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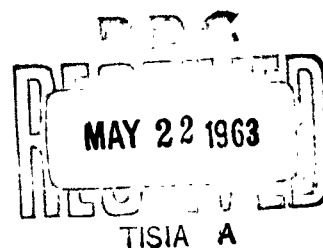
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OPERATIONAL TEST AND EVALUATION

AIR REFUELING
F-100 D/F WITH KC-135

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DECEMBER 1962

HEADQUARTERS
TACTICAL AIR COMMAND
United States Air Force
Langley Air Force Base, Virginia

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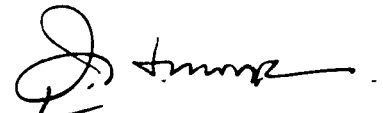
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Operational Test and Evaluation
Air Refueling F-100 D/F with KC-135

(7 thru 10) NA

Publication Review

This report has been reviewed and is approved


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FOREWORD

Air-to-air refueling with the F-100 D/F aircraft from a KC-135 tanker without the use of afterburner had not previously been explored with 335-gallon drop tanks. The 31st ~~TAC Ftr Wg~~ and the 407th ~~Ref Sq~~ from Homestead AFB, Fla., were tasked to fly 16 tactical fighter sorties and 4 tanker sorties, respectively, to gather data in order to determine the optimum altitude for refueling without the use of afterburners.

Individuals responsible for actual conduct of the test and preparation of this final report are:

Project Officer	-	Capt John E. Downey Hq TAC
TAC Test Supervisor	-	Capt Bobby G. Vinson Hq TAC

* Tactical Fighter Wing
** Refueling Squadron

ABSTRACT

Current F-100 air-to-air refueling procedures with the KC-135 tanker are built around using afterburner at 31,000 during hookup. This procedure is wasteful of fuel and does not allow for temperature changes. The proper procedure for maximum economy of fuel is to refuel without afterburner starting at the optimum cruise altitude of the receiver aircraft and using a toboggan procedure until a full offload of fuel is obtained. If clearance procedures restrict the block of altitudes required for a toboggan procedure or cell integrity is required, then a constant refueling altitude is obtained from the appropriate F-100 D/F military climb chart. This altitude is obtained by considering the maximum weight of the aircraft after refueling and adding or subtracting the appropriate gross weight for temperature above or below a standard day. This adjusted gross weight is used to enter the military thrust climb chart for the appropriate drag configuration to the "standard day cruise ceiling". Optimum refueling capabilities are directly proportional to this "standard day cruise ceiling" with one exception - adjustment for tanker weight. If the tanker aircraft is heavy (240,000 pounds) the optimum altitude is 500 feet below this "standard day cruise ceiling". As the tanker weight is reduced by each 40,000 pounds, the refueling altitude can be increased by 1000 feet.

The confusion in the past as to the optimum altitude to refuel stems from the fact that a change of 20°C. temperature changes the optimum refueling altitude 8000 feet. This temperature change at the same time changes the optimum cruise altitude. The temperature must be used both to compute the refueling altitude and the cruise altitude in order to obtain the full capability of both the receiver and tanker aircraft.

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1. BACKGROUND. Insufficient flight test data has been obtained for optimum use of the F-100 D/F aircraft with 335 gallon drop tanks while refueling with the KC-135 aircraft. "Stay-on" III did not fully explore refueling without afterburner. Current procedures in TACM-55-15 require the use of afterburner power when refueling above 24,000 feet. Pilots have reported that the 24,000 foot restriction can be raised. The use of afterburner power seriously affects the fuel consumption of the F-100 aircraft which, in effect, directly affects the KC-135 tanker capability. By raising this maximum altitude of 24,000 feet without the use of afterburner, our refueling and deployment capability can increase immeasurably.

2. DESCRIPTION OF TEST ITEMS. The 335 gallon drop tank is the elongated 275 drop tank that has been designed for an added fuel load without the detrimental drag experienced with the 450 gallon drop tank. The F-100 D/F aircraft is a standard Air Force aircraft that utilizes the probe to air-to-air refuel. The KC-135 aircraft is a standard Air Force aircraft that has a modified boom incorporating a drogue to receive the probe of the receiver aircraft.

3. PURPOSE OF THE TEST. To determine the optimum altitude for non-afterburner refueling of the F-100 D/F aircraft from the KC-135 tanker. Receiver configuration will include two 335 gallon drop tanks plus a centerline type VII pylon.

4. SCOPE OF THE TEST. This test evaluated the following unknown areas:

a. Optimum altitude for an F-100 aircraft to non-afterburner refuel from tanker gross weights of approximately 252,000, 210,000 and 164,000 pounds.

b. Ability of the receiver aircraft to initiate re-hookup at 33,300 and 35,100 pounds gross weight (approximately 2,000 pounds external and 3,700 pounds external fuel, respectively).

c. Performance with 20° of flaps while refueling at 280 KIAS and 300 KIAS.

d. Effects of downwash by application of full power on the outboard tanker engines while reducing the inboard engine power to maintain 280 KIAS and 300 KIAS, respectively.

e. Effect each 5° temperature has on maximum altitude obtainable.

f. Effects of refueling with boom extended at various trail angles and distances.

5. CONCLUSIONS AND RECOMMENDATIONS.

a. Conclusions:

(1) 24,000 feet is not the maximum altitude for refueling the F-100 D/F aircraft without afterburner.

(2) Temperature is the most influential single factor that controls the maximum altitude for non-afterburner refueling.

(3) For each 40,000 pounds that the tanker gross weight is reduced, 1000 feet can be added to the refueling altitude.

(4) The toboggan method is feasible and will allow the receivers to refuel at a higher altitude than can be accomplished at a constant altitude even with four receivers taking on a full load of fuels from one tanker.

(5) Present directives call for a cruise altitude that at only 10°C. above standard is 7500 feet higher than optimum cruise.

(6) 300 knots tanker indicated airspeed is not the optimum airspeed for refueling.

(7) The existing refueling techniques and directives outlined for the F-100 restrict the total capability of the aircraft.

(8) The use of 20° of flaps at any airspeed between 260 and 300 KIAS resulted in too much drag to be of any value.

(9) Varying the power on the tanker engines had no noticeable effect on receiver control during transfer.

(10) The optimum boom position is full length on the boom at maximum deflection down (38°) and deflected in azimuth 6° to the tanker's starboard side.

(11) Power changes by the tanker aircraft need to be smooth or the receiver aircraft will fall off.

(12) The use of afterburner power can be used for refueling if necessary.

(13) Approximately 200 pounds of fuel is saved each minute when refueling with military power instead of afterburner power. Two aircraft buddy refueling with a KC-135 tanker requiring three inflight refuelings would save 12,000 pounds of fuel and allow an increase in range of approximately 420 miles.

b. Recommendations:

(1) A refueling chart (Appendix IV) that incorporates all variables associated with non-afterburner refueling including receiver and tanker gross weight, temperature and drag configurations should be used to obtain the optimum constant altitude for refueling.

(2) Forecast temperature should be utilized by planners to determine the maximum altitude for refueling without afterburner with the F-100 D/F and the KC-135 aircraft.

(3) The tanker gross weight should be considered for the optimum refueling altitude and 1000 feet for each 40,000 pounds decrease in tanker gross weight should be added to the refueling altitude.

(4) Include the toboggan method of refueling in future planning if no altitude restrictions are imposed upon the refueling area or if cell integrity is not required.

(5) Use either the "Limited Altitude Profile" or the "Maximum Efficiency Toboggan Profile" according to altitude restrictions imposed upon the route being flown. (See Mission Profile Planning, page 24).

(6) 290 knots tanker indicated airspeed is the optimum airspeed for refueling.

(7) After coordination with SAC, TACM 55-15 and SACM 55-9 should be changed to incorporate the recommendations outlined in this report for the F-100 D/F aircraft.

(8) Do not use wing flaps while refueling.

(9) The tanker aircraft should use normal power on all engines.

(10) All refueling with the F-100 D/F be conducted with the boom at full length, maximum deflection down (38°), and deflected in azimuth 6° to the tanker's starboard side.

(11) Power changes by the tanker aircraft should be smooth and a loss of airspeed should be sacrificed instead of adding power.

6. TEST RESULTS AND DISCUSSION.

a. Schedule of Events: One complete mission will be flown each day for a period of four days commencing on Tuesday, 25 Sep 62, and ending on Friday, 29 Sep 62. One mission will include one KC-135 tanker, two F-100F's and two F-100D's. Each aircraft will refuel three times per sortie; once at 28,000 or 26,000, once at 29,000 or 27,000 and finally on a light tanker

at 31,000 or 28,000 feet. Deviations from these altitudes will be made while airborne to obtain the optimum altitude for the respective tanker gross weights. At T/O + 1+30 two designated receivers will flight test the possibility of refueling at 280 KIAS and 300 KIAS with and without the use of 20° of flap while varying power settings on the inboard engines of the tanker.

Monday, 24 September 1962 - 1330L - General briefing for all receiver pilots involved in the test program.

Tuesday, 25 September 1962 - 0900L - Flight briefing for tanker and receiver personnel involved in the daily program.

1300 - TOT for tanker

1306 - TOT for receivers

1800 - Debriefing and data collection

Wednesday, 26 September 1962 - 1000L - Flight briefing for tanker and receiver personnel involved in the daily program.

1300 - TOT for tanker

1306 - TOT for receivers

1800 - Debriefing and data collection

Thursday, 27 September 1962 - 1515L - Flight briefing for tanker and receiver personnel involved in the daily program.

1815 - TOT for tanker

1821 - TOT for receivers

2315 - Debriefing and data collection

NOTE: To reduce the possibility of an aircraft incident all receivers will hook up and receive a full fuel load at 26,000 feet, 27,000 feet, and 28,000 feet as would be accomplished during a deployment. By eliminating the intentional disconnect portion of the test, pilot fatigue during the night refueling will be greatly reduced.

Friday, 28 September 1962 - 1000L - Flight briefing for tanker and receiver personnel involved in the daily program.

1300 - TOT for tanker

1306 - TOT for receivers

1800 - Debriefing and data collection

MISSION TIMETABLE

NOTE: Each receiver will execute a disconnect and re-hookup at 33,300 pounds (2,000 pounds external, 9,600 pounds total) and 35,100 pounds (3,700 pounds external, 11,400 pounds total).

