Docket No.: SA-510
Exhibit No.: 9X-D

NATIONAL TRANSPORTATION SAFETY BOARD

Washington, D.C.

Boeing Memo B-U01B-14983-ASI Concerning Hydraulic Fluid Quality

Boeing Commercial Airplane Group
P.O. Box 3707
Seattle, WA 98124-2207

(1)

November 2, 1994
B-U01B-14983-ASI

Mr. Greg Phillips, AS-40
National Transportation Safety Board
490 L'Enfant Plaza East SW
Washington DC 20594-2000

Subject: USAir 737-300 Accident, N513AU/PP033 Near Pittsburgh, September 8, 1994

Reference: a) Boeing Maintenance Manual, D6-37521, section 29-15-00, pages 601-606, revision July 15, 1994
b) Boeing Document D6-24429, *An Analytical method for Contaminates in BMS 3-11 Fluids and Their Mixtures Using Differential IR Spectroscopy,* revision A, dated June 14, 1982

BOEING

Dear Mr. Phillips:

You recently asked us for in-service limits for hydraulic fluid used in the 737-300 airplane. The reference (a) manual provides our recommendations to 737-300 operators. Table 601 in the reference section provides in-service limits for specific gravity, percent water, neutralization number ("acid number"), viscosity, organic contamination, and elemental contamination. Please note that for organic contamination fluid, suppliers are using a more current method called Gas Spectroscopy in lieu of the reference (b) IR Spectroscopy . The reference (b) document does not include newer hydraulic fluids called Hyjet type IVA and IVA+.

I have enclosed a hydraulic system schematic and additional training information to assist in understanding the hydraulic system filtration on the 737-300 airplane.

All pressurized hydraulic fluid from each pump in the A, B, and Standby systems hydraulic pumps is filtered by a 15 micron absolute non-bypassing filter. These filters are located in the respective system's pressure module. The Boeing Maintenance Planning Document (MPD) schedule for the A, B, and System pressure filter replacement is at a C check interval. The enclosed table provides the recommended filter replacement schedule for all hydraulic filters. This interval was established through the Maintenance Review Board (MRB) process. Filter replacement ensures that flow and pressure from the hydraulic pumps is maintained to system components. As filters become loaded with particles, the pore size of the filter passages are reduced causing filtration to a lower micron level but at increase pressure loss. If filters are changed at the intervals recommended in the MPD, pressure losses are held to an acceptable level. PCU inlet filters for the flight control surfaces are changed on-condition during component overhaul. Particulate contamination is controlled by maintaining the hydraulic system in this manner unless contamination is induced during filter replacement or assembly of the component.

Boeing does not recommend any specific interval for replacing or sampling hydraulic fluid. The operational environment of the airplane hydraulic system can effect the service life of the hydraulic fluid. Therefore, intervals for fluid sampling or replacement/replenishing are established by the operator and their fluid supplier.

A question has been asked as to whether the servo valve on the rudder Power Control Unit (PCU) could be contaminated by particulate when the hydraulic system is pressurized or by backflow when the system is depressurized. When the system is pressurized, internal flow through the hydraulic system prevents particulate contamination by fluid downstream of the servo. When the hydraulic system is depressurized, fluid from the main body return system is inhibited from backflowing toward the A and B system rudder PCU by a check valve in the flight control module return line. The only return fluid that can access the rudder PCU is from flight control components (elevator and aileron PCUs). Return fluid, however, will not backflow into the PCU due to a check valve, internal to the PCU, which prevents flow out the pressure port.

