

INVESTIGATION REPORT	Preliminary	☐
	Final	☒

Accident ☒
Incident ☐

Reference		Commercial File	N/A
Accident / Incident report	RIs 2017 / 033	Preliminary Information report A(I)	N/A

Data				
Date of occurrence	Occurrence place		Operator	
21-02-2017	Porto Rico		Helicorp Inc	
Aircraft type	S/N		Registration	
AS350B3	3228		N413LP	
Engine type	S/N	TSN	TSO	
ARRIEL 2B	22082	1809	N/A	
Accessories				
Designation, P/N	S/N	Work performed	TSN	TSO
HMU 0292861320 Assy valves 0292958050	701B 407B	Tests	N/C	N/C
Circumstances reported to SAFRAN HELICOPTER ENGINES				
While performing an autorotation training flight, during the power recovery phase, the pilot reported an overspeed and completed the autorotation by carrying out a hard landing. On the ground, the presence of fire was observed in the engine compartment. It was contained thanks to extinguishers.				
Conclusion				
The tests performed on the HMU and on the assembly valve did not reveal any discrepancy able to explain the event. The simulations performed by Safran HE design office were able to show that in case of twist grip activation towards the full range ("flight" mode to "emergency +" mode) the free turbine over speed until blade shedding event was reachable.				

VALIDATION		APPROVAL	
DATE	Validated by	DATE	Approved by
19 Sept 2017	D2S TEA	20 Sept 2017	DLS / TEA

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1 INTRODUCTION

The HMU and assembly valve were on the engine Arriel 2B s/n 22082 which was on-board of helicopter AS350B3 registration N413LP which suffered a serious incident in Puerto Rico on 21 February 2017.

In relation with the event, these two equipment were tested to check if they have any discrepancy, which has allowed an overflow and therefore a free turbine overspeed.

1.1 DATE & LOCATION OF THE HMU AND ASSY VALVE TESTS

Date : 10th May 2017

Location : SafranHE, Tarnos plant France

1.2 ATTENDEES

The following organisations were present during the tests:

- BEA
- French Airbus Helicopters
- French SAFRAN Helicopter Engines

1.3 OTHER INFORMATION

N/A

1.4 BRIEF OVERVIEW OF ENGINE MODULAR COMPOSITION

The Arriel 2 is a modular engine composed by 5 modules.

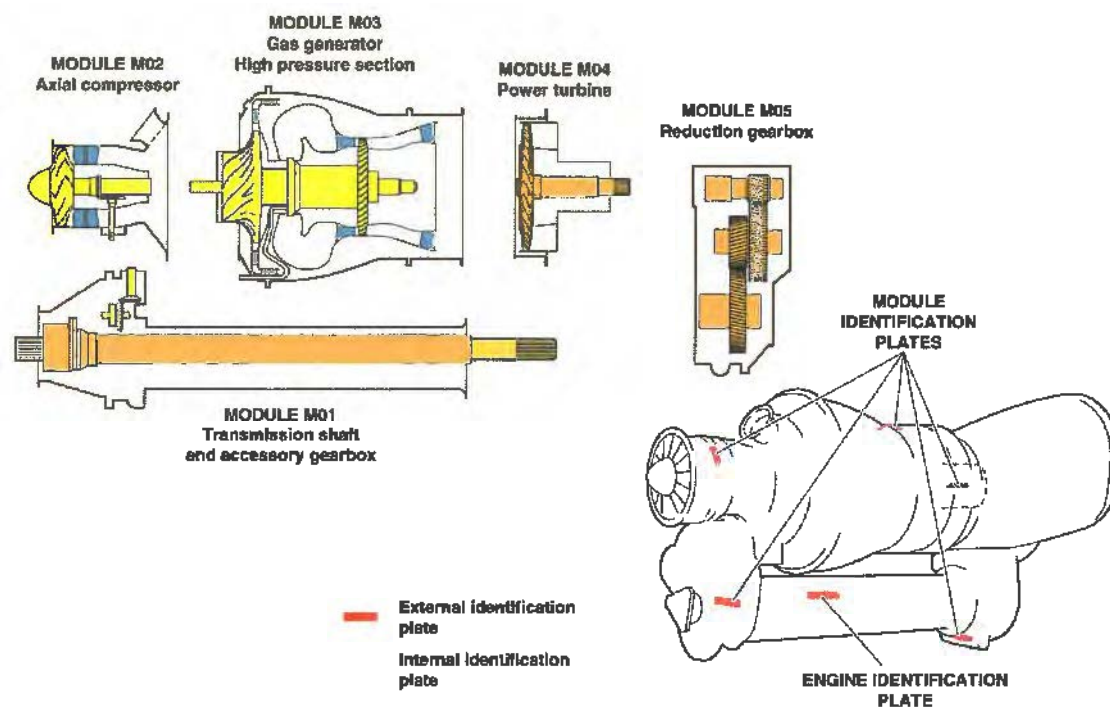
The module 01 is composed of an accessory gear box (driven by the gas generator) and a transmission shaft housed in a protection tube which connects the reduction gearbox to the accessory gearbox.

The module 02 is a single stage axial compressor.

The module 03 is a single stage centrifugal compressor with an annular combustion chamber and one axial turbine.

The module 04 is a single stage power turbine.

The module 05 is the reduction gearbox with three stages of helical gears.



2 PRELIMINARY CHECKS

2.1 EQUIPMENTS BOX

The HMU and the assy valve were delivered by BEA to Tarnos in a sealed box with BEA tape and also labels.

The box was opened in presence of the attendees of the investigations.



2.2 VISUAL CHECKS



Assembly valve



HMU

The assembly valve and the HMU are in good condition but quite dirty.

3 TESTS

All the tests were performed with requirements for new equipment.

3.1 HMU

Information:

Automatic mode: DECU controls the engine

Mixed mode: DECU compensates pilot input on the twist grip until it reaches its mechanical stop

Manual mode: the pilot controls the engine through the twist grip

Rotative effort Limiter

The HMU was found in good condition. It was installed on a test bench to perform tests. The first step was to verify the position of the rotative effort limiter. This part receives the power requested by the pilot in mixed mode and in manual mode (twist grip input). It was found clutched which is the normal position in operation.



The following tests were performed:

Automatic curve

See HMU tests page 2 table 2.1

In normal operation the engine operates with its DECU in automatic mode. The fuel flow is delivered to the engine accordingly to the automatic curve.

On this curve two points (at 20 and 25 l/h) are slightly out of tolerance. This out of limit, which is under idle level, does not explain the event.

Manual curve

See HMU tests page 8 table 7.1

This fuel flow Q versus P3 (air pressure at centrifugal compressor outlet called P2 or P3) curve is used when the engine is in manual mode and also in mixed mode to protect the engine from stall events.

The fuel flows are within limits.

Clutching areas and clutch transmission system

See HMU tests page 11 to 13 tables 11.1 to 11.3 and 12.1 and 13.1 and 15.1

These checks are in relation with the possibility of using manual and mixed modes. The checks show that clutching is possible in the tested conditions.

Maximum fuel flow on mechanic stop

See HMU tests page 3 table 2.7

This mechanic stop is an engine protection by limitation of the maximum fuel flow possibly delivered by the HMU to the engine. The maximum fuel flow associated to its mechanic stop is compliant.

