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Produced by the NASA Center for Aerospace Information (CASI)
This Design Note is submitted to NASA under Task Order BO105, Subtask (Integrated Entry Systems) in fulfillment of Contract NAS 9-13970

PREPARED BY:  
Dave Wade  
Subtask Manager  
488-5660, X227

APPROVED BY:  
R. K. Hamilton  
Task Manager  
488-5660, X227

APPROVED BY:  
J. C. Weitekamp  
Technical Manager  
488-5660, X232

APPROVED BY:  
R. R. Stephens  
Project Manager  
Engineering Systems Analysis  
488-5660, X204
1.0 SUMMARY

This design note documents the major developments which have taken place to date in the analysis of the power and energy demands on the APU/Hydraulic/Actuator Subsystem during the entry-to-touchdown (not including rollout) flight regime. These developments are in the form of two subroutines which were written for use with the Space Shuttle Functional Simulator (SSFS). The first subroutine calculates the power and energy demand on each of the three hydraulic systems due to control surface (inboard/outboard elevons, rudder, speedbrake, and body flap) activity. The second subroutine incorporates the R. I. priority rate limiting logic which limits control surface deflection rates as a function of the number of failed hydraulic systems.

Typical results of this analysis are included, and listings of the subroutines are presented in Appendices A and B.

This development work was conducted under Contract Number NAS 9-13970 Task Order B0205.

2.0 INTRODUCTION

The purpose of the APU/Hydraulic/Actuator Subsystem task is to establish fluid horsepower, peak horsepower and hydraulic energy duty cycles for each control surface and for each hydraulic system, and to evaluate the effect and impact of failed hydraulic systems.
on current actuator requirements and vehicle dynamics. The analysis employs the SSFS in order to generate 6 DOF trajectories, with control surface deflection rates being the parameters of greatest importance. Fluid horsepower demand is calculated for each surface as a direct function of the surface rate. Horsepower demand on each hydraulic system is then determined by summing the fluid horsepower demand from the appropriate control surfaces. The horsepower time history for each hydraulic system is integrated over the entire trajectory to determine the energy requirement for each hydraulic system due to control surface activity.

Hydraulic system failure analysis is accomplished by activating the priority rate limiting logic subroutine and by rerouting the control surface fluid horsepower demand to the appropriate hydraulic system.

3.0 DISCUSSION

The main components of the APU/Hydraulic/Actuator subsystem can be seen in Figure 1. Each hydraulic system consists basically of a fuel tank, an APU, and an hydraulic pump. Each of the three identical hydraulic systems is plumbed to each actuator or hydraulic motor such that any one system can drive all control surfaces.
APU / HYDRAULIC / ACTUATOR SUBSYSTEM

AERO CONTROL SURFACE ACTIVITY

HYDRAULIC ACTUATORS / MOTORS

HYDRAZINE FUEL

APU

HYDRAULIC PUMP

WATER BOILER (HEAT REMOVAL)

FIGURE 1
The horsepower demand on a hydraulic system (calculated at the pump) due to control surface activity is equal to the volume flow rate times the system pressure differential. The system pressure differential used here is 3000 psi. The volume flow rate is equal to the control surface deflection rate times the particular flow gradient of the actuator or hydraulic motor which corresponds to that control surface. Fluid horsepower demand is therefore calculated as follows:

\[ HP_f = Q \Delta P C_{HP} \]

where \( Q = K\delta \)

\( K = \) flow gradient (GPM / deg / sec)
\( \delta = \) surface deflection rate (deg / sec)
\( \Delta P = 3000 \) psi
\( C_{HP} = 0.0058333 \)

The body flap is an exception to this however, due to its unique control circuit configuration. The hydraulic flow rate is not proportional to the body flap deflection rate and an average flow rate is used (Reference B).

