Piston Middle Position Test, Variable Stator Vane Actuator of Engine CFM56-3 /-5 /-7

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Compressor is surely the most complex part of engine, and during projecting of engine, ensure safe operation of the compressor is very difficult job. In support of this is the fact that the most of accessories (sensors and actuators) are in connection with compressor, but two most importatnt systems are VBV and VSV systems. In this work, we will observe VSV system, respectively VSV Actuator.

Our research have a quest to decrees some remarked problems which occure during work on VSV Actuator, and of course we will offer a solution for remarked problem in term of adding another one point in test. Also, our sugestion is creating incoming inspection, pre-test inspection with the points to be listed in below.

Key Words: *Engine, CFM56, CFD analysis, Variable Stator Vane Actuator, Fuel Test Cell*

1. INTRODUCTION

Variable Stator Vane Actuator (VSV Actuator) is a single-ended, un-cushioned cylinder which is driven in either direction under fuel pressure. The actuator consists of a cylinder assembly, rod end clevis, gland assembly, piston assembly [1, 2], and for PN 1211313-series, electrical connector [3, 5, 6]. Unlike actuators with PN 1211175-series, actuators with PN 1211313-series, inner of piston contains a linear variable differential transformer (LVDT). Piston stroke is controlled by internal stops. [3] The piston incorporates a capped, performed packing to prevent cross piston leakage. The rod end of the actuator is protected against leakage by dual-stage performed packing. A system is provided to drain any leakage past the first stage seal. A scraper is provided to ensure the piston rod is drift free as it moves through the dual-stage seals. [1]

In accordance with name, VSV Actuator is used to vary the pitch of the variable compressor stator vanes, thereby controlling the air volume entering the core of the engine. Hydraulic pressure is applied to the unit through the head and rod ports. Primary seal leakage is relieved through the drain holes. The head and rod ports supply fuel pressure to opposite sides of the piston. The piston extends as head port pressure increases and rod port pressure simultaneously decreases. The piston retracts as rod port pressure increases and head port pressure simultaneously decreases. [2]

For VSV Actuators PN 1211313-series piston position is monitored by the LVDT which converts the linear position of the piston into an electrical signal. The LVDT consists of a primary winding, two secondary windings, and a steel core. The primary winding induces a voltage in each of the two secondary windings which is proportional to the position of the steel core that travels through the centre of the secondary windings. The LVDT core is connected to, and moves with the piston, producing a voltage output from two secondary windings that is proportional to piston position. [3, 5]

2. DESCRIPTION OF PROBLEM

Based on our experience we've noticed when VSV Actuators ship to our workshop, they sometimes were certified as overhaul (Figure 2), but its actually only tested. Our workshop have VSV Actuator overhaul on Capability list, so we are able to notice every trifle correlated with every accessory in CMM (Component Maintenance Manual). It is a serious advantage in compared with other workshops.

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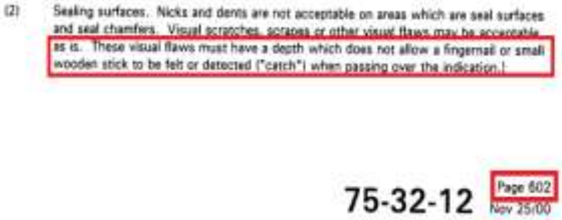
(2) Sealing surfaces. Nicks and dents are not acceptable on areas which are seal surfaces and seal chamfers. Visual scratches, scrapes or other visual flaws may be acceptable as is. These visual flaws must have a depth which does not allow a fingernail or small wooden stick to be felt or detected ("catch") when passing over the indication.)

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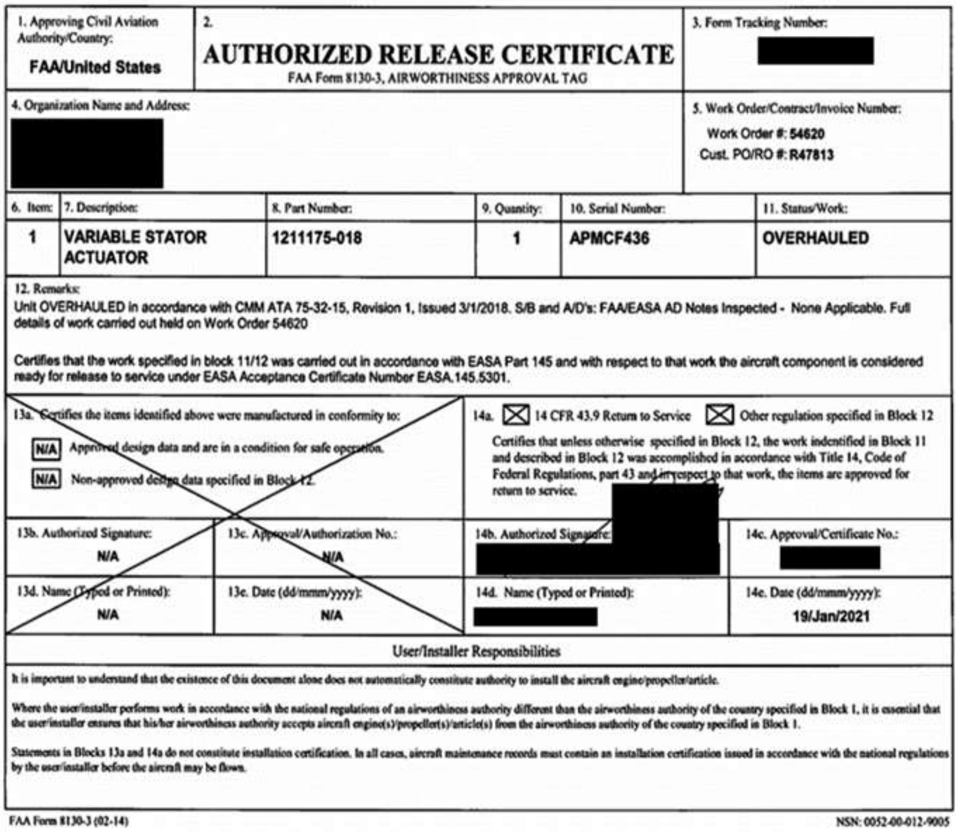
[5]