Transient curve on ground and on altitude

See "Courbe altitude et sol"

These curves are about engine stall protection during quick acceleration.

A fuel flow (CH) limitation is done versus P2 value.

The acceleration must be within the upper blue curve (stall protection) and the lower green curve (slow acceleration).

These curves are used in manual and mixed modes.

The ground and altitude curves are partly out of limits and do not exceed the maximum fuel flow. The consequence is a reduction of the stall margin protection.

HMU tests conclusion:

The discrepancies found are not noticeable.

None of the discrepancies found could explain a free turbine overspeed.

3.2 ASSEMBLY VALVE



The following picture shows the different parts of the assembly valve and the different functions at each phase (stop, start, normal running, shut-down).

Starting:

When start is selected, the start electro-valve and the stop electro-valve are electrically supplied. The valves open and permit the fuel supply to the start injectors.

When there is sufficient pressure, the pressurizing valve opens and fuel flows to the centrifugal injection wheel.

When the engine reaches self-sustaining speed the electrical supply to the start electro-valve is stopped. The valve closes the fuel supply and opens the P2 air supply to ventilate the start injectors.

Normal running

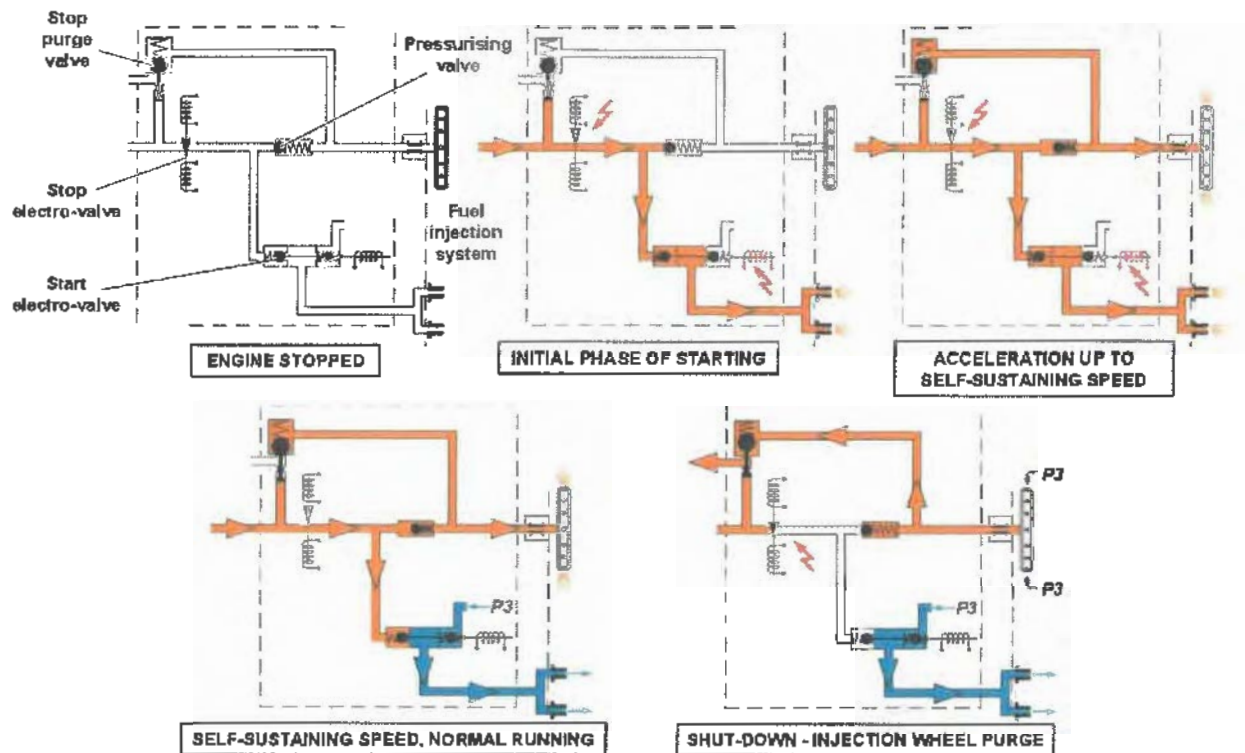
In this condition the fuel is supplied to the centrifugal injection wheel and the start injectors are still ventilated with P2 air.

Shut-down – Injection wheel purge

When Stop is selected:

- The stop electro-valve is energised and closed
- The pressurizing valve closed
- The injection wheel is no longer supplied with fuel
- The engine shuts-down
- The sudden but brief pressure rise, upstream of the stop electro-valve, causes the stop purge valve to temporarily open against its spring. The residual fuel is then returned to the tank.

As the fuel pressure decreases, the stop purge valve closes under the action of its spring.



FUEL VALVE ASSEMBLY - OPERATION

The first check was to verify the position of the shut off valve: it was found in closed position (normal position after engine shut down).

Assembly valve tests page 1 Table 1:

The pressure difference between start injectors (SID) and Injection wheel (SIP) is slightly out of minimum limit. The consequence is that the injection wheel receives the fuel slightly before normal operation. It has no consequence on engine operation.

Assembly valve tests page 3 table 6:

The leakage through the injection wheel (SIP) is out of limit. This happens during the start sequence. It has no effect on the engine governing.

The pressurizing valve, the start electro valve and the purge valve operations were found compliant.

4 HMU SIMULATION

The purpose of this chapter is to explore the possibility to reach the free turbine blade shedding speed in mixte mode in relation with the VEMD data. And also to evaluate twist grip and collective pitch values necessary to match NR and torque value recorded in the VEMD data.

The following calculations were performed with the HMU s/n 701B characteristics. Pressure 1013 mbar; temperature 26°C.

Information:

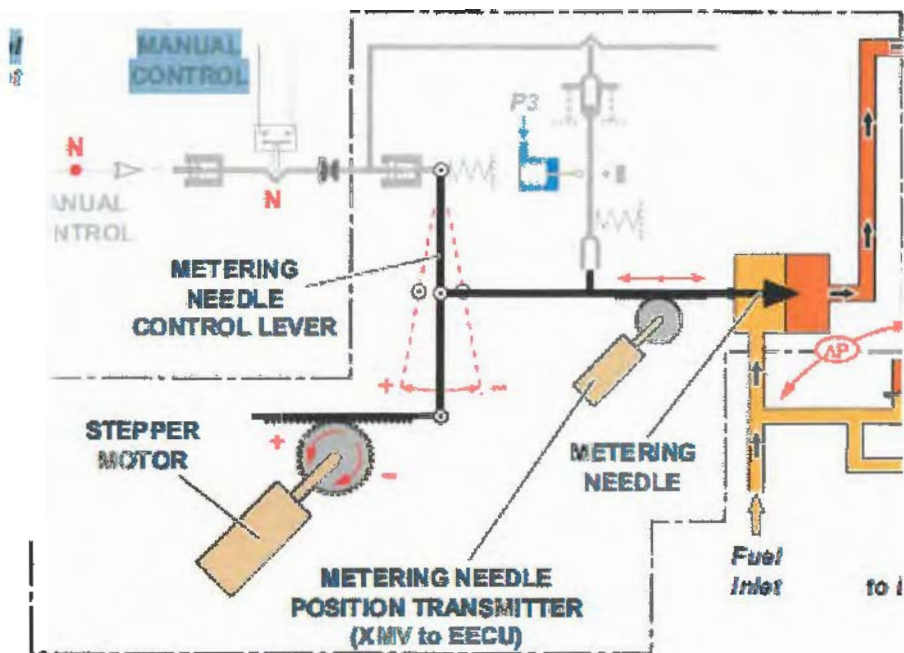
The required fuel flow is adjusted by a stepper motor actuator called "MPP" / Stepper Motor which activates the fuel flow needle (see here under schematic). This stepper motor could move from 0 to 530 increments ("inc.MPP"). Then it is on its mechanical stops.

