

## ENGINEERING EVALUATION

**SUBJECT:**

**Ram Air Modulation Linear  
Electromechanical Actuator or Ram Air  
Inlet Actuator (P/N 541674-4)  
Investigation Report**

|           |                         |
|-----------|-------------------------|
| No.       | : B737NG-EE-21-064      |
| Date      | : January 28, 2015      |
| Reference | : <i>See References</i> |
| A/C Type  | : B737-800/900ER        |
| Attention | : QA, LM, OEM, Planning |

**BACKGROUND**

The event covered by this evaluation is classified under the category of Pack Flow Control and Pack Cooling System; Zone Temperature Control and Indication; and Trim Air Pressure Regulation and Shutoff Control.

During recalled and descent the flight crew usually noted the sudden Pack Trip have lighted on. It has been reported for several aircraft in first quarter 2014 that B737-900ER Ram Air Modulation Linear Electromechanical Actuator (P/N 541674-4) were got 77 total defect transaction report removals and cross changed cases of B737-900ER during Q1 2014. Has been reported by warranty team data that Lion Air has gained 170 total removals during 2007 through Q1 2014 period of time. Most of them was found fault message Ram Air Actuator's when BITE was performed. There are also several finding when the aircraft on ground, some of them are AC motor burnt, limit switched out of specification, and motor bearing failed. Ram Air Actuator are located on 191GL (191GR) access panels.

Several instances of corroded Ram Air Door Actuators (RADA) have been found and there has been a case of failure of the RADA to close/open due to a corroded actuator. There are no Directive mandates from Boeing and/or OEM which requires a regular operational test and general inspection of the RADA for step ahead to gain a correct deployment.

Many operators told Boeing that they found rub damage on the ram air door actuators and link arm assemblies. Hence, in September 23, 2010 Boeing issued Service Bulletin SB 737-21-1174 that gives instructions to replace the shaft assemblies and link arm assemblies for the left and right ram air inlet systems. Lion Air have done to imply the SB 737-21-1174, and no significant effect on the RADA defect information up this time.

Having a basis from the information provided by Honeywell for several Repair Order numbers, Ram Air Modulation Linear Electromechanical Actuator (P/N 541674-4) part(s) or material was/were obtained many defect of rotor motor, bearing motor, AC motor, limit switch, actuator jack screw, actuator drive nut, capacitor, connector, spur gear, etc.

**Prepared by**

**Renni Ekaputri**

|                |    |    |          |      |
|----------------|----|----|----------|------|
| Distribution : | LM | QA | Planning | FILE |
|----------------|----|----|----------|------|

Page 1 of 22

## ENGINEERING EVALUATION

No. B737NG-EE-21-064

Date : January 28, 2015

### **DESCRIPTION**

This Engineering Evaluation is intended to provide details and describe concurrent problem on Lion Air's B737-800 and B737-900ER fleets with Ram Air Modulation Linear Electromechanical Actuator (P/N 541674-4) several defect cases to find causative reason regarding with several irregularity-finding. Moreover, the following evaluation is given recommendation to clarify Lion Air's RADA defect report: ram door full open light stays on when aircraft in the air; ram door full open light is not on, aircraft is on the ground; right pack ram air actuator fault; left pack ram air actuator fault; red inlet actuator fault light on the left ram air inlet actuator.

### **REFERENCES**

- [1]. AMM 21-51.
- [2]. Honeywell CMM 21-20-36.
- [3]. B737NG-FTD-21-03006.
- [4]. B737NG-FTD-21-03007.
- [5]. B737NG-FTD-21-04004.
- [6]. B737NG-FTD-21-07002.
- [7]. TASK 21-51-21-000-801.
- [8]. MLI-MLI-13-0046-29B.
- [9]. MLI-MLI-13-0046-09B.
- [10]. Boeing SB 7173-21-1174.
- [11]. B739-EA-21-315, Air Conditioning – Pack Flow Control and Pack Cooling System – Replacement of Shaft Assemblies and Link Arm Assemblies to Increase the Clearance for the Ram Air Inlet Actuators.
- [12]. B737NG-EA-21-445R1, Inspection of Rod/Link Arm Assembly for Gouges.
- [13]. B737NG-ER-21-024, Pack Trip Off Light-On Caused by Ram Air Actuator Problem.

### **INFORMATION**

Herewith several leading particulars facts and details of Ram Air Modulation Linear Electromechanical Actuator (P/N 541674-4):

- |                                |  |
|--------------------------------|--|
| 1. Component                   | : Ram Air Modulation Linear Electromechanical Actuator             |
| 2. P/N of Component            | : 541674-4   |
| 3. Vendor                      | : Honeywell  |
| 4. CMM                         | : 21-20-36, February 15, 2013                                      |
| 5. Operating Voltage           | : 115 VAC, 400 Hz, single phase                                    |
| 6. Rated Load                  | : 160 pounds (72.57 Kg)  |
| 7. Maximum Load                | : 200 pounds (90.71 Kg)  |
| 8. Travel time (at rated load) | : 15 seconds (maximum)   |
| 9. Retracted mechanical stop   | : 0.03 inch (0.762 mm) (minimum) from retract limit switch setting |
| 10. Extended mechanical stop   | : 0.03 inch (0.762 mm) (minimum) from extend limit switch setting  |

## ENGINEERING EVALUATION

No. B737NG-EE-21-064

Date : January 28, 2015

Here below is excerpt from several shop report related on the Ram Air Modulation Linear Electromechanical Actuator/Ram Air Actuator (P/N 541674-4) failure during 2011 through 2012.

**Table 1.** Removed and Repaired Actuator

| No | A/C Reg | S/N                | CSI   | CSN   | Repair shop        |
|----|---------|--------------------|-------|-------|--------------------|
| 1  | PK-LFK  | 106-6702           | 2473  | 5619  | GA TELESIS CKG SE  |
| 2  | PK-LFG  | 11407              | 12293 | 12737 | SARGENT AVBORNE    |
| 3  | PK-LFK  | 12670 (SEP 2012)   | 1266  | 7729  | SARGENT AVBORNE    |
| 4  | PK-LFK  | 12068              | 1136  | 10352 | SARGENT AVBORNE    |
| 5  | PK-LFO  | 12247              | 186   | 8399  | SARGENT AVBORNE    |
| 6  | PK-LGS  | 13891              | 5882  | 6619  | HONEYWELL          |
| 7  | PK-LGT  | 14047              | 5350  | 6152  | HONEYWELL          |
| 8  | PK-LGT  | 14221              | 60    | 5456  | HONEYWELL          |
| 9  | PK-LGM  | 13848              | 6004  | 6295  | HONEYWELL          |
| 10 | PK-LFV  | 99-1767 (AUG 2012) | 23    | 470   | ATLANTIC AEROSPACE |
| 11 | PK-LHQ  | 14668              | 2932  | 3767  | HONEYWELL          |
| 12 | PK-LGQ  | 13943              | 5140  | 6121  | HONEYWELL          |
| 13 | PK-LFM  | 9075 (JULY 2012)   | 1193  | 2118  | SARGENT            |
| 14 | PK-LGS  | 13893              | 5523  | 6445  | HONEYWELL          |
| 15 | PK-LGY  | 14267              | 4390  | 5438  | HONEYWELL          |
| 16 | PK-LGS  | 13981 (JUN 2012)   | 20    | 5719  | HONEYWELL          |
| 17 | PK-LGV  | 14133              | 4300  | 5467  | HONEYWELL          |
| 18 | PK-LHI  | 14358              | 3959  | 4731  | HONEYWELL          |
| 19 | PK-LFZ  | 13317              | 6572  | 7940  | HONEYWELL          |
| 20 | PK-LGR  | 13946              | 5068  | 6522  | HONEYWELL          |
| 21 | PK-LFW  | 13370              | 5999  | 7472  | HONEYWELL          |
| 22 | PK-LFV  | 12695              | 997   | 8816  | SARGENT AVBORNE    |
| 23 | PK-LGJ  | 13422              | 5947  | 7490  | HONEYWELL          |
| 24 | PK-LGV  | 14157              | 3910  | 5614  | HONEYWELL          |
| 25 | PK-LGU  | 13974              | 4032  | 5893  | HONEYWELL          |
| 26 | PK-LFM  | 12475              | 7832  | 9959  | SARGENT AVBORNE    |
| 27 | PK-LGT  | 14046              | 3844  | 5896  | HONEYWELL          |
| 28 | PK-LGQ  | 14273              | 1727  | 4809  | HONEYWELL          |
| 29 | PK-LGL  | 13573              | 4925  | 6944  | HONEYWELL          |
| 30 | PK-LFT  | 12670 (JAN 12)     | 5827  | 7729  | HONEYWELL          |
| 31 | PK-LFK  | 77-3812            | 204   | 4903  | SARGENT AVBORNE    |
| 32 | PK-LGG  | 97-1476            | 878   | 3806  | SARGENT            |
| 33 | PK-LFV  | 13-283             | 4616  | 8376  | HONEYWELL          |
| 34 | PK-LFW  | 13-368             | 4222  | 7799  | HONEYWELL          |
| 35 | PK-LFU  | 13-263             | 4508  | 8017  | HONEYWELL          |
| 36 | PK-LFJ  | 68-7615            | 85    | 1852  | GE TELESIS         |

