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AVRO CANADA - TYPE CF.105

SCHEDULE OF TESTS, MOCK-UPS AND WIND TUNNEL MODELS

This schedule is the contractual programme presently proposed for the AVRO CANADA CF.105. It will be modified as found necessary to take account of design changes.

The schedule is grouped under the following sections:-

(A) Wind Tunnel and special purpose model tests.

(B) Functional Tests, Rigs and Specimens.

(C) Structural Tests, Rigs and Specimens.

(D) Mock-ups.

Flight Test requirements are not listed in this schedule.

This schedule outlines the work involved with explanatory details of the individual tests and the purpose of these tests.

"A" WIND TUNNEL AND SPECIAL PURPOSE MODELS

(For description of models see Appendix "A")

No.

A.1. Model: Low Speed 7/100 Scale Complete Model
Tunnel: N.A.E. 6'7"x10' Tunnel.
Test: Aircraft landing configuration, missile jettisoning, canopy jettisoning and ground effects.

A.2. Model: Subsonic 1/20th Scale Complete Model
Tunnel: Cornell high speed variable density 8'6"x12" tunnel.
Test: Armament and dive brake design at low speed with high R.N.
Stability and control checks on transonic tunnel results.
Canopy and nacelle pressure plots.

A.3. Model: Spinning 1/24th Scale Complete Model
Tunnel: N.A.E. 15' diameter spinning tunnel.
Test: Spinning characteristics.

A.4. Model: Complete 3/100 Scale Model.
Tunnel: Cornell transonic 3'x4' Tunnel.
Test: Camber effects.
Stability and control.
Canopy and nacelle pressure plots.

A.5. Model: Partial Model
Tunnel: N.A.E. intermittent supersonic 10"x10" tunnel.
Test: Engine intakes.

A.6. Model: Reflection Plane Model 1/50th Scale
Tunnel: N.A.E. intermittent supersonic 16"x30" tunnel.
Test: Hinge moment measurements at M.N. greater than 1.2.

A.7. Model: Complete 1/80th Scale Model
Tunnel: N.A.E. intermittent supersonic 16"x30" tunnel.
Test: Lateral and directional stability and control at M.N. greater than 1.2.

A.8. Model: Free Flight Rocket Propelled ⅛th Scale Complete Model
Tunnel: Carde missile range.
Test: Steady state stability derivatives.
Dynamic damping derivatives.

"B" FUNCTIONAL TEST RIGS AND SPECIMENS

(For description of Rigs and Specimens see Appendix "B")

No.		
B.1.	Rig:	Mechanical Test Rig
	Specimen:	Complete set of aircraft mechanical equipment.
	Test:	Check on functioning, operating times and reliability of all systems.
B.2.	Rig:	Fuel Systems Rig
	Specimen:	Complete set of aircraft fuel system components.
	Test:	Fuel transfer and flow rates, line losses etc. at all aircraft attitudes.
B.3.	Rig:	Pressurization and Air Conditioning Rig
	Specimen:	Aircraft complete nose and equipment bays and air conditioning and refrigeration system.
	Test:	Check on functioning of pressurizing and cooling systems under all temperature conditions.
B.4.	Rig:	Engine Installation Rig
	Specimen:	Engine and afterburner, associated fuel system, fuselage intake approach surface and cowlings.
	Test:	Engine installation and operation, engine cooling, afterburner operation, intake duct performance and starting.
B.5.	Rig:	Flying Cockpit Rig
	Specimen:	Aircraft nost and cockpit mounted on Mk.2 CF.100 air frame.
	Test:	Suitability of control and equipment layout, take off and landing evaluation of cockpit.
B.6.	Rig:	Airborne Armament
	Specimen:	Aircraft missile launching devices in Mk.4 CF.100 armament bay.
	Test:	Airborne evaluation and development of missile launching means.
B.7.	Rig:	Fire Control Equipment Installation Rig
	Specimen:	Aircraft Radar nose and electronic bay.
	Test:	Check on installation and functioning of fire control equipment in aircraft.

"C" STRUCTURAL TEST RIGS AND TEST SPECIMENS

(For description of Rigs and Specimens see Appendix "C")

No.

C.1. Rig: Complete Aircraft Structural Test
Specimen: Complete wing and fuselage structure.
Test: The contractual requirements of R-1803-9A as called for in ARDCM 80-1 Chapter 3.6.

C.2. Rig: Control Surface Limit Load and Stiffness Tests
Specimen: Control surface and trailing edge structure.
Test: Strength and stiffness of control surfaces and mounting structure under limit loads.

C.3. Rig: Cockpit Pressurization Proof Tests
Specimen: Aircraft complete nose structure called for under B.3.
Test: Strength of pressurized cockpit under proof pressure.

C.4. Rig: Canopy and Windscreen Pressurization Test
Specimen: Canopy and windscreen mounted on special pressurizing rig.
Test: Proof and ultimate load of canopy and windscreen under varying temperature conditions.

C.5. Rig: Ground Resonance Test
Specimen: Complete mechanical rig B.1 and first model aeroplane.
Test: The contractual requirements of ANC.12 as called for in ARDCM 80 Chapter 4.4.

C.6. Rig: Armament Mounting Strength Test
Specimen: Missile and rocket pack lowering devices with weighted dummy stores.
Test: Proof and ultimate load test and stiffness of missile and rocket pack mounting gear.

C.7. Rig: Undercarriage and Tail Skid Drop Tests
Specimen: One main U/C gear complete with wheels and tyres.
One Tail skid and support structure.
Test: Proof and ultimate load tests.
Energy absorption of landing units.

C.8. Rig: Outer Wing Compression Test
Specimen: 3 spar compression box specimen to represent outer wing construction.
Test: Compression strength of the outer wing structure.

C.9. Rig: Inner Wing Panel Tests
Specimen: Range of representative skin and stringer compression panels.
Test: Allowable stresses for inner wing panel construction.

C.10. Rig: Transport Joint Test
Specimen: Sections of inner and outer wing transport joints.
Test: Stress distribution in joint details.

"C" STRUCTURAL TEST RIGS AND TEST SPECIMENS (CONT'D.)

No.

C.11. Rig: Effect of Elevated Temperatures
Specimen: Representative wing and fuselage sections.
Material test specimens.
Test: Determination of heat flow and transient heat conditions in aircraft structure.
Effect of elevated temperatures on material properties.

C.12. Rig: Fatigue Testing
Specimen: Details liable to fatigue.
Test: Determination of fatigue life of details.

"D" MOCK-UPS

(For description of Mock-ups see Appendix "D")

No.

D.1. **Mock-ups:** Cockpit and adjacent Structure
Purpose: Contractual requirements of ARDCM 80-1 chapter 0.24 to represent crew stations, inclosure, windshield controls, seats, armament control, instruments including radar and radio.

D.2. **Mock-up:** Armament Installation
Purpose: Space, layout and accessibility check of weapon installations to the contractual requirements of ARDCM 80-1 chapter 0.24.

D.3. **Mock-up:** Control Surface and Systems Operation
Purpose: Space layout and accessibility check of control surface mounting and operation to the contractual requirements of ARDCM 80-1 chapter 0.24.

D.4. **Mock-up:** Main Undercarriage Installation
Purpose: Space layout and accessibility check of undercarriage installation to the contractual requirements of ARDCM 80-1 chapter 0.24.

D.5. **Mock-up:** Radar and Fire Control System
Purpose: Space layout and accessibility check of the radar and fire control system to the contractual requirements of ARDCM 80-1 chapter 0.24.