<u>Takeoff Time and Event</u>	<u>Pounds</u>
TOT: Tanker -- Weight	268,000
TOT + 28: Level Off, 175 mi/1,300 lbs	252,000
TOT + 06: F-100F	35,600
F-100D	35,300
TOT + 28: Level Off, 130 mi/3,000 lbs	32,600
TOT + 33: Rendezvous and Position 5 Min	500
TOT + 33: Pedal 11 Commences Refueling	
Tanker Burns	1,500
Receiver Burns	600
Receiver Offloads	4,100
Tanker Weight @ End 6 min	246,400

NOTE: Prior to the second refueling Pedal II will burn fuel down to internal fuel remaining (26 minutes total to include 5.5 minutes of A/B).

<u>Takeoff Time and Event</u>	<u>Pounds</u>
TOT + 39: Pedal 12 Commences Refueling	
Tanker Burns	1,500
Receiver Burns	600
Receiver Offloads and Loiter Fuel	4,100 + 600 (4,700)
Tanker Weight @ End 6 min	240,200
TOT + 39: 4 Min Turn Required	
Tanker Uses	1,000
Fighter	400
Tanker Weight @ End 4 min	239,800

<u>Takeoff Time and Event</u>	<u>Pounds</u>
TOT + 43: Pedal 13 Commences Refueling	
Tanker Uses	1,500
Receiver Offload	5,200
Tanker Weight @ End 6 min	233,100
TOT + 49: Pedal 14 Commences Refueling	
Tanker Uses	1,500
Receiver Offload	5,800
Tanker Weight @ End 6 min	255,800
TOT + 55: Tanker Climbs, Turns and Offloads (dumps) to Simulate 1 Hour Cruise	15,000
Tanker Weight	210,200
TOT + 59: Completed 4 minute Turn	210,200
TOT + 59: Pedal 11 Commences Second Refueling	
Tanker Uses	1,200
Fighter Offloads	4,900
Tanker Weight @ End 6 min Refueling	204,100
TOT + 1:05 Pedal 12 Commences Second Refueling	
Tanker Uses	1,200
Fighter Offloads	5,100
Tanker Weight @ End 6 min	197,800
TOT + 1:11 Pedal 13 Commences Second Refueling	
Tanker Uses	1,200
Fighter Offloads	5,100
Tanker Weight @ End 6 min	191,500

<u>Takeoff Time and Event</u>	<u>Pounds</u>
TOT + 1:17 Pedal 13 Commences Second Refueling	
Tanker Uses	1,200
Fighter Offloads	5,100
Tanker Weight @ End 6 min	185,200
TOT + 1:23 Pedal 14 Commences Second Refueling	
Tanker Uses	1,200
Fighter Offloads	5,100
Tanker Weight @ End 6 min	188,900
TOT + 1:29 Pedal 11 and 12 Perform 30 Minute Test Program	
a. Effect 20° flaps	
b. Vary inboard tanker engines	
c. Boom position	
d. Changes in airspeed	
Tanker Uses	6,000
Tanker Weight @ End 30 min	182,900
TOT + 2:00 Tanker Dumps 17,500 Pounds and Climbs	164,400
TOT + 2:00 Pedal 11 Commences Third Refueling	
Tanker Uses	1,000
Fighter Offloads	4,900
Tanker Weight @ End 6 min	158,500
TOT + 2:06 Pedal 12 Commences Third Refueling	
Tanker Uses	1,000
Fighter Offloads	4,900
Tanker Weight @ End 6 min	152,600

<u>Takeoff Time and Event</u>	<u>Pounds</u>
TOT + 2:12 Pedal 13 Commences Third Refueling	
Tanker Uses	1,000
Fighter Offloads	4,900
Tanker Weight @ End 6 min	146,700
TOT + 2:18 Pedal 14 Commences Third Refueling	
Tanker Uses	1,000
Fighter Offloads	4,900
Tanker Weight @ End 6 min	140,800
TOT + 2:24 End Daily Test Program	

AIRCRAFT AND PILOT DATA

<u>ACFT</u>	<u>CONFIGURATION</u>	<u>PILOT</u>	<u>TOTAL PILOT HRS</u>	<u>TOTAL F-100 HRS</u>	<u>CALL SIGN</u>
<u>25 SEP 62</u>					
F 860	2/335	JOHNSON	1616	1200	PEDAL 11
D120	2/335 / PYLON	YOUNGBLOOD	1800	1300	PEDAL 12
F951	2/335 / PYLON	SULLIVAN	3777	789	PEDAL 13
D457	2/335	VINSON	1565	1150	PEDAL 14
<u>26 SEP 62</u>					
F919	2/335	YOUNGBLOOD	1800	1300	PEDAL 11
D120	2/335 / PYLON	HAVEY	678	450	PEDAL 12
F951	2/335 / PYLON	HUGHES	1252	950	PEDAL 13
D121	2/335 / PYLON	STRESING	2456	1100	PEDAL 14
<u>27 SEP 62</u>					
F919	2/335	RICHMOND	1211	600	PEDAL 11
F120	2/335 / PYLON	STRESING	2356	1100	PEDAL 14
<u>28 SEP 62</u>					
F951	2/335 / PYLON	JOHNSON	1616	1200	PEDAL 11
D118	2/335 / PYLON	YOUNGBLOOD	1800	1300	PEDAL 12
F950	2/335	LIVENS PARGER	1195	700	PEDAL 13
D120	2/335 / PYLON	HAVEY	678	450	PEDAL 14

1. It should be noted that both pilots and aircraft included in the test program were chosen at random. A pilot experience cross section for each flight included one relatively inexperienced pilot (500 hrs), one of average experience (100-1500 hrs) and two highly experienced (2000 and over hrs). This cross section was achieved on all flights, however, it is not readily apparent under the tabulation of total hours. For instance, Richmond had

just recently returned to active duty after serving with the National Guard, where he accumulated reciprocating engine experience. Pilots participating were selected from all four squadrons in the 31st Tactical Fighter Wing.

2. Aircraft chosen at random were all assigned to the 31st Tac Ftr Wg, which trims its aircraft slightly below normal.

3. Each mission included a tanker crew that had not previously participated in the test program. A different tanker was used on each flight.

MISSION DATA

A. Mission #1 -- 1 KC-135, 2 FLOOD and 2 FLOOF aircraft. (Pedal 11 and 14, 2-335's -- Pedal 12 and 13, 2-335's / Type VII Pylons)

1. Planned Objectives:

- a. To determine maximum altitude that FLOOF/D can refuel without the use of afterburner from a KC135 tanker. Receivers will initiate a re-hookup at various fuel weights less than a full load condition.
- b. Evaluate the effect of 20° of flaps.
- c. Effect of varying tanker engine power by reducing the inboard engine power to a minimum, while maintaining planned airspeed.
- d. Effects of varying the boom in length, azimuth and deflection.
- e. Effects of varying the refueling tanker airspeed from 260 KIAS to 300 KIAS.
- f. Effects of refueling at varying tanker gross weights.

2. Accomplishments:

- a. Hookups were accomplished up to 28,000 ft without the use of afterburner; however, the receivers fell off prior to receiving a full load. No re-hook capability was possible. Temperatures averaged / 10°C. above standard day. At 26,000 ft on a heavy tanker, receivers re-hooked with no considerable problem at 9600 lb and 11,400 lb internal fuel. However, re-hook at full load conditions proved marginal.
- b. Flaps extended 20° at all airspeeds, from 260 KIAS to 300 KIAS, developed excessive drag and proved to be of no value.
- c. The inboard engines were reduced to minimum power while maintaining maximum power (95%) on the outboard engines. No significant difference was noticed.
- d. The boom was varied in length azimuth and deflection.
 - (1) Full length extension (19 ft) was most satisfactory because it placed the receiver at the lowest position where he received the least downwash effect from the tanker.
 - (2) Varying the azimuth from 6° left to 6° right had no effect on power available for refueling stabilization. However, pilots commented that 6° to the tanker's starboard was most satisfactory, since it placed the receiver directly in line with the tanker's fuselage, and presented a balanced sight picture.

(3) Full range deflection (38°) was most satisfactory because, coupled with the full length extension, it placed the receiver at the lowest position where he received the least downwash effect from the tanker.

e. During the maximum power required refueling situation, tanker indicated airspeed was varied from 260 KIAS to 300 KIAS. Throughout the speed range very little receiver power advantage was noticed, however, at 290 KIAS more power was available. The increased angle of attack of the receiver offset the reduced power required for lower airspeed. It was determined that at 290 KIAS, rather than 300 KIAS, there was increased stability of both the drogue and the receiver aircraft and 1% more engine power was available.

f. Four receivers were refueled at tanker gross weights of 240,000 lb, 200,000 lb and 160,000 lb. It was determined that 1,000 ft increase in altitude between each of the aforementioned tanker weights resulted in identical receiver control conditions.

3. Mission Findings:

a. Optimum position for the boom is: maximum deflection, 38° down; 6° azimuth to the tanker's starboard and fully extended, 19 ft.

b. Optimum tanker refueling airspeed is 290 KIAS; however, no appreciable control difference exists at any airspeed ranging from 260 KIAS to 300 KIAS.

c. If the drogue commences excessive oscillation, it may be stabilized by cycling the boom to the fully retracted position and then back to fully extended.

d. Onload capability of the tested aircraft varied considerably. At initial hookup, transfer rates varied from 750 PPM to 1800 PPM. As the receivers increased their fuel loads, the transfer rates averaged very close to 400 PPM during the final 1500 lb of onload. Onloads averaged 1000 PPM; however, this varied considerably with various aircraft. Fuel burned by the receivers during the non-afterburner refueling operation averaged 100 PPM.

e. It was evident that optimum mission accomplishment was hindered somewhat due to lack of understanding on both the part of the tanker pilots and the receiver pilots.

(1) Receiver pilots are not thoroughly familiar with the systems operations of the tanker. The boom operator controls only the position of the boom from reference to three indicator gages that show extension, azimuth and elevation of the boom.

(2) Actual fuel transfer is controlled from the front cockpit position, normally by the co-pilot. He has three gages for reference: a flow rate gage; a total fuel remaining aboard the tanker gage; and an off-load gage, which is manually reset to zero at the completion of each receiver offload. In addition to these gages, he controls both the transfer and the rate of transfer by selection of various transfer pumps. Maximum offload capability is approximately 6000 PPM. It was determined that minimum output (two pumps operational) was most satisfactory for refueling of the F-100 aircraft. This minimum output will exceed the on-load capability of any F-100 aircraft. Any output in excess of this tends to "blow" the receiver off or prematurely force a disconnect.

