6.0 PROCEDURES AND PERSONNEL

A preliminary study has been made of the procedures and personnel necessary for rapid and efficient performance of the turnarounds and first line maintenance functions.

Three cases have been considered and the findings are presented under these separate headings:

1. Turnarounds at forward bases.
2. Turnarounds at main base in prepared hangar.
3. First line maintenance functions.

It is realized that these items are estimates and will have to be confirmed by practical demonstrations, when an aircraft becomes available. It is proposed that this be done during the contractor's demonstration of the complete weapon system.

No attempt is made to place servicing functions within the revised RCAF trade structure now being planned. The number of men suggested in this report is based on the optimum number of men required to perform certain tasks within a time limit. Existing tade classifications have been used.

6.1 TURNAROUNDS AT FORWARD BASES

To meet the operational requirements of four turnarounds in 15 minutes, it will be necessary to position the mobile ground equipment ready for immediate use. The equipment should be positioned in a manner similar to that illustrated in Figure 18 for the turnaround hangar at a main base.

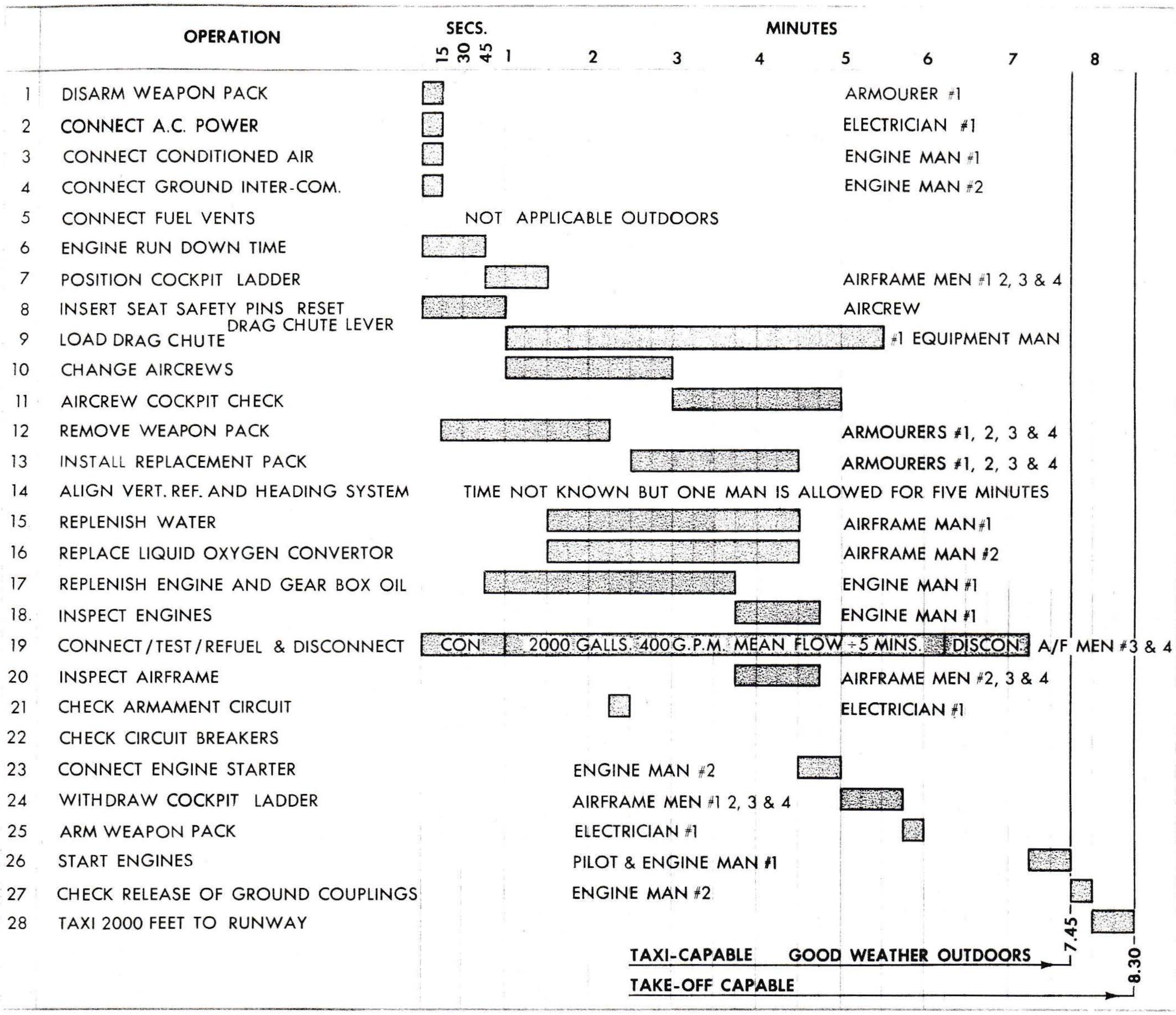
The time study illustrated in Figure 15 is based on four sets of mobile equipment being positioned on a planned site with each aircraft taxiing up to the correct position. Some time will be lost in bringing the mobile cockpit access platform, refuelling tender and water tanker into position when compared with the fixed facilities in the turnaround hangar.

From Figure 15, a time of 8-1/2 minutes appears reasonable under ideal weather conditions for the completion of a turnaround at a forward base. However, an allowance should be made for adverse weather conditions, when some of the work will be hazardous and more difficult to perform.

The tasks to be performed at a forward base turnaround are listed in Figure 15. From this analysis the number of men required to handle one aircraft is as follows:

Safety equipment workers	1
Armourers	4
Tender drivers	1
Airframe mechanics	2
Refuellers	2
Engine mechanic	2
Electrician	1
Turnaround controller	1
Total	14

Four such teams will be required to complete four turnarounds within fifteen minutes, handling four aircraft simultaneously. In addition, extra personnel and equipment will be required if it is desirable to sustain forward base activities for any length of time. These will be employed on the additional refuelling tenders necessary, and on servicing and replenishing the ground equipment rigs.



TOTAL TEAM

SAFETY EQUIPMENT	-1	
ARMOURERS	-4	
AIRFRAME	-4	(INCLUDES 2 REFUELLERS)
ENGINE	-2	
ELECTRICIAN	-1	
TENDER DRIVER	-1	
CONTROLLER	-1	SERVES TWO AIRCRAFT

REFUEL WITH ONE TENDER AT 500 GPM / MAX. AND ESTIMATED MEAN FLOW 400 GPM

FIG. 15 TURNAROUND TIME STUDY - FORWARD BASE - OUTDOORS

As the estimated time is 8-12 minutes, there are 6-1/2 minutes in hand to allow for adverse weather and still complete the turnarounds within 15 minutes.

It should be noted that the proposed refuelling tender is of 3200 gallon capacity and that one tender will therefore be required to refill each aircraft to the combat mission load of 2026 gallons.

6.2 TURNAROUNDS AT MAIN BASE

The RCAF has specified that turnaround at main bases should be performed under cover, and proposed that a type of turnaround hangar be built to realize the full turnaround capability of the ARROW.

It is suggested hydrant refuelling be incorporated at a flow rate of 1000 gpm through two hoses to each aircraft. This will reduce to an estimated 700 gpm due to shut-off of certain aircraft tanks as they become full, and this figure is used in the calculation.

The procedure to be adopted in the turnaround hangar is similar to that to be followed in the field, i.e. the aircraft taxies into the hangar. Electrical power and cooling air are plugged in prior to shutting down the engines, and the aircraft is then refuelled, rearmed and serviced. The aircraft may then be started and taxied out, or maintained at either readiness or standby.

From Figure 16 which lists the operations to be performed, it is calculated that an aircraft should be ready for taxiing in six minutes. Thus, two aircraft could be phased through one turnaround bay within fifteen minutes and one servicing team could handle the two aircraft.

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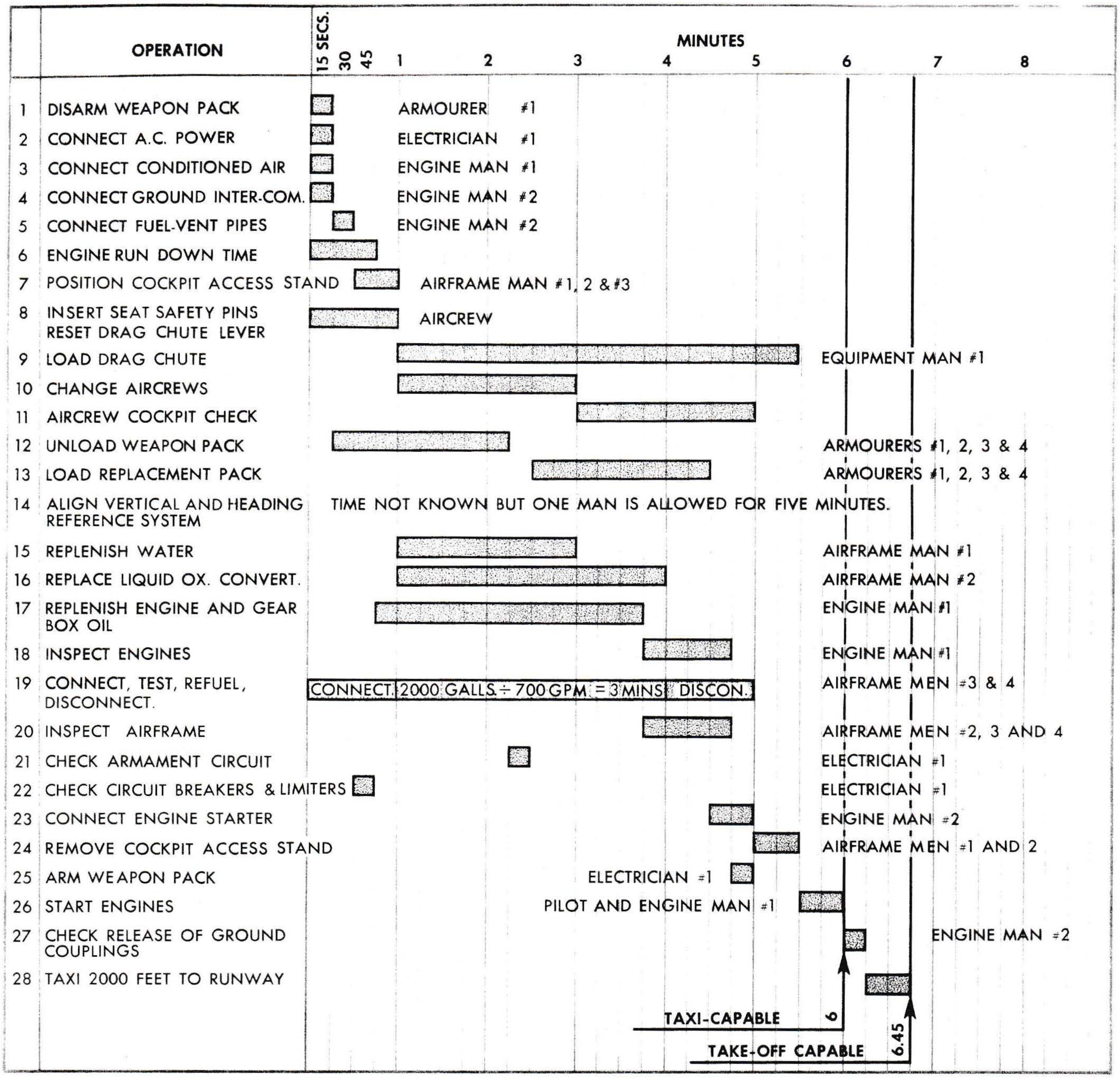


TOTAL TEAM: SAFETY EQUIPMENT —1
ARMOURERS—4
AIRFRAME—4 (INCLUDES 2 REFUELERS)
ENGINE —2
ELECTRICIAN —1
HYDRANT MAN—1 (SERVES 2 BAYS)
CONTROLLER—1 (SERVES 2 BAYS)