"Alpha manuel": this is the twist grip position on the HMU; The correspondence is 0° to 40° on "alpha manuel" to 0° to 92° on the twist grip beyond the flight notch (0°). 92° is the twist grip mechanical stop

TG: twist grip

CH: fuel flow

XPC: collective pitch



4.1 REQUIRED ENGINE POWER 540 kW (BASED ON VEMD DATA AND AH CALCULATIONS)

On the VEMD, when NG A discrepancy occurred, the Failure 1/10 registered TQ 75.3% and NR 513 rpm. With these data Airbus calculated a required engine power equal to 540 kW.

The here under curve started at neutral mode with 150 kW power (the reached power and NR would have been the same starting at hovering power 280 kW; power calculated by Airbus).

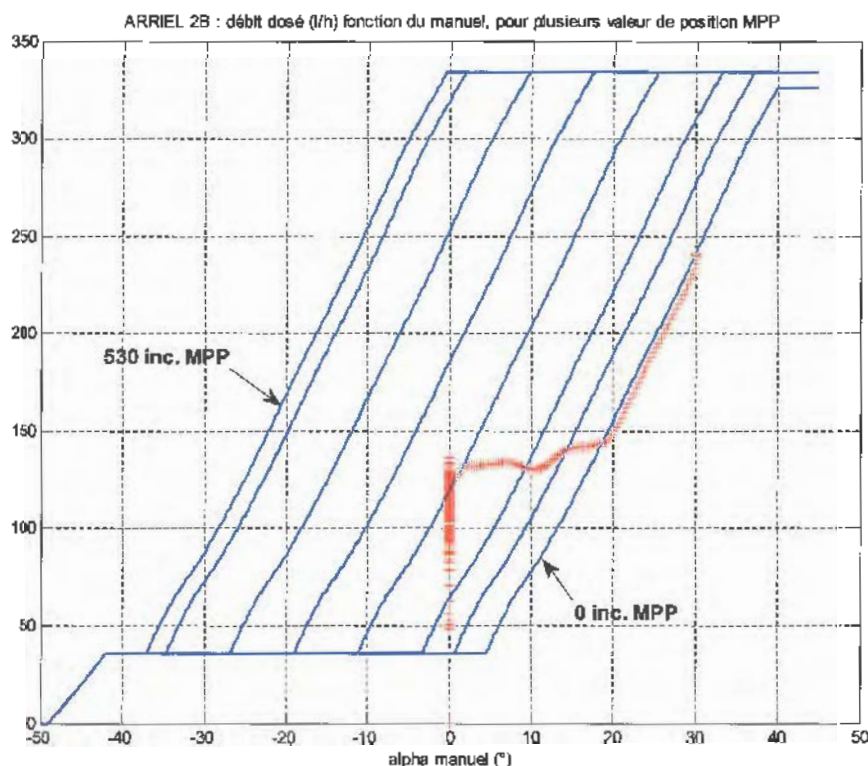
In these conditions, between twist grip 0° and 41° the DECU/ HMU were able to compensate a twist grip action until the stepper motor reaches its stop (0 inc.MPP). Between twist grip 41° and 69° the fuel flow increased to 241 l/h.

The fuel system was able to reach 540 kW engine power and 513 rpm for XPC value equal to 38%



and twist grip position of 69° above flight notch.

With the collective stick position corresponding to XPC value of 38%, the rotation of the twist grip from the flight notch towards the "emergency +" mode will first lead to a HMU compensation to maintain the nominal main rotor speed (390 rpm), then it will lead to the limit of the HMU compensation and to the main rotor overspeed (513rpm reached for twist grip 69°).



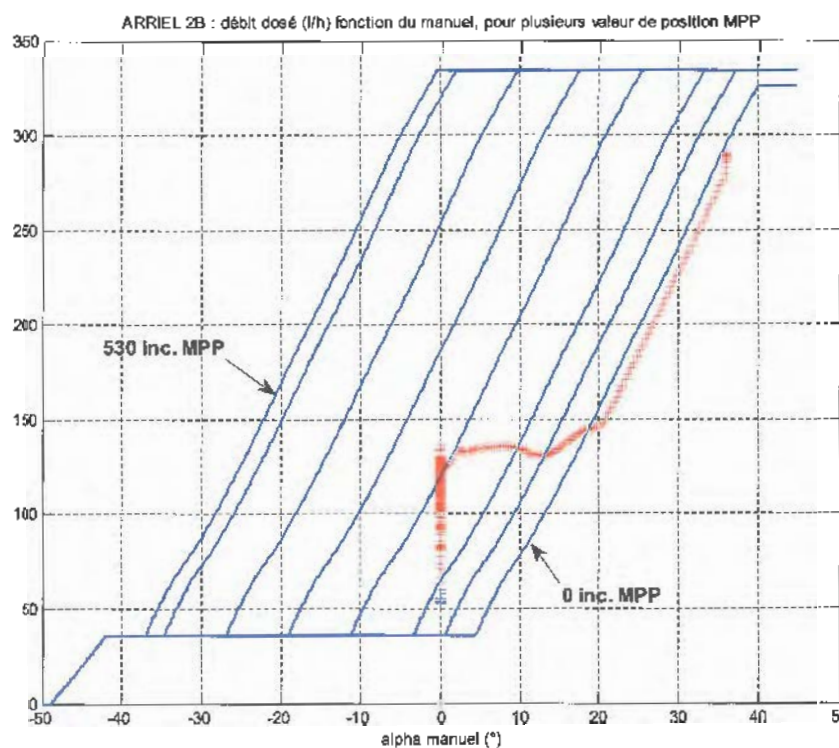
Alpha man		Twist grip
0	=	0
10	=	23
20	=	46
30	=	69
40	=	92

Fuel flow versus twist grip for different stepper motor position

4.2 REQUIRED ENGINE POWER 660 kW (BASED ON VEMD DATA AND AH CALCULATIONS)

On the VEMD when Invalid NF discrepancy occurred, the Failure 2/10 registered TQ 87.5 % and NR 545 rpm. With these data Airbus calculated a required engine power equal to approximately 660 kW. The here under curve started at neutral mode with 150 kW power (the reached power and NR would have been the same starting at hovering power 280 KW; power calculated by Airbus).

The fuel system was able to reach 660 kW engine power and NR 541 rpm for XPC value equal to 39% and twist grip position of 80° above flight notch.



Fuel flow versus twist grip for different stepper motor position

4.3 REQUIRED ENGINE POWER TO REACH BLADE SHEDDING LEVEL

The blade shedding speed is around NR 574 rpm (146%). To reach that value the required engine power is 770kW, for collective pitch within the range of 38-39% of the 2 previous cases (540kW and 660kW).