"E" MISCELLANEOUS TESTS

(These tests have to be allocated to Section "A", "B", "C" or "D" on next revision)

No.		
E.1.	Rig:	Integral Fuel Tank Specimen
	Test:	Method of construction and sealing of tank. Suitability of sealing and construction method under load.
	Specimen:	Sample box of wing tank construction and sealing.
E.2.	Rig:	Integral Fuel Tank Specimen
	Test:	Suitability of sealants under high temperature conditions.
	Specimen:	Same as E.1 (2nd specimen)
E.3.	Rig:	Simulated Fuel Cell
	Test:	Ability of pressure fuel system and valves to pick up fuel from shallow wing tanks.
	Specimen:	Fibre glass tank with observation windows.
E.4.	Rig:	Scale Model Fuel System
	Test:	Determination of fuel levels under various fuel loadings and aeroplane attitudes.
	Specimen:	$\frac{1}{8}$th scale plexiglass fuel system.
E.5.	Rig:	Bearing Test Rig
	Test:	Determination of deterioration of bearings under repeated loads at a high level.
	Specimen:	Sample bearings from various manufacturers.
E.6.	Rig:	Control Surface Hinge Test
	Test:	Deterioration of piano hinge under repeated loads at a high level.
	Specimen:	Sample piano hinge assembly.
E.7.	Rig:	Mobile Cockpit Rig
	Test:	Cockpit vision up to take off attitude.
	Specimen:	Trolley mounted wooden cockpit mock-up.
E.8.	Rig:	Non-Flying Prototype.
	Test:	This is a production service requiring further discussion.
E.9.	Rig:	Intake Ramp De-Icing.
	Test:	Ice accretion and de-icing methods for leading edge of intake shock wave ramp.
	Specimen:	Sample intake ramp for test in the N.R.C. Low Temperature tunnel.
E.10.	Rig:	Wing De-Icing Test
	Test:	Ice Accretion on very thin highly swept wing.
	Specimen:	Section of wing for test in the N.R.C.Low Temperature tunnel.
E.11.	Rig:	Antenna Radiation Patterns
	Test:	Radiation patterns for communications and navigational equipment antenna.
	Specimen:	Metal aircraft scale model with required radiators.

APPENDIX "A"

A. Wind Tunnel Test and Special Purpose Models

A.1. Low Speed 7/100 Scale Complete Model

Model. The model for this test will be a 7/100 scale complete model on a three-point support complete with undercarriage, undercarriage doors, flaps, dive brakes, missile support and jettisonable canopies.

Tunnel. The model will be tested in the N.A.E. Low Speed No.3 tunnel at a R.N. number approximately 5.6×10^6.

Test. The purpose of these tests will be to check miscellaneous items not covered by the Cornell tunnel tests of A.2. These will comprise:-

(a) Low speed stability and control characteristics with undercarriage down, flaps down, dive brakes extended and combinations of these variables.
(b) Jettisoning of Falcon missiles and rocket containers.
(c) Jettisoning of canopies.
(d) Ground effects.

A.2. Subsonic 1/20th Scale Complete Model

Model. This model will be a 1/20th scale sting mounted model with built in balances with attachment points for mounting missiles, missile doors and rocket pods.

Tunnel. Cornell 8'6"x12" high speed variable density tunnel operated at 2½ atmospheres pressure and achieving a R.N. number of 7.1×10^6.

Test. Tests will be conducted over a range of M.N. up to .95 and by inserting a liner in the tunnel at one specific M.N. of 1.2. The tests will comprise:-

(a) High R.N. number effects at M.N. of .3 for a range of elevator angles.
(b) Longditudinal stability and control at M.Ns. between .5 and .95.
(c) Lateral control M.Ns. between .5 and .95.
(d) Directional stability and control at M.Ns. between .5 and .95. This test will be conducted with the fin and rudder both on and off.
(e) Elevator angle effect on directional stability at M.Ns. between .5 and .95.
(f) Elevator effectiveness in yawed conditions between M.Ns. of .5 and .95 with dive brakes open and shut.
(g) Rudder effectiveness with dive brakes open.
(h) Aerodynamics effects on missiles in the firing position, with various combinations of missiles at a M.N. of .95.
(j) Effects of dive brakes in varying positions at M.N. from .5 to .95.

Tests b to j above will be repeated with a liner in the tunnel to raise the mach # to 1.2.

(k) Limited pressure plots on canopy and nacelle sides over a range of mach numbers.

A.3. **Spinning 1/24th Scale Complete Model.**

Model. This model will be a 1/24th scale spinning model.

Tunnel. N.A.E. 15' diameter spin tunnel achieving a R.N. number of $2x10^6$.

Test. These tests will be the mandatory spinning tunnel tests as required by ARDCM.80.

A.4. **Complete 3/100 Scale Model**

Model. 3/100 scale complete model with cambered and uncambered wing.

Tunnel. Cornell 3'x4' tunnel with transonic throat, achieving a R.N. of $1.5x10^6$.

Test. Tests from this tunnel will be in two parts:-

(1) Preliminary tests to determine the effect of camber on basic longditudinal stability and control. Tests carried out over a mach number range of .5 to 1.25 with full range of elevator deflections on the uncambered wing and elevator neutral for the cambered wing, with measuring forces.

(2) Final tests will be carried out using the cambered wing to determine:-

(a) Longditudinal stability and control over a mach range of .5 to 1.25 with full range of elevator angles.
(b) Lateral control over a mach number range of .5 to 1.25.
(c) Directional stability and control over a mach number range of .5 to 1.25. This test will be carried out with fin and rudder both on and off.
(d) Effects of dive brakes in varying positions at a mach number from .5 to 1.25. The tests of A.2 will provide a check on the accuracy of the results obtained from the tests of this section.

A.5. **Partial Model**

Model. Engine intake partial model.

Tunnel. N.A.E. intermittent supersonic 10"x10" tunnel.

Test. The purpose of these tests will be to obtain:-

(a) Pressure recovery data in the intake.
(b) Investigation of the intake shock pattern by Schlieren interference or other photographic methods.

A.6. **Reflection Plane Model**

Model. One half complete aircraft reflection plane model 1/50 scale with cambered wing only.

Tunnel. N.A.E. intermittent supersonic 16"x30" tunnel achieving a R.N. of 1.5×10^6.

Test. The purpose of the tests in this tunnel will be to extend the range of results obtained on hinge moment measurements from section A.4 to mach numbers greater than 1.25.

A.7. **Complete 1/80 Scale Model**

Model. Complete 1/80 scale model with cambered wing only mounted on three-point support.

Tunnel. N.A.E. intermittent supersonic 16"x30" tunnel achieving R.N. of 1×10^6.

Test. The purpose of the tests in this tunnel will be to extend the range of results obtained on stability and control from tests of A.4 to mach numbers greater than 1.25.

A.8. **Free Flight Rocket Propelled $\frac{1}{8}$th Scale Complete Model**

Model. Rocket propelled free flight $\frac{1}{8}$th scale complete model, mounted on rocket motor nose.

Tunnel. This model will be tested in free flight at the Carde missile range. A R.N. of 36×10^6 will be achieved and data will be telemetered from the model to the ground station.

Test. The purpose of these tests will be to obtain:-

(a) Steady state values of the stability derivatives
(b) Values of the dynamic damping derivatives.

APPENDIX "B"

B. Functional Tests, Rigs and Specimens

B.1. Mechanical Test Rig

Rig. All mechanical components for the aeroplane will be mounted on one co-ordinated test rig. This test rig will approximate the aircraft plan form and will be built up from steel girders. The following subsidiary functional rigs will be mounted on this co-ordinated rig:-

(1) Landing gear, landing gear doors and associated aeroplane structure.
(2) Control surfaces with associated aircraft structure and control system.
(3) Control surfaces hydraulic and mechanical system.
(4) Pilot's floor, pilot's seat, control column, rudder pedals, control trimming and nose wheel steering.
(5) Auto-pilot positional and damping stabilisation system with equipment to simulate flight manoeuvre.
(6) Dive brakes, flaps and associated aircraft structure.
(7) Dive brakes and flaps control system.
(8) High pressure pneumatic system and controls.
(9) Missile launching mechanism with doors and associated aircraft structure.
(10) Rocket pack, rocket pack lowering mechanism and associated aircraft structure.
(11) Engine and fuel system aircraft control system.