BOEING

If you have any questions, please contact Rick Howes, [redacted]

Very truly yours,

FLIGHT TEST

[redacted]
FOR

John W. Purvis
Director, Air Safety Investigation
Org. B-U01B, M/S 14-HM
Telex 32-9430, STA DIR PURVIS
[redacted]

Enc: A. Reference (a)
B. Reference (b)
C. Boeing MPD 737-300 Hydraulic Filter Replacement Schedule, dated August 17, 1994
D. Boeing 737-300 Maintenance Training Manual, pages 026 (29.11.012), 029 (29.11.014), 034 (29.11.015), 035 (29.11.018), and 095 (29.00.013)
E. Boeing 737-300 MPD, D6-38278, page 1-4

cc: Tom Haueter, AS-10 (letter only)
Hector Casanova, SCRA
Rick Lehnherr, BCSR - Pittsburgh

HYDRAULIC SYSTEMS A, B, AND STANDBY - INSPECTION/CHECK

1. General
   A. This procedure has one task. This task does a check of the hydraulic fluid.
   B. The operational environment of the airplane hydraulic system can affect the service life of the hydraulic fluid. You make a decision to take a sample of the hydraulic fluid for analysis if you find that it is necessary from your service experience. Make sure that the fluid analysis results agree with the fluid specification limits shown in Table 601. If the fluid properties are greater than the limits in Table 601, replace some quantity of fluid with new fluid until the fluid properties agree with the limits shown. You make a decision on the quantity of fluid to be replaced.

TASK 29-15-00-206-001

2. Hydraulic Fluid Check
   A. General
      (1) You must do the steps in this procedure to clean the bottles which will hold the fluid samples. If you do not do this, it is possible the fluid samples will not be correct. You must get two fluid samples from each hydraulic reservoir. Get one sample in a polyethylene bottle which has a capacity of one pint. Get the other sample in a glass bottle which has a capacity of one or two ounces.

   B. Equipment
      (1) Polyethylene Bottle (capacity of 1-pint and a polyethylene screw cap with a seal) - Commercially Available
      (2) Glass Bottle (capacity of 1- or 2-ounces and a polyethylene screw cap with a seal) - Commercially Available
      (3) Clean Polyethylene Bags (to hold the bottles) - Commercially Available
   C. Consumable Materials
      (1) B00129 Isopropyl Alcohol, approximately 1-pint, put through a micronic filter membrane
      (2) B00083 Petroleum Ether, approximately 1-pint, put through a micronic filter membrane.

(4)

(3) E00011 Nitric Acid (20% by volume), approximately 1-pint
(4) G01061 Distilled Deionized Water, approximately 1-pint

D. References
(1) 12-12-00/301, Hydraulic Reservoir
(2) 29-15-00/201, Hydraulic Systems A, B, and Standby

E. Access

TABLE 601
Hydraulic Fluid, BMS 3-11, Property Limits

FLUID PROPERTIES	IN-SERVICE FLUID LIMITS	TEST PROCEDURE
Visual	Must be transparent. No phase separation or precipitation. All colors are satisfactory.	Visual
Specific Gravity 25°C/25°C	0.995 - 1.066	ASTM D941
Percent of Water by weight	0.1 to 0.8	ASTM D1744 or Infared *[2]
Neutralization No. mg KOH/gm	1.5 max.	ASTM D974
Viscosity, cs at 100°F	6.0 to 12.5	ASTM D445
Organic Contamination	Not Found by Infrared	Infrared *[1]
Elemental Contamination		A Procedure with the Precision that Follows)
Calcium	50 ppm max. *[2]	± 4 ppm
Potassium	50 ppm max. *[2]	± 2 ppm
Sodium	50 ppm max.	± 3 ppm
Chlorine	200 ppm max.	± 20 ppm
Sulfur	500 ppm max. *[2]	± 10 ppm

*[1] If you think there is contamination, do the procedure in Boeing Document D6-24429, An Analytical Method for Contaminates in BMS 3-11 Fluids and Their Mixtures Using Differential IR Spectrdscopy.

*[2] Contamination is a quantity that is more than that in the new fluid. Compare the data from the fluid analysis with the limits put on the new fluid. The precision of ± 10 ppm is applicable to the total values in the range from 0 to 1000 ppm. In the range from 1000 to 3000 ppm, the precision will decrease to ± 50 ppm with some equipment.

(6)

F. Clean the Bottles

S 116-002

(1) Do these steps to clean the polyethylene bottle:
   (a) Clean the bottle fully in a solution of liquid detergent and hot water.
   (b) Flush the bottle two times in hot potable water that does not have minerals.
   (c) Flush the bottle two times in deionized water which was distilled two times.
   (d) Drain the water from the bottle.
   (e) Dry the bottle in the air of a laminar flow bench in a clean room.