## ENGINEERING EVALUATION

No. B737NG-EE-21-064

Date : January 28, 2015

From TRAX system database, the Ram Air Actuator problem during 2011 until 2012 :

**Table 2-A.** Actuator-Related Problem

| No | A/C Reg | S/N      | CSI   | Date       | Removal Reason   |
|----|---------|----------|-------|------------|--|
| 1  | PK-LFG  | 11407    | 12293 | 08/04/2012 | Pack trip  |
| 2  | PK-LFH  | 12068    | 8810  | 02/28/2011 | Actuator unserviceable                                       |
| 3  | PK-LFI  | 68-7615  | 1767  | 02/22/2012 | L/H ram door full open light not ill on ground               |
| 4  | PK-LFK  | 106-6702 | 2473  | 01/17/2011 | Pack trip  |
| 5  | PK-LFK  | 12670    | 1266  | 09/04/2012 | Pack light illuminated                                       |
| 6  | PK-LFK  | 12068    | 1136  | 02/15/2012 | BITE ON zone temp controller actuator failed                 |
| 7  | PK-LFK  | 12670    | 1266  | 09/04/2012 | Pack light illuminated                                       |
| 8  | PK-LFK  | 77-3812  | 204   | 08/18/2011 | Pack illuminated on recall                                   |
| 9  | PK-LFM  | 99-1767  | 36    | 10/26/2011 | LH pack ill on recall  |
| 10 | PK-LFM  | 9075     | 1193  | 05/03/2012 | Door deflector cannot fully open                             |
| 11 | PK-LFM  | 12475    | 7832  | 08/08/2011 | Ram air actuator rod is loosen                               |
| 12 | PK-LFO  | 12247    | 186   | 08/19/2012 | Pack ill on recall (message fault ACT ram air door)          |
| 13 | PK-LFO  | 12247    | 1864  | 07/15/2011 | Cross change of PK-LGF                                       |
| 14 | PK-LFQ  | 99-1767  | 411   | 06/27/2011 | ACT door sometimes failed                                    |
| 15 | PK-LFT  | 12670    | 5827  | 09/13/2011 | Pack on recall   |
| 16 | PK-LFT  | 13848    | 291   | 10/28/2012 | Pack on recall (BITE zone temp message "ACT")                |
| 17 | PK-LFT  | 12670    | 5827  | 09/13/2011 | Pack on recall   |
| 18 | PK-LFU  | 13263    | 4508  | 03/30/2011 | Left pack light illuminate on recall                         |
| 19 | PK-LFV  | 99-1767  | 23    | 12/31/2011 | ACT INOP   |
| 20 | PK-LFV  | 12695    | 997   | 12/29/2011 | RAM door to open position                                    |
| 21 | PK-LFV  | 13283    | 4616  | 04/09/2011 | Pack illuminate on recall                                    |
| 22 | PK-LFW  | 13368    | 4222  | 03/10/2011 | BITE message "RAM air actuator"                              |
| 23 | PK-LFZ  | 13317    | 6572  | 04/15/2012 | R/H RAM door actuator ill when BITE via zone temp controller |
| 24 | PK-LGJ  | 13422    | 5947  | 01/24/2012 | ACT is bad   |
| 25 | PK-LGL  | 13573    | 4925  | 10/18/2011 | Pack ill on recall   |

## ENGINEERING EVALUATION

No. B737NG-EE-21-064

Date : January 28, 2015

**Table 2-B. Actuator-Related Problem**

| No | A/C Reg | S/N   | CSI  | Date       | Removal Reason   |
|----|---------|-------|------|------------|--|
| 26 | PK-LGM  | 13848 | 6004 | 06/21/2012 | (pack on recall) MSG RAM door actuator)                        |
| 27 | PK-LGQ  | 13943 | 5140 | 02/24/2012 | LH pack ill on recall  |
| 28 | PK-LGQ  | 14273 | 1727 | 11/11/2011 | Pack on recall   |
| 29 | PK-LGR  | 13946 | 5068 | 03/26/2012 | message RAM air actuator                                       |
| 30 | PK-LGS  | 13891 | 5882 | 08/03/2012 | Pack on recall RAM air act ill                                 |
| 31 | PK-LGS  | 13893 | 5523 | 06/06/2012 | Pack LT illuminate "ACT" failed during BITE                    |
| 32 | PK-LGS  | 13981 | 20   | 06/08/2012 | LH pack ill on recall  |
| 33 | PK-LGT  | 14047 | 5350 | 06/22/2012 | Pack on recall (message "ACT")                                 |
| 34 | PK-LGT  | 14221 | 60   | 07/01/2012 | Pack on recall ill BITE message RAM door actuator              |
| 35 | PK-LGT  | 14046 | 3844 | 11/02/2011 | ACT failed   |
| 36 | PK-LGU  | 13981 | 4761 | 03/30/2012 | BITE via zone temp CTRLR found message RAM air actuator failed |
| 37 | PK-LGU  | 13974 | 4032 | 12/08/2011 | Pack on recall   |
| 38 | PK-LGV  | 14133 | 4300 | 04/27/2012 | BITE ZTC#2 found message "ACT"                                 |
| 39 | PK-LGV  | 14157 | 3910 | 02/22/2012 | BITE ON pack/zone temp confound message "ACT fail"             |
| 40 | PK-LGW  | 14221 | 4605 | 05/25/2012 | Message pack on recall   |
| 41 | PK-LGY  | 14267 | 4390 | 06/02/2012 | Pack illuminate on recall                                      |
| 42 | PK-LGZ  | 14273 | 3082 | 11/13/2011 | LH pack illuminate on recall                                   |
| 43 | PK-LHI  | 14358 | 3959 | 04/24/2012 | RAM door full open light not illuminate                        |
| 44 | PK-LHQ  | 14668 | 2932 | 07/10/2012 | Pack light ill on recall (message RAM door actuator on BITE)   |

Several defect transaction report of Ram Air Modulation Linear Electromechanical Actuator (P/N 541674-4):

**Table 3-A. Defect Serial Number of Ram Air Door Actuator (2008 through Q1 2014)**

| No | S/N   |       |       |       |       |
|----|-------|-------|-------|-------|-------|
| 1  | 9075  | 12355 | 12695 | 13317 | 13848 |
| 2  | 9322  | 12362 | 12753 | 13368 | 13851 |
| 3  | 11407 | 12400 | 12773 | 13370 | 13852 |
| 4  | 11414 | 12407 | 12856 | 13408 | 13854 |
| 5  | 11567 | 12413 | 12921 | 13415 | 13859 |
| 6  | 11570 | 12440 | 12931 | 13422 | 13891 |
| 7  | 12029 | 12470 | 12977 | 13432 | 13893 |
| 8  | 12068 | 12475 | 12980 | 13477 | 13943 |
| 9  | 12109 | 12499 | 13176 | 13482 | 13944 |
| 10 | 12116 | 12519 | 13262 | 13571 | 13946 |
| 11 | 12202 | 12668 | 13263 | 13573 | 13954 |
| 12 | 12231 | 12670 | 13283 | 13711 | 13974 |
| 13 | 12247 | 12673 | 13290 | 13780 | 13981 |
| 14 | 12332 | 12689 | 13311 | 13848 | 14046 |

