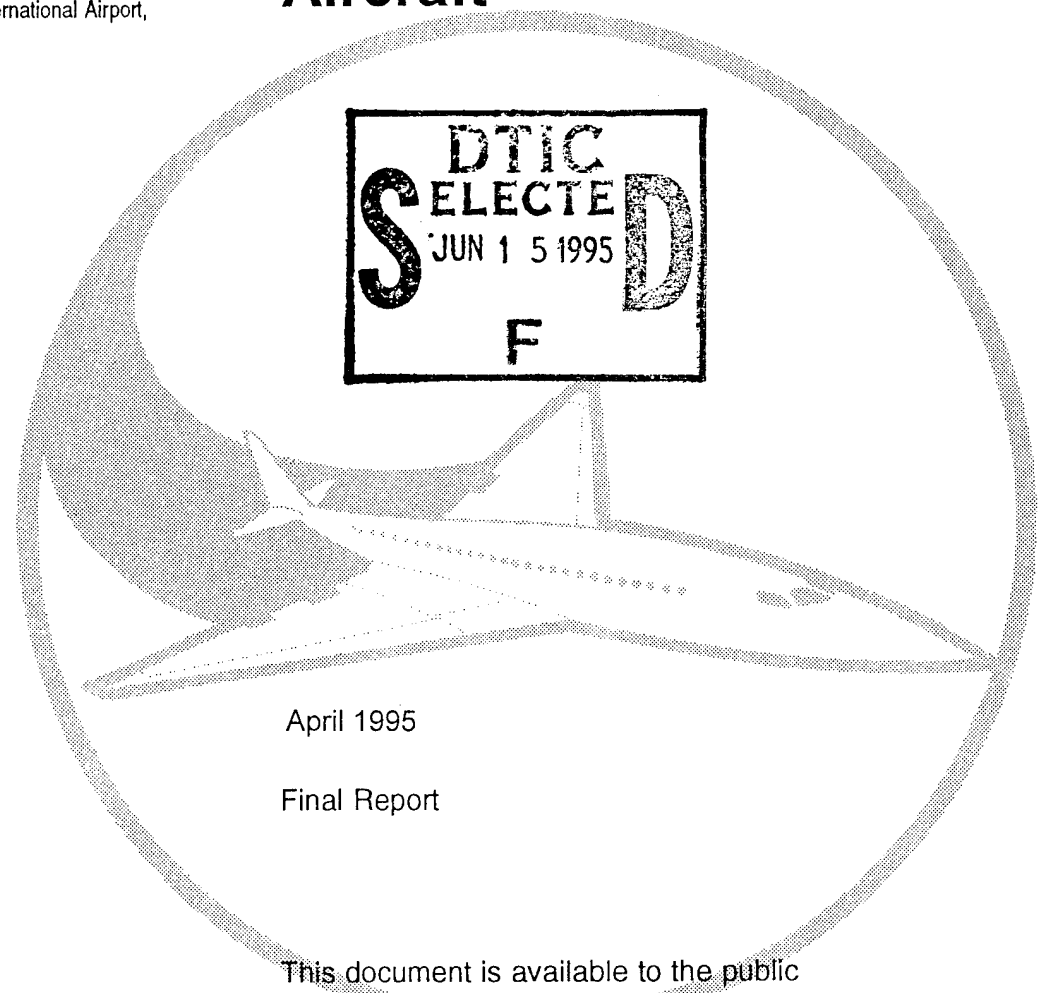
DOT/FAA/CT-94/89

FAA Technical Center
Atlantic City International Airport,
N.J. 08405

Corrosion of Fire-Damaged Aircraft



April 1995

Final Report

U.S. Department of Transportation
Federal Aviation Administration

NOTICE

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT/FAA/CT-94/89		

4. Title and Subtitle	5. Report Date
CORROSION OF FIRE-DAMAGED AIRCRAFT	April 1995
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
William T. Westfield	

9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Galaxy Scientific Corporation 2500 English Creek Avenue, Building 11 Pleasantville, NJ 08232	
	11. Contract or Grant No. DTFA03-89-C-00043

12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
U.S. Department of Transportation Federal Aviation Administration Technical Center Atlantic City International Airport, NJ 08405	Final Report
	14. Sponsoring Agency Code ACD-220

15. Supplementary Notes
FAA Technical Center Project Manager: Dr. Thomas Flournoy

16. Abstract
The Federal Aviation Administration (FAA) Western Pacific Regional Office issued a Significant Activity Report concerning a B727 that experienced extensive corrosion, well beyond what would have normally been expected for an aircraft with its operational time and cycles. This incident triggered interest in the possible connection between fire, extinguishment, and subsequent increased incidence of corrosion. The FAA Technical Center requested an investigation of the potential for this connection to exist by performing an analysis of available data.

Trends of aircraft operational hours, cycles, fire occurrence, and corrosion reports were developed. Data extending from 1974 to the present were accessed from the Aviation Research and Support database and the Service Difficulty Reports (SDRs) database, respectively.

Sufficient data to support a connection between fire and subsequent related corrosion were not available. Twenty-two aircraft were analyzed and none exhibited a pattern of corrosion that could definitely be associated with fire smoke or extinguishment. This result was supported by consideration of the intensity of the fire, the extinguishing agent and the time between the occurrence of the fire and the corrosion reports.

The study of SDRs indicates a significant increase in corrosion related SDRs beginning in 1988 and continuing through 1992. This increased SDR activity may be attributed to the overall aging of the jet fleet; the Aloha 737 fuselage failure in April 1988; and the issuance of aging aircraft corrosion inspection ADs in 1990.

17. Key Words	18. Distribution Statement
Corrosion SDR Operational Cycles	This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	37	

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EXECUTIVE SUMMARY

The Federal Aviation Administration (FAA) Western Pacific Regional Office issued a Significant Activity Report, appendix A, concerning a B727 that experienced extensive corrosion, well beyond what would have normally been expected for an aircraft with its operational time and cycles. This particular aircraft had a cabin fire approximately twelve years earlier. This incident triggered interest in the possible connection between fire, extinguishment, and subsequent increased incidence of corrosion. The FAA Technical Center requested an analysis of available data to determine if there was such a connection.

Service Difficulty Reports (SDRs) were reviewed to identify aircraft that experienced incidences of fire, smoke, extinguishment, and airframe corrosion. All SDRs from 1974 through 1994 were accessed using an SDR database; and supplemental information on aircraft operating history was extracted from a database provided by Aviation Research and Support (ARS) Limited. The ARS data was used to get owner/operator histories of aircraft that experienced fire and corrosion, and to identify aircraft of the same type and age with operating histories similar to fire and smoke aircraft.

Aircraft with fire, and more than twenty-five corrosion SDRs, were selected for analysis to determine if their corrosion could be attributed to fire, smoke or extinguishment of the fire. The analysis was limited to the aircraft interior. The corrosion locations were mapped from fuselage nose to tail using the location given in each SDR. The object was to identify concentrations of corrosion that could be related to the location of the fire or its smoke and subsequent extinguishment. Twenty-two aircraft were analyzed and none exhibited a pattern of corrosion that could definitely be associated with fire smoke or extinguishment. This result was supported by consideration of the intensity of the fire, the extinguishing agent and the time between the occurrence of the fire and the corrosion reports.

The fire/corrosion relationship was also assessed by studying fleetwide corrosion trends and corrosion of aircraft with operational histories similar to the aircraft with fires in the fuselage interior. The Boeing 727 was selected for these analyses.

The fleet analysis showed a rise in Boeing 727 corrosion reporting beginning in 1984, the year the first aircraft turned twenty years old. The rate of aging (age 20 years) between 1984 and 1994 averaged 80 aircraft per year or approximately 6 percent of the fleet per year. Annual corrosion reporting over the same period increased from, 115 in 1984, to, 5235 during 1994. The new corrosion inspection program resulting from the Aging Aircraft Initiative is believed to have contributed to the increase after 1988.

Study of other individual 727 aircraft with similar operating histories did not help establish fire as a cause of corrosion. No consistent bias toward corrosion was found by comparing aircraft that had fires with those that did not. Additionally, the 727s with the highest reported corrosion did not have fires. Four 727s without fires had more corrosion than the high corrosion 727 with fire.

It is concluded that the role, if any, that fire, smoke, and extinguishment play in corrosion of aircraft cannot be determined from the SDRs.