Figure 1 - Paragraph from Repair section, from CFM56-5B, identically is for CFM56-3-series, and CFM56-7B

But, actuators are often proclaim as a BER (Beyond Economical Repair) and than customer need to buy a new or overhauled actuator and problems beginning. To be honest, components manual not quite „happily" written. Per my opinion, incoming inspection not prominent, its involved in standard inspection, some inspection principles are described in REPAIR section (Figure 1) and some criterion of inspection are based on subjective feel. Now is very important to say, when piston or body assembly fall inspection, whole actuator is proclaim as BER, and than is necessary to replace ith serviceable actuator (new or overhaul). From its reason, possibly, word wide MRO departments usually skip suggestion from REPAIR section, and possibly try to ignore minor scratches on piston, if actuator pass test.

2.1. Detected negative influence

We discovered mentioned problem much early, but couldn't find enough good reason to represent them, and show the consequence which cause. VSV Actuator, with serviceable certificate (Figure 2) was install on engine and sent on test cell.


1. Approving Civil Aviation Authority/Country: FAA/United States

2. AUTHORIZED RELEASE CERTIFICATE
FAA Form 8130-3, AIRWORTHINESS APPROVAL TAG

3. Form Tracking Number: [redacted]

4. Organization Name and Address: [redacted]

5. Work Order/Contract/Invoice Number:
Work Order #: 54620
Cust. PO/RO #: R47813

6. Item:	7. Description:	8. Part Number:	9. Quantity:	10. Serial Number:	11. Status/Work:
1	VARIABLE STATOR ACTUATOR	1211175-018	1	APMCF436	OVERHAULED

12. Remarks:
Unit OVERHAULED in accordance with CMM ATA 75-32-15, Revision 1, Issued 3/1/2018. S/B and A/D's: FAA/EASA AD Notes Inspected - None Applicable. Full details of work carried out held on Work Order 54620

Certifies that the work specified in block 11/12 was carried out in accordance with EASA Part 145 and with respect to that work the aircraft component is considered ready for release to service under EASA Acceptance Certificate Number EASA.145.5301.

13a. Certifies the items identified above were manufactured in conformity to:
N/A Approved design data and are in a condition for safe operation.
N/A Non-approved design data specified in Block 12.

14a. ☒ 14 CFR 43.9 Return to Service ☒ Other regulation specified in Block 12
Certifies that unless otherwise specified in Block 12, the work indentified in Block 11 and described in Block 12 was accomplished in accordance with Title 14, Code of Federal Regulations, part 43 and in respect to that work, the items are approved for return to service.

13b. Authorized Signature:	13c. Approval/Authorization No.:	14b. Authorized Signature:	14c. Approval/Certificate No.:
N/A	N/A	[redacted]	[redacted]
13d. Name (Typed or Printed): N/A	13e. Date (dd/mmm/yyyy): N/A	14d. Name (Typed or Printed): [redacted]	14e. Date (dd/mmm/yyyy): 19/Jan/2021

User/Installer Responsibilities

It is important to understand that the existence of this document alone does not automatically constitute authority to install the aircraft engine/propeller/article.

Where the user/installer performs work in accordance with the national regulations of an airworthiness authority different than the airworthiness authority of the country specified in Block 1, it is essential that the user/installer ensures that his/her airworthiness authority accepts aircraft engine(s)/propeller(s)/article(s) from the airworthiness authority of the country specified in Block 1.

Statements in Blocks 13a and 14a do not constitute installation certification. In all cases, aircraft maintenance records must contain an installation certification issued in accordance with the national regulations by the user/installer before the aircraft may be flown.

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Figure 2 - Dual release certificate, serviceable part

During test, weren't noticed any irregularities, nothing out of the ordinary appeared. But after test, we found something unusually, for overhauled actuator, actually we found a lot of fuel on RH VSV Actuator drain port. For few previous actuator this value was over limits or far within limits, but for one of them, leakage was unusually high, but within limits. (Figure 3)

2.2. Detected negative influence

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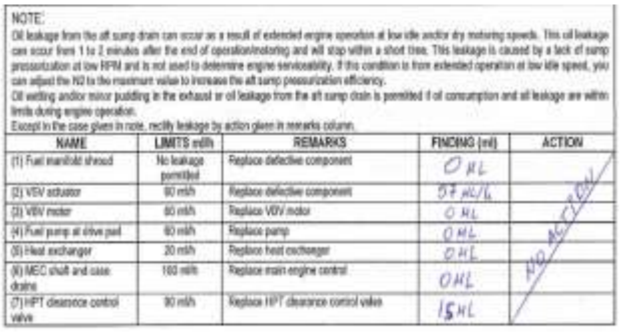
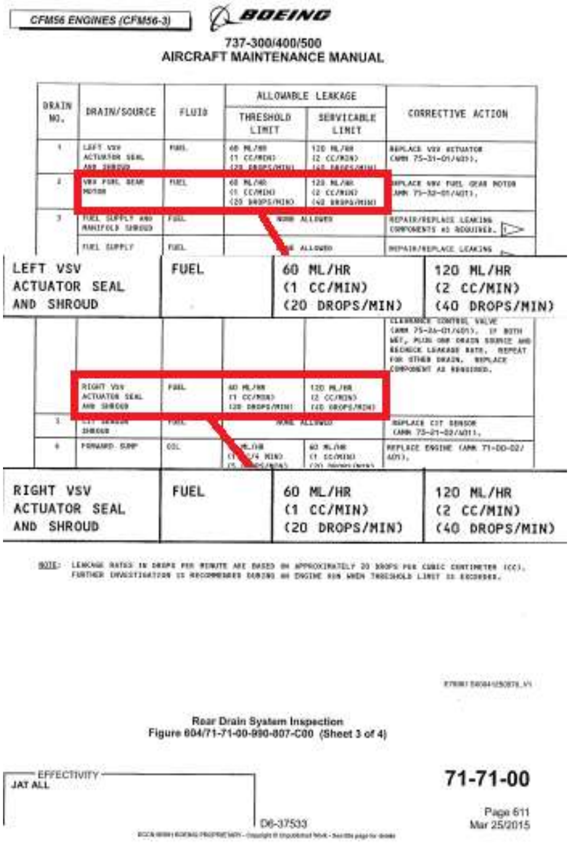