## ENGINEERING EVALUATION

No. B737NG-EE-21-064

Date : January 28, 2015

**Table 3-B.** Defect Serial Number of Ram Air Door Actuator (2008 through Q1 2014)

| No | S/N   |       |          |         |
|----|-------|-------|----------|---------|
| 1  | 14047 | 14733 | 15489    | 45-6419 |
| 2  | 14133 | 14791 | 15538    | 49-4401 |
| 3  | 14143 | 14840 | 15538    | 65-3109 |
| 4  | 14157 | 14874 | 15571    | 68-7615 |
| 5  | 14172 | 14913 | 15615    | 69-8146 |
| 6  | 14221 | 15017 | 15712    | 71-5328 |
| 7  | 14245 | 15061 | 15716    | 76-3392 |
| 8  | 14257 | 15105 | 15772    | 77-3812 |
| 9  | 14267 | 15109 | 15773    | 79-4577 |
| 10 | 14273 | 15149 | 15775    | 79-4590 |
| 11 | 14288 | 15151 | 15793    | 79-4590 |
| 12 | 14351 | 15222 | 15815    | 97-1476 |
| 13 | 14358 | 15283 | 16402    | 98-4333 |
| 14 | 14362 | 15309 | 16462    | 99-1767 |
| 15 | 14397 | 15310 | 101-5493 | 45-6419 |
| 16 | 14410 | 15360 | 106-6702 | 49-4401 |
| 17 | 14617 | 15371 | 108-1582 | 65-3109 |
| 18 | 14668 | 15415 | 13-6033  |         |
| 19 | 14698 | 15441 | 16-6615  |         |
| 20 | 14706 | 15463 | 34-1089  |         |

## ENGINEERING EVALUATION

No. B737NG-EE-21-064

Date : January 28, 2015

### **SYSTEM DESCRIPTION**

#### **Ram Air System**

The ram air system controls the flow of ram air to the primary and secondary heat exchangers. These are the ram air system components:

1. Ram air control temperature sensor
2. Pack/zone temperature controller
3. Ram air inlet actuator
4. Ram air inlet deflector door
5. Ram air inlet modulation panels
6. Impeller fan
7. Fan bypass check valve.

Ram air system controls the quantity of outside ambient air that flows through the heat exchangers. RAM DOOR FULL OPEN light is one of the controls and indications of the cooling system that might be often occurred in Lion Air's problem of Ram Air Modulation Linear Electromechanical Actuator (P/N 541674-4).

The primary heat exchanger efficiency decreases as dirt and contamination collect on the cooling surfaces. A RAM DOOR FULL OPEN light that stays on in flight can be an indication of a heat exchanger.

At takeoff, the ram air inlet deflector doors move to the faired position. The ram air exit louvers do not move. The RAM DOOR FULL OPEN light remains on.

The packs produce an air temperature which will satisfy the zone which requires the most cooling. Zone temperature is controlled by adding the proper amount of trim air to the air leaving the mix manifold through the zone supply ducts.

The quantity of trim air is regulated by individual trim air modulating valves. If air in a zone supply duct overheats, the associated amber ZONE TEMP light illuminates, and the associated trim air modulating valve closes. The trim air modulating valve may be reopened after the duct has cooled by pushing the TRIP RESET Switch.

The left controller contains with AFT CABIN zone, back-up control of CTL CABIN zone, LH pack temperature control valve, RH pack standby temperature control valve, LH ram air door. And right controller have FWD CABIN zone, primary control of CTL CABIN zone, RH pack temperature control valve, LH pack standby temperature control valve, RH ram air door.

## ENGINEERING EVALUATION

No. B737NG-EE-21-064

Date : January 28, 2015

The left controller contains with AFT CABIN zone, back-up control of CTL CABIN zone, LH pack temperature control valve, RH pack standby temperature control valve, LH ram air door. And right controller have FWD CABIN zone, primary control of CTL CABIN zone, RH pack temperature control valve, LH pack standby temperature control valve, RH ram air door.

The ram air system is used to provide cooling for the heat exchangers in the air conditioning system. Operation of the system is automatic. On ground, or in flight with the flaps not up, the ram door will move to the full open position for maximum cooling. The RAM DOOR FULL OPEN Light illuminates whenever the ram door is fully open.

A deflector door is installed forward of the ram air inlet doors to prevent debris ingestion prior to lift-off and after touchdown. The deflector door extends electrically when air-ground safety logic is in the ground mode.

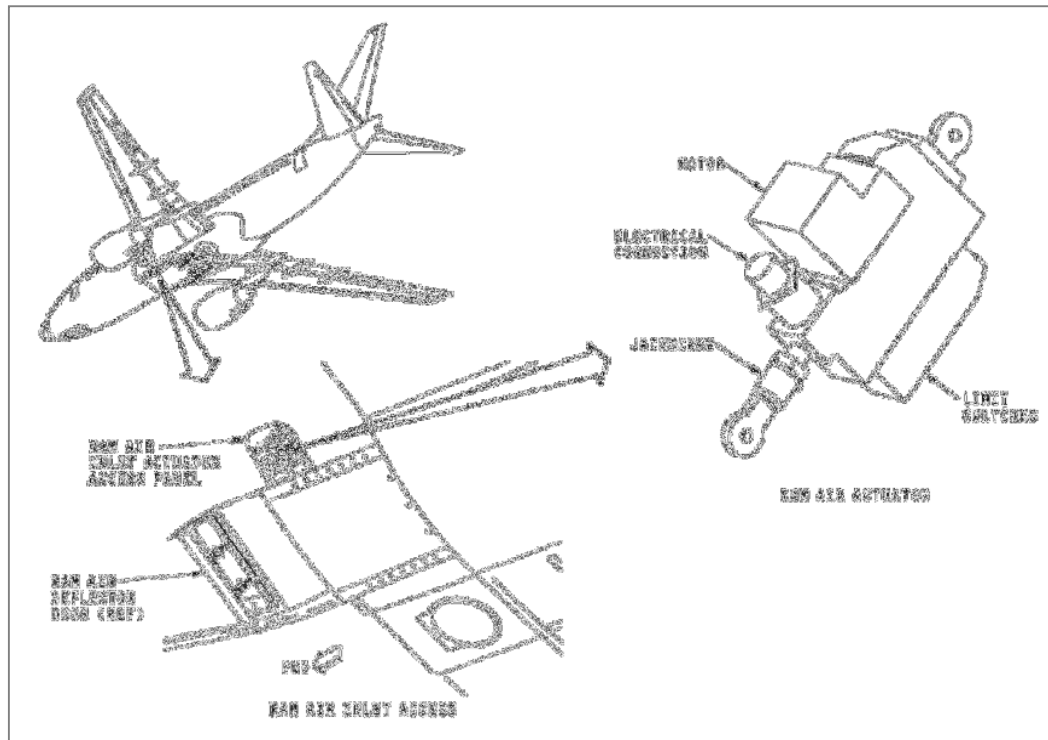


Figure 1. Air Conditioning – Cooling – Ram Air Actuator (Sheet 1 of 2)



# ENGINEERING EVALUATION

No. B737NG-EE-21-064

Date : January 28, 2015

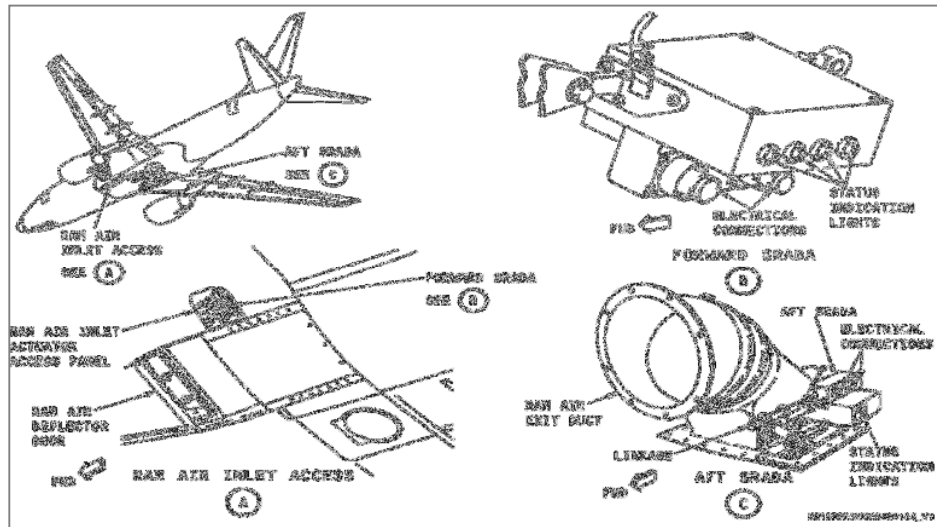


Figure 1. Air Conditioning – Cooling – Ram Air Actuator (Sheet 2 of 2)