Horsepower demand on each hydraulic system is then determined by summing the individual demands from the appropriate control surfaces according to the loss management matrix (see Figure 2) from Reference B. As an example, the horsepower demand on hydraulic system three at any one time (with no failures) would be equal to the sum of the fluid horsepower demand of the left outboard elevon and right inboard elevon, plus one-third of the demand from the rudder, speedbrake, and body flap.
**LOSS MANAGEMENT MATRIX**

<table>
<thead>
<tr>
<th>FAILURES</th>
<th>ELEVONS</th>
<th>RUDDER</th>
<th>SPEED BRAKE</th>
<th>BODY FLAP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LEFT</td>
<td>RIGHT</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>OUTBOARD</td>
<td>INBOARD</td>
<td>LOGIC</td>
<td>POWER</td>
</tr>
<tr>
<td>NONE</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>NO. 1</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>NO. 2</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>1</td>
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<td>2</td>
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<td>1</td>
</tr>
<tr>
<td>1 &amp; 2</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>1 &amp; 3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>2 &amp; 3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

**FIGURE 2**
The energy requirement for each hydraulic system is calculated by integrating that system's horsepower demand over the entire trajectory. The trapezoidal rule is used and the integration time step is approximately one-tenth of a second.

In the analysis of hydraulic system failure effects, the priority rate limiting subroutine is included in the simulation. This routine will limit the control surface deflection rates based on the number of failed hydraulic systems and the available flow from the remaining system(s). The source for this logic is Reference A. The rate limits for each case are shown in Figure 3.

4.0 RESULTS

Typical preliminary power and energy results due to control surface activity are shown in Figure 4. The actuator flow gradients used were obtained from Reference B.

The SSFS models used in generating these results include ACS 15, RCS 14 and AERO 23 (June '74 aerodynamics). The Entry Guidance is the December '74 ADC Guidance with the baseline 40/30° α-profile trajectory, and entry control is the August 12, 1974 version of the RI System X Entry DAP. TAEM guidance is from the Nov. '74 RI FSSR, and control is from the Jan '75 RI FSSR. Autoland guidance and control is from the Nov '74 RI FSSR. The WIND 9 model (Reference E) was used to stimulate steady state winds and gusts/turbulence, and the ATM 6 model was used to simulate the 1962 Standard Atmosphere.
## Priority Rate Limiting Logic

Control Surface Rate Limits (DEG / SEC)

<table>
<thead>
<tr>
<th>ELEVONS</th>
<th>RUDDER (FRL)</th>
<th>BODY FLAP</th>
<th>SPEED BRAKE * (FRL)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NO FAILURES</strong></td>
<td>20.0</td>
<td>10.0</td>
<td>-3.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>+1.0</td>
</tr>
<tr>
<td><strong>1 FAILURE</strong></td>
<td>20.0</td>
<td>10.0</td>
<td>-3.0 ( (Q_2-K_{QE2}\delta_{EL}+\delta_{ER}-K_{QR2}\delta_{RUD}-DBFL) \cos (35^\circ) )</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>( 0 \leq \delta_{SB} \leq 5.0 )</td>
</tr>
<tr>
<td><strong>2 FAILURES</strong></td>
<td>13.0</td>
<td>19.65-1.408(</td>
<td>\delta_{ELEVATOR}</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( \delta_{RUD} \leq 4.45 )</td>
<td>( 0 \leq \delta_{SB} &lt; 2.50 )</td>
</tr>
</tbody>
</table>

* SEE SPEED BRAKE "SOFT STOP" LOGIC ON FOLLOWING PAGE

**FIGURE 3a**
SPEED BRAKE "SOFT STOP" LOGIC (FOR $\delta_{SB} \leq 6^\circ$, AND $\dot{\delta}_{SB} \leq 0$)

<table>
<thead>
<tr>
<th></th>
<th>SPEED BRAKE RATE LIMIT (FRL; DEG / SEC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO FAILURES</td>
<td>-1.0</td>
</tr>
<tr>
<td>1 FAILURE</td>
<td>$-(Q_2 - K_{QE2}</td>
</tr>
<tr>
<td></td>
<td>$-1.0 \leq \delta_{SB} \leq 0$</td>
</tr>
<tr>
<td>2 FAILURE</td>
<td>$-(Q_1 - K_{QE1}</td>
</tr>
<tr>
<td></td>
<td>$-1.0 \leq \delta_{SB} \leq 0$</td>
</tr>
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</table>

