EASA Safety Conference
15th October 2013

- Non-desired effects of anti-icing fluids
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Statens haverikommission
Swedish Accident Investigation Authority

Incidents to BAe ATP aircraft from West Air Sweden and Next Jet Sweden.

The aircraft

- BAe ATP is a medium-sized turboprop aircraft for cargo and passenger operations.
- The aircraft is a development of the older HS 748.
- 64 aircraft was built during the years 1988 – 1996.
- Around 25% of the existing fleet is in service with two Swedish carriers.

Background

- With start in december 2009 SHK received a number of reports with similar operational symptoms.
- “Stuck” – or restricted elevator movement at Vr during T/O roll. Sometimes causing ”Elevator split”.
- Decision was taken to launch an investigation, based on an incident at HEL on January 11th 2010 involving A/C SE-MAP operated by West Air Sweden. On request the investigation was formally delegated to SHK by the Finnish AIB.

Additional incidents

- A compilation of occurrences were directly reported to SHK from West Air Sweden.
- During the communication with West Air it came to hand that similar incidents had occurred in another airline, Next Jet Sweden.
- The incidents appeared to be similar and occurred under the same conditions.
- Some of the incidents had been reported to the PI for Next Jet only, and had not been forwarded to CAA (Transportsyrelsen NRK) or SHK.

Reported incidents

Date	A/C	Airport	Incident	Result	De/Anti-icing	More
25 jan 07	LPV	BGO	Diff. rot. Elev split	Flight	I + II	
16 mar 09	LNX	BGO	Very heavy. Gap ice	Flight	Unknown	Diverted
30 nov 09	LLO	AJR	Diff. rot. Elev split	Flight	I + II	
10 dec 09	MAP	CPH	Diff. rot Elev split	Aborted T/O	I + IV	Third occ For CMD
22 dec 09	MAP	HEL	Diff. rot Elev split	Aborted T/O	I + IV	Two T/O attempts
23 dec 09	LLO	AJR	Diff. rot. Elev split	Aborted + Flight	I + II	Near accident
11 jan 10	MAP	HEL	Diff. rot. Elev split	Aborted T/O	I + II	
18 mar 10	LLO	HMV	Diff. rot. Elev split	Flight	I + II	Diverted
20 Oct 10	LLO	AJR	Diff. Rot. Elev. split	Flight	I + II	Diverted

”Near accident”

- A/C had been treated with type I/II before take off from a small airport in northern Sweden. Co-pilot was pilot flying.
- When Vr (99 kts) was reached the co-pilot tried to pull back the control column to rotate.
- The column was stuck at approx neutral position and the aircraft showed no sign of responding.
- The co-pilot pulled harder and informed the commander that ”something is wrong”. Speed was approx 10 – 15 knots above Vr.

”Near accident”

- The Commander took over the controls and pulled back the throttles in order to abort the take off.
- Simultaneously, and in that very same instant, the elevator systems split.
- The A/C lifted off the runway (near the runway end) with retarded throttles and only half elevator capacity.
- Thanks to the excess speed and the quick decision from the Commander to immediately give full power again, the A/C was kept airborne.

Investigation – common conditions

- Problem diagnostics:

- - Elevator stuck/restricted travel
- - Speeds around Vr or higher
- - Causing ”Standby controls” and/or ”split”
- - Only during winter conditions
- - Only in temperatures around 0° C.
- - Only after de icing of aircraft
- - Only after de/anti icing with type II/IV
- - Free elevator travel before and after T/O run

Continiued technical investigation

- Elevator and stabilizer investigated without remarks,
- Control columns and wiring systems investigated without remarks,
- Control Columns split – mechanically, via force or via Relief handle investigated without remarks. (At split, R/H Elevator can be maneuvered by the A/P Elevator Servo Motor from the R/H Control Column).