The complete rig will be achieved by absorbing the individual rigs numbers 1, 2, 6, 9 and 10 into the main rig. The functions covered by 3, 4, 5, 7, 8 and 11 will be built directly into the main rig, so that no separate hydraulic or high pressure pneumatic system rigs would be built.

Purpose. The rigs will check:-

(1) Undercarriage and associated structure
  (a) Clearances, deformations and operation under load of the undercarriage and door system.
  (b) Reliability of the undercarriage system under repeated operations.
  (c) Retractions and extension times for the undercarriage system.
  (d) Emergency conditions for the undercarriage.
  (e) Brake system functioning.
  (f) Nose wheel steering functioning.

(2) Control surfaces and associated structure
  (a) Deformation and operation of the control surfaces under load.
  (b) Reliability and rate of deterioration of the mechanical control system and jacks under repeated operations.
  (c) Evaluation of the transfer function for the mechanical part of the control system loop and variations of the lag of this system with repeated operations and temperature variations. This transfer function will include the servo jack conditions for a range of hydraulic fluid properties for a load input at the jack and a load input at the control surface.

B.1. **Mechanical Test Rig** (Cont'd.)

Purpose. (cont'd.)

(3) Control hydraulic system, including artificial feel.
(a) Repeated functioning of the hydraulic system over a range of fluid pressure and temperature conditions.
(b) Evaluation of the emergency conditions for the hydraulic circuit.
(c) Susceptibility of the system to air and dirt entrainment.
(d) Response and stability of the hydraulic loop and determination of its transfer function value over a full range of duty cycles, fluid flow, fluid pressure and temperature.
(e) Direct insertions of the rig into the analogue computor for checking the overall performance of the automatic control system with the automatic control loops represented mathematically.
(f) Operational check of the manual control mode in conjunction with automatic damping stabilisation of the aeroplane. Damping stabilisation will be simulated by excitation of the control valves.
(g) Stability check of the elevator manual mode in conjunction with the bob weight of the elevator artificial feel system.
(h) Functional testing of the artificial feel and trimming system in the manual modes.

(4) Auto control system with flight manoeuvre simulation.
(a) Functional testing of the positional auto pilot's circuits in conjunction with the control hydraulic and mechanical loops. Check of the stability and response characteristics of the systems with duty cycle and auto-pilot commands simulated by rate movements applied to gyros and loads applied to control surfaces.
(b) Functional testing of the damping auto-pilot circuits in conjunction with control hydraulic and mechanical loops with auto-pilot automatic or manual monitoring of the positional system. Damping commands simulated by sinusoidal input to the damping system.
(c) Functional testing of the artificial feel trimming devices of the automatic control system.
(d) Evaluation of the emergency conditions for the automatic control systems.

(5) Dive Brakes and flap functioning.
(a) Clearances, deformations and operation under load of the dive brake and flap system.
(b) Reliability of the system under repeated loadings.
(c) Operating times for the system.
(d) Emergency conditions for the system.

B.1. Mechanical Test Rig (Cont'd.)

Purpose (cont'd.)

(6) Missile launching mechanism and doors, rocket pack and lowering mechanism.
   (a) Clearances, deformations and operation under load of the missile launchers, doors and rocket pack.
   (b) Reliability of the system under repeated operations.
   (c) Operating times for the system with simulated fire control commands.
   (d) Emergency conditions for the system.

(7) High pressure pneumatic system.
   (a) Repeated functioning of the high pressure pneumatic system over a range of fluid pressure and temperature conditions.
   (b) Evaluation of the emergency conditions for the system.
   (c) System capacity check over a range of duty cycles.

(8) Engine and fuel system control.
   (a) Clearances, deformation in operation under load of the engine and fuel system controls.
   (b) Reliability of the system under repeated operations.
   (c) Emergency conditions for the system.

Equipment. The main rig will consist of the following equipment.

(1) Subsidiary main undercarriage rig.
(2) Subsidiary nose undercarriage rig.
(3) Subsidiary elevator control rig.
(4) Subsidiary aileron control rig.
(5) Subsidiary rudder control rig.
(6) Subsidiary missile launcher rig.
(7) Subsidiary rocket pack rig.
(8) Subsidiary dive brakes and flap rig.
(9) Main rig fram mounting.

The main rig mounting includes:-

(a) Pilot's seat, control column, rudder pedals, artificial feel system, nose wheel steering control.
(b) Interconnecting hydraulic and pneumatic system including hydraulic pumps, pneumatic pumps and intercooler pump drives, hydraulic and pneumatic accumulators.
(c) Mechanical control system between cockpit and surface jack valves.
(d) Automatic control system and flight manoeuvre simulating equipment.
(e) Cooling system for hydraulic oil to achieve temperature variations.
(f) Loading devices for undercarriage, undercarriage doors, control surfaces, missile launchers, missile launcher doors, rocket pack, dive brakes and flaps.

B.1. **Mechanical Test Rig** (Cont'd.)

Equipment (cont'd.)

The subsidiary rigs for attachment to the main frame require:-

Two main undercarriage units complete with retraction jack and recuperators.
Aircraft set of brakes with controls.
One nose undercarriage unit complete with retraction jack, nosewheel steering and retraction brake.
Aircraft set of undercarriage doors and jacks.
Four missile launchers, doors and door mechanism.
One rocket pack and extension jack.
Two elevators and trailing edge structure.
Pair of ailerons and trailing edge structure.
Rudder and trailing edge structure.
Aircraft set of control surface jacks and valves.

B.2. **Fuel System**

Rig. The aircraft fuel system will be reproduced on a rig which will simulate the aircraft fuselage and fuselage tanks and one wing tank. The rig will be mounted on pivots allowing all flight attitudes to be reproduced. The following items of equipment will be mounted on this rig:-

(1) Simulated fuselage and wing fuel tanks.
(2) Pressure and re-fuelling system.
(3) De-fuelling system.
(4) Fuel transfer system and tank.
(5) Fuel pressurization and inert gas system.
(6) Main engine supply system.
(7) Afterburner supply system.
(8) Engine booster pumps and oil coolers.
(9) Contents gauging system.

Purpose. The rig will check:-

(a) Fuel transfer rates and pressure losses for all aircraft attitudes and varying quantities of fuel under varying conditions of tank pressurization.
(b) The reliability under repeated operations of the fuel system and fuel contents gauging system.
(c) Emergency conditions for the fuel system.
(d) Functioning of the pressure re-fuelling system and emergency conditions for this system.
(e) Functioning of the afterburner system.
(g) Evaluation of the unuseable fuel under varying conditions.

B.2. Fuel System (Cont'd.)

Equipment. The following equipment will be required for the rig:-

One aircraft set of fuel contents gauging equipment.
One aircraft set pressure re-fuelling valves and piping.
One aircraft set main fuel system transfer valves.
Pressure regulating valves, pressure relief valves and associated piping.
One engine set, engine booster pumps and oil coolers with associated piping.
One aircraft set inert gas generator, valves and piping.
One set of tanks representing aircraft fuselage and wing tanks.
Pressurizing equipment for fuel tanks.

B.3. Pressurization and Air Conditioning

Rig. The rig will consist of an aircraft nose structure complete with windscreen, canopies, electronic compartments, armament bay and simulated miscellaneous equipment cooling systems, a compressor, cold air chamber and infra red heating equipment.

Purpose. The purpose of this rig will be:-

(a) Check the cabin pressurization and cooling system under extreme temperature and engine operating conditions.
(b) Check cooling flow rates to electronic compartments, armament bay and other miscellaneous equipment under extremes of temperature and engine operating conditions.
(c) Functional check of pilot's oxygen system.
(d) Functional check of canopy jettisoning system.
(e) Functional check of rain clearing, de-icing and de-misting system for the canopy and windscreen.
(f) Functional check of miscellaneous cockpit services, for example, anti "g" suit, ventilated suit etc.