NOTE:
Oil leakage from the aft sump drain can occur as a result of extended engine operation at low idle and/or dry motoring speeds. This oil leakage can occur from 1 to 2 minutes after the end of operation/motoring and will stop within a short time. This leakage is caused by a lack of sump pressurization at low RPM and is not used to determine engine serviceability. If this condition is from extended operation at low idle speed, you can adjust the N2 to the maximum value to increase the aft sump pressurization efficiency.
Oil wetting and/or minor puddling in the exhaust or oil leakage from the aft sump drain is permitted if oil consumption and all leakage are within limits during engine operation.
Except in the case given in note, rectify leakage by action given in remarks column.

NAME	LIMITS ml/h	REMARKS	FINDING (ml)	ACTION
(1) Fuel manifold shroud	No leakage permitted	Replace defective component	0 ML	NO ACTION
(2) VSV actuator	90 ml/h	Replace defective component	57 ML/L	
(3) VBV motor	60 ml/h	Replace VBV motor	0 ML	
(4) Fuel pump at drive pad	60 ml/h	Replace pump	0 ML	
(5) Heat exchanger	20 ml/h	Replace heat exchanger	0 ML	
(6) MEC shaft and case drains	160 ml/h	Replace main engine control	0 ML	
(7) HPT clearance control valve	90 ml/h	Replace HPT clearance control valve	15 ML	

Figure 3 - Work Card which show noticed value for leakage on RH VSV Actuator drain port.

According to AMM (Aircraft Maintenance Manual) (Figure 4.) we can review measured value.



CFM56 ENGINES (CFM56-3)
BOEING
737-300/400/500
AIRCRAFT MAINTENANCE MANUAL

DRAIN/SOURCE	FLUID	ALLOWABLE LEAKAGE THRESHOLD LIMIT	SERVICEABLE LIMIT
LEFT VSV ACTUATOR SEAL AND SHROUD	FUEL	60 ML/HR (1 CC/MIN) (20 DROPS/MIN)	120 ML/HR (2 CC/MIN) (40 DROPS/MIN)
RIGHT VSV ACTUATOR SEAL AND SHROUD	FUEL	60 ML/HR (1 CC/MIN) (20 DROPS/MIN)	120 ML/HR (2 CC/MIN) (40 DROPS/MIN)

Rear Drain System Inspection
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[4]

Figure 4 - Permit leakage per BOEING AMM for CFM56-3

On Figure 4. is displays page from AMM which related with operation of the actuator on the engine, operational test of actuator. This page refer to leakage on engine test cell or on wing, run-up and leakage on aircraft, engine on wing between two flights. Value for “Threshold limit” is related with engine on test cell or run-up, and “Serviceable limit” is related on aircraft.

In accordance with Work Card shown on Figure 3. and page from AMM on Figure 4, actuator is serviceable. But, after the engine spent the night on the test cell, we found a unexpected leakage. (Figure 5.)

Figure 5 - Static leakage caught after approximately 10 hours, actually within 10 hours.

By the finding we calculate that static leakage (measured value 71 ml/h) is higher than leakage measured during testing engine on test cell. Actually measured static leakage is higher even from the prescribed value into BOEING AMM shown on Figure 4.

2.3. Reason for including new remarks

Situation explained in previous paragraph and Figure 5. didn’t predicting by any maintenance manual, so we make decision to perform simple action on actuator: incoming inspection and test. But, it is important to say, our first thought was focused on piston of VSV Actuator.

Still on beginning of the consideration, on incoming inspection, we see finding scratches, nicks and burs on piston (Figure 6.). That mean actuator fall incoming inspection and further testing is unnecessary, but however, we make decision to perform test.

Figure 6 - Incoming inspection finding

Piston is really undetermined, and its very difficult to construe on right way, workshop with higher tolerance level can let as serviceable. After performing test, we found leakage, but within the prescribed limits, so test pass.

Therefore, we noticed that actuator is almost serviceable, if ignore, per FAA regulations mandatory, incoming inspection, actuator is serviceable. It is important to notice, that incoming inspection not mandatory per EASA regulations. Records from test and actuator behaviour on test cell are in limits, but we are talk about possibly hazard situation.

But, however certificate (Figure 2.) no way to be „overhaul“, this certificate can be only „tested“. Term „overhaul“ required whole inspection of each parts, and accomplishment of successfully test. Shown findings couldn’t be characterized as omission, its could be only characterized as misconception in understanding definition of overhaul.

Leakage into hood flaps, during engine resting on aircraft wing, in moment of engine start can possibly cause disastrous consequence. Maybe even like notorious catastrophe with fuel tank, as a consequence of sedimentation fuel in hood flaps.

Aim of its work is to decrees on solutions which can act preventively in purpose to avoid catastrophic consequence.