(3) Lack of radio discipline caused a major area of confusion. Receiver pilots do not recognize the fact that four different agencies within the tanker are transmitting on interphone during the refueling operation; the pilot, the co-pilot, the navigator and the boom operator. It is imperative that every transmission be preceded by a call sign.

(4) The co-pilot has no indication when a receiver has made contact and is stabilized for refueling. This must be called by the receiver.

(5) Generally, tanker pilots are too abrupt during any throttle change. The KC-135 has a great advantage over the F-100 in power to weight ratio. The tanker throttles must be "milked" ever so gently during any change, to enable the F-100 receiver to respond accordingly. When the receiver is stabilized and receiving fuel, airspeed should be sacrificed for power changes. This was especially evident during turns. This technique allowed for turns up to 20° of bank, without changing the established receiver's power.

f. Partial flaps are of no value during high altitude refueling within the speed range of 260 KIAS to 300 KIAS.

g. Varying inboard tanker engine power appeared to have no influence on the refueling operation.

4. Overall Mission Analysis: The mission was highly successful. Information outlined in Mission Findings will be invaluable for the establishment of more detailed refueling procedures and guidance than exist at the present time. It was determined that non-afterburner refueling at altitudes above 24,000 ft (the present restriction outlined in TACM 55-15, SACM 55-9) is not only possible, but will increase considerably the mission capability of the F-100 aircraft. During this first test program the aircraft were fully refueled at altitudes up to 28,000 ft. However, these altitudes, under the existing temperatures, are considered too high for operational purposes. At this time, the temperature, rather than a standard altitude figure, appears to be the controlling factor governing the optimum refueling altitude. There are two unknown factors that presently exist: (1) the

optimum altitude possible for refueling during standard day temperature conditions; and (2) what deviations from this altitude are caused by temperature changes. Future missions will be planned to solve these unknowns.

B. Mission #2 -- 1 KC-135, 2 F-100D and 2 F-100F aircraft. (Pedal 11, 2-335's and Pedal 12, 13 and 14, 2-335's / Type VII Pylon).

1. Planned Objectives:

a. To correlate the effects of temperature with the optimum refueling altitude of the F-100 aircraft.

b. Re-evaluate the findings of Mission #1.

2. Accomplishments:

a. The mission program called for refueling at 26,000, 27,000 and 28,000 ft at heavy, medium and light tanker loads, respectively. Intentional disconnects and re-hookups were to be accomplished by the receivers at 10,000 lbs and 12,000 lbs (full load). Temperatures at the prescribed altitudes averaged / 13°C. above standard day and / 3°C. above the Mission #1 average. At 26,000 ft the receivers had no difficulty taking on fuel up to 10,000 lbs and disconnecting; however, a re-hook at 10,000 lbs exceeded the aircraft capability. During the previous day's mission, at temperatures 3° cooler, no problem was encountered at virtually this same load. Altitudes were increased to 26,500 and 27,500 ft as the tanker fuel load decreased, rather than the planned 27,000 and 28,000 ft. This deviation of 500 ft was still insufficient to make up for the difference in temperature; however, 1000 ft closely simulated the previous day's operation. Once again, these altitudes did not allow for dependable re-hookups at the receiver's full load condition, indicating that the test was exceeding the capability of the receiver for the existing conditions.

b. Tanker engine power was varied during maximum control conditions. No effect was noted. This supports the findings of Mission #1.

c. The boom position was varied. All assumptions formulated during Mission #1 were proven correct.

d. Refueling at 290 KIAS was once again most satisfactory.

e. One thousand foot increase in altitude for the prescribed decreased tanker fuel load was proven correct.

f. Receiver and tanker pilots were specifically briefed on radio discipline and tanker systems operations prior to the mission. Improved air discipline and tanker-receiver cooperation was quite obvious.

g. A total of 69 hookups was accomplished during the mission.

3. Mission Findings:

- a. Boom position - same findings as Mission #1.
- b. Refueling airspeed - same findings as Mission #1.
- c. Fuel transfer rate - same findings as Mission #1.

4. Overall Mission Analysis: The mission was successful. Mission findings during Mission #1 were further substantiated. It was found that under the existing test conditions, 3° temperature variation represents approximately 1000 ft of altitude deviation. No basic standard day refueling altitude has been determined; however, the altitudes used during the completed tests exceed the capability of the aircraft under existing test conditions.

C. Mission #3 -- 1 KC-135, 2 F-100F aircraft. (Pedal 11, 2-335's and Pedal 14, 2-335's / type VII Pylon).

1. Planned Objectives:

- a. To continue correlation of temperature with optimum refueling altitude of the F-100 aircraft.
- b. To employ confirmed procedures derived from Missions #1 and #2 during nighttime operations.
- c. To test the feasibility of using a "toboggan" when the receiver approaches the point of maximum power control.

2. Accomplishments:

- a. Only two aircraft were available for the mission. Both of these were F-100F's.
- b. The mission called for refueling at 26,000, 27,000 and 28,000 ft at heavy, medium and light tanker loads, respectively. Receiver disconnects and re-hookups were to be accomplished at a full load condition only. This was to reduce pilot fatigue during the nighttime operation.
- c. Temperatures averaged / 14° above standard day temperatures. No problem was encountered while taking on a full load; however, re-hookup was difficult due to a maximum power condition. Once again, the 1000 ft between tanker gross weight conditions presented the receivers with identical control characteristics.
- d. At 29,000 ft the receiver unloaded until fall off became imminent. A "toboggan" was initiated by reducing tanker power and establishing a 300 FPM descent. The technique proved to be successful and a full load was taken on with no problem. The identical procedure was used

while refueling from 31,000 ft. A full load was taken on by two receivers with no problem. Total altitude lost while refueling both receivers was 3,300 ft.

3. Mission Findings:

a. Specific mission briefings are mandatory.

b. Optimum refueling airspeed is 290 KIAS on the tanker. However, during turns or during a toboggan, airspeed becomes secondary and may be depleted down to 260 KIAS.

c. Optimum boom position is full extension (19 ft), full elevation deflection (38°), and 6° azimuth to the tanker's starboard.

d. Receiver onload rate averages 1000 PPM.

e. The toboggan technique is very effective and insures a full onload at much higher altitudes than is possible during straight and level flight.

D. Mission #4 -- 1 KC-135, 2 F-100F aircraft and 2 F-100D aircraft (Pedal 13, 2-335's, Pedal 11, 12 & 14, 2-335's / type VII Pylon).

1. Planned Objectives:

a. After reducing all data collected during Missions 1, 2 and 3, it was found that the information could be applied directly to the flight tested performance charts contained in the F-100 Flight Handbook. By correlating the data and applying known information to the military thrust climb chart for the particular drag configuration being flown, any temperature, altitude and weight condition can be computed for any configuration. Substitution of weight for temperature enabled mission planning for a cross section of simulated temperatures. The Flight Handbook states that for each 10° temperature above standard day, 3000 lbs must be added to the gross weight when entering the chart. The F-100 aircraft can receive a full load and reconnect, with surplus power available, at optimum cruise altitude. This altitude is indicated for the total weight and temperature condition in the appropriate military thrust climb chart.

b. The mission was to be flown utilizing predetermined receiver weights to represent temperatures: standard plus 10°; standard; and standard minus 10° at the appropriate altitude indicated.

(1) The actual lower refueling altitude temperature for the daily mission was considered to be / 12.5° above standard. Twenty-three thousand feet was computed as the maximum altitude for a full receiver fuel load under this condition. All receivers should be able to fully onload at 23,000, disconnect and re-hook. Note that this was to be accomplished at the heavy tanker gross weight, where the most severe downwash effect is encountered.

(2) The actual medium refueling altitude temperature for the daily mission was considered to be $\neq 12.5^{\circ}$ above standard. Reducing the total fuel load to 9000 lbs (F-100F) and 9300 lbs (F-100D), respectively, would represent a reduction of virtually 10° in temperature, or simulate a near standard day full load. Considering this simulation, 27,000 ft was computed to represent the optimum altitude that a full onload and re-hook could be accomplished at 2.5° warmer than a standard day.

(3) The actual high refueling altitude temperature for the daily mission was considered to be $\neq 10^{\circ}$ above standard. Reducing the total fuel load to 6000 lbs (F-100F) and 6300 lbs (F-100D), respectively, would represent a reduction of virtually 20° in temperature, or simulate 10° cooler than standard day full load. Considering this simulation, 30,200 ft were computed to represent the optimum altitude that a full onload and re-hook could be accomplished at 10° cooler than a standard day.

c. Techniques to be used during a toboggan were to be finalized. Refueling four F-100's by use of the toboggan method was to be accomplished.

2. Accomplishments:

a. Due to altitude clearance restrictions, three aircraft were forced to refuel at 24,000 ft, rather than the planned 23,000 ft. They encountered difficulty during the re-hook at full load. Pedal 14 accomplished his program at 23,000 ft with no problems encountered. He had approximately 1% of power remaining when stabilized and fully loaded.

b. The 27,000 ft tests were accomplished as planned and the results were exactly as anticipated.

c. The 30,200 ft tests were accomplished as planned, and the results were exactly as anticipated.

d. During the three aforementioned tests, pilots reported 1% or more remaining when stabilized on the drogue with a full load. This is a very significant factor. The temperatures for the mission averaged $\neq 17^{\circ}$ warmer than standard. The mission was planned for $\neq 12.5^{\circ}$. The $\neq 4.5^{\circ}$ difference represents approximately 1500 ft of altitude, which means that the preplanned mission was completely successful as flown at 1500 ft above the computed optimum refueling altitude.

e. The flight was taken to 33,000 ft. The average fuel load was 4500 lbs remaining on each receiver. Pedal 11 initiated a contact in straight and level flight. When he approached maximum power, he called for a toboggan. A smooth power reduction was immediately initiated by the tanker and a 900 FPM descent was established. Extreme turbulence was encountered, but the receiver reported excellent control. Turbulence forced a disconnect at 10,600 lbs, 1400 lbs below maximum load. Re-hookup was accomplished with little problem. Full onload was accomplished at 28,000 ft and the tanker leveled and accelerated back to 290 KIAS. Pedal 12 contacted and refueled straight and level until a toboggan was necessary. 500 FPM was used and he completed refueling at 27,000 ft, where the tanker once again leveled and accelerated to 290 KIAS. During the refueling

operation, Pedal 12, 13 and 14 experienced extremely turbulent air conditions. Pedal 13 did not call for his toboggan soon enough, and required 7 minutes to re-hook under the adverse flight conditions. Pedal 14 encountered no problems and all four aircraft were refueled at 24,000 ft. This altitude was still 2000 ft above the full load optimum cruise altitude computed for the existing conditions.

