 (20Co/Al ₂ O ₃)	27.1	1.34	7.9	89.7
Co.053 (20Co0.5Ru/Al ₂ O ₃)	34.2	1.56	7.8	84.2
Co.041 (20Co0.5Ru8.5Zr/Al ₂ O ₃)	15.8	1.16	11.0	86.0
CAL.13 (20Co/0.5Ru0.3KAl ₂ O ₃)	28.1	1.28	6.4	90.9

(a) Catalyst weight: ca. 17g, Screened thru 150x400 mesh; Calcined and reduced externally; P = 450psig, T = 240°C, H₂/CO = 2; Total flow rate: 300 Sl/hr; Diluent: Ar = ca. 40%

(b) Catalyst weight: ca. 15g, Screened thru 150x400 mesh; Calcined and reduced externally; T = 240°C, P = 450 psi, H₂/CO ratio = 2, Total flow rate: ca. 15 L/min or 3 cm/sec linear velocity, Diluent: N₂: ca. 60%

Table 18. Performance of Co Catalysts in CSTR and SBCR

(AT 220°C)

CATALYST	ACTIVITY		SELECTIVITY (mol% C converted)	
	CO Conversion (%)	Rate (g CH ₄ /g cat/hr)	CH ₄	C ₃ +
CST REACTOR RESULTS^a				
Co.005 (20Co/Al ₂ O ₃)	32.6	0.72	4.8	94.1
Co.053 (20Co0.5Ru/Al ₂ O ₃)	25.5	0.56	9.1	88.6
Co.041 (20Co0.5Ru8.5Zr/Al ₂ O ₃)	20.7	0.45	10.5	86.9
CAL.13 (20Co0.5Ru0.3K/Al ₂ O ₃)	31.2	0.74	4.5	95.0
SBC REACTOR RESULTS^b				
Co.005 (20Co/Al ₂ O ₃)	10.7	0.53	0.0	98.4
Co.053 (20Co0.5Ru/Al ₂ O ₃)	14.4	0.66	4.3	94.3
Co.041 (20Co0.5Ru8.5Zr/Al ₂ O ₃)	9.1	0.41	0.0	97.8
CAL.13 (20Co0.5Ru0.3K/Al ₂ O ₃)	-	-	-	-

(a) Catalyst weight: ca. 17g, Screened thru 150x400 mesh; Calcined and reduced externally; P = 450psig, T = 220°C, H₂/CO = 2; Total flow rate: 300 SI/hr; Diluent: Ar = ca. 40%

(b) Catalyst weight: ca. 15g, Screened thru 150x400 mesh; Calcined and reduced externally; T = 220°C, P = 450 psi, H₂/CO ratio = 2, Total flow rate: ca. 15 L/min or 3 cm/sec linear velocity, Diluent: N₂: ca. 60%

Figure 1. H_2 TPR of various metal promoted Co/Al_2O_3 catalysts [30 cc/min of 5% H_2/Ar , $5^\circ C/min$]: (a) Co.005, (b) Co.053, (c) Co.069, (d) Co.067, (e) Co.068, (f) Co.066, (g) CoW.10

Figure 2. Effect of temperature and time-on-stream on CO conversion for Co.005

Figure 3. Effect of temperature and time-on-stream on rates of total hydrocarbon and C6+ formation for Co.005

Figure 4. Effect of temperature and time-on-stream on CO conversion for Co.053

Figure 5. Effect of temperature and time-on-stream on rates of total hydrocarbon and C₆₊ formation for Co_{0.053}

Figure 6. Effect of temperature and time-on-stream on CO conversion for Co.068

Figure 7. Effect of temperature and time-on-stream on rates of total hydrocarbon formation for Co.068

Figure 8. Effect of temperature and time-on-stream on rates of C₆₊ formation for Co.068

Figure 9. Effect of temperature and time-on-stream on CO conversion for Co.067

Figure 10 Effect of temperature and time-on-stream on rates of total hydrocarbon and C₆₊ formation for Co.067

Figure 11. Effect of temperature and time-on-stream on rates of total hydrocarbon and C₆₊ formation for Co.066

Figure 12. Effect of temperature and time-on-stream on CO conversion for CoW.10

Figure 13. Effect of temperature and time-on-stream on rates of total hydrocarbon and C6+ formation for CoW.10

HIGH TEMPERATURE RUN SBCR M3 RUN48

Catalyst No. COW.13, 15.5 gm.

HIGH TEMPERATURE RUN SBCR M3 RUN48

Catalyst No. COW.13, 15.5 gm.

Time — Hours into Run

□ a1.f117

HIGH TEMPERATURE RUN SBCR M3 RUN48

Catalyst No. COW.13, 15.5 gm.

HIGH TEMPERATURE RUN SBCR M3 RUN49

Catalyst No. Co.Q68, 15.5 gm.

CO Conversion %

Time - Hours into Run

□ a1.f117

HIGH TEMPERATURE RUN SBCR M3 RUN49

Catalyst No. Co.068, 15.5 gm.

Production Rate—gm C1+/gm cat/hr

Time — Hours into Run

□ a1.f117

HIGH TEMPERATURE RUN SBCR M3 RUN49

Catalyst No. Co.068, 15.5 gm.

HIGH TEMPERATURE RUN SBCR M3 RUN 50

Catalyst No. Co.066, 15.5 gm.

HIGH TEMPERATURE RUN SBCR M3 RUN 50

Catalyst No. Co.066, 15.5 gm.

Time — Hours into Run

□ 01.f117

HIGH TEMPERATURE RUN SBCR M3 RUN 50

Catalyst No. Co.Q66, 15.5 gm.

AGING RUN SBCR M4 RUN 37

Calsicat Catalyst No. CAL.13, 25.0 gm.

AGING RUN SBCR M4 RUN 37

Calsicat Catalyst No. CAL.13, 25.0 gm.

Figure 25

AGING RUN SBCR M4 RUN 37

Calsicat Catalyst No. CAL.13, 25.0 gm.

Time — Hours into Run

APPENDIX A

FIXED BED REACTION DATA

Co.068 - Run #2

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

SUMMARY REACTION DATA

Reaction Conditions:

P = 1.0 atm

T = 220 °C

H₂/CO = 2

weight of catalyst = 0.201 g

WHSV = 12.80 1/hr

time on stream = 23.5 hrs

CO₂ (% of CO) =

O/P = 0.01

0.00

CO conversion (%)	4.5
rate (g CH ₂ /g cat/hr)	0.25
alpha	0.61
C1 (wt%)	31.4
C2 - C4 (wt%)	32.0
C5 - C12 (wt%)	35.1
C13 + (wt%)	1.4

Performance of Co.068

Dates: 07/06/95 - 01/00/00 Run #2

flow rate = 90.0 cc/min, loading = 0.2 g, WHSV = 12.8 l/hr, H₂/CO ratio in feed = 2

time on stream, hr	2.5	5.5	8.5	11.5	14.5	17.5
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	30.58	30.77	31.08	30.88	31.01	31.12
C2	6.22	6.16	6.20	6.15	6.15	6.15
C3	13.07	12.90	13.07	12.96	13.06	13.07
C4	13.79	13.36	13.35	13.36	13.36	13.29
C5	12.53	12.05	12.03	12.12	12.11	12.02
C6	8.09	8.75	8.54	8.67	8.65	8.60
C7	5.45	5.52	5.37	5.42	5.42	5.38
C8	3.47	3.37	3.43	3.47	3.40	3.46
C9	2.14	2.10	2.14	2.28	2.15	2.22
C10	1.40	1.34	1.47	1.43	1.42	1.39
C11	0.90	0.90	0.88	0.88	0.89	0.90
C12	0.62	0.61	0.56	0.58	0.58	0.59
C13	0.37	0.55	0.34	0.34	0.33	0.36
C14	0.27	0.24	0.24	0.24	0.23	0.24
C15	0.24	0.20	0.20	0.19	0.20	0.20
alpha chain growth probability	0.61	0.60	0.60	0.60	0.60	0.60

C1 - C50 estimated total product distribution, weight %

C1	30.4	30.9	31.1	30.9	31.0	31.2
C2 - C4	32.9	32.5	32.7	32.5	32.6	32.6
C5 - C12	35.0	35.2	34.9	35.2	35.0	35.0
C13 - C50	1.6	1.4	1.3	1.3	1.3	1.3

CO conversion, %	5.0	4.6	4.7	4.6	4.6	4.6
rate, g CH ₂ /g cat/hr	0.28	0.26	0.26	0.26	0.26	0.26
CO ₂ formation, %						

Performance of Co.068

Dates: 07/06/95 - 01/00/00 Run #2

flow rate = 90.0 cc/min, loading = 0.2 g, WHSV = 12.8 l/hr, H₂/CO ratio in feed = 2

time on stream, hr	20.5	23.5	26.5	29.5	32.5	35.5
reaction temperature, °C	220	220	220	240	240	240
pressure, atm	1.0	1.0	1.0	1.0	1.0	1.0
flow, cc/min	90.0	90.0	120.0	120.0	120.0	120.0

C1 - C15 product distribution, weight %

C1	31.10	31.41	33.85	54.34	53.82	53.29
C2	6.16	6.11	6.69	8.93	8.79	8.72
C3	13.13	12.87	13.76	13.16	13.27	13.44
C4	13.29	13.01	13.14	10.50	10.42	10.56
C5	12.03	11.83	11.25	6.40	6.81	6.93
C6	8.57	8.47	9.43	3.25	3.45	3.54
C7	5.42	5.59	4.58	1.57	1.68	1.76
C8	3.41	3.59	2.73	0.83	0.89	0.87
C9	2.13	2.20	1.72	0.43	0.39	0.40
C10	1.47	1.47	0.92	0.18	0.20	0.21
C11	0.85	0.93	0.54	0.08	0.08	0.09
C12	0.59	0.57	0.30	0.11	0.04	0.05
C13	0.35	0.36	0.21	0.03	0.03	0.02
C14	0.23	0.24	0.14	0.01	0.01	0.01
C15	0.20	0.21	0.11	0.01	0.01	0.01
alpha chain growth probability	0.60	0.61	0.57	0.48	0.44	0.45

C1 - C50 estimated total product distribution, weight %

C1	31.1	31.4	33.8	54.4	53.9	53.3
C2 - C4	32.6	32.0	33.6	32.6	32.5	32.7
C5 - C12	34.9	35.1	31.8	12.9	13.6	13.9
C13 - C50	1.4	1.4	0.8	0.1	0.0	0.0

CO conversion, %	4.7	4.5	3.9	9.8	9.0	8.8
rate, g CH ₂ /g cat/hr	0.27	0.25	0.22	0.55	0.50	0.49
CO ₂ formation, %						

Performance of Co.068

Dates: 07/06/95 - 01/00/00 Run #2

flow rate = 90.0 cc/min, loading = 0.2 g, WHSV = 12.8 l/hr, H₂/CO ratio in feed = 2

time on stream, hr	38.5	41.5	44.5	48.8	51.8	54.8
reaction temperature, °C	240	240	240	240	240	240
pressure, atm	1.0	1.0	1.0	1.0	1.0	1.0
flow, cc/min	120.0	120.0	120.0	120.0	120.0	120.0

C1 - C15 product distribution, weight %

C1	52.89	52.63	52.16	52.13	51.67	50.93
C2	8.68	8.64	8.59	8.57	8.52	8.45
C3	13.57	13.68	13.80	13.86	13.94	14.12
C4	10.62	10.69	10.78	10.79	10.84	11.01
C5	7.01	7.06	7.17	7.18	7.26	7.44
C6	3.60	3.63	3.71	3.75	3.82	4.03
C7	1.76	1.79	1.87	1.85	1.89	1.99
C8	0.94	0.91	0.94	0.94	1.00	1.05
C9	0.43	0.45	0.46	0.42	0.47	0.42
C10	0.22	0.23	0.22	0.22	0.23	0.26
C11	0.10	0.10	0.10	0.10	0.10	0.12
C12	0.05	0.06	0.06	0.05	0.07	0.05
C13	0.02	0.03	0.03	0.03	0.03	0.03
C14	0.02	0.01	0.02	0.02	0.02	0.02
C15	0.02	0.01	0.01	0.01	0.02	0.02
alpha chain growth probability	0.44	0.45	0.45	0.44	0.46	0.44

C1 - C50 estimated total product distribution, weight %

C1	52.9	52.7	52.2	52.2	51.7	51.0
C2 - C4	32.9	33.0	33.2	33.3	33.3	33.6
C5 - C12	14.1	14.3	14.6	14.5	14.9	15.4
C13 - C50	0.0	0.1	0.1	0.0	0.1	0.0

CO conversion, %	8.7	8.6	8.4	8.4	8.3	7.9
rate, g CH ₂ /g cat/hr	0.49	0.48	0.47	0.47	0.46	0.45
CO ₂ formation, %						

Performance of Co.068
 Dates: 07/06/95 - 01/00/00 Run #2

flow rate = 90.0 cc/min, loading = 0.2 g, WHSV = 12.8 1/hr, H₂/CO ratio in feed = 2

time on stream, hr	57.8	61.8	64.8	67.8	70.6	0.0
reaction temperature, °C	240	240	240	240	240	0
pressure, atm	1.0	1.0	1.0	1.0	1.0	1.0
flow, cc/min	120.0	120.0	120.0	120.0	120.0	0.0

C1 - C15 product distribution, weight %

C1	50.63	50.69	51.34	49.94	55.49	0.00
C2	8.42	8.40	8.53	8.31	8.64	0.00
C3	14.22	14.18	14.58	14.30	13.17	0.00
C4	11.10	11.01	11.32	11.02	9.92	0.00
C5	7.52	7.46	7.66	7.58	6.38	0.00
C6	3.91	4.02	4.19	4.13	3.20	0.00
C7	2.02	2.01	1.13	2.22	1.56	0.00
C8	1.07	1.07	0.54	1.21	0.80	0.00
C9	0.50	0.52	0.28	0.54	0.33	0.00
C10	0.27	0.27	0.11	0.33	0.18	0.00
C11	0.11	0.12	0.08	0.13	0.08	0.00
C12	0.07	0.07	0.04	0.08	0.04	0.00
C13	0.03	0.04	0.02	0.04	0.02	0.00
C14	0.02	0.02	0.02	0.02	0.02	0.00
C15	0.02	0.02	0.02	0.02	0.02	0.00
alpha chain growth probability	0.46	0.46	0.42	0.46	0.44	0.00

C1 - C50 estimated total product distribution, weight %

C1	50.7	50.7	51.4	50.0	55.6	0.0
C2 - C4	33.8	33.6	34.5	33.7	31.8	0.0
C5 - C12	15.5	15.6	14.0	16.3	12.6	0.0
C13 - C50	0.1	0.1	0.0	0.1	0.0	0.0

CO conversion, %	7.9	7.8	7.5	7.6	8.3	0.0
rate, g CH ₂ /g cat/hr	0.44	0.44	0.42	0.42	0.47	0.00
CO ₂ formation, %						

CO Hydrogenation on Co.068 - ASF Product Distribution

CO Hydrogenation on Co.068

CO Hydrogenation on Co.068

Co.068 - Run #3

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

SUMMARY REACTION DATA

Reaction Conditions:

P = 1.0 atm

T = 220 °C

H₂/CO = 2

weight of catalyst = 0.213 g

WHSV = 12.09 1/hr

time on stream = 23.5 hrs

CO₂ (% of CO) =

O/P = 0.03

0.00

CO conversion (%)	5.7
rate (g CH ₂ /g cat/hr)	0.30
alpha	0.63
C1 (wt%)	30.0
C2 - C4 (wt%)	29.3
C5 - C12 (wt%)	38.6
C13 + (wt%)	2.1

Performance of Co.068

Dates: 07/21/95 - 07/24/95 Run #3

flow rate = 90.0 cc/min, loading = 0.2 g, WHSV = 12.1 l/hr, H₂/CO ratio in feed = 2

time on stream, hr	2.5	5.5	8.5	11.5	14.5	17.5
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	26.72	27.79	27.95	28.19	28.04	32.02
C2	5.33	5.39	5.61	5.64	5.56	5.21
C3	11.24	11.19	11.34	11.34	11.43	10.68
C4	12.51	12.30	12.37	12.35	12.45	11.60
C5	12.22	12.02	12.19	11.90	12.12	11.27
C6	9.54	9.60	9.45	9.16	9.40	8.75
C7	6.39	6.23	6.16	6.17	5.94	5.88
C8	4.43	4.31	4.12	4.24	4.15	4.07
C9	3.14	2.99	2.77	2.96	2.96	2.90
C10	2.18	2.08	1.92	2.06	2.03	1.97
C11	1.71	1.52	1.47	1.46	1.47	1.42
C12	1.10	1.05	1.03	1.00	1.01	0.89
C13	0.76	0.71	0.69	0.67	0.69	0.61
C14	0.54	0.52	0.50	0.48	0.46	0.46
C15	0.51	0.44	0.40	0.37	0.38	0.38
alpha chain growth probability	0.64	0.64	0.64	0.64	0.63	0.63

C1 - C50 estimated total product distribution, weight %

C1	27.0	28.1	28.3	28.6	28.4	32.4
C2 - C4	29.4	29.2	29.7	29.7	29.9	27.8
C5 - C12	41.1	40.3	39.7	39.5	39.6	37.7
C13 - C50	2.5	2.4	2.3	2.2	2.1	2.1