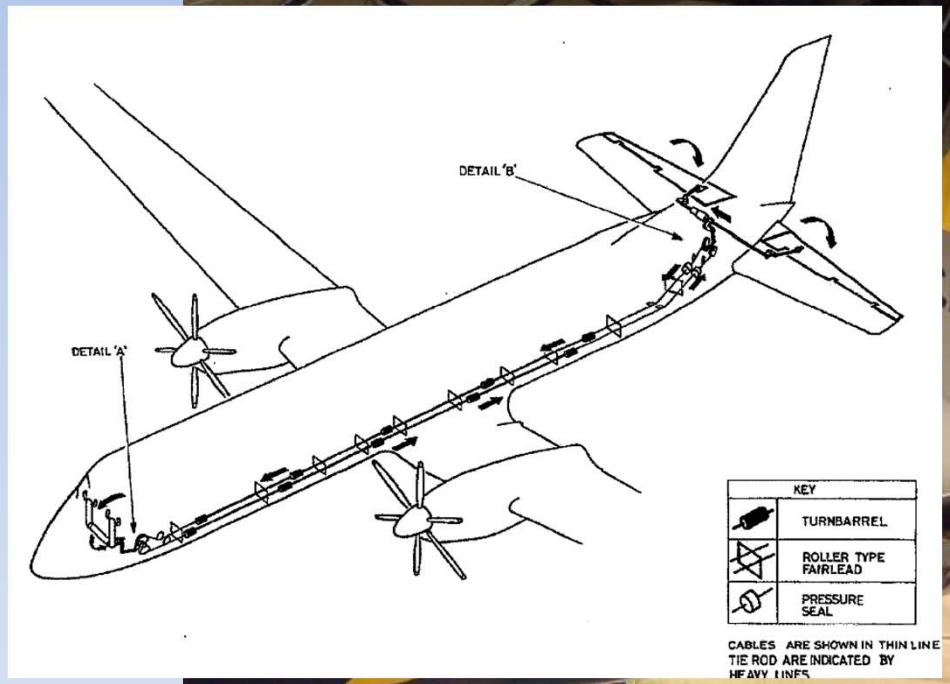
Continiued investigation

- Residuals from type II/IV fluids √
- Take-off techniques and routines √
- A/C out of balance (nose heavy) √
- Runway conditions (contaminations) √
- Slush from main wheels (sprayed on stabilizor) √
- But:
- No possible causes found…..

Other investigations

- As one of the common factors was anti-icing with type II/IV we examined the fluids used.
- No remarks on the fluids. Type II and IV from different brands were thoroughly tested at a laboratory. (Samples were taken from the smaller airports)
- There must be something else…..
- We noted that *not all A/C individuals* in the operators fleets were affected by these problems.
- We started to look at the incident aircraft individually…