**DEFINITIONS**

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<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>$Q_2$</td>
<td>MAX AVAILABLE FLOW/SYSTEM</td>
<td>39.01</td>
</tr>
<tr>
<td>$K_{QE2}$</td>
<td>ELEVON FLOW GRADIENT</td>
<td>1.362</td>
</tr>
<tr>
<td>$K_{QR2}$</td>
<td>RUDDER FLOW GRADIENT</td>
<td>0.650</td>
</tr>
<tr>
<td>$Q_1$</td>
<td>MAX AVAILABLE FLOW/SYSTEM</td>
<td>18.56</td>
</tr>
<tr>
<td>$K_{QE1}$</td>
<td>ELEVON FLOW GRADIENT</td>
<td>0.681</td>
</tr>
<tr>
<td>$K_{QR1}$</td>
<td>RUDDER FLOW GRADIENT</td>
<td>0.650</td>
</tr>
<tr>
<td>$\delta_{ELE}$</td>
<td>$1/2 (\delta_E + \delta_R)$</td>
<td></td>
</tr>
<tr>
<td>DBFL</td>
<td>BODY FLAP FLOW RATE /SPEED BRAKE FLOW GRADIENT</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$= 0.0$ IF BODY FLAP FIXED</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$= 2.503$ IF BODY FLAP IN MOTION</td>
<td></td>
</tr>
</tbody>
</table>

**FIGURE 3b**
## TYPICAL POWER AND ENERGY RESULTS

MISSION 3B, 40/30° α ADC ENTRY GUIDANCE, AFT C.G.,
STEADY STATE WINDS + GUSTS/TURBULENCE, JUNE '74 AERODYNAMICS

<table>
<thead>
<tr>
<th>CASE</th>
<th>HYDRAULIC SYSTEM 1</th>
<th>HYDRAULIC SYSTEM 2</th>
<th>HYDRAULIC SYSTEM 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MAXIMUM SURFACE HP_f</td>
<td>TOTAL SURFACE ENERGY (HP-IIRS)</td>
<td>MAXIMUM SURFACE HP_f</td>
</tr>
<tr>
<td>NO FAILURES</td>
<td>55.0</td>
<td>2.7</td>
<td>76.1</td>
</tr>
<tr>
<td>1 FAILURE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>#1 FAILED</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>#2 FAILED</td>
<td>96.6</td>
<td>6.3</td>
<td>96.6</td>
</tr>
<tr>
<td>#3 FAILED</td>
<td>98.8</td>
<td>6.3</td>
<td>96.6</td>
</tr>
<tr>
<td>2 FAILURES</td>
<td>119.2</td>
<td>12.7</td>
<td></td>
</tr>
</tbody>
</table>

**FIGURE 4**
Figures 5 through 33 show typical output plots from a 3B entry-to-touchdown trajectory for a two hydraulic systems failed case. Data are plotted at two second intervals throughout the trajectory and therefore some points are unavoidably missed. The rate limiting in this case had an effect on the vehicle dynamics resulting in sluggish touchdown conditions as well as extremely high peak load factor of \(-2.6 \text{ g's}\). The touchdown position was 280 feet beyond the runway threshold and 176 feet wide of the runway centerline with a sink rate of 9.7 ft/sec. This compares with 3200 feet beyond the threshold, one foot from the centerline and a 4 ft/sec sink rate for the now failure case.

5.0 CONCLUSIONS

The developments presented here represent the basic foundation in the analysis of the power and energy demands on the APU/Hydraulic/Actuator Subsystem. However, there are several other factors which must be included in the total picture. It should therefore be emphasized that the power and energy data presented here is only that portion of the total which is due to control surface activity.

