

NATIONAL TRANSPORTATION SAFETY BOARD  
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Forwarded to:

Honorable J. Lynn Helms  
Administrator  
Federal Aviation Administration  
Washington, D.C. 20591

SAFETY RECOMMENDATION(S)

A-83-70 through -81

The National Transportation Safety Board is continuing its investigation of the accident involving Air Canada Flight 797 which occurred on June 2, 1983, when the flightcrew of the McDonnell Douglas DC-9 airplane was forced to make an emergency landing at the Greater Cincinnati Airport because of an in-flight fire. The interior materials of the airplane's cabin continued to burn after the landing. Five crewmembers and 18 passengers were able to evacuate the burning cabin; the remaining 23 passengers died in the fire. The Safety Board's investigation has determined that the fire began in the airplane's left rear lavatory, but the source of ignition has not yet been identified.

The Safety Board convened a public hearing in Fort Mitchell, Kentucky, on August 16, 1983, to hear testimony on the facts and circumstances of the accident. Thirty-one witnesses appeared at the 4-day hearing. Testimony of the flightcrew, flight attendants, and surviving passengers corroborated other information that the first indication of a problem came about 1 hour 30 minutes after takeoff from Dallas-Fort Worth International Airport, Texas, while the flight was cruising at 33,000 feet when the pilots noticed that the three circuit breakers in the electrical supply to the left rear lavatory's 3-phase flushing motor had tripped. About 11 minutes after the breakers tripped, a flight attendant detected smoke emanating from the lavatory. Another flight attendant entered the lavatory and attempted to combat the fire using a CO2 extinguisher. His testimony disclosed that the smoke was coming from the wall liner and the vanity next to the airplane's rear bulkhead. His attempt to locate the source of the fire was thwarted by the smoke, and he discharged the extinguishing agent in the general vicinity of the liner and the vanity. Shortly thereafter, the first officer went aft, touched the lavatory door; it was so hot that he believed it unwise to open the door to assess or combat the source of heat. He returned to the cockpit and recommended to the captain that they begin an emergency descent. Testimony indicated that smoke was moving forward in the cabin as the flightcrew began the descent. Although the smoke subsided briefly, it subsequently began to thicken and moved rapidly forward through the entire airplane, including the cockpit. The captain donned his smoke goggles and an oxygen mask; he was able to land the airplane, although his visibility was restricted by the smoke

and condensation on the inside of his goggle lenses. As the airplane descended, the flight attendants distributed moist towels to a number of passengers so that they could breathe through the towels to filter out the smoke. All of the passengers who survived had used the moist towels or articles of clothing to filter out smoke and toxic gases as they breathed. They stated that the smoke in the cabin was so thick and black before the landing that they could not see passengers seated next to them and that they had difficulty in locating the emergency exits because of the restricted visibility. The evacuation stopped when the entire cabin suddenly erupted into flames. The autopsies of some of the nonsurviving passengers and their positions within the cabin indicate that they had succumbed to the toxic environment either while still in their seats or while trying to find an exit. The inside of the cabin became a nonsurvivable environment after the eruption of flames. Technical witnesses at the hearing attributed the sudden envelopment of the cabin by fire to the spontaneous ignition of hot gases trapped in the top of the fuselage.

While the source of ignition of the fire has not been determined, two sources of ignition of airplane lavatory fires have been identified in other accidents and incidents -- carelessly discarded cigarettes in the lavatory waste receptacles and overheated electrical components of the lavatory flushing system. Since the flushing motor circuit breakers may have tripped either as a result of damage to wiring caused by a fire or as a result of an electrical fault, the Safety Board is examining both of these as potential sources of ignition on the Air Canada airplane. The Safety Board, in previous Safety Recommendations, has expressed concern about lavatory ignition hazards as well as the need for enhancing a flightcrew's ability to detect and combat a fire in a lavatory.

The Safety Board participated in the investigation of the Varig Airlines, Boeing 707 accident near Paris, France, on July 11, 1973, in which 124 persons died after a fire erupted in the rear lavatory. As a result of that accident, the Safety Board, on September 5, 1973, issued the following Safety Recommendations to the Federal Aviation Administration (FAA):

Require a means for early detection of lavatory fires on all turbine-powered, transport-category aircraft operated under Part 121 of the Federal Aviation Regulations, such as smoke detectors or operating procedures for the frequent inspections of lavatories by cabin attendants. (Safety Recommendation A-73-67)

Require emergency oxygen bottles with full-face smoke masks for each cabin attendant on turbine-powered transport aircraft in order to permit the attendants to combat lavatory and cabin fires. (Safety Recommendation A-73-68.)