REFUEL FROM HYDRANT AT 1000 GPM/MAX. AND ESTIMATED MEAN FLOW OF 700 GPM

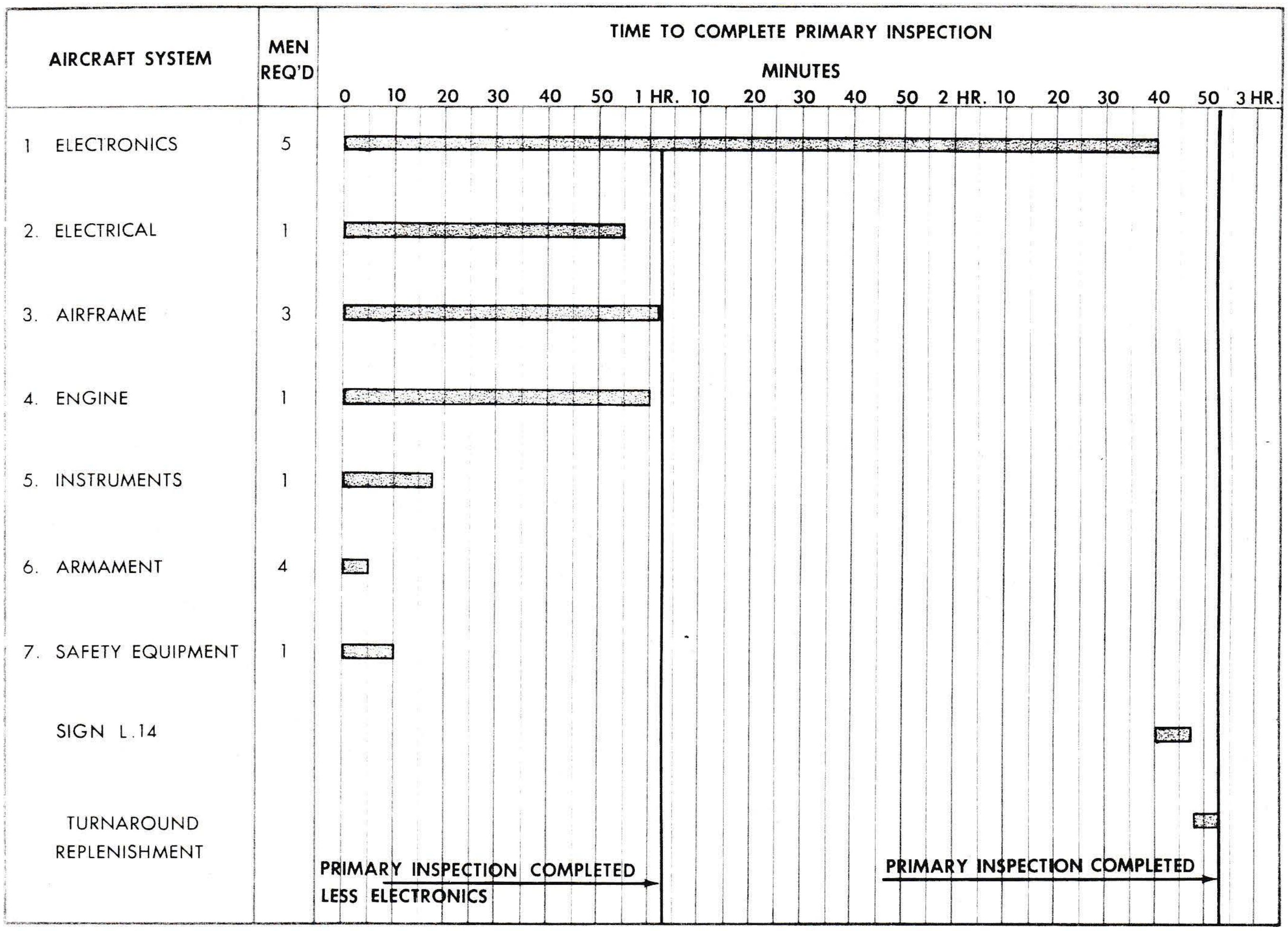
FIG. 16 TIME STUDY - TURNAROUND IN PREPARED HANGAR

Each team will consist of 14 men, as follows:

Safety equipment worker	1	
Armourer	4	
Airframe	2	
Refuellers	2	
Engine Mechanics	2	
Electrician	1	
Hydrant operator	1	serves 2 bays
Turnaround controller	1	serves 2 bays
Total	14	

6.3 FIRST LINE MAINTENANCE

It is considered that the primary inspection is the major function in 1st line maintenance and is typical of the work, the ground support equipment and manpower required. An assessment of the tasks to be performed has been made, using the ARROW 1 preliminary maintenance schedule, with due allowance for the ASTRA I system and other differences between ARROW 1 and 2 known to exist at present. These tasks are listed in Figure 17 as functions to be performed. No attempt has been made to determine an optimum sequence, as it is felt that this can only be achieved realistically, by practical demonstration. However, estimated times for primary inspection functions for the various trades are shown in Figure 17. This reveals that a primary inspection on the aircraft (less the ASTRA I system) may be completed in about 1 hour 5 minutes. However, it appears that 2 hours 55 minutes may be necessary to complete a primary inspection on the aircraft when the ASTRA system is included. Although the primary inspection cycle will ultimately be much longer, it is believed that the ARROW will be initially placed on a primary inspection cycle of 24 hours. It follows therefore, that about three hours will be spent each day on this task. A preliminary report



THE FOLLOWING ASSUMPTIONS HAVE BEEN MADE IN THIS ANALYSIS

THAT COCKPIT MAN A IS A SENIOR TECHNICIAN

THAT COCKPIT MAN B IS A SENIOR ELECTRONICS TECHNICIAN

THAT UNKOWN ASTRA MAINTENANCE REQUIREMENTS WILL NOT BRING TOTAL TIME OF PRIMARY INSPECTION TO MORE THAN 2 HOURS 40 MINS.

THAT NO RECTIFICATION WORK IS NECESSARY

FIG. 17 TIME STUDY SUMMARY - PRIMARY INSPECTIONS (CHART 1 OF 10)

MINUTES: 10 20 30 40 50 1 HR. 10 20 30 40 50 2 HR. 10 20 30 40 50 3 HR.

OPERATION	MINUTES
ASTRA I ELECTRONIC SYSTEM	
RADAR SUB-SYSTEM	
1 SEMI-AUTO TEST	ELECTRONICS #1 AND #3 (#1 IS COCKPIT MAN (B))
2 ANTENNA HYDRAULICS—LEVEL	ELECTRONICS #3
3 TRANSMITTER—POWER SUPPLY VOLTAGE TEST	ELECTRONICS #3
4 COOLING LIQUID—LEVEL	ELECTRONICS #3
COMPUTER SUB-SYSTEM	
1 SEMI-AUTOMATIC TEST	ELECTRONICS #3 WITH COCKPIT MAN (B)
2 PRESSURIZATION CHECK -DEHYDRATOR CRYSTAL CHECK	ELECTRONICS #3
INFRA-RED SUB-SYSTEM	
1 SEMI-AUTOMATIC TEST	ELECTRONICS #3
2 COOLING NITROGEN CHECK	ELECTRONICS #3
MISSILE AUXILIARY SYSTEM	
1 SEMI-AUTOMATIC TEST	ELECTRONICS #3
TELECOMMUNICATIONS	
1 AN/AIC—10A FUNCTION	ELECTRONICS #2 IN COCKPIT
2 AN/ARC—52 U.H.F. FUNCTION	ELECTRONICS #2
3 AN/APX—25A FUNCTION	ELECTRONICS #2
4 AN/APX—26 SELF TEST 5 AN/APX—27 SELF TEST	ELECTRONICS #2 AND 4 (FIN)
6 AN/APX—26 TRANSMITTER PERFORMANCE CHECK	ELECTRONICS #1 AND #4
7 AN/APX—26 RECEIVER FUNCTION CHECK	ELECTRONICS #1 AND #4
8 AN/APX—26 ELECTRICAL SYNCHRONIZER TEST	ELECTRONICS #1 AND #4
9 AN/APX—27 TRANSMITTER PERFORMANCE CHECK	ELECTRONICS #4
10 AN/ARA—25 UHF/DF RECEPTION & ROTATION	ELECTRONICS #1 AND 4
11 AN/ARN—6 RADIO COMPASS FUNCTION	ELECTRONICS #1

FIG. 17 TIME STUDY - PRIMARY INSPECTIONS (CHART 2 OF 10)

OPERATION	MINUTES (10 20 30 40 50 1 HR. 10 20 30 40 50 2 HR. 10 20 30 40 50 3 HR.)
DOPPLER TEST	NOT KNOWN AT PRESENT
VERTICAL HEADING AND REFERENCE SYSTEM	"
AUTOMATIC FLIGHT CONTROL SYSTEM TEST	"
DAMPING SYSTEM TEST	[bar: 1 HR. 40 – 2 HR. 10] ELECTRONICS #2 AND #5
DEAD RECKONING COMPUTER TEST	"
RADAR HOMER AN/ARD 501	"

NOTE:
IT IS ASSUMED THAT TESTS ON THE ABOVE WILL BE CARRIED OUT BY COCKPIT MEN A AND B AND ELECTRONICS MAN #5 AND THAT THE TIME TAKEN WILL NOT BRING THE AGGREGATE BEYOND 2 HOURS 40 MINUTES.

TOTAL ELECTRONICS TEAM 5 MEN.

FIG. 17 TIME STUDY - PRIMARY INSPECTIONS (CHART 3 OF 10)