CO conversion, %	6.0	5.9	5.6	5.6	5.3	5.6
rate, g CH ₂ /g cat/hr	0.32	0.31	0.30	0.29	0.28	0.30
CO ₂ formation, %						

Performance of Co.068

Dates: 07/21/95 - 07/24/95 Run #3

flow rate = 90.0 cc/min, loading = 0.2 g, WHSV = 12.1 l/hr, H₂/CO ratio in feed = 2

time on stream, hr	20.5	23.5	26.5	29.5	32.5	35.5
reaction temperature, °C	220	220	220	260	260	260
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	120.0	120.0

C1 - C15 product distribution, weight %

C1	27.63	29.49	27.95	72.36	66.02	62.05
C2	5.44	5.68	5.50	10.83	10.38	10.08
C3	12.03	11.23	12.07	8.24	11.08	11.88
C4	11.34	11.89	11.23	4.26	6.58	7.39
C5	12.01	11.41	11.69	2.24	3.09	4.30
C6	9.36	8.81	8.99	0.97	1.51	1.98
C7	6.31	6.07	6.34	0.38	0.61	1.02
C8	4.37	4.20	4.41	0.22	0.31	0.61
C9	3.05	2.97	3.15	0.14	0.15	0.27
C10	2.14	2.08	2.17	0.08	0.07	0.14
C11	1.57	1.52	1.55	0.04	0.03	0.06
C12	1.05	0.97	1.06	0.02	0.01	0.04
C13	0.67	0.65	0.69	0.02	0.01	0.02
C14	0.47	0.47	0.48	0.01	0.01	0.01
C15	0.39	0.42	0.42	0.01	0.00	0.01
alpha chain growth probability	0.63	0.63	0.64	0.47	0.38	0.39

C1 - C50 estimated total product distribution, weight %

C1	28.1	30.0	28.5	72.5	66.0	62.1
C2 - C4	29.3	29.3	29.3	23.4	28.1	29.4
C5 - C12	40.4	38.6	40.0	4.1	5.9	8.5
C13 - C50	2.1	2.1	2.2	0.0	0.0	0.0

CO conversion, %	5.2	5.7	5.2	25.4	14.4	13.0
rate, g CH ₂ /g cat/hr	0.27	0.30	0.27	1.35	0.76	0.69
CO ₂ formation, %						

Performance of Co.068

Dates: 07/21/95 - 07/24/95 Run #3

flow rate = 90.0 cc/min, loading = 0.2 g, WHSV = 12.1 1/hr, H₂/CO ratio in feed = 2

time on stream, hr	38.5	41.5	44.5	47.5	50.5	53.5
reaction temperature, °C	260	260	260	260	260	260
pressure, atm	1.0	1.0	1.0	1.0	1.0	1.0
flow, cc/min	120.0	120.0	120.0	120.0	120.0	120.0

C1 - C15 product distribution, weight %

C1	60.78	65.87	64.13	57.30	56.86	56.13
C2	9.96	9.53	9.52	9.54	9.46	9.35
C3	12.27	10.22	11.08	12.90	13.00	13.08
C4	7.78	6.23	6.67	8.51	8.63	8.76
C5	4.62	3.88	3.88	5.39	5.51	5.70
C6	2.21	2.08	2.12	2.83	2.96	3.13
C7	1.08	0.96	1.12	1.49	1.49	1.58
C8	0.59	0.51	0.61	0.81	0.83	0.89
C9	0.29	0.29	0.34	0.45	0.46	0.51
C10	0.14	0.15	0.17	0.23	0.26	0.25
C11	0.07	0.08	0.09	0.12	0.14	0.16
C12	0.05	0.05	0.06	0.09	0.08	0.09
C13	0.02	0.03	0.04	0.06	0.07	0.07
C14	0.01	0.02	0.02	0.04	0.04	0.04
C15	0.01	0.01	0.01	0.03	0.02	0.03
alpha chain growth probability	0.40	0.42	0.42	0.46	0.52	0.52

C1 - C50 estimated total product distribution, weight %

C1	60.8	65.8	64.2	57.2	56.9	56.1
C2 - C4	30.0	26.0	27.3	30.9	31.1	31.2
C5 - C12	9.1	8.1	8.5	11.7	11.9	12.5
C13 - C50	0.0	0.1	0.1	0.2	0.2	0.2

CO conversion, %	12.0	13.2	11.0	10.0	9.6	9.2
rate, g CH ₂ /g cat/hr	0.63	0.70	0.58	0.53	0.51	0.49
CO ₂ formation, %						

Performance of Co.068

Dates: 07/21/95 - 07/24/95 Run #3

flow rate = 90.0 cc/min, loading = 0.2 g, WHSV = 12.1 1/hr, H₂/CO ratio in feed = 2

time on stream, hr	56.5	59.5	62.5	65.5	68.5	71.5
reaction temperature, °C	260	260	260	260	260	260
pressure, atm	1.0	1.0	1.0	1.0	1.0	1.0
flow, cc/min	120.0	120.0	120.0	120.0	120.0	120.0

C1 - C15 product distribution, weight %

C1	55.73	56.37	55.45	54.81	54.49	54.27
C2	9.28	9.17	9.14	9.09	9.05	9.00
C3	13.19	12.99	13.19	13.25	13.27	13.24
C4	8.92	8.71	8.80	8.99	9.00	8.97
C5	5.84	5.74	5.95	6.04	6.06	6.11
C6	3.24	3.13	3.33	3.40	3.40	3.50
C7	1.60	1.63	1.75	1.81	1.86	1.90
C8	0.87	0.92	0.99	1.02	1.06	1.15
C9	0.50	0.47	0.52	0.55	0.56	0.60
C10	0.28	0.28	0.32	0.32	0.38	0.39
C11	0.18	0.14	0.16	0.19	0.23	0.23
C12	0.08	0.09	0.10	0.12	0.13	0.13
C13	0.06	0.07	0.07	0.08	0.10	0.10
C14	0.04	0.04	0.04	0.06	0.07	0.07
C15	0.02	0.03	0.02	0.03	0.04	0.04
alpha chain growth probability	0.52	0.52	0.51	0.53	0.54	0.54

C1 - C50 estimated total product distribution, weight %

C1	55.7	56.4	55.5	54.8	54.5	54.3
C2 - C4	31.4	30.9	31.2	31.3	31.3	31.2
C5 - C12	12.7	12.6	13.2	13.6	13.9	14.2
C13 - C50	0.2	0.2	0.1	0.2	0.3	0.3

CO conversion, %	8.8	8.8	8.3	8.0	7.7	7.5
rate, g CH ₂ /g cat/hr	0.46	0.46	0.44	0.42	0.41	0.40
CO ₂ formation, %						

Co.069 - Run #1

Co wt%	NM wt %	Promotor wt%		Support
20	Ru 2.00			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 = 23.5 hrs

CO₂ (% of CO) =

O/P = 0.01

CO conversion (%)	5.5
rate (g CH ₂ /g cat/hr)	0.31
alpha	0.66
C1 (wt%)	29.0
C2 - C4 (wt%)	27.6
C5 - C12 (wt%)	40.3
C13 + (wt%)	3.1

Performance of Co.069

Dates: 07/17/95 - 07/18/95 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	2.5	5.5	8.5	11.5	17.5	20.5
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	25.59	27.54	28.52	26.83	26.24	26.02
C2	4.46	4.90	4.85	4.73	4.67	4.47
C3	10.80	10.94	10.85	10.93	10.86	10.80
C4	11.48	11.39	11.30	11.51	11.42	11.37
C5	11.46	11.18	11.16	11.50	11.47	11.49
C6	9.12	9.00	8.63	9.15	9.14	9.23
C7	6.34	6.31	6.32	6.43	6.58	6.51
C8	4.55	4.55	4.61	4.68	4.79	4.99
C9	3.24	3.27	3.28	3.29	3.30	3.47
C10	2.38	2.50	2.45	2.49	2.81	2.64
C11	1.69	1.77	1.80	1.83	1.89	1.95
C12	1.35	1.29	1.31	1.33	1.56	1.49
C13	0.97	0.95	1.02	0.94	1.11	1.14
C14	0.65	0.70	0.62	0.73	1.08	1.19
C15	0.56	0.51	0.54	0.53	0.19	0.29
alpha chain growth probability	0.66	0.66	0.67	0.66	0.67	0.67

C1 - C50 estimated total product distribution, weight %

C1	26.7	28.1	28.9	27.4	26.6	26.4
C2 - C4	27.9	27.8	27.3	27.8	27.3	27.0
C5 - C12	42.0	40.8	40.3	41.6	42.2	42.5
C13 - C50	3.4	3.3	3.5	3.3	4.0	4.1

CO conversion, %	6.0	5.9	6.1	5.3	5.2	5.2
rate, g CH ₂ /g cat/hr	0.34	0.33	0.34	0.30	0.29	0.29
CO ₂ formation, %						

Performance of Co.069

Dates: 07/17/95 - 07/18/95 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	23.5	26.5	32.5
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	28.14	26.26	26.54
C2	4.71	4.51	4.53
C3	10.90	10.75	10.72
C4	11.17	11.16	11.11
C5	10.87	11.44	11.36
C6	8.43	9.27	9.17
C7	6.32	6.48	6.65
C8	4.67	4.71	4.91
C9	3.36	3.30	3.55
C10	2.45	2.41	2.72
C11	1.91	1.87	1.94
C12	1.35	1.59	1.49
C13	0.88	1.21	0.97
C14	0.74	0.82	0.74
C15	0.54	0.60	0.63
alpha chain growth probability	0.66	0.68	0.66

C1 - C50 estimated total product distribution, weight %

C1	29.0	26.6	27.1
C2 - C4	27.6	26.8	27.0
C5 - C12	40.3	42.1	42.5
C13 - C50	3.1	4.5	3.4

CO conversion, %	5.5	4.9	4.9
rate, g CH ₂ /g cat/hr	0.31	0.28	0.27
CO ₂ formation, %			

CoW.10 - Run #X

Co wt%	NM wt %	Promotor wt%		Support
10	Ru 0.50	Fe 10.00		Al ₂ O ₃

SUMMARY REACTION DATA

Reaction Conditions:

P = 1.0 atm

T = 220 °C

H₂/CO = 2

weight of catalyst = 0.201 g

WHSV = 12.78 1/hr

time on stream = 47.5 hrs

CO₂ (% of CO) =
O/P = 0.01

0.00

CO conversion (%)	1.2
rate (g CH ₂ /g cat/hr)	0.07
alpha	0.67
C1 (wt%)	31.8
C2 - C4 (wt%)	28.4
C5 - C12 (wt%)	36.3
C13 + (wt%)	3.4

Performance of CoW.10

Dates: 07/11/95 - 07/14/95 Run #X

flow rate = 90.0 cc/min, loading = 0.2 g, WHSV = 12.8 l/hr, H₂/CO ratio in feed = 2

time on stream, hr	2.5	5.5	8.5	11.5	17.5	20.5
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	34.93	34.68	39.61	37.03	35.32	34.05
C2	7.22	7.08	7.19	7.00	6.89	6.85
C3	11.96	11.84	11.28	11.43	11.58	11.82
C4	11.09	11.04	10.42	10.75	10.78	11.08
C5	10.04	10.10	9.40	9.56	9.72	10.35
C6	7.49	7.37	6.72	7.48	7.45	4.94
C7	5.16	5.15	4.73	4.96	5.27	5.72
C8	3.81	3.60	3.26	3.46	3.79	4.14
C9	2.88	2.70	2.29	2.57	2.69	3.04
C10	1.99	1.95	1.65	1.77	1.98	2.37
C11	1.38	1.48	1.25	1.33	1.47	1.67
C12	0.98	1.13	0.88	0.96	1.09	1.41
C13	0.61	0.80	0.63	0.59	0.73	1.00
C14	0.34	0.63	0.53	0.43	0.55	0.67
C15	0.12	0.47	0.16	0.41	0.41	0.15
alpha chain growth probability	0.62	0.66	0.65	0.63	0.65	0.66

C1 - C50 estimated total product distribution, weight %

C1	35.0	34.2	39.0	36.9	35.1	33.8
C2 - C4	30.3	29.5	28.4	29.1	29.0	29.6
C5 - C12	33.3	33.4	30.2	32.0	33.4	33.5
C13 - C50	1.5	2.9	2.4	2.0	2.5	3.2

CO conversion, %	1.5	1.5	1.3	1.3	1.2	1.1
rate, g CH ₂ /g cat/hr	0.08	0.08	0.07	0.07	0.07	0.06
CO ₂ formation, %						

Performance of CoW.10

Dates: 07/11/95 - 07/14/95 Run #X

flow rate = 90.0 cc/min, loading = 0.2 g, WHSV = 12.8 1/hr, H₂/CO ratio in feed = 2

time on stream, hr	23.5	26.5	32.5	35.5	38.5	41.5
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	32.27	35.23	37.41	34.85	33.71	27.95
C2	6.59	6.92	6.82	6.54	6.49	5.39
C3	11.58	12.06	11.28	11.15	11.12	9.38
C4	10.81	11.15	10.43	10.40	10.63	8.75
C5	10.19	9.77	9.49	9.60	9.55	8.02
C6	7.42	6.11	6.94	7.06	7.33	6.27
C7	5.63	5.02	4.48	5.24	4.76	8.85
C8	4.07	3.60	3.38	3.63	3.72	6.31
C9	3.00	2.73	2.50	2.62	2.65	4.63
C10	2.27	1.98	1.81	1.84	2.09	3.49
C11	1.70	1.52	1.33	1.40	1.54	1.97
C12	1.36	1.17	0.97	1.03	1.16	1.37
C13	0.95	0.84	0.67	0.71	0.80	0.96
C14	0.73	0.64	0.53	0.52	0.61	0.82
C15	0.63	0.55	0.52	0.52	0.60	0.99
alpha chain growth probability	0.67	0.66	0.65	0.65	0.66	0.68

C1 - C50 estimated total product distribution, weight %

C1	32.1	35.0	37.5	35.6	34.5	28.9
C2 - C4	28.8	29.9	28.6	28.7	28.9	24.3
C5 - C12	35.7	32.0	31.3	33.2	33.7	42.6
C13 - C50	3.5	3.0	2.5	2.5	2.9	4.2

CO conversion, %	1.4	1.4	1.5	1.4	1.4	1.6
rate, g CH ₂ /g cat/hr	0.08	0.08	0.08	0.08	0.08	0.09
CO ₂ formation, %						

Performance of CoW.10 Dates: 07/11/95 - 07/14/95 Run #X

flow rate = 90.0 cc/min, loading = 0.2 g, WHSV = 12.8 1/hr, H₂/CO ratio in feed = 2

time on stream, hr	47.5	50.5	53.5	56.5	59.5	62.5
reaction temperature, °C	220	220	220	280	280	280
pressure, atm	1.0	1.0	1.0	1.0	1.0	1.0
flow, cc/min	90.0	120.0	120.0	120.0	120.0	120.0

C1 - C15 product distribution, weight %

C1	30.80	35.53	36.69	46.48	45.16	43.97
C2	6.21	6.97	7.14	12.71	12.27	11.99
C3	11.04	11.66	11.74	14.84	12.88	12.71
C4	10.25	10.46	10.64	8.97	8.66	8.83
C5	9.69	9.48	9.21	6.27	6.47	6.94
C6	7.51	5.96	6.40	2.56	4.32	4.59
C7	5.52	4.86	5.28	2.40	2.83	3.24
C8	4.01	3.28	3.75	1.63	1.88	2.10
C9	3.11	2.29	2.55	1.03	1.10	1.35
C10	2.19	1.70	1.78	0.75	0.83	0.97
C11	1.76	1.16	1.29	0.55	0.59	0.52
C12	1.30	0.79	0.86	0.38	0.45	0.32
C13	0.95	0.85	0.59	0.19	0.25	0.24
C14	0.69	0.96	0.74	0.14	0.22	0.18
C15	0.59	0.81	0.78	0.22	0.25	0.19
alpha chain growth probability	0.67	0.66	0.67	0.58	0.61	0.59

C1 - C50 estimated total product distribution, weight %

C1	31.8	36.3	35.9	46.9	45.8	44.6
C2 - C4	28.4	29.7	28.9	36.8	34.3	34.0
C5 - C12	36.3	31.1	31.7	15.7	19.0	20.6
C13 - C50	3.4	2.9	3.5	0.6	1.0	0.8

CO conversion, %	1.2	1.1	1.0	3.6	1.9	1.5
rate, g CH ₂ /g cat/hr	0.07	0.06	0.06	0.20	0.11	0.08
CO ₂ formation, %						

Performance of CoW.10
 Dates: 07/11/95 - 07/14/95 Run #X

flow rate = 90.0 cc/min, loading = 0.2 g, WHSV = 12.8 l/hr, H₂/CO ratio in feed = 2

time on stream, hr	65.5	68.5	71.5	74.5	77.5	80.5
reaction temperature, °C	280	280	280	280	280	280
pressure, atm	1.0	1.0	1.0	1.0	1.0	1.0
flow, cc/min	120.0	120.0	120.0	120.0	120.0	120.0

C1 - C15 product distribution, weight %

C1	41.67	44.24	38.11	43.18	34.52	36.59
C2	11.67	11.07	11.10	12.27	11.02	10.24
C3	12.76	11.67	12.73	1.05	12.61	12.13
C4	9.33	8.56	9.68	10.87	9.66	9.50
C5	7.16	6.92	7.99	8.88	8.33	8.84
C6	4.55	4.81	5.06	5.91	5.16	5.10
C7	3.42	3.38	4.12	4.57	4.62	4.80
C8	2.27	2.30	2.99	3.15	3.39	3.39
C9	1.53	1.54	1.99	2.21	2.41	2.52
C10	1.16	1.13	1.42	1.68	1.87	1.77
C11	0.73	0.73	0.96	1.12	1.52	1.30
C12	0.56	0.64	0.73	0.84	1.09	1.05
C13	0.32	0.26	0.34	0.50	0.55	0.71
C14	0.18	0.18	0.23	0.34	0.52	0.54
C15	0.21	0.18	0.23	0.29	0.29	0.36
alpha chain growth probability	0.59	0.59	0.60	0.63	0.65	0.66

C1 - C50 estimated total product distribution, weight %

C1	42.8	45.4	39.1	44.4	35.0	36.6
C2 - C4	34.7	32.1	34.3	24.9	33.8	31.9
C5 - C12	21.8	21.7	25.6	29.1	28.7	29.0
C13 - C50	0.8	0.8	1.0	1.6	2.5	2.6

CO conversion, %	1.3	1.2	1.0	0.8	0.8	0.9
rate, g CH ₂ /g cat/hr	0.07	0.07	0.06	0.05	0.04	0.05
CO ₂ formation, %						

CO Hydrogenation on CoW.10

CO Hydrogenation on CoW.10

CO Hydrogenation on CoW.10 - ASF Product Distribution

APPENDIX B

CHRONOLOGY OF RUNS IN SLURRY BUBBLE COLUMN REACTORS

CHRONOLOGY OF RUNS MADE IN THE SLURRY BUBBLE COLUMN REACTORS DURING THE THIRD QUARTER OF 1995

Task 2.0 -- Catalyst Testing

Subtask 2.2 - Slurry Bubble Column Testing

Run No. 48 in the M3-SBCR was started on July 5th with a charge of 15.5 gm of Catalyst No. CoW.13. This catalyst contained 10% Co, 10% Fe, and 0.5% Ru on alumina support. The CO conversion at startup conditions (240°C) was low, 8.5%, with a CH₄ selectivity at 10.8%. CO conversion increased to 20.0% at 260°C, 25.2% at 280°C, 28.0% at 300°C, and dropped to 2.6% at 240°C. This catalyst showed low initial reactivity and lost some reactivity as the reaction temperature was increased. The CO conversion dropped to 2.6% when the temperature was lowered to 240°C. This was only 30% of the initial conversion. This catalyst showed low resistance to deactivation at higher temperatures.