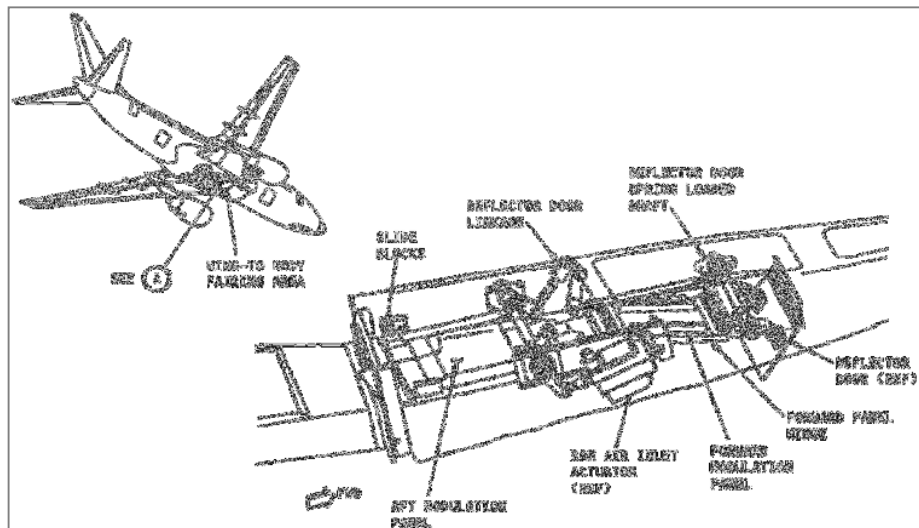


Figure 2. Ram Air Inlet Door Assembly

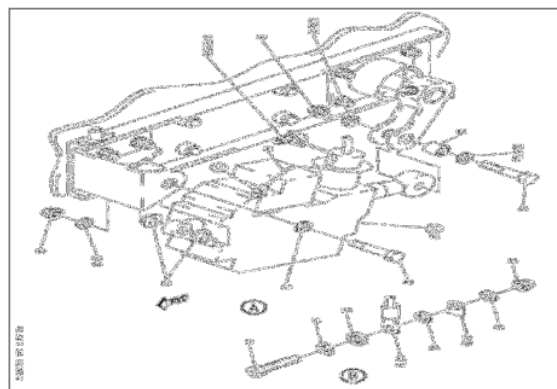


Figure 3. Ram Air Modulation Linear Electromechanical Actuator (P/N 541674-4)

# ENGINEERING EVALUATION

No. B737NG-EE-21-064

Date : January 28, 2015

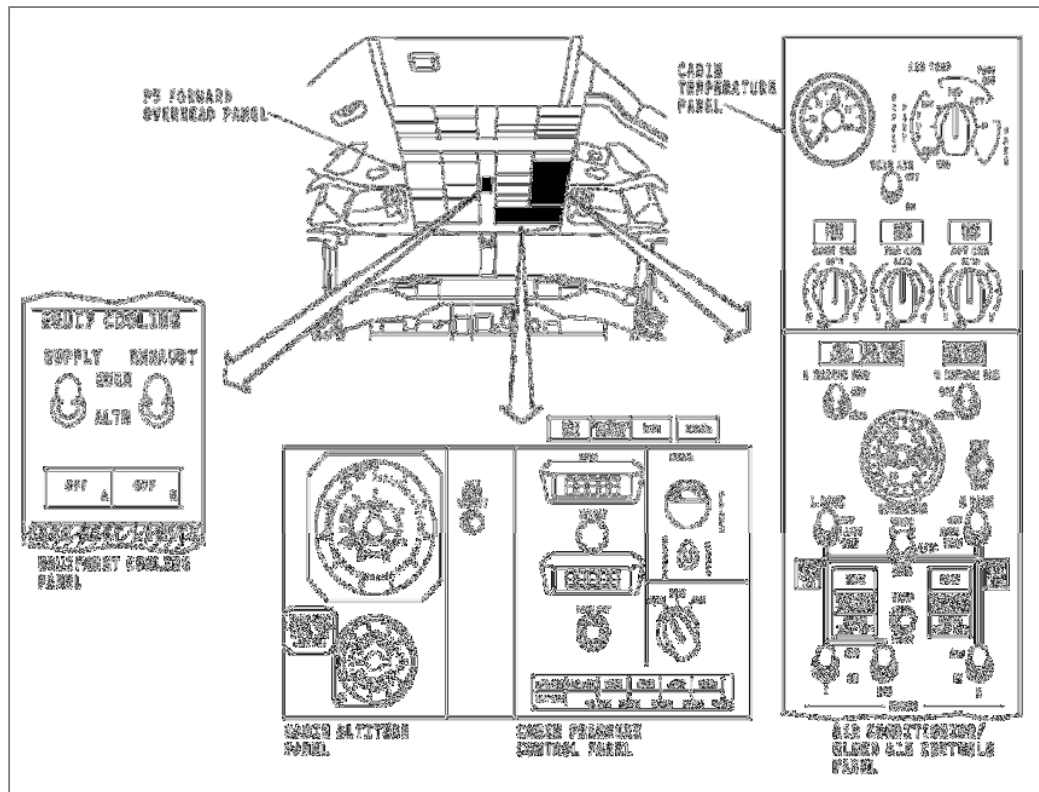


Figure 4. Air Conditioning Control Panel

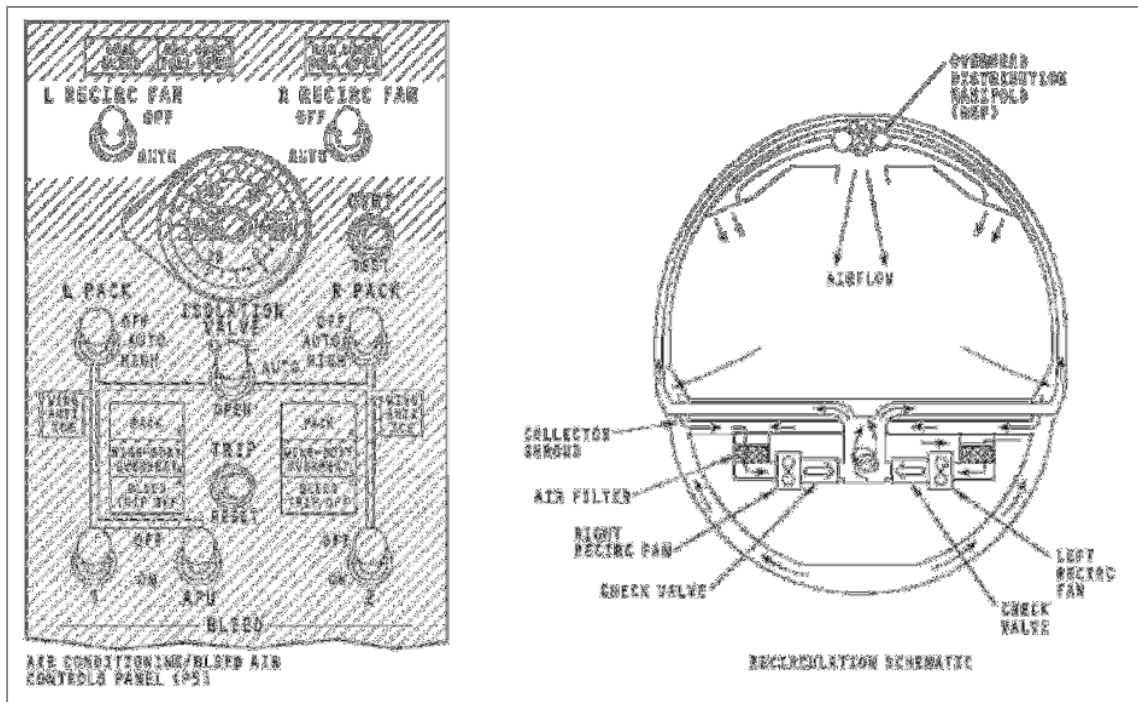
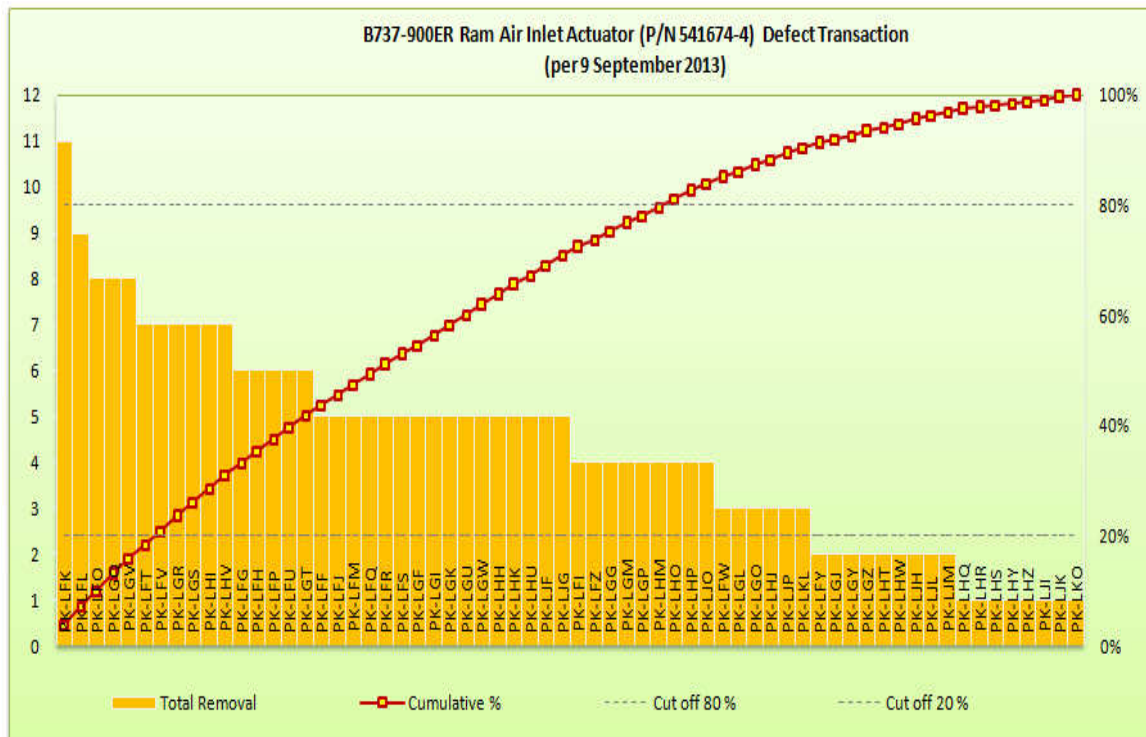