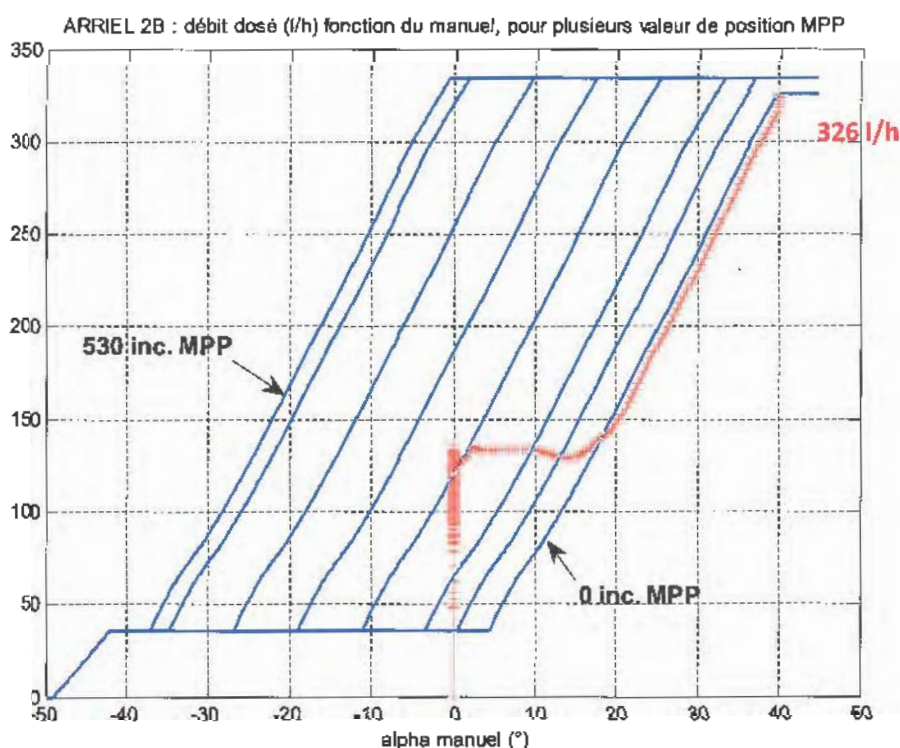
The here under curve started at neutral mode with 150 kW power (the reached power and NR would have been the same starting at hovering power 280 KW; power calculated by Airbus).

Then XPC was increased within 2 seconds to 38.5% whereas the manual was activated to twist grip 92° within two seconds.

Between twist grip 0° and 41° the DECU/ HMU were able to compensate a twist grip action but between twist grip 42° and 92° the fuel flow increased to 326 l/h.

The fuel system was able to reach 770 kW engine power and NR 574 rpm for a collective pitch value of 38.5% and a twist grip value of 92°.

This simulation evidenced that the pilot had the possibility to reach the blade shedding speed by turning the throttle towards the full range.



Fuel flow versus twist grip for different stepper motor position

4.4 SIMULATION TOOL

The simulation tool is not validated to such level of rotor speed, nevertheless it allows showing that the engine acceleration until the free turbine blade sheeding speed is possible in mixed mode.

5 CONCLUSION

The tests performed on the HMU and on the assembly valve did not reveal any discrepancy able to explain the event.

The simulations performed by Safran HE design office were able to show that in case of twist grip activation the blade shedding event was possible.

HMU tests
Assembly valve tests

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HMU S/N:	701B	W/O:		TEST OF HP/LP PUMP AND METERING VALVE
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1. Test of the HP/LP pump and metering valve assembly (TASK 73-23-03-703-001)

- A. Check of the metering valve and load limiter alignment in "neutral notch" position (TASK 73-23-03-773-001)

Table 1.1			
- Initial conditions			Tick off ☐ ☐
A			
B		$\Delta\alpha$	≤ 1.6
C			
		D	α accepted C $\pm 0.6^\circ$
		E	α accepted C $\pm 0.8^\circ$

For the test, refer to TASK: (73-23-03-773-001)

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B. Adjustment of metering valve flows in auto mode (TASK 73-23-03-773-001)

Table 2.1

HP/LP pump speed		Actuator		Resolver α in °		Pressure (kPa)			Q (l/hr)	
(%)	(rpm)	Hex. set point value	Decimal	Accepted	Read	Metering valve downstream pressure	LP outlet read	Metering valve ΔP read	Accepted	Read
10	1,188	000	0	353 ± 0.8		350			5^{+0}_{-5}	
16.5	1,960	014	20	356.5 ± 0.8		350			4 ± 2	
25	2,970	01E	30	358.2 ± 0.8	358.3	370	103		13^{+2}_{-3}	14.7
28	3,327	028	40	0 ± 0.8	0.02	385	115		20 ± 2	22.7
1	30	3,565	02E	1.05 ± 0.8	1.03	400	124		25 ± 2	27.3
	45	5,345	03C	3.5 ± 0.8	3.44	430	213		37 ± 3	38.5
	57	6,773	049	5.77 ± 0.8	5.78	475	> 270 315		46 ± 3	48
	68	8,080	064	10.5 ± 0.8	10.50	560	420		64 ± 4	65
	75	8,912	08C	17.5 ± 0.8	17.43	740	498		82 ± 4	84
	81	9,625	0B4	24.5 ± 0.8	24.58	920	564		108 ± 4	107
	85	10,100	0DC	31.5 ± 0.8	31.61	1,140	> 520 610		130 ± 4	132
	90	10,695	104	38.5 ± 0.8	38.64	1,350	663		157 ± 4	159
	92	10,932	12C	45.5 ± 0.8	45.88	1,580	693		183 ± 4	186.5
	95	11,289	154	52.5 ± 0.8	52.83	1,800	726		210.5 ± 4	212
	98	11,645	17C	59.5 ± 0.8	59.77	2,060	762		236 ± 4	239
	100	11,883	1A4	66.5 ± 0.8	66.87	2,380	787		265 ± 4	268
	101	12,000	1CC	73.5 ± 0.8	73.86	2,660	792		294 ± 4	296.5
	102	12,120	1F4	80.5 ± 0.8	80.34	2,900	806		318 ± 4	320
2	102.5	12,180	212	85.75 ± 0.8	86.18	3,110	> 720 808		330^{+8}_{-0}	337

For the test, refer to TASK: (73-23-03-773-001)

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- C. Reading of the metering valve flow in automatic mode, in a decreasing range
(TASK 73-23-03-773-001)

Table 2.6											
HP/LP pump speed		Actuator		Resolver α (degrees)		Pressure (kPa)	Q (l/hr)				
(%)	(rpm)	Hex. set point value	Decimal	Accepted	Read	Metering valve downstream pressure	Metering valve ΔP read	Read	Read on Table 2.1	Δ calculated Table 2.1 and 2.6	Δ accepted $\leq X$
102	12,120	1F4	500	80.5 ± 0.8	84.03	2,900		331	337	6	13
98	11,845	17C	380	59.5 ± 0.8	59.84	2,060		246	239	7	9
92	10,932	12C	300	45.5 ± 0.8	45.99	1,580		190.5	186.5	4	8
88	8,080	064	100	10.5 ± 0.8	10.17	560		65.7	65	0.7	5
30	3,565	02E	46	1.05 ± 0.8	1.13	400		27.5	27.3	0.2	4
											X

- D. Adjustment of the metering valve max. fuel flow to the mechanical stop
(TASK 73-23-03-773-001)

Table 2.7									
- Set point value: 245, resolver α read						A		Theoretical: $94.7 \pm 0.8^\circ$	
- Set point value: 247, resolver α read						B		Theoretical: $95 \pm 0.8^\circ$	
HP/LP pump speed		Actuator		Resolver α (deg.)		Pressure (kPa)		Q(l/hr) on mechan. stop	
(%)	(rpm)	Hex. set point value	Decimal	Accepted $A \pm 0.1^\circ$		Metering valve downstream pressure	LP outlet read	Metering valve ΔP read	Read
102.5	12,180	245	581	Adjusted: 94.76		3,350	801		361

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- E. Check of the metering valve fuel flow, following actuator de-energization
(TASK 73-23-03-773-001)

NOTE: After the actuator de-energization, the metering valve fuel flow must not increase by more than 2 l/hr.