Run No. 49 in the M3-SBCR was started on July 13th with a charge of 15.5 gm of Catalyst No. Co.068. This catalyst contained 20% Co and 1% Pd on alumina support. The CO conversion at startup conditions averaged 26.7%. The reaction temperature was increased to 260°C and the CO conversion rose immediately to 41%, but dropped to 34% in a 24-hour period. At 280°C, the conversion peaked at 50%, but decayed to 33%. At 300°C the CO conversion rose to 45%, but again drifted down to about 28% after 24 hours. The conversion at 240°C was only 3.8%, or about 15% of the initial conversion. This catalyst showed low resistance to deactivation at higher temperatures.

Run No. 50 was started in the M3-SBCR on July 24th with a charge of 15.5 gm of Catalyst No. Co.066. This catalyst contained 15% Co, 5% Fe, and 0.5% Ru on alumina. The CO conversion at startup conditions was 21.1% with a CH₄ selectivity of 11.3%. The catalyst activity was in the range expected for a 15% Co catalyst. At 260°C the CO conversion peaked at 45.5% and dropped down to 36.1%. At 280°C the CO conversion peaked at 47.6% and then dropped down to 36.9%. Finally, at 300°C the conversion reached 48% and settled down to 31.1% a few hours later. The conversion at 240°C was down to 3.7% or about 17.5% of the initial CO conversion. This catalyst is typical of other cobalt catalysts which have good initial catalytic activity, but deactivate fairly rapidly at reaction temperatures of 240°C and higher due to carbon or coke formation. Addition of Fe does not appear to reduce the activity loss.

Run No. 51 was started in the M3-SBCR on August 2nd with a charge of 58 gm of Catalyst No. C.3950. This catalyst is a sample of the iron catalyst used in the F-T Run II at Laporte, Texas. The catalyst was reduced in-situ as prescribed and the run conditions were changed to baseline conditions: 175 psi pressure, 270°C reaction temperature, 0.7 H₂/CO feed ratio, and a total gas feed space velocity of 3,335 SL/hr/Kg-Fe. The CO conversion was 17.4%, the CH₄ selectivity was 9.3%, and the CO₂ selectivity was 51.1%. The reactor temperature was raised to 300°C, the pressure to 600 psi, and the gas space velocity to 15,517 SL/hr/Kg-Fe. After 5 hours at these run conditions, the

bottom reactor thermocouple rose to 437°C. Within 2 hours the reactor plugged near the bottom just above the inlet filter. The run was terminated at this time and it will be repeated as soon as the reactor is cleaned out.

Run No. 52 was started in the M3-SBCR on August 10th with a charge of 58 gm of Catalyst No. C.3950. After reducing the catalyst in-situ as before, the conditions were changed to 270°C, 450 psi, 2/1 H₂/CO ratio, and a total gas flow of 900 SLH (approximately 15,517 SL/hr/Kg-Fe space velocity). The CO conversion was 19.0%, CH₄ selectivity was 33.4%, and the CO₂ selectivity was 34.8%. The CO conversion increased to 29.2% at 276°C, 29.4% at 279°C, 35.8% at 288°C and 92.3% at 299°C. The CO conversion increased to 97.8% when the pressure was raised to 600 psi. At this time the H₂/CO ratio was changed from 2/1 to 1/1. Within 2 hours, the temperature in the top section began to increase rapidly. The reactor heaters were turned off and the syngas flow was stopped, but the temperature increased above 350°C and the reactor plugged. The unit was shut down and clean out again.

Run No. 53 was started in the M3-SBCR on August 23rd with a charge of 58 gm of Catalyst No. C.3950. After reducing the catalyst in-situ as before, the reaction conditions were changed to 270°C, 450 psi, a 1/1 H₂/CO feed ratio, and a total gas flow of 900 SLH. The CO conversion was 21.9%, CH₄ selectivity was 12.9%, and the CO₂ selectivity was 45.6%. The higher CO content in the feed gas resulted in lower CH₄ selectivity, but much higher CO₂ selectivity. The CO conversion increased to 25.7% at 280°C, 25% at 290°C, and 28.5% at 300°C. The H₂/CO ratio was then lowered to 0.7/1. The CO conversion stayed at 27.2% and the CO₂ selectivity was essentially the same at 47.2%. The reactor pressure was then increased to 600 psi. The CO conversion increased slightly to 29.4%, but the CH₄ and CO₂ selectivities were unchanged. Over a period of 4 hours, the reaction temperature gradually increased until it reached 360°C at which time the reactor plugged again in the top section near the internal filter.

Synfluid was not fed continuously during any of the above three runs. Some synfluid was added daily to try to maintain the liquid slurry height in the reactor. Since there is no way to remove the heat of reaction, there was little we could do to stop the reactor temperature from running away once it got started. The reactor plugs may have been due to foaming or carbon formation during the temperature runaway. It has been difficult to run the iron catalyst in the SBCR. One more run will be made as soon as the run conditions are determined.

Run No. 55 was started in the M3-SBCR on September 21st with a charge of 43 gm of Catalyst No. C.3950 (the fourth run with this catalyst). After reducing the catalyst in-situ as before, the reaction conditions were changed to 270°C, 175 psi, an 0.7 H₂/CO feed ratio, and a total gas flow of 355 SHL (6,670 SL/hr/Kg-Fe space velocity). The CO conversion was 18.7%, production rate - 0.27 gm C₁+ /gm cat/hr, CH₄ selectivity - 9.5%, and the CO₂ selectivity was 49.1%. These were similar to those obtained in Run M3-51. The total gas rate was reduced in half to 180 SLH, and the CO conversion increased to 28.1%. The production rate dropped to 0.21 gm/gm/hr, the CH₄ selectivity dropped to 8.8%, and the CO₂ selectivity was similar at 48.6%.

The reaction temperature was increased to 300°C and the following yields were obtained: CO conversion - 35.5%, production rate - 0.26 g/g/hr, CH₄ selectivity - 12.5%, and CO₂ selectivity -

48.6%.

The reaction pressure was raised to 500 psi and the total gas rate was increased to 475 SLH. At this time the reaction temperature in the bottom of the reactor began to rise (up to 320°C) and the top temperature dropped to 290°C. The N₂ flow rate was increased to help remove the heat of reaction and to increase the gas superficial velocity to improve mixing. After 4 hours, the bottom temperature stabilized at 303°C, but the top temperature leveled out at 285°C, an 18°C differential temperature. Four hours later, while the unit was unattended, the reactor bottom temperature rose to 360°C and the reactor plugged solid. Up to this point, the CO conversion reached 65.1%, production rate - 1.31 g/g/hr, CH₄ selectivity - 18.7%, and the CO₂ selectivity peaked at 51.0%. It is obvious to us now that the heat removal capabilities of our unit had been exceeded, plus the operation requires a technician on duty whenever the more severe operating conditions are reached.

Task 4.0 - Catalyst Aging Studies

Run No. 37 was started in the M4-SBCR on August 14th with a charge of 25.0 gm of Catalyst No. Co.005. This was a base case catalyst containing 20% Co on an alumina support with no promoters. The synfluid feed was stopped on August 29th after 350 hours on stream. For the next 96 hours, the CO conversion stayed at 12.5%, the THC rate averaged 0.36 gm C₁+ / gm cat/hr, while the CH₄ selectivity was 5.2%.

At 449 hours the N₂ feed rate was lowered from 62% to 40% of the total gas feed rate and the H₂ and CO feed rates were increased at a 2/1 ratio while maintaining the same total gas feed rate. The CO conversion dropped to 8.6%, but the THC production rate increased to 0.41 gm/gm/hr, and the CH₄ selectivity jumped to 10.4%. These conditions were held for 240 hours and the CO conversion dropped to 7.6%, the THC production rate to 0.36 gm/gm/hr while the CH₄ selectivity averaged 10.8%.

At 663 hours on stream, the H₂/CO ratio was changed to 1.5/1 while maintaining the same total gas feed rate. The CO conversion dropped to 5.6%, THC production rate to 0.32 gm/gm/hr, and the CH₄ selectivity dropped to 8.4%.

The N₂ feed rate was lowered from 40% to 33% while maintaining the same total feed gas rate at 687 hours on stream. The CO conversion dropped again to 4.8%, the THC rate went down to 0.29 gm/gm/hr while the CH₄ selectivity rose up to 10.3%. The synfluid feed was restarted at 735 hours on stream. The CO conversion rose to 5.6%, the THC went up to 0.35 gm/gm/hr, and the CH₄ selectivity dropped to 8.6%. There is some beneficial effect of adding synfluid continuously during the operation.

At 759 hours the reaction conditions were returned to the initial conditions for Period 3. The CO conversion averaged 10.4%, the THC was 0.31 gm/gm/hr, and the CH₄ selectivity averaged 4.7%. This was a loss of about 28% of the initial catalyst activity after 806 hours on stream.

The run was extended for one more day to check the catalyst activity at 33% N₂ feed rate at a 1.5/1 H₂/CO feed ratio. The CO conversion returned to about the same value, 4.5% vs. 4.8%, the

THC to 0.28 gm/gm/hr vs. 0.29, and the CH₄ selectivities were similar, 9.7% vs. 10.3%. This run was shut down on September 18th after 830 hours of successful operation.

Run No. 38 in M4-SBCR was started on September 28th with a charge of 31 gm of Catalyst No. CAL.14. This catalyst contained 20% Co, 0.5% Ru, and 0.3% K on alumina support that was reduced and coated with soya wax. The CO conversion at startup conditions was 25.5%, the THC production rate was 1.23 gm C₁+/gm cat/hr, and the CH₄ selectivity was 6.2%. Calsicat had prepared this new batch of catalyst using a modified H₂ reduction and wax coating procedure to improve catalyst activity. The CO conversion was about 10% lower than a comparable catalyst (CAL.13) that was H₂ reduced as a powder and charged into the reactor slurried with synfluid under nitrogen. The THC production rates and CH₄ selectivities were very similar. The new catalyst reduction and waxing procedure by Calsicat has been improved. It would greatly simplify the preparation and charging of large batches of catalyst into a commercial reactor if the catalyst can be prepared with wax.

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 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 %CH ₄	%C ₂	%C ₃ +	%CO ₂	Alpha GC	Alpha Liq	Olefin/Paraf C ₃	C ₄	Olefins C ₆ -18, %	Comments
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 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 H2: psi	Synfl CO	Conv. cc/hr	Prod. %	Selectivities				Alpha GC	Alpha Liq	Olefin/Paraf		Olefins C6-18, %	Comments
											%CH4	%C2	%C3+	%CO2			C3	C4		
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 MS SCCR RUN RESULTS

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

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

(Conversion and selectivities are calculated using H₂ as an internal

standard in the GC analysis of the offgas.