Specimen.

One aircraft nose structure complete with windscreen canopy, pilot's seat, oxygen system, anti "g" system, anti "g" or pressure suit system, de-misting devices, de-icing devices, rain clearing devices, cockpit air-conditioning, control system, canopy operating and jettison system.
One aircraft set of air-conditioning, refrigeration and pressurization equipment.
One compressor with means to control outlet temperature, pressure and humidity.
Simulation of miscellaneous equipment requiring cooling, for example, alternators, fuel collector tank etc., dummy armament bay and space models of electronic equipment.

B.4. Engine Installation.

Rig. The rig will consist of a steel girder framework carrying the approach surface to the engine intake and the engine intake duct structure and to provide a mounting for the engine and afterburner cowling. This rig will be mounted in an engine test cell and it will be capable of taking the selected engine.

Purpose. The rig will check:-

(a) Installation clearances of the engine and afterburner in the hot and cold conditions.
(b) The efficiency of the intake entry, ducts and fuselage approach under a full range of sea level static operation conditions.
(c) The efficiency of the engine and afterburner cooling system.
(d) Afterburner and final nozzle control system functioning.
(e) Functioning of the starting system, wet starts etc.

Equipment. The following equipment will be required for the rig:-

One engine and afterburner combination of the selected type, complete with fuel system and afterburner controls and final nozzle.
One aircraft set of engine nacelle intake ducts and rear cowlings.
A set of nose fuselage formers and skins to reproduce intake approach surface.
One set of intake ramps and operating equipment.
One test cell rated for 25,000 lbs. thrust load.
Engine starting equipment.
One set of aircraft collector tanks and pressurizing equipment.
Steel frame rig for mounting the engine and cowlings.

B.5. Flying Cockpit

Rig. The rig will consist of CF.100 aeroplane fitted with simulated C.105 cockpit.

Purpose. The purpose of this flying rig will be to check:-

(a) Cockpit layout under flight conditions.
(b) Cockpit vision under take off and landing conditions.
(c) Cockpit conditioning, canopy de-misting, windshield de-misting and de-icing under actual flight conditions.
(d) Canopy jettisoning in flight.

Specimen.

One CF.100 Mk.2 aeroplane/less nose.
One C.105 nose and cockpit structure.
One transition structure for attaching C.105 nose to C.100 air frame.

B.6. <u>Airborne Armament.</u>

<u>Rig.</u> The rig will consist of a CF.100 Mk.4 aeroplane with a C.105 missile launching device installed in its armament bay.

<u>Purpose.</u> The purpose of this rig will be to:-

(a) Develop and prove in flight a suitable launching system for Falcon guided missile.
(b) Develop and prove in flight a suitable substitute 2" rocket container for carriage on the Falcon rails.
(c) To provide statistical data on missile and rocket firing for use in probability of kill analysis.

B.7. <u>Fire Control System Installation.</u>

<u>Rig.</u> The rig will consist of an aircraft nose structure and electronic compartment.

<u>Purpose.</u> The purpose of this rig will be to check:-

(a) The installation and wiring of the fire control system.
(b) The functioning and cooling of the fire control system.

<u>Equipment.</u> The equipment required for this rig will be one aircraft radar nose structure and electronic and missile auxilliary bay.

APPENDIX "C"

C. **Structural Test Rigs and Specimens**

C.1. **Complete Aircraft Structural Test**

Rig. Complete aircraft structural test.

Purpose. The tests on the specimen shall be those required by specification R-1803-9A. These tests are likely to include:-

(a) Proof and ultimate load tests for wing design cases.
(b) " " " " " " fuselage design cases.
(c) " " " " " " landing gear design cases.
(d) " " " " " " assymetric flight cases.
(e) " " " " " on control surfaces.
(f) " " " " " " control systems.
(g) " " " " " " dive brakes.
(h) " " " " " " flaps.
(j) " " " " " " engine supports.
(k) " " " " " " armament support structure.

Specimen. Complete wing, fuselage and empennage structure, including control surfaces, flaps, dive brakes, engine mountings, undercarriage supports, armament supports, external doors and fairings, but not including undercarriage units.

Complete mechanical control systems for all surfaces, including control jacks but not pilot's control system.

Not to include hydraulic, electrical or pneumatic systems.

Complete mechanical systems for doors, flaps, dive brakes and armament.

This specimen is the contractual static test article of specification R-1803-9A except for undercarriage and systems.

The undercarriage units will be tested by individual drop tests rather than the drop testing of the whole aeroplane and the systems will be covered by the rig tests of section "B" of this schedule.

C.2. **Control Surfaces Test**

Rig. The rigs for these tests will be the subsidiary rigs as described in Appendix "B" section B.1.

Purpose. The purpose of this rig will be to check the strength and stiffness of the control surfaces and supporting structure under limit loads prior to the availability of the major test component of C.1 and prior to the functional tests of B.1.

Equipment. The subsidiary rigs of Appendix "B" section B.1 will be mounted on a steel framework capable of resisting limit control surface loads.

C.3. **Cockpit Pressurization Test**

Rig. The rig for this test will be the subsidiary rig as described in Appendix "B" section B.3.

Purpose. The purpose of this rig will be to check the strength of the cockpit and canopy under proof pressure conditions.

Equipment. The subsidiary rig of Appendix "B" section B.3 will be used for this test at some convenient time during the tests of B.3. and prior to the availability of the major test component of C.1.

C.4. **Canopy and Windscreen Pressure Tests**

Rig. The rig for this test will consist of one aircraft set windscreen and canopy mounted on a steel substructure capable of resisting the pressurizing loads and means for pressurizing the specimen and varying the temperature.

Purpose. The purpose of this rig will be to check the proof and ultimate strength of the cockpit glazing over a wide range of temperatures up to 250°F. The ultimate factors for the glazing are much higher than those for the structure and therefore require a separate test.

Specimen. One aircraft set windscreen and canopy.
One rig for mounting the specimen.
Pressurizing equipment.
Infra red heating equipment.

C.5. **Ground Resonance Test**

Rig. Complete mechanical rig of B.1 and first model aeroplane.

Purpose. The tests on the specimens shall be those required by A.N.C.12 as called for in ARDCM 80 chapter 4.4. The mechanical rig of B.1 will be used to obtain preliminary information on modes etc. for the control circuits prior to the availability of the first model aeroplane.

Specimen. First model aeroplane.
Complete mechanical rig of B.1.
Vibration survey equipment.

C.6. **Armament Mounting Strength.**

Rig. The rig will consist of a steel girder structure capable of mounting the rocket and missile lowering mechanism and associated structure.

Purpose. The rig will check the strength under proof and ultimate loads of the missile launching and rocket lowering mechanisms using weighted dummy stores.

C.6. Specimen. One missile lowering mechanism complete with pneumatic devices.
One rocket pod lowering mechanism complete with pneumatic devices.
Aircraft supporting structure and steel rig for mounting specimen.
Compressed air supply.
Weighted dummy stores.

C.7. Undercarriage and Tail Skid Strength.

Rig. The rig will be the undercarriage manufacturers' drop test rig.

Purpose. To determine on test the proof strength and energy absorption characteristics of the undercarriage and tail skid assemblies. Energy absorption to ultimate requirements will be carried out on later production units when available.

Specimen. Manufacturers drop test rig.
Prototype main nose and tail undercarriage.
Wheels tyres and brakes before installation in first model aeroplane.
One production set of equipment for destructive testing.

C.8. Outer Wing Compression Strength.

Rig. The rig will consist of a normal compression-tension testing machine of a capacity and at a facility yet to be determined. Panel deflection measuring equipment and strain gauge equipment will also be required.

Purpose. To determine the compressive strength of the outer wing multispar close rib construction by the use of representative box specimens.