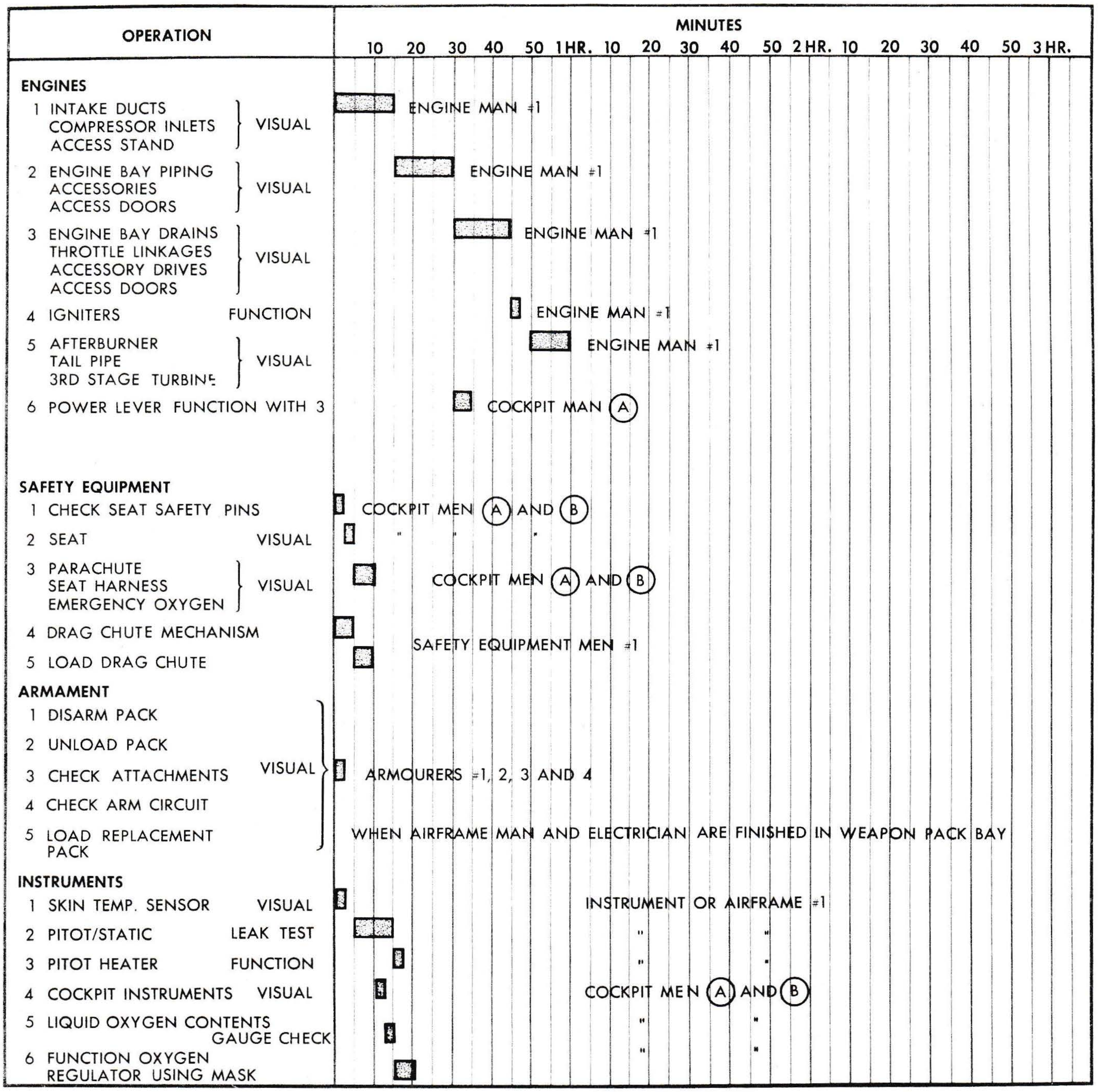


FIG. 17 TIME STUDY - PRIMARY INSPECTIONS (CHART 4 OF 10)

UNCLASSIFIED

OPERATION	MINUTES (10 20 30 40 50 1 HR. 10 20 30 40 50 2 HR. 10 20 30 40 50 3 HR.)
AIRFRAME NOSE	
1 NOSE LANDING GEAR CLEAN TIRES CHECK AND CHARGE 2 LANDING GEAR NITROGEN CHECK 3 FLYING CONTROLS CHECK 4 HYDRAULIC COMPONENTS—VISUAL 5 ELECTRONICS ACCESS DOORS. REMOVE AND REPLACE 6 WORKSTAND PLACE AND REMOVE	AIRFRAME MAN #1
ARMAMENT BAY ROOF 1 FUEL LEAKS VISUAL 2 BRAKE CONTROL VALVE VISUAL 3 MANUAL DUMP VALVE VISUAL 4 HOT AIR FILTER VISUAL 5 WEAPON PACK ATTACHMENT VISUAL 6 WORKSTAND PLACE AND REMOVE	AIRFRAME MAN #2
DUCT BAY 1 ACCESS DOORS 1, 2, 3 REMOVE AND REPLACE 2 FUEL TANKS DRAIN CONDENSATE 3 FUEL TRANSFER PUMPS 4 FUEL PRESSURE REGULATORS VISUAL 5 DIFFERENTIAL AIR AND PRESSURE REGULATOR 6 PRESSURE RELIEF VALVE VISUAL 7 FUEL PIPING 8 FUEL LEAKS VISUAL	AIRFRAME MAN #2

FIG. 17 TIME STUDY - PRIMARY INSPECTIONS (CHART 5 OF 10)

OPERATION	MINUTES: 10 20 30 40 50 1HR. 10 20 30 40 50 2HR. 10 20 30 40 50 3HR.
FUSELAGE DUCT	
1. ELECTRONIC EQUIPMENT ACCESS DOORS REMOVE AND REPLACE	AIRFRAME MAN #1
2. HYDRAULIC ACCUMULATORS COMPENSATORS BLEED/PRESSURIZE/TOP UP FLUID/ CLEAN / VISUAL	AIRFRAME MAN #1
POSITION AND REMOVE HYDRAULIC BLEED & CHARGE RIG NITROGEN TROLLEY	
3. OIL/FUEL HEAT EXCHANGERS SPEED BRAKE SELECTOR VALVE LANDING GEAR SELECTOR VALVE EMERGENCY EXTENSION BYPASS VALVE HIGH PRESSURE FILTER PRESSURE CONTROL VALVE SPEED BRAKE ACTUATORS THERMAL BY-PASS VALVE	AIRFRAME MAN #1
VISUAL CHECK ON ABOVE	
4. L.P. FUEL SHUT-OFF AND CROSS-FEED AND ISOLATION VALVE. CHECK IN CONJUNCTION WITH COCKPIT CONTROL	AIRFRAME MAN #1
ENGINE BAY	
1. ACCESS PANELS NOS. 1, 2, 3, & 4 REMOVE AND REPLACE	AIRFRAME MAN #2
2. AIR PRESSURE REGULATORS RELIEF VALVES AND PIPING — VISUAL	AIRFRAME MAN #2
3. ACCUMULATOR, HYDRAULIC PUMPS, PRESSURE SWITCH, HIGH PRESSURE FILTER — VISUAL	AIRFRAME MAN #2
4. ACCUMULATORS COMPENSATORS BLEED, PRESSURIZE TOP-UP FLUID VISUAL AND CLEAN	AIRFRAME MAN #2
5. AILERON AND ELEVATOR PARALLEL SERVO — VISUAL	AIRFRAME MAN #2

FIG. 17 TIME STUDY - PRIMARY INSPECTIONS (CHART 6 OF 10)

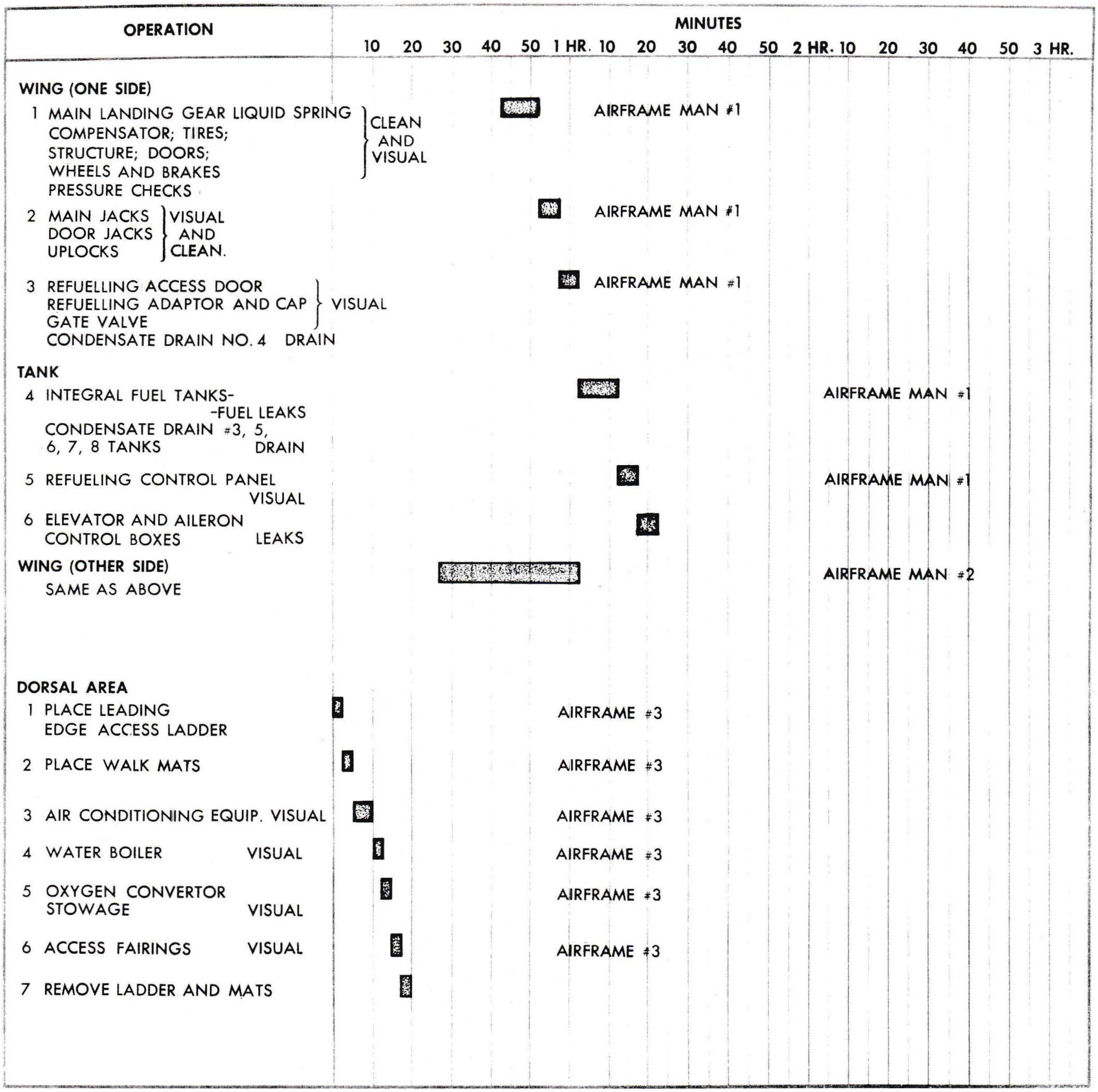


FIG. 17 TIME STUDY - PRIMARY INSPECTIONS (CHART 7 OF 10)

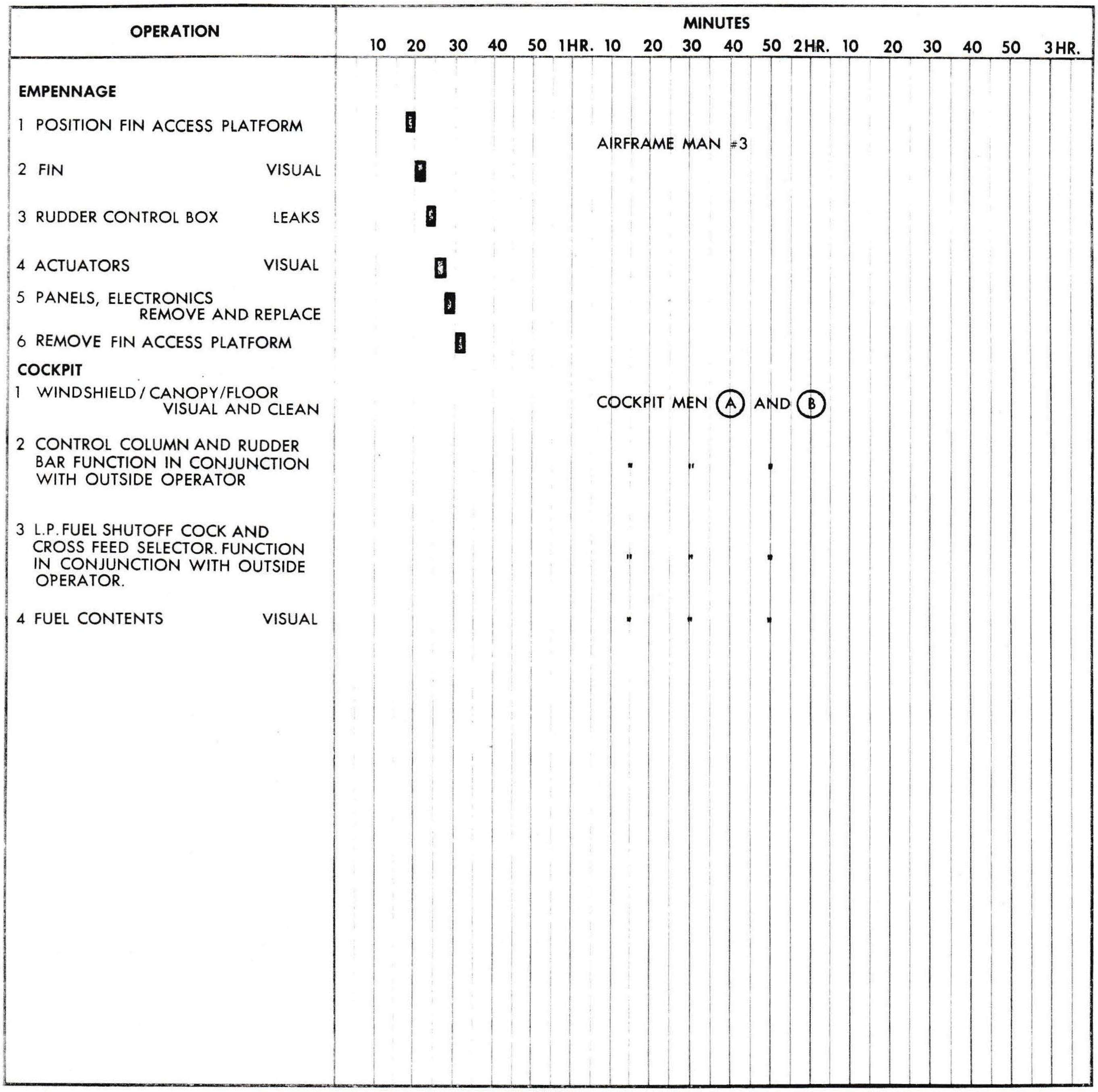


FIG. 17 TIME STUDY - PRIMARY INSPECTIONS (CHART 8 OF 10)