      NOTE: If a laminar flow bench is not available, put the bottle in a clean dry room, with the top in a down position. Keep all persons from the room until the bottle is dry and you put a cap on it.

   (f) After the bottle is dry, install a cap on the bottle.
   (g) Put the bottle in a new polyethylene bag.
   (h) Seal the bag with a knot or tape.
   (i) Identify the bag.

S 116-003

(2) Do these steps to clean the glass bottle:
   (a) Flush the bottle in a solution which has 20% by volume of nitric acid.
   (b) Flush the bottle two times in hot potable water that does not have minerals.
   (c) Flush the bottle two times in distilled water.
   (d) Flush the bottle with clean isopropyl alcohol which was put through a filter.
   (e) Flush the bottle with clean petroleum ether which was put through a filter.
   (f) Dry the bottle in the air of a laminar flow bench in a clean room.

      NOTE: If a laminar flow bench is not available, put the bottle in a clean dry room, with the top in a down position. Keep all persons from the room until the bottle is dry and you put a cap on it.

   (g) After the bottle is dry, install a cap on the bottle.
   (h) Put the bottle in a new polyethylene bag.
   (i) Seal the bag with a knot or tape.
   (j) Identify the bag.

G. Prepare for the Check

S 866-015

WARNING: MAKE SURE THAT PERSONS AND EQUIPMENT ARE CLEAR OF ALL CONTROL SURFACES BEFORE YOU SUPPLY HYDRAULIC POWER. THE AILERONS, RUDDERS, ELEVATORS, FLAPS, SLATS, SPOILERS, LANDING GEAR, AND THRUST REVERSERS CAN MOVE QUICKLY WHEN YOU SUPPLY HYDRAULIC POWER. THIS CAN CAUSE INJURY TO PERSONS AND DAMAGE TO EQUIPMENT.

(1) Supply hydraulic power to the hydraulic systems with the electric pumps (Ref 29-15-00/201).

S 866-016

(2) Operate all of the flight controls 6 to 8 times to mix the hydraulic fluid.

S 866-017

(3) Remove hydraulic power from the hydraulic systems (Ref 29-15-00/201).

NOTE: Get the samples of the hydraulic fluid not more than one hour after you stop the hydraulic system.

H. Procedure

S 686-004

(1) Open the sampling valve on the reservoir to supply a smooth flow of fluid.

S 686-005

(2) Drain a minimum of one pint of hydraulic fluid before you get a sample.

S 686-006

(3) Remove the caps from the bottles.

S 686-007

(4) Put one bottle in the fluid flow but do not touch the sampling valve.

S 686-008

(5) When the bottle is full, remove the bottle from the fluid flow.

NOTE: Do not close the sampling valve while the bottle is in the fluid flow. This can loosen the contamination and cause it to get into the sample.

(8)

S 686-009
(6) Fill the other bottle.

S 686-010
(7) Install the caps on the bottles.

S 686-011
(8) Close the sampling valve.

S 436-012
(9) Safety the sampling valve with a lockwire.

S 936-013
(10) Identify the bottles with this data:
- (a) Airplane model
- (b) Airplane number
- (c) Hydraulic system number
- (d) Date
- (e) Location.

S 616-014
(11) Fill the hydraulic reservoirs (Ref 12-12-01).

737-300 MPD Hydraulic Filter Replacement Intervals

System Filter	Interval
A & B Ground Service Disconnect	2C
A & B Case Drain for ACMP	3A
Standby Case Drain for EMP	1C
A & B Return Filters	2B
A & B Pressure Filter	1C
A & B Case Drain for EDP	2B
A & B Reservoir Fill Filter	1C
PTU Pressure Filter	1C

ACMP = Alternating Current Motor Pump
EMP = Electric Motor Pump
EDP = Engine Driven Pump
PTU = Power Transfer Unit
MPD Interval A = 200 hours
MPD Interval B = 800 hours
MPD Interval C = 3200 hours
MPD Interval D = 22400 hours