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

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

Run Cat.	Per Time	Time Temp	Pres H2	Synfl Conv.	Prod.	Selectivities	Alpha	Alpha Olefin/Paraf	Olefins	Comments																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
No	WT, g	No	Start	Stop	C	psi	CO	cc/hr	% Rate	%C ₁	%C ₂	%C ₃	%C ₄	%C ₅	%C ₆	%C ₇	%C ₈	%C ₉	%C ₁₀	%C ₁₁	%C ₁₂	%C ₁₃	%C ₁₄	%C ₁₅	%C ₁₆	%C ₁₇	%C ₁₈	%C ₁₉	%C ₂₀	%C ₂₁	%C ₂₂	%C ₂₃	%C ₂₄	%C ₂₅	%C ₂₆	%C ₂₇	%C ₂₈	%C ₂₉	%C ₃₀	%C ₃₁	%C ₃₂	%C ₃₃	%C ₃₄	%C ₃₅	%C ₃₆	%C ₃₇	%C ₃₈	%C ₃₉	%C ₄₀	%C ₄₁	%C ₄₂	%C ₄₃	%C ₄₄	%C ₄₅	%C ₄₆	%C ₄₇	%C ₄₈	%C ₄₉	%C ₅₀	%C ₅₁	%C ₅₂	%C ₅₃	%C ₅₄	%C ₅₅	%C ₅₆	%C ₅₇	%C ₅₈	%C ₅₉	%C ₆₀	%C ₆₁	%C ₆₂	%C ₆₃	%C ₆₄	%C ₆₅	%C ₆₆	%C ₆₇	%C ₆₈	%C ₆₉	%C ₇₀	%C ₇₁	%C ₇₂	%C ₇₃	%C ₇₄	%C ₇₅	%C ₇₆	%C ₇₇	%C ₇₈	%C ₇₉	%C ₈₀	%C ₈₁	%C ₈₂	%C ₈₃	%C ₈₄	%C ₈₅	%C ₈₆	%C ₈₇	%C ₈₈	%C ₈₉	%C ₉₀	%C ₉₁	%C ₉₂	%C ₉₃	%C ₉₄	%C ₉₅	%C ₉₆	%C ₉₇	%C ₉₈	%C ₉₉	%C ₁₀₀	%C ₁₀₁	%C ₁₀₂	%C ₁₀₃	%C ₁₀₄	%C ₁₀₅	%C ₁₀₆	%C ₁₀₇	%C ₁₀₈	%C ₁₀₉	%C ₁₁₀	%C ₁₁₁	%C ₁₁₂	%C ₁₁₃	%C ₁₁₄	%C ₁₁₅	%C ₁₁₆	%C ₁₁₇	%C ₁₁₈	%C ₁₁₉	%C ₁₂₀	%C ₁₂₁	%C ₁₂₂	%C ₁₂₃	%C ₁₂₄	%C ₁₂₅	%C ₁₂₆	%C ₁₂₇	%C ₁₂₈	%C ₁₂₉	%C ₁₃₀	%C ₁₃₁	%C ₁₃₂	%C ₁₃₃	%C ₁₃₄	%C ₁₃₅	%C ₁₃₆	%C ₁₃₇	%C ₁₃₈	%C ₁₃₉	%C ₁₄₀	%C ₁₄₁	%C ₁₄₂	%C ₁₄₃	%C ₁₄₄	%C ₁₄₅	%C ₁₄₆	%C ₁₄₇	%C ₁₄₈	%C ₁₄₉	%C ₁₅₀	%C ₁₅₁	%C ₁₅₂	%C ₁₅₃	%C ₁₅₄	%C ₁₅₅	%C ₁₅₆	%C ₁₅₇	%C ₁₅₈	%C ₁₅₉	%C ₁₆₀	%C ₁₆₁	%C ₁₆₂	%C ₁₆₃	%C ₁₆₄	%C ₁₆₅	%C ₁₆₆	%C ₁₆₇	%C ₁₆₈	%C ₁₆₉	%C ₁₇₀	%C ₁₇₁	%C ₁₇₂	%C ₁₇₃	%C ₁₇₄	%C ₁₇₅	%C ₁₇₆	%C ₁₇₇	%C ₁₇₈	%C ₁₇₉	%C ₁₈₀	%C ₁₈₁	%C ₁₈₂	%C ₁₈₃	%C ₁₈₄	%C ₁₈₅	%C ₁₈₆	%C ₁₈₇	%C ₁₈₈	%C ₁₈₉	%C ₁₉₀	%C ₁₉₁	%C ₁₉₂	%C ₁₉₃	%C ₁₉₄	%C ₁₉₅	%C ₁₉₆	%C ₁₉₇	%C ₁₉₈	%C ₁₉₉	%C ₂₀₀	%C ₂₀₁	%C ₂₀₂	%C ₂₀₃	%C ₂₀₄	%C ₂₀₅	%C ₂₀₆	%C ₂₀₇	%C ₂₀₈	%C ₂₀₉	%C ₂₁₀	%C ₂₁₁	%C ₂₁₂	%C ₂₁₃	%C ₂₁₄	%C ₂₁₅	%C ₂₁₆	%C ₂₁₇	%C ₂₁₈	%C ₂₁₉	%C ₂₂₀	%C ₂₂₁	%C ₂₂₂	%C ₂₂₃	%C ₂₂₄	%C ₂₂₅	%C ₂₂₆	%C ₂₂₇	%C ₂₂₈	%C ₂₂₉	%C ₂₃₀	%C ₂₃₁	%C ₂₃₂	%C ₂₃₃	%C ₂₃₄	%C ₂₃₅	%C ₂₃₆	%C ₂₃₇	%C ₂₃₈	%C ₂₃₉	%C ₂₄₀	%C ₂₄₁	%C ₂₄₂	%C ₂₄₃	%C ₂₄₄	%C ₂₄₅	%C ₂₄₆	%C ₂₄₇	%C ₂₄₈	%C ₂₄₉	%C ₂₅₀	%C ₂₅₁	%C ₂₅₂	%C ₂₅₃	%C ₂₅₄	%C ₂₅₅	%C ₂₅₆	%C ₂₅₇	%C ₂₅₈	%C ₂₅₉	%C ₂₆₀	%C ₂₆₁	%C ₂₆₂	%C ₂₆₃	%C ₂₆₄	%C ₂₆₅	%C ₂₆₆	%C ₂₆₇	%C ₂₆₈	%C ₂₆₉	%C ₂₇₀	%C ₂₇₁	%C ₂₇₂	%C ₂₇₃	%C ₂₇₄	%C ₂₇₅	%C ₂₇₆	%C ₂₇₇	%C ₂₇₈	%C ₂₇₉	%C ₂₈₀	%C ₂₈₁	%C ₂₈₂	%C ₂₈₃	%C ₂₈₄	%C ₂₈₅	%C ₂₈₆	%C ₂₈₇	%C ₂₈₈	%C ₂₈₉	%C ₂₉₀	%C ₂₉₁	%C ₂₉₂	%C ₂₉₃	%C ₂₉₄	%C ₂₉₅	%C ₂₉₆	%C ₂₉₇	%C ₂₉₈	%C ₂₉₉	%C ₃₀₀	%C ₃₀₁	%C ₃₀₂	%C ₃₀₃	%C ₃₀₄	%C ₃₀₅	%C ₃₀₆	%C ₃₀₇	%C ₃₀₈	%C ₃₀₉	%C ₃₁₀	%C ₃₁₁	%C ₃₁₂	%C ₃₁₃	%C ₃₁₄	%C ₃₁₅	%C ₃₁₆	%C ₃₁₇	%C ₃₁₈	%C ₃₁₉	%C ₃₂₀	%C ₃₂₁	%C ₃₂₂	%C ₃₂₃	%C ₃₂₄	%C ₃₂₅	%C ₃₂₆	%C ₃₂₇	%C ₃₂₈	%C ₃₂₉	%C ₃₃₀	%C ₃₃₁	%C ₃₃₂	%C ₃₃₃	%C ₃₃₄	%C ₃₃₅	%C ₃₃₆	%C ₃₃₇	%C ₃₃₈	%C ₃₃₉	%C ₃₄₀	%C ₃₄₁	%C ₃₄₂	%C ₃₄₃	%C ₃₄₄	%C ₃₄₅	%C ₃₄₆	%C ₃₄₇	%C ₃₄₈	%C ₃₄₉	%C ₃₅₀	%C ₃₅₁	%C ₃₅₂	%C ₃₅₃	%C ₃₅₄	%C ₃₅₅	%C ₃₅₆	%C ₃₅₇	%C ₃₅₈	%C ₃₅₉	%C ₃₆₀	%C ₃₆₁	%C ₃₆₂	%C ₃₆₃	%C ₃₆₄	%C ₃₆₅	%C ₃₆₆	%C ₃₆₇	%C ₃₆₈	%C ₃₆₉	%C ₃₇₀	%C ₃₇₁	%C ₃₇₂	%C ₃₇₃	%C ₃₇₄	%C ₃₇₅	%C ₃₇₆	%C ₃₇₇	%C ₃₇₈	%C ₃₇₉	%C ₃₈₀	%C ₃₈₁	%C ₃₈₂	%C ₃₈₃	%C ₃₈₄	%C ₃₈₅	%C ₃₈₆	%C ₃₈₇	%C ₃₈₈	%C ₃₈₉	%C ₃₉₀	%C ₃₉₁	%C ₃₉₂	%C ₃₉₃	%C ₃₉₄	%C ₃₉₅	%C ₃₉₆	%C ₃₉₇	%C ₃₉₈	%C ₃₉₉	%C ₄₀₀	%C ₄₀₁	%C ₄₀₂	%C ₄₀₃	%C ₄₀₄	%C ₄₀₅	%C ₄₀₆	%C ₄₀₇	%C ₄₀₈	%C ₄₀₉	%C ₄₁₀	%C ₄₁₁	%C ₄₁₂	%C ₄₁₃	%C ₄₁₄	%C ₄₁₅	%C ₄₁₆	%C ₄₁₇	%C ₄₁₈	%C ₄₁₉	%C ₄₂₀	%C ₄₂₁	%C ₄₂₂	%C ₄₂₃	%C ₄₂₄	%C ₄₂₅	%C ₄₂₆	%C ₄₂₇	%C ₄₂₈	%C ₄₂₉	%C ₄₃₀	%C ₄₃₁	%C ₄₃₂	%C ₄₃₃	%C ₄₃₄	%C ₄₃₅	%C ₄₃₆	%C ₄₃₇	%C ₄₃₈	%C ₄₃₉	%C ₄₄₀	%C ₄₄₁	%C ₄₄₂	%C ₄₄₃	%C ₄₄₄	%C ₄₄₅	%C ₄₄₆	%C ₄₄₇	%C ₄₄₈	%C ₄₄₉	%C ₄₅₀	%C ₄₅₁	%C ₄₅₂	%C ₄₅₃	%C ₄₅₄	%C ₄₅₅	%C ₄₅₆	%C ₄₅₇	%C ₄₅₈	%C ₄₅₉	%C ₄₆₀	%C ₄₆₁	%C ₄₆₂	%C ₄₆₃	%C ₄₆₄	%C ₄₆₅	%C ₄₆₆	%C ₄₆₇	%C ₄₆₈	%C ₄₆₉	%C ₄₇₀	%C ₄₇₁	%C ₄₇₂	%C ₄₇₃	%C ₄₇₄	%C ₄₇₅	%C ₄₇₆	%C ₄₇₇	%C ₄₇₈	%C ₄₇₉	%C ₄₈₀	%C ₄₈₁	%C ₄₈₂	%C ₄₈₃	%C ₄₈₄	%C ₄₈₅	%C ₄₈₆	%C ₄₈₇	%C ₄₈₈	%C ₄₈₉	%C ₄₉₀	%C ₄₉₁	%C ₄₉₂	%C ₄₉₃	%C ₄₉₄	%C ₄₉₅	%C ₄₉₆	%C ₄₉₇	%C ₄₉₈	%C ₄₉₉	%C ₅₀₀	%C ₅₀₁	%C ₅₀₂	%C ₅₀₃	%C ₅₀₄	%C ₅₀₅	%C ₅₀₆	%C ₅₀₇	%C ₅₀₈	%C ₅₀₉	%C ₅₁₀	%C ₅₁₁	%C ₅₁₂	%C ₅₁₃	%C ₅₁₄	%C ₅₁₅	%C ₅₁₆	%C ₅₁₇	%C ₅₁₈	%C ₅₁₉	%C ₅₂₀	%C ₅₂₁	%C ₅₂₂	%C ₅₂₃	%C ₅₂₄	%C ₅₂₅	%C ₅₂₆	%C ₅₂₇	%C ₅₂₈	%C ₅₂₉	%C ₅₃₀	%C ₅₃₁	%C ₅₃₂	%C ₅₃₃	%C ₅₃₄	%C ₅₃₅	%C ₅₃₆	%C ₅₃₇	%C ₅₃₈	%C ₅₃₉	%C ₅₄₀	%C ₅₄₁	%C ₅₄₂	%C ₅₄₃	%C ₅₄₄	%C ₅₄₅	%C ₅₄₆	%C ₅₄₇	%C ₅₄₈	%C ₅₄₉	%C ₅₅₀	%C ₅₅₁	%C ₅₅₂	%C ₅₅₃	%C ₅₅₄	%C ₅₅₅	%C ₅₅₆	%C ₅₅₇	%C ₅₅₈	%C ₅₅₉	%C ₅₆₀	%C ₅₆₁	%C ₅₆₂	%C ₅₆₃	%C ₅₆₄	%C ₅₆₅	%C ₅₆₆	%C ₅₆₇	%C ₅₆₈	%C ₅₆₉	%C ₅₇₀	%C ₅₇₁	%C ₅₇₂	%C ₅₇₃	%C ₅₇₄	%C ₅₇₅	%C ₅₇₆	%C ₅₇₇	%C ₅₇₈	%C ₅₇₉	%C ₅₈₀	%C ₅₈₁	%C ₅₈₂	%C ₅₈₃	%C ₅₈₄	%C ₅₈₅	%C ₅₈₆	%C ₅₈₇	%C ₅₈₈	%C ₅₈₉	%C ₅₉₀	%C ₅₉₁	%C ₅₉₂	%C ₅₉₃	%C ₅₉₄	%C ₅₉₅	%C ₅₉₆	%C ₅₉₇	%C ₅₉₈	%C ₅₉₉	%C ₆₀₀	%C ₆₀₁	%C ₆₀₂	%C ₆₀₃	%C ₆₀₄	%C ₆₀₅	%C ₆₀₆	%C ₆₀₇	%C ₆₀₈	%C ₆₀₉	%C ₆₁₀	%C ₆₁₁	%C ₆₁₂	%C ₆₁₃	%C ₆₁₄	%C ₆₁₅	%C ₆₁₆	%C ₆₁₇	%C ₆₁₈	%C ₆₁₉	%C ₆₂₀	%C ₆₂₁	%C ₆₂₂	%C ₆₂₃	%C ₆₂₄	%C ₆₂₅	%C ₆₂₆	%C ₆₂₇	%C ₆₂₈	%C ₆₂₉	%C ₆₃₀	%C ₆₃₁	%C ₆₃₂	%C ₆₃₃	%C ₆₃₄	%C ₆₃₅	%C ₆₃₆	%C ₆₃₇	%C ₆₃₈	%C ₆₃₉	%C ₆₄₀	%C ₆₄₁	%C ₆₄₂	%C ₆₄₃	%C ₆₄₄	%C ₆₄₅	%C ₆₄₆	%C ₆₄₇	%C ₆₄₈	%C ₆₄₉	%C ₆₅₀	%C ₆₅₁	%C ₆₅₂	%C ₆₅₃	%C ₆₅₄	%C ₆₅₅	%C ₆₅₆	%C ₆₅₇	%C ₆₅₈	%C ₆₅₉	%C ₆₆₀	%C ₆₆₁	%C ₆₆₂	%C ₆₆₃	%C ₆₆₄	%C ₆₆₅	%C ₆₆₆	%C ₆₆₇	%C ₆₆₈	%C ₆₆₉	%C ₆₇₀	%C ₆₇₁	%C ₆₇₂	%C ₆₇₃	%C ₆₇₄	%C ₆₇₅	%C ₆₇₆	%C ₆₇₇	%C ₆₇₈	%C ₆₇₉	%C ₆₈₀	%C ₆₈₁	%C ₆₈₂	%C ₆₈₃	%C ₆₈₄	%C ₆₈₅	%C ₆₈₆	%C ₆₈₇	%C ₆₈₈	%C ₆₈₉	%C ₆₉₀	%C ₆₉₁	%C ₆₉₂	%C ₆₉₃	%C ₆₉₄	%C ₆₉₅	%C ₆₉₆	%C ₆₉₇	%C ₆₉₈	%C ₆₉₉	%C ₇₀₀	%C ₇₀₁	%C ₇₀₂	%C ₇₀₃	%C ₇₀₄	%C ₇₀₅	%C ₇₀₆	%C ₇₀₇	%C ₇₀₈	%C ₇₀₉	%C ₇₁₀	%C ₇₁₁	%C ₇₁₂	%C ₇₁₃	%C ₇₁₄	%C ₇₁₅	%C ₇₁₆	%C ₇₁₇	%C ₇₁₈	%C ₇₁₉	%C ₇₂₀	%C ₇₂₁	%C ₇₂₂	%C ₇₂₃	%C ₇₂₄	%C ₇₂₅	%C ₇₂₆	%C ₇₂₇	%C ₇₂₈	%C ₇₂₉	%C ₇₃₀	%C ₇₃₁	%C ₇₃₂	%C ₇₃₃	%C ₇₃₄	%C ₇₃₅	%C ₇₃₆	%C ₇₃₇	%C ₇₃₈	%C ₇₃₉	%C ₇₄₀	%C ₇₄₁	%C ₇₄₂	%C ₇₄₃	%C ₇₄₄	%C ₇₄₅	%C ₇₄₆	%C ₇₄₇	%C ₇₄₈	%C ₇₄₉	%C ₇₅₀	%C ₇₅₁	%C ₇₅₂	%C ₇₅₃	%C ₇₅₄	%C ₇₅₅	%C ₇₅₆	%C ₇₅₇	%C ₇₅₈	%C ₇₅₉	%C ₇₆₀	%C ₇₆₁	%C ₇₆₂	%C ₇₆₃	%C ₇₆₄	%C ₇₆₅	%C ₇₆₆	%C ₇₆₇	%C ₇₆₈	%C ₇₆₉	%C ₇₇₀	%C ₇₇₁	%C ₇₇₂	%C ₇₇₃	%C ₇₇₄	%C ₇₇₅	%C ₇₇₆	%C ₇₇₇	%C ₇₇₈	%C ₇₇₉	%C ₇₈₀	%C ₇₈₁	%C ₇₈₂	%C ₇₈₃	%C ₇₈₄	%C ₇₈₅	%C ₇₈₆	%C ₇₈₇	%C ₇₈₈	%C ₇₈₉	%C ₇₉₀	%C ₇₉₁	%C ₇₉₂	%C ₇₉₃	%C ₇₉₄	%C ₇₉₅	%C ₇₉₆	%C ₇₉₇	%C ₇₉₈	%C ₇₉₉	%C ₈₀₀	%C ₈₀₁	%C ₈₀₂	%C ₈₀₃	%C ₈₀₄	%C ₈₀₅	%C ₈₀₆	%C ₈₀₇	%C ₈₀₈	%C ₈₀₉	%C ₈₁₀	%C ₈₁₁	%C ₈₁₂	%C ₈₁₃	%C ₈₁₄	%C ₈₁₅	%C ₈₁₆	%C ₈₁₇	%C ₈₁₈	%C ₈₁₉	%C ₈₂₀	%C ₈₂₁	%C ₈₂₂	%C ₈₂₃	%C ₈₂₄	%C ₈₂₅	%C ₈₂₆	%C ₈₂₇	%C ₈₂₈	%C ₈₂₉	%C ₈₃₀	%C ₈₃₁	%C ₈₃₂	%C ₈₃₃	%C ₈₃₄	%C ₈₃₅	%C ₈₃₆	%C ₈₃₇	%C ₈₃₈	%C ₈₃₉	%C ₈₄₀	%C ₈₄₁	%C ₈₄₂	%C ₈₄₃	%C ₈₄₄	%C ₈₄₅	%C ₈₄₆	%C ₈₄₇	%C ₈₄₈	%C ₈₄₉	%C ₈₅₀	%C ₈₅₁	%C ₈₅₂	%C ₈₅₃	%C ₈₅₄	%C ₈₅₅	%C ₈₅₆	%C ₈₅₇	%C ₈₅₈	%C ₈₅₉	%C ₈₆₀	%C ₈₆₁	%C ₈₆₂	%C ₈₆₃	%C ₈₆₄	%C ₈₆₅	%C ₈₆₆	%C ₈₆₇	%C ₈₆₈	%C ₈₆₉	%C ₈₇₀	%C ₈₇₁	%C ₈₇₂	%C ₈₇₃	%C ₈₇₄	%C ₈₇₅	%C ₈₇₆	%C ₈₇₇	%C ₈₇₈	%C ₈₇₉	%C ₈₈₀	%C ₈₈₁	%C ₈₈₂