3. Mission Findings:

a. Given a temperature, weight and aircraft configuration, exact optimum refueling altitudes can be computed from the appropriate military power climb chart in the Flight Handbook and adjusted for various tanker gross weights.

b. By use of the toboggan refueling method, optimum cruising altitudes can be planned for and utilized to insure maximum mission capability of the receiver aircraft.

c. The moment an aircraft exceeds its optimum cruising altitude, the greater must be the rate of descent during the initial stages of toboggan refueling. The reason for this is that the onload rate exceeds the altitude loss capability in order to maintain a standard flight condition during the descent.

d. It is logical to assume that improved capabilities derived from this test will also apply to any fighter aircraft in our present inventory.

OVERALL TEST ANALYSIS

1. The flying portion of this test program was conducted on four successive days. Four KC-135 sorties and fourteen F-100 sorties were flown. Included was one night mission.

2. Positive factors:

a. Temperature is the most influential single factor that controls the maximum altitude for non-afterburner refueling.

b. The existing refueling techniques and directives outlined for the F-100, restrict the total capability of the aircraft. Flight tested techniques and procedures developed during this test program provide guidance for optimum flight planning when air-to-air refueling is a mission requirement. Sufficient latitude has been included to allow for combinations of deficiencies as a result of aircraft performance, pilot experience or flight conditions.

c. Onload tests were performed at three tanker gross weights to solve the relative tanker downwash factor. In this report, these weights are referred to as heavy, medium and light (240,000 lbs, 200,000 lbs and 160,000 lbs). Data collection contained in this report includes reference to total tanker fuel load. Gross weight is derived by adding 105,000 lbs (tanker aircraft weight) to this figure. From flight test data it was determined that the military power optimum refueling altitude increases linearly 1000 ft between heavy, medium and light tanker weight conditions.

d. Refueling at any tanker airspeed from 260 KIAS to 300 KIAS required virtually the same power and aircraft control; however, 290 KIAS was determined to be the most suitable. Because of this flexible speed range, airspeed is considered a secondary factor during a refueling transfer. Each transfer should be initiated at 290 KIAS, but tanker power should not be increased after contact is stabilized, or a disconnect will most likely occur. Airspeed should be sacrificed during tanker attitude changes, such as in turns or in toboggans. The tanker pilots were generally found to use abrupt power changes that exceeded the capability of the F-100 aircraft. Proposed toboggan techniques require very gentle power reductions by the tanker pilots.

e. The boom should be extended at full length, 19 ft; at full deflection, 38° down; and deflected in azimuth 6° to the tanker's starboard side. This places the receiver in the lowest relative position where the least downwash is encountered. The azimuth deflection places the receiver directly in line with the tanker's fuselage and presents a balanced sight picture.

f. Receiver pilots require additional instruction on tanker systems operations. Obvious lack of knowledge on the part of the receivers during the test program resulted in unnecessary confusion. Areas requiring specific emphasis are:

(1) Receiver pilot's responsibilities.

- (2) Boom operator's responsibilities.
- (3) Pilot and co-pilot responsibilities.
- (4) Fuel transfer operation.
- (5) Necessity for strict radio discipline.

A training program requiring all receiver pilots to fly one mission aboard a KC-135 would greatly enhance mission proficiency.

g. Considering temperature, weight and configuration, any optimum military power refueling altitude can be obtained from the appropriate military power climb chart contained in the Flight Handbook. This is accomplished by considering the maximum weight of the aircraft at the required fuel load specified. This weight must be adjusted for the forecast temperature condition at the refueling point (3000 lb increase or decrease for each 10° deviation from standard day). Optimum refueling capabilities are directly proportional to the optimum cruise line specified in the climb chart, with one exception -- adjustment for tanker weight must be applied. Optimum refueling at the heavy tanker weight is 500 ft below the optimum cruise altitude, medium weight is 500 ft above the optimum cruise altitude and light weight is 1500 ft above the optimum cruise altitude. As a result of this up-to-date refueling concept, sound reasoning completely refutes the validity of the existing non-afterburner refueling directive. (Reference TACM 55-15, SACM 55-9, page 16, para 2a, quoted below):

"Performance. Recommended operational planning altitude for initial contact and refueling F-100 D/F aircraft is 28,000 feet and 300 tanker KIAS when equipped with two 450 gallon tanks and 31,000 feet and 300 tanker KIAS when equipped with 335 gallon tanks. All refueling above 24,000 feet will be accomplished using afterburner and partial speed brakes (15-17 inches). The F-100 D/F aircraft can onload a full fuel load without using afterburner at 24,000 feet or below at an airspeed of 300 tanker KIAS."

For a specific thrust setting, Mach number, and pressure altitude, there is a drastic change in thrust with changes in ambient temperature. This temperature is not considered in any of our existing refueling directives or operational plans. For instance, a fully loaded F-100F at 31,000 ft, as directed in TACM 55-15, will be 7,500 ft above its optimum cruise altitude when the temperature is 10° above standard. It will be 2,750 ft above optimum under standard temperature conditions.

h. A very effective toboggan procedure has been developed from flight test results of this program. It affords a flight of receivers the opportunity to cruise climb or step climb, utilizing the maximum cruise performance of the aircraft. It also enables the receiver aircraft to refuel with military power from virtually any altitude by varying the rate of descent of the toboggan maneuver. By using a step descent, numerous aircraft can be completely refueled prior to reaching the optimum cruise

altitude programmed for a full receiver. During a toboggan maneuver the first receiver contacts at straight and level flight and onloads until 1/2% to 1% of full power is required. He must call for a toboggan in sufficient time to prevent a disconnect (during the tests, most pilots had a tendency to delay too long). The tanker pilot immediately and very gently reduces the tanker power 1% on all engines. This provides the receiver with an immediate power advantage during the deceleration. The tanker then initiates a descent of 700 to 900 FPM. (The higher the altitude above optimum full load altitude, the greater is the required descent). During the descent, smoothness of control is primary. Power, airspeed and rate of descent may be varied at the receiver's request. At full onload the first receiver disconnects; the tanker levels and accelerates back to 290 KIAS. Succeeding receivers then contact and follow the same procedures. However, as altitude decreases, each receiver can onload more fuel prior to calling for a toboggan and less rate of descent is required. After all receivers are refueled, optimum cruise power for a full load condition must be selected and a slight descent must be continued until optimum cruise power will maintain straight and level optimum cruise flight conditions. This method of seeking the optimum cruise flight level is just the reverse of cruise climbing, while accomplishing the same results.

3. Negative factors:

a. The use of 20° of flaps at any airspeed between 260 and 300 KIAS resulted in too much drag to be of any value.

b. Varying the power on the tanker engines had no noticeable effect on receiver control during transfer.

c. Varying the boom azimuth from 6° port to 6° starboard had no effect on receiver control during transfer. Pilots prefer the starboard position, because it gives them a balanced sight picture.

MISSION PROFILE PLANNING

1. Conclusive results of the test program insure two accurate methods of mission profile planning, to include military power air-to-air ~~air-to-air~~ fueling.

a. Limited altitude profile: If, due to airspace availability, restricted block altitudes prevent optimum cruise climb or step climb procedures, a mean optimum block altitude can be computed. In this case, the optimum refueling altitude computed from the appropriate military power climb chart will be the lower limit of the block altitude. The upper limit will be the mean altitude between the optimum cruise altitude for a full receiver, and the optimum cruise altitude computed for the weight condition at the following refueling point.

b. Maximum efficiency toboggan profile: To obtain the maximum range possible, a cruise climb profile must be planned. By using the toboggan method of refueling, the receiver simply follows a programmed optimum mission profile with respect to the aircraft weight and flight conditions. Since all refueling operations are conducted between the lower and upper optimum cruise levels, the mission is not restricted by maximum refueling altitude requirements.

2. Although this test was conducted for the F-100 aircraft, it can be assumed that the same principles prescribed for mission planning will apply for any type of receiver aircraft.

ALTITUDE TEMPERATURE CORRELATION

ALTITUDE	AVERAGE TEMP	HOMESTEAD AVERAGE TEMP	TEMP MIS. #1	TEMP MIS. #2	TEMP MIS. #3	TEMP MIS. #4
33,000	-50	-41	--	--	--	-35
32,000	-48	-38.5	--	--	--	--
31,000	-46.5	-36.5	--	--	-32	--
30,000	-44	-34	--	--	--	-28
29,000	-42.5	-32.5	--	--	-29	-26
28,000	-40.5	-30.5	-28	-27	-26	-24
27,000	-38	-28	-27	-25	-24	-22
26,000	-36.5	-26.5	-25	-23	-22	-19
25,000	-34	-24	--	-21	--	-16
24,000	-32	-21.5	--	--	--	-14
23,000	-30.5	-19.5	--	--	--	-12

(ALL TEMPERATURES IN DEGREES CENTIGRADE)

NOTE: All test conditions accomplished during Mission #4 averaged $\pm 17^{\circ}$ above standard day temperature. By entering the Flight Handbook charts and compensating for this unusual temperature condition, each test result was exactly as planned. Refueling altitude for any temperature and weight condition can be derived from the flight test data contained in the handbook tables.

