TIB #02

Radiator
Mechanical Design Parameters

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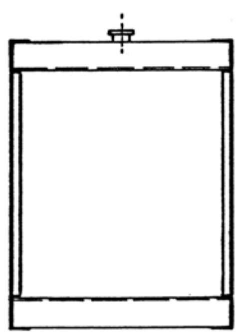
There are two radiator construction types:-

1. Solder Tank
2. Bolt on Tank

1. The soldered tank radiator is simply a core with tanks and side bands mostly 16BG (1.6mm) and relies heavily on the core for its strength.

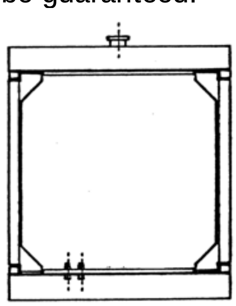
   It is therefore limited to small units.



SOLDER TANK RADIATOR

2. The bolt on unit, by contrast, has a structural frame, that provides the basis for offering long core life.

   It permits better, cleaner design and for combined deaeration systems a positive baffle can be guaranteed.



BOLT ON TANK RADIATOR

Essentially the "frame" must provide adequate core support, without twisting or racking, and permit thermal expansion of the core.

Thermal expansion is taken up with <u>internal</u> side supports in the header plate.

<u>External</u> side supports are used for :-

A floating tank - for 2mm header plates, or
Fixed tank- for 0.6 - 1.6mm header plates

3. The mechanical features for consideration are :-

   (a) Standard configuration – non deaerting top tank

   (b) Deaerated - external tank either pressurized or ball valve make up

   (c) Deaerated - combined tank

   (d) Fan Cowl

   (e) Fan guard

   (f) Core guard

4. <u>Deaeration Tank</u> - commonly known as deaeration, it performs numerous functions, it:

   (a) provides a fill point.

   (b) provides a quiescent area to allow entrained air to separate from water while the engine is running.

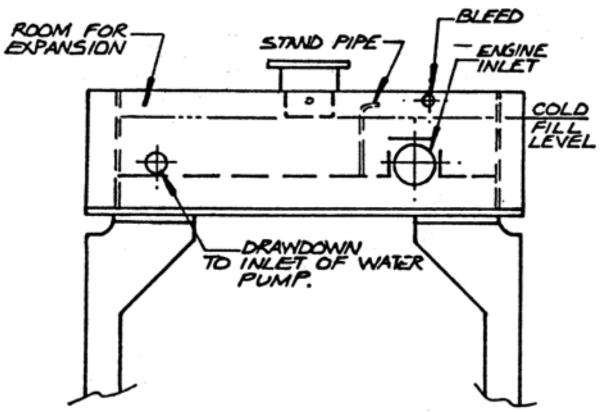
(c) provides a positive head to the water pump.

(d) provides for water make up. (Draw down capacity).

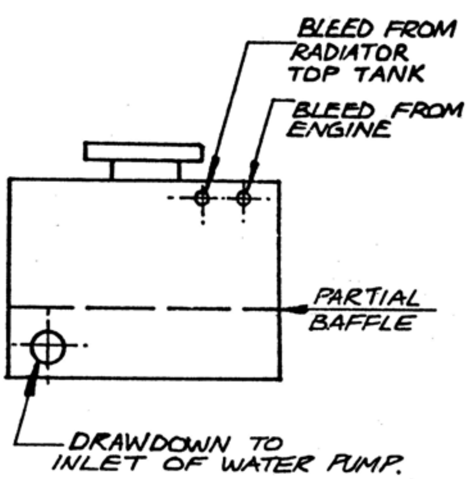
(e) enables coolant to expand from cold to operating temperature without loss of coolant - (approx. 5% of system over 140°F) - filler extension is used to set cold fill level.

Types

(a) Combined Top Tank



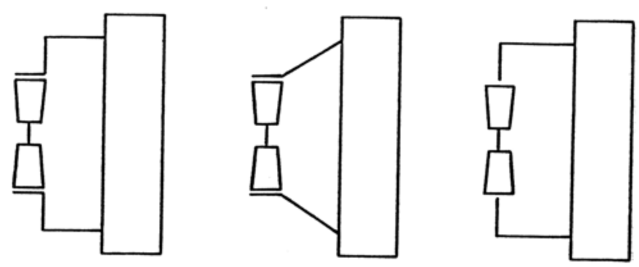
(b) Separate Expansion Tank



5. Fan Cowls come in all shapes and sizes; box, tapered, oval holes, round holes, pressure ring, straight edge, fibreglass, plastic, sheetmetal, hand fabricated, pressed and so on. Their price also varies greatly.

   There is a proliferation of theory based on design proposals. However, from a practical viewpoint, consider the following:

Pressure Rings



A pressure ring is only of value if:

(a) tip clearance can be controlled to 3mm (max.)

(b) the fan is operating in a restriction free inlet condition (blower fan)

(c) the radiator core is at least the fan hub diameter away from the fan, and

(d) the fan is central on the core

Under these conditions, maximum fan performance can be achieved eg: 60,000 CFM at 1.2" WG from 25 hp with aerofoil fans.