1. INTRODUCTION.

1.1 BACKGROUND.

Fires of various origin and severity have occurred in commercial transport aircraft, both during in-flight operations and during ground operations. In most cases, detection and extinguishment of the fire was rapid with no structural damage occurring. However, in some cases the fire was more severe and the extinguishment process more involved, resulting in structural repair after extinguishment.

The extinguishment of fires in commercial transport aircraft can be achieved in various ways. Those fires that occur in-flight in areas of the aircraft such as the engine compartments or the baggage areas are protected by an installed fire extinguishing system that typically employs halogen type agents and is controlled from the cockpit.

The fires that occur in the cockpit or in passenger compartments are usually extinguished by the flight crew or flight attendants. Extinguishing agents vary from the halogen type, to dry chemical materials, to carbon dioxide, to water, or any other fluids that are in proximity to the fire. This investigation is concerned with fire events where substantial corrosion was detected subsequent to the fire.

The specific event that triggered this investigation occurred in October 1979 on a Boeing 727 operated by United Airlines (UAL). The aircraft, registration number N7296U, entered service in March 1979. A fire was reported to have occurred in the aircraft on October 26, 1979, after a ground cleanup crew had secured the aircraft. The fire was subsequently extinguished, but no information is available as to what extinguishing agent or system was used. Subsequent to the extinguishment, the aircraft was repaired, inspected, and returned to service. In March 1991, after accumulating 36,575 hours of flight time and 20,334 landing cycles, the aircraft underwent a scheduled Heavy Maintenance Visit (HMV). In the process of removing the interior furnishings to inspect the fuselage shell for defects, extensive corrosion of the fuselage was found. The corrosion levels in the crown area were well beyond what would be expected. Furthermore, the corrosion extended almost the full length of the fuselage, beyond the area that could have been expected to be directly affected by the fire. A Significant Activity Report (SAR) was issued by the FAA's Western Pacific Regional Office on this aircraft in May 1991 (reproduced in appendix A of this document). The severity of this damage was sufficient enough to cause the aircraft to be removed from service and dismantled.

This incident on the UAL Boeing 727 prompted concern on the part of the FAA that fire damage effects may extend beyond a direct heat effect. The extensive corrosion was hypothesized to have been the result of combustion residue, such as soot, smoke, or extinguishing agents migrating to the other areas of the crown, combining with moisture, and forming a corrosive environment. Therefore, the FAA requested that an analysis be conducted to determine whether routinely collected data indicated the possibility of a widespread problem.

1.2 PURPOSE.

The primary purpose of this investigation was to determine the existence and extent of corrosion on aircraft whose structure was exposed to either direct heat from a fire, to the products resulting from the use of various extinguishing agents, or to the by-products of the agents employed. The corrosion characteristics and histories of these aircraft were then compared to aircraft that had experienced similar operational profiles, but had not experienced fire situations. The following commercial transports were examined: Boeing B727, B737, B747, McDonnell-Douglas DC8, DC9, DC10, and Lockheed L1011.

2. TECHNICAL APPROACH.

2.1 DATABASE UTILIZATION.

Individual aircraft operational histories were obtained from the Aviation Research and Support (ARS) database, which provided aircraft accumulated flight hours and cycles, along with the dates of manufacture, manufacturing line number, service entry date, and operator(s).

The SDR database (1974 through 1994) was accessed to identify, for each model of aircraft, all reports involving smoke, fire, and/or extinguishment. The aircraft part or parts involved in the event were identified, as well as the location of the specific part and its condition. A corrosion reporting history was extracted from the SDR database for each aircraft with fire smoke and extinguishment.

2.2 DATABASE QUERY PROCEDURES.

The approach taken was to first define the number of specific instances of fire or smoke that occurred for each aircraft type of concern. Data for all models of Boeing B727, B737, and B747 aircraft; all models of McDonnell-Douglas DC-8, DC-9, and DC-10 aircraft; and the Lockheed L1011 aircraft were examined.

The SDR database is comprised of one record for each report. Data fields used for this study were: SDR date; aircraft serial number; flag fields coded for fire, smoke or extinguishment; part name, location and condition; and remarks fields discussing the reason for the SDR and action taken to correct the problem. All records with indications of fire, smoke, extinguishment or corrosion were extracted for analysis.

Listings of all corrosion SDRs were made for each aircraft model by serial number. Similarly, listings were made of all SDRs where mention of fire, smoke, and some form of extinguishment were employed. These two listings were compared to identify those aircraft that were common to both lists. Then for each aircraft model, aircraft with fire and over 25 corrosion reports were selected for analysis.

3. RESULTS AND DISCUSSION.

3.1 INCIDENCE OF CORROSION IN FIRE-DAMAGED AIRCRAFT.

The relationship between the occurrence of a fire event and subsequent corrosion reporting was investigated for B727, B737, B747, DC8, DC9, DC10, and L1011 aircraft. Emphasis was placed on those aircraft which exhibited the highest number of corrosion-related SDRs after a fire had been reported (see table 1). The time frame of these reports was also examined. It was noted that whenever an aircraft was undergoing heavy maintenance, clusters of SDRs were made on or close to the same calendar date. Reports for each of the aircraft in table 1 were analyzed to determine: the relative proximity of corrosion to the location of the fire, the elapsed time between the fire and the reported corrosion, the severity of the fire, the method of extinguishment, and levels of corrosion reporting before and after the fire.

TABLE 1. AIRCRAFT EXHIBITING THE HIGHEST NUMBER OF CORROSION SDRs (AFTER A FIRE WAS REPORTED)

B727	B737	B747	DC8	DC9	DC10	L1011
S/N - SDRs	S/N - SDRs	S/N - SDRs	S/N - SDRs	S/N - SDRs	S/N - SDRs	S/N - SDRs
19118 - 132	19426 - 51	20324 - 59	46094 - 78	45842 - 58	46768 - 31	193B1072 - 20*
21483 - 65	20365 - 39	19730 - 45	46109 - 73		46506 - 29	193B1107 - 19*
20295 - 30	20492 - 28	19676 - 35	45968 - 60			
19801 - 26	20361 - 27	19670 - 33				
19971 - 26		19729 - 31				

*No L1011s with more than 25 corrosion reports. These two are the high corrosion aircraft.

Appendix B contains SDR descriptions of all fires reported for these aircraft. Interior fuselage fires were of primary interest to this study.

Once the aircraft that with post-fire corrosion patterns were identified, operational data were examined. The ARS database was queried to identify "sister" aircraft that had been built around the same time; were operated by the same airlines; had accumulated similar flight cycles and hours; but had not experienced a fire event. These aircraft were then examined in the SDR database and their corrosion reports extracted.

In addition to the analysis of the individual aircraft of table 1, fleetwide corrosion trends were analyzed. Corrosion reports were evaluated to identify trends in total and average levels of corrosion reporting. These studies showed that the high number of corrosion reports on certain aircraft were a result of aircraft age and the corrosion inspection programs mandated for aging aircraft beginning in 1990. The aging aircraft corrosion Airworthiness Directives (ADs) are listed in table 2. These ADs mandate improved Corrosion Inspection Programs for aging aircraft. Fleetwide trends in reporting further indicate that no clear linkage between fires and corrosion can be deduced from the SDR data.

TABLE 2. CORROSION PREVENTION AND CONTROL AIRWORTHINESS DIRECTIVES

Product	AD Number	Issue Date	Effective Date
Boeing Model 707/720	90-25-07	December 31, 1990	December 31, 1990
Boeing Model 727	90-25-03	December 31, 1990	December 31, 1990
Boeing Model 737	90-25-01	December 31, 1990	December 31, 1990
Boeing Model 747	90-25-05	December 31, 1990	December 31, 1990
Douglas Model DC-8	92-22-07	October 1, 1992	January 12, 1993
Douglas Model DC-9/MD-80	92-22-08	October 1, 1992	January 12, 1993
Douglas Model DC-10	92-22-09	October 1, 1992	January 12, 1993
Lockheed L-1011	93-20-03	October 8, 1993	December 17, 1993
BAe BAC 1-11	93-02-14		March 19, 1993
Fokker F28	94-05-02	February 18, 1994	April 7, 1994
Airbus A300	94-18-02	August 19, 1994	October 11, 1994

A peripheral issue that might effect the results of the study was variation in SDR reporting by different airlines. A survey of the SDR database was made to determine the significance of this. Airlines operating the aircraft types included in this study did show a variation in SDR system usage. Twelve of fourteen airlines involved had similar reporting levels. One airline reported unusually low numbers of corrosion events and one airline, a major cargo carrier, reported an unusually high number of corrosion events. Based on the aircraft types studied (Table 1) and their operating histories it is concluded that the reporting levels by different airlines does not effect the results of this study. Airline reporting data is included for reference in appendix C.