Organize a government/industry task force on aircraft fire prevention to review design criteria and formulate specific modifications for improvements with respect to the fire potential of such enclosed areas as lavatories in turbine-powered aircraft operating under the provisions of Part 121 of the Federal Aviation Regulations. (Safety Recommendation A-73-70.)

Following the investigation of the Pan American World Airways, Inc., Boeing 707 accident that occurred on November 3, 1973, while the flightcrew was attempting to land at Boston, Massachusetts, after the detection of a fire in the cargo compartment, the Safety Board issued these additional Safety Recommendations to the FAA:

Provide operators of the subject aircraft with data to enable flightcrews to identify smoke sources, and require operators to establish procedures in their operating manuals to control and evacuate smoke effectively during the specific flight regimes. (Safety Recommendation A-73-121, issued January 10, 1974.)

Require that transport category airplanes certificated under Part 4B of the Civil Air Regulations prior to the effective date of amendment 4B-8 comply with Part 25.1439 of the Federal Aviation regulations. (Safety Recommendation A-74-5, issued February 6, 1974.)

Require that a one-time inspection be made of all smoke goggles provided for the flightcrew of all transport category airplanes to assure that these goggles conform to the provisions of Part 25.1439 of the Federal Aviation Regulations. (Safety Recommendation A-74-6, issued February 6, 1974.)

As a result of two other lavatory fires, one aboard a Boeing 747 airplane on July 17, 1974, and the other aboard a Boeing 727 airplane on August 9, 1974, the Safety Board recommended that the FAA:

Require that automatic-discharge fire extinguishers be installed in lavatory waste paper containers on all transport aircraft. (Safety Recommendation A-74-98, issued December 5, 1974.)

In response to Safety Recommendation A-73-67, the FAA issued an Air Carrier Operations Bulletin (No. 1-76-17, "In Flight Lavatory Fires") instructing Principal Operations Inspectors to encourage air carriers to prohibit smoking in the lavatories and to institute routine flight attendant inspections of lavatories before takeoff and periodically during flight. This action was followed by an Airworthiness Directive which required the installation of "No Smoking" and "No Cigarette Disposal" signs in the lavatories of transport category airplanes.

Although these actions fell short of the Safety Board's intention to promote the installation of smoke detectors such as those using ionization and photo-electric technology to trigger an alarm signal, the Safety Board, in May 1979, closed Safety Recommendation A-73-67 and assessed the FAA's action as acceptable. While the Safety Board at that time was sympathetic to the industry's position that the lack of demonstrated reliability and the potential for false alarm problems associated with such smoke detectors would degrade their effectiveness, it is now convinced that the technology exists to provide an effective and reliable early warning fire detection system in the lavatories of transport category airplanes. Further, the Safety Board notes that the FAA report "Feasibility and Tradeoffs of a Transport Fuselage Fire Management System," (FAA RD 76-54, dated June 1976) concludes that such systems are feasible with current technology.

Safety Recommendations A-73-68 and A-74-5 both addressed the need for standards and requirements for protective breathing equipment to provide flightcrew members with a supply of oxygen and a mask for eye protection so that they could continue to perform necessary airplane control functions and cabin duties, as well as firefighting functions in the event of an in-flight fire.