Specimen. A number of box type compression panel specimens containing 3 spars and 3 ribs.
Compression testing machine.
Measuring equipment.

C.9. Inner Wing Compression Panel Strength.

Rig. The rig will consist of a compression testing machine of a capacity and at a facility yet to be determined. Panel deflection measuring and strain gauging equipment will be required. The fixity coefficient of the machine must also be measured.

Purpose. To determine the compressive strength of representative stringer-skin panels for the inner wing over a range of variables, including panel length and ratio of stringer to skin area.

Specimen. A number of skin-stringer panels, 3 stringer pitch or more wide of varying lengths and construction.
Compression testing machine.
Measuring equipment.

C.10. **Wing Transport Joint Strength.**

Rig. Compression-tension testing machine of a capacity and at a facility yet to be determined.

Purpose. To determine detail strength values for the type of construction used for the wing transport joints.

Specimen. Representative sections of the wing transport joints.
Compression and tension testing machine.

C.11. **Effect of Elevated Temperatures.**

Rig. Compression and tension testing machine with facilities for surface heating of the specimens.
Temperature and load measuring equipment.

Purpose. To determine heat flow, transient heat conditions and strength under and after subjection to elevated temperatures of representative portions of the air frame.

Specimen. Representative types of construction of the air frame at locations yet to be established.
Surface heating equipment.
Material test specimens.
Compression-tension testing machine.
Temperature and load measuring equipment.

C.12. **Fatigue Strength.**

Rig. Equipment for mounting and testing under repeated load and at elevated temperatures of aircraft sub-assemblies suspected of liability to low fatigue life.

Purpose. To determine fatigue life and type of failure of points of detail design suspected liable to this trouble. The scope of these tests has not yet been determined.

Specimen. Sub-assemblies as later determined.
Repeated loading rigs.

TABLE 1

CF-105 STRUCTURAL PLASTIC AND ANTENNA REASEARCH MODEL PROGRAMS

STRUCTURAL PLASTIC MODEL PROGRAM

Model Scale and Type		Date of Completion of Model	Purpose of Test	Test Facility	Estimated Test Date	Remarks
1/5	3% Fin with Portion of Wing	Sept. 15/54	Checking Deflections and Stresses in Comparison with the Results obtained by Stress Analysis.	Avro	Jan./55	Completed.
1/5.25	Front Portion of Fuselage with Air Ducts and Fuel Tanks	Feb. 1/55	Checking Deflections and Stresses for Applied Unit Load Cases.	Avro	Apr./55	Completed.
1/5.25	Segment of Front Fuselage Structure	Apr. 7/55	Checking the Effect of Stiffness of Ducts on Deflection of Front Fuselage.	Avro	Apr./55	Completed Aug./55.
1/5.25	Centre Wing Portion with Fin, Front and Rear Fuselage Structure	June 15/55	Checking Deflections and Stresses Due to Loads applied to the Fin.	Avro	June/Sept./55	Suspended until Costs and Program reviewed.
1/5.25	Complete Structural Model of Aircraft	Aug. 31/55	Checking Deflections and Stresses Due to Different Loading Cases. This test will serve also as a study for the static test of the full size aircraft.	Avro	Oct./Dec./55	(Suspended until Costs and Program reviewed.)

Note: All the above models were designed and manufactured by Avro.

ANTENNA RESEARCH MODELS

Model Scale and Type		Date of Completion of Model	Purpose of Test	Test Facility	Estimated Test Date	Remarks
1/48	Complete Model Sheet Metal	Jan./55	Free Flight Model Antenna Research.	Sinclair Radio Lab.	Jan./55	Complete.
Modified 1/48 Model		June/55	Low Frequency Radio Compass Research	Sinclair Radio Lab.	June/55	Complete, Sept./55.
1/18	Complete Model Cast Aluminum	Apr./55	UHF and L-Band Antenna	Sinclair Radio Lab.	Apr./55	Complete, Aug./55.
1/8	Complete Model Sheet Copper	July/54	Exp. UHF and L-Band Antenna Research	Sinclair Radio Lab.	Aug./54	Complete, July/55.
Full Scale Belly Mock-up - 2 Models		Oct./55	UHF and L-Band Antenna Research	Sinclair Radio Lab.	Oct./55	Extensive test period.
Full Scale Fin Mock-up		June/55	Fin Cap Antenna and X-Band Antenna Research	Sinclair Radio Lab.	June/55	Complete, Sept./55.

Note: All the above antenna models were designed and manufactured by Sinclair Laboratories Ltd.

3218 Part 2

CF-105 WIND TUNNEL PROGRAM

Model Scale and Type	Model Designed & Manufactured by	Completion Date of Model	Purpose of Test	Test Facility	Test Date	Remarks
3/100 Complete Model Sting Mounted	Cornell, Buffalo	Sept./53 Complete	Subsonic and Transonic 3 Axis Stability & Control	Cornell 3' x 4' Transonic 10'x 12'Subsonic	Stage 1 Complete Sep/53	Long.Stab., with & without Camber, t/c 3%, M = 0.5 - 1.23
					Stage 2 Complete Apr/54	Long.Stab.,Lat.Stab. & Control, Camber, t/c 3½%, M = 0.5 - 1.23.
					Stage 3 Complete Jun/54	Long.Stab. Check, Direc. Stab. & Control, New Nose, New Canopy, M = 0.5 - 1.23.
					Stage 4 Complete Jul/54	Notch Invest., Complete Test with Optimum Notch, Low Speed, High Angle of Attack, M = 0.5.
					Stage 5 Complete Oct/54	Notch Invest. at all Speeds, Long. & Direc. Stab., High R.N. New Nose, L.E. Extension & Notch, M = 0.5 -1.23
4/100 Complete Model Sting Mounted	Cornell, Buffalo	Mar./55 Complete	Transonic Armament Tests Falcon & Sparrow Missile Long. & Dir. Stab. & Control	Cornell 3' x 4' Transonic	Stage 1 Complete Mar/55	Long. & Direc. Stab. Comparison 0.03 & 0.04 Scale Models. M = 0.5 - 1.23
					Stage 2 Complete Mar/55	Transonic Force Tests on Missiles, Armament Bay Pressures, Bay Door Hinge Moments. M = 0.9 - 1.2.
					Stage 3 Complete Mar/55	Transonic Tests for Missile Effect on Aircraft. M = 0.95 - 1.2.
					Stage 4 Complete Apr/55	Transonic Force Tests on Missile for Trajectory Analysis. M = 0.95 - 1.2.
					Stage 5 Complete May/55	Long. Stab. Investigate L.E. Droop. M = 0.5 - 1.2.
					Stage 6 Complete May/55	Complete Long. & Direct. Stab. & Control Tests with Optimum Droop. M = 0.5 - 1.2.
					Stage 7 Complete May/55	Investigation at High R.N. & High Angle of Attack. M = 0.5.
1/10 Reflection Plane Wing	NAE, Ottawa	Jan/55	Subsonic, Preliminary Study of Icing Conditions on Long. & Lat. Control	NAE, Ottawa 10' x 5.7' Low Speed	Complete Jan./55	This test was an extension to NAE icing research program. Model was approximate only.
1/8 Reflection Plane Wing	Avro	Mar/55 Complete	Subsonic, More Advanced Study of Icing Conditions with Notch & L.E. Extension Included.	NAE, Ottawa. 10' x 5.7' Low Speed.	Complete Mar/55.	
7/100 Complete Model	Avro & NAE	Apr/55 Initial Completion	Subsonic, Canopy & Missiles Jettison, Ground Effects.	NAE, Ottawa 10' x 5.7' Low Speed	May/55	One run completed at high incidence at end May. Further testing scheduled for June-July/55, but suspended due to model re-work for notch, L.E. ext., droop. Est. ready Nov./55.
1/80 Complete Model Sting Mounted	Avro	Apr/55 Complete	Supersonic, Lateral & Direc. Stability & Control.	NAE, Ottawa 16" x 30" Supersonic	July/55	Balance not ready. Start test approx. Mid-July/55. M = 1.23, 1.36, 1.56, 1.8 & 2.0. Model returned to Avro for re-work for notch, L.E. droop,ext Est. ready Nov./55.