COMPONENT FUNCTIONAL DESCRIPTION

CASE DRAIN FILTER

1. Purpose

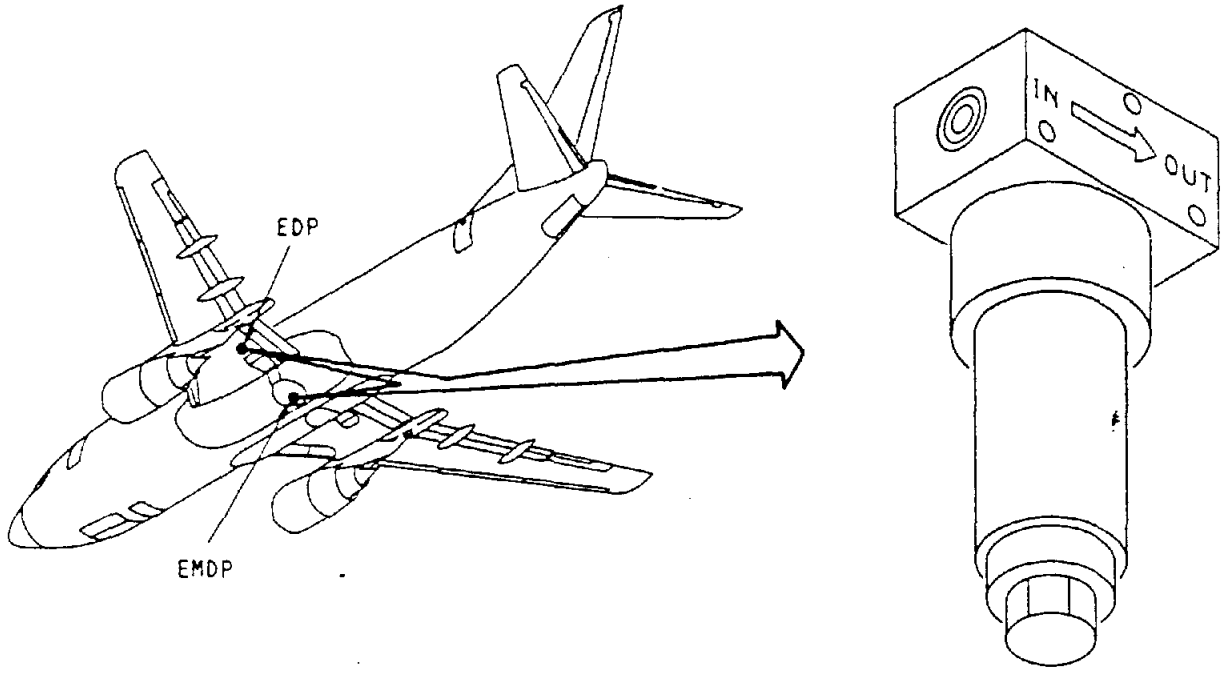
A case drain filter is installed in each pump case return line to detect pump wear and prevent contamination of the system.

2. Location

The System A engine-driven pump case drain filter is located in the left wing, aft of the outboard end of the landing gear support beam. The electric motor driven pump case drain filter is directly beneath the pump in the main wheel well, left side.

3. Physical Description/Features

It consists of a noncleanable filter inside a metal housing. An arrow on the filter housing indicates direction of flow through the filter. An isolation check valve on the downstream outlet of each filter prevents reverse flow from the opposing pump. If a hydraulic system pump is replaced due to malfunction, the respective case drain filter element must also be replaced.