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 C5-18, %	Comments
												XC _{H4}	XC ₂	XC ₃₊	XC _{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	21.3	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	0.49	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	24.3	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 SCCR 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. rates: 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	N2: CO	Synfl cc/hr	Conv. %	Prod. Rate	Selectivities				Alpha GC	Alpha Liq	Olefin C1	Paraf C4	Olefins C5-18, %	Comments
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	0.39	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	153	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	0.39	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
30	CO.053	29.6	1	26	39	240	450	2.0	20	41.8	1.02	22.6	2.9	71.5	3.05	0.66	--	0.99	0.65	19.6	
30	CO.053	29.6	2	55	63	260	450	2.0	20	46.9	1.11	40.6	5.5	46.0	7.98	0.65	--	0.83	0.64	--	
30	CO.053	29.6	3	79	87	280	450	2.0	20	41.4	0.96	41.9	6.5	42.0	9.63	0.40	--	2.06	1.35	--	
30	CO.053	29.6	4	103	111	240	450	2.0	20	19.9	0.49	19.2	3.6	75.8	1.45	0.64	--	4.29	2.50	--	
30	CO.053	29.6	5	131	135	265	450	2.0	20	36.4	0.89	36.4	5.2	54.4	4.04	0.53	--	2.45	1.60	--	
30	CO.053	29.6	6	154	159	280	450	2.0	20	39.6	0.96	48.3	5.9	39.0	6.84	0.40	--	2.44	1.62	--	
30	CO.053	29.6	7	174	183	300	450	2.0	20	40.7	0.94	42.4	6.8	40.7	10.2	0.47	--	3.11	2.03	--	
30	CO.053	29.6	8	198	207	309	450	2.0	20	38.3	0.85	22.8	7.3	58.3	11.6	0.62	--	3.76	2.48	--	G.C.Calib
30	CO.053	29.6	9	220	231	310	450	2.0	20	37.5	0.87	55.5	7.2	25.5	11.8	0.13	--	3.93	2.67	--	
30	CO.053	29.6	10	242	254	320	450	2.0	20	40.8	0.90	61.7	7.4	14.5	16.4	0.00	--	3.62	2.63	--	
30	CO.053	29.6	11	270	279	320	450	1.0	20	30.8	0.92	42.9	6.0	26.9	24.2	0.30	--	5.68	4.28	--	

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	Per wt, g	Time No	Time Start	Temp Stop	Pres C	N2: psi CO	Synfld cc/hr	Conv. %	Prod. Rate	Selectivity %C ₂ H ₄ %C ₂ H ₆ %C ₃ +	Alpha GC	Alpha Liq	Olefin/Paraf C ₃ C ₄	Olefins C ₆ -C ₁₈ , %	Comments
31	Co.055	15.0	1	23	39	240	450 2.0	20	30.0	1.46 23.7	3.73 70.2	0.61	0.81	0.90 0.60	20.3	
31	Co.055	15.0	2	71	87	220	450 2.0	20	9.1	0.44 10.6	2.53 85.7	0.61	0.85	2.89 1.80	--	
31	Co.055	15.0	3	98	110	240	450 2.0	20	25.8	1.26 23.9	3.94 70.1	0.58	--	1.06 0.70	--	
31	Co.055	15.0	4	143	159	240	450 1.0	20	14.7	1.06 5.5	1.44 91.7	0.78	0.83	5.71 3.22	--	
31	Co.055	15.0	5	196	207	240	600 1.0	20	16.1	1.16 4.7	1.21 92.8	0.80	0.83	6.17 3.11	33.6	
31	Co.055	15.0	6	222	234	240	450 2.0	20	29.1	1.42 18.0	2.84 77.8	0.69	--	1.40 0.91	--	
32	Co.044	16.4	1	23	39	240	450 2.0	20	20.9	0.93 6.7	1.91 90.8	0.77	0.83	3.42 2.17	23.1	
32	Co.044	16.4	2	71	87	220	450 2.0	20	10.3	0.46 0.0	0.92 98.8	0.85	--	4.33 4.50	--	
32	Co.044	16.4	3	102	110	240	450 2.0	20	21.8	0.97 6.4	1.72 91.3	0.79	--	3.00 1.77	--	
32	Co.044	16.4	4	143	159	240	450 1.0	20	9.87	0.25 2.1	3.19 92.5	0.61	0.87	7.33 4.00	--	
32	Co.044	16.4	5	174	182	240	450 2.0	20	20.2	0.89 6.8	1.85 90.8	0.79	--	2.92 1.75	--	
33	Co.053	31.4	1	24	39	240	450 2.0	20	41.4	0.94 23.2	3.14 69.6	0.65	0.76	0.82 0.58	21.7	G.C. Calib
33	Co.053	31.4	2	54	63	240	300 2.0	20	35.2	0.47 29.9	3.93 59.6	0.55	--	0.89 0.70	--	
33	Co.053	31.4	3	78	87	240	300 2.0	20	38.7	0.38 31.1	3.90 57.5	0.54	--	0.97 0.71	--	
33	Co.053	31.4	4	102	111	250	300 2.0	20	39.6	0.38 43.1	4.60 41.1	0.38	--	0.99 0.77	--	
33	Co.053	31.4	5	126	135	260	300 2.0	20	37.7	0.37 42.1	4.59 42.4	0.42	--	1.76 1.21	--	
33	Co.053	31.4	6	150	159	260	450 2.0	20	45.0	0.44 43.2	4.80 40.9	0.44	--	1.35 0.95	--	
33	Co.053	31.4	7	174	183	260	450 2.0	20	45.7	0.73 46.4	4.63 40.2	0.43	--	1.06 0.77	--	
33	Co.053	31.4	8	198	207	260	450 2.0	20	49.2	0.98 44.4	4.26 43.5	0.51	--	0.87 0.65	--	
33	Co.053	31.4	9	222	230	240	450 2.0	20	16.1	0.38 33.7	4.79 59.2	0.35	--	3.14 1.91	--	
34	Co.060	15.6	1	23	32	240	450 2.0	20	31.4	1.46 14.0	2.34 82.2	0.75	0.79	1.61 1.00	23.1	G.C. Calib
34	Co.060	15.6	2	71	87	220	450 2.0	20	13.0	0.60 0.1	1.77 97.8	0.81	0.88	4.00 2.83	--	G.C. Calib
34	Co.060	15.6	3	102	111	240	450 2.0	20	28.8	1.34 14.1	2.40 82.2	0.73	--	1.87 1.17	--	
34	Co.060	15.6	4	150	157	240	450 1.0	20	13.5	0.94 4.3	1.75 92.5	0.77	0.85	7.00 4.67	--	
34	Co.060	15.6	5	191	207	240	600 1.0	20	12.8	0.89 2.2	1.64 94.9	0.82	0.86	6.60 4.33	38.5	G.C. Calib
34	Co.060	15.6	6	222	230	240	450 2.0	20	24.9	1.16 13.8	2.78 82.2	0.74	--	2.73 1.73	--	
35	Co.041	26.0	1	23	39	240	450 2.0	20	35.7	1.00 13.6	2.13 82.9	0.79	0.82	1.09 0.74	18.2	
35	Co.041	26.0	2	54	63	250	450 2.0	20	42.1	1.17 27.3	4.61 64.4	0.65	--	0.49 0.41	--	G.C. Calib
35	Co.041	26.0	3	78	87	260	450 2.0	20	45.1	1.24 41.7	6.83 44.9	0.51	--	0.35 0.37	--	
35	Co.041	26.0	4	102	111	260	450 2.0	20	46.7	0.77 39.1	4.55 49.9	0.56	--	0.66 0.52	--	
35	Co.041	26.0	5	126	135	260	450 2.0	20	49.6	0.61 39.4	4.02 49.6	0.57	--	0.70 0.52	--	
35	Co.041	26.0	6	150	159	260	450 2.0	20	47.9	0.95 33.1	3.93 58.7	0.64	--	0.75 0.52	--	
35	Co.041	26.0	7	174	183	260	450 2.0	20	49.7	1.24 30.9	4.38 61.3	0.66	--	0.71 0.49	--	
35	Co.041	26.0	8	198	206	240	450 2.0	20	19.6	0.55 17.3	2.64 79.1	0.71	--	2.08 1.63	--	

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 C3	C4	Olefins C5-18, %	Comments
36	Co.032	15.9	1	23	39	240	450	2.0	20	24.0	1.10	9.1	1.8	88.2	0.83	0.77	0.83	3.23	2.00	25.2	
36	Co.032	15.9	2	71	87	220	450	2.0	20	7.7	0.35	0.0	1.5	97.8	0.77	0.81	0.91	4.00	3.33	--	
36	Co.032	15.9	3	102	111	240	450	2.0	20	21.1	0.97	8.7	2.4	88.2	0.68	0.78	--	3.08	1.86	--	G.C. Calib
36	Co.032	15.9	4	126	135	240	450	1.0	20	9.5	0.65	1.4	1.2	96.5	0.87	0.83	--	7.67	4.50	--	
36	Co.032	15.9	5	150	159	240	450	2.0	20	18.2	0.83	8.9	1.6	88.9	0.64	0.78	--	3.36	2.36	--	
36	Co.032	15.9	6	174	183	250	450	2.0	20	23.3	1.07	14.5	3.0	81.6	1.01	0.73	--	2.29	1.48	--	
36	Co.032	15.9	7	199	207	260	450	2.0	20	25.3	1.17	23.5	3.8	71.2	1.51	0.61	--	1.76	1.15	--	G.C. Calib
36	Co.032	15.9	8	222	230	240	450	2.0	20	11.0	0.51	10.4	2.9	85.9	0.88	0.67	--	3.33	2.33	--	
37	Co.045	15.9	1	23	39	240	450	2.0	20	14.8	0.67	8.0	1.7	89.4	0.91	0.76	0.84	2.78	1.90	20.3	
37	Co.045	15.9	2	54	63	220	450	2.0	20	5.1	0.23	0.0	1.5	97.7	0.77	0.80	0.88	4.00	3.00	--	
37	Co.045	15.9	3	78	87	240	450	2.0	20	13.8	0.63	8.2	1.9	89.0	0.89	0.76	--	3.00	1.80	--	
37	Co.045	15.9	4	102	111	240	450	1.0	20	6.5	0.44	0.1	1.4	97.3	1.16	0.82	--	5.00	2.00	--	
37	Co.045	15.9	5	126	135	240	450	2.0	20	13.4	0.61	0.6	1.8	88.9	0.80	0.79	--	2.00	0.00	--	
37	Co.045	15.9	6	150	159	250	450	2.0	20	19.6	0.91	17.5	2.5	80.0	--	0.77	--	--	0.00	--	G.C. Calib
37	Co.045	15.9	7	174	183	260	450	2.0	20	27.4	1.26	30.1	5.2	62.2	2.49	0.61	--	0.83	0.60	--	
37	Co.045	15.9	8	198	207	240	450	2.0	20	13.7	0.63	9.3	1.7	87.4	0.78	0.75	--	2.67	1.67	--	
38	Co.058	15.9	1	23	39	240	450	2.0	20	28.0	1.28	11.9	2.1	85.1	0.91	0.75	0.85	1.88	1.17	22.4	
38	Co.058	15.9	2	47	63	220	450	2.0	20	11.7	0.54	1.4	1.4	96.9	0.38	0.81	--	4.00	3.00	--	
38	Co.058	15.9	3	74	88	240	450	2.0	20	12.7	0.87	3.2	1.3	94.5	1.01	0.81	--	7.25	4.40	--	
38	Co.058	15.9	4	96	111	240	450	2.0	20	26.4	1.21	11.9	2.2	85.0	0.87	0.74	--	2.09	1.26	--	
39	Co.064	15.9	1	23	39	240	450	2.0	20	34.2	1.56	13.6	2.3	82.6	1.55	0.73	0.85	1.40	0.92	21.0	G.C. CALIB
39	Co.064	15.9	2	47	62	220	450	2.0	20	15.0	0.68	4.6	1.2	93.8	0.44	0.78	--	4.17	2.38	--	
39	Co.064	15.9	3	71	87	240	450	2.0	20	15.9	1.09	4.7	1.2	92.9	1.28	0.80	--	7.86	3.88	--	
39	Co.064	15.9	4	95	111	240	450	2.0	20	33.1	1.52	15.7	2.6	80.3	1.52	0.72	--	1.37	0.90	--	
40	Co.063	15.0	1	23	40	240	450	2.0	20	8.7	0.43	6.5	0.9	92.6	0.09	0.74	--	7.67	3.40	25.9	
40	Co.063	15.0	2	47	63	220	450	2.0	20	2.0	0.95	0.1	0.0	99.9	0.00	0.67	--	7.00	7.00	--	
40	Co.063	15.0	3	71	87	240	450	1.0	20	3.6	0.27	2.3	1.3	95.9	0.54	0.76	--	13.00	5.50	--	
40	Co.063	15.0	4	95	111	240	450	2.0	20	9.5	0.46	8.1	1.9	89.6	0.40	0.74	--	4.80	3.17	--	
41	Co.062	15.0	1	23	38	240	450	2.0	20	6.6	0.32	3.5	0.3	95.3	1.00	0.76	0.89	9.50	3.50	25.9	
41	Co.062	15.0	2	47	62	220	450	2.0	20	1.8	0.09	0.0	0.0	99.9	0.00	0.88	--	4.00	5.00	--	
41	Co.062	15.0	3	71	86	240	450	1.0	20	2.7	0.19	0.1	1.0	96.9	1.99	0.77	--	10.00	4.00	--	
41	Co.062	15.0	4	95	109	240	450	2.0	20	5.6	0.27	4.3	2.1	92.0	1.60	0.74	--	5.70	4.00	--	

Table I
(Continued)

SUMMARY OF M3 SBCR RUN RESULTS

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

)Conversion is total CO conversion over the period (I).

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

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

)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 C5-18, I	Comments
												XCH4	XC2	XC3+	XCO2			C3	C4		
42	Co.065	15.9	1	23	38	240	450	2.0	20	27.6	1.25	7.9	2.0	88.6	1.61	0.78	0.84	2.94	1.88	28.0	G.C.Calib
42	Co.065	15.9	2	47	62	220	450	2.0	20	10.0	0.46	0.0	2.0	97.3	0.67	0.82	--	5.33	3.25	--	
42	Co.065	15.9	3	71	86	240	450	1.0	20	13.1	0.89	1.2	1.5	95.7	1.67	0.84	--	7.00	5.50	--	
42	Co.065	15.9	4	95	110	240	450	2.0	20	26.2	1.19	9.0	2.1	87.3	1.57	0.78	--	3.06	2.13	--	
43	COW.12	9.1	1	23	38	240	450	2.0	20	6.1	0.47	20.3	6.1	66.3	7.29	0.61	0.83	3.63	2.33	11.9	
43	COW.12	9.1	2	54	62	279	450	2.0	20	25.1	1.86	32.4	5.4	51.3	11.0	0.52	--	1.62	1.12	--	
44	COW.11	15.6	1	23	38	240	450	2.0	20	4.7	0.20	8.4	6.3	74.4	10.9	0.60	--	5.40	3.50	--	
44	COW.11	15.6	2	47	62	260	450	2.0	20	12.7	0.51	18.6	6.1	59.8	15.4	0.56	--	4.57	3.00	--	
44	COW.11	15.6	3	71	80	280	450	2.0	20	24.5	0.94	25.6	6.3	47.3	20.8	0.49	--	3.38	2.29	--	
45	Fe.01	15.9	1	23	38	240	450	2.0	20	3.4	0.14	0.0	7.5	84.8	7.7	0.72	0.77	2.80	1.50	--	
45	Fe.01	15.9	2	71	62	280	450	2.0	20	14.5	0.55	17.2	8.8	54.0	19.9	0.54	--	1.51	1.00	--	
45	Fe.01	15.9	3	95	109	300	450	2.0	20	19.0	0.66	23.3	10.0	39.8	26.7	0.44	0.76	1.36	1.05	14.0	
46	COW.05	15.7	1	23	38	240	450	2.0	20	4.9	0.23	10.9	6.5	81.9	0.74	0.60	0.78	3.11	2.14	13.3	
46	COW.05	15.7	2	71	86	280	450	2.0	20	14.0	0.66	44.2	10.0	42.5	2.84	0.41	0.82	0.82	0.68	14.0	
46	COW.05	15.7	3	95	110	300	450	2.0	20	19.4	0.89	54.4	11.0	28.2	6.39	0.16	0.78	0.69	0.62	9.8	
47	Co.070	15.6	1	23	38	240	450	2.0	20	22.8	1.07	10.9	2.7	85.7	0.70	0.75	0.85	2.60	1.56	24.5	
47	Co.070	15.6	2	47	63	220	450	2.0	20	8.6	0.40	0.0	4.3	95.7	0.02	0.82	--	--	--	--	
47	Co.070	15.6	3	71	87	220	450	1.0	20	1.2	0.08	0.0	--	94.5	--	0.62	--	--	--	--	
47	Co.070	15.6	4	95	111	240	450	1.0	20	5.3	0.37	3.7	4.2	90.3	1.76	0.71	--	--	--	--	
47	Co.070	15.6	5	119	135	240	450	2.0	20	19.8	0.93	10.4	2.1	86.8	0.68	0.76	--	2.85	1.71	--	
47	Co.070	15.6	6	143	158	240	600	2.0	20	20.5	0.96	9.6	2.2	87.6	0.61	0.77	--	2.36	1.40	--	
48	Cow.13	15.5	1	23	38	240	450	2.0	20	8.5	0.39	10.9	8.1	76.9	4.30	0.74	0.89	4.00	3.00	21.0	G.C.Calib
48	Cow.13	15.5	2	47	62	260	450	2.0	20	20.0	0.90	19.9	5.0	68.5	6.61	0.64	--	2.56	1.74	--	
48	Cow.13	15.5	3	71	86	279	450	2.0	20	25.7	1.11	34.5	6.0	48.1	11.4	0.48	--	2.17	1.52	--	
48	Cow.13	15.5	4	95	110	300	450	2.0	20	28.0	1.12	41.2	7.4	32.0	19.4	0.35	--	2.22	1.61	--	
48	Cow.13	15.5	5	117	133	240	450	2.0	20	2.62	0.12	12.3	18.6	62.9	6.2	0.66	--	5.00	3.50	--	
49	Co.068	15.5	1	23	39	242	450	2.0	20	26.7	1.26	18.9	4.6	75.3	1.19	0.68	0.77	0.52	0.34	20.3	
49	Co.068	15.5	2	47	62	259	450	2.0	20	34.5	1.62	35.3	6.4	55.0	3.38	0.54	--	0.35	0.27	--	
49	Co.068	15.5	3	71	86	278	450	2.0	20	34.6	1.61	53.2	7.5	33.0	6.30	0.34	--	0.59	0.46	--	
49	Co.068	15.5	4	102	110	299	450	2.0	20	28.4	1.31	63.2	8.4	20.3	8.11	--	--	1.07	0.81	--	
49	Co.068	15.5	5	114	116	241	450	2.0	20	3.8	0.18	34.8	16.7	45.8	2.65	0.55	--	2.57	1.60	--	
50	Co.066	15.5	1	23	38	240	450	2.0	20	21.1	0.99	11.3	3.5	83.6	1.58	0.72	0.81	3.19	1.94	--	
50	Co.066	15.5	2	47	62	260	450	2.0	20	36.1	1.66	21.6	4.2	70.1	4.09	0.64	--	1.72	1.13	--	
50	Co.066	15.5	3	71	86	279	450	2.0	20	36.9	1.66	37.6	6.2	48.1	8.10	0.47	--	2.01	1.37	--	
50	Co.066	15.5	4	95	110	299	450	2.0	20	31.1	1.35	40.7	7.9	39.7	11.7	0.37	--	3.35	2.27	--	
50	Co.066	15.5	5	119	133	239	450	2.0	20	3.7	0.17	15.1	17.0	64.6	3.31	0.67	--	7.00	12.00	--	