The additional factors which go to make up the total power and energy demand include power spool/hydraulic motor leakage flow, control flow, pump efficiency curves, and S.F.C. curves. These factors will be dealt with in future studies, and a more detailed analysis will follow.

6.0 REFERENCES

A) Aerodynamic Control Surface Limiting - FSSP Charges, Rockwell International Internal Letter No. SSA/FSA/-74-440, 17

December 1974
B) Update of Hydraulic Subsystem Power Capability Analysis, Rockwell International Internal Letter No. 388-200-75-001, 2 January 1975

C) Space Shuttle Orbiter Approach and Landing Test, Level C, FSSR Document No. SD74-SH '271, 30 September 1974


E) SSFS Model Documentation Series, WIND 9, Lockheed Electronics Company, Inc., LEC-4939, November 1974

F) Entry to Touchdown Nominal 3B APU-Hydraulics Trajectory, Informal Presentation to Aaron Cohen by R. L. Barton (EX43), 21 February 1975
MISSION 3B WITH TWO HYDRAULIC SYSTEM FAILURES
WIND 9 TURBULENCE

FIGURE 5

NAME WADE, D. E.
DATE 3/6/75
PROJ. 3304 JDIV. CODE
EX 43 TAPE NO. 6217
BLDG BETA 80X BETA
EXT 488-5660 X 227
FCRM 00 01 OTHER
WBS 1.2

FIGURE 5

ALTITUDE VS TIME

0 10,000 20,000 30,000 40,000 (X10,000)
0 40,000 80,000 120,000 160,000 200,000 240,000 280,000 (X10^1)

TAKE-OFF
AUTOLAND

REPRODUCIBILITY OF ORIGINAL PAGE IS POOR
FIGURE 6

MISSION 3B WITH TWO HYDRAULIC SYSTEM FAILURES
WIND 9 TURBULENCE

TIME (SECONDS)

MACH NUMBER

0.000  40.000  80.000  120.000  160.000  200.000  240.000  280.000

0.000  40.000  80.000  120.000  160.000  200.000  240.000  280.000

TAEN

AUTOLAND
FIGURE 7

MISSION 3B WITH TWO HYDRAULIC SYSTEM FAILURES
WIND 9 TURBULENCE
FIGURE 8

MISSION 3B WITH TWO HYDRAULIC SYSTEM FAILURES

WIND 9 TURBULENCE

触死 - GEODETIC

车辆纬度 vs 长度

t = 0
h = 400,000 ft

着陆
FIGURE 9

MISSION 3B WITH TWO HYDRAULIC SYSTEM FAILURES
WIND 9 TURBULENCE

DYNAMIC PRESSURE (PSI)

0.000 40.000 80.000 120.000 160.000 200.000 240.000 280.000
TIME (SECONDS) (X10^1)

FIGURE DYNAMIC PRESSURE

TAEH

AUTOLAND
FIGURE 10

MISSION 38 WITH TWO HYDRAULIC SYSTEM FAILURES
WIND 9 TURBULENCE

FIGURE ATTACH AND PITCH ANGLES
FIGURE 11

MISSION 3B WITH TWO HYDRAULIC SYSTEM FAILURES
WIND 9 TURBULENCE

FIGURE SIDESLIP AND YAW ANGLES
FIGURE 12

MISSION 3R WITH TWO HYDRAULIC SYSTEM FAILURES
WIND 9 TURBULENCE

FIGURE BANK ANGLE AND COMMAND BANK ANGLE
FIGURE 13

MISSION 3B WITH TWO HYDRAULIC SYSTEM FAILURES
WIND 9 TURBULENCE

FIGURE RELATIVE FLIGHT PATH ANGLE
FIGURE 14

MISSION 3B WITH TWO HYDRAULIC SYSTEM FAILURES
WIND 9 TURBULENCE

FIGURE LIFT TO DRAG RATIO

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR
FIGURE 15

MISSION 3D WITH TWO HYDRAULIC SYSTEM FAILURES
WIND 9 TURBULENCE

FIGURE 14

C.G. LOAD

TIME (SECONDS)