Table 2.8								
Speed		Actuator		Resolver α (degrees)		Pressure (kPa)	Q (l/hr)	
(%)	(rpm)	Hex. set point value	Decimal	Theoretical accepted	Read	Metering valve downstream pressure	Read	Accepted
							Q l/hr	
100	11,883	1A4	420	66.5 ± 0.8	66,88	2,380	268,2	266 ± 4 l/hr
A 100	11,883			$\leq 66.5 \pm 0.8$	66,50	Read:	267,2	$\leq Q_{rel} + 2$ l/hr

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- F. Check of ΔP constant operation for N ranging from 5,800 to 6,300 rpm and 6,250 to 5,800 rpm with a flow of 46 l/hr (TASK 73-23-03-773-001)

Table 3.1					
Set point value for actuator	Res. alpha	N	Flow read	Metering valve downstream pressure	ΔP
Hexa read	Degree read	rpm	l/hr	kPa	kPa
Ø 46	513	6,100	46 ± 0.5	475	

Table 3.2						
Increasing N				Decreasing N		
N (rpm)	Q l/hr	Metering valve downstream pressure	ΔP	Q l/hr	Metering valve downstream pressure	ΔP
5,800	46,9	487		46	470	
5,850						
5,900						
5,950						
6,000						
6,050						
6,100						
6,150						
6,200						
6,250						
6,300	47,1	489				

Q max. (l/hr)	Read: 47,1	(for increasing and decreasing N)
Q min. (l/hr)	Read: 46	(for increasing and decreasing N)
(Q max. - Q min.) l/hr =	Calculated: 1,1	Accepted ≤ 2.5 l/hr

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- G. Check and adjustment of the microswitch operation to the neutral notch – Automatic and manual mode (TASK 73-23-03-773-001)

Table 4.1							
Initial conditions							
Manual control to the neutral notch	Set point value for actuator		Resolver α (degrees)		Q (l/hr)	Box lights	
	Hex.	Decimal	Theoretical	Read	Read	Acquisition of metering valve resolver α	Neutral notch, auto mode
0 °	154	340	52.5 $\pm$ 0.8			OFF	ON
Check of lever released from neutral notch position, in the acceleration range							
Metering valve resolver α for signal acquisition when control lever released from neutral notch position				Box lights			
				Acquisition		Neutral notch, auto mode	
Accepted: $\leq$ 54.5		Read: 53,84		ON		OFF	
Check of return to neutral notch position in AUTO mode							
Accepted: $\leq$ 54.5		Read: 53,17		ON		ON	
Check of lever released from neutral notch position, in the deceleration range							
Accepted: $\geq$ 50.5		Read: 51,55		ON		OFF	
Check of return to neutral notch position in AUTO mode							
Accepted: $\geq$ 50.5		Read: 52,11		ON		ON	

- H. Rotary load limiter. Check of mechanical stops: full flow stop and engine shut-down (SUB-TASK 73-23-03-773-001)

NOTE: To be read during the tests.

Table 5.1		
Neutral notch of the rotary load limiter	Low stop (engine shut-down), deceleration range	Full flow stop, acceleration range
0°	30.4 mm ± 0.05	+ 22.33 mm ^{+0.26} / ₊₀
0°	Read: 30.4	Read: 22.45

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- I. Adjustment of the anti-flame out stop (A). Check of the fuel flow at low stop > 21 l/hr (B). Check of the protection device clutch transmission system at low flow (*) (TASK 73-23-03-773-001)

Initial conditions before engaging the clutch transmission system

Table 6.1				
Set point values to be set			Adjusted acceleration limiter, P3 to be set in kPa	Clutch torque read on tool (N.m)
Automatic mode, neutral notch position				
Actuator set point value (hex.)	Metering valve resolver α read	Q (l/hr)		
212	86,17	> 310	800	1,9
154	51,78	210	460	2,7
056	8,14	56,8	130	2,2
04A	6,08	50,1	130	2,5

* 044	4,94	Read	130
		45.5	

		≤ 3
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Table 6.2								
Conditions to be set								
C Automatic mode, neutral notch position			B			A		
Actuator set point value (hex.)	Metering valve resolver α angle read	Q (l/hr)	Metering valve resolver α angle read	Q (l/hr), read	Q (l/hr), accepted	Metering valve resolver α angle read	Q (l/hr) read	ΔP in kPa, read
212					21 ≤ Q ≤ 40	2,67	35,2	
154	52,85	213				2,91	36,4	
056	8,18	57,3				2,93	36,6	
04A	6,13	50,5				2,36	34	

*		Read				2,40	34,1	
		45.5					Accepted	32 ≤ Q ≤ 40

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J. Adjustment of the acceleration limiter to max. stop = relative f(P3) (TASK 73-23-03-773-001)

Table 7.1							
N (rpm)	Q (l/hr)	P3 relative kPa	Met. valve downstream pressure in kPa	Hexa set point value read	resolver α read	Q (l/hr), read	Metering valve ΔP (kPa), read
Initial values to be set, before the clutch device is engaged: rack to neutral notch – light ON							
11,829	147	345	1,200	0FO	35,04	147	
Values below to be set after engaging the clutch device				Q(l/hr) read = increasing f(P3)			
N (rpm)		P3 relative kPa	Metering valve downstream pressure in kPa	Q (l/hr), to be obtained		Q (l/hr), read	
8,888	Increasing P3 ↓	103	770	83 $\begin{smallmatrix} 0 \\ -8 \end{smallmatrix}$		83,5	
10,171		174	920	104 $\begin{smallmatrix} 0 \\ -11 \end{smallmatrix}$		99,5	
11,098		237	1,120	131 $\begin{smallmatrix} 0 \\ -13 \end{smallmatrix}$		123	
11,829		345	1,500	180 $\begin{smallmatrix} 0 \\ -13 \end{smallmatrix}$		170	
11,873		449	1,820	222 $\begin{smallmatrix} 0 \\ -15 \end{smallmatrix}$		212	
12,000		536	2,270	259 $\begin{smallmatrix} 0 \\ -16 \end{smallmatrix}$		251	
12,138		618	2,600	292 $\begin{smallmatrix} 0 \\ -15 \end{smallmatrix}$		290	
12,180		734	3,110	338 $\begin{smallmatrix} 0 \\ -8 \end{smallmatrix}$		330	