3. EXPLANATION FOR SOLUTION AND PRINCIPLE OF RESOLUTION

In order to support our assertion, and provide a solution on evident problem, we will perform measurement, and numerical solution. Suggestion is to adding another one point as part of testing VSV Actuator. Our experience is shown that piston’s sealing surface is usually worn on the middle of sealing surface, so it is necessary to find a way for test quote surface.

We have intention to find solution that will not deviate from other test points, in accordance with that, we invent test point named „Piston Sealing Surface Mid-stroke Leakage Test“. Solution involves placed piston in middle position, and pressurized with fuel on adequate pressure. Same test already exsist, but only for VSV Actuator P/N 1211175-007.

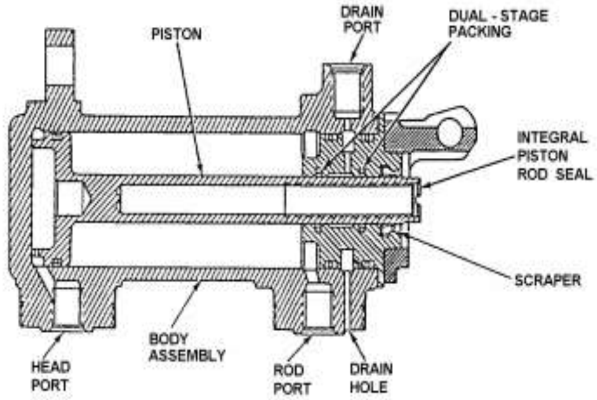
Leakage measurement will be performed on serviceable unit, current actuator S/N APMCF436, like almost serviceable unit, and obviously unserviceable unit. Each of these three actuators will be subjected to same test: Piston Sealing Surface Mid-stroke Leakage Test.

Idea for numerical analysis is based on distribution of pressure and velocity inside of body assembly during fluid settlement. Based on received results, and in accordance with expressed formulas, we come to results which can compare with experimental results.

By comparing the obtained results, idea is to determine relevant value for new test point mid-stroke, in order to give the best and the most accuracy solution. Based on results our assignment is to find right value of input pressure and for permit leakage or conclude that leakage isn’t permitted.

3.1. Experimental solution

As mentioned in previous paragraph, our idea is to test VSV Actuator in three state, with piston in mid-stroke position. All three actuators will be test under five different measured points; the best way to determine measure points is empirical. Measurement need to show leakage per time unit, thus measurement of each measure point will least three minute. As a test fluid we using Calibration Fluid (MIL-C-7024 type II). On this way receive quantity of leakage fuel as mass flow or volume flow, relevant physics parameter.



[2]

Figure 7 - Cross section of VSV Actuator body

Measured value will be used for determination permitted leakage. Measurement of leakage will be performed on two place on VSV Actuator body, on drain port and on piston seal. (Figure 8.)

Table 1. Show measured leakage on drain port obtained at the specified pressures during 60 sec.

No	P [PSI]	VSV Act. 1	VSV Act. 2	VSV Act. 3
		V [cc/min]	V [cc/min]	V [cc/min]
1	20	0	0	0.04
2	50	0	0.03	1.2
3	70	0	1.1	2.3
4	80	0	1.5	4.1
5	100	0	2.8	9.2

In the Table 1. VSV Act. 1 represent serviceable unit, VSV Act. 2 represent actuator S/N APMCF436, and VSV Act. 3 represent unserviceable unit. The same applies to Table 2.

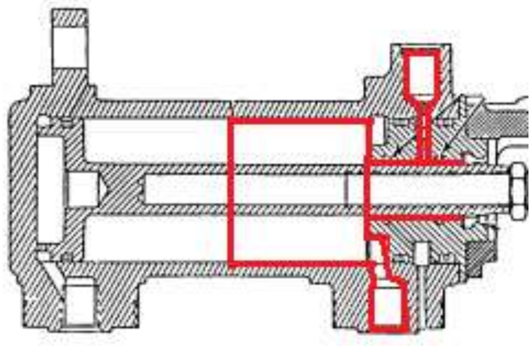
Table 2. Show measured leakage on piston seals obtained at the specified pressures during 60 sec.

No	P [PSI]	VSV Act. 1	VSV Act. 2	VSV Act. 3
		V [cc/min]	V [cc/min]	V [cc/min]
1	20	0	0	0
2	50	0	0	0
3	70	0	0	0.01
4	80	0	0	0.07
5	100	0	0	0.24

Measurement goal is to find point in which leakage rapidly rise, respectively pressure at which leakage increase.

3.2. Numerical solution

For numerical calculation we make decision to use program COMSOL Multiphysics, fluid flow mod. In accordance with experimental measurement, choose inlet pressures which will using for determination distribution across controlled area (Figure 9). Based on distribution we can determine pressure which influence on piston seals, and calculate leakage rang.



[2]

Figure 8 - Controlled area into body assembly

According to Figure 8. and controlled area on Fig. 9. fluid entered throurg ROD PORT, and outer ports are DRAIN PORT and Piston seals. At initial moment inside of actuator is fullyfilled with air; than we start to input working fluid (keroesen JP-1,Jet Fuel, fuel oil #1 liquid). Through the outer ports air release actuator, pushed out by fuel. Roughness of walls are, in accordance with aircraft standards, within than 32 µm. At the area of seals, walls are marked as leakage walls, with low level of porosity. Therefore, area of its part is less than piston leading edge circumference, thickness is actually infinitesimal.

Cause after one second, pre-seals area will be fully coverage with approximately inlet pressure. For better observing pressure distribution, the best way is to use contour lines (Figure 10.), by the movement of contour lines we can see better pressure distribution. At the moment when contour lines settle inside controlled area, we can be sure that exists only interaction between input and output area.