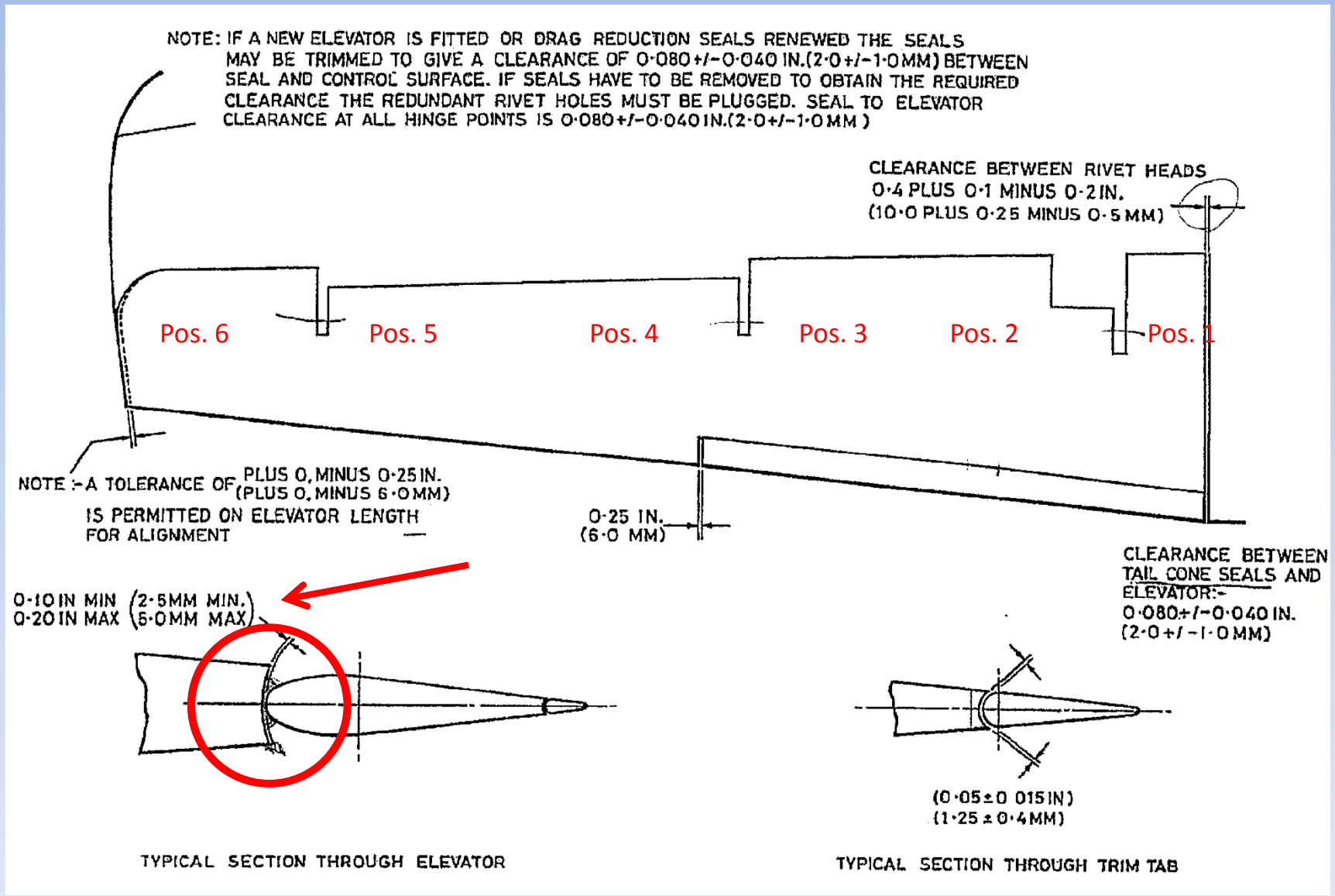
Brief technical review



Conventional type of stabilizor section (NPE)

Command signals to elevator via cable system from L side

Pre test measurements



Technical examiations

- All the affected A/C individuals had an average clearence between stabilizor and elevator that was **less** than the determined minimum gap according to AMM.
- This implied a real ”break through” in the investigation, but how to proceed…?
- As the incidents always had occurred in connection with two step deicing, we started with a look at the different fluids used on the aircraft.

De- and anti- icing fluids

- SAE (G-12 ADF) develop standards, specifications and recommended practices regarding de- and anti-icing fluids.
- Type I is tested according to AMS 1424 (low speed ramp test), V_R speeds 60 to 100 kts.
- Type II, III and IV is tested according to AMS 1428 (high speed ramp test), V_R speeds 100 kts or above).
- FAA and TC yearly publishes a list of “qualified fluids”. This list is also used by AEA. There is no certification of de- and antiicing fluids.

De- and anti- icing fluids

- Type I fluids consists of glycol (propylene), mixed with hot water and is mainly used for de-icing of aircraft.
- Type II, III and IV fluids are so called pseudoplastic fluids where thickening agents are added to the glycol to increase the viscosity and are mainly used for anti-icing purposes. Viscosity values are between 300 (type III) up to about 30.000 (type IV) mPa.s.
- The agents consists of polymeres, that could be described as molecules that will shear when the stress from the increased air pressure during take off is high enough. The fluid will then literally return to type I and flow of the aircraft surfaces.

De- and anti- icing fluids

- The addition of thickening agents gives the following advantages:
- The fluid film stays longer on the surfaces to which they have been applied,
- The rate of dilution from precipitation is significantly reduced,
- When diluted, the viscosity properties of the fluid is maintained – or in some conditions increased.
- Result: Significantly increased HOT.