CASE DRAIN FILTER 109285

COMPONENT FUNCTIONAL DESCRIPTION

SYSTEM "A" PRESSURE MODULE — Same as B

1. Purpose

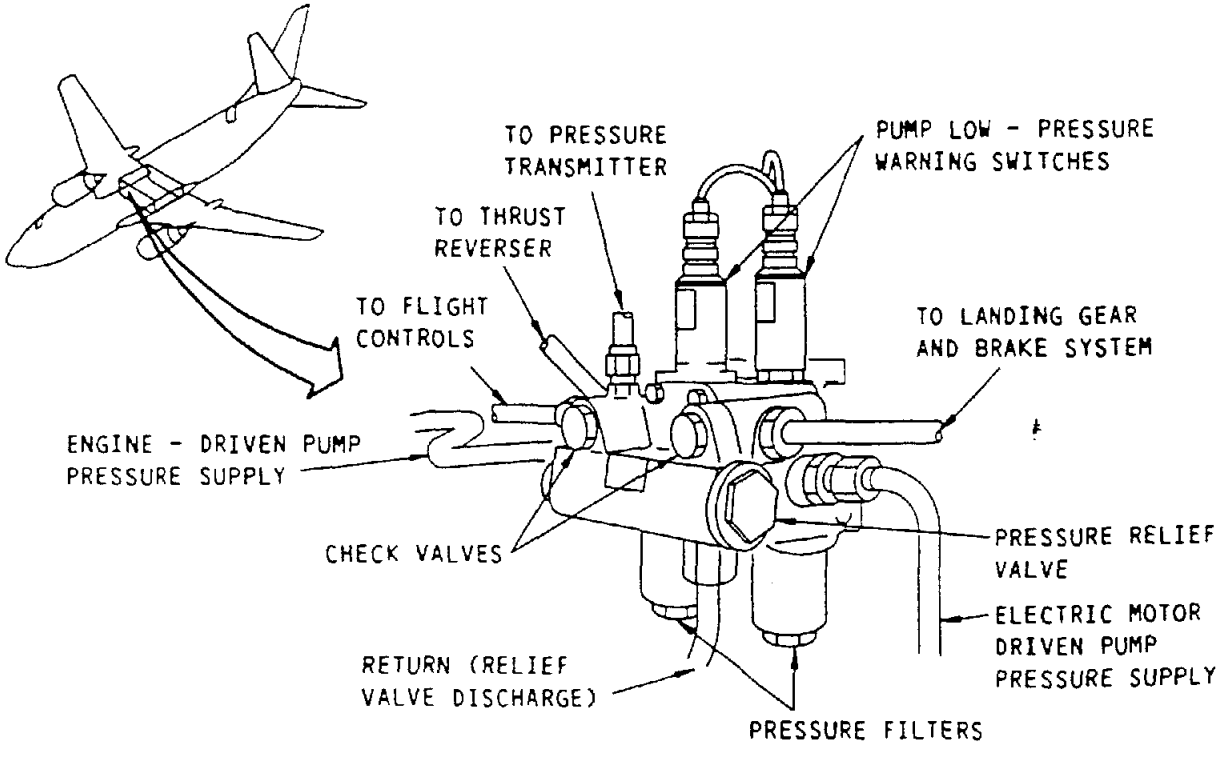
The pressure module filters and distributes pump outputs to user systems.

2. Location

The module is located on the left forward wall of the main wheel well.

3. Physical Description/Features

The pressure module consists of a housing containing cartridge-type pressure filters, pump low pressure warning switches, a pressure relief valve, check valves, and fittings for attaching system tubing connectors. A non-bypass cartridge-type filter in the pressure line from each pump filters the fluid before it is delivered to the using components. It consists of a non-cleanable filter element inside a metal bowl. Check valves are installed downstream of the pressure filters and low pressure warning switches to isolate them from the output of the opposite pump. Components can be individually replaced in the module.



SYSTEM "A" PRESSURE MODULE 109093

COMPONENT FUNCTIONAL DESCRIPTION

SYSTEM "A" RETURN FILTER

1. Purpose

   The A system return filter element removes contaminants from the return fluid before it enters the reservoir.

2. Location

   The system "A" return filter module is located on the left forward wall, main gear wheel well.

3. Physical Description/Features

   The return filter module consists of a filter bowl, replaceable filter element and a filter head. The filter head incorporates a bypass valve, shutoff valve, two check valves and a differential pressure indicator.

   When restricted flow causes a pressure drop of 65 psi across the element, the differential pressure indicator becomes visible, indicating that the filter is contaminated and should be replaced.