In response to recommendation A-73-68, the FAA issued a revision to the Federal Aviation Regulations effective February 1, 1977, which required the installation of protective breathing equipment in each isolated separate compartment of the airplane in which crewmember occupancy is permitted during flight. This revision was not responsive to the recommendation since it did not provide for portable protective breathing equipment in passenger compartments. Also, the FAA issued an NPRM in 1975 proposing to amend 14 CFR 25.1439 to include new standards for oxygen masks and eye coverings. However, the proposal was later withdrawn with the reasoning that further testing was needed to establish the standards. The FAA's last response regarding Recommendations A-73-68 and A-74-5, in August 1981, advised the Safety Board that an updated Technical Standard Order (TSO) would be prepared to prescribe minimum standards for emergency equipment to provide flightdeck and cabin crewmembers with eye and respiratory protection from toxic atmospheres during in-flight emergencies. The FAA has stated that it intends to issue an Advisory Circular after it adopts the TSO to recommend that operators upgrade the protective breathing equipment aboard their airplanes to meet the new TSO standards. The FAA has stated that the Advisory Circular would also recommend that operators provide equipment beyond regulatory requirements for cabin attendants. The Safety Board assumes that the issuance of TSO-C99, "Protective Breathing Equipment," on June 27, 1983, completed the first phase of FAA's intended action. An FAA witness from the Civil Aero Medical Institute testified at the Safety Board's public hearing in the Air Canada case that much of the equipment in current use fails to comply with the newly established minimum standards. He described serious shortcomings particularly in the effectiveness and fit of smoke goggles. Another FAA witness from Aviation Standards Office of Airworthiness stated that he was not aware of any FAA plans for regulatory action to require that the protective breathing equipment currently installed on transport category airplanes in accordance with the provisions of 14 CFR 25.1439, and 14 CFR 121.337 meet the minimum standards prescribed in TSO-C99. Furthermore, the FAA has not indicated that it intends to require by regulation the installation of portable protective breathing equipment which would be immediately available in passenger compartments for use by cabin attendants in combating cabin fires. The Safety Board believes that regulatory action is required and that an Advisory Circular recommending voluntary action by operators is not adequate to assure passenger safety.

In evaluating the FAA's actions regarding Safety Recommendation A-73-70, the Safety Board acknowledged that the establishment of the Special Aviation Fire and Explosion Reduction (SAFER) Advisory Committee in May 1978 would be responsive to the recommendation. The mandate of this committee, which was composed of government and industry representatives, went beyond the specific scope of the safety recommendation and considered the broader aspect of the airplane fire problem by addressing the postcrash scenario. The SAFER committee's short-term recommendations were directed primarily toward actions to inhibit the ignition and rapid propagation of a postcrash fuel-fed fire. The committee determined that there was a need for continued research in interior cabin materials before new testing procedures and standards could be established regarding the flammability, smoke, and toxic emission characteristics of cabin materials.

Although the FAA's action to convene the SAFER committee was viewed as responsive to Safety Recommendation A-73-70, the Safety Board maintained the recommendation in an open status pending further progress toward the implementation of safety enhancing improvements to airplane cabin interiors. The Safety Board has received no further response from the FAA regarding this recommendation since March 14, 1979. However, the Safety Board has followed and encouraged the continuing research being

conducted at the FAA's Technical Center at Atlantic City, New Jersey. The Safety Board believes that this research has identified several potential cabin improvements which could be implemented now. The Administrator has announced FAA's intention to issue two Notice of Proposed Rulemaking's (NPRM's) on October 11, 1983, proposing new performance standards for the use of fire-blocking materials on passenger seats to inhibit the propagation of cabin fires and new standards for emergency lighting that would be more effective for passengers evacuating smoke-filled cabins. One of the parties to the Air Canada accident investigation has recommended that, in addition to relocating the cabin emergency lights, tactile aisle markers like those on the overhead stowage bins on many airplanes should be installed near to the floor to guide persons to emergency exits in the smoke-filled environment. The Safety Board agrees with this recommendation. Further, in addition to the proposed improvements already announced by the Administrator, the FAA tests conducted at the Technical Center have identified other needed upgrading of equipment. These tests have demonstrated vividly that the performance of hand fire extinguishers with the Halon extinguishing agent is significantly superior to the performance of the carbon dioxide, dry chemical or water type hand extinguishers and that safety will be enhanced by replacing the latter types of extinguishers with the Halon type. The Safety Board strongly encourages the FAA to expedite the rulemaking actions to make fire-blocking seat materials, improved emergency lighting, tactile emergency exit indicators, and hand fire extinguishers using advanced technology extinguishing agents mandatory in the transport airplane fleet as early as practicable.