3.2 PRESENTATION OF STUDY DATA FOR THE BOEING 727 AIRCRAFT.

This section provides examples of the data analysis steps used to evaluate all aircraft types. The Boeing 727 aircraft type is selected as an example.

3.2.1 Frequency of Corrosion Before and After the Fire.

Fire dates and corrosion reporting are related for five high corrosion 727s in table 3. The corrosion SDRs after the fire date were reported in the 1988 to 1992 time frame for all of these aircraft. Except for S/N 21483 and S/N 19801 the fire dates and the corrosion report dates are within 24 months of each other. It is doubtful, given the low intensity of the fires, that fire related corrosion could have developed in such a short period of time.

TABLE 3. B727: NUMBER OF CORROSION SDRs BEFORE AND AFTER A SINGLE FIRE EVENT

AIRCRAFT S/N	DELIVERY DATE	NUMBER OF FIRES	FIRE DATE	CORR. SDRs < FIRE	CORR. SDRs > FIRE
19118	03/07/67	1	12/22/89	12	132
19801	08/07/68	1	09/03/85	0	26
19971	11/02/68	1	05/16/91	2	24
20295	11/18/69	1	10/07/88	1	30
21483	05/31/78	1	09/06/79	0	65

The 727 showing the most likely fire/corrosion relationship is S/N 21483. Data shown in figure 1 shows a possible fire/corrosion relationship, a fire in 1979 followed by high corrosion events reported 13 years later in 1992. Also, the first major incidence of corrosion reporting in 1992 occurred when the aircraft was less than 15 years old.

3.2.2 Boeing 727 S/N 21483, Mapping of Fire Location Versus Corrosion Location.

Mapping of interior fuselage corrosion locations and the fire location are shown in figure 2 for this aircraft. Nineteen corrosion events are shown within 200 inches of the fire. Data contained in the nineteen corrosion reports does not establish a definite relationship between the fire and corrosion. Mapping of corrosion location versus fire location for the other aircraft indicated no concentration of corrosion at or near the fire site.