Table 7.2					
Position of the read value of α control axle	Hex. set point value read	Metering valve resolver α angle	Flow in l/hr	Metering valve downstream pressure, read in kPa	P3 relative kPa read
0° neutral	0CD	28.8° ± 0.8	> 110	990	380
		Read: 29,31	Read: 123,4		
Acceleration range 22.33 mm	0CD	Read:	75 $\begin{smallmatrix} 0 \\ -5 \end{smallmatrix}$	620	0
			Adjusted: 84,9		

For the test, refer to TASK: (73-23-03-773-001)

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K. Sealing test between the fuel chamber and P3 body (TASK 73-23-03-773-001)

Table 8.1		
No fuel in P3 body	Tick off	☐

For the test, refer to TASK: (73-23-03-773-001)

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- L. Check of the clutch transmission system, in the acceleration range, for P3 min., with lever in neutral notch position (TASK 73-23-03-773-001)

Table 9.1

N (rpm)	Q (l/hr)	P3 relative (kPa)	Metering valve downstream pressure (kPa)	Hex. set point value read	Resolver α read	Q (l/hr) read	Auto light ON Tick off
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Condition to be set before the clutch device is engaged:

9,800	120	388	990				☐
-------	-----	-----	-----	--	--	--	--------------------------

Table 9.2

Set	Test A		Test B
P3 relative kPa	Auto light		Clutch torque, in the acceleration range ≤ 4.5 N.m Read:
	ON	OFF	
	Tick off	Tick off	
110	☐	☐	
120	☐	☐	
130	☐	☐	
140	☐	☐	
150	☐	☐	
160	☐	☐	
170	☐	☐	
180	☐	☐	
190	☐	☐	
200	☐	☐	
210	☐	☐	
220	☐	☐	
230	☐	☐	
240	☐	☐	

Values to be set after the clutch device is engaged:

Values to be read:

Table 9.3		
N (rpm)	P3 relative kPa	Metering valve downstream pressure
12,180	734	3,110

Q l/hr requested	Q l/hr read	Metering valve ΔP (kPa)
338 $^{+0}_{-8}$		

For the test, refer to TASK: (73-23-03-773-001)

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N. Check of the protection clutch at Q max. = f(P3) (TASK 73-23-03-773-001)

Table 11.1							
N (rpm)	Q (l/hr)	P3 relative kPa	Metering valve downstream pressure (kPa)	Hex. set point value read	α of resolver read	Q (l/hr) read	Metering valve ΔP (kPa) read
Condition to be set before the clutch device is engaged:							
11,752	131.7	287	1,080	009	34,05	131,7	
Clutch torque, neutral notch position in the acceleration range: Values to be set after the clutch device is engaged				$\leq 3 \text{ N.m}$	Read: 1,9		
Values to be read							
N (rpm)	P3 relative kPa	Metering valve downstream pressure (kPa)		α metering valve resolver read	Q (l/hr), to be obtained	Q (l/hr), Read	Metering valve ΔP (kPa)
12,180	734	3,110		83,10	338 $^{+0}_{-8}$	329	

Table 11.2							
N (rpm)	Q (l/hr)	P3 relative kPa	Metering valve downstream pressure (kPa)	Hex. set point value read	α of resolver read	Q (l/hr) read	Metering valve ΔP (kPa) read
Condition to be set before the clutch device is engaged:							
11,752	149.4	325	1,240	0F2	35,63	149,1	
Clutch torque, neutral notch position in the acceleration range: Values to be set after the clutch device is engaged				$\leq 3 \text{ N.m}$	Read: 1,7		
Values to be read							
N (rpm)	P3 relative kPa	Metering valve downstream pressure (kPa)		α metering valve resolver read	Q (l/h), to be obtained	Q (l/h), Read	Metering valve ΔP (kPa)
12,180	734	3,110		83,45	338 $^{+0}_{-8}$	330	

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Table 11.3							
N (rpm)	Q (l/hr)	P3 relative kPa	Metering valve downstream pressure (kPa)	Hex. set point value read	α of the resolver read	Q (l/hr) read	Metering valve ΔP (kPa) read
Condition to be set before the clutch device is engaged:							
11,752	173.3	373	1,450	118	42,14	173,1	
Clutch torque, neutral notch position in the acceleration range:				$\leq 3 \text{ N.m}$	Read:	2,1	
Values to be set after the clutch device is engaged				Values to be read			
N (rpm)	P3 relative kPa	Metering valve downstream pressure (kPa)	α of metering valve resolver read	Q (l/hr), to be obtained	Q (l/hr), Read	Metering valve ΔP (kPa)	
12,180	734	3,110	84	338 $\begin{smallmatrix} +0 \\ -8 \end{smallmatrix}$	332		

- O. Check of the clutch transmission system to acceleration for metering valve flow in auto mode 20 l/hr. Make sure the flow obtained is > 320 l/hr (TASK 73-23-03-773-001)

Table 12.1								
Manual control to the neutral notch Condition to be set after clutching				Manual control lever on Q max. stop Check Q > 320 l/h				
Actuator set point value (hex.)	α of the metering valve resolver read	Q to be set 20 l/h	Clutch torque on C.m $\leq 3 \text{ N.m}$	P3 (kPa), set	Q (l/h) read	Q (l/hr) read	Metering valve ΔP (Kpa) read	α of the metering valve resolver read
024	359,31	Read: 20,6	Read: 1,0	734	328 Q > 320	3,110		82,76

- P. Check of the clutch transmission system engagement in the deceleration range for OEI 30s ISA + 38 with a margin of + 20 l/hr (TASK 73-23-03-773-001)

Table 13.1							
Position of the rack (mm)	Q (l/hr) to be set	Q (l/hr) read	Metering valve downstream pressure (kPa), to be set	Metering valve ΔP (kPa) read	P3 (kPa) to be set	α of the metering valve resolver, read	Set point value for actuator (hex), read
Initial condition: Manual control lever to the neutral notch							
0	151.7	151,7	1,240		287	36,37	0FB
Clutch torque on C.m			$\leq 3 \text{ N.m}$	Read:	1,9		
Check, C.m in deceleration range							
22.33		36,12	500		100	2,85	
		Accepted 32 < Q < 50					

For the test, refer to TASK: (73-23-03-773-001)

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Q. Check of return to auto mode after manual shut-down (TASK 73-23-03-773-001)

Table 14.1	
Test conditions	
Rack in the deceleration range	Actuator set point value (hex.)
30.4 mm	056
Light OFF	

Check return to auto mode			
Rack to neutral notch	Light ON in auto mode		α of metering valve resolver read
$0^\circ \pm 0.05$	Yes	☒	8.57
		Tick off	

R. Check of the clutch travel areas during shut-down and check of the return to the neutral notch in auto mode (TASK 73-23-03-773-001)

Table 15.1									
Initial conditions to be set before clutching							≤ 2 mm	Check of return to auto mode	
Test	Manual control travel	Actuator set point value (hex.) obt.	Actuator set point value (dec.)	Actuator set point value (hex.)	Resolver α accepted	Resolver α read	Light OFF	α read	Light ON
							Tick off		Tick off
A	Decel.	04A	74		≥ 6.05	6.73	☒	6.50	☒
A1	Accel.	04A	74		≥ 6.05	6.50	☒	6.80	☒
B	Decel.	056	86		☒	☒	☒	8.77	☒
B1	Accel.	056	86		☒	☒	☒	8.79	☒
		Accepted			Read	Obt.			
C	Decel.	≤ 062			05C	10.05	☒	9.62	☒
C1	Accel.	≤ 062			05C	10.05	☒	9.96	☒