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	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 C3	C4	Olefins C6-C18,%	Comments
---	---	---	---	---	---	---	---	---	---	---	---	%CH4	%C2	%C3+	%CO2	---	---	---	---	---	---
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	33.6	
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	0.85	5.71	3.44	--	
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	0.79	2.87	1.79	25.9	G.C.Repair

Feed Gas Rates

Per N2 H2 CO Total
No SLH SLH SLH SLH

1	565	225	112	902
2	565	225	112	902
3	565	225	112	902
4	565	169	169	903
5	565	169	169	903
6	565	225	112	902
7	733	112	56	901
8	733	112	56	901
9	551	234	117	912
10	367	348	175	890

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 (2).

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: Synfl CO	Conv. %	Prod. cc/hr	Selectivities	Alpha GC	Alpha Liq	Olefin/Paraf C3	Olefins C4	Comments					
											IC1+ IC2 IC3+ IC02										
33	Co.053	31.4	1	24	39	240	450	2.0	20	41.4	0.94	23.2	3.1	69.6	4.06	0.65	0.76	0.82	0.58	21.7	G.C. Calib
33	Co.053	31.4	2	54	63	240	300	2.0	20	35.2	0.47	29.9	3.9	59.6	6.37	0.55	--	0.89	0.70	--	
33	Co.053	31.4	3	78	87	240	300	2.0	20	38.7	0.38	31.1	3.9	57.5	7.48	0.54	--	0.97	0.71	--	
33	Co.053	31.4	4	102	111	250	300	2.0	20	39.6	0.38	43.1	4.6	41.1	11.3	0.38	--	0.99	0.77	--	
33	Co.053	31.4	5	126	135	260	300	2.0	20	37.7	0.37	42.1	4.6	42.4	10.9	0.42	--	1.76	1.21	--	
33	Co.053	31.4	6	150	159	260	450	2.0	20	45.0	0.44	43.2	4.8	40.9	11.1	0.44	--	1.35	0.95	--	
33	Co.053	31.4	7	174	183	250	450	2.0	20	45.7	0.73	46.4	4.6	40.2	8.77	0.43	--	1.06	0.77	--	
33	Co.053	31.4	8	198	207	260	450	2.0	20	49.2	0.98	44.4	4.3	43.5	7.84	0.51	--	0.87	0.85	--	
33	Co.053	31.4	9	222	230	240	450	2.0	20	16.1	0.38	33.7	4.8	59.2	2.24	0.35	--	3.14	1.91	--	

Feed Gas Rates

Per N2	H2	CO	Total
No SLH	SLH	SLH	SLH

1	563	225	112	900
2	338	135	67	540
3	250	100	50	400
4	250	100	50	400
5	250	100	50	400
6	250	100	50	400
7	160	160	80	400
8	100	200	100	400
9	563	225	112	900

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 (2).

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 CS-18,2	Comments
												IC ₁ +	IC ₂	IC ₃ +	IC ₄			C ₃	C ₄		
35	C0.041	26.0	1	23	39	240	450	2.0	20	35.7	1.00	13.6	2.1	82.9	1.41	0.79	0.82	1.09	0.74	18.2	G.C. Calib
35	C0.041	26.0	2	54	63	250	450	2.0	20	42.1	1.17	27.3	4.6	64.4	3.78	0.65	--	0.49	0.41	--	
35	C0.041	26.0	3	78	87	260	450	2.0	20	45.1	1.24	41.7	6.8	44.9	6.58	0.51	--	0.35	0.37	--	
35	C0.041	26.0	4	102	111	260	450	2.0	20	46.7	0.77	39.1	4.6	49.9	6.40	0.56	--	0.66	0.52	--	
35	C0.041	26.0	5	126	135	260	450	2.0	20	49.6	0.61	39.4	4.0	49.6	7.00	0.57	--	0.70	0.52	--	
35	C0.041	26.0	6	150	159	260	450	2.0	20	47.9	0.95	33.1	3.9	58.7	4.32	0.64	--	0.75	0.52	--	
35	C0.041	26.0	7	174	183	260	450	2.0	20	49.7	1.24	30.9	4.4	61.3	3.50	0.66	--	0.71	0.49	--	
35	C0.041	26.0	8	198	206	240	450	2.0	20	19.6	0.55	17.3	2.6	79.1	0.93	0.71	--	2.08	1.63	--	

Feed Gas Rates

Per No	N ₂ SLH	H ₂ SLH	CO SLH	Total SLH
1	568	225	112	905
2	568	225	112	905
3	568	225	112	905
4	341	135	68	544
5	253	100	50	403
6	163	160	80	403
7	103	200	100	403
8	571	225	112	908

Table II

DATE: 12/30/94

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
30	CO.053	29.6	41.8	1.02	22.6	2.9	71.5	3.1	0.66	0.77	0.99	0.65	19.6
31	CO.055	15.0	30.0	1.46	23.7	3.7	70.2	2.3	0.61	0.81	0.90	0.60	20.3
32	CO.044	16.4	20.9	0.93	6.7	1.9	90.8	0.6	0.77	0.83	3.42	2.17	23.1
33	CO.053	31.4	41.4	0.94	23.2	3.1	69.6	4.1	0.65	0.76	0.82	0.58	21.7
34	CO.060	15.6	31.4	1.46	14.0	2.3	82.2	1.5	0.75	0.79	1.61	1.00	23.1

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 II
(Continued)

DATE: 09/30/95

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	---
35	Co.041	26.0	35.7	1.00	13.6	2.1	82.9	1.4	0.79	0.76	1.09	0.74	18.2
36	Co.032	15.9	24.0	1.10	9.1	1.8	88.2	0.8	0.77	0.83	3.23	2.00	25.2
37	Co.045	15.9	14.8	0.67	8.0	1.7	89.4	0.9	0.76	0.84	2.78	1.90	20.3
38	Co.058	15.9	28.0	1.28	11.9	2.1	85.1	0.9	0.75	0.85	1.88	1.17	22.4
39	Co.064	15.9	34.2	1.56	13.6	2.3	82.6	1.6	0.73	0.85	1.40	0.92	21.0
40	Co.063	15.0	8.7	0.43	6.5	0.9	92.6	0.1	0.74	--	7.67	3.40	25.9
41	Co.062	15.0	6.6	0.32	3.5	0.3	95.3	1.0	0.76	0.89	9.50	3.50	25.9
42	Co.065	15.9	27.6	1.25	7.9	2.0	88.6	1.6	0.79	0.84	2.94	1.88	28.0
43	COW.12	9.1	6.1	0.47	20.3	6.1	66.3	7.3	0.61	0.83	3.63	2.33	11.9
44	COW.11	15.6	4.7	0.20	8.4	6.3	74.4	10.9	0.60	--	5.40	3.50	--
45	Fe.01	15.9	3.4	0.14	0.0	7.5	84.8	7.7	0.71	0.77	2.80	1.50	--
46	COW.05	15.7	4.9	0.23	10.9	6.5	81.9	0.7	0.60	0.78	3.11	2.14	13.3
47	Co.070	15.6	22.8	1.07	10.9	2.7	85.7	0.7	0.75	0.85	2.60	1.56	24.5
48	COW.13	15.5	8.5	0.39	10.9	8.1	76.9	4.3	0.74	0.89	4.00	3.00	21.0
49	Co.068	15.5	26.7	1.26	18.9	4.6	75.3	1.2	0.68	0.77	0.52	0.34	20.3
50	Co.066	15.5	21.1	0.99	11.3	3.5	83.6	1.5	0.72	0.81	3.19	1.94	--

Note: All catalysts were screened thru 150 x 400 mesh.

Catalyst No. COW.12 contains 10% Co plus 10% Fe. It is also full size.

Catalyst No. Fe.01 contains 30% Fe and no cobalt.

Catalyst No. Co.070 contains 13% Co with no promoter.

Catalysts Nos. COW.11 and COW.13 contained 10% Co plus 10% Fe.

Catalyst No. Co.066 contains 15% Co plus 5% Fe and 0.5% Ru.

Table III

M3 SBCR RUN RESULTS

COMPARISON OF CATALYST ACTIVITY AT SIMILAR RUN CONDITIONS

Period No.	Temp.	Pres.	H ₂ /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 C ₃	Paraf C ₄	Olefin C ₆₋₁₈
---	---	---	---	---	%CH ₄	%C ₂	%C ₃ +	%CO ₂	---	---	---	---	---
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	--
31	CO.055	15.0	9.1	0.44	10.6	2.5	85.7	1.1	0.61	0.85	2.89	1.80	--
32	CO.044	16.4	10.3	0.46	0.0	0.9	98.8	0.3	0.85	--	4.33	4.50	--
34	CO.060	15.6	13.0	0.60	0.1	1.8	97.8	0.4	0.81	0.88	4.00	2.83	--

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 III
(Continued)

DATE: 06/30/95

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 C3	C4	Olefin C6-18,
---	---	---	---	---	%CH4 %C2 %C3+ %CO2	---	---	---	---	---
36	Co.032	15.9	7.7	0.35	0.0 1.5 97.8 0.77	0.81	0.91	4.00	3.33	--
37	Co.045	15.9	5.1	0.23	0.0 1.5 97.7 0.77	0.80	0.88	4.00	3.00	--
38	Co.058	15.9	11.7	0.54	1.4 1.4 96.9 0.38	0.81	--	4.00	3.00	--
39	Co.064	15.9	15.0	0.68	4.6 1.2 93.8 0.44	0.78	--	4.17	2.38	--
40	Co.063	15.0	2.0	0.09	0.1 0.0 99.9 0.00	0.67	--	7.00	7.00	--
41	Co.062	15.0	1.9	0.09	0.0 0.1 99.9 0.00	0.88	--	4.00	5.00	--
42	Co.065	15.9	10.0	0.46	0.0 2.0 97.3 0.67	0.82	--	5.33	3.25	--
47	Co.070	15.6	8.6	0.40	0.0 4.3 95.7 0.02	0.82	--	--	--	--

Note: All catalysts were screened thru 150 x 400 mesh.

Table IV

DATE: 12/30/94

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	--
31	CO.055	15.0	14.7	1.06	5.5	1.4	91.7	1.4	0.78	0.83	5.71	3.22	--
32	CO.044	16.4	9.9	0.25	2.1	3.2	92.5	2.2	0.61	0.87	7.33	4.00	--
34	CO.060	15.6	13.5	0.94	4.3	1.8	92.5	1.5	0.77	0.85	7.00	4.67	--

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 IV
(Continued)

DATE: 06/30/95

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	---
36	Co.032	15.9	9.5	0.65	1.4	1.2	96.5	0.87	0.83	--	7.67	4.50	--
37	Co.045	15.9	6.5	0.44	0.1	1.4	97.3	1.16	0.82	--	5.00	2.00	--
38	Co.058	15.9	12.7	0.87	3.2	1.3	94.5	1.01	0.81	--	7.25	4.40	--
39	Co.064	15.9	15.9	1.09	4.7	1.2	92.9	1.28	0.80	--	7.86	3.88	--
40	Co.063	15.0	3.6	0.26	2.3	1.3	95.9	0.54	0.76	--	13.00	5.50	--
41	Co.062	15.0	2.7	0.19	0.1	1.0	96.9	1.99	0.77	--	10.00	4.00	--
42	Co.065	15.9	13.1	0.89	1.2	1.5	95.7	1.67	0.84	--	7.00	5.50	--
47	Co.070	15.6	5.3	0.37	3.7	4.2	90.3	1.76	0.71	--	2.85	1.71	--

Note: All catalysts were screened thru 150 x 400 mesh.

Table V

DATE: 12/30/94

M3 SBCR RUN RESULTS

COMPARISON OF CATALYST ACTIVITY AT SIMILAR RUN CONDITIONS

Period No.	Temp.	Pres.	H ₂ /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		
					%CH ₄	%C ₂	%C ₃ +	%CO ₂			C ₃	C ₄	C ₆ -18, %
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	1.3	0.82	0.85	5.71	3.44	33.6
31	CO.055	15.0	16.1	1.16	4.7	1.2	92.8	1.3	0.80	0.83	6.17	3.11	33.6
34	CO.060	15.6	12.8	0.89	2.2	1.6	94.9	1.2	0.82	0.86	6.60	4.33	38.5

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 S8CR 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	N ₂ : CO	Synfl cc/hr	Conv. %	Prod. Rate	Selectivities %				Alpha GC	Alpha Liq	Olefin C ₃	Paraf 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	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 C3 C4	C6-18, %	Comments
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	--		

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	H2: CO	Synfl cc/hr	Conv. %	Prod. Rate	Selectivities				Alpha GC	Alpha Liq	Olefin/Paraf		Olefins C5-18,2	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	H2/CO:
16	CAL.04	16.1	2	54	153	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	H2/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	0.25	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	1.25	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
22	BlendB	30.5	1	23	39	240	450	2.0	20	35.6	1.64	12.7	1.6	79.4	6.29	0.75	0.81	1.40	0.81	27.3	
22	BlendB	30.5	2	78	87	240	450	1.0	20	15.8	1.07	1.5	0.9	90.5	7.06	0.80	0.83	5.00	2.22	38.5	G.C. Calib
22	BlendB	30.5	3	125	135	240	450	0.7	20	10.6	0.86	0.8	0.8	92.6	5.83	0.82	0.87	7.33	3.20	33.6	G.C. Calib
22	BlendB	30.5	4	150	158	240	450	1.0	20	14.1	0.99	3.9	1.0	91.0	4.07	0.80	--	5.40	2.25	--	
22	BlendB	30.5	5	174	183	240	450	2.0	20	30.1	1.44	13.2	1.8	82.4	2.56	0.75	--	1.33	0.69	--	
22	BlendB	30.5	6	191	207	250	450	1.0	20	23.5	1.63	10.0	1.9	82.1	6.02	0.74	--	2.92	1.15	--	
22	BlendB	30.5	7	223	232	280	450	1.0	20	26.9	1.79	17.8	3.1	68.4	10.7	0.64	--	3.00	1.88	--	
22	BlendB	30.5	8	247	255	280	450	0.7	20	17.1	1.34	8.8	2.6	78.8	9.8	0.70	--	6.00	3.53	--	
23	CAL.09	15.0	1	23	40	240	450	2.0	20	17.4	0.84	0.02	1.2	97.9	0.95	0.84	0.88	5.40	3.33	29.4	G.C. Calib
23	CAL.09	15.0	2	57	63	220	450	2.0	20	6.6	0.32	0.2	0.9	98.0	0.92	0.90	--	4.00	3.00	--	

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. I Rate	Selectivities				Alpha GC	Alpha Liq	Olefin/Paraf C3	Olefins C4	Comments
												ICH4	IC2	IC3+	IC02					