SAMPLE PROFILES

1. Limited Altitude Profile (Reference profile appendix #1)

a. Given:

- | | |
|---|----------------------------------|
| (1) Temperature | /2°C. above stand |
| (2) F-100F / 2-335's / type VII pylon
full fuel load | 35,600 lbs |
| (3) F-100F / 2-335's / type VII pylon
minimum load (5000 internal) | 28,300 lbs |
| (4) Tanker refueling weights | 240,000; 200,000;
160,000 lbs |

b. Solution:

-
- (1) Add 20% of 3000 lbs to total weight for temp 600 lbs
- (2) Standard cruise ceiling, full load 27,400 ft
- (3) Standard cruise ceiling, minimum load 35,100 ft
- (4) Heavy weight refueling altitude
(standard cruise ceiling -500 ft) 26,900 ft
- (5) Medium weight refueling altitude
(standard cruise ceiling / 500 ft) 27,900 ft
- (6) Light weight refueling altitude
(standard cruise ceiling / 1500 ft) 28,900 ft
- (7) Mean cruising altitude 31,250 ft

2. Maximum Efficiency Toboggan Profile (Reference profile appendix #2)

a. Given:

- | | |
|---|----------------------------------|
| (1) Temperature | /10°C. above stand |
| (2) F-100F / 2-335's / type VII pylon
full load | 35,600 lbs |
| (3) F-100F / 2-335's / type VII pylon
minimum load (5000 lbs internal) | 28,300 lbs |
| (4) Tanker refueling weights | 240,000; 200,000;
160,000 lbs |

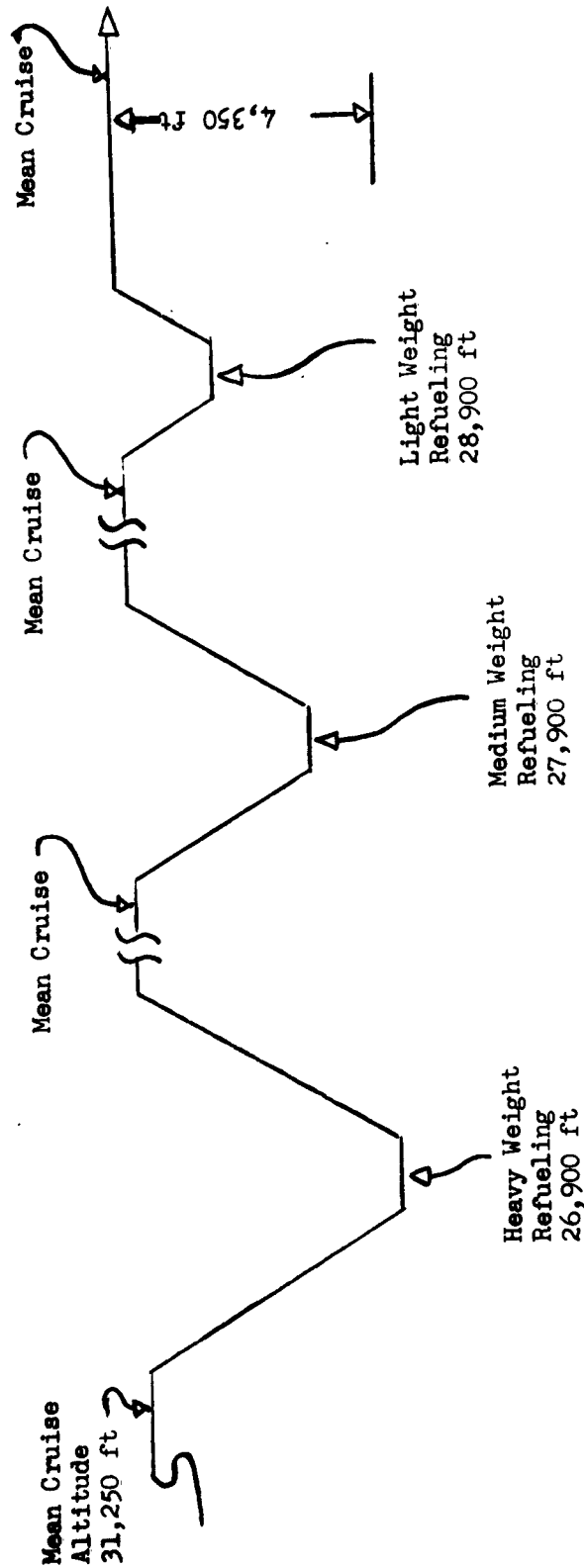
b. Solution:

- | | |
|--|-----------|
| (1) Add 100% of 3000 lbs to weight for temperature | 3,000 lbs |
| (2) Standard cruise ceiling full load | 23,500 ft |
| (3) Standard cruise ceiling, minimum load | 33,500 ft |
| (4) Heavy weight refueling altitude
(standard cruise ceiling -500 ft) | 23,000 ft |
| (5) Medium weight refueling altitude
(standard cruise ceiling / 500 ft) | 24,000 ft |
| (6) Light weight refueling altitude
(standard weight / 1500 ft) | 25,000 ft |

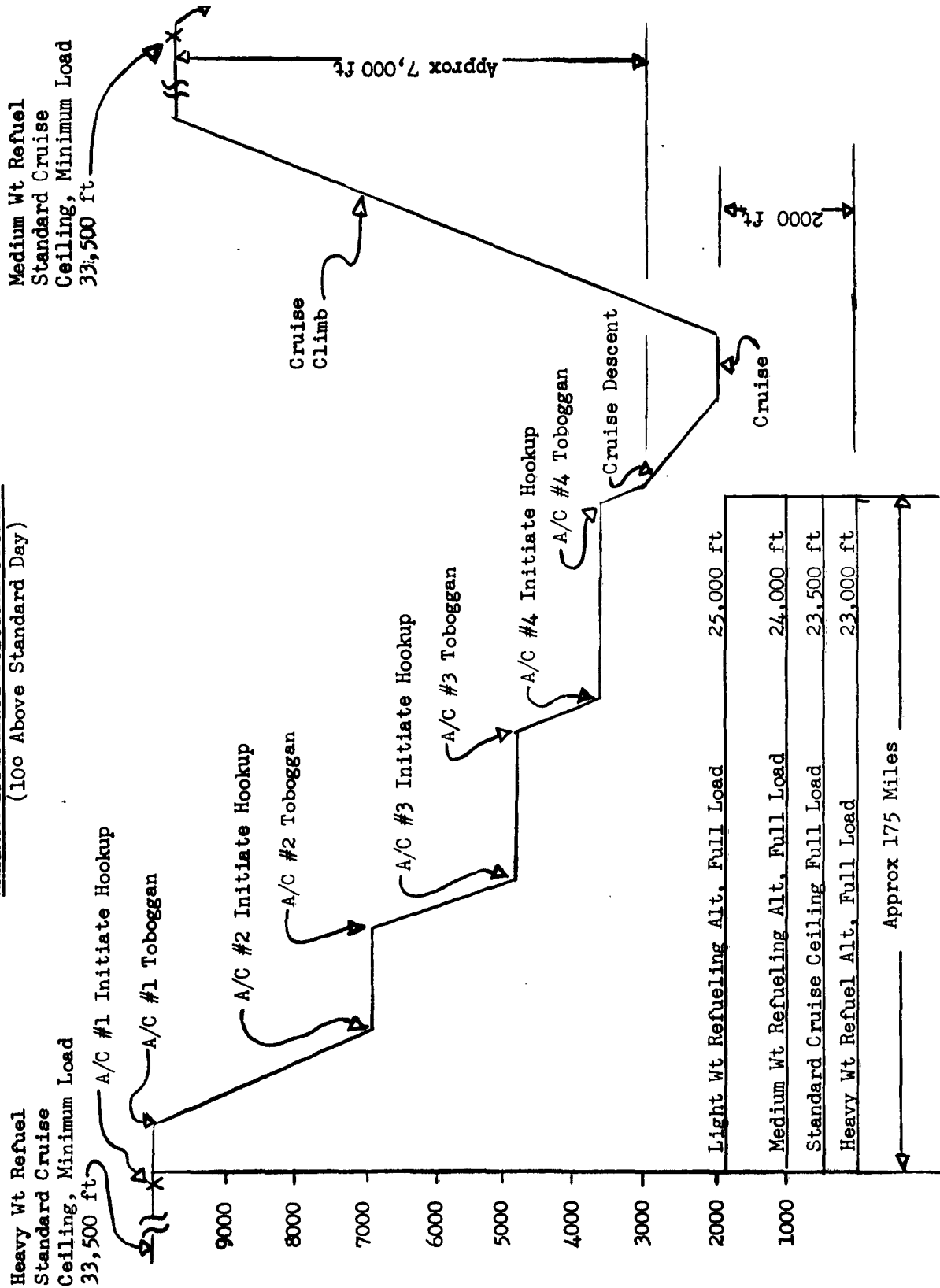
DISTRIBUTION LIST

HQ USAF		USAFSAWC	1	50 TFW	5
AFORQ-TA	1	836 AD	5	5 AF	3
AFOOP-TA	1	4440 Acft Dlvr		13 AF	3
AFMME	1	Gp	1	8 TFW	5
AFSSA	1	4 TFW	1	18 TFW	5
USAFE		354 TFW	5	405 TFW	5
OTREQ	3	31 TFW	5	41 AD	1
PACAF		832 AD	2	39 AD	1
PFORQ	3	27 TFW	5	313 AD	1
ASD		474 TFW	5	315 AD	1
TACSO-A	1	388 TFW	5	314 AD	1
AFLC		4510 CCr Tng		322 AD	1
MCFLC	1	Wg	3	366 TFW	5
APGC		831 AD	2	HQ TAC	
TACLO-P	1	479 TFW	1	DMEM	1
ESD		355 TFW	1	DOTR	1
TACSO-E	1	401 TFW	5	DOOP	2
9 AF	3	4520 CCr Tng		DIRQ	1
12 AF	3	Wg	3	DOPL	3
19 AF	1	17 AF	3	DPLPR	1
837 AD		36 TFW	1	DCRB	1
TACT	1	48 TFW	5	DMS	1
ASTIA		20 TFW	5	OIH	1
TIS	1	49 TFW	1	DOC	1
AU		81 TFW	1	OA	1
AUL3T	1	7272 ABW	1	OS	1
AGOS				LN	2
N-8	1			DORQ-T	10
AFSC	1			SEG	3
BSD					
TACSO-B	1				
AFSWC					
TACLO-S	1				

