

MEMORANDUM

Lyndon B. Johnson Space Center



REFER TO: CB	DATE: February 4, 1981	INITIATOR: CB/DCLeestma:ms:2/4/81:3721	ENCL: 1
TO: Distribution		CC	
FROM: CB/D. C. Leestma		SIGNATURE: <i>David C. Leestma</i> David C. Leestma	
SUBJ: DPS Encyclopedia			

This is a rough draft of an SM OPS 2 display for the DPS encyclopedia. It has been prepared as a possible reference document, review document, and complete display data book. System descriptions and sensor locations are included to provide an overall description of the system the display is designed to monitor.

Request you review this draft and provide comments on format and scope of content (i.e., is it useable?, does it provide enough detail?, too much detail?, etc.). Please return to me no later than Monday, February 8.

Distribution:

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- CB/D. H. Peterson

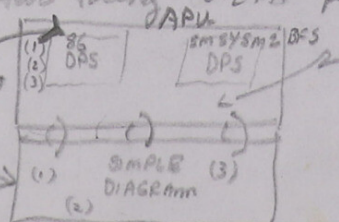
Dave - Good work Roy

P.S.

I thought the write up was pretty good & much more crew oriented than the workbooks / current DPS Ency. I think you need to be very careful to keep the detail down, and I have indicated some suggested cuts. Generally, extraneous numbers detract and should be left for SFOM type pubs in my opinion.

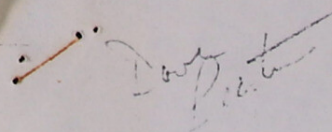
I would like to see a summary page(s) of each system which could be put on two facing 8 1/2 x 11 pages for quick reference when studying / planning systems.

DPS Displays greatly reduced in prime size. Only show DPS products. numbers give



- (1) EGT 900°-1160° F (FB)
- (2)
- (3)
- (4) OIL T - RTN from H₂O Boiler 250-280° F (FB)
- (5) GG Bed T: 190 < T < 250° Normal Start
T > 250° O'RICE start

These would make a really handy quick reference and need not be overly complicated since they would only summarize your more detailed writeup.



APU/HYD

I GENERAL

The APU/HYD display is an SM display (DISP 86) available only in OPS 2. It provides data on the Auxiliary Power Unit (APU) and Hydraulic (HYD) subsystem.

II BACKGROUND

The APU/HYD system consists of three independent subsystems and their interfaces. Each subsystem consists of three identical and independent units. The APU subsystem serves only one purpose: that is to provide mechanical shaft power to the hydraulic main pump attached to the APU gear box. Liquid hydrazine provides the chemical energy to drive the APU turbine. The APU turbine provides rotational shaft power to the gear box which, through gear reduction, drives the APU fuel pump, lube oil pump and the hydraulic main pump.

The hydraulic subsystem consists of three independent hydraulic power generation, control and distribution systems. Each of the systems consists of the components necessary to generate, distribute, control, monitor and use hydraulic power and to thermally condition the hydraulic fluid. The system provides hydraulic fluid flow at pressures required to operate the actuators controlling the Orbiter elevons, rudder/speedbrake, body flap, landing gear, wheel brakes, nose wheel steering, SSME thrust vector control, SSME propulsion control valves, and ET umbilical retractor. Circulation of the hydraulic fluid for thermal conditioning when the APU's are not operating is accomplished by electrically driven circulation pumps.

The water spray boiler (W/B) subsystem consists of three independent systems which provide automatic thermal conditioning through water evaporation for removing heat from the APU lube oil and hydraulic fluid.

The three hydraulic subsystems are connected to aerosurface actuator switching valves. They provide the capability of sustaining a single system failure without affecting full operational performance. With two system failures, the third system will provide hydraulic power sufficient to operate all actuators at a reduced rate.

III DISPLAY INFORMATION

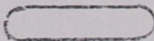
The APU/HYD display (DISP 86) allows the crew to monitor the APU and HYD subsystems while on-orbit. The APU and HYD parameters are arranged in two sections, left and right, respectively. The APU side of the display contains all the parameters necessary to monitor the APU subsystem during on-orbit operations. The HYD side of the display allows assessment of the HYD subsystem status, APU/HYD water spray boiler (W/B) status, and HYD switching valve (SW VLV) status.

Certain selected APU/HYD parameters are also available on the SM SYS SUMMARY 2 display in OPS 2. Other pertinent APU/HYD information on-orbit also appears on the APU/ENVIRON THERM display (DISP 88), HYD THERM display (DISP 87), and the BFS THERMAL display (OPS 0). During ascent and entry, critical APU/HYD parameters are displayed on the BFS SM SYS SUMMARY 2 display.

IV DISPLAY INTERPRETATION

The parameters have been numbered on the display (FIG 1) in such a way that the sensor on the simplified schematics (FIGs 2,3), the set of limits

and messages on TABLES 1-1 ¹⁻² and the explanation below all bear the same number for easy reference. An "M" may appear in any status column indicating that the data is missing. Values below those listed in the L column will cause an "L" to appear in the status column and those greater than listed in the H column will produce an H. If the parameters are *software* limit sensed, the value which triggers the warning or alert can be found in the ↓ column for lower limit and the ↑ column for upper limit.