24	CO.053	28.5	1	23	39	240	450	2.0	20	50.4	1.28	14.1	2.1	81.8	2.03	0.75	0.79	1.14	0.68	-- G.C. Calib
24	CO.053	28.5	2	54	63	250	450	2.0	20	53.5	1.34	24.2	3.6	67.9	4.24	0.66	--	0.66	0.48	--
24	CO.053	28.5	3	78	87	250	450	2.0	30	55.3	1.36	38.2	5.2	49.0	7.64	0.53	--	0.53	0.47	--
24	CO.053	28.5	4	102	110	250	450	2.0	30	52.8	2.13	29.1	4.0	62.1	4.79	0.64	--	0.68	0.49	--
24	CO.053	28.5	5	125	135	250	450	2.0	30	58.9	1.90	28.5	3.9	62.8	4.90	0.65	--	0.70	0.48	--
24	CO.053	28.5	6	146	158	250	450	2.0	30	42.6	1.74	26.9	3.8	66.3	2.96	0.65	--	0.99	0.67	--
24	CO.053	28.5	7	175	182	250	450	2.0	30	51.5	1.31	31.6	4.5	60.0	3.90	0.60	--	0.94	0.65	--
24	CO.053	28.5	8	199	208	250	450	2.0	30	58.1	1.89	27.6	3.7	65.1	3.67	0.66	--	0.88	0.56	--
24	CO.053	28.5	9	218	231	250	450	2.0	30	62.9	2.05	23.2	3.0	70.6	3.20	0.71	--	0.93	0.58	--
24	CO.053	28.5	10	259	263	275	450	2.0	30	72.1	2.24	39.1	5.0	46.4	9.53	0.57	--	0.41	0.34	--
24	CO.053	28.5	11	290	304	250	450	2.0	30	48.8	1.62	29.0	3.8	65.4	1.83	0.65	--	1.78	1.09	--

Feed Gas Rates

Per No	N2 SLH	H2 SLH	CO SLH	Total SLH
1	563	225	112	900
2	563	225	112	900
3	563	225	112	900
4	360	360	180	900
5	288	288	144	720
6	540	360	180	1080
7	563	225	112	900
8	200	288	144	632
9	108	288	144	540
10	108	288	144	540
11	108	288	144	540

Table VI
(Continued)

SUMMARY OF M4 SACR 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: Synfl CO	Conv. %	Prod. Rate	Selectivities				Alpha GC	Alpha Liq	Olefin/Paraf C3	Olefins C4	Comments C5-18,2	
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	
26	CAL.10	15.6	1	23	39	240	450	2.0	20	21.9	1.01	5.4	1.5	91.9	1.25	0.79	0.85	3.60	2.27	25.9
26	CAL.10	15.6	2	54	63	240	450	2.0	20	21.7	1.30	8.3	1.1	89.9	1.10	0.80	--	3.78	2.45	--
26	CAL.10	15.6	3	78	87	240	450	2.0	20	17.2	1.04	11.7	1.4	86.1	1.39	0.76	--	3.57	2.30	--
26	CAL.10	15.6	4	102	111	240	450	2.0	20	17.7	1.01	11.9	1.4	86.0	1.40	0.77	--	3.52	2.28	--
26	CAL.10	15.6	5	118	125	240	450	2.0	20	16.2	0.75	4.9	1.7	92.3	1.10	0.77	--	4.29	2.75	--

Feed Gas Rates

Per No	N2 SLH	H2 SLH	CO SLH	Total SLH
1	563	225	112	900
2	108	288	144	540
3	54	288	144	486
4	25	274	137	436
5	563	225	112	900

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 (Z).

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				Alpha GC	Alpha Liq	Olefin/Paraf C ₃ C ₄		Olefins C ₅ -18, Z	Comments
25	CO.056	15.0	1	23	39	240	450	2.0	20	11.4	0.55	7.8	3.6	87.2	1.43	0.67	0.87	3.60	2.30	20.3	
25	CO.056	15.0	2	47	63	220	450	2.0	20	4.5	0.22	0.3	2.7	95.7	1.27	0.73	--	4.67	3.00	--	
26	CAL.10	15.6	1	23	39	240	450	2.0	20	21.9	1.01	5.4	1.5	91.9	1.25	0.79	0.85	3.60	2.27	25.9	
26	CAL.10	15.6	2	54	63	240	450	2.0	20	21.7	1.30	8.3	1.1	89.9	0.68	0.80	--	3.78	2.45	--	
26	CAL.10	15.6	3	78	87	240	450	2.0	20	17.2	1.04	11.7	1.4	86.1	0.78	0.76	--	3.57	2.30	--	
26	CAL.10	15.6	4	102	111	240	450	2.0	20	17.7	1.01	11.9	1.4	86.0	0.73	0.77	--	3.52	2.28	--	
26	CAL.10	15.6	5	118	126	240	450	2.0	20	16.2	0.75	4.9	1.7	92.3	1.10	0.77	--	4.29	2.75	--	
27	Co.050	14.6	1	23	39	240	450	2.0	20	20.4	1.01	6.8	1.9	90.2	1.04	0.78	0.87	2.50	1.69	18.9	
27	Co.050	14.6	2	78	87	220	450	2.0	20	8.1	0.39	0.0	4.8	92.6	2.56	0.79	0.87	8.50	3.00	--	
27	Co.050	14.6	3	102	111	240	450	2.0	20	19.8	0.98	9.1	2.6	87.0	1.30	0.76	--	2.50	1.69	--	
27	Co.050	14.6	4	142	157	240	450	1.0	20	8.4	0.61	1.1	2.9	93.3	2.78	0.79	0.90	6.25	5.00	--	
27	Co.050	14.6	5	173	182	240	450	2.0	20	17.3	0.87	9.9	3.0	85.4	1.74	0.75	--	2.50	1.75	--	
28	Co.057	15.8	1	23	40	240	450	2.0	20	18.7	0.86	5.3	1.5	92.3	0.98	0.81	0.85	3.27	2.36	23.1	
28	Co.057	15.8	2	71	88	220	450	2.0	20	6.0	0.27	0.0	1.9	97.2	0.93	0.79	--	5.50	4.00	--	G.C.Repair
28	Co.057	15.8	3	102	112	240	450	2.0	20	19.4	0.90	7.7	2.1	89.3	0.97	0.77	--	3.70	2.27	--	
28	Co.057	15.8	4	126	135	240	450	1.0	20	8.1	0.56	1.3	4.6	92.7	1.44	0.79	--	7.33	5.67	--	
28	Co.057	15.8	5	150	159	240	450	2.0	20	18.0	0.83	7.6	3.3	88.0	1.00	0.76	--	3.89	2.30	--	
28	Co.057	15.8	6	175	184	250	450	2.0	20	25.3	1.16	13.2	2.8	82.5	1.60	0.73	--	2.30	1.45	--	
28	Co.057	15.8	7	198	208	260	450	2.0	20	29.7	1.36	22.7	3.9	70.7	2.75	0.65	--	1.39	0.92	--	
28	Co.057	15.8	8	222	231	240	450	2.0	20	13.8	0.63	8.7	2.6	87.4	1.34	0.75	--	3.11	2.11	--	
29	Co.061	45.4	1	39	41	240	450	2.0	20	29.0	0.46	14.4	2.6	81.6	1.53	0.72	0.80	1.49	0.94	18.9	G.C.Calib
29	Co.061	45.4	2	54	64	220	450	2.0	20	11.8	0.19	3.9	1.9	93.5	0.73	0.77	--	3.67	2.29	--	Cat.Loss
29	Co.061	45.4	3	78	86	240	450	2.0	20	24.4	0.39	13.3	2.5	83.2	1.08	0.72	--	1.67	1.08	--	Cat.Loss
30	Co.011	15.9	1	23	40	240	450	2.0	20	8.0	0.36	5.8	3.9	87.8	2.49	0.71	0.89	5.75	3.00	22.4	G.C.Repair
30	Co.011	15.9	2	54	64	250	450	2.0	20	15.8	0.72	10.0	3.0	84.8	2.28	0.74	--	4.22	2.40	--	
30	Co.011	15.9	3	78	87	260	450	2.0	20	23.6	1.06	18.1	3.7	74.5	3.72	0.67	--	2.21	1.54	--	G.C.Repair
30	Co.011	15.9	4	102	111	270	450	2.0	20	28.3	1.26	26.5	3.4	64.9	5.23	0.60	--	1.67	1.14	--	
30	Co.011	15.9	5	126	135	278	450	2.0	20	28.5	1.27	34.5	4.0	55.1	6.43	0.53	--	1.84	1.26	--	
30	Co.011	15.9	6	150	159	280	450	2.0	20	36.0	0.95	40.3	4.5	47.9	7.32	0.48	--	1.77	1.20	--	
30	Co.011	15.9	7	174	183	280	450	2.0	20	38.5	0.77	43.7	4.7	43.7	7.90	0.45	--	1.93	1.29	--	
30	Co.011	15.9	8	198	207	280	450	2.0	20	36.0	1.15	38.5	4.5	50.9	6.07	0.52	--	2.18	1.43	--	
30	Co.011	15.9	9	222	230	240	450	2.0	20	4.4	0.20	6.9	4.0	85.5	3.63	0.66	--	6.00	3.67	--	

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 (Z).

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: Synfl CO	Conv. cc/hr	Prod. %	Selectivities				Alpha GC	Alpha Liq	Olefin/Paraf			Olefins C5-18,Z	Comments
											XC14	XC2	XC3+	XC02			C3	C4			
30	Co.011	15.9	1	23	40	240	450	2.0	20	8.0	0.36	5.8	3.9	87.8	2.49	0.71	0.89	5.75	3.00	22.4	G.C.Calib
30	Co.011	15.9	2	54	54	250	450	2.0	20	15.8	0.72	10.0	3.0	84.8	2.28	0.74	--	4.22	2.40	--	
30	Co.011	15.9	3	78	87	260	450	2.0	20	23.6	1.06	18.1	3.7	74.5	3.72	0.67	--	2.21	1.54	--	
30	Co.011	15.9	4	102	111	270	450	2.0	20	28.3	1.26	26.5	3.4	64.9	5.23	0.60	--	1.67	1.14	--	G.C.Calib
30	Co.011	15.9	5	126	135	278	450	2.0	20	28.5	1.27	34.5	4.0	55.1	6.43	0.53	--	1.84	1.26	--	
30	Co.011	15.9	6	150	159	280	450	2.0	20	36.0	0.95	40.3	4.5	47.9	7.32	0.48	--	1.77	1.20	--	
30	Co.011	15.9	7	174	183	280	450	2.0	20	38.5	0.77	43.7	4.7	43.7	7.90	0.45	--	1.93	1.29	--	
30	Co.011	15.9	8	198	207	280	450	2.0	20	36.0	1.15	38.5	4.5	50.9	6.07	0.52	--	2.18	1.43	--	
30	Co.011	15.9	9	222	230	240	450	2.0	20	4.4	0.20	1.9	4.0	85.5	3.63	0.66	--	6.00	3.67	--	

Feed Gas Rates

Per No	N2 SLH	H2 SLH	CO SLH	Total SLH
1	558	225	112	895
2	558	225	112	895
3	558	225	112	895
4	558	225	112	895
5	558	225	112	895
6	338	135	67	540
7	250	100	50	400
8	160	160	80	400
9	558	225	112	895

Table VI
(Continued)

SUMMARY OF M4 SBCR CALSICAT CATALYST AGING RUN

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 (Z).

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 ZCH4	ZC2	ZC3+	ZCO2	Alpha GC	Alpha Liq	Olefin/Paraf C3	C4	Olefins C5-18,Z	Comments
33	CAL.13	15.9	1	23	39	241	450	2.0	20	28.1	1.28	6.4	1.4	90.9	1.29	0.81	0.85	3.64	2.15	23.8	
33	CAL.13	15.9	2	47	63	240	450	2.0	20	25.4	1.21	6.7	1.3	90.8	1.17	0.81	--	3.80	2.45	--	
33	CAL.13	15.9	3	71	87	240	450	2.0	20	25.7	1.18	6.8	1.3	90.8	1.14	0.80	--	3.80	2.25	--	
33	CAL.13	15.9	4	95	111	240	450	2.0	20	25.1	1.15	6.7	1.4	90.6	1.24	0.80	--	4.33	2.55	--	
33	CAL.13	15.9	5	119	135	238	450	2.0	20	22.4	1.02	5.7	1.4	91.8	1.14	0.80	--	4.25	2.50	--	
33	CAL.13	15.9	6	143	159	243	450	2.0	20	27.4	1.25	7.9	1.7	89.0	1.40	0.79	--	3.54	2.13	--	
33	CAL.13	15.9	7	162	178	240	450	2.0	20	23.8	1.09	6.4	1.5	91.0	1.13	0.80	--	4.88	2.55	--	
33	CAL.13	15.9	8	186	203	240	450	2.0	20	22.5	1.03	6.3	1.6	91.1	1.07	0.79	--	4.50	2.60	--	G.C.Calib
33	CAL.13	15.9	9	210	231	241	450	2.0	20	23.2	1.06	6.7	1.6	90.5	1.12	0.81	0.86	4.22	2.45	25.2	
33	CAL.13	15.9	10	234	255	240	450	2.0	20	21.9	1.00	6.4	1.6	90.9	1.05	0.79	--	4.50	2.78	--	
33	CAL.13	15.9	11	262	279	240	450	2.0	20	22.0	1.00	6.3	1.6	91.1	1.02	0.80	--	4.37	2.50	--	
33	CAL.13	15.9	12	282	303	240	450	2.0	20	21.4	0.98	6.1	1.5	91.4	1.01	0.80	--	4.25	2.78	--	
33	CAL.13	15.9	13	306	327	240	450	2.0	20	20.1	0.92	5.9	1.6	91.5	1.05	0.80	--	4.71	2.56	--	
33	CAL.13	15.9	14	331	351	240	450	2.0	20	20.3	0.93	6.0	1.7	91.1	1.12	0.79	--	4.13	2.67	--	
33	CAL.13	15.9	15	360	373	240	450	2.0	20	18.5	0.85	7.2	1.5	90.3	0.98	0.80	--	4.20	3.00	--	G.C.Calib
33	CAL.13	15.9	16	385	398	240	450	2.0	20	19.8	0.91	6.8	1.4	90.8	1.02	0.79	0.85	4.71	2.40	24.5	
33	CAL.13	15.9	17	402	423	240	450	2.0	20	18.4	0.84	7.5	1.6	89.9	1.09	0.78	--	4.00	2.50	--	
33	CAL.13	15.9	18	428	447	239	450	2.0	20	17.2	0.78	7.1	1.6	90.3	1.06	0.78	--	4.43	2.88	--	
33	CAL.13	15.9	19	510	519	241	450	2.0	20	15.6	0.71	6.9	1.5	90.6	1.11	0.78	--	4.67	2.63	--	Down 48hr
33	CAL.13	15.9	20	522	543	241	450	2.0	20	14.5	0.66	6.8	1.2	91.1	0.88	0.77	--	4.50	3.00	--	
33	CAL.13	15.9	21	546	567	240	450	2.0	20	14.0	0.64	6.9	1.2	91.1	0.76	0.77	0.88	5.40	3.00	26.6	
33	CAL.13	15.9	22	570	591	240	450	2.0	20	13.6	0.62	6.9	1.5	90.7	0.98	0.77	--	5.40	3.00	--	
33	CAL.13	15.9	23	596	614	240	450	2.0	20	14.1	0.64	7.0	1.5	90.6	0.95	0.77	--	4.50	3.00	--	
33	CAL.13	15.9	24	617	638	240	450	2.0	20	13.5	0.62	7.0	1.5	90.6	0.87	0.77	--	5.40	2.86	--	
33	CAL.13	15.9	25	641	662	240	450	2.0	20	13.1	0.60	7.1	1.5	90.5	0.86	0.76	--	6.50	2.86	--	
33	CAL.13	15.9	26	665	686	240	450	2.0	20	12.8	0.59	7.3	1.4	90.6	0.73	0.76	--	5.20	2.86	--	
33	CAL.13	15.9	27	689	710	240	450	2.0	20	12.6	0.58	7.2	1.4	90.5	0.86	0.76	--	5.20	2.86	--	
33	CAL.13	15.9	28	713	734	240	450	2.0	20	12.4	0.57	7.5	1.6	90.0	1.01	0.76	0.84	5.20	2.86	25.9	
33	CAL.13	15.9	29	737	758	240	450	2.0	20	12.4	0.57	7.6	1.5	90.2	0.74	0.76	--	5.20	2.86	--	
33	CAL.13	15.9	30	761	782	241	450	2.0	20	12.3	0.56	7.9	1.6	89.6	0.82	0.76	--	5.20	3.00	--	
33	CAL.13	15.9	31	785	806	241	450	2.0	20	12.3	0.56	7.8	0.7	90.9	0.52	0.76	--	6.50	2.86	--	
33	CAL.13	15.9	32	811	830	241	450	2.0	20	12.0	0.55	7.7	1.1	90.6	0.61	0.75	--	6.50	2.86	--	
33	CAL.13	15.9	33	833	854	240	450	2.0	20	11.7	0.54	7.7	1.5	90.1	0.74	0.75	--	5.20	2.86	--	
33	CAL.13	15.9	34	857	878	241	450	2.0	20	11.8	0.54	8.0	0.6	91.0	0.50	0.76	--	6.50	2.86	--	
33	CAL.13	15.9	35	881	902	240	450	2.0	20	11.5	0.53	8.0	0.3	91.2	0.47	0.76	--	6.50	2.86	25.9	
33	CAL.13	15.9	36	905	926	240	450	2.0	20	11.3	0.52	8.6	1.1	89.9	0.44	0.75	--	6.50	3.17	--	
33	CAL.13	15.9	37	929	950	240	450	2.0	20	11.3	0.52	8.8	1.3	89.5	0.46	0.75	--	6.50	3.17	--	
33	CAL.13	15.9	38	953	974	240	450	2.0	20	11.3	0.52	9.2	1.6	88.4	0.81	0.74	--	5.00	2.71	--	
33	CAL.13	15.9	39	977	998	240	450	2.0	20	11.3	0.52	9.3	1.6	88.4	0.75	0.75	--	5.00	3.33	--	
33	CAL.13	15.9	40	1001	1022	241	450	2.0	20	10.8	0.49	10.2	0.8	88.4	0.52	0.74	--	5.00	2.86	--	
33	CAL.13	15.9	41	1031	1046	241	450	2.0	20	12.9	0.60	9.3	0.0	90.7	0.00	0.77	--	5.40	3.00	--	
33	CAL.13	15.9	42	1049	1069	240	450	2.0	20	11.2	0.52	9.4	0.6	89.6	0.37	0.75	--	5.50	2.86	22.4	