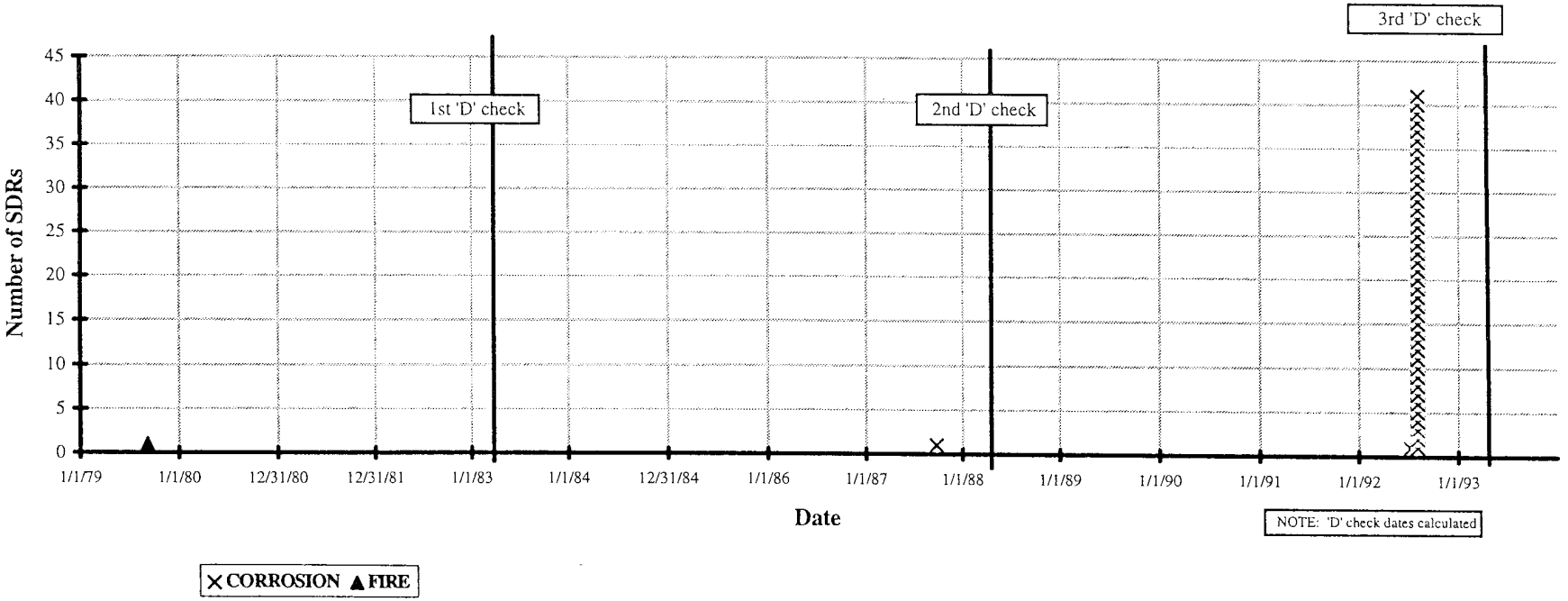

FIGURE 1. B727, S/N 21483: FREQUENCY OF CORROSION SDRs BEFORE AND AFTER A FIRE EVENT

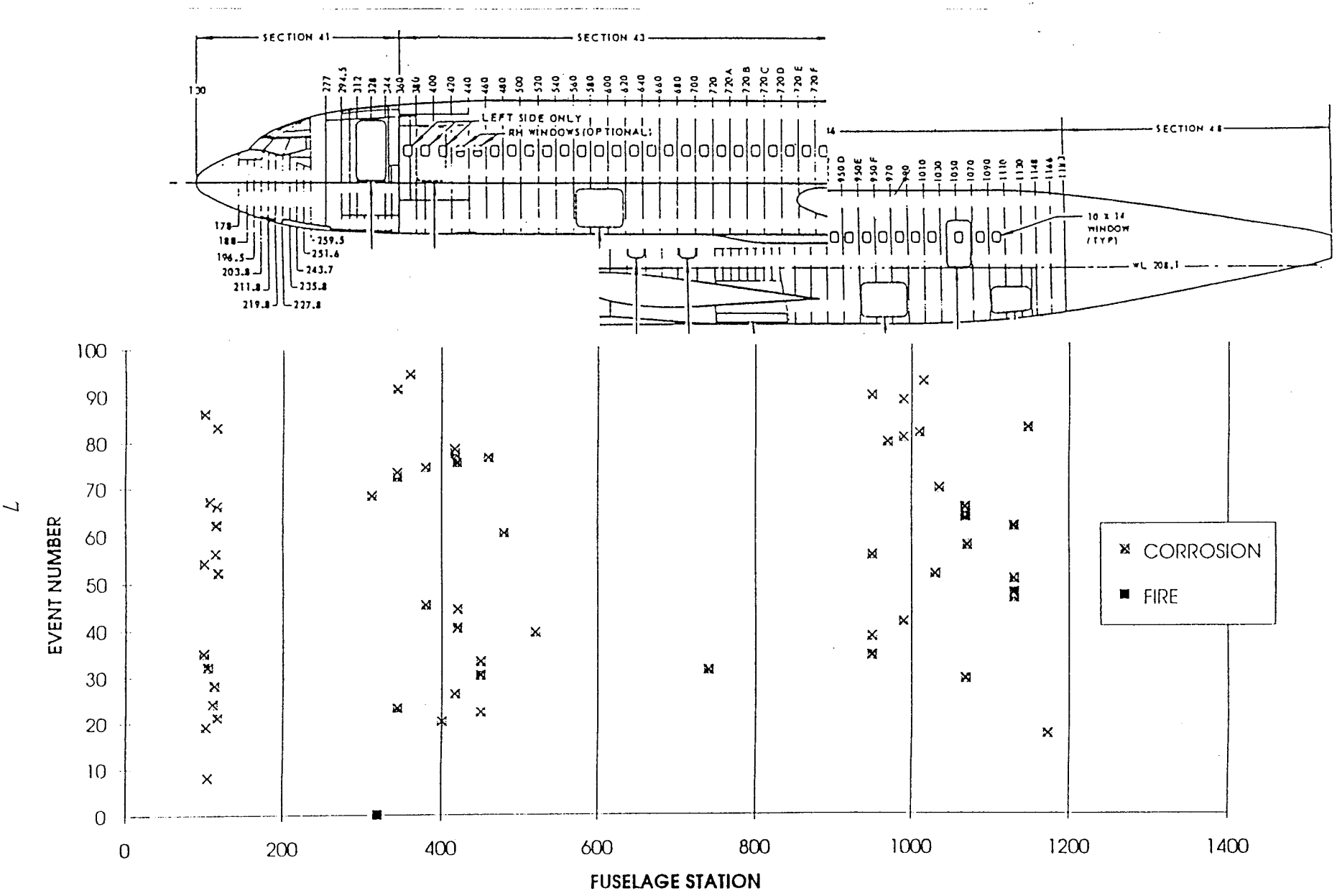

FIGURE 2. B727, S/N 21483: CORROSION AND FIRE SDRs AS A FUNCTION OF FUSELAGE STATION

3.2.3 Corrosion in Sister Aircraft.

In this context a "sister aircraft" is one with no fire that is similar to an aircraft with a fire in terms of its make-model-series and operational history. For the study it is assumed that ownership and operation by the same airline(s) equates to a similar operational history. Additional similarity is assumed if the sister aircraft is from the same production run as the aircraft with the fire. The five 727s from table 1 all had identifiable sister aircraft as indicated by serial number and airline in table 4. Serial numbers 19118, 19801, 20295 and 21483 show higher corrosion reporting than their sister aircraft. Again when all factors were considered, i.e., the date, difference between the fire and corrosion and their relative location on the aircraft, sister aircraft do not prove a cause and effect relationship between fire and corrosion. Also, seventy-four 727s without fires had higher corrosion levels than S/N 20295.

TABLE 4. B727: CORROSION SDRs FOR AIRCRAFT WITH SAME OPERATORS AND OPERATIONAL HISTORIES
(Aircraft in bold experienced a fire event)

Serial Number	Total SDRs	Corrosion SDRs	Operator(s)
19117	178	65	UPS, Braniff, Orion
19118	**345**	**144**	**UPS, Braniff, Orion**
19119	336	131	UPS, Braniff, Orion
19800	79	5	Continental
19801	**82**	**26**	**Continental**
19802	75	22	Continental
19970	147	39	Northwest
19971	**103**	**26**	**Northwest**
19972	93	12	Northwest
20294	67	7	Northwest
20295	**113**	**31**	**Northwest**
20296	5	0	Northwest
21482	78	7	Delta, Western
21483	**95**	**65**	**Delta, Western**
21484	36	12	Delta, Western

3.2.4 Fleetwide Corrosion Reporting Trends 727 Aircraft.

Fleetwide trends in aircraft corrosion were studied to see if aircraft with fires stand apart from overall fleet trends. It was found that on average the corrosion reporting for the 727 fleet has been low but has been increasing since 1984 when the first 727 became twenty years old. Figure 3 and table 5 illustrate this trend versus calendar time. Figure 4 highlights 1988 through 1994 and includes total fleet size and total aircraft over twenty years of age during that period. The aircraft aging trend is relatively flat and doesn't fully explain the increase in corrosion SDRs. A possible explanation as indicated on figure 4 might be increased corrosion awareness due to the Aloha incident (Boeing 737 fuselage failure) and the issuance of the Aging Aircraft Corrosion inspection ADs (table 2).

TABLE 5. B727 AIRCRAFT FLEET - TABULATED CORROSION REPORTING HISTORY

Year	Number of Aircraft in Service	Number of Aircraft Over 20 Years Old	Total Number of Aircraft Over 20 Years Old	Number of Corrosion SDRs
1974	823	0	0	35
1975	875	0	0	113
1976	919	0	0	120
1977	977	0	0	77
1978	1067	0	0	53
1979	1174	0	0	102
1980	1257	0	0	137
1981	1317	0	0	171
1982	1335	0	0	122
1983	1356	0	0	76
1984	1401	59	59	115
1985	1414	84	143	199
1986	1421	106	249	353
1987	1431	137	386	552
1988	1442	113	499	460
1989	1454	98	597	1249
1990	1570	47	644	2269
1991	1597	31	675	1564
1992	1521	40	715	3191
1993	1236	88	803	3765
1994	1197	86	889	5235

The conclusion is that when considered against the fleetwide trend in corrosion reporting, the corrosion of the fire damage aircraft cannot be attributed to fire, but is more likely due to aircraft aging and the aging aircraft inspection initiatives.

3.2.5 Effect of Individual Airline Reporting on This Study.

Variations in SDR system usage are known to exist. Reporting trends for the airlines operating the aircraft of Table 1 were compiled to see if unusual reporting patterns by the airlines could influence the study. Results are presented in appendix C. One airline, a large cargo operator, shows a higher than usual number of SDRs for its 727 aircraft. Another, a large passenger airline, shows almost no corrosion reporting for its 727 aircraft. Since this study was looking for aircraft with high numbers of corrosion reports, aircraft from airlines with low reporting, are not part of the analysis. The high reporting level for the cargo carrier might be due to the fact that the 727s used are cargo conversions of passenger aircraft. Conversion from passenger to cargo configuration is a major structural modification that would present the airline with an opportunity to do needed structural inspections throughout the fuselage. Serial number 21483 is such an aircraft.