LIMITED ALTITUDE PROFILE



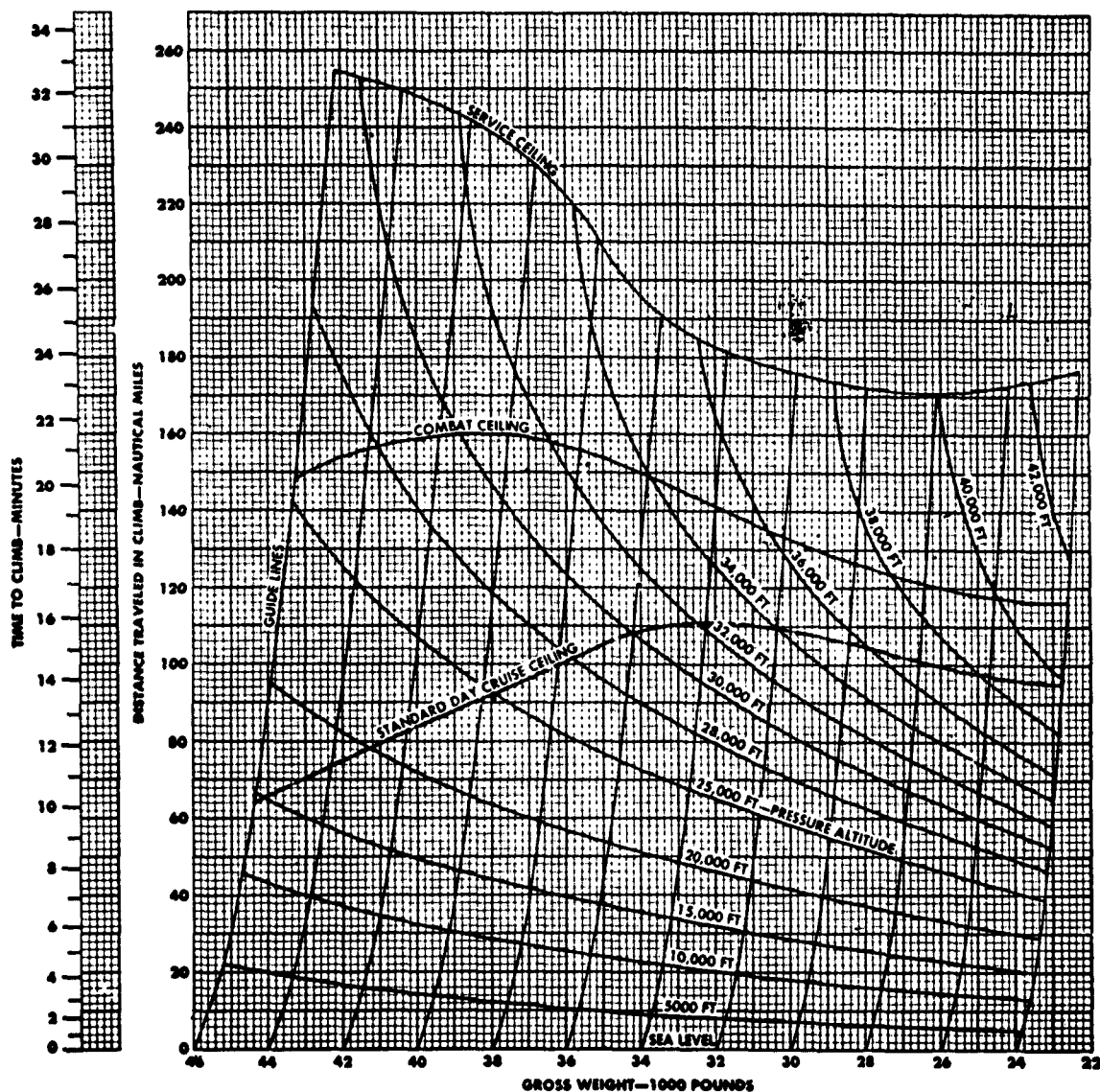
MAXIMUM EFFICIENCY TOBOGGAN PROFILE
(100 Above Standard Day)



DATA AS OF: 1 OCT 1959
 BASED ON: FLIGHT TEST

MILITARY THRUST CLIMB CONFIGURATION DRAG NO. 50

MODEL: F-100F
 ENGINE: J57-21



REMARKS:

1. FOR EACH 10°C RISE IN AIR TEMPERATURE ABOVE STANDARD DAY CONDITIONS, INCREASE GROSS WEIGHT 3000 POUNDS BEFORE ENTERING CHART.
2. FOR EACH 10°C BELOW STANDARD DAY CONDITIONS, APPLY CORRECTION IN THE OPPOSITE DIRECTION.
3. ALL DATA COMPUTED FROM TIME BEST CLIMB SPEED IS ATTAINED.
4. WHEN ENGINES ARE INTENTIONALLY DOWN-TRIMMED: FOR EACH ONE INCH OF MERCURY, ADD 1000 POUNDS TO THE CLIMB GROSS WEIGHT. THIS IS IN ADDITION TO THE TEMPERATURE CORRECTION DEFINED IN REMARKS 1 AND 2.
5. FOR CLIMB INITIATED IMMEDIATELY AFTER TAKE-OFF, SUBTRACT 1000 POUNDS OF FUEL FROM STATIC GROSS WEIGHT FOR START, TAXI, TAKE-OFF, AND ACCELERATION TO CLIMB SPEED, BEFORE ENTERING CLIMB CHART.

CLIMB SPEEDS			
ALTITUDE (FEET)	TRUE MACH NUMBER	IND MACH NUMBER	CAS (KNOTS)
50,000	.88	.85	215
45,000	.88	.85	240
40,000	.88	.85	270
35,000	.88	.85	300
30,000	.88	.85	335
25,000	.82	.79	345
20,000	.74	.74	355
15,000	.70	.68	355
10,000	.64	.62	355
5,000	.47	.46	285
SEA LEVEL	.30	.30	200

F-100F-1-53-3005

~ KC135/F100 MILITARY POWER REFUELING ALTITUDE ~

KC135 WT X 1000

10 15 20 25 30

35 40 45 50 55 60 65 70 75 80 85 90 95 100

105 110 115 120 125 130 135 140 145 150 155 160 165 170 175 180 185 190 195 200

200 205 210 215 220 225 230 235 240 245 250 255 260 265 270 275 280 285 290 295 300

300 305 310 315 320 325 330 335 340 345 350 355 360 365 370 375 380 385 390 395 400

400 405 410 415 420 425 430 435 440 445 450 455 460 465 470 475 480 485 490 495 500

500 505 510 515 520 525 530 535 540 545 550 555 560 565 570 575 580 585 590 595 600

600 605 610 615 620 625 630 635 640 645 650 655 660 665 670 675 680 685 690 695 700

700 705 710 715 720 725 730 735 740 745 750 755 760 765 770 775 780 785 790 795 800

800 805 810 815 820 825 830 835 840 845 850 855 860 865 870 875 880 885 890 895 900

900 905 910 915 920 925 930 935 940 945 950 955 960 965 970 975 980 985 990 995 1000

1000 1005 1010 1015 1020 1025 1030 1035 1040 1045 1050 1055 1060 1065 1070 1075 1080 1085 1090 1095 1100

1100 1105 1110 1115 1120 1125 1130 1135 1140 1145 1150 1155 1160 1165 1170 1175 1180 1185 1190 1195 1200

1200 1205 1210 1215 1220 1225 1230 1235 1240 1245 1250 1255 1260 1265 1270 1275 1280 1285 1290 1295 1300

1300 1305 1310 1315 1320 1325 1330 1335 1340 1345 1350 1355 1360 1365 1370 1375 1380 1385 1390 1395 1400

1400 1405 1410 1415 1420 1425 1430 1435 1440 1445 1450 1455 1460 1465 1470 1475 1480 1485 1490 1495 1500

1500 1505 1510 1515 1520 1525 1530 1535 1540 1545 1550 1555 1560 1565 1570 1575 1580 1585 1590 1595 1600

1600 1605 1610 1615 1620 1625 1630 1635 1640 1645 1650 1655 1660 1665 1670 1675 1680 1685 1690 1695 1700

1700 1705 1710 1715 1720 1725 1730 1735 1740 1745 1750 1755 1760 1765 1770 1775 1780 1785 1790 1795 1800

1800 1805 1810 1815 1820 1825 1830 1835 1840 1845 1850 1855 1860 1865 1870 1875 1880 1885 1890 1895 1900

1900 1905 1910 1915 1920 1925 1930 1935 1940 1945 1950 1955 1960 1965 1970 1975 1980 1985 1990 1995 2000

2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070 2075 2080 2085 2090 2095 2100

2100 2105 2110 2115 2120 2125 2130 2135 2140 2145 2150 2155 2160 2165 2170 2175 2180 2185 2190 2195 2200

2200 2205 2210 2215 2220 2225 2230 2235 2240 2245 2250 2255 2260 2265 2270 2275 2280 2285 2290 2295 2300

2300 2305 2310 2315 2320 2325 2330 2335 2340 2345 2350 2355 2360 2365 2370 2375 2380 2385 2390 2395 2400

2400 2405 2410 2415 2420 2425 2430 2435 2440 2445 2450 2455 2460 2465 2470 2475 2480 2485 2490 2495 2500

2500 2505 2510 2515 2520 2525 2530 2535 2540 2545 2550 2555 2560 2565 2570 2575 2580 2585 2590 2595 2600

2600 2605 2610 2615 2620 2625 2630 2635 2640 2645 2650 2655 2660 2665 2670 2675 2680 2685 2690 2695 2700

2700 2705 2710 2715 2720 2725 2730 2735 2740 2745 2750 2755 2760 2765 2770 2775 2780 2785 2790 2795 2800

2800 2805 2810 2815 2820 2825 2830 2835 2840 2845 2850 2855 2860 2865 2870 2875 2880 2885 2890 2895 2900

2900 2905 2910 2915 2920 2925 2930 2935 2940 2945 2950 2955 2960 2965 2970 2975 2980 2985 2990 2995 3000

3000 3005 3010 3015 3020 3025 3030 3035 3040 3045 3050 3055 3060 3065 3070 3075 3080 3085 3090 3095 3100

3100 3105 3110 3115 3120 3125 3130 3135 3140 3145 3150 3155 3160 3165 3170 3175 3180 3185 3190 3195 3200

3200 3205 3210 3215 3220 3225 3230 3235 3240 3245 3250 3255 3260 3265 3270 3275 3280 3285 3290 3295 3300

3300 3305 3310 3315 3320 3325 3330 3335 3340 3345 3350 3355 3360 3365 3370 3375 3380 3385 3390 3395 3400

3400 3405 3410 3415 3420 3425 3430 3435 3440 3445 3450 3455 3460 3465 3470 3475 3480 3485 3490 3495 3500