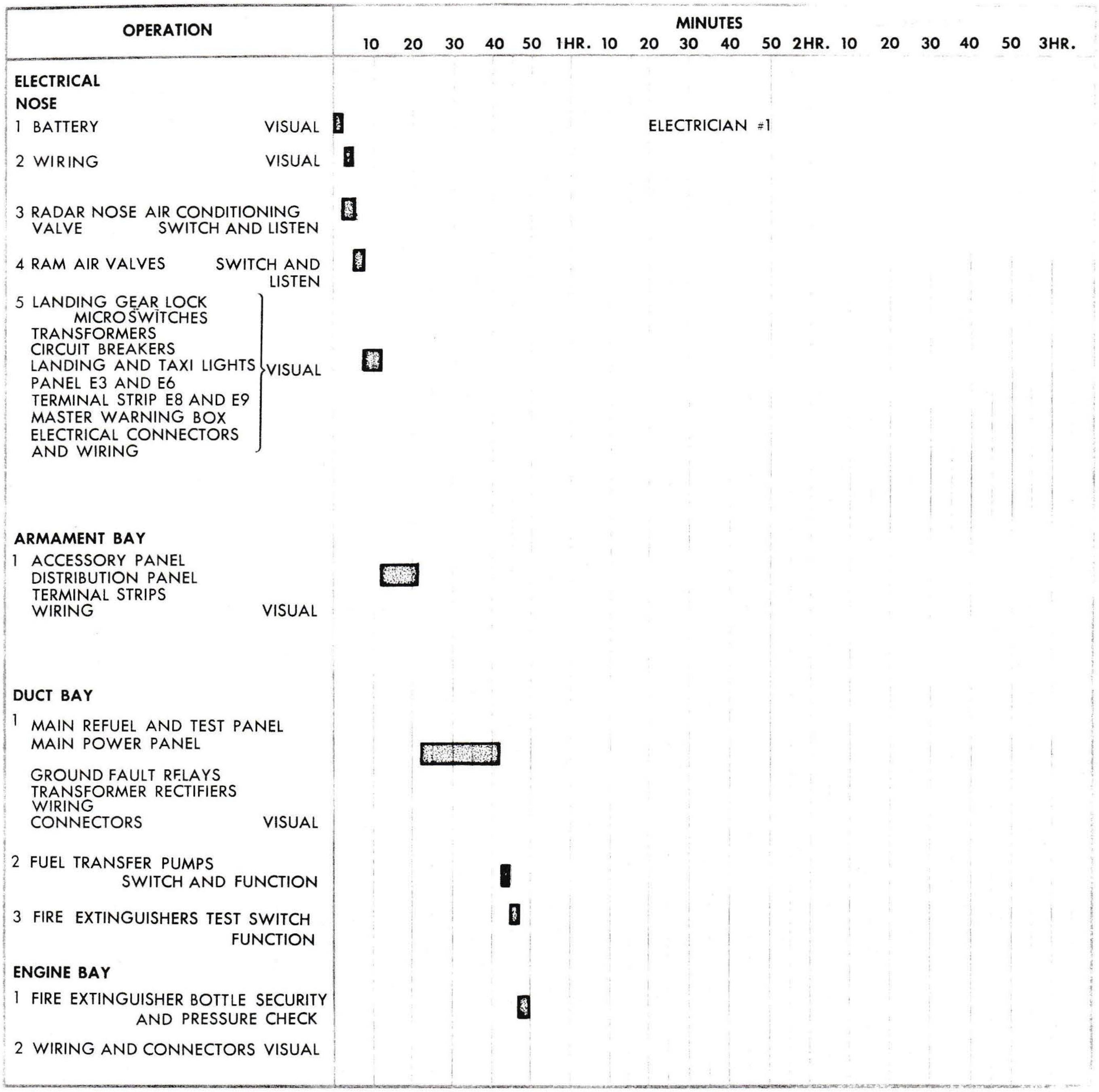


FIG. 17 TIME STUDY - PRIMARY INSPECTIONS (CHART 9 OF 10)

OPERATION		MINUTES (10 20 30 40 50 1 HR. 10 20 30 40 50 2 HR. 10 20 30 40 50 3 HR.)
ENGINES		
1. ELECTRICAL CONNECTORS AND WIRING IGNITERS ETC.		ELECTRICIAN #1
WINGS AND FIN		
1. NAVIGATION LIGHTS	VISUAL	
2. LANDING GEAR MICROSWITCH	VISUAL	
3. ELECTRICAL CONNECTORS AND WIRING	VISUAL	ELECTRICIAN #1
4. REFUELLING PANEL LIGHTS AND SWITCHES	FUNCTION	
COCKPIT		
1. FIRE DETECTION	TEST	COCKPIT MAN (A) AND (B)
2. COCKPIT LIGHTS	TEST	COCKPIT MAN (A) AND (B)
3. BAILOUT WARNING LIGHTS		COCKPIT MAN (A) AND (B)
4. NAVIGATION AND LANDING AND TAXI LIGHTS	TEST	COCKPIT MAN (A) AND (B)
5. CANOPY ACTUATORS INTERNAL AND EXTERNAL	TEST	COCKPIT MAN (A) AND (B)
6. DRAG CHUTE SOLENOID	TEST	
FINAL		
1. SIGN L14 OR EQUIVALENT MAINTENANCE CARDS		
2. TURNAROUND COMPLETED		

FIG. 17 TIME STUDY - PRIMARY INSPECTIONS (CHART 10 OF. 10)

on the ASTRA maintenance, recommends that this equipment should have a primary inspection every 48 hours. Consequently, it is desirable that the ARROW match this as soon as possible.

While the aircraft is on primary inspection, it appears desirable that a senior technician (basically an airframe technician), should occupy the front cockpit to perform complete cockpit checks, plus an electronic specialist in the rear cockpit.

The number of men necessary to perform the primary inspection has been calculated from the tasks to be performed (as listed in Figure 17). The team is as follows:

Electronic mechanics	5
Electricians	1
Airframe mechanics	3
Engine mechanics	1
Instrument mechanics	1
Safety equipment worker	1
Electronic technician (rear cockpit)	1
Controller, senior technician	1
Total	14 + 10 servicing crew = 24 men

Refuelling and reloading have not been included in the figures above. These functions are considered as part of the turnaround, and it will be advisable to complete them before commencing the primary inspection. Rearming and the replacement of the liquid oxygen converter would of course be performed after the primary inspection was completed.

Data System Techs must be added for Cold Lake operations

7.0 HANGARS

7.1 OPERATIONAL REQUIREMENTS

Specification AIR 7-4 Issue 4 states that the building facilities for one squadron will consist of the following:

(a) Hangar(s) to accommodate two aircraft at standby

(b) Hangar(s) to accommodate five aircraft undergoing turnaround or first line maintenance.

(c) Hangar(s) to accommodate seven aircraft undergoing 2nd or 3rd line maintenance.

This was based on a squadron strength of 12 operational and 2 trainer aircraft.

However, the specification will be amended to show a squadron strength of 12 aircraft disposed as follows:

(a) Two aircraft in the standby hangar(s)

(b) Four aircraft in the turnaround and 1st line maintenance hangar(s)

(c) Six aircraft in the 2nd line maintenance hangar(s)

This aircraft distribution assumes a 50% aircraft availability for 1st line activity. However, this figure can be expected to improve and 75% should be considered as a reasonable wartime objective.

7.2 PROPOSED HANGAR SIZES

7.2.1 COMBINED TURNAROUND AND 1st LINE MAINTENANCE HANGAR

To meet the 100% covered space requirements for aircraft undergoing 1st line maintenance and to satisfy the turnaround specification, this hangar

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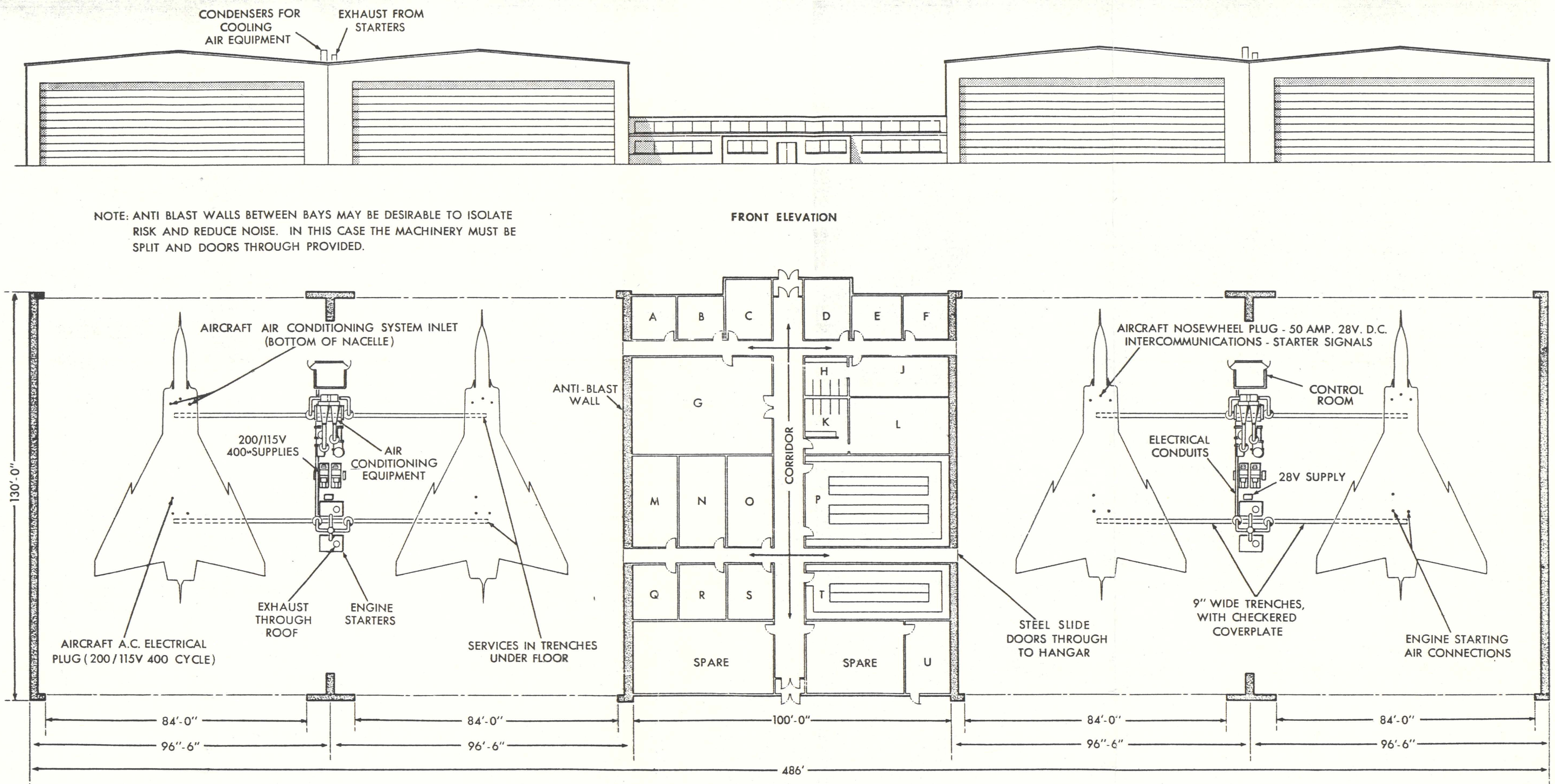