Class 3 alert messages are listed for FDA'd parameters. Messages *enclosed in*  indicate a hardware-produced warning annunciated on the C&W matrix on F7. Software Class 2 warnings will illuminate the *BACKUP C/W* ALARM light on the F7 ^{CFW} matrix, turn on the MASTER ALARM lights and tone, and flash the listed fault message on the CRT. *Software Class 3 alerts* will turn on the *SM ALERT* light and tone, and flash the listed fault message on the CRT.

XXXX/XXX/086			APU/HYD			XX X DDD/HH:MM:SS DDD/HH:MM:SS						
APU			1	2	3	HYD						
B/U			EGT	XXXXS	XXXXS	XXXXS	B/U	P	XXXXS	XXXXS	XXXXS	
EGT			XXXXS	XXXXS	XXXXS	RSVR	T	XXXXS	XXXXS	XXXXS		
SPEED			%	XXXXS	XXXXS	XXXXS	QTY	XXXXS	XXXXS	XXXXS		
FUEL			QTY	XXXXS	XXXXS	XXXXS	ACCUM	P	XXXXS	XXXXS	XXXXS	
TK			P	XXXXS	XXXXS	XXXXS	W/B					
OUT			P	XXXXS	XXXXS	XXXXS	H2O	QTY	XXXXS	XXXXS	XXXXS	
VLV			A	XXS	XXS	XXS	N2	P	XXXXS	XXXXS	XXXXS	
B				XXS	XXS	XXS	REG	T	XXXXS	XXXXS	XXXXS	
OIL			T	XXXXS	XXXXS	XXXXS	REG	P	XXXXS	XXXXS	XXXXS	
OUT			T	XXXXS	XXXXS	XXXXS	BYP	VLV	XXXXS	XXXXS	XXXXS	
OUT			P	XXXXS	XXXXS	XXXXS	VENT	T	±XXXXS	±XXXXS	±XXXXS	
GBX			P	XXXXS	XXXXS	XXXXS	TANK	T	±XXXXS	±XXXXS	±XXXXS	
N2			P	XXXXS	XXXXS	XXXXS	BLR	T	±XXXXS	±XXXXS	±XXXXS	
BRG			T	XXXXS	XXXXS	XXXXS						
GG			BED	T	XXXXS	XXXXS	XXXXS					
PUMP/VLV			COOL				SW VLV	PR	S1	S2		
PMP			T	XXXXS	XXXXS	XXXXS	ELEV	L	OB	3XS	1XS	2XS
VLV			T	XXXXS	XXXXS	XXXXS			1B	2XS	1XS	3XS
							R	1B	3XS	1XS	2XS	
								OB	2XS	1XS	3XS	
							RUD/SPDBK	1XS	2XS	3XS		
										(XX)		

Show copy of Sm SYS Summ 2 Also
 Since BFS Sm SYS Summ 2 is Primary REF
 Define OPS 1, 3, 6

Why is this labeled "Cool"? Looks like the Temps relate strictly to the fuel pump + its valves
 and not the coolant system!

