VARIOUS METHODS OF DEFUELING THE C105 AND THE REQUIREMENT FOR PRESSURIZED AIR

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1. INTRODUCTION

The purpose of this report is to discuss the various methods of defueling the CF105 aircraft, and advise the RCAF of the requirements for pressurized air, Fuel Tender design and aircraft handling procedures.

Two main requirements for pressurized air exist. First, pressurized air is required for defueling the aircraft and secondly, pressurized air is required for carrying out field checks on the aircraft fuel system and fuel pressurization system.

Pressurized air for defueling may not be required if certain penalties are accepted. These penalties are discussed in Section 2 where the various methods of defueling are outlined.

The quantity of air required for field tests on the fuel pressurization system is of a much larger order than that required for defueling. This is shown in Section 3.

If the RCAF decide that field testing is required and the pressurized air is supplied, then it follows that the air requirement for refueling will be catered for. The quantities of air shown in the tables for the various refueling cases are for 1 tank system only (half the pressurization system). If both sides are to be defueled at the same time, the flow rate would be multiplied by 2 and the pressure would remain the same.

2. DEFUELING CASES AND REQUIREMENTS FOR PRESSURIZED AIR

Case I Defuel all transfer tanks by pressurized air and fuel tender pump suction.

Defuel collector tanks by removing an access panel and draining through the condensate drain.

(a) J75 Aircraft

Defueling Rate (I.G.P.M.)	Nozzle Pressure (P.S.I. Gauge)	Minimum Req'd Air Supply
20	0	14.8 c.f.m. @ 4.5 p.s.i.
40	0	18.3 c.f.m. @ 4.6 p.s.i.
60	0	21.8 c.f.m. @ 4.75 p.s.i.
80	0	25.3 c.f.m. @ 5.1 p.s.i.
100	0	29.0 c.f.m. @ 5.4 p.s.i.
120	0	32.6 c.f.m. @ 6.1 p.s.i.
140	0	36.3 c.f.m. @ 7.2 p.s.i.
160	0	40.4 c.f.m. @ 8.8 p.s.i.
180	0	44.6 c.f.m. @ 10.7 p.s.i.

(b) PS13 Aircraft

Defueling Rate (I.G.P.M.)	Nozzle Pressure (P.S.I. Gauge)	Minimum Req'd Air Supply
20	0	9.3 c.f.m. @ 1.5 p.s.i.
40	0	17.1 c.f.m. @ 1.7 p.s.i.
60	0	21.6 c.f.m. @ 2.0 p.s.i.
80	0	27.2 c.f.m. @ 3.3 p.s.i.
100	0	33.5 c.f.m. @ 5.9 p.s.i.
120	0	38.2 c.f.m. @ 7.8 p.s.i.
140	0	42.7 c.f.m. @ 10.5 p.s.i.

The above defueling rates are the rates available at the refueling adaptor with the various air supplies as indicated above. Whether this rate can be maintained depends upon the ability of the defueling tender to handle this flow rate from the refueling nozzle to the tender tank. For example, if an air supply of 44.6 c.f.m. @ 10.7 p.s.i. is supplied, a flow rate of 180 g.p.m. is available. If the tender equipment cannot handle this flow, a pressure build-up will occur at the nozzle and the flow rate will drop. On the other hand, if the tender could handle more than 180 g.p.m., a negative pressure might result at the nozzle and it would cause fuel to flow from the collector tank and possibly drain faster than the transfer tanks. This would cause the tender pump to cavitate and the remaining fuel in the transfer tanks would be trapped.

Disadvantages of Case I

1. It would be necessary for the tender operator to be able to control the r.p.m. on the defueling pump to ensure that the nozzle pressure never drops below atmospheric and cause the collector tank to drain before the transfer tanks. It would be possible to install a suitable restrictor in the collector tank defueling line to prevent this from happening.

   If the defueling rate must be maintained, the tender operator must ensure that the pressure does not build up in the nozzle or the defueling rate will decrease.

2. Removing a collector tank access cover is a time consuming operation. Although in some cases it is necessary to remove the cover anyway to trouble shoot it is visualized that the collector tank might have to be drained to check the gauging system.

3. Draining from the condensate drains would necessitate a redesign to provide some means of attaching a hose to the drain fitting. Draining into barrels would present a fire hazard.

Advantages of Case I

1. Case I permits the use of a standard RCAF compressor manufactured by Godfrey Engineering Ref. 4G/1529 which supplies 70 cu. ft. free air/min @ 10 p.s.i. gauge.