Figure 5. Air Conditioning – Recirculation System

## ENGINEERING EVALUATION

No. B737NG-EE-21-064

Date : January 28, 2015



Graph A. B737-900ER Defect Transaction of Ram Air Door Actuator (P/N 541674-4)  
(2008 through 9 September 2013)

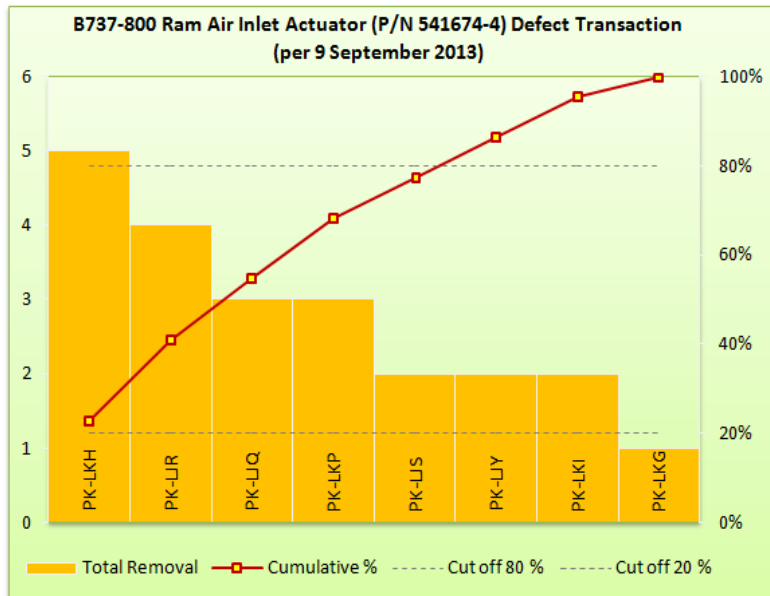
Above graph is represent frequency of defect transaction, and arranged with longest bars on the left (PK-LFK) and the shortest (PK-LKO) to the right. From the depicted graph shows 64 aircrafts were defected on the ram air door actuator. Once we have the values for each aircraft, we would require a dummy series to display the "cutoff 80% and 20%" in the Pareto chart. We could often notice that about 80% of the ram air door actuator defective products are subjected by about 20% of the defect.

Separate that PK-LFK, PK-LFL, and PK-LFO are the major aircraft with ram air door actuator problems from the many possible aircrafts so we can focus our improvement efforts.

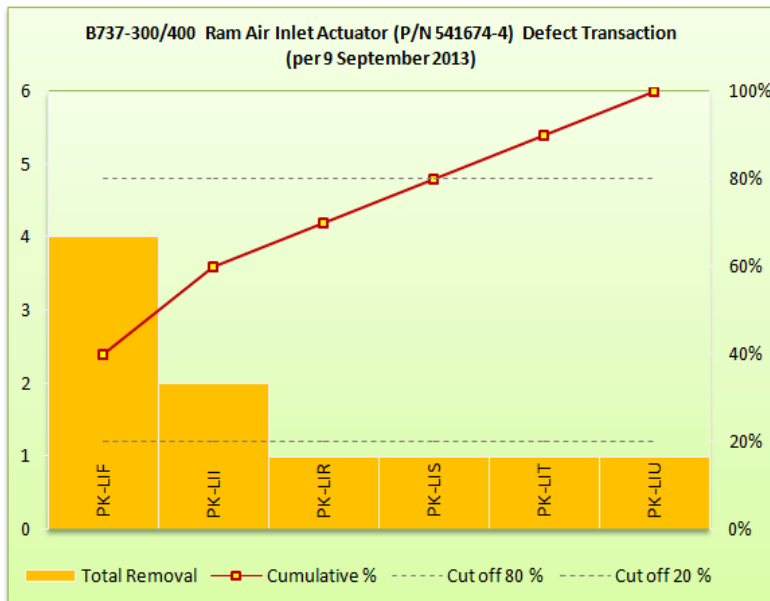
## ENGINEERING EVALUATION

No. B737NG-EE-21-064

Date : January 28, 2015



Graph B. B737-800 Defect Transaction of Ram Air Door Actuator (P/N 541674-4)  
(2008 through 9 September 2013)

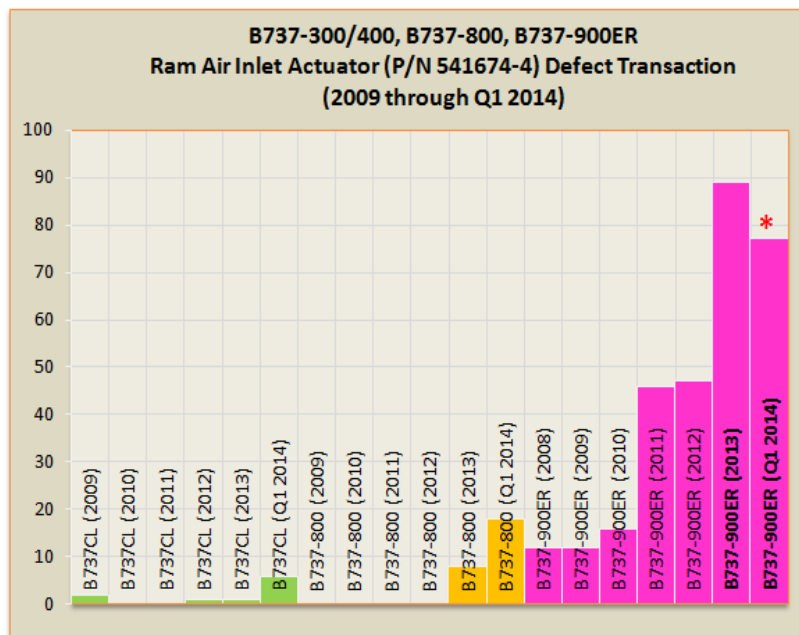


Graph C. B737-300/400 Defect Transaction of Ram Air Door Actuator (P/N 541674-4)  
(2008 through 9 September 2013)