Note:

1. Aerofoil fans give the best performance under these conditions.

2. These conditions cannot be achieved with blower fans on diesel engines.

If these conditions cannot be achieved, then the cost of pressure rings, tapered cowls, etc outweigh the benefits.

Since most truck engines have vertical fan belt adjustment and the engines move in the chassis, the nominal side tip clearance is 20mm and vertical varies from 12mm to 76mm.

Under these circumstances 50% efficiency is the best that can be expected. A simple box cowl well sealed at the radiator edge with the fan mounted half way into the cowl will give the best results.

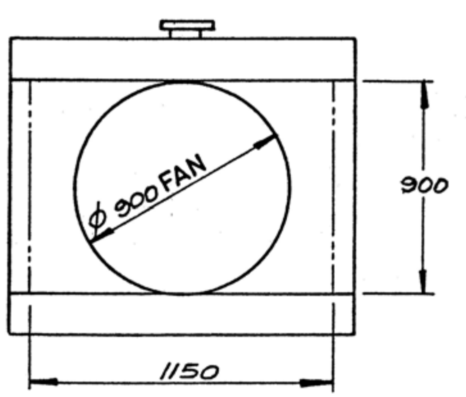
A sophisticated sheetmetal cowl could cost ~$500, whereas a simple box only ~$150.

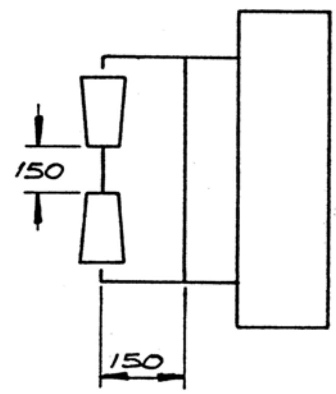
Based on the tip clearance that can be achieved, it would be cheaper to invest in more core, and less cowl.

If the ideal conditions are not available, then the installation must compromise between maximising performance and minimising cost.

The options are limited.

Example 1 - a typical radiator and oil cooler combination unit. A 900mm diameter, steel bladed blower fan, mounted on a V series engine.





Tip clearance	12mm all round
Fan to core	approx. 150mm
Fan hub	approx. 150mm
Radiator core	900mm x 1150mm
Pressure Ring	YES

In theory, a good installation

However, results of Anemometer Air Flow test (below) show uneven air distribution.

46	44	30	36
47	14	7.4	38
43	3.3	0	42
48	25.5	43	49

In practice, a disaster

A second cowl fitted.

Tip clearance	12mm all round
Fan	half in/half out
Cowl	Simple Box
Pressure Ring	NO

41	**57**	**46**	**39**
42	**55**	**44**	**38**
41	**45**	**46**	**49**
52	**47**	**61**	**47**

Average Velocity 47 ft/sec

Results of the second Anemometer Air Flow test shows even distribution.

A good installation

The analysis of this comparison is that the air entry conditions for the fan were disturbed by engine components such as hoses, alternators, thermostat housing etc; almost creating an air starve or pre-stall condition.

With the removal of the pressure ring, the fan was able to operate and maintain a steady pressure on the core.

Results:

Avge airflow	15 ft/sec (increase)
JW temperature	14°F (decrease)
Oil temperature	17°F (decrease)

Example 2 The fan location compared to the engine may also effect the air flow and therefore performance.

This example compares three engine speeds with two different 17" blower fans at different fan locations.

Charts

15	**23**	**28**	**24**	1
28	**22**	**24**	**24**	2
19	**17**	**23**	**20**	3
21	**32**	**26**	**35**	1
17	**25**	**24**	**33**	2
18	**32**	**26**	**37**	3
27	**27**	**10**	**33**	1
27	**12**	**3**	**28**	2
23	**25**	**6**	**25**	3
18	**21**	**27**	**27**	1
34	**10**	**16**	**25**	2
29	**16**	**23**	**30**	3

1250 RPM
Average Face Velocity
1 – 25 ft/sec
2 – 22 ft/sec
3 – 23 ft/sec

22	32	41	32	1
42	34	33	36	2
30	28	35	27	3
28	47	39	51	1
23	37	38	49	2
25	49	39	52	3
42	39	15	45	1
38	20	-7	42	2
33	40	8	45	3
25	31	40	46	1
48	17	25	38	2
40	25	34	41	3

1800 RPM
Average Face Velocity
1 – 36 ft/sec
2 – 33 ft/sec
3 – 34 ft/sec

28	40	52	37	1
48	37	43	40	2
37	32	42	36	3
36	60	48	69	1
30	46	47	62	2
33	60	49	68	3
50	51	19	58	1
47	28	6	54	2
43	48	11	58	3
33	41	49	56	1
59	22	32	47	2
51	31	45	55	3

2250 RPM
Average Face Velocity
1 – 45 ft/sec
2 – 40 ft/sec
3 – 44 ft/sec

Results:

(a) Not all 430mm fans have the same performance.

(b) Air entry conditions to blower / fan radiator units are by no means constant.

In summary,

- bolt on radiators are better than soldered,
- fan cowls of simple design for blower diesel mounted units are the optimum
- each pilot or prototype unit must be evaluated in its installation for air flow and heat transfer.

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