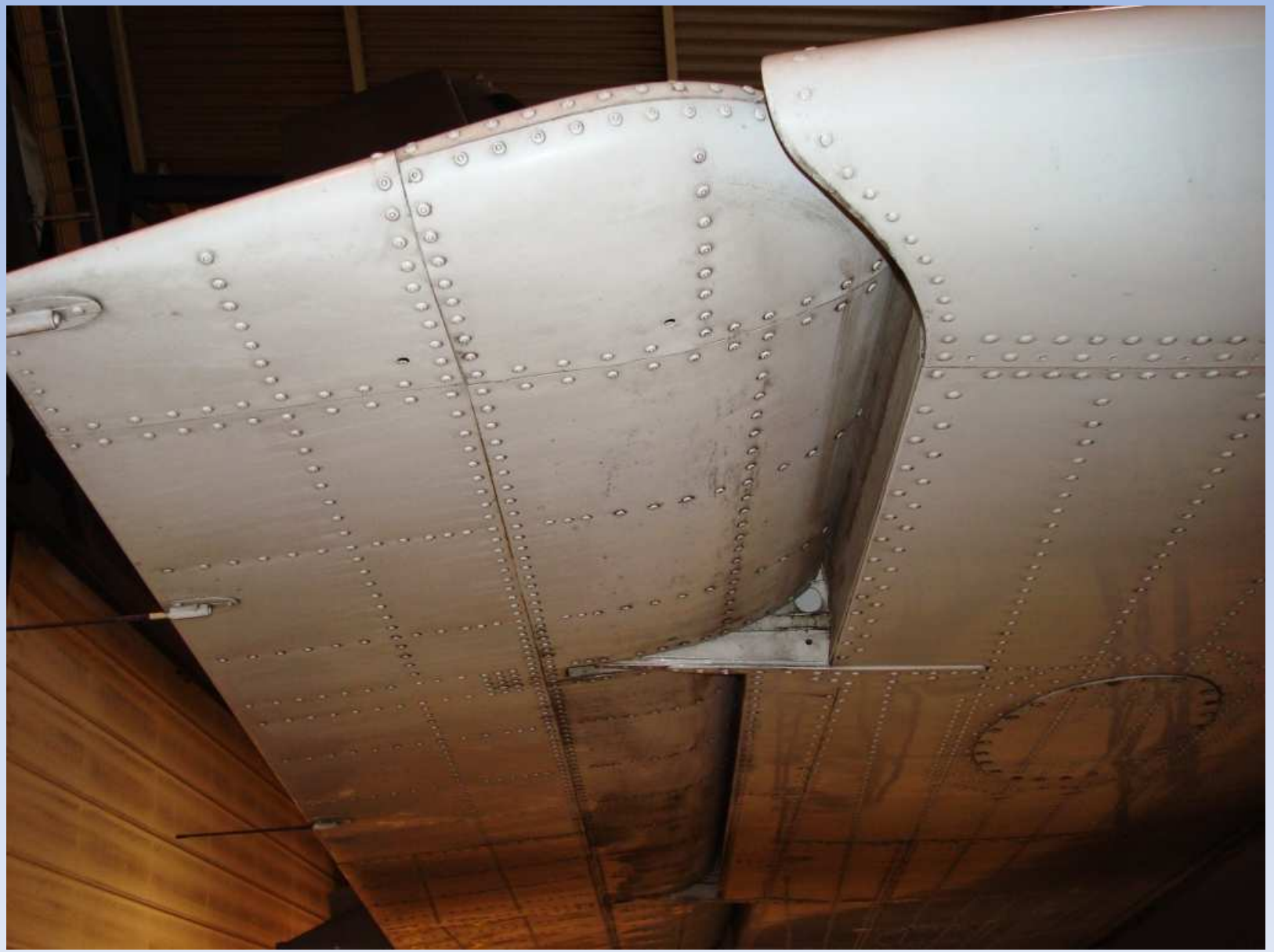
Preparation for practical tests

- SHK decided – together with the operator – to exercise practical tests in order to confirm the theory:
- *High viscosity fluids in combination with too narrow gap between stabilizor and elevator, could cause the phenomenon that lead to the incidents with stuck elevator.*
- So….

Preparation for practical tests

- Authorization for the test runs was obtained,
- Crew was briefed and provided with relevant instructions and test schedule,
- Video cameras were mounted on the upper- and underside of the interesting area of the stabilizor,
- First test run was made with SE-MAP.