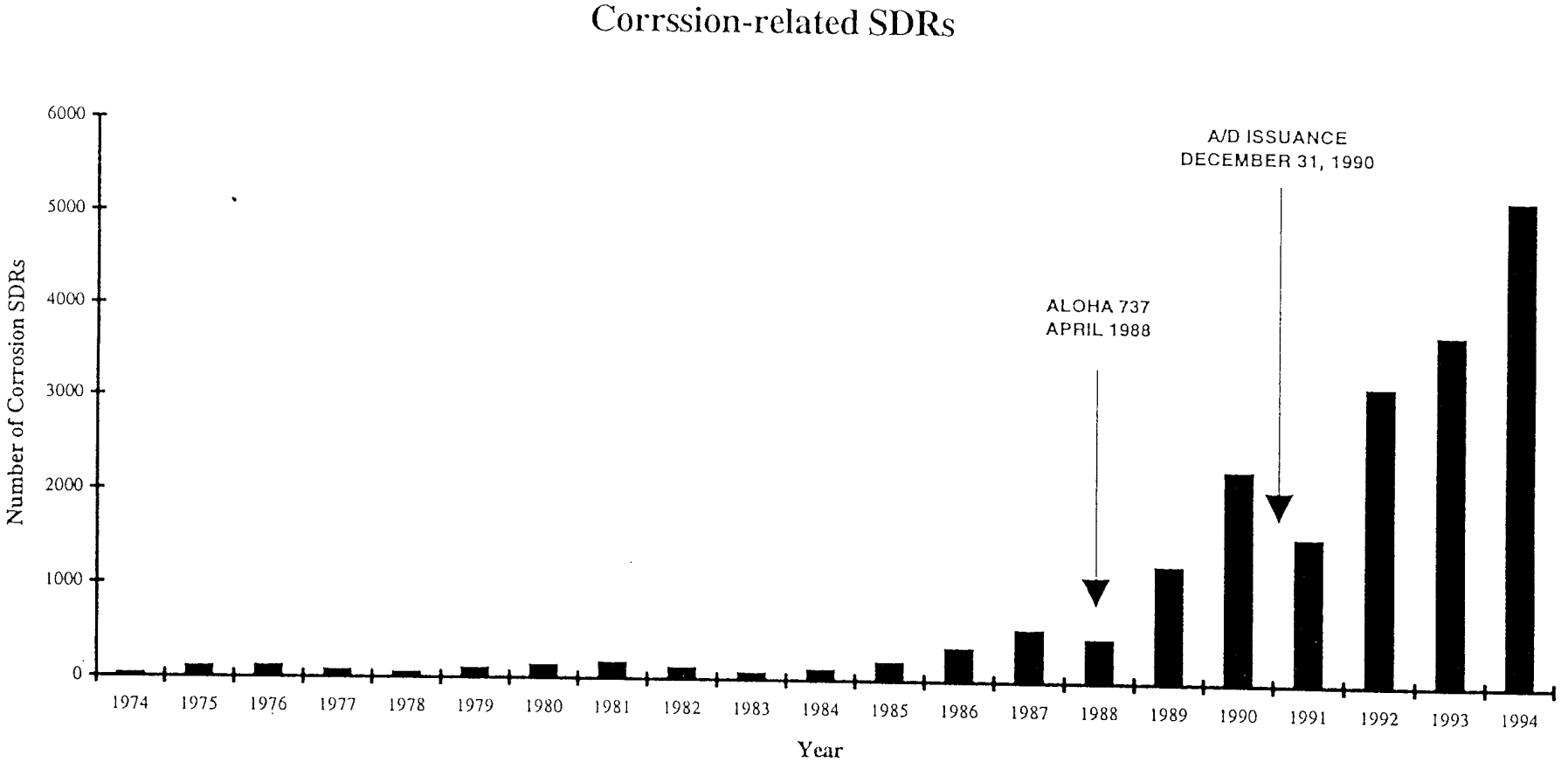

FIGURE 3. FLEETWIDE CORROSION REPORTING HISTORY FOR THE BOEING 727 AIRCRAFT

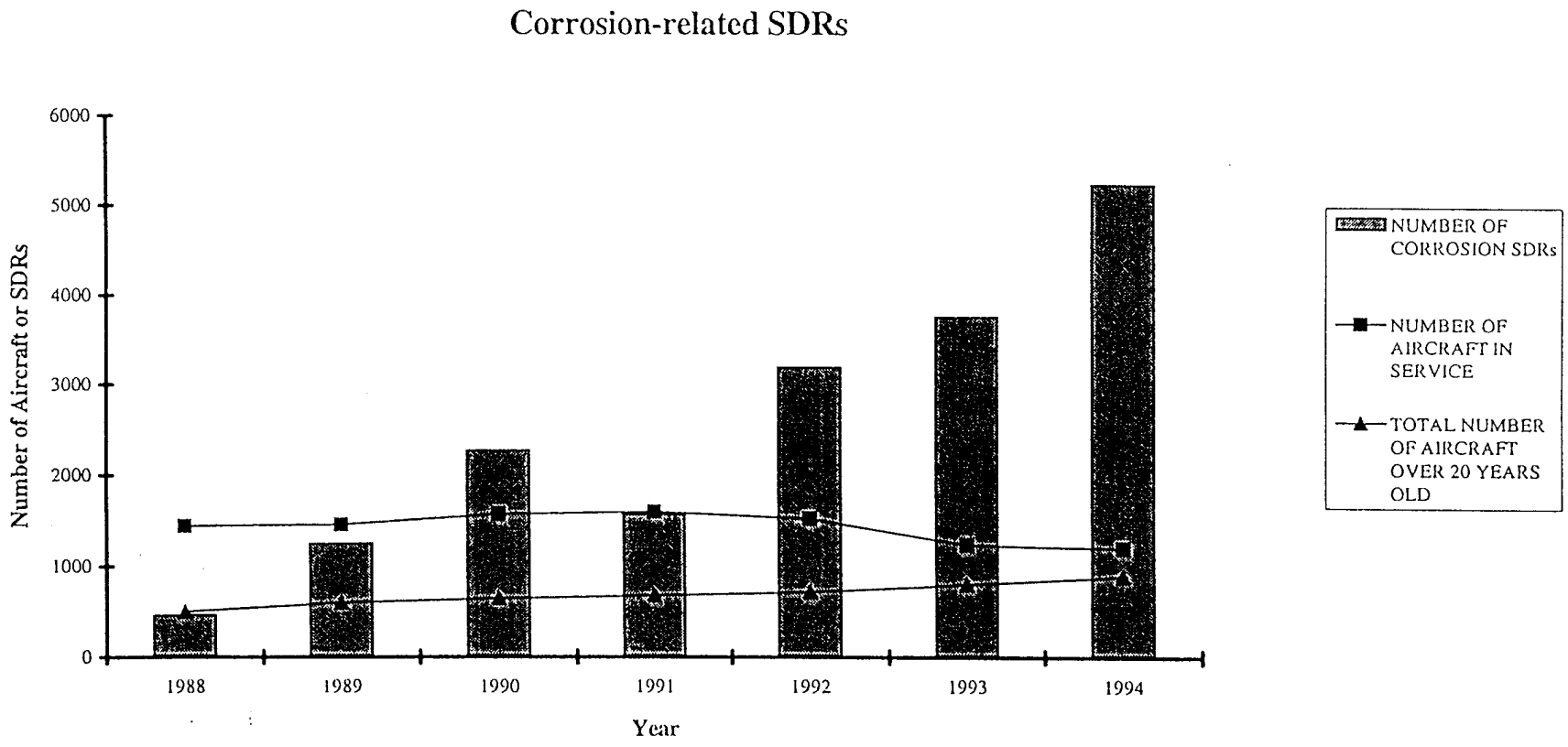

FIGURE 4. CORROSION REPORTING 1988 TO 1994 RELATED TO AIRCRAFT AGE AND FLEET SIZE, B727 AIRCRAFT

4.0 CONCLUSIONS.

For the aircraft studied it is not possible to show that the fire, smoke or extinguishing agents cause corrosion of the aircraft structure. This conclusion is based upon the following findings.

1. For aircraft with high (greater than 25) corrosion SDRs the corrosion was found to be randomly distributed throughout an aircraft's fuselage.

2. No evidence exists that aircraft with fire and corrosion have higher levels of corrosion than aircraft with no fire.

3. Review of fleetwide corrosion reporting for the 727 aircraft gave no indication that corrosion trends are affected by small fires.

Appendix A
Significant Activities Report

Posted: Tue May 28, 1991 12:07 PM EST
CJJB-1547-9002
From: AWP205
To: AFS13S
CC: AVR1, ALLFSDIV, AWP.FSDOS
Subj. SIGNIFICANT ACTIVITIES REPORT

SIGNIFICANT ACTIVITIES
FLIGHT STANDARDS DIVISION
WESTERN-PACIFIC REGION

United Airlines (UAL). During a Heavy Maintenance Visit (HMV), UAL discovered extensive corrosion damage from the floor up on B-727, N7296. The corrosion is worst in the fuselage crown area, and extends from Fuselage Station (FS) 340 to 1183. UAL estimates the repair will take 40,000 man hours. A decision has not been made on whether the repair will be done by UAL or contracted out to Boeing (or whether the aircraft will be repaired at all). The aircraft interior was fire damaged in late 1979 or early 1980. A Boeing team performed those repairs. There is a strong possibility that the present corrosion is the result of chemical reaction from either combustion products or the extinguishing agent from that fire. UAL has reviewed HMV packages from several sister aircraft produced before and after this aircraft. The packages did not reveal similar corrosion.

[Reproduction of original document]

Appendix B

Descriptions of Aircraft Fires Included in the Study of Corrosion of Fire Damaged Aircraft

AIRCRAFT WITH FIRE RELATED SDRs

Mo	Da	Yr	Type	Serial #	Partname	Partcond	Partloc
09	10	81	1011	193B1072	SERVING CART	BURNED	SC-2

Remarks: WHEN PLUGGING SERVING CART IN AT SC-2,A FIRE OCCURRED.REMOVED PLUG AND USED CO-2 ON CART PLUG.NO DAMAGE.REPLACED RECEPTACLE

09	22	86	1011	193B1107	LAVATORY BIN	TRASH FIRE	NR 2 POS

Remarks: BOS - DURING CRUISE, IT WAS NECESSARY TO USE THE WATER FIRE EXTINGUISHER FROM THE R4 DOOR TO PUT OUT A SMUDGE FIRE IN THE AFT NR 2 LAVATORY TRASH BIN APPARENTLY CAUSED BY CARELESS DISPOSAL OF SMOKING MATERIAL. CLEANED TRASH BIN AND REPLACEDWATER FI
RE EXTINGUISHER. CHECK C-4B - 07/01/86 - LAX.

03	16	87	1011	193B1107	OVEN	FOOD FIRE	LWR GALLEY

Remarks: LAX - NECESSARY TO USE TWO HALON FIRE EXTINGUISHERS TO PUT OUT FOOD FIRE IN LOWER GALLEY DURING CRUISE. CHECKED AND CLEANED ALL OVENS. OP CHECKS NORMAL. REPLACED FIRE EXTINGUISHERS.