KEY

A SPARE
B L 14
C LINE CREW
D MAINTENANCE CONTROL
E MAINTENANCE CONTROL
F RECORDS
G SMOKE ROOM
H WASHROOM
J WOMEN'S LOCKERS
K WASHROOM
L MEN'S LOCKERS
M ELECTRIC SHOP
N ELECTRONICS
O BATTERY SHOP
P STORES
Q ARMAMENT SHOP
R TELECOMMUNICATIONS
S INSTRUMENTS
T TOOL CRIB
U INFLAMABLE STORES

FIG. 18 POSSIBLE LAYOUT FOR COMBINED TURNAROUND AND 1ST LINE MAINTENANCE FOR ONE SQUADRON

will have to incorporate separate bays, large enough for engine changing for which 30 feet is required behind the aircraft. Space will be required for servicing equipment, personnel, spares, sub-stores and offices.

The hangar and its associated services are illustrated in Figure 18. It should be noted that the blast wall in this illustration separates each pair of bays from the shop area only.

7.3 HANGAR LOCATION

Two points dictate the optimum sites for 1st line hangars. These are:

(a) Department of Transport regulations.

(b) The noise nuisance factor.

Condition (a)

The Department of Transport regulations require that hangars should not be sited within 1000 feet of the centre line of runways. It will be seen from Figure 19 that this requirement is met in the proposed layout of an ideal air base for the ARROW weapon system.

Condition (b)

The noise nuisance factor associated with a single ARROW 2 at take-off is presented in Tables 1, 2 and 3. These figures have been derived from empirical rules but are, however, believed to be sufficiently accurate for this appraisal, pending the publication of field trials results. These trials were recently conducted on an Iroquois engine at RCAF station North Bay. It will be seen from Table 2 that at 1500 feet from the centre line of the runway, a noise level of 123 decibels may be expected in still air. Attenuation due to distance would be further varied by weather conditions and the

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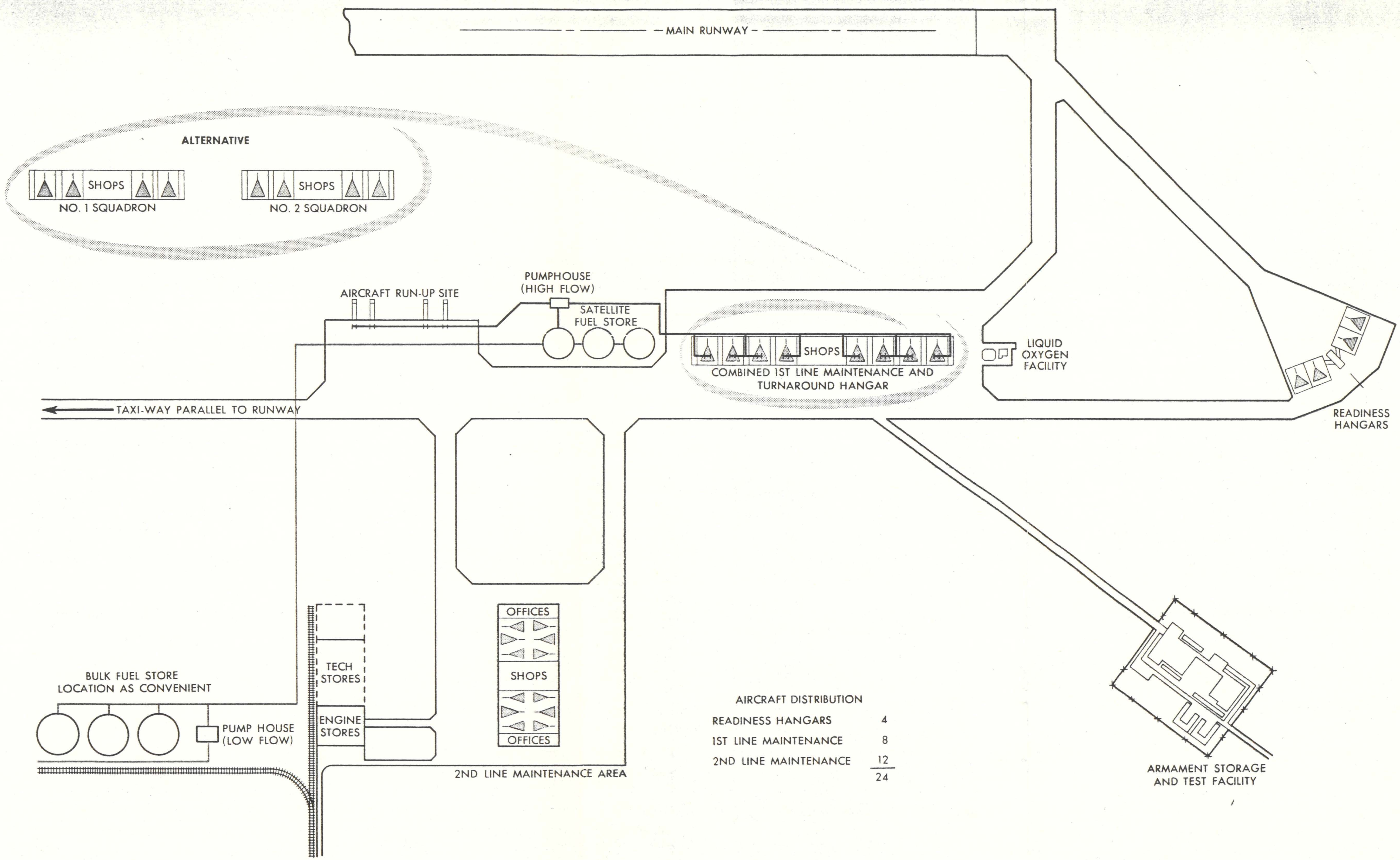


FIG. 19 PROPOSED AIR BASE LAYOUT FOR 2 SQUADRONS (TURNAROUND AND 1ST LINE MAINTENANCE COMBINED)

insulating effect of buildings. For example if this level reduces to 118 decibels, a noise level is achieved comparable to that which may be expected within the turnaround hangar from aircraft taxiing in and out.

Table 1

SOUND PRESSURE LEVELS AT TAKE-OFF

ENGINES	CONDITION	STATIC THRUST PER ENGINE	NOISE LEVEL AT 150 FEET
2-Orenda Iroquois	Afterburner OFF	18,400 lb	141 decibel
2-Orenda Iroquois	Afterburner ON	25,000 lb	148 decibel

Table 2

ATTENUATION DUE TO DISTANCE

DISTANCE (FEET)	DECIBEL DROP	NOISE LEVEL AFTERBURNER OFF	NOISE LEVEL AFTERBURNER ON
150	NIL	141	148
225	2	139	146
300	6	135	142
500	12	129	136
1000	20	121	128
1500	25	116	123
2000	30	111	118
2500	33	108	115
3000	36	105	112
4000	42	99	106
5000	48	93	100
6000	53	88	95
7000	60	81	88

Table 3

INTERPRETATION OF NOISE LEVELS

DECIBELS	LEVELS
70	Average street
80	Noisy office
90	Noisy factory
100	Boiler factory
110	Annoyance level
120	Discomfort level
140	Pain threshold
150	Mechanical damage threshold to human tissue

The maximum noise level occurs at approximately 135° and 225° from the aircraft heading. Consequently, a distance of 1500 feet along either of these lines will give a distance of $1500 \div \sqrt{2}$, say 1000 feet from the line of travel of the aircraft.

The performance of 1st line maintenance in the turnaround hangar will necessitate the hangar being sited farther from the main runway, than if it was reserved for turnarounds only. In order to obtain attenuation of take-off noise to 115 db, it will be necessary to site the hangar at least 2,000 ft from the main runway.

The 2nd line maintenance area will be at least 2,000 ft from the turnaround area, and 4000 ft from the main runway in order to reduce the noises from these sources to approximately 103 db. This noise level is estimated to occur approximately nine times per day, i.e., the peacetime number of daily sorties, per squadron.

7.4 LIGHTING AND HEATING

7.4.1 LIGHTING

(a) No new major lighting requirements are necessary in the existing RCAF hangars for 1st line maintenance, but all lighting in the turnaround hangar should be explosion proof in view of the large quantity of fuel to be handled at turnarounds.

The hydrant pressure-refuelling proposed for use in the turnaround hangar comprises a completely closed circuit with the aircraft fuel tanks being vented to atmosphere by extractor fans through flexible piping. However, it is recommended that all lighting be explosion proof to reduce the fire risk - if a fuel leak did occur during refuelling it would be at very high flow rate.

(b) Explosion proof, portable underwing lighting is desirable for 1st line maintenance in view of the high wing construction of the ARROW and the fact that most of the work will be carried out from under the aircraft.

(c) Taxiing into the turnaround hangar at night would be facilitated if the internal hangar lights were arranged to form a centre line, i.e. a guide line for the pilot.

7.4.2 HEATING

The temperature in the combined turnaround and 1st line maintenance hangar should be at least 50°F. This will provide a comfortable working temperature and prevent freezing of the water supply lines for replenishing the aircraft's water boiler.

7.5 EQUIPMENT INSTALLATION

The equipment, comprising engine starters, air conditioning plant and a-c generators should be readily removable for overhaul. The cooling air, starting air and fuel venting pipes should be ducted under the hangar floor to locations under the aircraft. Flexible hoses would be run from these outlets. Refuel hoses and power leads would be reeled out from the hangar wall.

The position of the aircraft in the hangar will be constant and the relative positions of the ground service connections on the aircraft are shown in Figure 13.