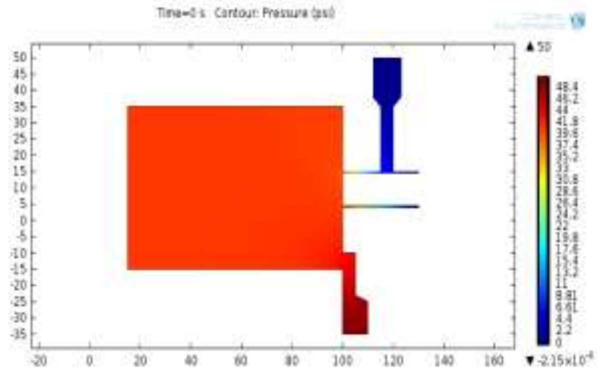


Figure 9 - Distribution of pressure for initial inlet

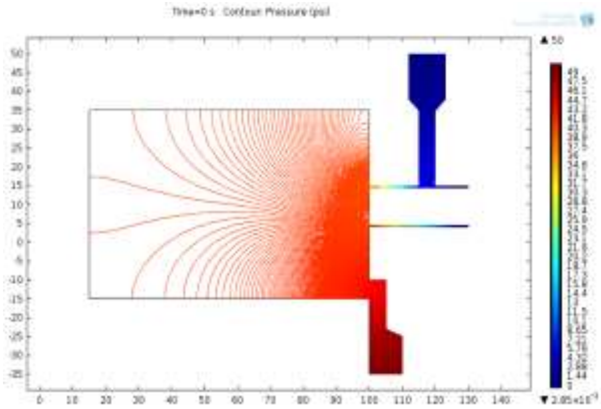


Figure 10 - Distribution of pressure contour for initial inlet

Distribution of velocity along controlled area will be support as arrows which have a purpose to show direction of velocity distribution. (Figure 11.) Initialy, controlled area is full of air, and after pressurized with fuel, air will escape through the outlet ports. Its explined initial increasing of velocity on drain port, is actually air velocity. Depended the time, velocity on drain port will slowly decrease, and after air fully abandon controlled area, velocity on drain port will decrease to value which only can generate fuel flow. In some cases, for low pressure, this value will be zero.

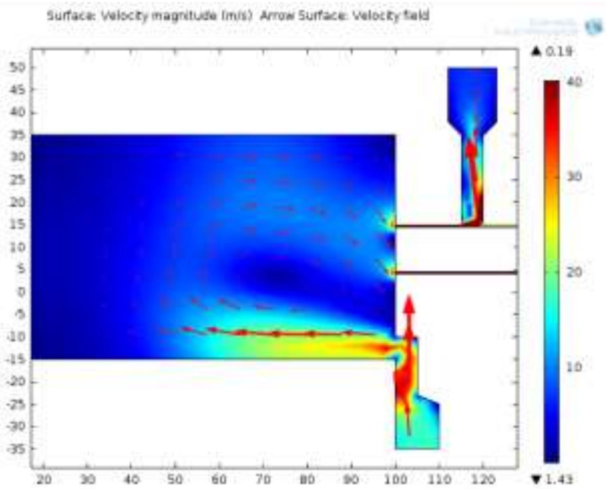


Figure 11 - Distribution of velocity for first ten seconds

4. RESULTS

Idea is to determine leakage as mass flow thru porosity area according to ASME PTC 19.4 [7] American National Standard. Based on experimental results, we can determine surface of empty space among seals.

According to experimental measurement from Table 1 and Table 2.

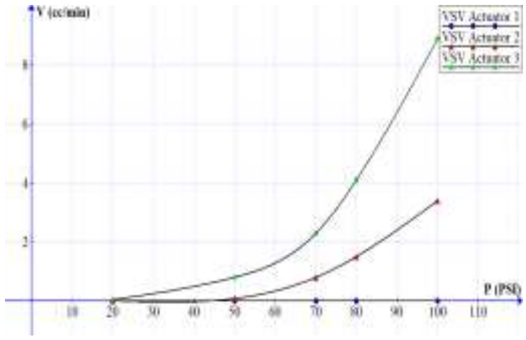


Figure 12 - Distribution of pressure for initial inlet

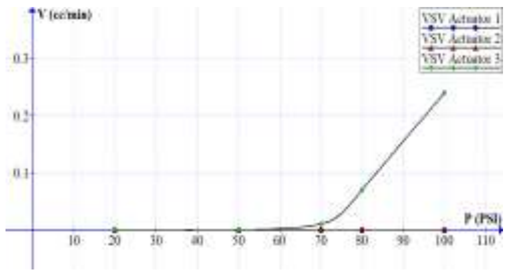


Figure 13 - Distribution of pressure for initial inlet

As it shown helped by test cell we can measure leakage as volume flow, but no as mass flow, so its necessary to expressed volume flow as function of mass flow:

$$\dot{V} = \frac{dV}{dt} = \frac{d}{dt}\left(\frac{m}{\rho}\right) = \frac{1}{\rho} \cdot \dot{m} \qquad (1)$$

Per ASME PTC 19.4, flow measurement, mass flow can be expressed as:

$$\dot{m} = \rho v \cdot C_d \cdot \epsilon_1 \cdot 2\pi R dR \qquad (2)$$

where ϵ_1 represent expansion factor:

$$\epsilon_1 = \left[r^{\frac{2}{k}} \left[\frac{k}{k-1}\right] \left[\frac{1-r^{\frac{k-1}{k}}}{1-r}\right] \left[\frac{1-\beta^4}{1-\beta^4 r^{\frac{2}{k}}}\right] \right]^{0.5} \qquad (3)$$

thus, r represent proportionality between pressures p_1 and p_2:

$$r = \frac{p_2}{p_1} = \left(\frac{\rho_2}{\rho_1}\right)^k = \left(\frac{T_2}{T_1}\right)^{\frac{k}{k-1}} \qquad (4)$$

k ratio between specific heat capacity at constant pressure and specific heat capacity at constant volume:

$$k = \frac{C_p}{C_V} \qquad (5)$$

and β represent thermal expansion/contraction of secondary d and primary element D:

$$\beta = \frac{d}{D} \qquad (6)$$

and where C_d is discharge coefficient:

$$C_d = C_0 - \frac{0.185}{Re_d^{\frac{1}{5}}} \left[1 - \frac{361.239}{Re_d}\right]^{\frac{4}{5}} \qquad (7)$$

factor C_0 represent average value of leading constant and Re_d Reynolds number. [7] According to experimental set up and expressed equations, as a volume flow we got equation:

$$\dot{V} = \sqrt{\frac{2p}{\rho}} \cdot C_d \cdot \epsilon_1 \cdot 2\pi R dR \qquad (8)$$

