B737 NG CBT - AIR CONDITIONING SYSTEM

COURSE OUTLINES

TABLE OF CONTENT

COURSE START

1-The material contained in this training program is based on the information obtained from current state, local and company regulations and it is to be used for training purposes only. At the time of designing this program contained then current information. In the event of conflict between data provided herein and that in publications issued by the authority, the authority shall take precedence.

AIR CONDITIONING SYSTEM

2-This chapter covers the airplane air conditioning system and provides an overview of its organization, operation, controls and indications. Here is the chapter outline: * Introduction * Pack flow control valve * Cooling packs * Distribution * Zone temperature control * Pack/zone temperature controllers * Controls and indications * Modes of zone temperature control * Equipment cooling

INTRODUCTION

3-The purpose of the air conditioning system is to supply fresh air at correct temperature and pressure to the cockpit and cabin and to provide equipment cooling. The conditioned air is also used, with additional components, for the pressurization of the airplane which will be discussed later.

4-The system consists of mainly five segments: Supply, cooling packs, distribution, temperature control and regulation, and cockpit controls and indications.

5-The air conditioning system receives air supply from the bleed air duct.

6-Normally, the left pack uses bleed air from engine No. 1 and the right pack uses bleed air from engine No. 2.

7-The APU can supply bleed air for two pack operation on the ground, or one pack operation in flight.

8-Most external air carts are capable of supplying adequate bleed air for two pack operation.

9-The cooling segment contains two identical cooling packs which are identified as LEFT PACK and RIGHT PACK depending on the bleed air manifold to which they are connected. Each pack flow control valve feeds its respective pack with bleed air. The pack cools the hot bleed air to basic temperature and removes water as necessary

10-The distribution system supplies conditioned air to the passenger and flight compartments. This also provides pressurization regulated by an outflow valve. The system incorporates a mixing manifold which mixes cold air from the packs with the recirculating cabin air to regulate the air temperature. Mixing manifold can also receive conditioned air from an external air cart through a ground connection.

11-The pack/zone temperature controllers automatically regulate the temperature of air supplied to cockpit and cabin by controlling the pack outlet temperature and amount of trim air added to the air leaving the mixing manifold.

12-The controls and indications in the flight deck let the flight crew manage the operation of air conditioning system. Let's take a look at main components of the system in more detail.

PACK FLOW CONTROL VALVE

13-Two pack flow control valves, one for each pack, are installed at the beginning of the air conditioning system. Each valve is electrically controlled and pressure operated. Pack switch on the air conditioning/bleed air control panel lets you control the respective pack valve.

14-Primary function of pack flow control valve is to control and adjust the inlet airflow to its respective pack; thus to determine the amount of air going to cabin. The valve is spring loaded to the closed position when the air pressure is not available.

COOLING PACKS

15-The airplane incorporates two identical cooling packs that operate automatically and independently from each other. One pack can supply a sufficient quantity of conditioned air and pressure for all operations.

16-Each cooling pack mainly consists of heat exchangers, air-cycle machine, ram air system water separator, overheat sensors, temperature control valve and standby temperature control valve.

Heat exchanger

17-There are two heat exchangers used to improve cooling effect. A primary heat exchanger and a main heat exchanger which are installed together so they appear to be one component. Heat exchangers are located in ram air duct and use ram air flow to decrease the temperature of hot air.

Air cycle machine

18-Air cycle machine is the main unit which cools the hot bleed air. It consists of a compressor, an expansion turbine and a cooling fan. They are connected on the same shaft and turbine drives the compressor and the cooling air fan.

19-Operation sequence of the air cycle machine is as follows. The hot bleed air from the pack valve goes to primary heat exchanger where it is cooled. The air then flows to compressor. The air is compressed in the compressor, so both its temperature and pressure increase. The air then flows to secondary heat exchanger where its temperature decreases, but the pressure stays the same. Now, the air goes to turbine. As the air expands in turbine, both its temperature and pressure decrease, and the power to drive the compressor and cooling fan is generated. The air then goes to distribution system.