FIGURE 1
APU/HYD DISPLAY

? What is PMP LK P on Sm SYS SUMM 2

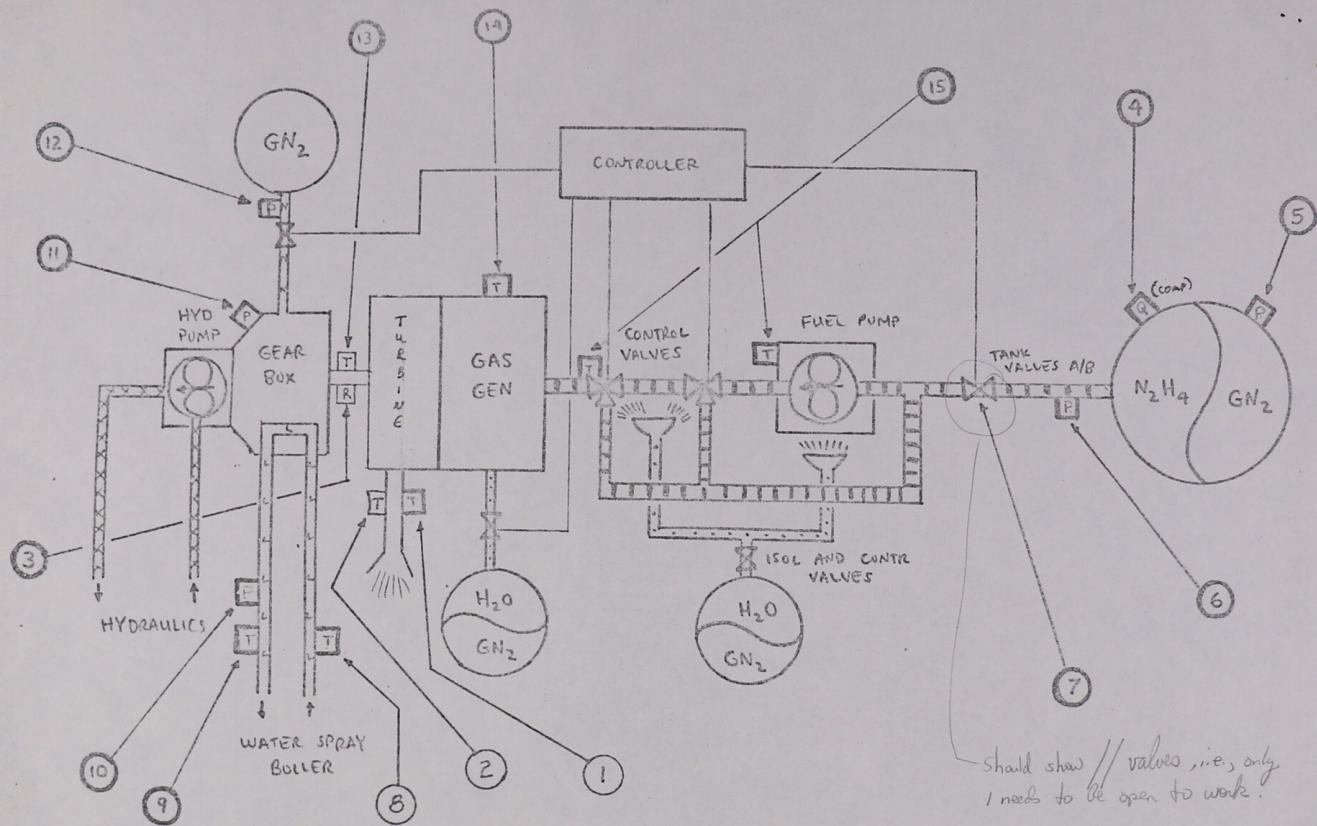


FIGURE 2

APU SCHEMATIC

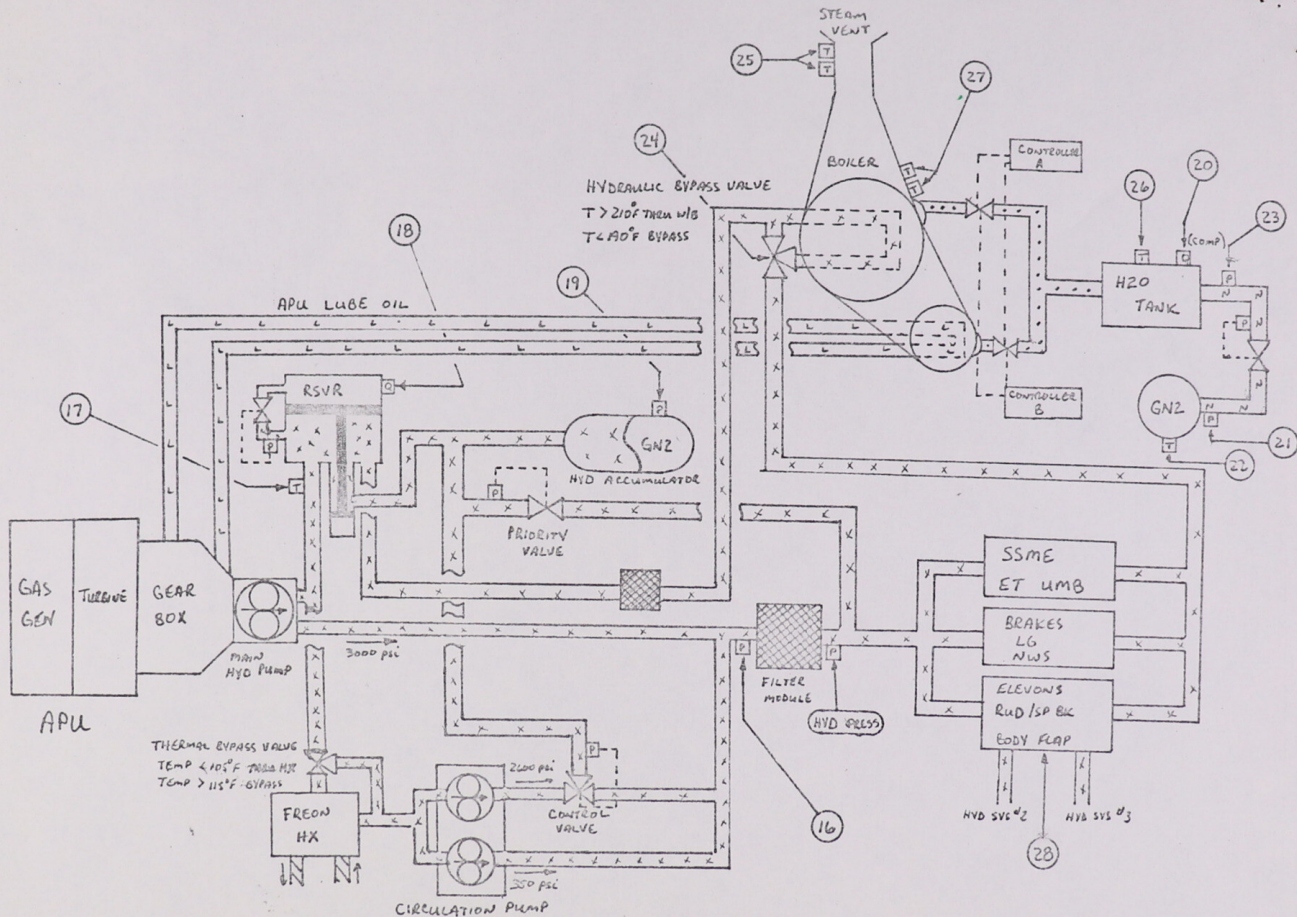


FIGURE 3

HYDRAULIC and WATER BOILER SYSTEM SCHEMATIC

T H	PARAMETER	U N I T S	DISPLAYED RANGE		SOFTWARE LIMITS		HARDWARE LIMITS		N O T E S	ALARM CLASS	C/W LIGHTS / FAULT MESSAGE	SENSOR MML ID (SYSTEM #)
			L	H	↓	↑	LOWER	UPPER				
1	APU	B/U EGT	DEG F	0	1500	—	1260	—	—	2	(BACKUP C/W ALARM) SB6 APU TEMP ↑	V46T0140A
2		EGT	DEG F	0	1500	—	—	—	1260	(a) 2	(APU TEMP)	V46T0142A
3		SPEED %	PERCENT	0	167	—	—	80	129	(c) 2	(APU UNDER SPEED) (APU OVER SPEED)	V46R0135A
4		FUEL QTY	PERCENT	0	100	50	—	—	—	(a) 3	SB6 APU/HYD APU	V72Q6001V
5		TK P	PSIA	0	500	110	350	—	—	(a) 3	SB6 APU/HYD APU	V46P0100A
6		OUT P	PSIA	0	500	—	—	—	—	—	—	V46P0105A
7		VLV A,B	TEXT	"CL"	"OP"	"OP"	—	—	—	(d) 3	SB6 APU/HYD APU	VLVA-V46X015E VLVB-V46X015E
						"CL"	—	—	—	(e) 3		
8		OIL T	DEG F	0	500	—	290	—	290	(a) 2	(APU TEMP) (BACKUP C/W ALARM) SB6 APU TEMP ↑	V46T0150A
9		OUT T	DEG F	0	400	40	330	—	—	3	SB6 APU/HYD APU	V46T0154A
10		OUT P	PSIA	0	200	25 0	150 150	—	—	(b) 3 (c) 3	SB6 APU/HYD APU	V46T0153A
11		GBX P	PSIA	0	30	3	—	—	—	3	SB6 APU/HYD APU	V46P0151A
12		N2 P	PSIA	0	300	—	—	—	—	—	—	V46P0152A
13		BRG T	DEG F	0	500	—	400	—	—	3	SB6 APU/HYD APU	V46T0161A
14		GG BED T	DEG F	0	500	258	—	—	—	3	SB6 APU/HYD APU	V46T0122A