Equation (8) proving asseration from previous paragraph that thicknes of circumference infinitesimal and its expressed as *dR*. From equation (8) can see that all members are avaliable exceptr *dR*, thus:

$$dR = \frac{\dot{V}}{\sqrt{\frac{2p}{\rho}} \cdot C_d \cdot \epsilon_1 \cdot 2\pi R} \qquad (9)$$

In porpose to equation (9) will be correctly expresed is necessary to multiply dR with coefficient of proportionality; because leakage didn't linear increase with pressure $\dot{V} \neq k \cdot \sqrt{p}$.

Declination of discharge coefficient C_d and thermal expansion factor ϵ_1 which will be generated as a consequence of pressure increase are negilch. But declination of every parameter in equation are significlant refflection on infinitesimal value dR. Therefore, for fully correctly expression is necessary:

$$\dot{V} = \sqrt{\frac{2p}{\rho}} \cdot C_d \cdot \epsilon_1 \cdot 2\pi R \cdot b dR \qquad (10)$$

where b represent coefficient of proportionality for infinitesimal value *dR*.

By experimental results shown on Figure 12 and Figure 13, we can to notice that on inlet pressure value of 80 PSI, leakage rapidly increase. Therefore, more extensive numerical analysis will be performed on condition when inlet pressure is about 80 PSI.

Group of Figure 14.-series, shown development of velocity distribution during time. Its necessary to observe a moment when distribution of velocity settle inside the area.

Follow the arrows and filled area marked with different colours define with legend from side we can determine distribution. Based on shown observation is evident that after 20 seconds distribution of velocity settle in. Its confirm by identity distribution between Figure 14.4. and Figure 14.5.

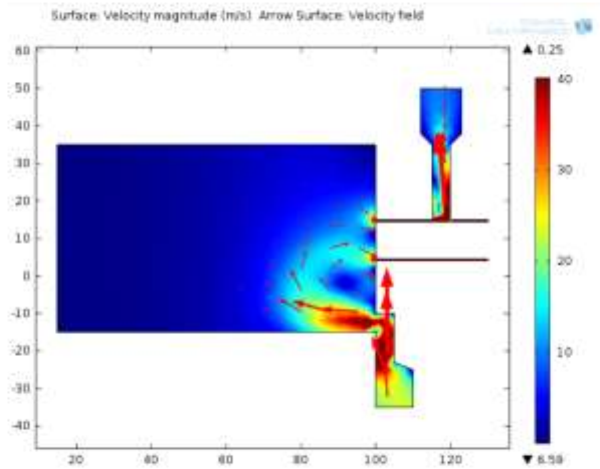


Figure 14.1 - Distribution of velocity after 2 seconds

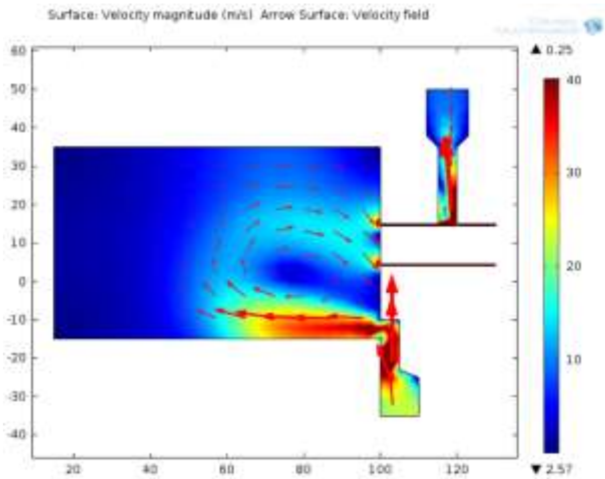


Figure 14.2 - Distribution of velocity after 6 seconds

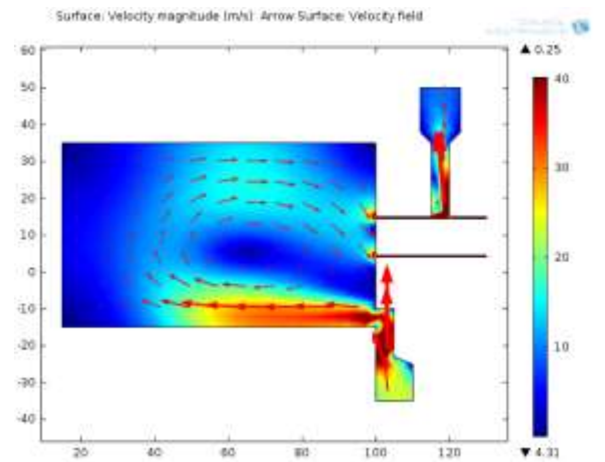


Figure 14.3 - Distribution of velocity after 10 seconds

After 20 seconds, fluid continue to move along establishing paths, visualized by red arrows. Dimension of arrows represent intensity of velocity into denoted point or controlled area. Thus, larger arrows represent high velocity intensity, while smaller arrows represent low velocity intensity.