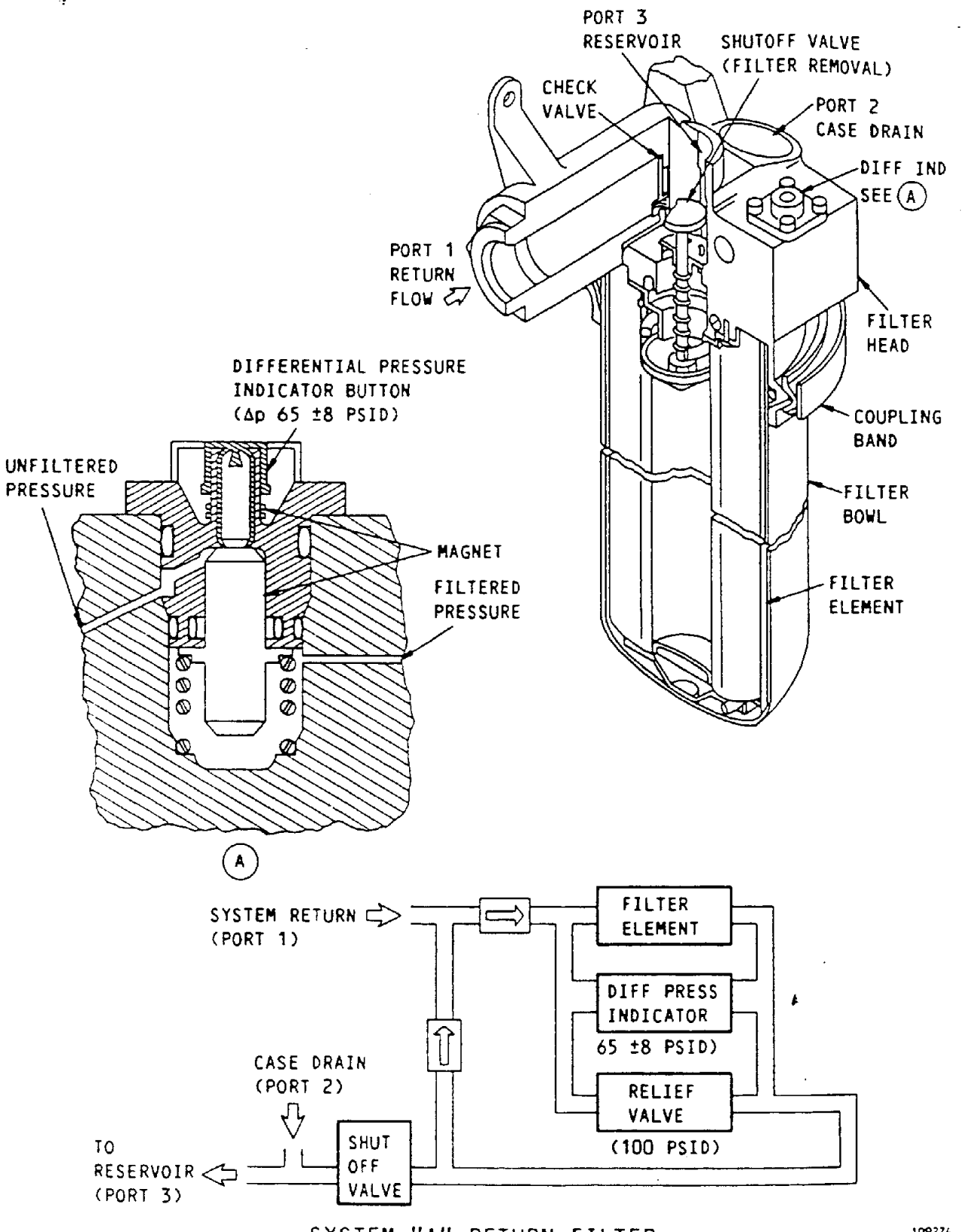
   When restricted flow causes an excessive pressure drop of 100 psi across the element, the bypass valve opens and allows fluid to bypass the filter, and flow directly into the reservoir.

4. Operation

   Two check valves are installed in the filter head to direct return flow from the system through the filter and to prevent backflow through the filter into the system.