TABLE 2(cont'd.)

CF-105 WIND TUNNEL PROGRAM

Model Scale and Type	Model Designed & Manufactured by	Completion Date of Model	Purpose of Test	Test Facility	Test Date	Remarks
1/40 Fuselage Intake	Avro	Apr./55 Complete	Supersonic, Study of Air-flow through the Intakes.	NAE, Ottawa 10" x 10" Supersonic	Mid-June/55	M = 1.4, 1.8 & 2.0. Commenced Mid-June/55 Preliminary tests complete. Further testing continues.
1/50 Reflection Plane	NAE, Ottawa	Sept./55	Supersonic, Long. Stab. & Control. Lat. Control.	NAE, Ottawa 16" x 30" Supersonic	Oct./55	Test date not finalized, but probably Oct./55. M = 1.23, 1.36, 1.56, 1.8 & 2.0.
1/24 Complete Model	NAE, Ottawa	June/55	Subsonic, Spin Characteristics and Recovery.	NAE, Ottawa Spinning Tunnel	Not finalized.	Model Design Complete.
1/6 Fuselage Intake	Avro	Oct./55. Deliver to Cleveland by Oct.1/55.	Supersonic, Study of Air-flow through Intakes.	NACA, Cleveland 8' x 6' Supersonic Lewis Lab.	Nov./55	Model Instrumented by Lewis Lab. during Oct./55. Model Design complete July 15/55.
3/100 Complete Model	Cornell, Buffalo.	Oct./55	Supersonic, Directional Stab. at High Angles of Attack.	Bedford, England 3' x 3' Supersonic.	Not finalized.	Use of Bedford facility improbable due to scheduled capacity. Langley 4 ft. supersonic and 4 ft. Unitary Plan supersonic investigated. Both heavily booked. Space may be arranged in Unitary Plan tunnel. Required, 3 speeds between M = 1.4 & 2.0.
1/50 Canopy Model with Dorsal and Nose Fuselage.	Avro	May/54	High Subsonic Rake Survey of Canopy and Dorsal.	NAE, Ottawa 10" x 10" Supersonic.	Complete, June/54.	Rake surveys with original canopy and canopy modified in water tunnel. M = 0.71 and 0.88.

CF-105 WATER TUNNEL PROGRAM

Model Scale and Type	Model Designed & Manufactured by	Completion Date of Model	Purpose of Test	Test Facility	Test Date	Remarks
3/100 Canopy Model with Dorsal and Nose Fuselage.	Avro	May/54	Water Tunnel Test with Visual Flow Check on Canopy/Dorsal Combination.	NAE, Ottawa. Water Tunnel 9.84" x 13.11"	Complete, May/54	Test to determine whether loss of fin effectiveness might be caused by flow breakaway around the canopy. Canopy modified for optimum flow.

NOTE: The programmes and costs for the outstanding wind tunnel tests to be carried out by NAE on the 7/100, 1/80, 1/50 and 1/24 scale models are under review.

TABLE 3

CF-105 FREE FLIGHT MODEL PROGRAM

Model Scale and Type	Completion Date of Model	Purpose of Test	Test Facility	Estimated Test Date	Remarks
1/8 2 Crude Models	Dec./54	Check Firing Technique, Telemetering and Tracking.	CARDE Range, Picton, Ont.	Dec./54	Complete Dec. 15/54.
1/8 1 Crude Model	Apr./55	Check Functioning of Yaw Impulse and α - β Vanes.	CARDE Range, Picton, Ont.	May/55	Complete May 1/55.
1/8 1 Drag Model, Straight L.E. plus Notch.	Apr./55	Telemetry System Check and Preliminary Drag Check incl. Flow through Air Intakes and Ducts.	CARDE Range, Picton, Ont.	May/55	Complete May 1/55.
1/8 1 Crude Model	Apr./55	Re-check Functioning of Yaw Impulse and α - β Vanes.	CARDE Range, Picton, Ont.	June/55	Complete June 15/55.
1/8 2 Drag Models, Ext. L.E., Notch and Droop (1 to include Area Rule Mods.)	June & July, 1955	Check Drag with two different air intakes and ducts.	CARDE Range, Picton, Ont.	1st - Aug. 26/55 2nd - Sept. 30/55	Doppler Tracking delayed until Oct./55, (possibly use kine-theodolite).
1/8 2 Yaw Stability Models, Ext. L.E., Notch and Droop. Area Rule Mods.	Sept./55	Check Directional Stability.	CARDE Range, Picton, Ont.	Oct. 31/55	Stop work issued July/55 pending investigation of costs. FFM now under review to determine which tests are absolutely essential with present budget limitation. Sept. 16/55 Program for these models is now re-established.
1/8 2 Models with Movable Elevators. Ext. L.E., Notch, Droop and Area Rule Mods.	Oct./55	Check Longitudinal Stability.	CARDE Range, Picton, Ont.	Dec. 15/55	
1/8 1 Spare Model plus Five Boosters.		The program for spares will be decided after firing the above models.			