For the test, refer to TASK: (73-23-03-773-001)

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- S. Leak test through air vent of the HP/LP pump shaft sealing ring (TASK 73-23-03-773-001)

Table 16.1				
Manual control to neutral notch			Actuator set point value 212 (hex.)	
Priming pressure at the LP pump inlet (rel. kPa)	N	rpm	Metering valve downstream pressure	Leak accepted ≤ 4 ml/hr
150	0 %	0	0	
50	0 %	0	0	
50	102.5 %	12,180	3,110	

- T. Check of the drain valve operation (TASK 73-23-03-773-001)

Table 17.1	
Valve open, drain flow in l/hr	$24 \leq Q \leq 33$
	Read:
Drain valve closing	150^{+30}_{-0} kPa
	Read:
Drain valve sealing	3 drops. max. in 60 s
	Read:

- U. External sealing test of the HP/LP pump assy (TASK 73-23-03-773-001)

Table 18.1		
- External sealing (no leakage observed)	Tick off	

- V. Sealing test of P3 chamber under 16^{+2}_{-0} kPa (relative pressure) (TASK 73-23-03-773-001)

Table 20.1		
P3 chamber is tight	Tick off	☐

For the test, refer to TASK: (73-23-03-773-001)

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W. Check of the sealing ring of the HP/LP pump (TASK 73-23-03-773-004)

Table 21.1		
	Air pressure relative to the air vent ring circuit (kPa)	Sealing of the ring
18^{+2}_{+0}	Air pressure OK ☐	OK ☐

X. Check of the resisting torque of the HP/LP pump (TASK 73-23-03-773-001)

Table 22.1		
Torque ≤ 0.15 N.m.	Read:	☐

Y. Check of the bonding resistance for a 10 A testing current (TASK 73-23-03-465-002)

Table 23.1		
Bonding resistance between the resolver connector and the seating face	$< 2.5 \text{ m}\Omega$	
Bonding resistance between the actuator connector and the seating face	$< 2.5 \text{ m}\Omega$	
Bonding resistance between the microswitch connector and the seating face	$< 2.5 \text{ m}\Omega$	
Bonding resistance between the fuel LP pressure switch connector and the seating face	$< 2.5 \text{ m}\Omega$	
Bonding resistance between the pre-blockage pressure switch connector and the seating face	$< 2.5 \text{ m}\Omega$	

For the test, refer to TASK: (73-23-03-773-001)

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REJECT OF PARTIAL BENCH No. _____

Problem met during the test

	Code
Comments:	

Partial test bench operator

<i>Date:</i>	<i>Stamp:</i>
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Corrective action implemented

	Code
Comments:	

<i>Date:</i>	<i>Stamp:</i>
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Repair performed on the HMU

	Code
Comments:	

Assembly operator

<i>Date:</i>	<i>Stamp:</i>
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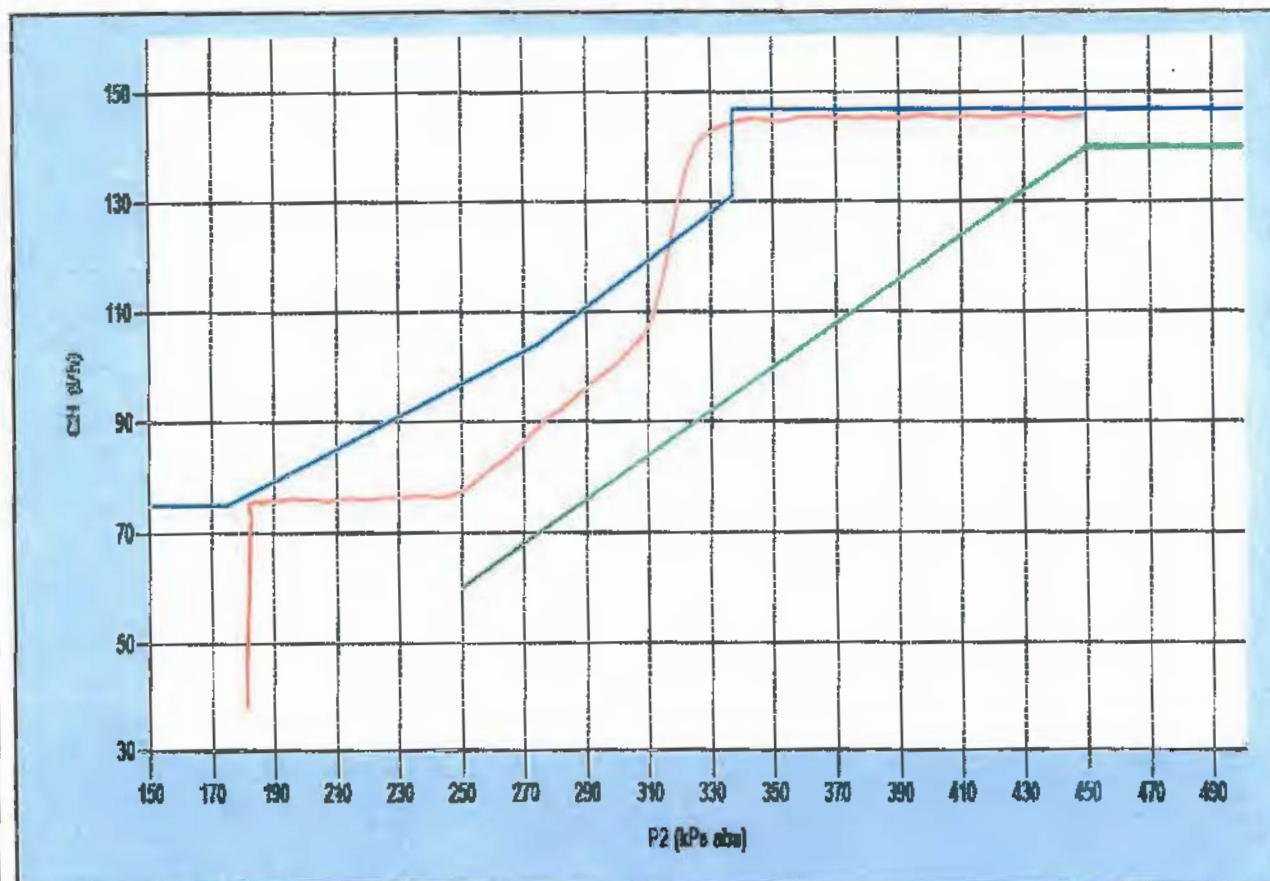
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DATE	OPERATEUR	CONTROLEUR	COURBE - TABLEAU	N° Individuel de l'ensemble :	701B
11/05/2017	SARRIAS		ARRIEL2B	Référence :	0292861320

Limiteur d'accélération (ALTITUDE)



Valeurs initiales :

CH : 38.0
P2 : 181.3

l/h
kPa abs

Valeurs finales :