Water separator

20-During cooling process, water in the air should be removed. This is required to prevent water particles from freezing in lines and valves due to very low temperature and to avoid passenger discomfort and corrosion. Therefore, a high pressure water separator is fitted in cooling pack to remove and collect water from the air before it goes into the distribution

system. The collected water is then sent to water spray nozzle which injects the water into the ram air duct. This cools the ram air stream by evaporation.

Ram air system

21-Ram air system in each pack incorporates ram air duct and adjustable ram air inlet and exit doors. Position of inlet door affects the cooling effect of heat exchangers which, in turn, influences the pack outlet temperature.

22-When the ram air inlet door opens more, greater amount of cooling air passes through the heat exchangers and the pack supplies cooler air.When the door is closed more, the pack cooling effect is reduced.

23-Ram air inlet doors are fully open for maximum cooling during ground operation and slow flight with the flaps not fully retracted. In normal cruise, the doors move as necessary between open and closed. Whenever a ram door is fully open, A RAM DOOR FULL OPEN light illuminates

24-In normal cruise, the doors move as necessary between open and closed. Whenever a ram door is fully open, A RAM DOOR FULL OPEN light illuminates.

25-The cooling air fan driven by the air cycle machine’s turbine supplies heat exchangers with cooling air during ground operations and slow flight when there is a little or no ram effect.

26-The deflector doors installed forward of the ram air inlet doors make sure ice, rocks, and other unwanted material do not go into the ram air inlet prior to liftoff and after touchdown.

27-When the airplane is on the ground, the door extends to give protection to the ram air inlet. When the airplane is in the air, the deflector door retracts.

Overheat sensors

28-Each pack incorporates overheat protection which is provided by temperature sensors located in the cooling cycle. When an overheat condition is detected the pack valve closes and the PACK light illuminates on the air conditioning/bleed air controls panel.

Temperature control valves

29-Each pack incorporates a normal temperature control valve and a standby temperature control valve.

30-The normal temperature valve controls the pack outlet temperature by controlling the amount of hot air which is added to cool air downstream of the air cycle machine. If the pack outlet temperature is too low, the temperature control valve opens more. If the pack outlet temperature is too high, the valve closes more.

31-In the event of failure of a normal temperature control valve or its associated controller, a standby temperature control valve enables the control of the affected pack temperature.

DISTRIBUTION

32-The conditioned air is distributed to three main zones in the airplane: Cockpit, forward cabin and aft cabin. This is achieved by the distribution system.

33-The distribution system supplies conditioned air to the three airplane zones, provides ventilation of lavatories and galleys and supplies cooling air to electronic equipment.

34-The distribution system consists of mix manifold, recirculating fans and distribution ducts.

35-The left air conditioning pack supplies the conditioned air for the flight compartment. Excess cold air from the left pack and cold air from the right pack goes into mix manifold before it is distributed to passenger cabin zones.

Recirculation system

36-Two recirculating fans pull in the cabin air from forward cargo compartment, clean the air with their filters and send it back to mix manifold. Each recirculation fan operates when the respective recirculation fan switch is set to AUTO.

37-The recirculation system decreases the use of engine bleed air. This enables better thrust management and reduces fuel consumption.

ZONE TEMPERATURE CONTROL

38-Each airplane zone has different cooling and heating requirements. On the other hand, mix manifold could supply conditioned air at the same temperature to all zones, which is not suitable for the occupants. Therefore, there is a need for temperature regulation system to compensate different cooling or heating effects on the zones.

39-Zone temperatures are regulated via a trim air pressure regulating and shutoff valve, and trim air modulating valves.

Trim air pressure regulating and shutoff valve

40-The trim air pressure regulating and shutoff valve regulates the flow and pressure of the air supplied to the trim air modulating valves. The valve is electrically controlled via TRIM AIR switch and pressure operated.

41-When it is energized, the valve is opened by pneumatic air pressure. When the valve is de-energized, a spring closes the valve.

Trim air modulating valves

42-There are three trim air modulating valves. Each valve controls the amount of hot air mixed with cold supply to optimize its associated zone temperature. When the trim air pressure regulating and shutoff valve closes for any reason, the trim air modulating valves also close automatically.