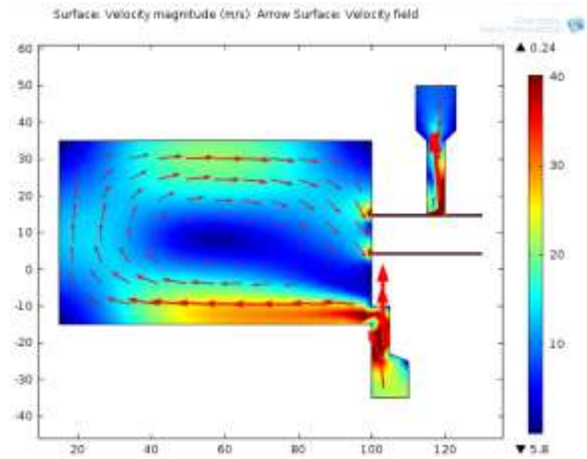


Figure 14.4 - Distribution of velocity after 20 seconds

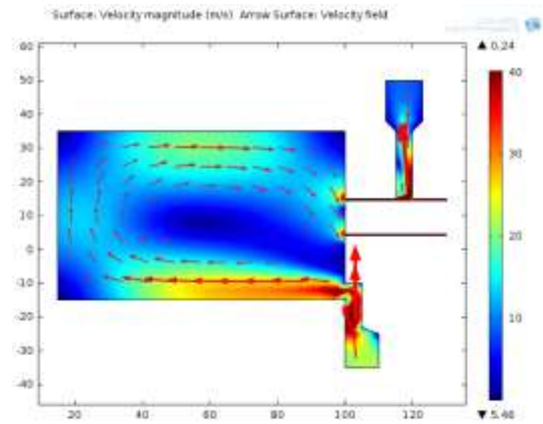


Figure 14.5. Distribution of velocity after 60 seconds

Series of Figure 15, shows distribution of pressure contour lines in differet time interval, from initial to final 60 seconds. Also, in almost identical time interval, as in velocity distribution, pressure contour lines distributed along controlled area. On the pressure scale we can evident negativ value of pressure, its actualy encourages from atmospheric pressure, which prevail on drain port at initial moment against pressure which generate leakage. Leakage appears when injected pressure prevail seals and atmosphere pressure.

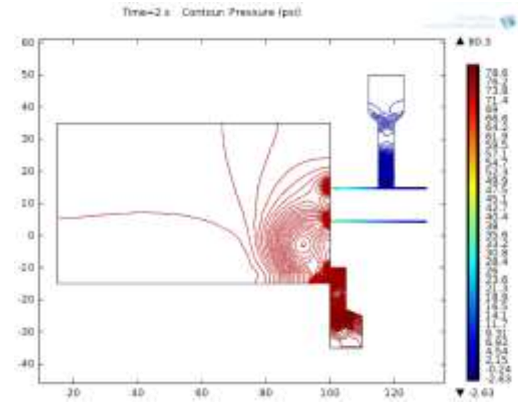


Figure 15.1 - Distribution of pressure contour lines after 2 seconds.

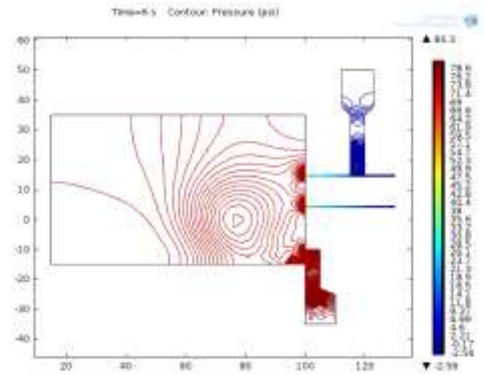


Figure 15.2 - Distribution of pressure contour lines after 6 seconds.

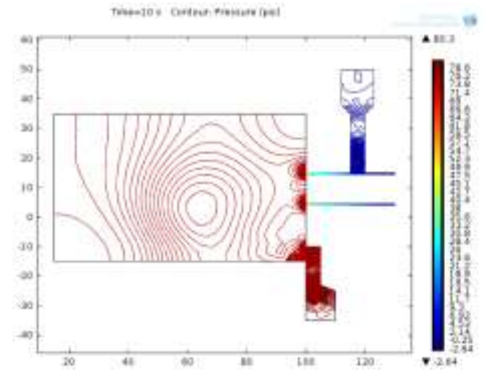


Figure 15.3 - Distribution of pressure contour lines after 10 seconds.

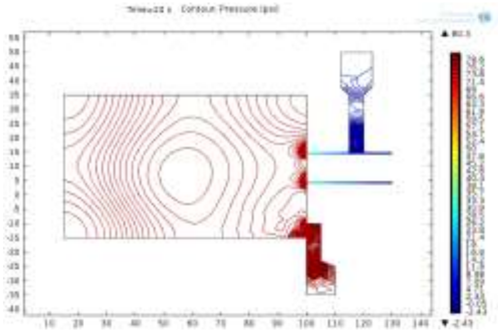


Figure 15.4 - Distribution of pressure contour lines after 24 seconds.

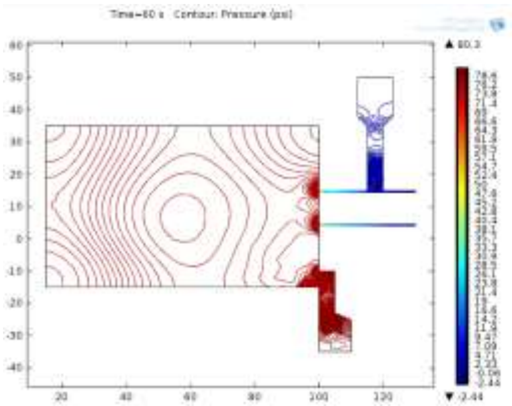


Figure 15.5 - Distribution of pressure contour lines after 60 seconds.