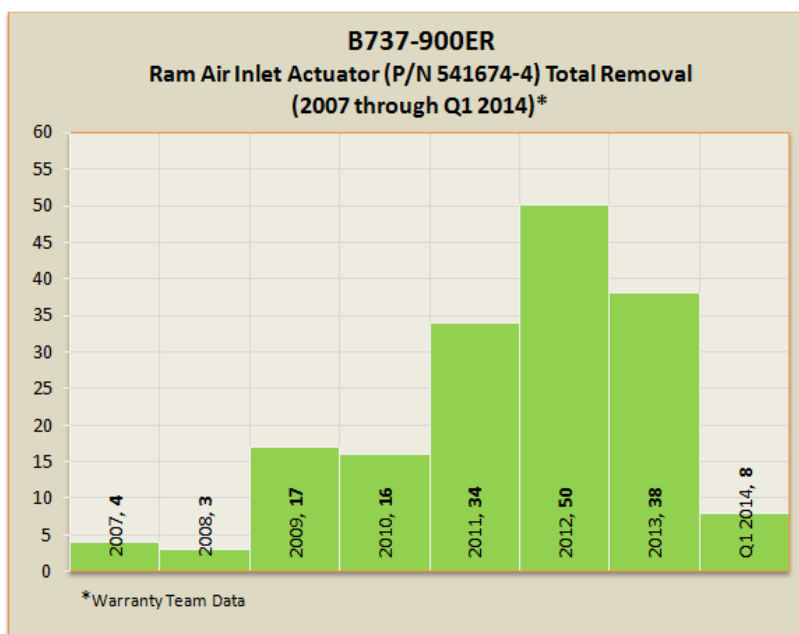
## ENGINEERING EVALUATION

No. B737NG-EE-21-064

Date : January 28, 2015



Graph D. B737-300/400, B737-800, B737-900ER Defect Transaction of Ram Air Door Actuator (2009 through Q1 2014)

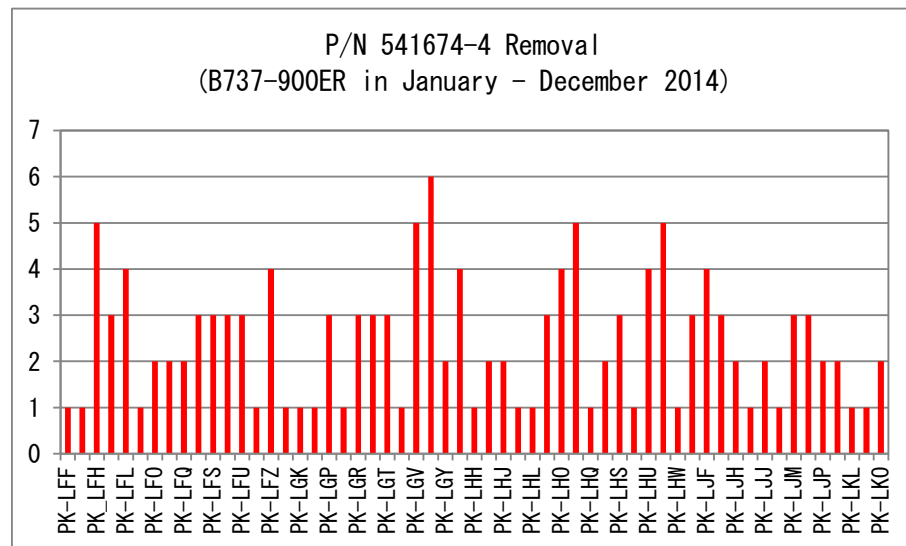


Graph E. B737-900ER Defect Transaction of Ram Air Door Actuator (2007 through Q1 2014)

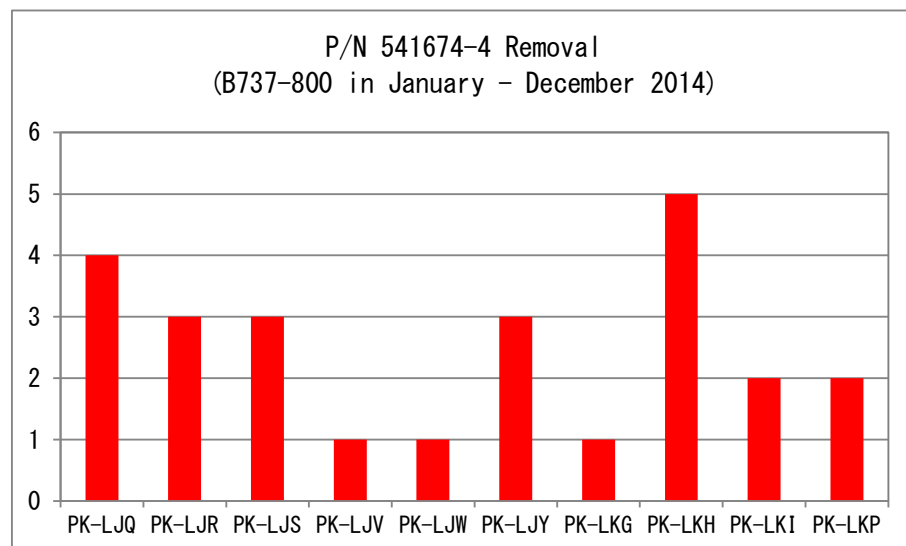
## ENGINEERING EVALUATION

No. B737NG-EE-21-064

Date : January 28, 2015



Graph F. P/N 541674-4 Total Removal of Boeing B737-900ER in 2014



Graph G. P/N 541674-4 Total Removal of Boeing B737-800 in 2014

## ENGINEERING EVALUATION

No. B737NG-EE-21-064

Date : January 28, 2015

| A/C Type   | Total Flight Hour (FH)<br>per 2014 | MTBR    | MTBUR    |
|------------|------------------------------------|---------|----------|
| B737-900ER | 168256                             | 2438.49 | 4054.36  |
| B737-800   | 73019                              | 5841.52 | 11233.69 |

Table A. Mean Time Between Removal P/N 541674-4 in 2014

| P/N          | Reg.Aircraft | Failure                      | Total<br>Defect | Cumulative %<br>(Defect) | Cut off % |
|--------------|--------------|------------------------------|-----------------|--------------------------|-----------|
| 541674-4     | B737-900ER   | PACK LT ILL ON RECALL        | 40              | 28.99%                   | 0.8       |
| 541674-4     | B737-900ER   | CROSSCHANGE                  | 33              | 52.90%                   | 0.8       |
| 541674-4     | B737-900ER   | ROBBING                      | 21              | 68.12%                   | 0.8       |
| 541674-4     | B737-900ER   | MSG FORM ZTC " ACT "         | 13              | 77.54%                   | 0.8       |
| 541674-4     | B737-900ER   | PACK ON RECALL WITH MSG RADA | 8               | 83.33%                   | 0.8       |
| 541674-4     | B737-900ER   | FOR SERVICE                  | 7               | 88.41%                   | 0.8       |
| 541674-4     | B737-900ER   | NOT RUNNING                  | 6               | 92.75%                   | 0.8       |
| 541674-4     | B737-900ER   | ACTUATOR WEAK                | 3               | 94.93%                   | 0.8       |
| 541674-4     | B737-900ER   | ACT FAILED                   | 1               | 95.65%                   | 0.8       |
| 541674-4     | B737-900ER   | ACT STUCK                    | 1               | 96.38%                   | 0.8       |
| 541674-4     | B737-900ER   | MOTOR WEAK                   | 1               | 97.10%                   | 0.8       |
| 541674-4     | B737-900ER   | NOT PROPERLY MODULATE        | 1               | 97.83%                   | 0.8       |
| 541674-4     | B737-900ER   | PZC FOUND MSG ACTUATOR       | 1               | 98.55%                   | 0.8       |
| 541674-4     | B737-900ER   | RE-INSTALLED                 | 1               | 99.28%                   | 0.8       |
| 541674-4     | B737-900ER   | STUCK CLOSED                 | 1               | 100.00%                  | 0.8       |
| <b>Total</b> |              |                              | <b>138</b>      |                          |           |