The connections at the aircraft, reading from the front of the aircraft to rear, are summarized in the following table:

GROUND SERVICE CONNECTION	DETAILS OF CONNECTION
1 Nose leg receptacle Wiring Quantity - 1 per A/C	Lanyard operated quick disconnect plug to AVRO STANDARD 2 CS-C-142 Plug manufactured by E. B. Wiggins #9500 A 5V.
2 Air conditioning supply Hose Quantity - 2 per A/C	Automatic quick disconnect couplings to AVRO Dwg. 7-2252-198 3-1/2 inch dia. insulated flexible hose

GROUND SERVICE CONNECTION	DETAILS OF CONNECTION
3 A-C supply Wiring Quantity - 1 per A/C	ARROW 1 AM 3430 - complete with cable in standard lengths ARROW 2 AVRO Standard CS-P-123 complete with cable (This item not yet qualified) AVRO Dwg. 7-4427-79 and AVRO Spec. E-531
4 Static discharge A/C to hangar floor Quantity - 1 per A/C	Quick disconnect, static coupling complete with cable. Appleton Electric Co. Type #9386
5 Engine starting, compressed air connections (2) Hoses (2) Line diagram - Starting air supply to two bays	Lanyard-operated, quick-disconnect coupling, Wiggins # GSC-141-3A 3-1/2" insulated, flexible hoses
6 Refuel nozzle (hose) Refuel adaptor (aircraft) Quantity - 2 per A/C	MIL-N-5878 A (to mate with A/C adaptor MIL-A-5878 B)
7 Fuel tank vent outlets Quantity - 2 per A/C	Figure 9. NOTE: The hangar fuel tank vent outlet must be protected by a safety gauze to eliminate possibility of ignition flash back to the venting system

Controls for engine starting, intercom. and telescramble should be routed to a control room. The control room should be well insulated against aircraft and equipment noise. It is suggested that this room be constructed of metalclad, soundproof material similar to the soundproof rooms manufactured by Industrial Acoustics Co. Inc., New York or Koppers Co. Inc., Baltimore. These vendors offer what appears to be suitable soundproof rooms with attenuation of better than 40 decibels, particularly in the frequency ranges which would effect voice communication. "Noise lock" windows and doors are also available plus "quiet duct" ventilators for use when the doors are closed. As noise levels of up to 120 decibels may be expected in the turn-around hangar during taxiing away a reduction in noise levels down to 80-85 is essential if communication is to be maintained.

The catwalk from the crew room to the cockpit should be suspended from the roof to permit a clear taxi-way for the aircraft after completion of the turn-around. The end of the catwalk must be retractable to ensure adequate tail clearance, and it is suggested that at least ten feet of the catwalk should be either capable of withdrawal or hoisting back to the vertical position.

7.6 POWER REQUIREMENTS

7.6.1 TURNAROUNDS ONLY

During turnarounds the ASTRA I system will be maintained at standby. Consequently a 550 volt 60 cycle 3 phase power supply will be required to each aircraft as follows:

(a)	400 cps generator (output 40 KVA)	- 50 KVA
(b)	Cooling air machinery (esimated)	- 134 KVA
(c)	28 volt d-c 50 amp (rectified)	- 1.5 KVA
(d)	Hydrant refuel pumps 2 per aircraft (estimated 30 KVA per pump delivering 500 gpm at 70 psi.)	- 60 KVA
	Total	245.5 KVA

For a four bay-turnaround hangar in which four aircraft are being turned around simultaneously, a total of 982 KVA will be required. The other hangar services such as lighting and heating which have not been included should be added to this total.

7.6.2 1st LINE MAINTENANCE

For 1st line maintenance, 550 volt 60 cycle 3 phase electrical power outlets will be required at each aircraft position to operate ground servicing rigs, in addition to the a-c power and cooling air. These are as follows:-

(a)	400 cps generators (output 40 KVA)	- 50 KVA
(b)	Cooling air machinery	- 134 KVA
(c)	28 volt d-c 50 amp (rectifier)	- 1.5 KVA
(d)	4000 psi hydraulic rig	- 105 KVA
(e)	Radar hydraulic rig	- 5 KVA
(f)	Nitrogen compressor	- 14 KVA
	Total	309.5 KVA

In addition, 110 volt 60 cycle outlets will be required for electronic test equipment at 10 KVA.

In a 4-bay turnaround hangar, in which maintenance is to be performed, each bay should be equipped with outlets for the above equipment, but is is unlikely that each bay would consume maximum power simultaneously.

Assuming that two aircraft are on turnarounds and two on first line maintenance, the total load for four bays would be as follows:-

2 turnarounds at 245 KVA each	=	490 KVA
2 1st line maintenance at 309 KVA each		618 KVA
	Total	1108 KVA

The other hangar services such as lighting, heating and power tools which have not been included should be added to this total.

An emergency supply should be provided as insurance against main hydro-electric failure.

7.7 HYDRANT REFUELLING

7.7.1 THE CASE FOR HYDRANT REFUELLING

Hydrant refuelling is proposed for use in turnaround hangars at air bases which are to be equipped with ARROW 2 squadrons. This is the most economical and efficient method of dealing with the large quantities of fuel involved in the daily operation of interceptor squadrons, using high performance gas turbine aircraft. The main advantage of the hydrant system is its ability to handle the large quantity of fuel involved at all times, and at delivery rates in excess of that proposed for the squadron tenders. The daily quantity of fuel required by two squadrons operating at 25 combat missions per day at the present combat fuel load, is 25 x 2026 Imperical gallons, i.e. 50,650 gallons. (It should be noted also that the combat fuel load is likely to be increased on subsequent marks of ARROW).

7.7.1.1 Tender Requirements

The proposed tender will have a capacity of 3,200 gallons and a delivery rate of 250 gallons per minute through each of two hoses. Each tender can serve one aircraft through two refuelling points. Thus four tenders will be required per squadron to actively support the turnaround hangar to meet the specification that four aircraft be turned around in fifteen minutes. Consequently on a two squadron airbase eight tenders will be required. Since one tender can fill only one aircraft to the combat load of 2,026 gallons, it follows that a redeployment of tenders must be made to meet a succeeding wave of four aircraft. In this case, two tenders will be required per aircraft as the tenders now only hold 3200 - 2026 = 1174 gallons. The eight tenders would then need replenishing from bulk stock. Replenishment of these eight tenders would be required twice a day, on the basis of total fuel required per day, divided by total tender capacity as follows:

$$\frac{\text{25 sorties (2 squadrons) x 2026 gallons per sortie}}{\text{8 tenders x 3200 gallons each}}$$

$= \frac{50,650}{25,600}$ i.e. 2 refills are required.

During these two refuelling periods there would be no refuelling facility available at the turnaround hangar, unless four more tenders were stading by, already filled, while the eight empty tenders were being refilled.

The total number of tenders required will therefore, be 12 plus one in immediate reserve. This figure does not allow for rotation through the garage for periodic maintenance. At this minimum figure of 13 tenders, the total capital outlay is estimated to be $312,000. The cost of garage and maintenance facilities, spares, overheads and labour must be added to this figure.

7.7.1.2 Hydrant Requirements

The hydrant system only requires the following:

(a) Satellite storage tanks located near the turnaround hangar.

(b) 16 pumps at 500 gpm each (i.e. two for each of eight turnaround bays). These pumps plus two reserve pumps, would be located in a pump house near the satellite tanks.

(c) Piping from the satellite tanks to the aircraft.

(d) Pumps and piping from the bulk store to the satellite tanks.

(e) Dispensers with filters, water separators, air separators and flow meters.

The pumps proposed for the hydrant system would be capable of delivering 500 gallons per minute per hose, making a total of 1000 gallons per minute to each aircraft. The aircraft has been designed to receive fuel at 1000 gallons per minute through two refuel points at 50 psig at the nozzle with a desirable maximum surge pressure of 90 psig (but not exceeding 120 psig).

It is evident that the hydrant system will double the tender delivery rate. This is mainly due to the fact that a larger pumping station may be used than could be transported in a tender.

Other advantages of the hydrant system are:

(a) Elimination of the eight tenders, which are major items requiring large space for manoeuvring, with consequent hindrance to other operations.

(b) Subject to further investigation, the possible elimination of cooling requirements for the fuel. The fuel in the aircraft tanks should not exceed 70°F prior to take-off on a mission involving flight at Mach 2 or 110°F prior to take-off on missions involving flight at Mach 1.5.

Fuel in tenders standing in hot sun can attain 110°F and although this problem will require a solution for forward base activities it can be minimized by the use of hydrant supply from buried storage tanks and delivery lines, at main base.

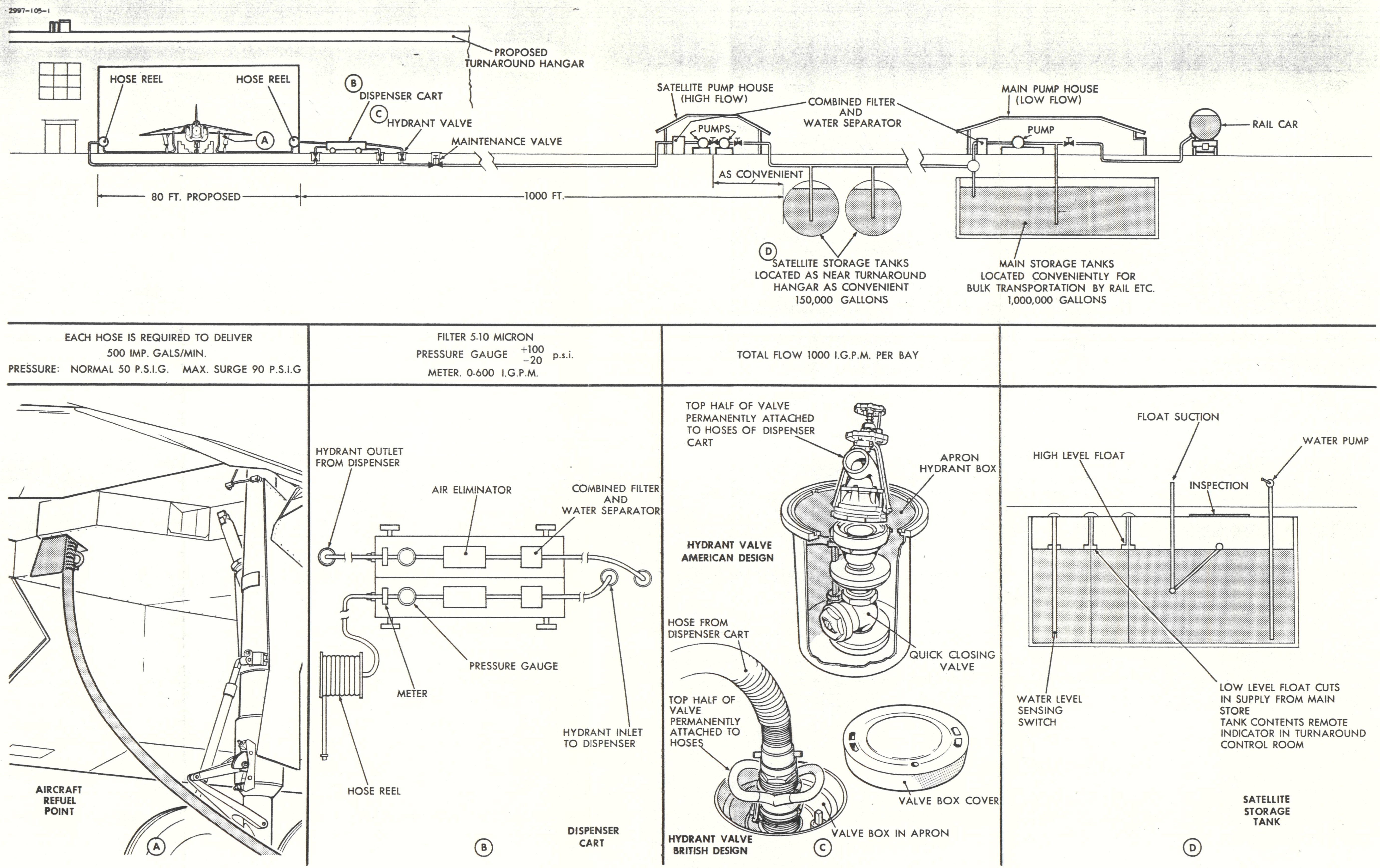


FIG. 20 LAYOUT OF ESSENTIALS OF HYDRANT REFUEL SYSTEM

7.7.2 ESSENTIALS OF PROPOSED HYDRANT REFUELLING SYSTEMS (FIGURE 20)

(a) Main Storage Tank Area

This area contains the main tanks which may be above or below ground. The location of the area will be dictated by the geographical characteristics of each air base and the local facilities for receipt of bulk supplies.

