VOLVO

Dokumentnamn
CONFERENCE NOTES

Mottagare		Datum	Reg nr	Blad nr
The Boeing Co	3 copies	22.2.64		
AB Sveadiesel	2 "	Ärende		
AB Bofors	3 "	Volvo installation of Boeing 502-10MA turbine engine		
AB Volvo	5 "	Utfärdare, (tj ställe, namn, tel)		
		6730, L Ahlfors		277603

Std tab

Place: AB Volvo, Stensjövik

Date: January 22-24, 1964

Present: Mr. L P Evans, Boeing Co, Seattle
Mr. F Grumme, AB Sveadiesel (part time)
Mr. G Henke "
Mr. L Ahlfors, AB Volvo

Subjects:
1. Study of 502-10MA engines nos 1018 and 1020.
2. Principles of engine mounting to frame and combining gears of the power pack.
3. Testing of torque loads on turbine engine.
4. Vehicle steering and braking system and transcient torque loads caused thereof.
5. Air intake system
6. Inclination tests
7. Miscellaneuos

AB Volvo as above
Lars Ahlfors
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1. STUDY OF 602-10MA ENGINES NOS 1018 AND 1020

The following observations were made and the photos mentioned below were given to Boeing.

1.1 Engine No 1018

Failure of thrust bearing of gas producer (photo no 28066)

Severe rubbing between impeller (photo nr 28067) and diffuser assembly (photo nr 28070).

Blades of compressor turbine wheel partly burnt off (photo No 28064 and 28073).

Guide vanes of nozzle box deteriorated (photo no 28065).

Rubbing contact between output turbine wheel and nozzle ring at angular position three o'clock viewed from output end (photo no 28068 of nozzle ring).

Blades of output turbine wheel damaged. Blades bent in direction opposite to normal driving torque (photo no 28071).

Fret corrosion on pilot dia of output shaft and of splines of same shaft.

Timing of planetary pinions lost. Backlash of lower, left hand pinion 0.008". Torque required for slightly tightening of corresponding lock nut 100 ft.lbs. For other two pinions 120 resp. 140 ft.lbs.

Wear of driving side of gear teeths seemed to be normal for all meshes of output section (both high and low speed meshes).

Ununiform wear of non-driving face of same teeths. Surface seemed to be scored slightly. Volvo promised to send photos to Boeing.

1.2 Engine no 1020

Also this engine had wheel rub of output turbine. Position three o'clock (same position as for no 1017, 1018 and 1019).

cont.

Timing of the output gears of this engine was the best one of the four engines (no 1017 - 1020) inspected up to now. The backlash was checked in accordance with the overhaul manual. The torque required for slightly tightening the lock nuts was thereafter checked. See table below.

Planetary pinion no	1	2	3
Angular position of output shaft			
A	0.0000	0.0000	0.0004"
B	0.0000	0.0008"	0.0000
C	0.0000	0.0000	0.0063"
Torque req'd for slightly tight'ng of locknut ft x lbs	210	220	180

Wear of high speed gears was considered as normal. Inspection of low speed gears via accessory drive openings of output casing revealed no wear of these gears either.

1.3 Volvo promised to investigate the driving conditions for the vehicles in question to find out whether excessive torque loads could have been imposed on the output coupling of engines 1017 - 1019.
Volvo also promised to collect information regarding the vehicle operation related to the thrust bearing failure of engine 1018.
The short report Volvo have received from the Army regarding the failure of engine 1018 was translated for Mr Evans.

cont.

2. PRINCIPLES OF ENGINE MOUNTING TO FRAME AND COMBINING GEARS OF THE POWER PACK.

2.1 Volvo reviewed the principles used for mounting the turbine engine to the frame and combining gears.
The effect of restraining the output casing at the flange, torsionally, was discussed.
Such restraining would mean that the engine structure could be twisted in case of a frame deflection due to ununiform temperature or similar as the two front mounts are bolted tight to the frame of the power pack without use of rubber mounts or similar.

2.2 Boeing was asked to consider the question of max permissible movements (tilt) of the front mounts in case the output section is fixed angularly.
Boeing was aslo asked to consider the question regarding max. permissible reaction torque on the turbine engine with respect to deflection of its structure. (What is the limitary factor at present, the strength of the engine structure or the torque capacity of taper joints of the planetary pinions?)

2.3 Drawings nr SK-HY-7091, 396369, 392219 and 57321 giving details of the coupling between the gas turbine and the combining gearbox was given to Boeing.
Volvo promised to give Boeing a diagram giving the characteristics of the layrub element used in this coupling.

3. TESTING OF TORQUE LOADS ON TURBINE ENGINE

Volvo informed Boeing that they had started preparations for testing the torque loads by means of strain gauges on the bolts at the front mounts.
The device was first to be calibrated at a bench test on the engine using a dynamometer connected to the output coupling. After further bench tests with an engine mounted in the complete power pack tests would finally be made in a vehicle.

cont.

Due to the tight test schedule for the vehicles it is not likely that this later test can be done before May.
Volvo asked Boeing to investigate whether there was another, better, position for strain gauges on the engine for measurement of reaction torque.