Temperature sensors

43-The zone temperature control system also incorporates duct temperature sensors and duct overheat switches.

44-There are three duct temperature sensors, one installed in the cockpit, forward cabin and aft cabin zones. Each zone sensor measures corresponding zone temperature and gives duct temperature feedback to the pack/zone temperature controllers.

45-The duct overheat switch is used to detect an overheat condition in the related zone supply duct. It sends a signal to turn on the associated zone temperature light on the cabin temperature panel. It also provides an overheat signal to close the respective trim air modulating valve.

PACK/ZONE TEMPERATURE CONTROLLERS

46-The air conditioning system incorporates two identical, integrated pack/zone temperature controllers which automatically control the packs outlet temperature and the temperature in each of three airplane zones.

47-Pack control section in each controller provides the following functions: Control of its respective pack outlet temperature by positioning the temperature control valve, standby control of the opposite pack outlet temperature by positioning the standby temperature control valve, control of the pack compressor temperature by modulating the ram air flow through ram air inlet.

48-Zone control section in each controller controls the zone temperature through trim air modulating valve and provides output of system status data for indicating on the cabin temperature control panel.

49-The left pack/zone temperature controller provides left pack control, left ram air control and right pack standby control. The left controller also provides temperature control for the aft passenger zone and back-up temperature control for the flight compartment zone.

50-The right pack/zone temperature controller provides right pack control, right ram air control and left pack standby control. It also provides temperature control for the forward passenger zone and primary temperature control for the flight compartment zone.

CONTROLS AND INDICATIONS

51-The controls and indications for the air conditioning system are on the forward overhead panel on the air conditioning/bleed air controls panel and cabin temperature control panel.

Air conditioning and bleed air controls panel

52-There are two pack switches, one for each pack, on the air conditioning and bleed air controls panel. The pack switch lets you control the bleed air that goes into the respective pack.

53-Each pack switch controls the corresponding pack valve. When the switch is set to OFF, the respective pack valve closes fully and bleed air does not flow into the pack. .

54-When the switch is selected to HIGH, the pack adjusts to high flow. With the pack switch in HIGH position and APU

bleed air switch ON, the pack provides maximum flow rate when the airplane is on the ground.

55-When you set the switch to AUTO, the pack regulates to low flow or high flow as necessary to maintain sufficient pressurization and conditioned air in the cabin.

56-When both engine bleed air switches are off and one pack is operating from APU, the pack regulates to high flow.

57-With both packs operating, each pack adjusts to low flow.

58-If only one pack is operating, operating pack regulates to high flow in flight with flaps up.

59-Two recirculation fan switches provide control of recirculation fans. When the switch is in OFF position, the respective fan does not operate.

60-When the switch is selected to AUTO, the corresponding fan operates depending on air conditioning pack operation and air/ground logic.

61-During flight, with the fan switches in AUTO, the left recirculation fan operates when both packs are operating provided that either PACK switch is not in HIGH position. The right recirculation fan operates when both packs are operating provided that both PACK switches are not in HIGH position.

62-On the ground, with the fan switches in AUTO, the left recirculation fan operates when either pack switch is not in HIGH position. The right recirculation fan operates even if both PACK switches are in HIGH.

63-RAM DOOR FULL OPEN lights illuminate when the respective ram air door is full open. Note that when the airplane on the ground, the RAM DOOR FULL OPEN lights should illuminate.

64-If the RAM DOOR FULL OPEN light illuminates during flight cruise mode, it may be due to one of these three possible problems: Ram air system may have a blockage or heat exchangers are dirty, or an electrical failure has occurred.

65-The same panel also incorporates PACK lights which illuminate when an overheat condition is detected in the corresponding pack. This condition is called pack trip off. A pack trip off condition causes the related pack valve to close and requires you to reset the system. The PACK light also illuminates if both primary and standby pack controls for the same pack fail.

Cabin temperature control panel

66-The cabin temperature control panel is another flight crew interface for system control and indication. The three temperature selectors give automatic temperature control for their related zones within a range of approximately 65°F (18°C) to 85°F (30°C).