12	22	89	727	19118	DETECTOR	FAILED	APU

Remarks: BUF - DURING ROUTINE MAINTENANCE CHECK, THE APU CAUGHT ON FIRE. THE APU FIRE WARNING FAILED TO PRODUCE A VISUAL OR AUDI BLE WARNING, ALTHOUGH IT HAD CHECKED GOOD PRIOR TO APU START AND ALSO AFTER THE FIRE WAS EXTINGUISHED. S/D - MAINTENANC E REPLAC
ED THE APU, INCORPORATING NEW FIRE LOOP. AIRCRAFT RETURNED TO SERVICE.

09	03	85	727	19801		FIRE DAMAGE	NR 3 GALLEY

Remarks: FOOD FIRE IN NR 3 GALLEY OVEN WITH MINIMAL SMOKE. ATTENDANT EXTINGUISHED FIRE. OVEN BREAKERS PULLED. CLEANED OVEN.

07	14	86	727	19971	SENSOR	SHORTED	NR 2 FIREWALL

Remarks: TPA- NR 2 ENGINE FIRE WARNING CAME ON AFTER TAKEOFF, DISCHARGED FIRE BOTTLE, DUMPED FUEL AND RETURNED. CLEARED SHORTED FIRE WARNING LOOP ON FIREWALL NEAR ENGINE MOUNT.

07	31	87	727	20295		SMOKE	AFT LAVATORY

Remarks: DTW - FLIGHT 414 - SMOKE IN RIGHT AFT LAVATORY TRASH CONTAINER CAUSED BY CIGARETTE. USED PORTABLE FIRE EXTINGUISHER, NO DAMAGE TO AIRCRAFT OR HEAT INDICATORS. REPLACED FIRE BOTTLES WITH SERVICEABLE UNITS.

Mo	Da	Yr	Type	Serial #	Partname	Partcond	Partloc
04	03	89	727	20295	HOSE	RUPTURED	NR 3 ENGINE

Remarks: TPA - FLIGHT 447 - DURING CLIMB TPA-MSP, NR 3 ENGINE FIRE WARNING LIGHT ILLUMINATED. BOTH FIRE EXTINGUISHING BOTTLES WE RE DISCHARGED AND THE ENGINE WAS SHUT DOWN. THE AIRCRAFT DUMPED 12,000 POUNDS OF FUEL AND RETURNED TO TPA WITHOUT FURTH ER INCID
ENT. INVESTIGATION REVEALED THAT 13TH STAGE BLEED AIR FROM THE THRUST REVERSER SUPPLY HOSE HAD BURNT 8 WIRES IN THE PYLON CAUSING THE FIRE WARNING. A NEW THRUST REVERSER SUPPLY HOSE WAS INSTALLED. THE FOLLOWING PARTS WERE REPLACE D - WIRES, CONNE
CTOR P/N CA3106KRS1651P, AND ELEMENTS NWA STOCK NR 124SE521 AND 124DE762.

09	06	79	727	21483		OVERHEATED	FWD GALLEY

Remarks: N O 1 OVEN STARTED SMOKING & CAUGHT ON FIRE.FIRE PUT OUT WITH CHEM.EXTING.ROW 3.FOUND TEMP SELECTOR SW FAULTY.RPL OVEN.

07	02	90	727	21483	BRAKE	DAMAGED	NR 2

Remarks: CVG - FLIGHT 615 - DURING LANDING, SMALL FIRE AT LEFT MAIN GEAR AREA. FIRE DEPARTMENT CALLED BUT NOT NEEDED TO EXTINGUI SH. FOUND PIECE OF RUNWAY-JOINT-RUBBER WEDGED ONTO NUMBER 2 BRAKE, WHICH IGNITED AS BRAKES HEATED UP. REPLACED NUMBER 2 BRAKE
AS PRECAUTION AND NUMBER 1 TIRE DUE TO THERMAL FUSE RELEASE.

01	24	80	737	19426	FIRE WARNING	FALSE	APU

Remarks: DURING DESCENT APU F/W + BELL CAME ON SHUT DWN FIRED BOTTLE MAINT CK SYS OPS CK OK

02	08	80	737	19426	APU	FIRE	AFT BODY

Remarks: DURING AN ATTEMPT TO START APU HAD FIRE WARNING.DISCHG FIRE BOTTLE.SUSPECT APU COLD SOAKED-RAW FUEL INTO EXH AREA

03	12	90	737	19426	LOOP	DEFECTIVE	NR 1 ENGINE

Remarks: HNL-LIH - FLIGHT 307 - FLIGHT EXPERIENCED NR 1 ENGINE OVERHEAT LIGHT. FLIGHT CREW PERFORMED OVERHEAT PROCEDURE, LIGHT REMAINED ON. CREW PERFORMED ENGINE FIRE PROCEDURE. DECLARED EMERGENCY, RETURNED TO HNL. PERFORMED AN UNEVENTFUL SINGLE ENGINE
LANDING WITH NO INJURIES OR EQUIPMENT DAMAGE. MAINTENANCE PERFORMED NR 1 ENGINE OVERHEAT INSPECTION, NO DAMAGE NOTED. REPLACED FAULTY OVERHEAT LOOP CONNECTOR AND AFT FIRE BOTTLE. OPS CHECK OK, AIRCRAFT RETURNED TO SERVICE.

01	12	79	737	20361		BURNED	NO 3 GALLEY OVEN

Remarks: MINOR FIRE AT AFT GALLEY OVEN.PULLED CB & FIRE SUBSIDED.REPLACED FAULTY NO 3 GAL LEY OVEN & CHECKED OK.

Mo	Da	Yr	Type	Serial #	Partname	Partcond	Partloc
03	11	88	737	20361	FIRE SEAL	CRACKED	APU

Remarks: DEN - APU FIRE WARNING LIGHT ILLUMINATED. FIRED EXTINGUISHER AND STILL HAD INTERMITTENT WARNING. PLACARDED APU INOPERA TIVE AND COLLARED CIRCUIT BREAKER. SHOP INSPECTION REVEALED THE APU FIRE SEAL CRACKED. REPLACED FIRE SEAL AND PERFORME D APU OP
ERATIONAL TEST. TESTED GOOD.

07	31	80	737	20365		FIRE	RT ENG

Remarks: CREW REPORTED RT ENG F-W CAME ON.DISCHG FIRE BOTTLES AND SHUT DOWN ENG.INSP ENG FOUND OK REPLACED DISCHG FIRE BOTTLE

06	16	86	737	20365		FIRE WARN	APU

Remarks: DEN - ON ARRIVAL, CREW REPORTED APU FIRE WARNING LIGHT AND BELL CAME ON. PULLED APU FIRE WARNING HANDLE AND DISCHARGED FIRE BOTTLE. MAINTENANCE INSPECTED APU AND NO EVIDENCE OF OVERHEAT OR DAMAGE WAS FOUND. PLACARDED APU INOPERATIVE PER THE B-73
7 MINIMUM EQUIPMENT LIST.

05	01	87	737	20365	DETECTOR	FAILED	APU

Remarks: TUL - AFTER TAKEOFF FROM TUL, THE APU FIRE WARNING LIGHT ILLUMINATED AND THE WARNING BELL SOUNDED. THE FIRE HANDLE WAS PULLED AND THE LIGHTS REMAINED ILLUMINATED. THE FIRE BOTTLE WAS FIRED AND THE LIGHTS CONTINUED TO REMAIN ILLUMINATED. AIRCRAFT
RETURNED TO TUL. INSPECTION OF APU FOUND NO EVIDENCE OF FIRE. DISCONNECTED THE FIRE WARNING SYSTEM, PULLED CIRCUIT BREAKERS AND PLACARDED THE APU INOPERATIVE. INVESTIGATION REVEALED FIRE DETECTOR UNIT HAD FAILED. REPLACED DETECTOR.

07	17	89	737	20365	PLUG	DIRTY	APU

Remarks: ELP - FLIGHT 557 - THE APU FIRE WARNING LIGHT ILLUMINATED IN FLIGHT AND THE APU FIRE BOTTLE WAS DISCHARGED. MAINTENANCE FOUND NO EVIDENCE OF APU FIRE. THE FIRE DETECTION SYSTEM FAILED A RESISTANCE TEST. THE D4934 CONNECTOR WAS FOUND DIRTY. THE PLUG
WAS DISCONNECTED AND CLEANED AND A SUBSEQUENT RESISTANCE CHECK WAS GOOD.

