

UNITED STATES OF AMERICA  
NATIONAL TRANSPORTATION SAFETY BOARD  
WASHINGTON, D.C. 20594

RE: Investigation of an  
Aircraft Accident occurring  
On September 8, 1994 near  
Pittsburgh, Pennsylvania

Submission of PARKER  
HANNIFIN CORPORATION

Honorable James Hall  
Chairman, National Transportation Safety Board  
490 L'Enfant Plaza, S.W.  
Washington, D.C. 20594

Re: Investigation of an Aircraft Accident  
Occurring on September 9, 1994  
Near Pittsburgh, Pennsylvania

## **I. Introduction**

Parker Hannifin Corporation ("Parker"), as a Party to the Systems Group of the National Transportation Safety Board's investigation into the subject crash, at the request of the Board and pursuant to the provisions of 49 CFR Section 845.27, is pleased to make this submission.

As the Board is aware, Parker is the original equipment manufacturer of various components which are incorporated into the power control unit for the rudder system for the Boeing 737 aircraft. Parker performs repair and overhaul activity for these components, and supports certain Airworthiness Directives relevant to the power control unit. At the Board's invitation, Parker has participated in the Systems Group during the course of this extensive investigation.

## **II. Summary of Participation**

From the days immediately following the crash of Flight 427, September 8, 1994, to the present, Parker has supported the Board, the manufacturer of the aircraft, Boeing, and other Parties in the investigation.

### **a) Crash Location Investigation**

Shortly after the September 8, 1994 crash, at the request of the NTSB, Parker supplied two engineers with knowledge of the workings of Parker manufactured component parts incorporated into the Boeing 737 aircraft to work on site in Pittsburgh where the wreckage of the aircraft was maintained. These engineers provided input to the investigating team designed to preserve the integrity of various components for examination and subsequent detailed functional testing.

**b) Participation in Key NTSB Systems Group Testing**

Parker supported the following tests, and related events, which were conducted primarily at Boeing's facilities, Parker's facilities, or NTSB facilities:

**1994**

Crash Location Investigation, Pittsburgh, Pennsylvania - (September 1994)

Examination of Key Flight Control Components, at Boeing - (September 18-19)

Examination of Rudder Power Control Unit and Functional Testing, at Parker -  
(September 20-23)

Systems Group Meeting, at Boeing - (October 3-8)

Fluid Contamination Test – (October 31)

Systems Group Meeting, at Boeing – (November 14-19)

Systems Group Meeting, at Boeing – (December 6-8)

NTSB Metallurgical Examination of Servo Valve – (December 12-14)

**1995**

Systems Group Rudder PCU Servo Valve Tests at Parker – (January 9)

Boeing EQA Chip Shear Tests for Rudder PCU Servo Valve – (January 10-12)

NTSB Public Hearing regarding USAir Flight 427 Investigation, Pittsburgh, Pennsylvania -  
(January 22-28)

Systems Group Rudder PCU Servo Valve Testing, at Parker – (Ogden, Utah) (March 6)

NTSB All Party Meeting, Washington D.C. – (March 13)

NTSB All Party Meeting, Seattle, Washington – (May 8-9)

Systems Group Meeting, Seattle, Washington – (May 10-11)

NTSB All Party Meeting, Pittsburgh, Pennsylvania – (August 23)

NTSB Public Hearing, Springfield, Virginia – (November 15-17)

NTSB Facilities Tour, at Parker – (November 28-29)

## **1996**

Systems Group Rudder PCU Tests, at Parker – (January 28)  
NTSB Expert Panel Kickoff Meeting – (February 8-9)  
Systems Group Standby Rudder Galling Test, at Boeing – (February 25, March 7)  
Systems Group Rudder PCU Tests at Parker – (May 13-16)  
Thermal Tests, Rudder PCU, at Canyon Engineering – (June 27)  
Systems Group Meeting, at Parker – (June 29)  
Systems Group LVDT Tests, at Parker – (July 22)  
Pre-Thermal Test Activity, Rudder PCU, at Parker – (August 20-21)  
Thermal Tests at Canyon Engineering – (August 22-28)  
Post-Thermal Test Activity, Rudder PCU, at Parker – (August 29)  
Dynamic Tests, Flight Control Systems, at Boeing – (September 16-20)  
Thermal Tests, Rudder PCU, at Boeing – (October 6-11)  
NTSB All Party Meeting, Pittsburgh, Pennsylvania – (October 31)  
Systems Group Meeting, at Parker – (November 20-22)