It is desirable that these tanks be below ground to ensure a supply of cool fuel. The size of the tanks will be dictated by operational considerations. This will be based on the number of sorties to be flown from the air base, the combat role fuel load and the duration of combat conditions which it is desired to maintain, without the need for bulk replenishment. As this information is not yet available, the following examples of fuel quantities involved, have been based on 25 training missions per day, per two squadrons.

Assuming a 20 day period of sustained hostilities without replenishment of the main base supply, the bulk store would require a capacity of 1,013,000 gallons. i.e. 20 days at 25 sorties per day using 2026 gallons per sortie.

(b) Satellite Tanks

The satellite tanks would be required as close to the turnaround hangar as possible in order to minimize the delivery line length. The satellite tanks will be replenished at a lower rate from the main storage tanks, by pumping units located at the main bulk store. The capacity of the satellite tanks will be determined by the daily consumption rate and the duration of time considered tolerable for isolation from the bulk supply.

Assuming a three day isolation from main tank area, the capacity of satellite tanks would be 3 days at 25 sorties per day using 2026 gallons each sortie = 151,950 gallons.

(c) Pump Houses

A pump house is required at each of the storage tank areas. The main bulk fuel store pump house will be capable of maintaining the satellite tanks full at all times. This will ensure that full capacity is available at the satellite tanks in the event of any failure or breakdown in the fuel supply system.

The satellite tank pump house will deliver fuel at 500 gpm through each of two lines to two hydrant valves for each aircraft, with 50 psig pressure at the aircraft nozzle. An emergency electric power supply will be available at each pump house.

The maximum number of aircraft to be refuelled simultaneously in the proposed turnaround hangar is eight. Thus, the total power requirements will be based on 16 pumps, each pumping 500 gpm at the same time, and this amounts to an estimated 16 x 30 = 480 hp. There should be two standby pumps with suitable change-over valves to permit them to supply any delivery line.

A typical pump, to meet the requirement, is the GORMAN-RUPP centrifugal pump. This pump consumes 30 hp at delivery head of 70 psig. The basic dimensions of this unit are estimated at 6 ft by 2 ft by 2 ft high, weighing about 400 lbs. Further investigation is proposed, to establish optimum pumps and equipment layout, before firm recommendations can be made.

(d) Pipe Lines

The major factors in the design of pipe lines are fluid pressure, fluid velocity, type of fluid, pipe line lengths and shut-off closing times. Pipe line lengths should be kept to a minimum, particularly in the case of the lines from the satellite tanks to the hydrant valve in order to reduce the friction losses to a minimum. All underground pipe lines should be treated to prevent corrosion. Above ground route markers should be laid to prevent inadvertent damage by excavators. Two pipe lines carrying 500 gpm each will be required from the satellite tanks to each aircraft position.

There will be a total of eight aircraft bays in the prepared turnaround hangar and 16 lines will be required from the satellite tank pump house, i.e. two lines to each aircraft.

Flexible link-up hoses will be 2 1/2 in. diameter of proven material, terminating in a nozzle at the aircraft coupling.

(e) Filtration

A ten micron filter will be required in each of the delivery lines to the aircraft. Specifications MIL-F-5007 and 8593 require gas turbines to operate on fuel strained to 200 mesh (74 microns). Standard practice for normal use, as recommended by the American Petroleum Institute (Bulletin 1501/55) is ten microns. Five to ten micron filtration equipment is available with combined water separation capabilities. A typical unit for flow rates at 500 gallons per minute is the Fram-Warner Lewis vertical separator/filter, four feet in diameter and seven feet high. The use of these units assumes separate lines at 500 gpm. In this case, two units will be required per aircraft.

It is desirable that these units be located as close to the aircraft as possible in order to eliminate the possiblity of foreign matter, such as pipe scale, being delivered to the aircraft tanks. The aircraft filters will retain small quantities of contaminants without prejudice to the fuel flow, but large deposits of scale could cause fuel starvation.

(f) Hydrant Valves

These hydrant valves are specially designed for quick coupling and uncoupling without loss of fuel and are set flush in the floor. Hydrant valves in current use are available to take a 2-1/2 inch hose. As these are the same size as the NATO aircraft coupling, it would be economical to standardize on this size. Two valves would be required for each aircraft; i.e. each refuelling bay in the turnaround hangar would have four hydrant valves. A shut-off valve is required in each line upstream of the hydrant valve, to shut-off the supply for maintenance on the valve.

(g) Hydrant Dispensers

These are normally mobile carts or self-propelled trucks carrying hose reels, air eliminators, metering units, filters and water separators.

The units are mobile to permit their removal from the flight apron to give incoming aircraft free access to the hydrant. In the proposed turnaround hangar the dispensing equipment would be located in a central section between each pair of bays. Mobility is required, however, so that the equipment can be moved for servicing and filter cartridge changing. The mobile rig should be vapour proof to localize fumes from leads. A ventilation outlet in the trolley would be connected to a blown air duct with an outlet at hangar roof level.

There is no known trolley suitable for the purpose discussed, but design would only consist of mounting standard equipment on a suitable trolley.

One trolley would be required to service one aircraft. Each trolley would carry two sets of the following:

Air eliminator.

Fuel meters.

Combined water separator and filter

Anti-surge valve

Inlet hose - short (hydrant to dispenser)

Outlet hose - short (dispenser to hangar floor pipe)

Stowage for pipes

(h) Method of Control

The main feed pumps at the satellite tanks may be started automatically by pressure drop at commencement of refuelling, or by push button control. The latter method is preferred as the hazards of maintaining the system constantly under pressure are eliminated. Push button control may be effected by either the operator who couples the hose to the aircraft or by the man who reads the refuel meters and operates the flow control valve on the dispenser unit. As the latter does not require remote electrical control, it is to be preferred.

7.7.3 CONCLUSION

The case for hydrant refuelling has been reviewed and shown to be desirable from the operational point of view, in that double the tender flow rates may be used with consequent improvement in turnaround time. Ultimate operating costs are considerably less than using the equivalent mobile tenders. It is also believed that the initial capital cost may be acceptable when offset against the reduced number of tenders required. However, the initial capital cost has not been investigated. This is deferred pending RCAF acceptance of the hydrant refuelling concept.

8.0 FACILITIES REQUIRED FOR STORING AND HANDLING LIQUID OXYGEN

8.1 SERVICING TECHNIQUE

For crew breathing, liquid oxygen is carried in the aircraft in a 5 litre (1.32 U.S. gallon) converter. An inherent feature of liquid oxygen converters is that a delay of about 10 minutes is required between filling and production of gaseous oxygen. This time plus the five to ten minutes required for refilling means that the turnaround time becomes excessive. Consequently, the converter has been designed to be readily removable and replaceable with a fully charged unit. Thus, a supply of fully charged converters will be necessary. These must be stored outside the hangar area in a location free from oil and grease. The storage facility would also be required to handle the converter servicing and periodic checks. AVRO's proposals for this facility are illustrated in Figure 21 and described as follows:

8.2 DESCRIPTION OF PROPOSED FACILITY

The facility consists essentially of three areas:

1. Carport area for bulk storage tanks.
2. Workshop and converter storage room
3. Garage and loading area.

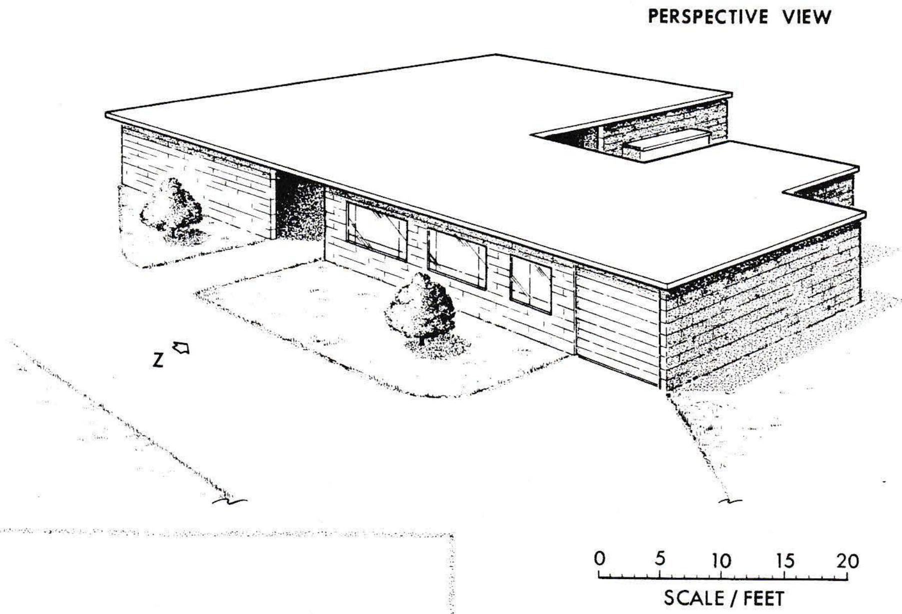
8.2.1 CARPORT AREA FOR BULK STORAGE TANKS

This area will house the bulk storage tanks and mobile trailers. The requirements for one squadron are calculated to be one 500 gallon tank and one 50 gallon tank. The tanks are stored in the open but are protected by a roof and side walls. Storage in the open is more economical since building cost is reduced and there is no requirements for special ventilation

3082-105-1

KEY

A 500 GALLON TANK 12½ X 5½ X 6 FT.
B 50 GALLON TANK 9 X 6 X 5 FT.
C BENCH & TRAY FOR CONVERTER FILLING
D ELECTRICAL AND INSTRUMENTS BENCH
E BENCH
F FIRST AID
G FIRE EXTINGUISHERS
H DESK
J CHAIR
K WORK BENCH
L STORAGE RACKS FOR CONVERTERS
M CABINET
N SPECIAL CLEANING EQUIP.
O TOOLS
P SPECIAL CLOTHING LOCKER
Q SHOWER
R TOILET
S TRANSPORTATION FOR CONVERTERS
T FAN EXTRACTOR