0.000  40.000  80.000  120.000  160.000  200.000  240.000

0.000  800.000  120.000  160.000  200.000  240.000

0.000  1.000  2.000  3.000  4.000

TAEM  AUTOLAND

STRUCTURAL
DESIGN LIMIT

BFS

FIGURE  C.G. LOAD
FIGURE 16

MISSION 3D WITH TWO HYDRAULIC SYSTEM FAILURES
WIND 9 TURBULENCE

TAEM
AUTOLAND

ELEVATOR AND AILERON POSITIONS
FIGURE 17

MISSION 3B WITH TWO HYDRAULIC SYSTEM FAILURES
WIND 9 TURBULENCE
FIGURE 18

MISSION 3B WITH TWO HYDRAULIC SYSTEM FAILURES
WIND 9 TURBULENCE

FIGURE LEFT ELEVON POSITION
FIGURE 19

MISSION 3D WITH TWO HYDRAULIC SYSTEM FAILURES
WIND 9 TURBULENCE

FIGURE RUDDER POSITION

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR
FIGURE 20

MISSION 3B WITH TWO HYDRAULIC SYSTEM FAILURES
WIND 9 TURBULENCE

FIGURE SPEED BRAKE POSITION
FIGURE 21
MISSION 3B WITH TWO HYDRAULIC SYSTEM FAILURES
WIND 9 TURBULENCE

FIGURE BODY FLAP POSITION

TIME (SECONDS)
MISSION 3B WITH TWO HYDRAULIC SYSTEM FAILURES
WIND 9 TURBULENCE

FIGURE 22

RIGHT INBOARD + OUTBOARD ELEVON HINGE MOMENTS

SIFS

TIME (SECONDS) (X10^1)

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR
FIGURE 23
MISSION 3B WITH TWO HYDRAULIC SYSTEM FAILURES
WIND 9 TURBULENCE

FIGURE LEFT INBOARD + OUTBOARD ELEVON HINGE MOMENTS

TIME (SECONDS)
MISSION 3B WITH TWO HYDRAULIC SYSTEM FAILURES
WIND 9 TURBULENCE

FIGURE 24

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR.
FIGURE 25

MISSION 3B WITH TWO HYDRAULIC SYSTEM FAILURES
WIND 9 TURBULENCE

FIGURE SPEED BRAKE HINGE MOMENT
FIGURE 26
MISSION 38 WITH THE HYDRAULIC SYSTEM FAILURES
WIND 9 TURBULENCE

FIGURE 27
BOOT FLAP HINGE MOMENT

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR
FIGURE 27

MISSION 38 WITH TWO HYDRAULIC SYSTEM FAILURES
WIND 9 TURBULENCE
FIGURE 28

MISSION 3B WITH TWO HYDRAULIC SYSTEM FAILURES
WIND 9 TURBULENCE

FIGURE LEFT ELEVON RATE
FIGURE 29

MISSION 3R WITH TWO HYDRAULIC SYSTEM FAILURES
WIND 9 TURBULENCE

---

FIGURE RUDDER RATE

TIME (SECONDS)

SSFS

(WIND 9 TURBULENCE)
FIGURE 30

MISSION 3A WITH TWO HYDRAULIC SYSTEM FAILURES
WIND 9 TURBULENCE

FIGURE 30

SPEED BRAKE RATE

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR
FIGURE 31

MISSION 3D WITH TWO HYDRAULIC SYSTEM FAILURES
WIND 9 TURBULENCE

TAEM

AUTOLAND

SSFS

TIME (SECONDS)

BODY FLAP RATE (DEG/SEC)

FIGURE 31

BODY FLAP RATE

TIME (SECONDS)