Table B. P/N 541674-4 Total Removal of Boeing B737-900ER in 2014

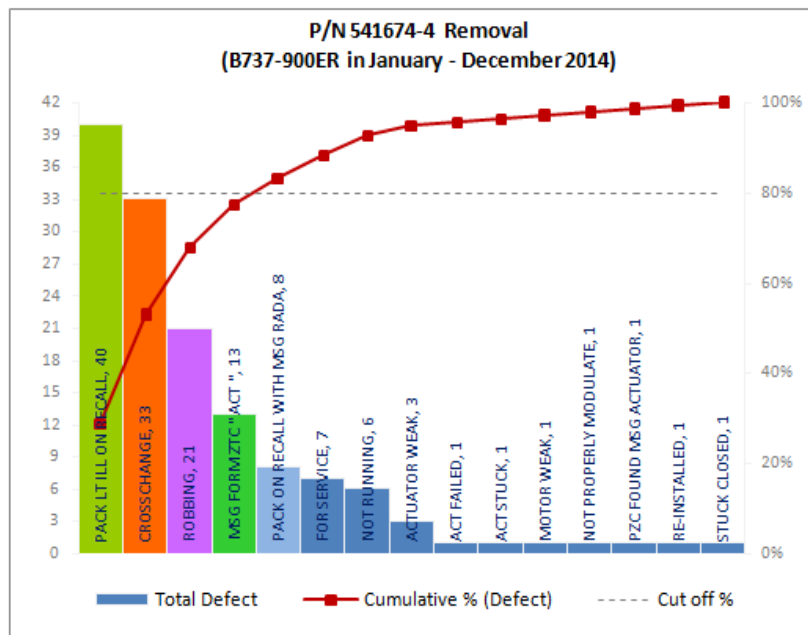
| P/N          | Reg.Aircraft | Failure              | Total<br>Defect | Cumulative %<br>(Defect) | Cut off % |
|--------------|--------------|----------------------|-----------------|--------------------------|-----------|
| 541674-4     | B737-800     | CROSSCHANGE          | 6               | 24.00%                   | 0.8       |
| 541674-4     | B737-800     | PACK ILL ON RECALL   | 6               | 48.00%                   | 0.8       |
| 541674-4     | B737-800     | ROBBING              | 4               | 64.00%                   | 0.8       |
| 541674-4     | B737-800     | FOR SERVICE          | 3               | 76.00%                   | 0.8       |
| 541674-4     | B737-800     | MSG FORM ZTC " ACT " | 3               | 88.00%                   | 0.8       |
| 541674-4     | B737-800     | STUCK CLOSE          | 2               | 96.00%                   | 0.8       |
| 541674-4     | B737-800     | REPLACED             | 1               | 100.00%                  | 0.8       |
| <b>Total</b> |              |                      | <b>25</b>       |                          |           |

Table C. P/N 541674-4 Total Removal of Boeing B737-800 in 2014

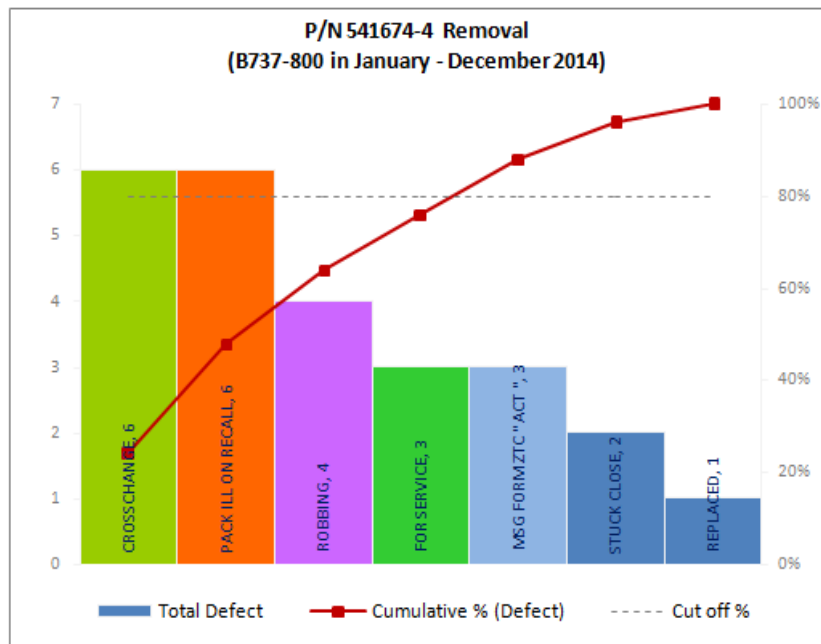
# ENGINEERING EVALUATION

No. B737NG-EE-21-064

Date : January 28, 2015



Graph H. Pareto of P/N 541674-4 Total Removal in 2014 (B737-900ER)



Graph I. Pareto of P/N 541674-4 Total Removal in 2014 (B737-800)



## ENGINEERING EVALUATION

No. B737NG-EE-21-064

Date : January 28, 2015

### EVALUATION

#### Engineering Economy Aspect

Some economic equivalence problems are coming concurrent with Ram Air Modulation Linear Electromechanical Actuator (P/N 541674-4) defect transaction report involve projected cash-flow patterns that are changing at an average rate, each period.

These defects have caused an unbalance money-time relationships effect. There are many fundamental reasons why return to capital in the form of interest and profit is an essential ingredient of engineering economy. Thus, when capital (borrowed or equity) is involved. There is a cost for the capital employed in the sense that the Lion Air's project must provide a sufficient return to be financially attractive to customer.

We can predict the equivalence calculations for *a decreasing geometric gradient series* from TRAX database of Ram Air Modulation Linear Electromechanical Actuator (P/N 541674-4) value.

Simulation begins with TRAX database of Ram Air Modulation Linear Electromechanical Actuator (P/N 541674-4) is **\$3,000 (overhaul)** at the end of year one and decreases by 20% per year after the first year, and the interest rate is 25% per year, up to the fourth year and one year artificially simulation. The desired quantities are as follows:

$$P = \frac{\$3,000[1 - (P/F, 25\%, 4)(F/P, -20\%, 4)]}{0.25 - (-0.2)}$$

$$P = \frac{\$3,000}{0.45} [1 - (0.4096)(1 - 0.2)^4]$$

$$P = \$6,666.67(0.83222) = \$5,548.133$$

$$A = \$5,548.133(A/P, 25\%, 4) = \$2,349.08$$

$$F = \$5,548.133(F/P, 25\%, 4) = \$13,545.21 \text{ (Lost value for one RADA in four year)}$$

$$P = \frac{\$3,000[1 - (P/F, 25\%, 1)(F/P, -20\%, 1)]}{0.25 - (-0.2)}$$

$$P = \frac{\$3,000}{0.45} [1 - (0.8)(1 - 0.2)^1]$$

$$P = \$6,666.67(0.36) = \$2,400$$

$$A = \$2,400(A/P, 25\%, 1) = \$3,000$$

$$F = \$2,400(F/P, 25\%, 1) = \$3,000 \text{ (Lost value for one RADA in one year)}$$

P = Present Sum of Money

F = Future Sum of Money

A = End-of-Period Cash Flows

## ENGINEERING EVALUATION

No. B737NG-EE-21-064

Date : January 28, 2015

### **Fault Finding**

Investigation revealed that the failure was caused by mostly incorrectly bearing, rotor assembly, screw, ring, nut, washer, switch, capacitor in the ram air actuator. This condition, if not corrected, could result in failure of the ram air actuator to deploy when necessary during flight, which could result in reduced controllability of the aircraft.

We estimates that 77 total defect transaction report removals and cross changed cases of B737-900ER during Q1 2014 of ram air actuator. Thus LION AIR's fleet would be affected by provided failure, that it would take approximately several work hours per aircraft to accomplish the proposed inspection, and that the average labor rate per work hour. Has been reported by warranty team data that Lion Air has gained 170 total removals during 2007 through Q1 2014 period of time.

Mostly, pack trip off was caused by the indication of pack temperature has exceeded limit (note: this is pack temperature not output temperature). Several trigger that can causes RAM DOOR FULL OPEN light stays on, and the aircraft in the air are:

1. Ram air actuator, M326 (left) or M327 (right)
2. Dirty heat exchangers or blocked airflow to heat exchangers
3. Air conditioning accessory unit, M324 (left) or M1455 (right)
4. Trailing edge flaps up switch, S1051 (left side)
5. Flap/slat electronics unit, M1746 (right)
6. Ram air sensor, T481 (left) or T482 (right)
7. Pack/zone temperature controller, M1442 (No. 1) or M1443 (No. 2)
8. Fan bypass check valve
9. Wiring problem

And the other possible causes of RAM DOOR FULL OPEN light is not on, aircraft is on the ground are:

1. RAM DOOR FULL OPEN light, L12 (left) or L13 (right)
2. Ram air actuator, M326 (left) or M327 (right)
3. Air conditioning accessory unit, M324 (left) or M1455 (right)
4. Proximity switch electronics unit (PSEU), M2061
5. Wiring problem

There are several major defects are effecting aircraft, most of them are:

1. Ram door in full open position.
2. Indicates pack trip off due to overheat or indicates failures of both primary & standby pack controls (Pack continues to operate). During Master Caution recall, indicates failure of either primary or standby pack control. Will extinguish upon Master Caution reset.
3. Indicates a pack trip off. Packs valve automatically closes & mix valves drive full cold. Trips are caused by pack temperatures exceeding limits or duct overheat.