3500 3505 3510 3515 3520 3525 3530 3535 3540 3545 3550 3555 3560 3565 3570 3575 3580 3585 3590 3595 3600

3600 3605 3610 3615 3620 3625 3630 3635 3640 3645 3650 3655 3660 3665 3670 3675 3680 3685 3690 3695 3700

3700 3705 3710 3715 3720 3725 3730 3735 3740 3745 3750 3755 3760 3765 3770 3775 3780 3785 3790 3795 3800

3800 3805 3810 3815 3820 3825 3830 3835 3840 3845 3850 3855 3860 3865 3870 3875 3880 3885 3890 3895 3900

3900 3905 3910 3915 3920 3925 3930 3935 3940 3945 3950 3955 3960 3965 3970 3975 3980 3985 3990 3995 4000

4000 4005 4010 4015 4020 4025 4030 4035 4040 4045 4050 4055 4060 4065 4070 4075 4080 4085 4090 4095 4100

4100 4105 4110 4115 4120 4125 4130 4135 4140 4145 4150 4155 4160 4165 4170 4175 4180 4185 4190 4195 4200

4200 4205 4210 4215 4220 4225 4230 4235 4240 4245 4250 4255 4260 4265 4270 4275 4280 4285 4290 4295 4300

4300 4305 4310 4315 4320 4325 4330 4335 4340 4345 4350 4355 4360 4365 4370 4375 4380 4385 4390 4395 4400

4400 4405 4410 4415 4420 4425 4430 4435 4440 4445 4450 4455 4460 4465 4470 4475 4480 4485 4490 4495 4500

4500 4505 4510 4515 4520 4525 4530 4535 4540 4545 4550 4555 4560 4565 4570 4575 4580 4585 4590 4595 4600

4600 4605 4610 4615 4620 4625 4630 4635 4640 4645 4650 4655 4660 4665 4670 4675 4680 4685 4690 4695 4700

4700 4705 4710 4715 4720 4725 4730 4735 4740 4745 4750 4755 4760 4765 4770 4775 4780 4785 4790 4795 4800

4800 4805 4810 4815 4820 4825 4830 4835 4840 4845 4850 4855 4860 4865 4870 4875 4880 4885 4890 4895 4900

4900 4905 4910 4915 4920 4925 4930 4935 4940 4945 4950 4955 4960 4965 4970 4975 4980 4985 4990 4995 5000

5000 5005 5010 5015 5020 5025 5030 5035 5040 5045 5050 5055 5060 5065 5070 5075 5080 5085 5090 5095 5100

5100 5105 5110 5115 5120 5125 5130 5135 5140 5145 5150 5155 5160 5165 5170 5175 5180 5185 5190 5195 5200

5200 5205 5210 5215 5220 5225 5230 5235 5240 5245 5250 5255 5260 5265 5270 5275 5280 5285 5290 5295 5300

5300 5305 5310 5315 5320 5325 5330 5335 5340 5345 5350 5355 5360 5365 5370 5375 5380 5385 5390 5395 5400

5400 5405 5410 5415 5420 5425 5430 5435 5440 5445 5450 5455 5460 5465 5470 5475 5480 5485 5490 5495 5500

5500 5505 5510 5515 5520 5525 5530 5535 5540 5545 5550 5555 5560 5565 5570 5575 5580 5585 5590 5595 5600

5600 5605 5610 5615 5620 5625 5630 5635 5640 5645 5650 5655 5660 5665 5670 5675 5680 5685 5690 5695 5700

BASE LINE

REFUELING ALT. X 1000 FT.

FOR EACH ONE INCH OF
MERCURY THAT ENGINES
ARE DOWN-TRIMMED, ADD
1000 POUNDS TO THE
UNDERWEIGHT

F-100 WT. X 1000 LBS.

STAN. DAY

120°C

110°C

100°C

90°C

STAN. TEMP.

TEMP. °C

DENSITY ALT. X 1000 FT.

APPENDIX IV

TEST DATA

<u>CALL SIGN</u>	<u>A/C</u>	<u>MIN FOR TRANSFER</u>	<u>TOTAL FUEL TRANSF'D</u>	<u>RECEIVER FUEL AT DISCONNECT</u>	<u>TANKER FUEL AT DISCONNECT</u>	<u>HOOK-UP</u>	<u>FLIGHT CONDIT</u>	<u>ACT TEMP</u>	<u>STAND TEMP</u>	<u>DIFF</u>	<u>A/S</u>	<u>REMARKS</u>
<u>26,000 FEET</u>												
Pedal 13 Sullivan Schmidt	F 951	7 min	2350	9,600	133,000	#1	Smooth	-25°C	-36.5°	+11.5°	300	No Difficulties Encountering Re-hook Smooth
Pedal 13 Sullivan Schmidt	F 951	5 min	3200	11,400	129,500	#2	IFR Rough Air	-25°C	-36.5°	+11.5°	300	Some Difficulties Over Control but Re-hooked
Pedal 13 Schmidt	F 951	-	-	Full	-	#3	Smooth	-25°C	-36.5°	+11.5°	300	Unable to Re-hook at Full Load Condition
Pedal 14 Vinson	D 457	3 min	3700	9,600	127,000	#1	Smooth In Turn	-25°C	-36.5°	+11.5°	300	Initially Rough but Smoothed Out - Re-hook Smooth
Pedal 14 Vinson	D 457	2 min	1500	11,300	123,500	#2	Smooth	-25°C	-36.5°	+11.5°	300	No Problem Re-hooking
Pedal 14 Vinson	D 457	-	-	Full	117,000	#3	Smooth	-25°C	-36.5°	+11.5°	300	Re-hooked with Full Power In Turn
Pedal 11 Youngblood Johnson	F 919	4 min	1800	10,000	146,000	#1	Smooth	-22°C	-36.5°	+14.5°	300	Re-hooked but pushed Off -Finally Got On
Pedal 11 Youngblood	F 919	3 min	2400	Full	140,000	#2	Smooth	-23°C	-36.5°	+13.5°	290	Full Power to Remain On
Pedal 12 Havey	D 191	3 min	2600	10,000	136,000	#1	Smooth	-23°C	-36.5°	+13.5°	300	Rough On Controls But Stayed On
Pedal 12 Havey	D 191	-	-	-	130,000	#2	Smooth	-23°C	-36.5°	+13.5°	300	Very Rough On Controls No Hookup Accomplished

<u>CALL SIGN</u>	<u>A/C</u>	<u>MIN FOR</u> <u>TRANSFER</u>	<u>TOTAL</u> <u>FUEL</u> <u>TRANSF'D</u>	<u>RECEIVER</u> <u>FUEL AT</u> <u>DISCONNECT</u>	<u>TANKER</u> <u>FUEL AT</u> <u>DISCONNECT</u>	<u>HOOK-</u> <u>UP</u>	<u>FLIGHT</u> <u>CONDIT</u>	<u>ACT</u> <u>TEMP</u>	<u>STAND</u> <u>TEMP</u>	<u>DIFF</u>	<u>A/S</u>	<u>REMARKS</u>
Pedal 13 Hughes Sayre	F 951	3 min	2900	10,000	128,000	#1	Smooth	-22°C	-36.5°	+14.5°	300	Smooth
	F 951	-	-	-	126,000	#2	Smooth	-22°C	-36.5°	+14.5°	300	Over Controlling No Hookup
Pedal 14 Stresing	D 121	5 min	2700	10,000	123,000	#1	Smooth	-24°C	-36.5°	+12.5°	300	Very Smooth - No Problems
Pedal 14 Stresing	D 121	5 min	-	10,600	118,000	#2	Smooth	-24°C	-36.5°	+12.5°	300	Very Smooth - Good Hookup but Fell Off
Pedal 11 Richmond	F 919	3 min	4700	Full	137,000	#1	Smooth	-22°C	-36.5°	+14.5°	290	Took on Full Load No Re-hookup
Pedal 14 Stresing	F 120	4 min	5460	Full	130,000	#1	Smooth	-22°C	-36.5°	+14.5°	290	Took on Full Load No Re-hookup

26,000 FEET

<u>CALL SIGN</u>	<u>A/C</u>	<u>MIN FOR TRANSFER</u>	<u>TOTAL FUEL TRANSF'D</u>	<u>RECEIVER FUEL AT DISCONNECT</u>	<u>TANKER FUEL AT DISCONNECT</u>	<u>HOOK- UP</u>	<u>FLIGHT CONDIT</u>	<u>ACT TEMP</u>	<u>STAND TEMP</u>	<u>DIFF</u>	<u>A/S</u>	<u>REMARKS</u>
						26,000	FEET					
Pedal 13 Hughes Sayre	F 951	3 min	3000	10,000	88,000	#1	Smooth	-25°C	-37°	+12°	300	Very Rough on Controls
Pedal 13 Hughes	F 951	-	300	-	-	#2	Smooth	-25°C	-37°	+12°	300	Pilot Over Control No Re-hook
Pedal 14 Stressing	D 121	4 min	3100	10,000	84,000	#1	Rough Air	-24°C	-37°	+13°	300	Very Smooth - No Problem
Pedal 14 Stressing	D 121	2 min	1500	Full	80,000	#2	Rough Air	-24°C	-37°	+13°	300	Re-hooked Full Load No Problem
Pedal 14 Stressing	F 120		4600	Full	93,000	#1	Smooth	-24°C	-37°	+13°	290-275	Fell Off at Full Load - 500 lbs