2. Case I does not require any design changes to the aircraft if the nozzle pressure is controllable by providing means of varying the r.p.m. of the tender suction pump r.p.m.

Case II Defuel all transfer tanks by pressurized air and Fuel Tender pump suction.

Defuel the collector tanks by pressurized air and Fuel Tender pump suction.

The air requirements for defueling the transfer tanks are described in Case I.

The collector tank air requirements for defueling are as follows:

(a) J75 Aircraft

Defueling Rate (I.G.P.M.)	Nozzle Pressure (P.S.I. Gauge)	Minimum Req'd Air Supply
10	- 6.1 p.s.i.	14.2 c.f.m. @ 12 p.s.i.
15	- 7.25 p.s.i.	14.5 c.f.m. @ 12 p.s.i.
20	- 7.70 p.s.i.	14.75 c.f.m. @ 12.2 p.s.i.
30	- 8.00 p.s.i.	15.60 c.f.m. @ 12.3 p.s.i.
40	- 8.10 p.s.i.	16.00 c.f.m. @ 12.5 p.s.i.

(b) PS13 Aircraft

10	- 3.9 p.s.i.	14.2 c.f.m. @ 12 p.s.i.
15	- 4.2 p.s.i.	14.5 c.f.m. @ 12 p.s.i.
20	- 4.6 p.s.i.	14.75 c.f.m. @ 12.2 p.s.i.
30	- 5.7 p.s.i.	15.60 c.f.m. @ 12.3 p.s.i.
40	- 6.8 p.s.i.	16.00 c.f.m. @ 12.5 p.s.i.

In order to defuel the collector tanks, a combination of pressurized air and fuel tender pump suction at the nozzle is required. The pressurized air enters the collector tank through the negative 'G' valve to assist the pump suction in fuel transfer.

Disadvantages of Case II

1. Same as Disadvantage #1 for Case I.

2. A high tender pump suction is required to drain the collector tank. To defuel at 40 g.p.m. a suction of -8.10 p.s.i. or 16.5" Hg. is required.

   It is believed that this amount of suction is not available on existing tenders but could be provided if new defueling equipment is made available for the CF105.

3. Fuel tender defueling pump r.p.m. must be controllable in order to guarantee a definite nozzle suction pressure.

Advantages of Case II

1. Not necessary to remove collector tank access covers.

2. Quicker method of refueling the collector tank than by Case I.

3. No fire hazard.

4. No redesign to the condensate drain to provide for the attachment of defueling hose.

5. The standard RCAF Godfrey compressor could still be used for draining the collector tank although the maximum pressure available would be only 10 p.s.i. This would mean that the suction at the nozzle would have to increase slightly or the defueling rate would drop slightly. Since the collector tank could normally be drained in about 4 minutes at a rate of 40 g.p.m. a slight extension of this time is not considered to be serious.

Case III Defuel all transfer tanks by pressurized air and Fuel Tender pump suction.

Remove collector tank access cover and suck fuel out of collector tank without using pressurized air.

Transfer tanks are defueled with air requirements described in Case I.

The fuel tender suction requirements are as follows:

(a) J75 Aircraft

Defueling Rate (I.G.P.M.)	Nozzle Pressure (P.S.I. Gauge)
10	- 2.4
15	- 3.5
20	- 3.9
30	- 4.2
40	- 4.3

(b) PS13 Aircraft

10	- .20
15	- .40
20	- .75
30	- 1.70
40	- 2.90

Disadvantages of Case III

1. Same as Disadvantage #1 Case I.

2. Removing access panel is time consuming operation, although in many cases the reason for draining the collector tank is because of trouble shooting in the tank which would require the panel removal.

Advantages of Case III

1. Suction requirements are much less than Case II. On J75 aircraft a maximum of -4.3 p.s.i. (8.75" Hg.) is required for a defueling rate of 40 g.p.m. as compared to -8.10 p.s.i. (16.5" Hg.) for Case II.

Case IV Defueling without Air Supply

Defuel transfer tanks by Fuel Tender suction and draining the collector tanks by one of the following methods:

1. Removing an access panel and draining through the condensate drain valve.

2. Removing an access panel and defueling with suction hose inserted in the tank.

3. Remove a seal over the flame trap vent, placed there during transfer tank defueling, remove an access panel and suck fuel from the collector tank.