15	Pump/VLV	PMP T	DEG F	0	500	—	200	—	—	3	SB6 APU/HYD APU	V46T0192A
15	COOL	VLV T	DEG F	0	450	—	209	—	—	3	SB6 APU/HYD APU	V46T9158A

NOTES: (a) Metered on cockpit panel FB
 (b) APU CONTROL - START/RUN or START DRINK/RUN
 (c) APU CONTROL - OFF

(d) APU SPEED < 80%
 (e) APU SPEED > 80%

TABLE 1-1 APU PARAMETER LIMITS/DISPLAYS

C T	PARAMETER			U NITS	DISPLAYED RANGE		SOFTWARE LIMITS		HARDWARE LIMITS		N OTES	AL ARM C L A S S	C/W LIGHTS / FAULT MESSAGE	SEN SOR M M L I D (SYSTEM #)
					L	H	↓	↑	LOWE R	UPPE R				
16	HYD	B/U	P	PSIA	0	4000	2760	-	-	-		2	C/W LIGHTS / FAULT MESSAGE	SEN SOR M M L I D (SYSTEM #)
17		RSVR	T	DEGF	-75	300	10	230	-	-		3	BACKUP C/W ALARM S86 HYD PRESS ↓	VSBP0115A
18		QTY	PERCENT		0	100	20	95	-	-	(a)	3	S86 APU/HYD HYD	VSBT0101A
19		Accum	P	PSIA	0	4000	1930	-	-	-		3	S86 APU/HYD HYD	VSBP9116A
20	W/B	H2O	QTY	PERCENT	0	100	78	-	-	-	(a)	3	S86 APU/HYD W/B	V72Q6040V
21		N2	P	PSIA	0	3500	2300	-	-	-		3	S86 APU/HYD W/B	VSBP0147A
22			T	DEGF	32	221	-	-	-	-		-	---	VSBT0105A
23		REG	P	PSIA	0	75	22	32	-	-	(b) (c)	3	S86 APU/HYD W/B	VSBP0104A
24		BYP	VLV	TEXT	"BYP"	"W/B"	-	-	-	-		-	---	VSBX0181E
25		VENT	T	DEGF	122	185					(d)			CNTLR A-VSBT0165A CNTLR B-VSBT0164A
26		TANK	T	DEGF	32	221	40	-	-	-	(e) (f)	3	S86 APU/HYD W/B	VSBT0161A
27		BLR	T	DEGF	32	212	45	120	-	-	(e) (f)	3	S86 APU/HYD W/B	CNTLR A-VSBT0162A CNTLR B-VSBT0163A
28		SW	VLV	TEXT	"*" or blank		-	-	-	-		-		