The FAA acted promptly in response to Safety Recommendation A-73-121 to assess the adequacy of the smoke removal procedures on the Boeing 707 airplane. As a result of the FAA's assessment and tests, the relevant section of the airplane's Flight Manual was revised to include improved and clearer smoke removal procedures. Both the recommendation and the FAA's actions were specifically directed to the Boeing 707 airplane. On that basis, Safety Recommendation A-73-121 was closed and FAA's response was deemed acceptable. However, the circumstances of the Air Canada accident indicate that the flightcrew encountered difficulty in controlling smoke in the cockpit of the McDonnell Douglas DC-9 airplane. The Safety Board is continuing to investigate the procedures used by the flightcrew; however, the Safety Board is concerned about the applicability of the prescribed procedures when a cabin fire continues to generate smoke and toxic gases. Further, testimony at the public hearing disclosed uncertainties among both flightcrew and expert witnesses regarding optimal smoke control procedures, such as the best use of cabin air conditioning systems. The Safety Board, consequently, believes that smoke removal procedures in all types of air carrier airplanes should be reassessed.

The FAA did not concur in the Safety Board's recommendation to require that automatic-discharge fire extinguishers be installed in lavatory waste receptacles on all transport airplanes (Safety Recommendation A-74-98). The FAA reasoned that the combined actions of installing fully sealed waste receptacles to assure fire containment and extinguishment, as required by Airworthiness Directives for transport category airplanes, and the prohibition of smoking in airplane lavatories eliminated the need for mandatory installation of automatic-discharge fire extinguishers. Although automatic-discharge fire extinguishers have been installed in the lavatory waste receptacles of some airplanes, including the Air Canada DC-9, 1/ they have not been required and are not generally installed. The Safety Board closed Safety Recommendation 74-98 after assessing FAA's action as unacceptable.

1/ The Halon-type extinguisher in the Air Canada airplane's waste receptacle discharged, however, the source of the fire was external to the receptacle and the discharge agent was not effective in extinguishing the fire.

Moreover, the Safety Board is concerned that the FAA's actions to assure a sealed design of the lavatory waste receptacle have not been adequate. On June 25, 1983, a flight attendant aboard an Eastern Air Lines McDonnell Douglas DC-9 airplane noticed smoke coming from the right rear lavatory as the airplane was being taxied to the gate after landing. It was determined that the fire had started within the lavatory waste receptacle and propagated behind the vanity to the lavatory aft wall before it was extinguished by the airport fire department. The inspection of the undamaged left rear lavatory in the airplane revealed that the upper area of the waste chute behind the disposal door was not sealed to contain a fire, and there was no fire extinguisher in the receptacle. Further, it was evident that waste could accumulate in the enclosed area of the vanity adjacent to the waste receptacle. Following this incident, the Safety Board's personnel have observed similar discrepancies aboard other airplanes. As a result, the Safety Board on July 1, 1983, issued the following Safety Recommendation:

Issue a Telert maintenance bulletin to all principal airworthiness inspectors to inspect immediately all lavatory paper and linen waste receptacle enclosure access doors and disposal doors on the applicable aircraft for proper operation, fit, sealing, and latching for the containment of possible trash fires, in accordance with the requirements of AD 74-08-09. (Safety Recommendation A-83-46.)

On the same day that the recommendation was issued, the FAA issued a telegraphic General Notice (GENOT), No. 8320.283, describing discrepancies in airplane lavatories observed by FAA inspectors and emphasizing the need for an aircraft lavatory maintenance and inspection program designed to correct these discrepancies. The Safety Board believes that this immediate action was appropriate; however, it appears that the continued fire containment integrity of lavatory waste receptacles cannot be assured even with periodic inspection. Thus, the Safety Board will continue to advocate that more positive protection against fires in and adjacent to waste receptacles be provided by an automatic-discharge fire extinguisher.

Until recently, Safety Board recommendations and related FAA actions to minimize the lavatory fire hazard have focused on the waste receptacle as the most common fire origin. However, since the Air Canada accident, the Safety Board has been examining the potential hazard of overheated electrical components associated with the lavatory flush pump motor circuits. Concern regarding this safety hazard was expressed in Safety Recommendations A-83-47 through A-83-49 which were issued on July 19, 1983, after the Safety Board's investigation of an incident which occurred on July 12, 1983, involving an American International Airways DC-9 on the ground at Charlotte, North Carolina, from which smoke was observed coming from the airplane's right rear lavatory while it was being serviced. Shortly thereafter, maintenance personnel observed that several circuit breakers had tripped, including the 5 ampere breakers for the 3-phase electric flushing motor. Examination of the components disclosed that the flushing motor had overheated, that a phase-to-phase short had taken place in the motor, and that the flushing circuit timer had been damaged by overvoltage. As a result, the Safety Board recommended on July 19, 1983, that the FAA:

Issue an Airworthiness Directive (1) to require an immediate inspection of the lavatory flushing pump motor and the associated wiring harnesses between the timing components and the motor in the lavatories of transport category airplanes for evidence of moisture-induced corrosion or deteriorated insulation and to require that flushing pump motors or

wiring harnesses which exhibit such conditions be replaced, and (2) to establish appropriate periodic intervals for repetition of these inspections. (Safety Recommendation A-83-47.)

Establish, in conjunction with the flush pump motor, timer, and airframe manufacturers, a procedure which airline maintenance personnel could employ to verify that the electrical circuitry of lavatory flushing pump motors has not been damaged by corrosion or other causes so as to produce excessive heat during motor operation. (Safety Recommendation A-83-48.)

Issue a Maintenance Alert Bulletin to require Principal Maintenance Inspectors to assure that airlines have an acceptable program (1) for the frequent removal of waste from all areas of the lavatory with particular attention to those enclosed areas in and around the waste receptacles, and (2) which gives sufficient emphasis to areas susceptible to the accumulation of fluids in the vicinity of wire harnesses and other electrical components which can cause corrosion. (Safety Recommendation A-83-49.)

The FAA has not yet responded to the Safety Board regarding actions it intends to take to implement these recommendations. The Safety Board has been further convinced that its recommended actions are vital by two other incidents involving overheated flushing motors which produced smoke in airplane lavatories -- one involving an Eastern Air Lines DC-9 on July 17, 1983, and the other involving a U.S. Air DC-9 at Pittsburgh, Pennsylvania, on August 29, 1983. In both incidents, the airplanes were being serviced on the ground when smoke was observed coming from the flushing motors. On inspection, both motors had indications of overheat of internal windings.

Tests conducted during the investigation of the Air Canada accident and the testimony of technical experts at the Safety Board's public hearing have indicated that certain failure modes can cause significantly elevated temperatures on the motor case without tripping the related circuit breakers in the 3-phase electrical supply. The temperatures could be high enough to ignite paper waste in direct contact with the motor case. The Safety Board recognizes that circuit breakers are designed to protect the wiring against short circuit overload and that they do not provide thermal protection for components. Therefore, the Safety Board believes that component overheat protection should be added, particularly in lavatory flush motor circuits by selection of circuit breakers with minimum practical trip currents and by incorporating independent thermal protection in the components.

In summary, the Safety Board believes that the potentially catastrophic consequences of airplane lavatory or other cabin fires, as illustrated by the tragic Air Canada accident, make it imperative that the FAA address the cabin fire safety issues in a coherent program which will result in expedited positive actions. Further, the Safety Board believes that the circumstances of the Air Canada accident have emphasized the validity of the corrective measures which have been recommended previously. The evidence indicates that a fire may have been burning in the lavatory for more than 10 minutes before it was detected by passengers or cabin attendants. Had the lavatory been equipped with a suitable smoke detector, the flightcrew and cabin attendants probably would have been alerted to the fire while it was in a controllable stage. As it was, by the time the fire was detected, the flight attendant could not determine the source because smoke obscured his field of vision; consequently, he could not discharge

the CO2 fire extinguisher directly on the burning fire and he was not successful in extinguishing it. A Halon-type extinguisher might have been more effective under these circumstances. Once the smoke thickened, the firefighting effort was seriously hindered because neither the flight attendant nor the first officer had portable protective breathing equipment available near the lavatory to permit them to penetrate or remain in the smoked filled area.

During the descent to the landing, the passengers and crew were in an increasingly irritating and toxic atmosphere. Their chances for survival would have been greatly enhanced had they been provided with an effective breathing apparatus to reduce their intake of noxious gases. The survivors stated that the moist towels which were distributed by the flight attendants permitted easier breathing. More persons would probably have survived had they been able to more quickly orient themselves and find the emergency exits. Further, the sudden eruption of the cabin in flames may have been forestalled had the passenger seats had fire-blocking characteristics which would have afforded the passengers additional evacuation time.