## **1997**

Chip Shear Tests, at Boeing - (Everett, Washington) (February 18-21)  
NTSB Expert Panel Closeout Meeting, Washington D.C. – (April 3)  
Systems Group Meeting with Boeing - (Washington, D.C.) (April 15)  
Rudder PCU Servo Valve Jam Testing, Joint Performance Group/Systems Group  
Meeting, at Boeing – (June 5-6)  
NTSB Technical Review – (June 25)  
Rudder PCU Servo Valve Testing, KC Shih Theory Tests, Rate After Jam Tests,  
At Parker – (August 19-22)

c) Participation in NTSB Public Hearings

Parker provided drawings, displays, and testimony by engineers with experience in the operation of the rudder power control unit, and other assistance at the two public hearings by the NTSB relating to the investigation into the crash of USAir Flight 427.

d) Provision of Equipment and Personnel for Testing and Related Activities

Parker provided hardware, test stands, engineering support, facilities, drawings, documentation, and related assistance to Boeing and to the NTSB for purposes of the investigation.

Parker has devoted hundreds of hours over the past several years in support of the Board's investigation.

### **III. Summary of Key Findings Regarding the Rudder Power Control Unit**

The Main Rudder Power Control Unit (PCU) along with other key flight control components, were transported to Boeing's facilities under the NTSB's carefully monitored chain-of-custody and oversight procedures. There the PCU was visually examined, x-rayed, and photographed. Subsequently, on September 21-22, 1994, the NTSB convened the Systems Group at Parker's facilities for examination and testing of the PCU. The functional testing, performed at the direction and control of the NTSB, revealed that the PCU operated normally. No anomalies of the PCU used on USAir Flight 427 were discovered.

As outlined above, in the succeeding months and years, Parker continued its participation in various tests related to the main rudder PCU conducted under the direction of the NTSB Systems Group. These tests examined operation of the rudder PCU in extreme environments, some of which exceeded the conditions which could realistically be found in aircraft operation. None of these tests revealed any evidence of a rudder system malfunction which could have caused or contributed to the crash of Flight 427. The key tests and their findings are as follows:

1. **Contamination Testing (Chip Shear Forces)**

Testing of the effects of particulate contamination on the operation of the servo valve was conducted under the direction of the NTSB. (See Exhibit 9R, Docket No. SA-510, Systems Group Chairman's Factual Report Addendum.) By way of background, it should be noted that the pressurized flow of hydraulic fluid through the servo valve provides a constant flushing and cleansing force. Additionally, the normal movement of the servo valve slide and sleeve acts to clear any particulate contamination in the metering ports by their "shearing" force against one another. A variety of potential contaminants to the servo valve were tested, including stainless steel, music wire, and Al-Ni-Bronze. The servo valve was determined to shear all tested forms of particulate contamination, with the exception of hardened steel, 52100 (Rc 61). In that one instance in which the 52100 hardened steel chip did not shear, a witness mark was left on the slide land. No such witness mark was found on the Flight 427 accident unit. Consequently, it may be concluded that the main rudder PCU from Flight 427 was not adversely affected by any contamination in the hydraulic system.

2. **Thermal Shock Tests**

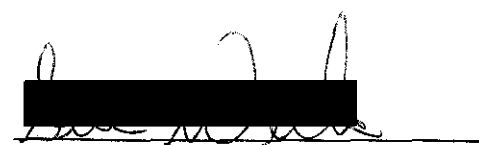
Tests were also performed under the direction of the NTSB to determine whether the rudder PCU was subject to seizure in the event of thermal shock to the unit. The conclusion reached by Boeing was that the accident PCU would not seize if subjected to thermal shocks or temperature differentials consistent with those which could be encountered in realistic flight conditions.

3. **Rudder PCU Servo Valve Performance Testing** (August 1997)

In August 1997, the Systems Group reconvened at Parker's facilities for further performance testing of the Rudder PCU from the accident aircraft in Flight 427. Notwithstanding the variety of tests to which the PCU had been subjected, the unit continued to operate normally.

A significant indication of the reliability of the main rudder PCU from Flight 427 is a comparison of the performance of the unit at the time of its original manufacture in 1987 as measured by the acceptance test, its performance at the time of its testing during removal from service in September 1992, its performance when tested immediately following the accident in September 1994, and finally, its performance when tested in August 1997 after having been subjected to numerous tests and conditions outside the normal flight environment of the unit. In each of these instances, the PCU consistently operated normally and within specifications. In sum, after years of one of the most critical examinations in aviation history, there is no evidence that the main rudder PCU from Flight 427 malfunctioned or was other than fully operational.

Respectfully submitted,

A handwritten signature in dark ink, appearing to read 'Steve Weik', is written over a solid black rectangular redaction box. The signature is fluid and cursive.

Steve Weik  
Manager, Technical Integrity  
Parker Hannifin Corporation