67-Each selector has these temperature set points: AUTO provides automatic temperature control for the associated

zones. C (cool) sets a temperature of 65°F (18°C) and W (warm) sets a temperature of 85°F (30°C). When you turn the selector to the OFF position, the related trim air modulating valve closes.

68-The panel incorporates a zone temperature light for each zone. Flight deck zone temperature light comes on when an overheat condition is detected in the supply duct or when both primary and standby temperature control channels fail. Forward or aft cabin zone temperature light turns on when an overheat condition is detected in associated supply duct.

69-The trim air switch controls the trim air pressure regulating and shutoff valve. It has two positions. ON: Trim air pressure regulating and shutoff valve opens. OFF: Trim air pressure regulating and shutoff valve closes.

70-During single pack operation with the TRIM AIR switch set ON, zone temperature is controlled the same as during two pack operation. If the TRIM AIR switch is selected to OFF, the pack regulates to supply air at average temperature demands of all three zones.

71-The Air Temperature Source Selector lets you select a location to see its temperature. These are the positions: Supply duct: Selects respective zone supply duct temperature. Passenger cabin: Selects forward or aft passenger cabin temperature. Pack: Selects left or right pack temperatures.

72-The Air Temperature Indicator shows the temperature at the location selected with the air temperature source selector

MODES OF ZONE TEMPERATURE CONTROL

73-There are five modes of zone temperature control: Balanced mode, unbalanced mode unbalanced average temperature mode, standby pack average temperature mode and fixed temperature mode.

74-The mode of operation in which the both packs output the same temperature is called balanced mode.

75-The pack/zone temperature controller receives zone temperature demands from the selectors on the cabin temperature control panel. The controllers compare the compartment temperature selections with the actual temperature in the zone to determine the zone that requires the most cooling. The controller then calculates the required pack outlet temperature for the zone with the lowest temperature requirement. Both packs are controlled to provide the pack outlet temperature that matches the zone with the coldest demand.

76-The pack/zone temperature controller then controls the trim air modulating valves to satisfy the desired zone temperatures. Because the packs supply air at the temperature of the coldest zone, this zone does not require trim air and its trim air modulating valve remains closed. The controllers inject hot trim air into the ducts of the other two zones to match the desired zone temperature.

77-In unbalanced mode each pack is controlled independent of the other.

78-The temperature control shifts to unbalanced mode when the flight deck trim air system or both primary and backup flight deck temperature controls fail.

79-In this mode, the left pack is controlled to satisfy only the temperature requirement of the flight compartment. The right pack is controlled to satisfy the colder demand of the two passenger cabin zones.

80-The unbalanced average temperature mode of operation is activated if either of the passenger cabin zone trim air, or all trim air is lost, or if the trim air switch is OFF.

81-The left pack is again controlled to satisfy the temperature requirement of the flight deck. However, the right pack is controlled to satisfy the average temperature demands of the forward and aft passenger cabin zones.

82-When all zone controls and primary pack controls fail, the temperature control shifts to standby pack average temperature mode. The trim air modulating valves will close. The standby pack controls regulate the packs to supply air at temperatures which will satisfy the average temperature demand of the two cabin zones. The flight deck zone temperature selector will have no effect on the standby pack controls.

83-Fixed cabin temperature mode is when all temperature selectors are set to OFF. The pack controls will command the left pack to maintain a fixed temperature of 75°F (24°C) and the right pack to maintain 65°F (18°C) as measured at the pack temperature sensor.

ABNORMAL CONDITIONS

84-Now let’s take a look at some abnormal conditions related to air conditioning system. We will discuss two non-normals: Zone temperature and pack trip off.

Zone light

85-As you remember zone temperature light comes on under two conditions: Overheat in supply duct and failure of temperature control system.

86-If an overheat condition is detected in a supply duct, the respective ZONE TEMP light on the cabin temperature control panel comes on immediately and the related trim air modulating valve closes. Master caution and air conditioning annunciator light illuminate.

87-Select a colder temperature for the affected cabin with the related temperature selector. Push the TRIP RESET switch on the air conditioning/bleed air controls panel to reset the zone temperature control system. If the duct has cooled below limits, light extinguishes and system operates normally, if the light has illuminated due to an overheat condition

88-If duct temperature increases rapidly, turn off the trim air switch.