To promote a comprehensive program to address the potentially hazardous situation posed by in-flight fires, the Safety Board is issuing new Safety Recommendations rather than reiterating relevant Safety Recommendations previously issued to the FAA. The Safety Board will close Safety Recommendations A-73-68, A-73-70, and A-74-5 as having been superseded.

Accordingly, the National Transportation Safety Board recommends that the Federal Aviation Administration:

Expedite testing to establish standards for smoke or fire detectors for use in airplane lavatories for the early detection of fires independent of passenger or cabin attendant sensory perceptions and initiate rulemaking at the earliest possible date to require installation of the detectors on transport category airplanes. (Class II, Priority Action) (A-83-70)

Require the installation of automatic thermal discharge-type fire extinguishers effective in sensing and extinguishing fires in and adjacent to lavatory waste receptacles on transport category airplanes. (Class II, Priority Action) (A-83-71)

Require that the hand fire extinguishers carried aboard transport category airplanes to comply with 14 CFR 25.851(a) use a technologically advanced agent such as Halon extinguishant. (Class II, Priority Action) (A-83-72)

Evaluate the electrical circuit protection, including reduced circuit breaker rated values and integral component thermal protection devices, needed to eliminate the potential for overheating of the wiring and components in the lavatory flushing pump motor systems in transport category airplanes and issue airworthiness directives as required. (Class I, Urgent Action) (A-83-73)

Require that protective breathing equipment, including smoke goggles, currently carried aboard transport category airplanes to comply with 14 CFR 25.1439 and 14 CFR 121.337 which do not meet the minimum performance standard prescribed in Technical Standard Order (TSO) C99 or equivalent be replaced with equipment which meets the standards. (Class I, Urgent Action) (A-83-74)

Amend 14 CFR 121.337 to prescribe a minimum number of portable protective breathing apparatus with full face masks which will be carried in the passenger compartment of transport category airplanes readily accessible to cabin attendants and flightdeck crews. (Class I, Urgent Action) (A-83-75)

Expedite the research at the Civil Aero Medical Institute necessary to develop the technology, equipment standards, and procedures to provide passengers with respiratory protection from toxic atmospheres during in-flight emergencies aboard transport category airplanes. (Class II, Priority Action) (A-83-76)

Evaluate and change as necessary the procedures contained in the FAA-Approved Airplane Flight Manuals (AFM) of transport category airplanes relating to the control and removal of smoke to assure that these procedures address a continuing smoke source and are explicit with regard to the presence of fire and the optimum use of cabin pressurization and air conditioning systems. (Class II, Priority Action) (A-83-77)

Expedite the rulemaking action to require at the earliest possible date that passenger seats with fire-blocking materials be installed in transport category airplanes. (Class II, Priority Action) (A-83-78)

Expedite the rulemaking action to require at the earliest possible date that cabin emergency lighting be installed for optimum effectiveness during passenger evacuation from smoke-filled cabins. (Class II, Priority Action) (A-83-79)

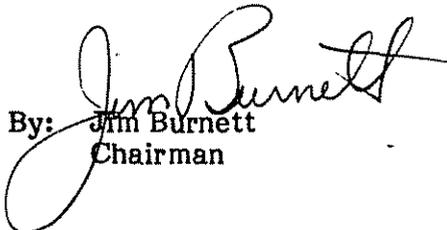
Require the installation of tactile aisle markers on overhead stowage bins and cabin floors or seats of all transport category aircraft which will help passengers to find their way to emergency exits in evacuations when visibility in the cabin is restricted or when the cabin atmosphere is toxic, requiring the passengers to remain close to the floor. (Class II, Priority Action) (A-83-80)

Require that the location of the tactile emergency exit indicators be depicted in the passenger briefing cards and included in the flight attendant oral briefings. (Class II, Priority Action) (A-83-81)

BURNETT, Chairman, concurred in all of the recommendations except A-83-80 and A-83-81; GOLDMAN, Vice Chairman, McADAMS, BURSLEY, and ENGEN, Members, concurred in these recommendations.

BURNETT, Chairman, filed the following comments regarding A-83-80 and A-83-81:

These recommendations assume that airplane passengers can be trained to locate tactile aisle markers during an emergency and use the markers as a guide during evacuation. I do not believe that this is feasible or practical. Therefore, I can not support either of these recommendations.

By:   
Jim Burnett  
Chairman