Suction requirements for Transfer Tanks are as follows:

(a) J75 Aircraft

Defueling Rate (I.G.P.M.)	Nozzle Pressure (P.S.I. Gauge)
20	- 4.5
40	- 4.6
60	- 4.8
80	- 5.0
100	- 5.5
120	- 6.1
140	- 7.2
160	- 8.8
180	- 10.7

(b) PS13 Aircraft

20	- 1.6
40	- 1.7
60	- 2.0
80	- 3.3
100	- 5.9
120	- 7.7
140	- 10.40

Disadvantages of Case IV

1. The suction pressure required to defuel the transfer tanks is quite high.

   For example, to defuel at 100 g.p.m. a neg. pressure of 5.9 p.s.i. is required (12" Hg.).

2. Disadvantages of removing collector tank access cover were discussed previously.

3. It is felt that defueling with a suction hose inserted in the tank is unacceptable due to fire hazard and the necessity for having a special hose fitted with an adaptor to mate with the refueling nozzle.

Advantages of Case IV

1. Eliminate the necessity of having an air supply for defueling.

2. Since the flame trap will be redesigned for the PS13 Aircraft to provide an attachment for a hose to duct fuel vapour away during refueling, it would be possible to provide a seal to pick up on the same fitting.

3. PRESSURIZED AIR REQUIREMENTS FOR FIELD TESTING

The following tests will probably be required on operational aircraft in the field. The air requirements are noted for each test.

3.1 Tests

3.1.1 Pressure Regulation Test

This test is done to check the pressure regulation for functioning. The minimum air supply for this test is:

39.6 c.f.m. @ 50 p.s.i.a.

3.1.2 Fuel Transfer Flow Tests

This test is done to check the transfer systems for proper functioning. Fuel is forced through the transfer system, by-passing the booster pumps, into a tender through a defueling line connected to the engine feed line. The minimum air requirement for the test for one sub system is:

42.1 c.f.m. @ 50 p.s.i.a.

3.1.3 Fuel System Leak Test

This test is done to check the complete system including all tanks and piping couplings for leaks. The minimum air requirement for this test is:

42.1 c.f.m. @ 50 p.s.i.a.

3.1.4 Fuel-no-air Valve Leak Check

By pressurizing the tanks and disconnecting the transfer lines at the flow proportioner, signs of escaping air may be detected and thereby the proper functioning of the fuel-no-air valves may be established. The minimum air requirement for this test is:

42.1 c.f.m. @ 50 p.s.i.a.

3.2 Air Supply

Air may be provided for these tests, by using the Engine Starter Unit. This unit will supply air at 1350 c.f.m. @ 35 p.s.i.g. at a temperature of approximately 450°F maximum. Since the fuel system units are designed to operate at a maximum temperature of 350°F, the starter air will have to be cooled. Means of cooling the starter air will be investigated further when the air requirement for field testing is established by the RCAF.

4. CONCLUSIONS

4.1 Ground Support Equipment

The RCAF Godfrey Compressor 4G/1529 will supply the air required for defueling the CF105 but will not supply air at a high enough pressure to meet the field testing requirements.

If the RCAF decide that field testing is required, the pressurized air necessary to carry out these tests may be supplied by the Engine Starter Unit. As explained in Paragraph 3.2, the air will have to be cooled. A preliminary check shows that this is feasible.

4.2 Recommended methods of Defueling

Two methods of defueling the CF105 are recommended.

(a) Defueling with Pressurized Air

If air is available, Case II is recommended as the method for defueling. In Case II, the transfer tanks are defueled by pressurized air and tender pump suction. The collector tanks are then defueled by pressurized air and fuel tender suction. If the tender is designed to handle only 100 - 140 gallons a minute (referring to air requirements on pages 2 and 3) and pressurized air is supplied that will give a fuel flow of 180 g.p.m. in the aircraft, then the danger of creating a negative pressure at the nozzle and causing fuel to flow from the collector tank will be eliminated. In this case, tender pump suction will not be required. The collector tank may then be defueled by applying the same air supply and starting the tender pumps. This will build up a negative suction pressure at the nozzle and cause fuel to flow from the collector tank.

(b) If pressurized air is not available, Case IV (3) is recommended. In this case, while the transfer tanks are being drained by tender pump suction, a seal would be attached to the flame trap containing the collector tank outboard vent line from the air release valve. This would prevent air from entering the collector tank and thus keep the collector tank from draining. When the transfer tanks are empty, the seal would be removed from the flame trap and the collector tank drained.