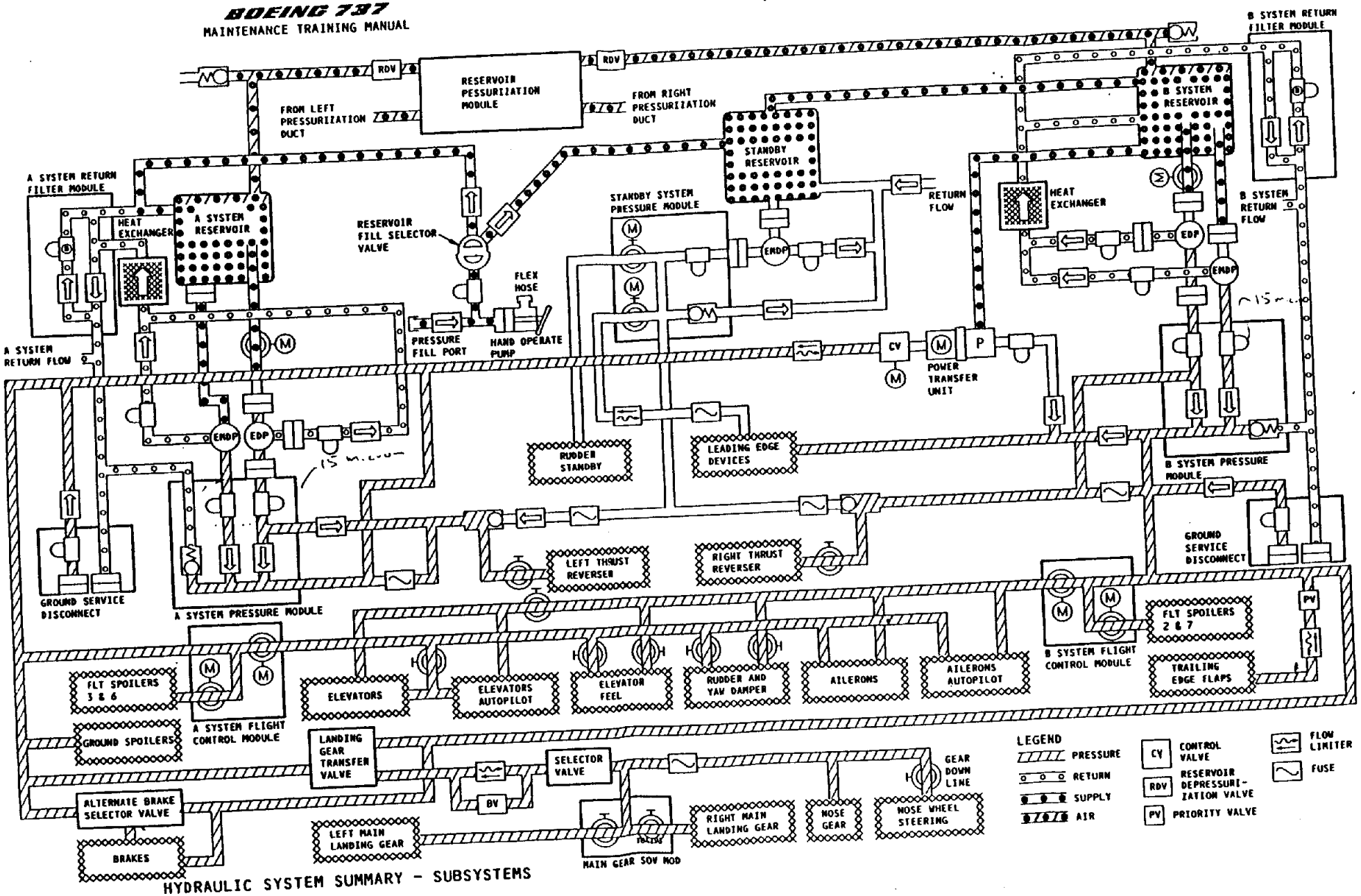
5. Maintenance Practices

   The shutoff valve prevents fluid draining from the reservoir when the filter bowl is removed.