Elevator section BAe ATP



West Air SE-MAP pre Taxi test # 1

SE-MAP original (West Air)

Position	AMM min	MAP L/H	Diff (mm)	MAP R/H	Diff (mm)
1	2,5	2,1	-0,4	2,5	0,0
2	2,5	2,1	-0,4	2,0	-0,5
3	2,5	2,1	-0,4	2,3	-0,3
4	2,5	2,1	-0,4	1,9	-0,6
5	2,5	2,7	0,2	1,5	-1,0
6	2,5	1,0	-1,5	1,7	-0,8
Average	**2,5**	**2,0**	**-0,5**	**2,0**	**-0,5**

West Air SE-MAP taxi test # 1 – Type IV

Set up:

- 14 liter/wing
- TOW 17250 kg
- Index 55
- V_R = 99 knots

RESULT

- Pre/Post movem. OK
- Heavy movement
- Stuck Elevator at V_R
- No split

West Air SE-MAP taxi test # 2 – Type I

Set up:
- 50 litre/wing
- TOW 17250 kg
- Index 55
- VR = 99

RESULT
- Pre/Post movem. OK
- Easy movement
- Free Elevator at VR

West Air SE-MAP taxi test # 3 – Type I + II

Set up:
- 25 liter/wing (II)
- TOW 17250 kg
- Index 55
- V_R = 99

RESULT
- Pre/Post movem. OK
- Stuck Elevator at V_R
- No split

West Air SE-MAP taxi test # 5 – Type IV

SE-MAP *after* Elevator change (West Air)

Position	AMM min	MAP L/H	Diff (mm)	MAP R/H	Diff (mm)
1,0	2,5	3,3	0,8	2,4	-0,1
2,0	2,5	4,2	1,7	2,4	-0,1
3,0	2,5	3,8	1,3	2,7	0,2
4,0	2,5	3,2	0,7	2,5	0,0
5,0	2,5	2,8	0,3	2,5	0,0
6,0	2,5	3,0	0,5	2,2	-0,3
Average	**2,5**	**3,4**	**0,9**	**2,5**	**±0,0**

Set up:

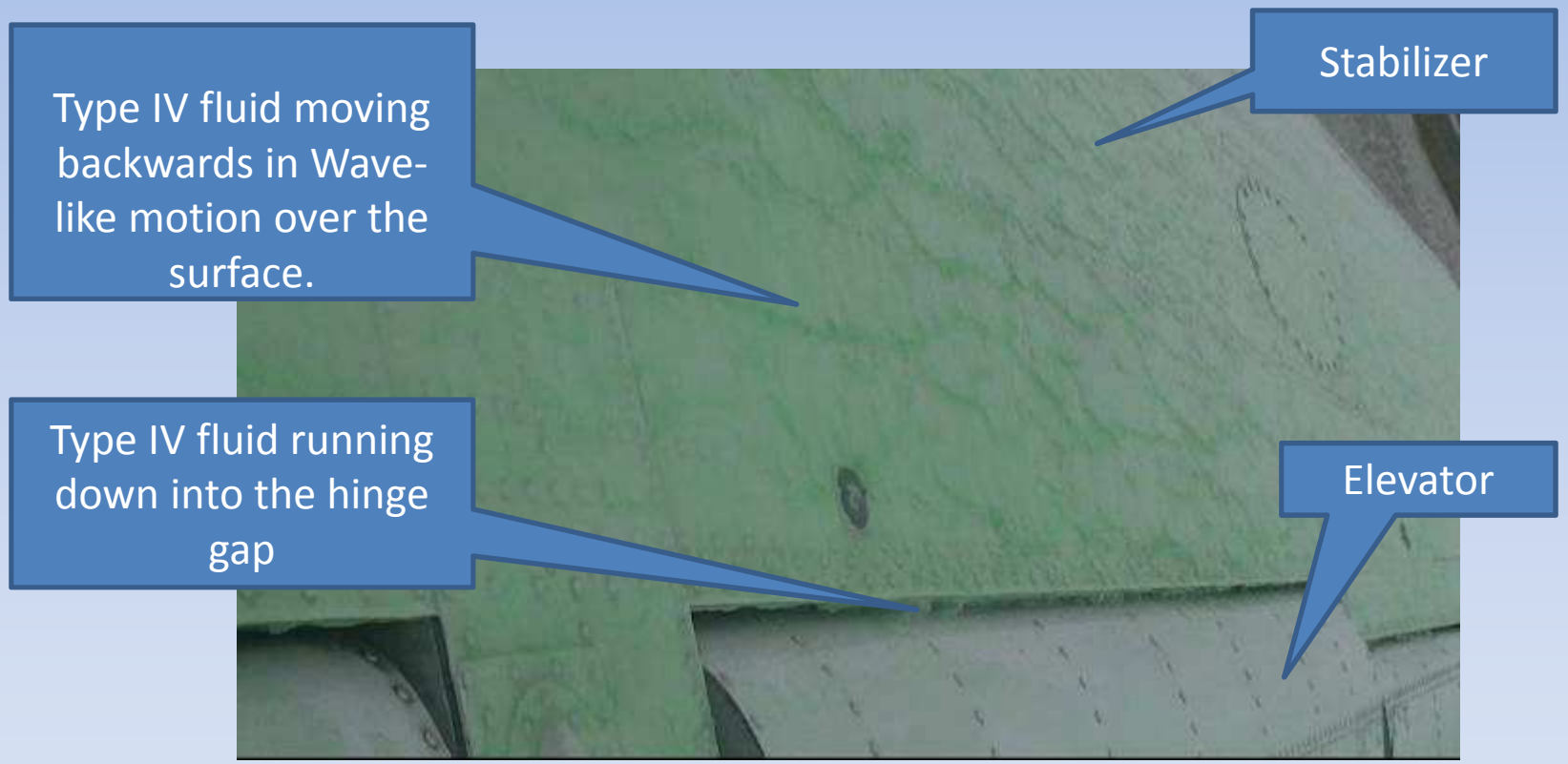
- 14 liter/wing
- TOW 17250 kg
- Index 55
- V_R = 99