(X10^1)
FIGURE 32

MISSION 3B WITH THE HYDRAULIC SYSTEM FAILURES
WIND 9 TURBULENCE

---

FIGURE TOTAL FLUID HP

SSFS 030975 8 TIME

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR
FIGURE 33

MISSION 3B WITH TOP HYDRAULIC SYSTEM FAILURES
WIND 9 TURBULENCE

TOTAL FLUID ENERGY (HP-SEC)

0.000 10,000 20,000 30,000 40,000

SSFS 03/07s 6 TIME 0.000 40,000 80,000 120,000 160,000 200,000 240,000 280,000

(10^4)

FIGURE TOTAL FLUID ENERGY
# Appendix A

## Reproducibility of the Original Page Is Poor

### Appendix A

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**SOURCE USED:** CODE(1) 000472; DATA(1) 00024; CLARK COMM(2) 000000

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**SUBROUTINE PRATE**

- **REAL** KWE, KKX1, KW2, KWEZ, KQRZ

**COMMON**: ASC/ASC(1), LCC/LCC/ENV(1), LCC/LCC/LEC(1), PRAEC(9)

**EQUIVALENCE**: ENV(327) TIME

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2. EQUIVALENCE(ASC(12) DFL)
3. EQUIVALENCE(ASC(15) DFL)
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6. EQUIVALENCE(ASC(14) DFL)
7. EQUIVALENCE(ASC(16) DFL)
8. EQUIVALENCE(ASC(17) DFL)
9. EQUIVALENCE(ASC(18) DFL)
10. EQUIVALENCE(ASC(19) DFL)

**PRAEC**

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9. 9 (ASC(9))
10. 10 (ASC(10))
11. 11 (ASC(11))
12. 12 (ASC(12))
13. 13 (ASC(13))
14. 14 (ASC(14))
15. 15 (ASC(15))
16. 16 (ASC(16))
17. 17 (ASC(17))
18. 18 (ASC(18))
19. 19 (ASC(19))
20. 20 (ASC(20))
**PRIOITY RATE LIMITING LOGIC**

This routine determines control surface deflection rate limits as a function of the number of failed hydraulic systems.

**SOURCE:** 12 DEC 74 RK 11 BACKUP DYNAMIC CONTROL SURFAC LIMITING

```
C **PRIOITY RATE LIMITING LOGIC**
C
C **PRIOITY RATE LIMITING LOGIC**
C
C **PRIOITY RATE LIMITING LOGIC**
C
C **PRIOITY RATE LIMITING LOGIC**
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GU TO 00

C  CONTINUE

1 HYDRAULIC SYSTEM OPERATING

DURMAX=13.000UTR
DULLY=50.000(UDLELY+UDRELY)
DURMAX=17.050UTR=1.408*ABS(UDLELY)
DURMAX=DURMAX*COS(35.000UTR)
IF(DURMAX*10.450*UTR) DURMAX=4.450*UTR
DURFUP=#1*UTR=KWE1*ABS(UDLELY)=KWE1*ABS(UDRELY)=KWR1*ABS(DURUD)=
1000*UTR
DURFUP=DURFUP*COS(35.000UTR)
IF(DURFUP*10.250*UTR) DURFUP=2.500*UTR
IF(DURFUP=10.250*UTR) DURFUP=00
IF(DURFCL=00.000*UTR) GU TO 00
DURFCL=(101.0UTR=KWE1*ABS(UDLELY)=KWE1*ABS(UDRELY)=KWR1*ABS(DURUD)=
1000*UTR
DURFCL=DURFCL*COS(35.000UTR)
IF(DURFCL<=4.450*UTR) DURFCL=4.450*UTR
IF(DURFCL<=4.450*UTR) DURFCL=00
GO TO 70
60 CONTINUE

C  SPEED BRAKE SOFT STOP

DURFCL=(101.0UTR=KWE1*ABS(UDLELY)=KWE1*ABS(UDRELY)=KWR1*ABS(DURUD)=
1000*UTR)
DURFCL=DURFCL*COS(35.000UTR)
IF(DURFCL<=1.000*UTR) DURFCL=-1.000*UTR
IF(DURFCL<=1.000*UTR) DURFCL=00
70 CONTINUE
DURFUP=1.500*UTR
DURFUP=1.500*UTR
60 CONTINUE
RETURN
END

Compilation: No diagnostics.

Reproducibility of the original page is poor.
# APPENDIX B

## SUBROUTINE FHP

<table>
<thead>
<tr>
<th>COMMON/ACSL/ACSL1</th>
<th>COMMON/ENVVAL/ENV1</th>
<th>COMMON/LECCUM/LECCUM1</th>
<th>COMMON/FMPC/FMPC1</th>
</tr>
</thead>
</table>

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DATA C /104/
REAL LEVLNM
EQUIVALENCE(ENV1),TVLM)
EQUIVALENCE(ACSL3),LEVLNM)
EQUIVALENCE(ACSL3),LEVLNM)
EQUIVALENCE(ACSL3),LEVLNM)
EQUIVALENCE(ACSL3),LEVLNM)
EQUIVALENCE(ACSL3),LEVLNM)

1  (FMPC(21),FPFL1)
2  (FMPC(10),FPFL1)
3  (FMPC(21),FPFL1)
4  (FMPC(21),FPFL1)
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100 (FMPC(21),FPPL1)
```

## REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR.
COMPUTE FLUID MONEY POWER FOR EACH SURF.

FPELU = RED*ELVNH1*K1D*3CC*074*605633
FPELU = RED*ELVNH1*K1D*3CC*074*605633
FPELU = RED*ELVNH1*K1D*3CC*074*605633
FPELU = RED*ELVNH1*K1D*3CC*074*605633
FPRU = RED*PRUNAT1*K1D*3CC*074*605633/COS(120*647)
FPSU = RED*PSKRA1*K1D*3CC*074*605633/COS(120*647)
FPDF = 0.0
IF (FPRATE*GT+1.0) FPBF = 1.0*500.0*3.000.0*004.0

HYDRAULIC SYSTEM POWER AND ENERGY ANALYSIS

FAILS = 0.
FAILS = 0. ZERO OR ONE HYD SYS FAIL

IF (FAILS = 0) 17D+10=3.17U

NORMAL OR SINGLE SYSTEM FAILURE OPERATION

FPS1 = FPERU+FPKRU/3+FPSD/3+FPDF/30
FPS2 = FPELI+FPKRU/3+FPSD/3+FPDF/30
FPS3 = FPERU+FPKRU/3+FPSD/3+FPDF/30
FPS4 = FPELI+FPKRU/3+FPSD/3+FPDF/30
FPS5 = FPERU+FPKRU/3+FPSD/3+FPDF/30
FPS6 = FPELI+FPKRU/3+FPSD/3+FPDF/30
FPS7 = FPERU+FPKRU/3+FPSD/3+FPDF/30
FPS8 = FPELI+FPKRU/3+FPSD/3+FPDF/30
FPS9 = FPERU+FPKRU/3+FPSD/3+FPDF/30
FPS10 = FPELI+FPKRU/3+FPSD/3+FPDF/30

SAVE MAX VALUES

IF (FPELI = LT+FPELMA) GO TO 10
FPELMA = FPELI

IF (FPRU = LT+FPRMA) GO TO 20
FPKMA = FPRU

IF (FPSU = LT+FPSMA) GO TO 30
FPKLMA = FPSU

IF (FPDF = LT+FPDFA) GO TO 40
FPDFA = FPDF

IF (FPBF = LT+FPBFH) GO TO 50
FPBFH = FPBF

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR.
170 CONTINUE
171 GO TO 330

TO SYSMMS FAILED OPERATEON

170 IF (FT+L*FPT+H) GO TO 171
171 FPTA=FPT
172 IC=TVEH*TVEM
173 FET=5*(FPT+FPL)*UTC+FET
174 FL=FPT
175 TVEM=TVEN
176 CONTINUE
177 RETURN
178 END

NO DIAGNOSTICS.