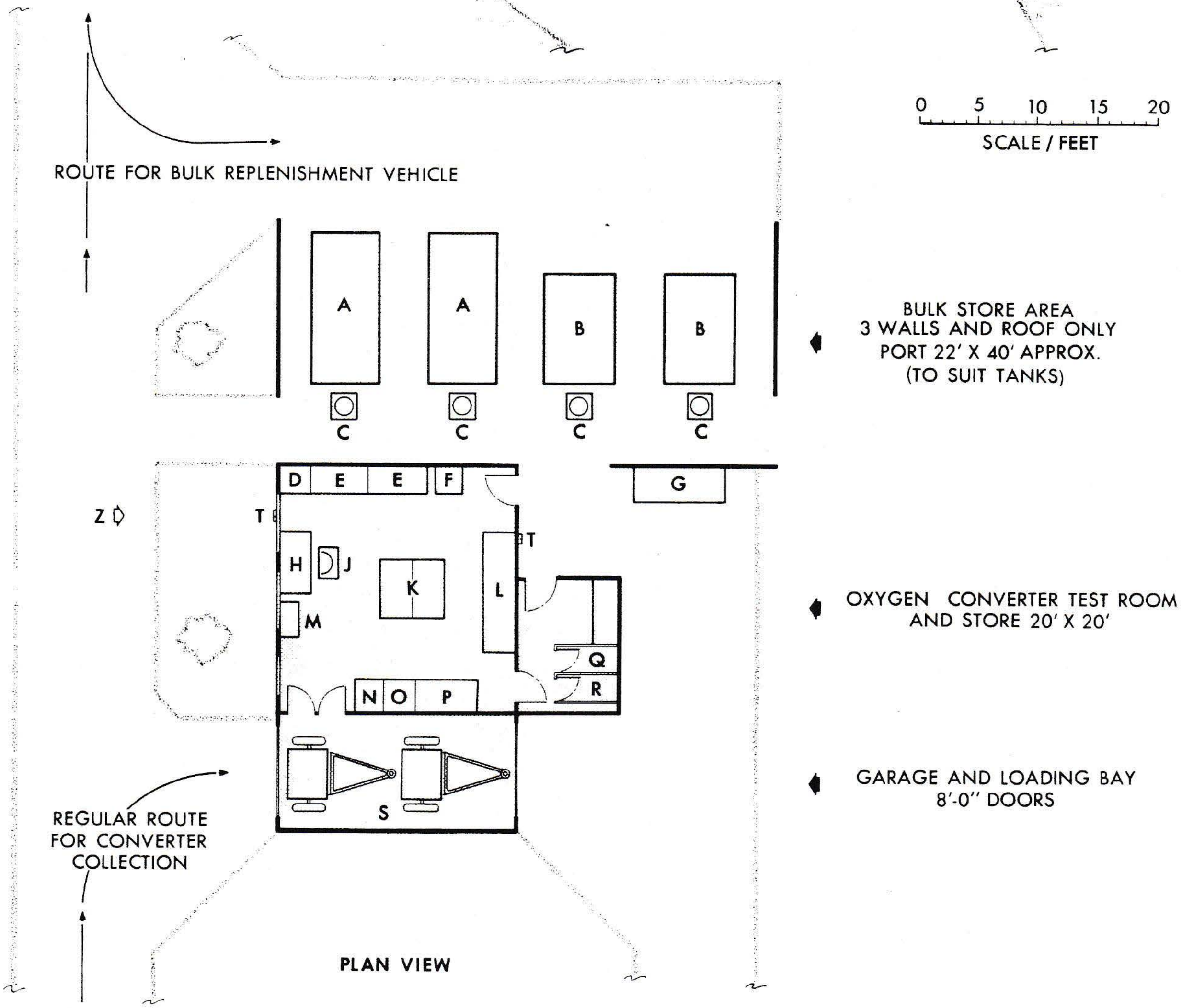


FIG. 21 LIQUID OXYGEN FACILITY (PROPOSED LAYOUT FOR AIR BASE WITH TWO ARROW SQUADRONS)

equipment to prevent concentration of oxygen gas. Details of the tanks are as follows:

(a) <u>50 gallon trailer (USAF Type MA-1)</u>

This consists of a vacuum insulated container mounted on a four wheel trailer. The unit is normally used for charging converters in aircraft on the flight line, but in this case it is proposed for static use pending airlift for forward base activities.

The leading particulars of the trailer are:

Weight-full		1550 lb
Weight-empty		1000 lb
Length		106 in.
Height		51 in.
Width		67 1/2 in.
Evaporation loss rate	-	2.5 gallons (5%) per 24 hours.

The loss rate over a seven days period would be 17.5 gallons, leaving 32.5 gallons for servicing aircraft converters. This quantity would fill 24 converters if there was no wastage during filling. However, a wastage factor must be allowed because during the initial stages of converter filling there will be a discharge of gas until the delivery hose is cooled down to liquid oxygen temperature (- 297°F). This figure will depend on the length of hose and frequency of filling. A realistic figure cannot be quoted until some operating experience is obtained. However, a 50 gallon trailer will be adequate for the forward base activity specified in AIR 7-4 i.e. six aircraft at forward base for refill on landing, and six refills after a combat sortie to enable the aircraft to return to main base.

(b) 150 gallon storage tank (USAF Type B-1)

This tank is similar in construction to the 50 gallon trailer and may be mounted on a trolley or skid. It is air transportable and may be used instead of the 50 gallon trailer to support forward base activities if extended operations are likely.

The leading particulars of this tank are as follows:

Weight-full	2330 lb
Weight-empty	890 lb
Length	100 1/2 in
Width	50 in
Height	54 1/2 in
Evaporation	3.3 gallons in 24 hours (2.2%)

The loss rate over seven days will therefore be 23 gallons, leaving 127 gallons for servicing aircraft converters. This quantity would fill 97 converters if there was no wastage during filling.

(c) 500 gallon storage tank (USAF Type C. 1)

This tank is normally reserved for bulk storage at main base. It is normally used to replenish the 50 gallon trailer which in turn charges the converters. However, the tank could be modified to enable it to fill converters direct. This is desirable in the proposed facility.

The leading particulars are:

Weight-full	7315 lb
Weight-empty	2340 lb
Length	146 1/2 in
Width	65 1/2 in
Height	70 1/2 in
Evaporation	5 gallons in 24 hours (1%)

The loss rate in seven days would amount to 35 gallons, i.e. 140 gallons in a four week period. This would leave 360 gallons for filling converters, if there was no wastage.

The peacetime requirement per squadron will be based on nine sorties per day. Assuming 20 effective days per month, and a full converter required at each sortie, 180 converter fills will be required per month. This will amount to 252 gallons which can be met from the 360 gallons left in main tank, with 30% left over for wastage. The actual amount likely to be wasted is not known, but if operating experience shows this to be higher, the total quantity stored may be increased.

From the foregoing, a suitable bulk storage for one squadron would consist of one 500 gallon tank plus one 50 gallon trailer. Double this quantity would be required for two squadrons. The proposed method of storage would be in the carport area already described, with converters being filled in the open. The converters would be placed on mounting trays secured to a stand positioned near to the bulk tank. This will reduce the wastage as short delivery pipes could be used and advantage taken of natural ventilation to avoid concentration of oxygen gas. This is possible in an enclosed building as the technique of filling converters necessitates an initial discharge of gas to cool the pipes and convertors, and finally a discharge of liquid to ensure that the converter is full.

A vacuum pump will be required for periodic maintenance of the vacuum insulation of the foregoing tanks. A rotary vacuum pump, type USAF/MA-1/ number 8200-957320 or similar, will be necessary. A power supply will be required to operate the pumps.

8.2.2 WORKSHOP AND CONVERTER STORAGE ROOM

A space of 20 ft by 20 ft appears necessary to accommodate the following:

(a) Storage shelves for converters, at a convenient height. Space for 30 converters should be allowed for two squadrons:

Number of aircraft in 1st line requiring space converters.	12
Number of aircraft in second line with converters removed for storage and servicing	12
Spare	6
Total	30

The space required would amount to approximately 15 ft by 3 ft by 7 ft. The dimensions of the converter are shown on AVRO drawing 7-2154-14.

(b) Workbench for checking converter quantity capacitance probe. A liquid oxygen quantity gauging system will be required for this purpose. The wiring diagram is illustrated in AVRO report No. 72/SYSTEMS 21/30. A mains power supply will be required to operate a rotary converter for supply of 115V 400 cycle A-C power at 2 amps.

(c) Work bench and scales for weighing and checking evaporation loss.

(d) Locker to store special clothing for personnel employed in filling converters.

(e) Locker for special tools and cleaning materials.

(f) Desk and records.

(g) First aid equipment. The requirement for special clothing and first aid suitable for handling liquid oxygen has not been investigated as it is felt this should be the subject of specialist advice.

8.2.3 TRANSPORT TRAILER GARAGE

This area is proposed for parking the trailers when they are not in use, and for providing a covered space for loading. The transportation trailers are designed to RCAF drawing 55165. The trailer will be in constant use and the approach and exit route shown on the proposed layout will confine oil spillage from the tractors to an area remote from the bulk store.

8.3 SAFETY PRECAUTIONS

(a) The installation of bulk liquid oxygen should be made in consultation with specialists of the supply agency. Outside storage is to be preferred for reasons stated previously, and for quick access for removal of tanks in the event of a fire in the area.

(b) Special safety precautions for personnel are contained in RCAF EO 20-115-9A and in AVRO report 71/MAINT 21/2 (ARROW 1 - Oxygen, Ground Servicing Equipment).

(c) The workshop and converter storage room should be adequately vented.

(d) A basement is undesirable as oxygen gas is heavier than air.

(e) A plensiful water supply should be available in case of spillage of liquid oxygen.

(f) A staff of two is desirable in this facility at all times in case of accidents.

(g) Heating should be piped from an adjacent area if possible in order to avoid having a heating unit near the oxygen facility.

9.0 REFERENCE DOCUMENTS

1.	AIR 7-4 Issue 3 and 4.	RCAF Specification for Supersonic All-Weather Interceptor Aircraft CF-105.
2.	RCAF Report S 1038 CH-180 (AMTS/D.M.Eng) 30 April 1956.	Concept of Base Operation for CF-105.
3.	RCAF Report S 1038 CH-100 December 1955.	CF-105 Aircraft - Maintenance Concept.
4.	RCAF Report (Appendix A to Minutes to 32nd Meeting of the ARROW Co-ordinating Committee).	CF-105 Aircraft - Basic Data for Maintenance Planning.
5.	AAMS 105/2 Issue 2 EMS-8	Model Specification for ARROW Mk. 2 Supersonic Interceptor Fighter. Model Specification for Iroquois.
6.	AVRO Report P/Systems 8R	Load Analysis and Power System for ARROW 2 Aircraft.
7.	AVRO Report LOG/105/24	Evaluation Study of Proposed Mobile Ground Power Equipment.
8.	AVRO Report LOG/105/4	Automatic Disconnect Couplings
9.	AVRO Report LOG/105/43	Power Plant Ground Support Equipment.
10.	AVRO Report LOG/105/1	Preliminary Analysis of Operational Ground Facilities.
11.	Motor Generator Corporation Report MISC. No. 1	Problems in Power Distribution 120/208V. 3 Phase; 4 wire, 400 cycle.
12.	AVRO Report LOG/105/9	ARROW 2 Readiness Facility.
13.	AVRO Report LOG/105/36	CF-105 - Preliminary Study of Proposed Armament Storage and Test Facility.
14.	AVRO Report LOG/105/5/4	Estimate of Electrical Power to be Supplied by Ground Power Units.
15.	AVRO Report LOG/105/16	Evaluation of the Method and Time Required to Carry Out an Engine Change on the CF-105.

16.	AVRO Report LOG/105/18	Refuelling and De-fuelling.
17.	Society of Automotive Engineers Report #61. March 1957.	Hydrant Refuelling
18.	RCA Report	Preliminary Maintenance Study ASTRA I.
19.	RCAF Report S1006D - 100 (AMTS/D.I.E. ENG)	Liquid Oxygen Ground Support Equipment Required by RCAF.
20.	Air Research Manufacturing Co. G.T. 5189-R 6 Jan./56	Proposal for Gas Turbine Compressors for Trailer Mounted.
21.	AVRO Report LOG/105/49	Defuelling and Air Pressurization Requirements.
22.	AVRO Report No. 71/ Systems/16/53	ARROW Defuel Requirements.
23.	AVRO Report No. 72/ Systems 18/29	ARROW 2 Low Pressure Pneumatic Systems
24.	AVRO Report No. 72/ Systems 22/48	Air Conditioning System.
25.	AVRO Report No. 72/ Systems 20/51	Ice Protection System.
26.	AVRO Report No. 72/ Systems 13/17	ARROW 2 ASTRA I Systems
27.	AVRO Report No. 70/ Maint 13/1	Damper System.
28.	Motor Generator Corporation Report.	Electrical Servicing of Commercial Jet Aircraft.
29.	Motor Generator Corporation Report.	Aircraft Ground Power Equipment (Motor Generator Corp.)
30.	AVRO Report C1-5-R-0022	A Proposal for Cables and Junction Boxes in the Readiness Hangars (Intercom).
31.	AVRO Report No. 72/ Systems 21/30	Oxygen System - ARROW 2.

32. AVRO Report No. 71/ MAINT 21/2 — Maintenance Instructions - ARROW 1

33. RCAF EO 20-115-9A — Storages and Handling of Liquid Oxygen.