RESULT

- Pre/Post movem. OK
- Free elevator at V_R

Tests

Picture from video (upper surface) while taxiing out. Speed approx 20 kts.



Tests

Picture from video (underside) while taxiing out. Speed approx 20 kts.

Tests

Picture from video at attempted rotation (underside). Speed approx 100 knots.

Swirls at certain positions when fluid runs out. Most of the fluid comes ”threadlike”.

Elevator stuck in neutral position. Not possible to move control column more backwards for rotation

Large amounts of fluid dripping from gap at attempted rotation.

The continued investigation

- After the tests SHK immediately called to a meeting with the TC holder, concerned authorities (CAA and EASA) and operators, as there could be potential flight safety risks under certain conditions.
- At the meeting it was emphasized that the purpose of the investigation from SHK:s side was to *point out the problem* – not to solve it.
- The further handling of the issue was thereby submitted to the TC holder and the concerned authorities.

Measures taken

- The TC holder issued a Technical Operational Response, based on a Service Bulletin where operators should inspect and measure elevator clearance.
- Aircraft that did not pass the inspection were not allowed to operate under conditions where application of any de- or anti-icing fluid was needed.

Measures taken

- EASA initially issued a Safety Information Bulletin (SIB) regarding risk for high stick forces after application of Type II/IV fluids on aircraft with non-powered elevators.
- The SIB was followed by an AD regarding BAe ATP aircraft, with a specified inspection programme, followed by operating restrictions after application of fluids containing thickening agents.

Epilogue

- SHK issued the following recommendations in the report:
- <u>EASA should:</u>
- Work for an extension of EASA's remit to include certification of fluids used for ground de- and antiicing of aircraft.
- Investigate the possibility of tightening requirements on aircraft design organizations in terms of demonstrating that the aircraft has full manoeuverability during all phases of the take off procedure after application of de- and antiicing fluids.

Epilogue

- <u>EASA should: (cont.)</u>
- Actively consider the value of a wider use of Type III fluids (or correspondant fluids), within the field of European Civil Aviation.
- <u>ICAO should:</u>
- Within the international flight safety community, work to ensure that in the future, the issuing of requirements, specifications and definitions of areas of use, aircraft de- and antiicing fluids are made the responsibility of airworthiness authorities.

Epilogue

- EASA has responded to all recommendations and taken appropriate actions. Regarding the extension of responsibilities, the issue will probably be proposed to the European Commission.
- ICAO has referred to the existing manuals, Doc 9640/9760 and an update of 8335, but has not replied to the recommendation that fluid specifications and requirements should be the responsibility of airworthiness authorities.

Lessons

- Did we learn anything from this….?

- Hopefully yes.

Lessons

- Investigating- and rule making authorities:
- *Awareness of the problem and possible necessity for a future fluid certification.*
- Aircraft design- and manufacture organizations:
- *Knowledge of that even small changes of the aircraft design can cause unexpected and negative effects to the aircraft performance.*
- Operators of small/medium NPE aircraft:
- *Awareness of the possible unwanted effects when using high viscosity anti-icing fluids.*

- Thank you for your attention!

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