SYSTEM "A" RETURN FILTER

109274



HYDRAULIC SYSTEM SUMMARY - SUBSYSTEMS

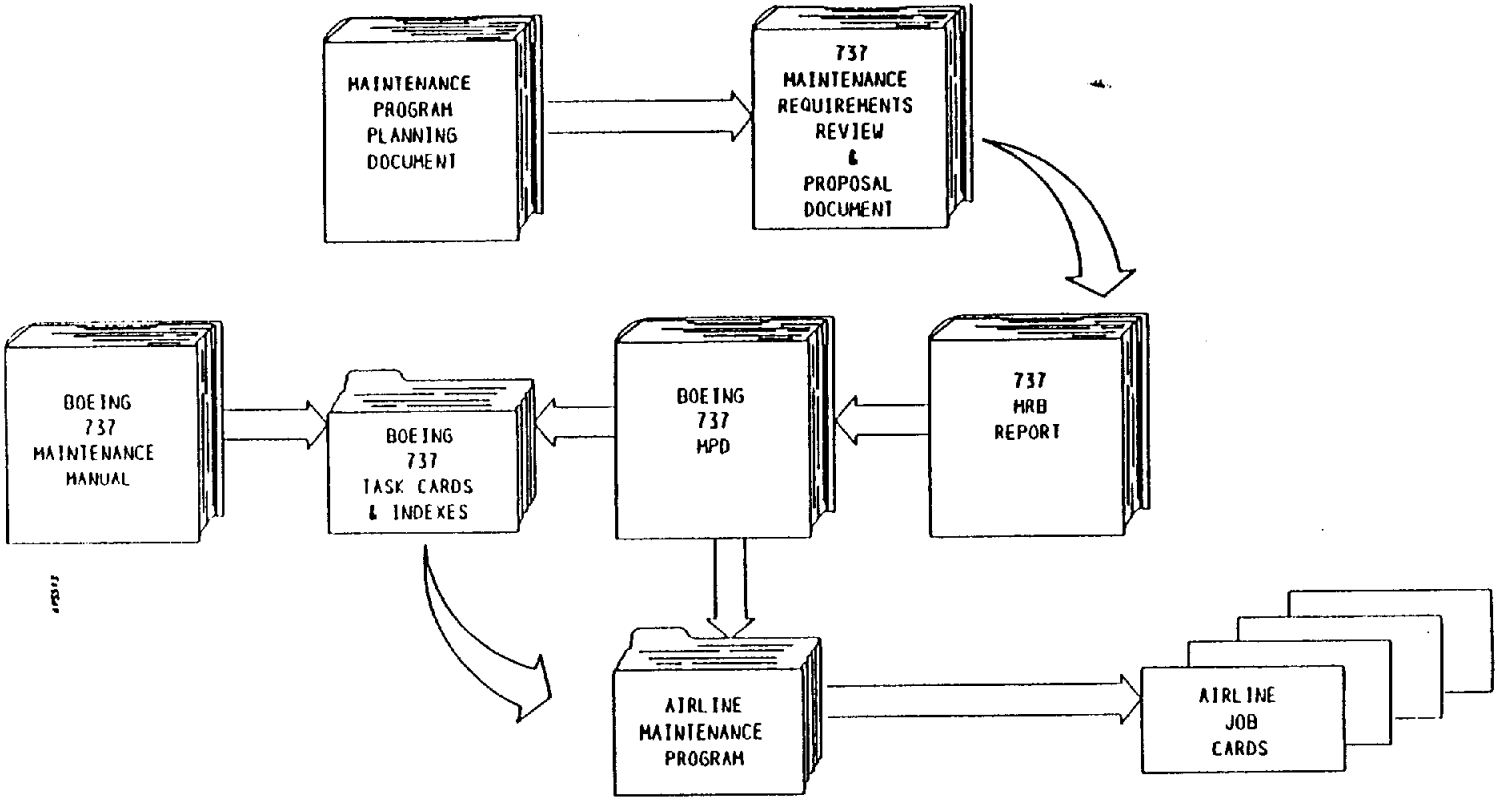


FIGURE 1

737-300/400/500 MAINTENANCE PROGRAM DEVELOPMENT

MPD737-1