NOTES: (a) Metered on cockpit panel / B

(d) Parameter blank when BOILER CNTLR - OFF

(b) BOILER CNTLR PWR/HTR - A and BLR N2 SUPPLY - ON

(e) BOILER CNTLR PWR/HTR - A

(c) BOILER CNTLR PWR/HTR - B or OFF, or BLR N2 SUPPLY - OFF

(f) BOILER CNTLR PWR/HTR - B

TABLE 1-2 HYD/W/B PARAMETER LIMITS / DISPLAYS

① B/U EGT - This is the backup APU exhaust gas temperature to the primary reading (②) that is gauged on cockpit panel F8. The hot gasses from the turbine are dumped overboard via the exhaust duct at a maximum flow rate of .25 lb/sec of the byproducts of hydrazine decomposition. The normal operating limits for APU EGT are from 900-1160° F. Backup EGT is also displayed on the SM SYS SUMM 2 display. High EGT may indicate a fire in the exhaust duct, gas generator injection failure, or turbine failure.

Extraneous Info

② EGT - This measurement is from the primary APU exhaust gas temperature sensor. It drives the EGT meter on cockpit panel F8 and is hardwired to the "APU TEMP" caution and warning light. Operating range and possible out of limit failures are the same as for B/U EGT ①. APU EGT is also displayed on the SM SYS SUMM 2 display.

③ SPEED % - This is the measurement of APU turbine speed. The turbine assembly consists of a two-stage, single wheel turbine. High pressure, high temperature gas from the gas generator is routed to the first stage nozzles, then further expanded and routed at supersonic velocities back through the second stage nozzles and into the exhaust duct.

Each APU has its own controller to provide speed control, logic for start up and shut down, signal conditioning and malfunction detection. Design speed of the turbine (100 percent) is 72,000 rpm. However, the normal operating speed (103 percent) is ~~74,160 rpm~~ and the high speed (113 percent) is ~~81,360 rpm~~. Due to the inertia of the turbine, speed is controlled to ±8 percent of the speed selected (HIGH or NORM) on the APU SPEED SELECT switch (panel R2).

The APU controller has two-speed control logic circuits to maintain the selected turbine speed. A 103 percent/115 percent two-level comparator and signal conditioner receive speed signals from one magnetic pickup unit (MPU)

on the turbine shaft and a 113 percent comparator and signal conditioner receives speed signals from another MPU.

With the APU SPEED SELECT switch in the NORM position, the 103/115 percent comparator logic will regulate the turbine at 103 percent of design speed by modulating the primary fuel control valve to provide the proper fuel flow to the gas generator.

With the APU SPEED SELECT switch in the HIGH position, the 113 percent comparator logic will regulate the turbine at 113 percent of design speed by modulating the secondary fuel control valve to provide the proper fuel flow to the gas generator.

If 103 percent speed was selected and its logic fails to modulate the primary fuel control valve, the 113 percent comparator will automatically take over. If the 113 percent speed was selected and its logic fails to modulate the secondary fuel control valve, the backup 115 percent logic in the two-level 103 percent/115 percent comparator will automatically take over and modulate the primary valve to regulate the turbine at 115 percent of design speed.

An automatic overspeed (>129 percent) and underspeed (< 80 percent) shutdown feature is built into APU controller logic. The circuit is capable of shutting down the APU only if the APU AUTO SHUTDOWN switch (panel R2) is set to ENABLE. The INHIBIT position bypasses the circuit. If a underspeed or overspeed occurs, an APU UNDERSPEED or APU OVERSPEED light will illuminate on the C&W matrix or panel F7. APU SPEED is also displayed on the SM SYS SUMM 2 display. There is no backup C&W alarm for APU speed. Turbine speed out-of-limits may indicate MPU transducer failure, controller failure, pulse valve failure, or a gearbox failure.

④. FUEL QUANTITY - APU fuel tank quantity is computed by the GPC using inputs from the temperature and pressure sensors mounted on the tank and feedlines. PVT computations use pressure from the nitrogen side of the tank and surface temperature from the hydrazine (N_2H_4) side of the tank. The fuel tank assembly stores and provides for positive expulsion of the liquid hydrazine to the APU gas generator. The assembly consists of a 28-inch diameter spherical titanium tank with a useable fuel capacity of 346 lbs. The normal operating fuel quantity is 25-100 percent capacity. The fuel tank and feedlines are maintained at 55-65° F by insulation and thermostatically controlled heaters. Fuel quantity is also gauged on cockpit panel F8 and displayed on the SM SYS SUMM 2 display. Low fuel tank quantity may be caused by GN2 leak, hydrazine leak, or PVT input parameter(s) out-of limits (i.e., transducer shift). If a transducer error is suspected, an on-orbit capability exists for the crew to substitute nominal values for a failed parameter via Table Maintenance procedures or via ground uplink.