CH : 145.7
P2 : 449.0

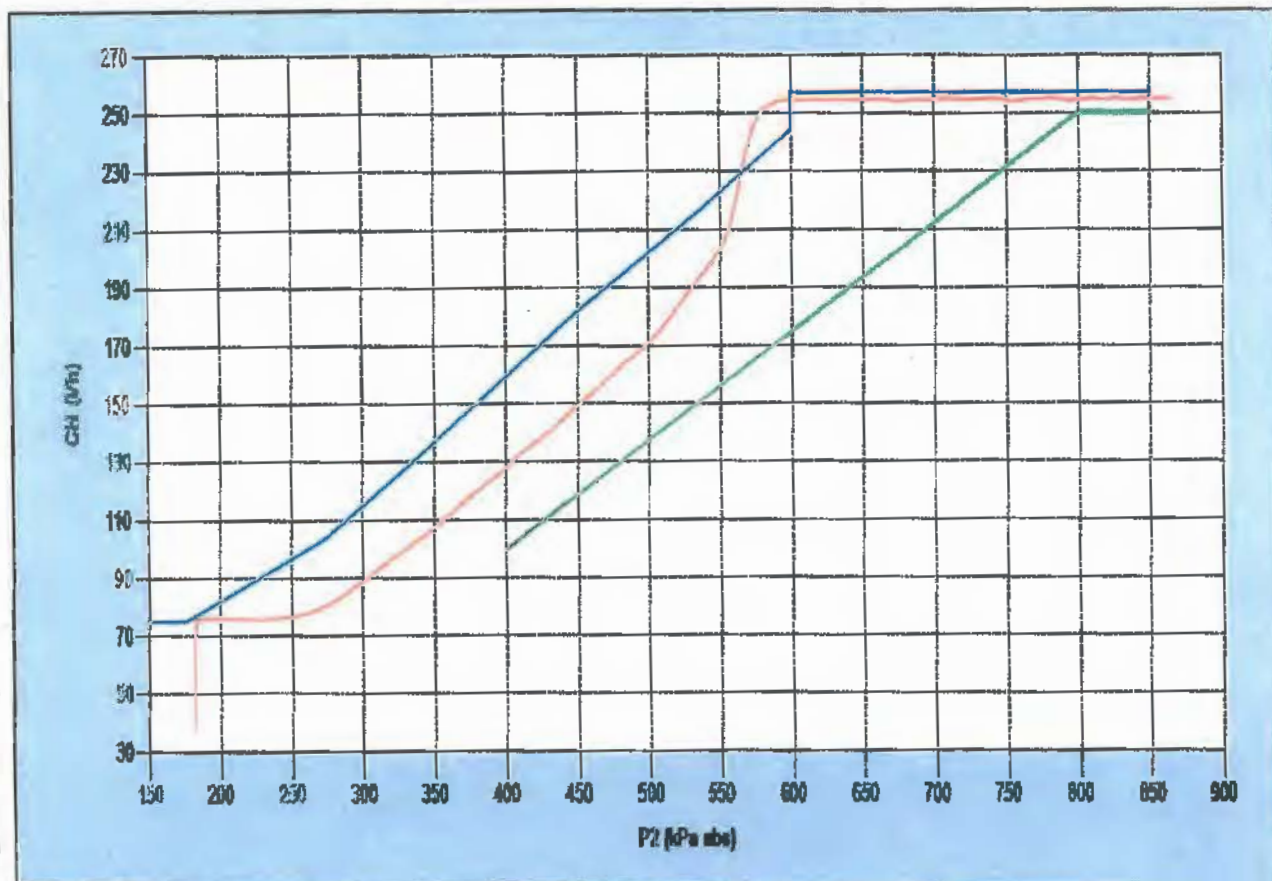
l/h
kPa abs

TURBOMECA

Selon CCT : 73.23.03 - Edition : 26
TM2335G001 - TL0327P101 - TL0322Px04

DATE	OPERATEUR	CONTROLEUR	COURBE - TABLEAU	N° individuel de l'ensemble :	
11/05/2017	SARRIAS		ARRIEL2B	Référence :	701B 0292861320

Limiteur d'accélération (SOL)



Valeurs initiales :

CH : 37.2
P2 : 182.0

l/h
kPa abs

Valeurs finales :

CH : 254.5
P2 : 863.8

l/h
kPa abs

TURBOMECA

Selon CCT : 73.23.03 - Edition : 26
TM2335G001 - TL0327P101 - TL0322Px04

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S/N:	407B	W/O:		TEST OF THE VALVE ASSEMBLY
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1. Test procedure of the valve assembly (Task 73-14-01-770-001)

NOTE: During the tests, the adjusted valve assembly must be installed in the horizontal position on the test bench.

A. Check of the pressurizing valve calibration (Sub-Task 73-14-01-770-011)

- Stop electro-valve open
- Start electro-valve energized

Table 1		
Flow through SIP	ΔP between SID and SIP (kPa)	
(l/hr)	Accepted	Read
20	$300 \leq \Delta P \leq 320$	284
350	$450 \leq \Delta P \leq 550$	505

B. Sealing of the pressurizing valve (Sub-Task 73-14-01-770-014)

- Stop electro-valve open
- Start electro-valve energized

Table 2		
Pressure in SID (kPa)	Leakage accepted through SIP (l/hr)	Leakage measured
150	0.04 max.	0 drop

C. Check of the strainer and stop electro-valve ΔP (Sub-Task 73-14-01-770-015)

- Stop electro-valve open
- Start electro-valve energized

Table 3		
Flow through SIP l/hr	ΔP between EC and SID (kPa)	
	Accepted	Read
350	< 200	131

ECD Leo Ruge

For the test, refer to Task: (73-14-01-770-001)

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D. Check of the start electro-valve (Sub-Task 73-14-01-770-016)

- Stop electro-valve open
- Start electro-valve de-energized
- SID tool valve closed

Table 4				
	Flow through SIP	Pressure in EC	Leakage through P2 air vent	
	(l/hr)	(kPa)	Accepted	Read
	35	$975 \leq P \leq 1\,025$	10 drops max.	1 drop

E. Check of the SID fuel sealing (Sub-Task 73-14-01-770-016)

- Stop electro-valve open
- Start electro-valve de-energized

Table 5			
Pressure in EC	Flow through SIP	Leakage through SID	
(kPa)	(l/hr)	Accepted	Read
500	20	5 drops	2 drop / min
1,000	50	5 drops	1 drop / min
3,800	150	5 drops	1 drop / min

For the test, refer to Task: (73-14-01-770-001)

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F. Check of the stop electro-valve (Sub-Task 73-14-01-770-017)

- Stop electro-valve open
- Start electro-valve de-energized

NOTE: Do not re-open the stop electro-valve when the valve assembly is under pressure.

Table 6

Flow (l/hr)	Set SIP (kPa)
Theoretical 350 Flow read: 350	3,700

- Disconnect the SIP pressure gauge; close the stop electro-valve and record.

P at EC (kPa)		Leakage through automatic drain (kPa)		Stop time	
Accepted	Read	Accepted	Read	Max.	Read
5,200 max.	4445	20 cm ³ max.	1	40 ms	39,9

- Record the leakage through SIP

Leakage through SIP in 1 mn	
Accepted	Read
10 drops max.	3 ml/min

Stop electro-valve closed	Yes ☐	No ☐
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F. External sealing check (Sub-Task 73-14-01-770-018)

Sealing conforming	Yes ☐	No ☐
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REJECT OF PARTIAL BENCH No. _____

Problem met during the test

	Code
Comments:	

Partial test bench operator

Date:	Stamp:
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Corrective action implemented

	Code
Comments:	

Date:	Stamp:
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Repair performed on the valve assembly

	Code
Comments:	

Assembly operator

Date:	Stamp:
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