SUMMARY OF M4 SBGR COBALT ONLY CATALYST AGING RUN

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 C ₃	Paraf C ₄	Olefins C _{5-18, %}	Comments
37	C0.005	25.0	1	1	18	216	450	2.0	20	8.1	0.23	0	--	--	--	--	--	--	--	--	--
37	C0.005	25.0	2	20	38	221	450	2.0	20	12.5	0.36	1.5	3.9	93.9	0.71	0.90	0.89	--	--	26.6	
37	C0.005	25.0	3	41	62	221	450	2.0	20	14.4	0.42	2.9	--	96.5	0.60	0.91	--	--	--	--	Repair G.C
37	C0.005	25.0	4	65	86	221	450	2.0	20	14.9	0.43	3.4	5.0	91.1	0.49	0.88	--	6.33	--	--	
37	C0.005	25.0	5	89	110	221	450	2.0	20	14.4	0.42	3.6	9.0	86.8	0.60	0.85	--	6.67	7.50	--	
37	C0.005	25.0	6	113	134	221	450	2.0	20	14.1	0.41	3.8	8.0	87.7	0.58	0.85	--	5.00	15.00	--	
37	C0.005	25.0	7	137	158	222	450	2.0	20	14.8	0.43	4.4	6.6	88.5	0.55	0.82	0.90	5.50	3.20	23.1	
37	C0.005	25.0	8	165	182	221	450	2.0	20	14.1	0.41	4.3	5.3	89.9	0.50	0.80	--	5.50	4.25	--	
37	C0.005	25.0	9	185	206	220	450	2.0	20	13.3	0.39	3.9	3.6	92.0	0.53	0.79	--	5.25	3.20	--	
37	C0.005	25.0	10	209	230	221	450	2.0	20	13.6	0.39	5.1	3.2	91.3	0.51	0.78	--	5.50	2.67	--	
37	C0.005	25.0	11	233	254	221	450	2.0	20	13.5	0.39	4.7	3.6	91.2	0.48	0.78	0.89	4.60	3.20	22.4	
37	C0.005	25.0	12	257	278	221	450	2.0	20	13.3	0.39	4.5	3.1	91.9	0.49	0.78	--	4.40	2.67	--	
37	C0.005	25.0	13	281	302	221	450	2.0	20	13.1	0.38	4.7	3.3	91.5	0.49	0.78	--	4.40	2.67	--	
37	C0.005	25.0	14	305	326	221	450	2.0	20	12.7	0.37	4.9	4.1	90.5	0.52	0.78	--	4.40	2.67	--	
37	C0.005	25.0	15	329	350	221	450	2.0	20	12.4	0.36	4.9	3.9	90.6	0.54	0.77	--	4.60	2.67	--	
37	C0.005	25.0	16	353	374	221	450	2.0	0	12.5	0.36	5.2	3.8	90.5	0.54	0.77	0.83	4.60	2.67	--	Stop Syn F
37	C0.005	25.0	17	377	397	221	450	2.0	0	12.5	0.36	5.1	3.3	90.9	0.56	0.77	--	4.60	2.67	--	
37	C0.005	25.0	18	401	422	221	450	2.0	0	12.9	0.37	5.3	3.9	90.4	0.42	0.77	0.87	4.80	2.83	--	
37	C0.005	25.0	19	425	446	221	450	2.0	0	12.3	0.36	5.1	3.1	91.6	0.44	0.77	--	4.60	2.83	--	
37	C0.005	25.0	20	449	470	221	450	2.0	0	8.6	0.41	10.4	2.5	86.7	0.37	0.72	--	4.14	2.63	--	
37	C0.005	25.0	21	473	494	221	450	2.0	0	9.1	0.43	10.5	2.6	86.5	0.37	0.74	--	4.43	2.63	25.2	
37	C0.005	25.0	22	497	518	221	450	2.0	0	8.9	0.42	10.8	2.8	85.9	0.45	0.73	0.86	4.43	2.63	--	
37	C0.005	25.0	23	521	542	221	450	2.0	0	8.7	0.41	10.9	2.7	85.9	0.50	0.73	--	4.43	2.63	--	
37	C0.005	25.0	24	545	554	221	450	2.0	0	8.5	0.41	10.9	3.2	85.3	0.50	0.72	--	4.43	3.00	--	
37	C0.005	25.0	25	574	590	221	450	2.0	0	8.1	0.38	10.9	3.5	84.9	0.55	0.72	--	4.29	2.86	--	
37	C0.005	25.0	26	593	614	221	450	2.0	0	7.9	0.37	10.8	3.5	85.1	0.54	0.72	--	4.14	2.86	--	
37	C0.005	25.0	27	617	638	220	450	2.0	0	7.6	0.36	10.8	3.1	85.6	0.57	0.72	0.86	4.00	2.71	--	
37	C0.005	25.0	28	641	662	220	450	2.0	0	7.6	0.36	10.8	2.6	85.9	0.54	0.72	--	4.00	2.71	--	
37	C0.005	25.0	29	674	686	221	450	1.5	0	5.6	0.32	8.4	2.6	88.2	0.78	0.73	--	5.00	2.83	--	
37	C0.005	25.0	30	698	710	221	450	1.5	0	4.8	0.29	10.3	3.0	85.9	0.81	0.71	0.85	5.00	3.40	--	
37	C0.005	25.0	31	731	734	215	450	1.5	0	3.2	0.19	8.3	4.5	85.1	2.03	0.70	--	4.50	12.00	--	
37	C0.005	25.0	32	742	758	221	450	1.5	20	5.6	0.35	8.6	3.1	87.6	0.71	0.75	--	4.80	3.20	--	Add Syn F1
37	C0.005	25.0	33	774	782	220	450	2.0	20	10.4	0.31	4.7	3.0	91.6	0.70	0.75	--	4.40	2.50	--	
37	C0.005	25.0	34	785	806	220	450	2.0	20	10.3	0.29	4.7	2.9	91.6	0.70	0.75	--	3.67	2.50	--	
37	C0.005	25.0	35	813	830	220	450	1.5	20	4.5	0.28	9.7	3.3	86.2	0.82	0.72	--	4.60	3.20	--	

Feed Gas Rates

Per No	N ₂ SLH	H ₂ SLH	CO SLH	Total SLH
1	563	225	112	900
20	360	360	180	900
29	360	324	216	900
30	300	360	240	900
33	563	225	112	900
35	300	360	240	900

Table VI
(Continued)

SUMMARY OF M4 SBCR CALSICAT CATALYST TEST RUN

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 C ₃	Olefins C ₄	Comments
38	CAL.14	15.0	1	17	25	240	450	2.0	20	25.5	1.23	6.2 1.8 91.0 1.04	0.79	4.75	2.80	--	Shut Down

Table VII

DATE: 12/30/94

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/Paraf Olefin		
					%CH4	%C2	%C3+	%CO2			C3	C4	C5-18, %
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
23	CAL.09	15.0	17.4	0.84	0.0	1.2	97.9	0.95	0.83	0.88	5.40	3.33	29.4
24	CO.053	28.5	50.4	1.28	14.1	2.1	81.8	2.03	0.75	0.79	1.14	0.68	21.7
25	CO.056	15.0	11.4	0.55	7.8	3.6	87.2	1.43	0.67	0.87	3.60	2.30	20.3
26	CAL.10	15.6	21.9	1.01	5.4	1.5	91.9	1.25	0.79	0.85	3.60	2.27	25.9
27	Co.050	14.6	20.4	1.01	6.8	1.9	90.2	1.04	0.78	0.87	2.50	1.69	18.9

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.

Cat. No. CAL.09 was prereduced and coated with Soya.

Table VII
(Continued)

DATE: 03/31/95

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,%
---	---	---	---	---	%CH4	%C2	%C3+	%CO2	---	---	---	---	---
28	Co.057	15.8	18.7	0.86	5.3	1.5	92.2	0.98	0.81	0.85	3.27	2.36	23.1
29	Co.061	45.4	29.0	0.46	14.4	2.6	81.6	1.53	0.72	0.80	1.49	0.94	18.9
30	Co.011	15.9	8.0	0.36	5.8	3.9	87.8	2.49	0.71	0.89	5.75	3.00	22.4
31	CAL.12	15.9	27.6	1.26	7.9	1.0	90.0	1.11	0.79	0.84	3.50	2.07	25.2
32	CAL.11	15.9	30.6	1.40	7.8	1.4	89.6	1.18	0.80	0.84	3.91	3.33	26.6
33	CAL.13	15.9	28.1	1.28	6.4	1.4	90.9	1.29	0.81	0.85	3.64	2.15	23.8

Note: Catalysts for all runs were screened thru 150 x 400 mesh.

Catalyst No. Co.061 contains 30 % cobalt.

DATE: 03/31/95

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 %CH4	%C2	%C3+	%CO2	Alpha GC	Alpha Liq	Olefin/Paraf C3	C4	Olefin C6-18, %
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
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	--
23	CAL.09	15.0	6.6	0.32	0.2	0.9	98.0	0.92	0.90	--	4.00	3.00	--
25	CO.056	15.0	4.5	0.22	0.3	2.7	95.7	1.27	0.73	--	4.67	3.00	--
27	Co.050	14.6	8.1	0.39	0.0	4.8	92.6	2.56	0.79	0.87	8.50	3.00	--
28	Co.057	15.8	6.0	0.28	0.0	1.8	97.2	0.93	0.79	--	5.50	4.00	--
29	Co.061	45.4	11.8	0.19	3.9	1.9	93.5	0.73	0.77	--	3.67	2.29	--

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.

Cat. No. CAL.09 was prereduced and coated with Soya.

Cat. No. Co.061 contains 30 % cobalt.

DATE: 03/31/95

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 C3	C4	Olefin C6-18,%
---	---	---	---	---	---	---	---	---	---	---	---	---	---
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	--
27	Co.050	14.6	8.4	0.61	1.1	2.9	93.3	2.78	0.79	0.90	6.25	5.00	--
28	Co.057	15.8	8.1	0.56	1.3	4.6	92.7	1.44	0.79	--	7.33	5.67	--

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

DATE: 03/31/95

M4 SBCR RUN RESULTS

COMPARISON OF CATALYST ACTIVITY AT SIMILAR RUN CONDITIONS

Period No.	Temp.	Pres.	H ₂ /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		
---	---	---	---	---	%CH ₄	%C ₂	%C ₃ +	%CO ₂	---	---	C ₃	C ₄	C ₆ -18, %
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.

Table XI

DATE: 10/03/95

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
23	CAL.09	15.0	17.4	0.84	0.1	1.2	97.9	0.95	0.83	0.88	0.3K	0.5Ru	Al
26	CAL.10	15.6	21.9	1.01	5.4	1.5	91.9	1.25	0.79	0.85	0.3K	0.5Ru	Al
31	CAL.12	15.9	27.6	1.26	7.9	1.0	90.0	1.11	0.79	0.84	0.3K	0.5Ru	Al
32	CAL.11	15.9	30.6	1.40	7.8	1.4	89.6	1.18	0.80	0.84	0.3K	0.5Ru	Al
33	CAL.13	15.9	28.1	1.28	6.4	1.4	90.9	1.29	0.81	0.85	0.3K	0.5Ru	Al
38	CAL.14	15.0	25.5	1.23	6.2	1.8	91.0	1.04	0.79		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.

Cat. Nos. CAL.09 and CAL.14 were prereduced and coated with Soya.

Cat. No. CAL.10 was prepared on Condea Alumina.

APPENDIX D

DESCRIPTION OF CSTR REACTOR SYSTEM AND EXPERIMENTAL PROCEDURE

DESCRIPTION OF CSTR REACTOR SYSTEM AND EXPERIMENTAL PROCEDURE

1. Description of CSTR Reactor System

A schematic flow diagram of the CSTR reactor system that was operated at the University of Kentucky Center for Applied Energy Research located in Lexington, Kentucky is shown in Figure E-1.

The system consists of 3 mass flow meters, one each for H_2 , CO, and Argon. There are two CO purification traps for removing iron carbonyls from the CO feed stream. The reactor is a one liter stirred autoclave with two internal filters. The autoclave temperature is controlled by an external electrical heater with a programmable controller. The reactor pressure is controlled by a manually operated Tesome back-pressure regulator. The off gas and vapor products pass through a hot trap (200°C), a lower temperature hot trap (100°C), and a cold trap (0°C) that is cooled by an external refrigeration unit. The cold trap off gas is vented to a manifold that can direct this gas to the blowdown or to a gas measuring device connected to a gas chromatograph. The gas measuring device was a 500 ml volume bubble column. The gas volume was calculated from the measured rates corrected to standard temperature and pressure.

2. Reactor Charge Procedure

Approximately 16 gm of catalyst was hydrogen reduced in the fluidized column at EI's research lab in Pittsburgh, Pennsylvania. The catalyst was slurried in approximately 150 ml of synfluid and put in a plastic bottle protected under nitrogen. Four bottles of catalyst slurry were transported to Lexington, Kentucky by William Gall. Before charging the reactor, the bottles were shaken by hand to reslurry the catalyst. The autoclave vessel bottom was lowered and pivoted to one side. An argon purge line was placed in the autoclave and the vessel was purged for several minutes. A hand held purge line was placed into the top of the catalyst bottle and held there while the catalyst slurry was poured into the autoclave. The bottle was rinsed with about 100 ml synfluid under N_2 purge. The vessel bottom was pivoted back under the head and bolted shut. The reactor was charged and ready for startup.

3. Reactor Run Procedure

The reactor was brought up to the initial run conditions and held there for several hours. At the end of the initial startup conditions, an off gas rate was taken, an off gas G.C. analysis was done, and all the product collection vessels were drained. The first catalyst tested was run at six sets of reaction conditions, while the three additional catalysts were run at seven sets of reaction conditions.

Liquid samples were removed only after the first, fourth, and last run periods. Each run lasted approximately 3 days. The following parameters were studied: reaction temperature, total gas feed rate and inert gas concentration. The reaction pressure was held at 450 psi and the H_2/CO ratio at 2.0.

4. Data Calculations

Mass balance data was obtained from the mass flow meter rates, off-gas rate, and off-gas G.C. analysis. These data were entered into a PC computer, and the gas conversions, reaction rates, and product selectivities were calculated. Some of the liquid products were analyzed by a liquid G.C. to determine the product distribution (alpha) value.

Figure E-1

FTS CSTR Reactor System

572 Iron Works Pike
Lexington, KY 40511-8433
FAX: 606-257-0302

August 24, 1995

William Gall
Senior Project Engineer
Energy International
135 William Pitt Way
Pittsburgh, PA 15238

Bill,

Here are the selectivity and rate data for the four runs we conducted. After looking at the data closely, it is clear that there is an analytical problem which makes calculating the rates and selectivities difficult. GC's taken at the conditions with high flow rates and high argon composition add up to greater than 100% with some as high as 120%. We do not encounter this problem with our runs which do not use argon and are conducted at much lower flow rates; in fact, the problem seems to disappear with the low flow rates used at the end of your runs. Possible causes for this problem that we can think of include:

1. Our standard gas used for calibrations contains only 2% argon whereas the argon composition of the exit stream is >60%.
2. Flow rates about 5X higher than we normally use might have entrained oil from the traps which would affect the GC detector.

We are confident that our mass flow controllers performed correctly because we calibrated them before and after each run. This makes it possible to calculate what the argon composition in the exit stream should be.

$$Ar_{ex} \text{ (mol\%)} = Ar_{in} / (\text{Total flow out})$$

To do the selectivity and rate calculations I assumed the remaining gases comprised $100 - Ar_{ex}$ mol%. Each component was then corrected in proportion to the measured value from the GC. This does assume that each component was affected in the same ratio. If you have any questions please contact me at (606) 257-0324.

Sincerely,

A handwritten signature in cursive script, appearing to read "Bob O'Brien".

Bob O'Brien

UK

Equal Opportunity/
Affirmative Action University

					One Liter CSTR Studies at the University of Kentucky CAER													
					Run No. LGX-185 Catalyst No.- CAL-13 Charge- 16 g													

One Liter CSTR Studies at the University of Kentucky CAER

Run No. LGX-186 Catalyst No.- Co.005 Charge- 17 g

					One Liter CSTR Studies at the University of Kentucky CAER											
					Run No. LGX-186 Catalyst No.- Co.005 Charge- 17 g											
										</						

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