⑤. TK P - This is the measurement of the APU fuel tank GN2 pressure. The fuel tank contains a diaphragm to separate the GN2 pressurant from the hydrazine. When fully fueled, the tank is pressurized to 325 psia at 70° F with GN2. The normal operating range for fuel tank pressure is 135-260 psia. Tank pressure is used by the GPC for APU fuel tank PVT quantity computations and is also gauged on cockpit panel F8. Low fuel tank pressure may indicate a GN2 or hydrazine leak or fuel tank heaters failed OFF. High fuel tank pressure may indicate fuel tank heaters failed ON.

⑥. OUT P - This is the measurement of the APU fuel tank output pressure. The pressure of the fuel output from the tank is used by the GPC for fuel tank PVT quantity computations. Normal operating pressure is 135-260 psia. There are no associated software limits or fault displays for fuel tank output pressure. Low output pressure may indicate a

?
Conflict

GN2 or hydrazine leak.

⑦ VLV A(B) - This display indicates the position of the two (A&B) fuel tank isolation valves. The fuel tank isolation valves isolate the APU fuel tank from the APU fuel pump and gas generator. The valves are controlled by the crew through the APU FUEL TK VLV switches on panel R2 during APU activation and shut down. The fuel isolation valve drivers are also connected to the APU UNDERSPEED/OVERSPEED circuit for automatic underspeed/overspeed protection. The two valves are normally closed without power. The valves and feedlines are thermally controlled by insulation and heaters at 55-65° F. The fuel tank valves should not be left open for extended periods (> 20 minutes on orbit) without fuel flow. If the isolation valve (A or B) is OPEN and turbine speed is < 80 percent, the fault message will appear after a 5 minute delay indicating the isolation valve is OPEN and the APU is not operating.

⑧ OIL T - This is the measurement of the APU lube oil temperature as it returns to the gearbox from the W/B and is also gauged on cockpit panel F8. Lubrication of the APU gearbox is provided by a scavenger-type lubrication system utilizing an internal oil pump (driven by the gearbox assembly). Lube oil is routed from the gearbox through a water spray boiler for cooling. The cooled oil returns through a filter, then to an accumulator which is used to compensate for thermal expansion and leakage. The accumulator is pressurized with nitrogen to provide pressure for positive flow back to the gearbox. The normal operating return temperature of the lube oil is 250-280° F when the APU is operating. Lube oil return temperature is also displayed on the SM SYS SUMM 2 display. While on orbit lube oil line heaters are thermostatically controlled to maintain lube oil temperatures between 50-70° F. The upper software limit

of 290° F will be reset to 80° F via TMBU after gearbox temperature is stabilized on-orbit. Low lube oil temperature ($< 45^{\circ}$ F) indicates either the line heater or thermostat is failed off. High lube oil temperature ($> 80^{\circ}$ F on-orbit) indicates line heater or thermostat is failed on. High lube oil temperature ($> 240^{\circ}$ F APU operating) may indicate W/B failure, gearbox over-pressure, or excessive gearbox loading.

⑨. OUT T - This is the measurement of the APU gearbox lube oil output temperature. The normal operating temperature of the lube oil output is 270°-320° F when the APU is operating. While on-orbit lube oil line heaters are thermostatically controlled to maintain lube oil temperatures at 50°-70° F, lube oil output temperature is also displayed on the SM SYS SUMM 2 display. The upper software limit of 330° will be reset to 80° F via TMBU after gearbox temperature is stabilized on-orbit. Low lube oil output temperature ($< 40^{\circ}$ F) indicates either the line heater or thermostat is failed off. High lube oil output temperature ($> 80^{\circ}$ F on-orbit) indicates line heater or thermostat is failed on. High lube oil output temperature ($> 330^{\circ}$ F APU operating) may indicate excessive gearbox loading or gearbox over-pressure.

⑩. OUT P - This is the measurement of the gearbox lube oil pump output pressure. The reduction gears in the gearbox assembly reduce the turbine speed to 12,215 rpm for the gearbox lube oil pump. The lube oil pump has a discharge rate of 4.33 GPM at a normal operating pressure of 30-70 psia. An overpressure relief valve dumps excess oil back to the inlet side of the oil pump to preclude lube jet from flooding the gears and causing a decrease in efficiency from churning losses. Lube oil output pressure is also displayed on the SM SYS SUMM 2 display. The software limits are preconditioned as a function of the APU CONTROL switch. With the switch OFF, the lower software limit is set to 0 psia. With the switch in START/RUN or START ORIDE/RUN, the lower software limit is set to 40 psia (see Table ___). A limit sense time delay is incorporated into the software logic so no fault message will appear after an APU CONTROL switch position change unless the OUT P is still out-of-limits after

*Delete
delete
Delete*

10 seconds. With the APU operating, low output pressure indicates lube oil leak and high output pressure indicates a restriction in the lube oil line or a gearbox repressurization circuit failure causing overpressurization of the gearbox.