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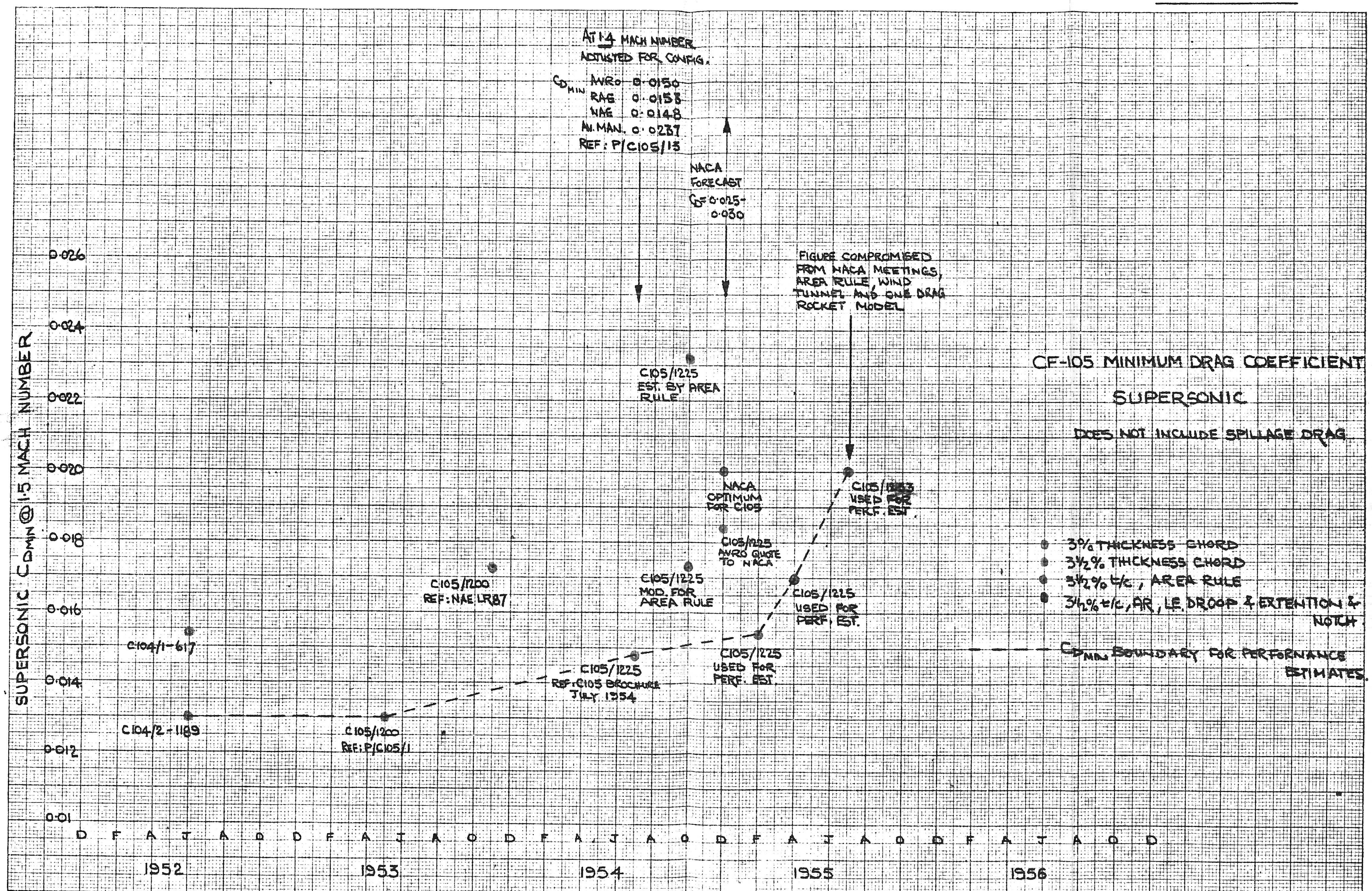
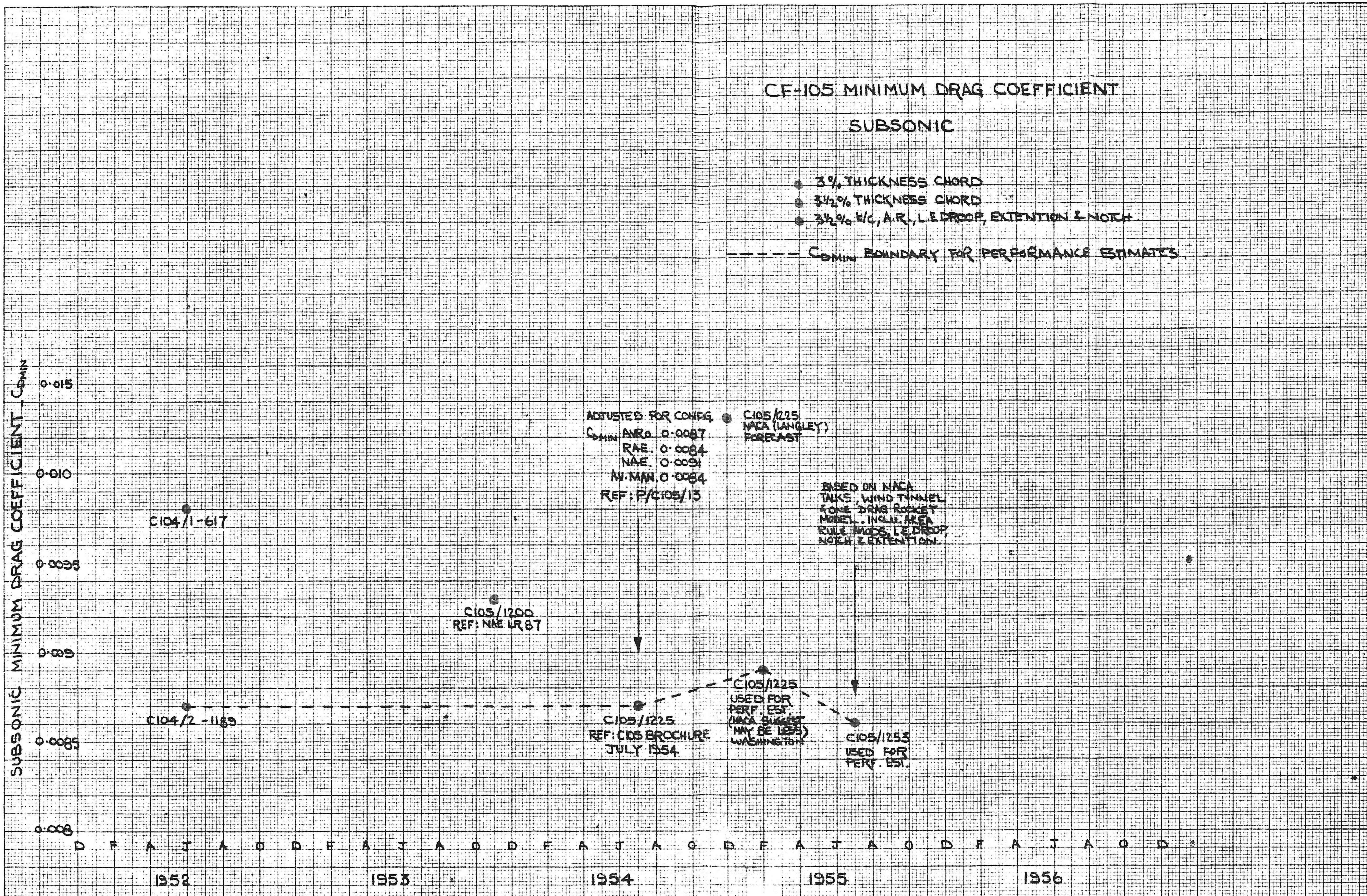
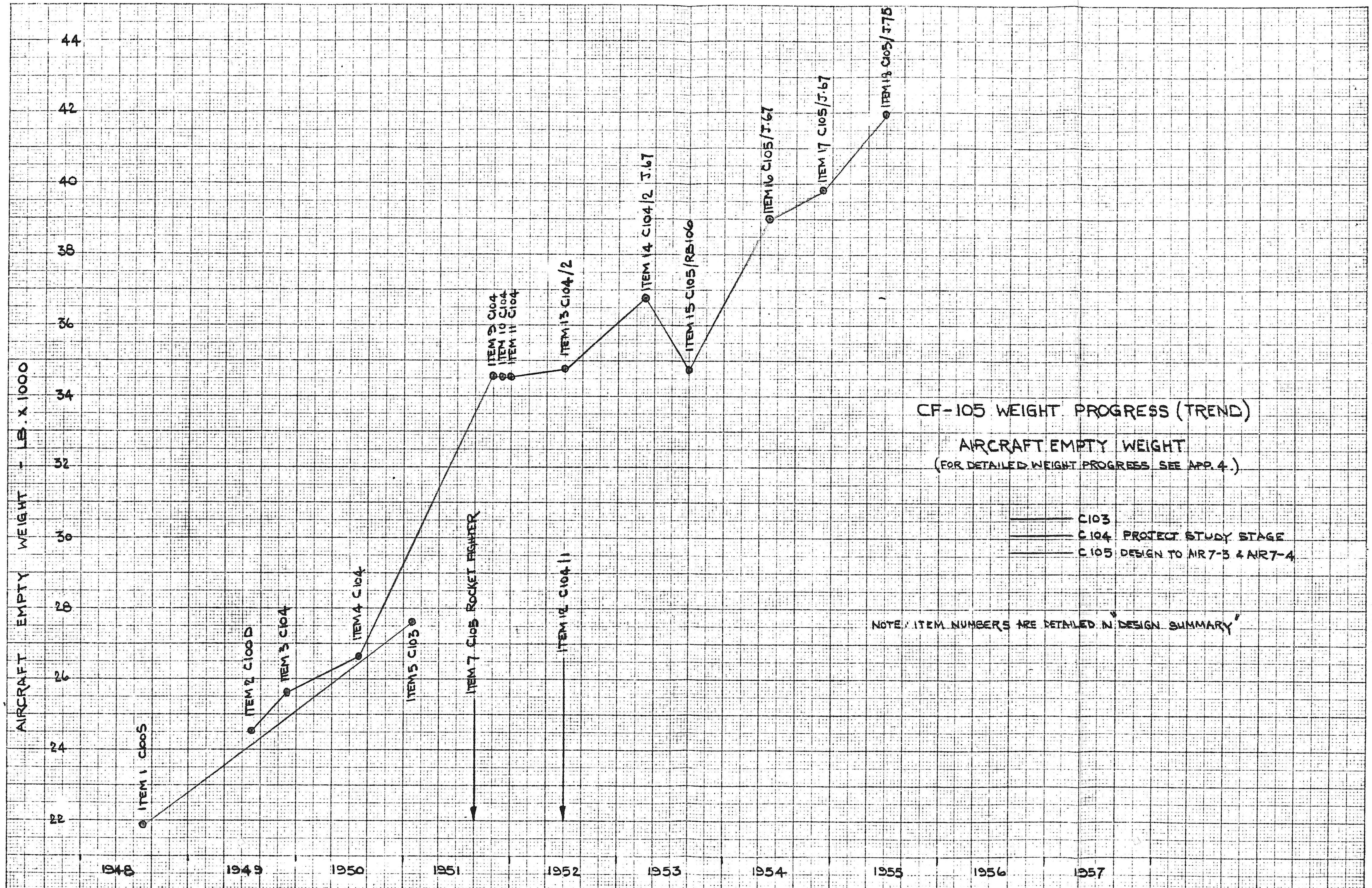
APPENDIX 1