89-When you set the trim air switch to OFF, the trim air pressure regulating and shutoff valve closes. The temperature control system shifts to the unbalanced average temperature mode.

90-The zone light also illuminates when there are failures in temperature controllers. Let’s start with flight deck

temperature control system failure.

91-When both primary and backup flight deck temperature controls fail, zone temperature light comes on immediately and cannot be reset. MASTER CAUTION and air conditioning annunciator lights illuminate. The system shifts to unbalanced mode.

92-If the primary flight deck temperature control fails, the ZONE TEMP light comes on only when the master caution system is recalled. The temperature control system automatically switch to the back up control.

93-If forward or aft cabin temperature control fails, the ZONE TEMP light illuminates only when the master caution system is recalled. The temperature control system automatically switches to the unbalanced average temperature mode

Pack trip off

94-A pack trip off occurs when a pack overheat is detected or when the primary and standby pack controls have failed.

95-If an overheat condition is detected in a cooling pack, the respective PACK light comes on immediately and the related pack valve closes. Master caution and air conditioning annunciator light illuminate.

96-Select all temperature selectors to a warmer temperature to reduce the load on the affected pack. Push the trip reset switch. If the pack temperature has cooled bellow limits, the light extinguishes If it has illuminated due to an overheat condition.

97-When both primary and standby pack controls for the same pack fail, the PACK light comes on immediately and cannot be reset. MASTER CAUTION and air conditioning annunciator lights illuminate. In this case the pack will continue to operate without control if excessive temperatures do not cause the pack to trip off.

98-If a primary or standby pack control fails, PACK light comes on only when the master caution system is recalled. If a primary pack control fails, control of the pack changes to the standby pack control in the opposite controller

EQUIPMENT COOLING

99-The equipment cooling system provides proper cooling of electronic components in the flight deck and the E/E compartment to keep their temperature within the acceptable range.

100-The equipment cooling system consists of a supply system, an exhaust system, low flow sensors and overboard exhaust valve.

Supply system

101-The supply system incorporates two fans to move air. A normal fan and an alternate fan. The supply fan draws the cool air from passenger cabin and supplies it to flight deck displays, center aisle stand and equipment racks in the E & E compartment.

102-The exhaust system also incorporates a normal fan and an alternate fan. The exhaust fan pulls warm air from the displays, the overhead and aft electronic panels, circuit breaker panels in the flight deck, and equipment racks in the E & E compartment.

Low flow sensors

103-The supply and the exhaust systems use low flow sensors to monitor the air flow through the system. When there is insufficient cooling airflow, the sensor supplies a warning signal to the flight deck for annunciation.

Overboard exhaust valve

104-The overboard exhaust valve controls the amount of equipment cooling exhaust air that flows overboard.

105-When the airplane is on the ground, the valve is normally open until the airplane pressurizes.

106-When the airplane is in pressurized flight, the normal position for the overboard exhaust valve is closed. The warm exhaust air flows under the forward cargo compartment floor and heats the forward cargo compartment.

CONTROLS AND INDICATIONS

107-The controls and indications for the equipment cooling system are on the forward overhead panel.

108-The equipment cooling panel incorporates an equipment cooling SUPPLY switch and an equipment cooling EXHAUST switch. Each switch has two positions: Normal and alternate.

109-When the supply switch is set to normal, the normal supply fan operates. When the switch is selected to alternate, alternate fan supplies cool air for equipment cooling.

110-When the exhaust switch is set to normal, the normal exhaust fan operates. When the switch is selected to alternate, alternate fan removes warm air from around electrical equipment.

111-When there is a loss of airflow due to failure of a supply or exhaust fan, related OFF light illuminates.

112-When this happens on the ground, alerting is provided through the crew call horn in the nose wheel well.

113-When the OFF light illuminates, select the related alternate fan. This will restore airflow and extinguish the OFF light within approximately 5 seconds.

114-Note that, in some airplanes, the equipment cooling exhaust OFF light is inhibited when the exhaust fan is shut off due to a forward cargo fire warning

COURSE END

115-End of course. ?