⑪. GBX P - This is the measurement of the APU gearbox GN2 pressure. The ~~two~~ gearbox ~~accumulators are~~ ⁷⁵ pressurized with nitrogen (~~1-35 psia~~) to provide pressure for positive lube oil flow to the lube jets. Scavenger lines near the tips of the gears return the lube oil to the inlet side of the lube oil pump. The normal gearbox operating pressure is 5-15 psia. The gearbox is repressurized with GN2 wherever an APU START/RUN command is initiated and gearbox pressure is ≤ 5.5 psia. Low gearbox pressure may indicate a gearbox GN2 or lube oil leak.

Put in this para

⑫. N2 P - This is the measurement of the APU gearbox GN2 tank pressure. The GN2 tank supplies the GN2 pressure to repressurize the gearbox ^{and the two gearbox} accumulators prior to APU start. If the APU CONTROL switch is in START/RUN or START ORIDE/RUN and the gearbox pressure is < 5.5 psia, the gearbox GN2 repressurization circuit will open a valve allowing the GN2 tank to repressurize the ~~two~~ gearbox ^{and} accumulators. The valve will close when the gearbox pressure > 8 psia. The normal operating range of the gearbox GN2 tank is 100-300 psia. There are no software limits or fault messages for gearbox GN2 tank pressure. Low N2 P (< 100 psia) indicates a GN2 leak.

⑬. BRG T - This is the measurement of the APU gearbox drive shaft bearing temperature. The APU turbine provides rotational shaft power directly to the APU gearbox. The normal operating range for bearing temperature is 270° - 320° F. High bearing temperature may indicate possible gearbox failure.

⑭ GG BED T - This is the measurement of the gas generator catalytic bed temperature. The gas generator assembly consists of a catalytic bed using a granular catalyst (SHELL 405) within a pressure chamber mounted inside an exhaust chamber. Hydrazine propellant decomposes when it contacts the catalyst and hot gasses are produced. The hot gasses are directed to the turbine first- and second-stage nozzles. The gas generator bed heaters are used to preheat the catalyst bed to $> 190^{\circ}$ F for smooth propellant decomposition. The thermostatic control range is 360° - 425° F since the heater is used to maintain fuel line temperatures as well as gas generator bed temperature. The normal observed operating range of the gas generator bed temperature is 360° - 500° F. The upper limit is the sensor limit of 500° F while the design operating temperature of the catalyst bed is 1700° F; therefore, when the APU is operating, GG BED T will read 500 H. Low APU GG BED T may indicate heater or driver circuit failure, signal conditioner failure, or APU CONTROL switch shorted. If GG BED T transducer fails or shifts $< 190^{\circ}$ F, APU START ORIDE must be used for APU start.

→ Consequences?

ORIDE starts 209 sec timer delay to allow water injection cooling to $< 250^{\circ}$ F. Is the T sensor different? What happens if you try to start an APU with a cold GG Bed?

15

PMP T, VLV T - PMP T and VLV T are the APU fuel pump and secondary control valve temperatures. After APU shutdown, heat soak-back could cause the fuel pump and/or fuel control valve temperature to exceed 200°F. A water spray system is installed to cool the fuel pump and valve to 170°-175°F after APU shutdown to prevent formation of a hydrazine bubble. The two redundant cooling systems (A&B) are crew selectable on panel R2 (APU FUEL PUMP/VLV COOL) and require APU CNTLR PWR selected ON. After APU shutdown with the APU Fuel Pump/VLV Cool switch (A or B) in AUTO, water will spray 1 sec on and 4 sec off until the desired temperature range is reached. High PMP T or VLV T (^{>200°F} 209° F) may indicate water spray system failure, APU CNTLR PWR - OFF, or fuel pump/valve heaters failed on. Low PMP T or VLV T indicate heaters failed off.

①6. B/U P - This is the backup hydraulic pressure reading to the primary reading that is gauged on cockpit panel F8. The APU-driven main hydraulic pump provides hydraulic flow and pressure to the hydraulic system. The pump is a viable displacement type with an inlet pressure range of 55-75 psia. With the APU at normal speed, the main hydraulic pump provides 0-63 GPM at 3000 psia. The pump provides at 69.6 GPM with the APU at high speed. When the HYD MAIN PUMP PRESS is set to LOW, an electrically operated depressurizing valve reduces main pump discharge pressure to 500-1000 psia, thereby reducing APU torque requirements during start-up. Operating limits for the hydraulic system are from 2760 to 3100 psia with a normal operating range of 3000 psia (HYD MAIN PUMP PRESS - NORM). On orbit with the APU's OFF (main hyd pumps inop), the electrically driven circulation pumps can maintain a nominal pressure of 350 psia. Low hydraulic pressure may be caused by APU shutdown, main pump failure, loss of hydraulic fluid, or HYD MAIN PUMP PRESS switched to low.