5. DISCUSION

Adhering to our intention to aviod subjective sense and based on measurement values we determine inlet pressure and permitted leakage on choosen pressure. According to equation (10) and measured results, preview across diagrams Figure 12. and Figure 13, our suggestion is using as inlet pressure value of 100 PSI.

According to results, our recommendation is to allowed leakage for DRAIN port on 100 PSI will be 0.2 cc/min, while for piston seals, leakage will be deny, no leakage permitted. Actuators, usually are good sealed on piston seals, but however, recheck is always desirable. Recommended test point time is three minutes, for its time, fluid can fullyfilled gland channel, and established permanent pressure on outer.

Based on FAA regulations requirements, our suggestion to manufacturer is to including maintenance manual determine some kind of pre-test inspection, we call its incoming inspection. Purpose of incoming inspection is to cover inspection available on assembled parts, detecting irregularities which is visible on assembly level. Maybe most important thing which preview this work can be preventation to unserviceable part pass the test. Figure 16. show example of regular preview schedule scope of work.

Workscope *(Does not have to be signed by engineering)*	
1	Preliminary Inspection of VSV Actuator
2	Incoming Inspection of VSV Actuator
3	Test of VSV Actuator
4	Disassembly the VSV Actuator
5	VSV Actuator – Piston Inspection
	VSV Actuator – Actuator Body Assembly Inspection
	VSV Actuator – Gland Inspection
	VSV Actuator – Rod End Clevis Inspection
	VSV Actuator – Clevis Inspection
	VSV Actuator – Check all metallic parts for burrs, dents, defective, threading and other damage
6	Assembly the VSV Actuator
7	Perform Test
	Unit Serviceable?
8	Prepare the unit for Storage
9	Final Inspection and Shop Visit Summary

Figure 16 - Example of correct schedule scope of work

Mentioned pre-test or incoming inspection needs to include criterion of piston inspection given in REPAIR section, and possibly eject criterion from REPAIR section, because it isn't necessery to be there. Beside visually check of piston, incoming inspection need to include visual check of all other parts which are visible when actuator assembled.

Per our opinion, the best way will be acceptance both of previous suggestion, pre-test inspection and addition point into TEST section. But, toward our knowledge and experience, even one of this two suggestion will be completely enough, both will be perfect. Necessary to note, that an actuator which was a observing subject not isolated case, but its was an interesting phenomenon. He shown, if you requred of me to be gentelman, misconceptions of subjective sense.

6. CONCLUSION

Therefore, according to noticed assisted us to understand importance of leakage, especially on VSV Actuators. Voluminous analysis performed during this work, have goal to support our suggestion and preview importance of work. Introduction of mandatory incoming inspection before test must be necessary, and involved soon as possible. On this concrete example we can evident importance to avoid individual conclusion, by introducing quality measurements. Aviation is serious and accuracy business, so that no recommendation leave decisions to subjective sense. Suggested test point have a determined quantity value, based on harmonization between experimental and numerical results.

7. ACKNOWLEDGMENT

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REFERENCES

[1] Actuator, Variable Stator, Component Maintenance Manual with Illustration Parts List, 75-32-11, CFMI-TP.CM.2, Revision 9, *CFM56_3_CMM_ REV_75-32-11. CM002_TSN.09_R_20191030*, August 29.2019.

[2] Actuator, Variable Stator, Component Maintenance Manual with Illustration Parts List, 75-32-15, CFMI-TP.CM.522, Revision 1, *CFM56_3_CMM_ REV_75-32-15. CM522_TSN.01_R_20180301*, March 1.2018.

[3] Actuator, Variable Stator, Component Maintenance Manual with Illustration Parts List, 75-32-13, CFMI-TP.CM.426, Revision 5, *CFM56_5B _CMM_REV_75-32-13.CM426_TSN.05_R_ 201710331*, March 31.2017.

[4] BOEING 737-300/400/500 Aircraft Maintenance Manual – *ENGINE VENTS AND DRAINS – INSPECTION/CHECK*, *Page block* 71-71-00/601, March 25.2015

[5] CFM56-5A/B/C/-7B Variable Stator Actuator, Component Maintenance Manual 75-32-12, CFMI-TP.CM.129, Revision 5, *CFM56_5B/7B_CMM_ REV_75-32-12. CM129_TSN.05_R_20001125*, November 25.2000.

[6] CFM56-7B VSV Actuator, Component Maintenance Manual, 75-32-14, CFMI-TP.CM.2, Revision 2, *CFM56_7B_CMM_REV_75-32-14. CM392 _TSN.01_R_20030415*, November 15.2012.

[7] Flow Measurement, ASME PTC 19.5-2004, *An American National Standard*, The American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990, pp 19-54. May 2004.

REZIME

TEST KLIPA U SREDNJEM POLOŽAJU, „VARIABLE STATOR VANE ACTUATOR“ MOTORA CFM56-3 /-5 /-7

Kompresor je svakako najsloženiji deo motora i tokom projektovanja motora, obezbediti siguran rad kompresora tokom leta je veoma težak posao. U prilog tome ide i činjenica da je većina motorskih agregata (senzora i aktuatora) ima ulogu da obezbedi siguran rad kompresora, a od njih dva najvažnija sistema su VBV i VSV sistem. U ovom radu, mi ćemo razmatrati VSV sistem, odnosno VSV aktuator.

Naše istraživanje ima zadatak da ukaže na pojedine probleme koji se javljaju tokom rada na VSV aktuatoru i, naravno mi ćemo ponuditi rešenje za navedene probleme u obliku dodavanja još jedne tačke testa. Takođe, predlažemo i kreiranje ulazne inspekcije, ili inspekcije pre testa, sa tačkama koje će biti nabrojane u nastavku.

Ključne reči*: motor, CFM56, CFD analiza, Variable Stator Vane Actuator, gorivni probni sto*