CALL SIGN	A/C	MIN FOR TRANSFER	TOTAL FUEL TRANSF'D	RECEIVER FUEL AT DISCONNECT	TANKER FUEL AT DISCONNECT	HOOK-UP	FLIGHT CONDIT	ACT TEMP	STAND TEMP	DIFF	A/S	REMARKS
27,000 FEET												
Pedal 11 Johnson Vinson	F 860	3 min	2800	9,600	104,000	#1	Smooth	-27°C	-38°	+11°	300	Hooked up in turn
Pedal 11 Johnson Vinson	F 860	3 min	3000	11,400	100,500	#2	Smooth	-27°C	-38°	+11°	300	No Problem Re-hooking
Pedal 11	F 860	-	-	Full	97,000	#3	Smooth	-27°C	-38°	+11°	300	No Re-hook at Full Load
Pedal 12 Youngblood	D 120	3 min	2500	9,600	97,000	#1	Smooth	-27°C	-38°	+11°	300	Hooked up No Problem
Pedal 12 Youngblood	D 120	3 min	2400	Full	93,000	#2	Smooth	-27°C	-38°	+11°	300	Pushed Off at Full Load-Unable Re-hook
Pedal 13 Schmidt Sullivan	F 951	-	3500	9,700	90,000	#1	Smooth	-27°C	-38°	+11°	300	Erratic Control-Fell Off (16 min to Hook)
Pedal 13 Schmidt	F 951	3 min	1200	Full	84,500	#2	Smooth	-27°C	-38°	+11°	300	Re-hooked at Full Load
Pedal 14 Vinson	D 457	2 min	2800	9,600	79,000	#1	Smooth	-27°C	-38°	+11°	300	Hooked up Very Smooth
Pedal 14 Vinson	D 457	4 min	3200	Full	74,000	#2	Smooth	-27°C	-38°	+11°	300	Disconnected at Full Power - No Reconnect
Pedal 11 Youngblood	F 919	3 min	3200	10,000	105,000	#1	Smooth	-25°C	-38°	+13°	290	No Problem Hookup

<u>CALL SIGN</u>	<u>A/C</u>	<u>MIN FOR TRANSFER</u>	<u>TOTAL FUEL TRANSF'D</u>	<u>RECEIVER FUEL AT DISCONNECT</u>	<u>TANKER FUEL AT DISCONNECT</u>	<u>HOOK-UP</u>	<u>FLIGHT CONDIT</u>	<u>ACT TEMP</u>	<u>STAND TEMP</u>	<u>DIFF</u>	<u>A/S</u>	<u>REMARKS</u>
Pedal 11 Youngblood Johnson	F 919	-	2500	Full	97,000	#2	Smooth	-25°C	-38°	+13°	290	Had Difficulty Making Hookup & could not Re-hook at Full Load
Pedal 12 Havey	D 191	3 min	3500	10,000	96,000	#1	Smooth	-26°C	-38°	+12°		Good Cont No Problem with Hookup
Pedal 12 Havey	D 191	2 min	1800	Full	91,000	#2	Smooth	-26°C	-38°	+12°		No Re-hook at Full Load

<u>CALL SIGN</u>	<u>A/C</u>	<u>MIN FOR TRANSFER</u>	<u>TOTAL FUEL TRANSF'D</u>	<u>RECEIVER FUEL AT DISCONNECT</u>	<u>TANKER FUEL AT DISCONNECT</u>	<u>HOOK-UP</u>	<u>FLIGHT CONDIT</u>	<u>ACT TEMP</u>	<u>STAND TEMP</u>	<u>DIFF</u>	<u>A/S</u>	<u>REMARKS</u>
						<u>27,500 FEET</u>						
Pedal 13 Hughes	F 951	3 min	3300	10,000	58,000	#1	Smooth	-27°C	-39.5°	+12.5°	290	Good Smooth Hookup
Pedal 13 Hughes	F 951	-	3200	Full	54,000	#2	Smooth	-27°C	-39.5°	+12.5°	290	Rough on Controls- No Hookup Full Load
Pedal 14 Stressing	D 121	6 min	5900	Full	50,000	#1	Smooth	-27°C	-39.5°	+12.5°	290	Very Smooth-Took Full Load- No Re-hook Attempted
Pedal 11 Youngblood Johnson	F 919	4 min	5000	Full	41,000	#1	Mild Turbulance	-27°C	-39.5°	+12.5°	290	Fell Off at Full Load
Pedal 12 Havey	D 191	5 min	5200	Full	34,000	#1	Smooth	-26°C	-39.5°	+13.5°	290	Very Smooth -Took Full Load- No Re-hook Attempted

<u>CALL SIGN</u>	<u>A/C</u>	<u>MIN FOR TRANSFER</u>	<u>TOTAL FUEL TRANSF'D</u>	<u>RECEIVER FUEL AT DISCONNECT</u>	<u>TANKER FUEL AT DISCONNECT</u>	<u>HOOK- UP</u>	<u>FLIGHT CONDIT</u>	<u>ACT TEMP</u>	<u>STAND TEMP</u>	<u>DIFF</u>	<u>A/S</u>	<u>REMARKS</u>
						<u>28,000 FEET</u>						
Pedal 11 Johnson Vinson	F 860	2 min	2000	8500	147,000	#1	Smooth	-29°C	-40.5°	+11.5°	300	Fell Off -No Re-hook Capability
Pedal 12 Youngblood	D 120	2 min	2300	-	139,000	#1	Smooth	-29°C	-40.5°	+11.5°	300	Fell Off -No Re-hook Capability
Pedal 11 Johnson Vinson	F 860	3 min	4100	9600	59,000	#1	Smooth	-28°C	-40.5°	+12.5°	300	Smooth Hookup
Pedal 11 Johnson Vinson	F 860	4 min	2600	Full	53,500	#2	Smooth	-28°C	-40.5°	+12.5°	290	Full Load Easily Taken No Re-hook Capability
Pedal 12 Youngblood	D 120		3800	9600	45,500	#1	Smooth	-28°C	-40.5°	+12.5°	290	Hooked up in Turn Very Smooth
Pedal 12 Youngblood	D 120	3 min	2300	Full	41,000	#2	Smooth	-28°C	-40.5°	+12.5°	290	Full Load -No Re-hook Capability

HOOK UP	CALL SIGN	A/C	MIN FOR TRANS-	TOTAL FUEL TRANS-	RECEIVER FUEL AT RE-HOOK	TANKER FUEL	FLIGHT CONDIT	ALT	ACT TEMP	STAND TEMP	DIFF	A/S	REMARKS
DATE 28 SEPT 62													
#1	Pedal 11 Johnson	F 951	3 min	4000	Full	145,000	Smooth	24,000	-14°C	-32°	+18°	290	Initial Hookup & Full Load Very Good Unable Re-hook at Full Load
#1	Pedal 12 Youngblood	D 118	6 min	4700	Full	137,000	Smooth	24,000	-14°C	-32°	+18°	290- 274 In Turn hook at Full Load	Initial Hookup & Full Load Very Good, No Re- hook at Full Load
#1	Pedal 13 Livensparger	F 950	6 min	4800	Full	131,000	Rough Air	23,000	-12°C	-30.5°	+18.5°	290 In Turn	Good Hookup & Full Load Re-hook with Full Load
#1	Pedal 14 Havey	D 120	5 min	5700	Full	123,000	Slightly Turbulent	23,000	-12°C	-30.5°	+18.5°	290	Two Re-hooks at Full Load with No Problem
#2	Pedal 11 Johnson	F 951	Simu- lated Load	- Full	Simu- late Full 9000#	116,500	Smooth	27,000	-22°C Sim -35°C	-38°	+3°	290	Good Hookup-Felt same as Full Load-Re-hooks accomplished easily
#2	Pedal 12 Youngblood	D 118	Simu- lated Load	- Full	Simu- late Full 9300#	111,000	Smooth	27,000	-22°C Sim -35°C	-38°	+3°	290	Good Hookup -Felt same as Full Load- Re-hooks accomplished easily
#2	Pedal 13 Livensparger	F 950	Simu- lated Load	Full	Simu- late Full 9000#	109,000	Smooth	27,000	-22°C	-38°	+3°	290	Good Hookup -Felt same as Full Load-Re-hooks accomplished easily
#2	Pedal 14 Havey	D 120	Simu- lated Load	Full	Simu- late Full 9000#	107,000	Smooth	27,000	-22°C Sim -35°C	-38°	+3°	290	Good Hookup -Felt same as Full Load- Re-hooks accomplished easily

HOOK UP	CALL SIGN	A/C	MIN FOR TRANS- FER	TOTAL FUEL TRANS- FER'D	RECEIVER FUEL AT RE-HOOK	TANKER FUEL	FLIGHT CONDIT	ALT	ACT TEMP	STAND TEMP	DIFF	A/S	REMARKS
DATE 28 SEPT 62													
#3	Pedal 11 Johnson	F 951	Simu- lated Full Load	-	Simulate Full 6000#	105,000	Rough Air	30,200	-27°C Sim -52°C	-45.5° Sim -55.5°	+3°	290	Good Hookup- Felt same as Full Load -Re-hooks accomplished easily
#3	Pedal 12 Youngblood	D 118	Simu- lated Full Load	-	Simulate Full 6300#	104,000	Smooth	30,200	-29°C Sim -54°C	-45.5° Sim -55.5°	+1.5°	290	Good Hookup- Felt same as Full Load -Re-hooks accomplished easily
#3	Pedal 13 Liversparger	F 950	20 sec	1100	Sim Full -1000# 5000	102,000	Smooth	30,200	-31°C Sim -56°C	-45.5° Sim -55.5°	-.5°	290	Excellent Hookup -Rec 1000# & Re-hooked with No Problem
#3	Pedal 14 Havey	D 120	40 sec	1000	Sim Full -1000# 5300	100,000	Smooth	30,200	-31°C Sim -56°C	-45.5° Sim -55.5°	-.5°	290	Excellent Hookup -Rec 1000# & Re-hooked with No Problem
TOBOGGAN, REFUELING 4 F-100's STARTING AT 33,000 FEET													
#4	Pedal 11 Johnson	F 951	11 min (1) 5800 (2) 2300		10,600	98,200	Smooth	33,000	-35°C → -24°C	-50° → -40.5°	+15° → +16.5°	290 280	4 Min Re-hook After Dis- connect -Pilot Technique Average 800 FPS Descent
#4	Pedal 12 Youngblood	D 118	4 min (1) 7600		4,800	87,100	Very Rough Air	28,000	-24°C → -22°C	-40.5° → -38°	+16.5° → +16°	290 290	Excellent Control 400- 600 FPM Descent
#4	Pedal 13 Livensparger	F 950	14 min (1) 5600 (2) 2600		10,000	78,500	Very Rough Air	27,000	-22°C → -16°C	-40.5° → -34°	+18.5° → +18°	290 275	Did not call for Toboggan in time -Spent 7 min in Rough Air for Re-hook
#4	Pedal 14 Havey	D 120	5 min (1) 8200 (2) 230		11,900	67,800	Very Rough Air	25,000	-16°C → -13°C	-34° → -32°	+18° → +19°	290	Excellent control -Fell off due to Rough Air & Re-hooked No problem