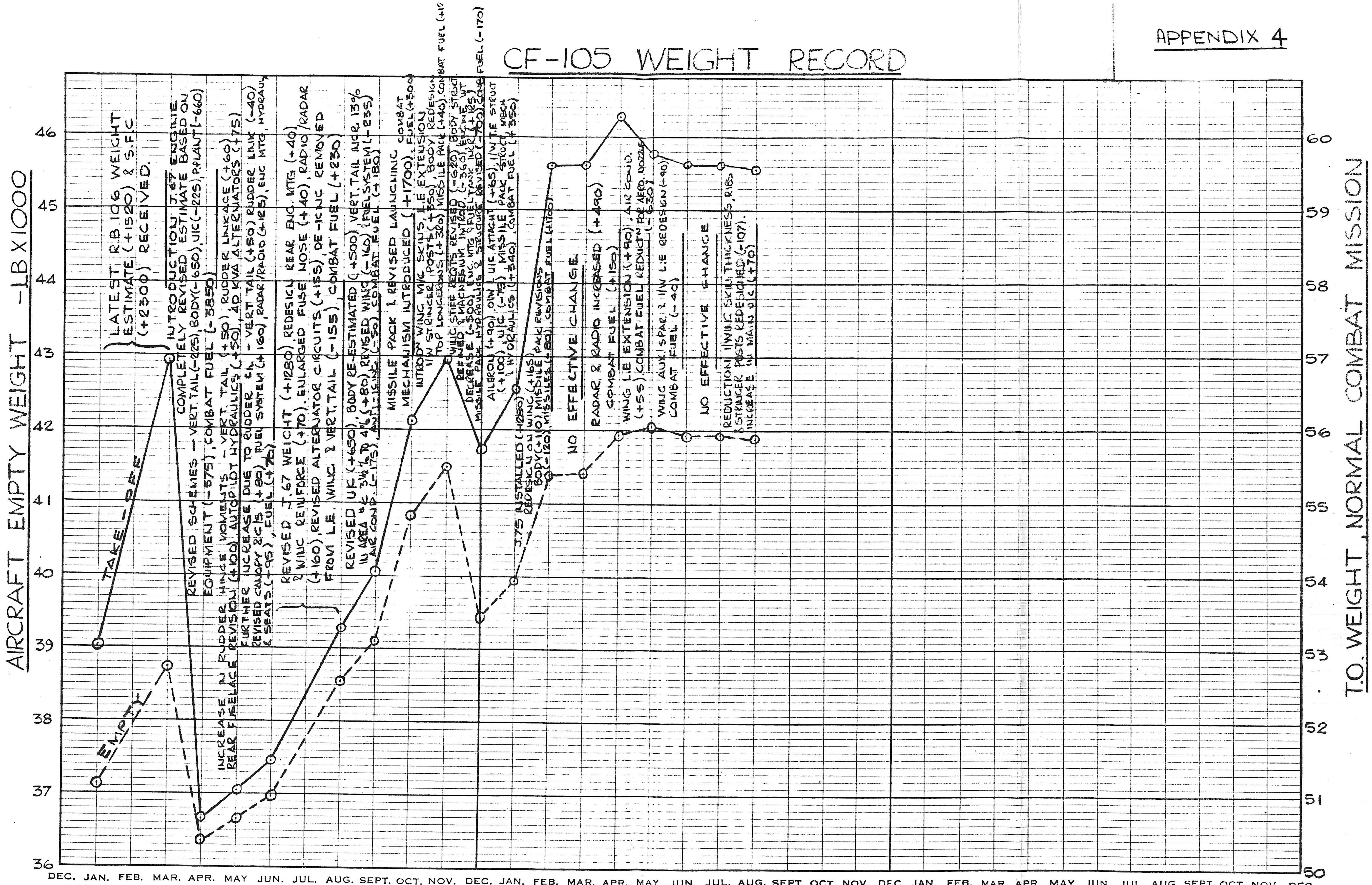
SEPTEMBER 12/55


CF-105 MINIMUM DRAG COEFFICIENT
SUBSONIC
3% THICKNESS CHORD
3½% THICKNESS CHORD
3½% t/c, A.R., L.E.DROOP, EXTENTION & NOTCH
C DMIN BOUNDARY FOR PERFORMANCE ESTIMATES
SUBSONIC MINIMUM DRAG COEFFICIENT, C DMIN
0·015
0·010
0·0095
0·009
0·0085
0·008
ADJUSTED FOR CONFIG.
C DMIN AVRO 0·0087
RAE. 0·0084
NAE. 0·0091
AV.MAN. 0·0084
REF: P/C105/13
C105/1225
NACA (LANGLEY)
FORECAST
BASED ON NACA
TALKS, WIND TUNNEL
& ONE DRAG ROCKET
MODEL. INCLU. AREA
RULE MODS, L.E.DROOP,
NOTCH & EXTENTION.
C104/1-617
C105/1200
REF: NAE LR 87
C104/2 - 1189
C105/1225
REF: C105 BROCHURE
JULY 1954
C105/1225
USED FOR
PERF. EST.
(NACA SUGGEST
MAY BE LESS)
WASHINGTON
C105/1253
USED FOR
PERF. EST.
D F A J A O D F A J A O D F A J A O D F A J A O D F A J A O D
1952
1953
1954
1955
1956


CF-105 WEIGHT PROGRESS (TREND)
AIRCRAFT EMPTY WEIGHT
(FOR DETAILED WEIGHT PROGRESS SEE APP. 4.)
C103
C104 PROJECT STUDY STAGE
C105 DESIGN TO AIR7-3 & AIR7-4
NOTE: ITEM NUMBERS ARE DETAILED IN "DESIGN SUMMARY"
AIRCRAFT EMPTY WEIGHT - LB. X 1000
44
42
40
38
36
34
32
30
28
26
24
22
1948
1949
1950
1951
1952
1953
1954
1955
1956
1957
ITEM 1 C100S
ITEM 2 C100D
ITEM 3 C104
ITEM 4 C104
ITEM 5 C103
ITEM 7 C105 ROCKET FIGHTER
ITEM 9 C104
ITEM 10 C104
ITEM 11 C104
ITEM 12 C104 II
ITEM 13 C104/2
ITEM 14 C104/2 J.67
ITEM 15 C105/RB106
ITEM 16 C105/J.67
ITEM 17 C105/J.67
ITEM 18 C105/J.75

APPENDIX 4

CF-105 WEIGHT RECORD



4	3	2	1	ISSUE
7 SEPT 55	25 AUG 55	1 AUG 55	10 JUNE 55	