4. VEHICLE STEERING AND BRAKING SYSTEM AND TRANCIENT TORQUE LOADS CAUSED THEREOF.

4.1 The steering and breaking system was reviewed with Mr. Evans as well as the power train of the power pack.
The calculation method behind diagram nr 4112 and 4113 was described.
Volvo pointed out that the loads given on these diagrams were based on torque capacity of 800 kg.m for the clutches and 700 kg.m for the brakes given by Bofors.

4.2 Volvo promised to investigate whether the capacities of the brakes and clutches could have been higher than the rated values for the test vehicles at some driving conditions considering both slipping and breakaway torque.

4.3 In this connection Volvo mentioned that gear shifts were at first made only with both engines stopped but later (after March 63) with the engines at idle and the vehicle standing still.
Further, the freewheels have been locked since early 1962 when both engines are running. When the piston engine is running alone the freewheel of the gasturbine is open and vice versa (except when the gasturbine is used for starting the piston engine).

cont.

5. AIR INTAKE SYSTEM

5.1 An air intake box with guide vanes was studied in the laboratory.
Volvo promised to send latest issue of drawings 394630, 392963 and 392973.
The guide vanes are, however, not yet shown on any drawings.

5.2 Volvo mentioned that with engine no 1073 the following power was obtained at a bench test.

	Air inlet temp.	Atmosph press	Power	Exhaust temp.
Free inlet bell	+20°C	758 mm Hg	275	635°C
With complete intake system with intake louvres, oil cooler etc. but without the oil system connected	+28°C	760 mm Hg	240	638°C
Same as above but with the oil system connected	+28,5°C	760 mm Hg	222	652°C

5.3 Volvo mentioned that since October 1962 the test vehicles had only been operated without the intake system.
The preproduction series of vehicles are using the intake system including oil cooler and guide vanes.
The VK 155 vehicle (30 engine order) will, however, have oil to water cooling for the turbine engine.

6. INCLINATION TESTS

6.1 Volvo informed Boeing that some simple tests had just been carried out with a complete engine operated at different inclinations.

cont.

Photo nos 28040, 28041 and 28046 showing the test set-up was given to Mr. Evans.

6.2 Photo no 27869 of a previous, preliminary test set-up was also given to Boeing. This set-up consisted of a loose gas producer sump and a separate oil pump (gear-type) connected to the sump by transparent plastic tubes. The pump was sucking through the same hole in the casting as the ordinary gas producer pump is using in the complete engine.

6.3 The tests with the complete engine had showed two limiting factors as for inclined operation:

6.3.1 Oil breather submersion with sudden loss of oil via the breather tube as a result.
At high gas producer speeds and the engine inclined to the right with the gas producer low a sudden oil rejection through the breather pipe occurred (as this pipe is vented in direction towards the exhaust pipe the oil caught fire). Some figures as for the critical angles were given to Boeing.
Volvo promised to send Boeing further information on this point.

6.3.2 Low oil pressure.
Different combinations of inclinations length- resp. sidewise were tested to check the oil pressure at various gas producer and output shaft speeds. An oil strainer acc. to Beeing drg 46-13169 was used. Due to interference with the Helicoil insert the pilot dia of the strainer had however to be smaller, giving a diametrical clearance of approx. 0.013" to the bore in the sump.
At idle 10-12 psi was set as a lower limit and 20-22 psi at full speed. Some test results were given to Boeing.
Volvo promised to send further information on these tests.

cont.

6.4 Volvo mentioned that the results obtained from the inclination tests had made restrictions as for the operation of the vehicles necessary until a solution was found. The restrictions now means that at pitch angles above 20° no roll is permitted when the output section is low (with respect to the oil pressure) and with the gas producer low no roll is allowed to the right (due to oil breather submersion. Right as veiwed from output end of gas turbine).

7. MISCELLANEOUS

7.1 Volvo drew Boeings attention to the possibility of getti a too high oil level in the oil sump due to a risk of interference between the oil dip stick and a steel pipe through the sump. Some times the stick has passed above this pipe when checking the oil level instead of below, thus deflecting the stick uppwards giving a false indication of a necessity of oil to be added. (Note the risk of oil rejection due to breather submersion at inclined operation.)

7.2 The correct interpreting of the oil marks on the dip stick was discussed. Volvo mentioned that they estimated the decrease of the oil level due to filling up of the oil lines and part of the cooler when starting the engine after a longer storage to be about 19 mm (counted from the "full" mark) or ¾ litre. The cooler is designed to trap the oil when stopping the engine but some portion will be drained out.
Mr. Evans was of the opinion that the marks on the stick referred to the levels when the cooler and pipe were filled.

7.3 Boeing mentioned that a report from Boeing on burner tests and carbon build-up could be expected in February.

7.4 Volvo asked for the military specifications related to the oil temp. and EGT indicators. (This has been further dealt with in a later letter from Boeing).

cont.

7.5 The complete power pack as well as some components thereof were studied in the laboratory.
An air intake box with guide vanes was also shown to Mr. Evans.