08	31	76	737	20492	SWITCH	DEFECTIVE	TAIL CONE

Remarks: F/W APU-NO DMG FOUND.S/D REPLACED APU OVTMP SWITCH.

08	22	77	737	20492		INOPERATIVE	AC SYS

Remarks: RT PACK INTERMITTENTLY GIVING OFF SLIGHT AMOUNT OF SMOKE.REPLACED CABIN AIRCONDITIONING TEMP CTL VLV & DUAL MIX VLV

Mo	Da	Yr	Type	Serial #	Partname	Partcond	Partloc
11	08	77	737	20492		SHORTED	COCKPIT

Remarks: AIR TURN BACK DUE SMOKE IN COCKPIT.FOUND SMOKE COMING FROM RADAR INDICATOR.REPLACED INDICATOR

02 17 83 747 19670 COFFEEMAKER BURNED A GALLEY
Remarks: TWO FIRE EXTINGUISHERS USED TO EXTINGUISH ELECTRICAL FIRE IN A-GALLEY COFFEEMAKER. REPLACED COFFEEMAKER.

08 17 87 747 19670 CONNECTOR FAULTY NR 3 ENGINE
Remarks: LGW--DURING CRUISE THE NR 3 ENGINE FIRE WARNING CAME ON. MONITORING WAS ON A-LOOP AS B-LOOP WAS PLACARDED INOPERATIVE. SHUT DOWN NR 3 ENGINE AND DISCHARGED LEFT FIRE EXTINGUISHER BOTTLE. FOUND THE FWD LOWER A-FIRE DETECTOR LOOP CONNECTOR FAULTY.
REPLACED CONNECTOR PART NUMBER 878239-02. REPLACED FIRE EXTINGUISHER BOTTLE. RUNUP WAS NORMAL.
B-FIRE DETECTION LOOP ON NR 3 ENGINE REMAINS PLACARDED INOPERATIVE.

09 19 88 747 19670 CIGARETTE SEAT 16-1
Remarks: LHR - FLIGHT 704 - DURING FLIGHT, PASSENGER DROPPED LIT CIGARETTE BEHIND SIDEWALL PANEL AT SEAT 16-1. USED HALON FIRE EXTINGUISHER. AREA CHECKED AND NO EVIDENCE FOUND OF IGNITION OR DAMAGE OF MATERIAL FROM CIGARETTE. REPLACED FIRE EXTINGUISHER
P/N C03108-1. CHECK C-2A 7/28/88 JFK.

04 03 87 747 19676 FIRE R5 LAV
Remarks: FLIGHT 801 - JFK - DURING CRUISE, THE SMOKE DETECTOR IN THE LAVATORY AT R5 DOOR SOUNDED. FOUND SMALL WASTE PAPER FIRE. EXTINGUISHED WITH PORTABLE WATER FIRE EXTINGUISHER. NO DAMAGE FOUND. REPLACED WASTE RECEPTACLE AND WATER FIRE EXTINGUISHER.
CHECK C-8C - 1/20/87 - JFK.

07 21 86 747 19729 FIRE MALFUNCTION LOWER AFT CARGO
Remarks: LGW--DURING DESCENT FLIGHT 014 EXPERIENCED THE LOWER AFT CARGO COMPARTMENT FIRE DETECTION INDICATOR ILLUMINATE INTERMITTENTLY. CREW FIRED BOTH BOTTLES AND THE INDICATION CEASED. AIRCRAFT CONTINUED AND LANDED UNEVENTFULLY.
S/D -UP ON INVESTIGATION NO EVIDENCE OF FIRE WAS NOTED. PERFORMED INSPECTION AND FUNCTIONAL CHECK OF WARNING SYSTEM. NO DEFECTS NOTED. REPLACED BOTH BOTTLES AND RETURNED AIRCRAFT TO SERVICE WHERE IT HAS OPERATED WITHOUT FURTHER INCIDENT OF THIS NATURE.

03 10 93 747 19729 OVEN FAN RUBBNG GALLEY
Remarks: LGW - FLT 0028 - A SMALL FIRE STARTED IN THE NR 2 FIRST CLASS GALLEY OVEN WHILE IN FLIGHT. A HALON FIRE EXTINGUISHER WAS USED AND THE FIRE CEASED. THE FIRE WAS CONTAINED WITHIN THE OVEN.
MAINTENANCE FOUND THAT THE OVEN CIRCULATING FAN WAS
RUBBING AGAINST OVEN LINER AND THERE WAS BURNED FOOD AND PACKAGING IN THE OVEN. NO OTHER DISCREPANCIES WERE OBSERVED. THE OVEN WAS REMOVED AND REPLACED AND OPERATION CHECKED GOOD. IN ADDITION, THE FIRE EXTINGUISHER WAS REMOVED AND REPLACED.

Mo	Da	Yr	Type	Serial #	Partname	Partcond	Partloc
10	27	89	747	19730	TRASH BIN	SMOKE	RIGHT LAVATORY

Remarks: AKL - FLIGHT 0001 - THE RIGHT LAVATORY SMOKE DETECTOR BEGAN CHIMING ON ARRIVAL IN AKL DUE TO SMOKE IN THE TRASH BIN. A PASSENGER HAD BEEN SMOKING IN THE LAVATORY. THE SMOKE CEASED UPON USE OF WATER FIRE EXTINGUISHERS.

07	29	74	747	20324	CONTAINER	BURNT	R/H AFT LAV

Remarks: PAX RPTD FIRE IN COACH AFT LAV.STEW.USED EXT TO PUT OUT FIRE IN TOWEL DISP CONTAINER.

05	11	76	747	20324	O RING	CUT	NO3 ENGINE

Remarks: SMOKE FROM NO3 ENG-FIRE IN DRIP PAN & TROUGH.FUEL FROM CUT O RING IN FLEX LINE CONNECTOR AT HORIZ FIREWALL

07	05	77	747	20324	O-RING	LEAKING	NO4 ENGINE

Remarks: NO 4 ENG SHUTDOWN DUE F-W.FIRE DAMAGE TO RVR COWL & AFT ENG WIRING.FOUND FUEL PUMP DR SHFT LEAKING. GANG DRAIN O-R

08	23	83	747	20324	FIRE	FAULTY	ZONE 3

Remarks: ZONE 3 MAIN DECK FIRE DETECTION LIGHT CAME ON. DISCHARGED FIRE BOTTLE. REPLACED ZONE 3 FIRE DETECTOR.

11	02	78	DC10	46506	.WASTE	BURNED	NO 5 LAV

Remarks: EXTINGUISHED FIRE IN NO 5 LAV WAST CONTAINER.FOUND DRINKING CUP BURNED.NO A-C FIRE DAMAGE.REPL H2O EXTINGUISHER

03	11	88	DC10	46506	DUCT	RUPTURED	NR 3 ENGINE

Remarks: LAX - TRIP 040/03 - ON CLIMBOUT EN ROUTE LAX-JFK, NR 3 ENGINE FIRE WARNING CAME ON. SECURED ENGINE AND DISCHARGED BOTH EXTINGUISHERS. DUMPED FUEL AND RETURNED TO LAX. LANDED WITHOUT INCIDENT. REPLACED RUPTURED CROSSOVER DUCT. AIRCRAFT TT 45298

Mo	Da	Yr	Type	Serial #	Partname	Partcond	Partloc
12	16	85	DC10	46768	ENCODER	FAILED	CABIN SEAT 12J

Remarks: DUR:NG CRUISE SMOKE WAS REPORTED COMING FROM UNDER SEAT 12-J. THE INVESTIGATION REVEALED THE SMOKE WAS COMING FROM AN OVERHEATED DEMULTIPLEXER/ENCODER. THE ENCODER WAS DISCONNECTED AND COOLED DOWN WITH A FIRE EXTINGUISHER BY THE CREW. NO EVIDENCE OF FIRE WAS FOUND. THE ENCODER WAS REPLACED.