## ENGINEERING EVALUATION

No. B737NG-EE-21-064

Date : January 28, 2015

Several facts have been noted on the Repair Order that performed at Honeywell:

| Component               | Finding Description   |
|-------------------------|---|
| S/N 34-1089; RO 14674;  | AC Motor burnt, etc.  |
| S/N 68-7615; RO 38025;  | Rotor motor rubbing against stator rotor, bearing motor dry.            |
| S/N 69-8146; RO 13150;  | AC Motor was burnt; limit switches high resistance, etc.                |
| S/N 106-6702; RO 44868; | Act jack screw assembly binding, act drive nut assembly thread damaged. |
| S/N 117-3995; RO 13156; | Limit switch out of specs, motor ID plate illegible.                    |
| S/N 12355; RO 71076;    | Bearing was rough, rotor assembly worn.                                 |
| S/N 12407; RO 778009;   | Capacitor was dented, connector was burned, etc.                        |
| S/N 12470; RO 82455;    | Open capacitor-filter assembly, switch assembly was out of calibration. |
| S/N 12475; RO 63128;    | Bearing and Hardware was worn, housing with nut rail bent.              |
| S/N 13263; RO 51241;    | Bearing rough, housing worn.  |
| S/N 13317; RO 87663;    | Worn spur gear/switch assembly /gear/bearing.                           |
| Etc                     | Etc   |

On March 10<sup>th</sup>, 2014, System Engineering (SSE-BAT) have asked several questions for the next RADA tests (stall load & limit switch) that previously being suggested by Service Engineering of Boeing. Through Boeing Message **MLI-MLI-13-0046-29B**, the message was also distributed to the Honeywell.

This problem (Ram Air Inlet Actuator RADA P/N 541674-4) has previously been investigated in 2012 through 2014. On September 23<sup>rd</sup>, 2010, Boeing Service Bulletin **SB 737-21-1174** was released to replace the Shaft Assemblies and Link Arm Assemblies which can increase the clearance for the Ram Air Inlet Actuators in the Pack Flow Control and Pack Cooling System. We compiled an engineering product **B739-EA-21-315** to perform that Service Bulletin. Boeing was also advised Lion Air to perform Ram Air Inlet Actuator Test using pull gauge, **MLI-MLI-13-0046-09B**. Lion Air issued **B737NG-EA-21-539** [Bell Crank Arm of Ram Air Inlet System Test/Measurement] for 29 selected aircraft (26 of B737-900ER; 3 of B737-800). And the result are:

1. High rate of corrosion.
2. The tension test (8-12 lbs) is more likely out of spec.
3. Poor of play between the bell crank arm/link arm assembly with the ram air inlet shaft assembly and bearing housing (stuck).
4. The stacked formation of bolt-washer-bushing is uniformly low
5. Poor of lubrication (dry condition); and/or overwhelmed grease that cover the linkage which can create more debris exist.
6. Poor of play between the bell crank arm/link arm assembly with the ram air inlet shaft assembly and bearing housing (stuck).

## ENGINEERING EVALUATION

No. B737NG-EE-21-064

Date : January 28, 2015

Hence, field reports indicate that some high time aircraft have been found with severe corrosion, wear, and the restricted motion on the ram air inlet door actuator. These condition could cause distortion or failure of the bell crank of ram air inlet door actuator, leading to possible operational interference or stuck condition (which the ram door unable to get rid). We may assure the evaluation are maintained which will accurately reflect Ram Air Door Actuator have **a lower reliability** when it was performed.

Number of Engineering Product and/or Recommendation:

1. **B789-EA-21-315**, Air Conditioning - Pack Flow Control and Pack Cooling System - Replacement of Shaft Assemblies and Link Arm Assemblies to Increase the Clearance for the Ram Air Inlet Actuators, February 23, 2011.

**Objective:** Determined a test of left and right Ram Air Inlet Systems to make sure that the systems operate correctly.

2. **B737NG-ER-21-024**, Pack Trip Off Light-On Caused by Ram Air Actuator Problem, January 29, 2013.

**Objective:** This Engineering Report is intended to address the identified undesired/unsafe condition. And provide the evaluation of component's reliability.

3. **B737NG-EA-21-445R1**, Inspection of Rod/Link Arm Assembly for Gouges, April 26, 2013.

**Objective:** This Engineering Authorization provides instruction to perform one time inspection to check and find if any gauge or other damages existed on rod arm assembly.

4. **B737NG-EA-21-539**, Bell Crank Arm of Ram Air Inlet System Test/Measurement, June 19, 2013.

**Objective:** The purpose of this test was trying to obtain the sampling data of the linkages rotation force.

## ENGINEERING EVALUATION

No. B737NG-EE-21-064

Date : January 28, 2015

### **SUGGESTION**

#### **Operator**

1. Preparing to discuss the problem with OEM (Honeywell) and Boeing about designation to reduce or eliminate the stuck actuator by effectively diminishing corrosion.
2. In cases where guidance is not provided, operators should liaise with manufacturers and other qualified entities to obtain advice in order to develop suitable procedures if actuator motor, gear train, capacitor-filter, nut assembly, internal switches, gear housing will break again.
3. **Immediately** after this kind of problem, Lion Air decided to perform stall load and limit switches test and send it to BOEING or HONEYWELL, any time evidence indicates possible corrosion and crack propagation. It refers to **Honeywell CMM 21-20-36**.
4. Relevant with the stock problem, daily demand of P/N 541674-4 is **0.15**. Or, in duration of one week B737-900ER will need **one part** of P/N 541674-4, approximately.

#### **Maintenance/Engineering in Charge**

1. In conjunction with the dirty heat exchanger or blocked airflow to heat exchanger when fault of Ram Door Full Open Light Stays ON, aircraft in the air is finding, engineering in charge may check the possible cause.
2. Be important to check the defect of L/H or R/H forward Ram Air Actuator when Ram Door Full Open Light is Not ON, aircraft is on the ground.
3. Notice if there is fault in pack/zone temperature controller when PACK or ZONE TEMP lights come ON intermittently during MASTER CAUTION recall, **FIM 21-62 Task 848**.

#### **Boeing and Honeywell**

1. Based on provided data evaluation described in the report herein, Boeing and Honeywell is being expected to give proactively monitor this case and give their corporation to deal with this unresolved problem.

# ENGINEERING EVALUATION

No. B737NG-EE-21-064

Date : January 28, 2015

## APPENDIX I. RAM AIR DOOR ACTUATOR MEASUREMENT

Result of B737NG-EA-21-539 [Bell Crank Arm of Ram Air Inlet System Test/Measurement] for 29 selected aircraft (ref. MLI-MLI-13-0046-09B).

|                       |        |        |        |        |        |        |        |        |        |        |        |        |  |
|-----------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--|
| Spec = 8 lbf - 12 lbf |        |        |        |        |        |        |        |        |        |        |        |        |  |
|                       | PK-LFK | PK-LFP | PK-LHM | PK-LHK | PK-LGK | PK-LGL | PK-LFR | PK-LGO | PK-LFH | PK-LFT | PK-LFZ | PK-LGP |  |
| Left Arm              | ok     | ok     | ok     | out    | out    | ok     | ok     | ok     | out    | out    | out    | ok     |  |
| Right Arm             | ok     | ok     | ok     | ok     | out    | ok     | ok     | out    | out    | out    | out    | ok     |  |
|                       | PK-LGQ | PK-LHL | PK-LFJ | PK-LGJ | PK-LHS | PK-LJF | PK-LJI | PK-LJZ | PK-LKK | PK-LFG | PK-LGU | PK-LHO |  |
| Left Arm              | ok     | ok     | ok     | ok     | ok     | out    | ok     | ok     | ok     | ok     | out    | out    |  |
| Right Arm             | ok     | out    | ok     | ok     | ok     | out    | ok     | ok     | ok     | ok     | ok     | out    |  |
|                       | PK-LHY | PK-LJG | PK-LKJ | PK-LHI | PK-LKI |        |        |        |        |        |        |        |  |
| Left Arm              | out    | out    | ok     | out    | ok     |        |        |        |        |        |        |        |  |
| Right Arm             | out    | ok     | ok     | out    | ok     |        |        |        |        |        |        |        |  |



Figure I-1: PK-LFK Actuator



Figure I-1: PK-LGL Actuator



Figure I-1: PK-LFT Actuator

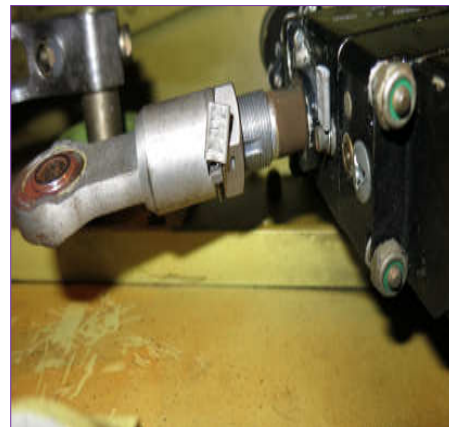


Figure I-1: PK-LFZ Actuator