07	27	78	DC8	45968		BLOWN	LMLG NO 5&6

Remarks: ABORTED T-O DUE NO 5 & 6 TIRES BLEW.PASSENGERS EVAC.FIRE DAMAGE TO LT WW,INBD FLAP & SPOILER.REASON UNK FOR DELAMIN

06	10	81	DC8	45968		FIRE	LT MAIN GEAR

Remarks: ON TAXI HAD FIRE AT NO 1 MAIN WHEEL.FLAME EXTINGUISHED BY FIRE TRUCK.REPLACED NO 1 WHEEL AND BRAKE,NO 2 AS PRECAUTION

12	11	87	DC8	46070	LOOP	SHORTED	NR 1 ENGINE

Remarks: PPG - FLIGHT 483 - ENGINE FIRE WARNING ON NR 1, COMPLETED PHASE 1 AND 2 CHECKLISTS, BOTH BOTTLES DISCHARGED. CHECKED ENGINE AND FOUND BOTTOM FIRE DETECTION LOOP DEFECTIVE. REPLACED LOOP AND BOTH FIRE BOTTLES.
ENGINE RUNUP AND FUNCTIONAL CHECK NORMAL.

12	18	87	DC8	46070	PINS	LOOSE	FIRE LOOP

Remarks: FIRE WARNING ON NR 3 ENGINE, 2 HOURS INTO FLIGHT. NR 3 ENGINE SHUTDOWN. FIRE BOTTLES DISCHARGED. LIGHT REMAINED ON ONE HOUR, WILL NOT TEST. WINDMILL TIME 2.0. ALSO WITH FIRE HANDLE FULL FORWARD AND FUEL LEVER ON, A FUEL FLOW OF 700 POUNDS
RESULTS. AIRCRAFT RETURNED TO HNL. FOUND LOOSE PINS AT LOWER FIRE DETECTION LOOP CONNECTOR. ERRONEOUS FIRE WARNING. REPLACED LOWER DETECTOR ELEMENT AND CLEANED FIRE LOOP AT CONNECTOR. REPLACED INBOARD AND OUTBOARD FIRE BOTTLES. GROUND RUNUP
AND OPERATIONAL CHECK OK.

05	08	92	DC8	46070	FIRE DETEC	SHORTED	NR 3 ENGINE

Remarks; NR 3 ENGINE FIRE DETECTION WARNING LIGHT CAME ON IN CRUISE. ENGINE WAS SHUT DOWN AND BOTH FIRE EXTINGUISHING BOTTLES WERE DISCHARGED. THE FIRE DETECTION WARNING LIGHT REMAINED ON WITH NO DETECTABLE FIRE INDICATION OTHER THAN THE LIGHT AND FIRE
BELL. AIR TURN BACK TO SEA. REPLACED NR 3 ENGINE LOWER FIRE DETECTION LOOP. FIRE WARNING TEST NORMAL. INSPECTED ENGINE, NO DAMAGE NOTED. INSPECTED MAIN OIL SCREEN, FOUND CLEAN. REINSTALLED SCREEN, LEAK CHECK OKAY.
REPLACED BOTH FIRE EXTINGUISHING BOTTLES.

Mo	Da	Yr	Type	Serial #	Partname	Partcond	Partloc
12	26	79	DC8	46094	CANNON PLUG	FAILED	ENG NO 3

Remarks: SHUT DOWN NO 3 ENG DISCHG 1 BOTTLE.DUMPED FUEL AND RETURNED.REPLACED SHORTED CAN NON PLUG ON FIRE DETECTOR

06	23	80	DC8	46094	LOOP	CHAFED	NO 3 ENG

Remarks: SHUT DOWN NO 3 ENG DUE F-W.DISCHG FIRE AGENT.FOUND LOOP ON FIRE DETECTOR CHAFING ON ENG COWLING.REPLACED DETECTOR

12	12	80	DC8	46094	DETECTOR	LOOSE	NO 3 ENG

Remarks: SHUT DOWN NO 3 ENG DUE F-W IND.DISCHG FIRE BOTTLES.DIVERTED.FOUND FIRE LOOP CONNECTOR LOOSE.SECURED CONNECTION.

02	12	81	DC8	46094	DETECTOR	BROKEN	NO3 ENG

Remarks: FIRE WARNING NO 3 ENG.SHUT DOWN ENG,DISCHG BOTH FIRE BOTTLES.FOUND ELECTRICAL CONNECTOR ON FIRE DETECTOR BROKEN.REPL

11	02	90	DC8	46094	ELEMENT	INTERMITTEN	NR 4 ENGINE

Remarks: FLIGHT CREW REPORTED INTERMITTENT NR 4 FIRE LIGHT, SHORT CIRCUIT LIGHT AND FIRE HANDLE. FIRED BOTH BOTTLES AND DISCONNECTED NR 4 GENERATOR DRIVE. MAINTENANCE REPLACED NR 4 RIGHT LOWER CORE FIRE ELEMENT AND BOTH RIGHT FIRE BOTTLES (P/N 899 827).
SYSTEM CHECKS NORMAL.

09	05	86	DC8	46109	BRAKE	WORN	LANDING GEAR

Remarks: ATL - AFTER LANDING AND TAXIING TO RAMP, NR 8 BRAKE CAUGHT FIRE AFTER MAINTENANCE HAD PARKED THE AIRCRAFT. FIRE WAS EXTINGUISHED BY MAINTENANCE PERSONNEL. REMOVED AND REPLACED NR 8 BRAKE AND NR 7 AND NR 8 TIRE. AIRCRAFT RETURNED TO SERVICE.

09	27	76	DC9	45727	COFFEE MAKER	SHORTED	GALLEY

Remarks: NOTICED SMELL OF ELECTRICAL SMOKE FROM NO 2 COFFEE MAKER.REPLACED COFFEE MAKER FOUND NO EVIDENCE OF SMOKE OR FIRE

Mo	Da	Yr	Type	Serial #	Partname	Partcond	Partloc
05	07	80	DC9	45727		FAILED	APU COMP

Remarks: APU FIRE WARNING LITE CAME ON DURING APU START.DISCHG FIRE BOTTLE.FOUND APU STARTER HAD OVERHEATED.REPL APU + F-BTL.

06	03	80	DC9	45727	RELAY	BURNED	APU STARTER

Remarks: WHILE STARTING APU,STARTED MOTOR BURNED.FIRE EXTINGUISHED WITH HAND FIRE EXTINGUISHER.STARTER RELAY STICKING.RPL

08	15	77	DC9	45842		SMOKE	FWD BAGGAGE BIN

Remarks: STOPPED A-C ON TAXIWAY,PASSENGERS UNLOADED THRU FWD ENTRANCE.FIRE IN MAILBAG IN FWD BAGGAGE BIN.CLEANED INSP AREA.

06	24	80	DC9	45842	DUCT	RUPTURED	RIGHT ENGINE

Remarks: RETURNED WITH RT ENG SHUT DOWN DUE F-W.DISCHG FIRE BOTTLE.FOUND NOSE COWL ANTI-ICE DUCT RUPTURED.REPL DUCT,OIL P SW

Appendix C
Operator Histories — SDR Reporting Frequency

AIRCRAFT	OPERATOR	TOTAL SDRs	CORROSION SDRs
B727	American	5394	820
B727	Continental	3365	691
B727	Delta	2615	601
B727	United Parcel	5998	2954
B727	Northwest	5511	681
B727	TWA	3570	282
B727	United	3598	8
B737	Continental	1362	144
B737	Delta	467	89
B737	United	1649	13
B737	USAir	3494	887
B737	Southwest	4600	15
B747	Continental	437	136
B747	United	968	26
B747	Northwest	4175	642
B747	TWA	1915	282
B747	PanAm	1393	87
DC8	Delta	425	13
DC8	United Parcel	3570	912
DC8	United	1346	7
DC8	Braniff	306	21
DC8	Airborne Express	354	83
DC8	Arrow Air	221	3
DC9	American	1167	32
DC9	Continental	2031	221
DC9	Delta	962	60
DC9	Eastern	3812	106
DC9	Northwest	7242	279
DC9	TWA	1362	133
DC9	Airborne Express	1699	509
DC9	USAir	3877	433
DC10	American	2015	314
DC10	Continental	689	108
DC10	Delta	44	1
DC10	Eastern	35	5
DC10	Northwest	1740	321
DC10	USAir	1401	18
L1011	Delta	1605	278
L1011	Eastern	2401	155
L1011	TWA	1897	169

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