①7. RSVR T - This is the hydraulic fluid reservoir temperature. The reservoir provides pressurized hydraulic fluid to the main pump inlet by means of a differential area piston actuated by system pressure. The reservoir also maintains inlet pressure to the circulation pump during on-orbit conditions when the main system is quiescent. The reservoir will operate throughout the entire fluid temperature range of -40° F to +275° F with a normal operating range of 10° F to 230° F. RSVR T is also shown on the SM SYS SUMM 2 display. Low reservoir temperature (<10° F) may be caused by a hydraulic circulation pump failure, SM thermal control software failure, incorrect circulation pump switch position data assigned by SM thermal software, abnormally rapid system cool down, or hydraulic freon heat exchanger thermal control bypass valve failed in the bypass position. High reservoir temperature can only occur if the APU's are operating. High reservoir temperature may be caused by a failure of the water spray boiler hydraulic bypass valve in the BYPASS position, water spray boiler failure, or water spray boiler controller failure.

18. RSVR QTY - This is the direct measurement of the amount of hydraulic fluid in the hydraulic reservoir. The reservoir has a maximum capacity for approximately 1850 in.³ of hydraulic fluid, under pressure, to provide pump inlet precharging and to allow for volumetric expansion and contraction.

Hydraulic fluid reservoir quantity is gauged on cockpit panel F8 and also present on the SM SYS Summary 2 display.

Normal reservoir quantity limits are from 20% to 95%. Low or high reservoir quantity may indicate fluid leaking into or from one hydraulic system into another. Low hydraulic reservoir quantity may also indicate a hydraulic leak, transducer shift or thermal contraction.

19. ACCUM P - This is the measurement of the hydraulic accumulator GN₂ pressure. The GN₂ precharged accumulator provides positive pressure to pressurize the reservoir, assuring positive main pump inlet fluid pressure during zero-g starts. During orbit insertion, when the APU's are shut down, a pressure retaining valve closes, trapping the accumulator pressure. This allows the reservoir to continue to function and supply pressurized hydraulic fluid to the circulation pump inlet while operating on-orbit. The accumulator also dampens pressure impulses and minimizes pump supply pressure ripples. The accumulator pressure is maintained during on-orbit flight by low flow, high pressure discharge from the circulation pump. Normal operating pressure is approximately 2500-2600 psia. Low accumulator pressure may be caused by a hydraulic leak, GN₂ leak, priority valve leak, unloader valve failure, or circulation pump failure.

20. H2O QTY - Water spray boiler H2O storage tank quantity is computed by the GPC using the following measured parameters: water boiler H2O storage tank temperature, water boiler GN₂ regulated output pressure, water boiler GN₂ tank pressure, and water boiler GN₂ tank temperature. The water feed system provides and delivers expendable water to the

Extraneous
Info - Delete

water spray boiler. The system consists of a bellows-type H₂O storage tank with a capacity of 142 lbs. and water feed valves controlled on demand by fluid outlet temperatures (ascent, orbit, and entry) and liquid level sensors (ascent and entry). The hydraulic fluid outlet set point temperature is 208° F and the APU lube oil outlet set point temperature is 265° F. There are two redundant controllers (A & B) for each W/B that provide for automatic thermal conditioning and W/B operation. Only one controller will be on the line at a time. Only the primary controller A has the PVT computation for water quantity. The normal operating H₂O quantity is 78-100% capacity and is gauged on cockpit panel F8. Water boiler H₂O QTY is also presented on the SM SYS SUMM 2 display. Low H₂O tank quantity may be caused by a H₂O low, PVT input parameter(s) out-of-limits, or BOILER CNTLR PWR/HTR - B selected.

When BOILER CNTLR PWR/HTR - B is selected, H₂O QTY will go to zero.

The SM ALERT will sound ^{and} an APU/HYD W/B fault message will appear.

Controller B does not provide GN2 regulated output pressure or GN2 tank temperature to the GPC for H₂O tank quantity computations.

Controller A (if available) must be periodically selected to monitor H₂O tank quantity.

(21) N2 P - This is the measurement of the water boiler GN2 tank pressure. The GN2 system provides GN2 regulation for positive expulsion of water during water boiler operations. The nominal operating pressure of the GN2 tank is 2300-2500 psia. GN2 pressure is used by the GPC for H₂O storage tank quantity computations. Low GN2 tank pressure may indicate a GN2 leak.

(22) N2 T - This is the measurement of the water boiler GN2 tank temperature. GN2 tank temperature is used by the GPC for H₂O storage tank quantity computations. The normal operating range of GN2 tank temperature is 45-100° F. There are no associated software limits or fault displays. When BOILER CNTLR PWR/HTR - B is selected, GN2 tank temperature will indicate 31L (off-scale low) since this parameter is not provided by *controller B.*

- 23) REG P - This is the measurement of the GN2 regulated pressure provided to the water boiler H2O storage tank. The GN2 system consists of a high pressure regulator set at 24.5-26 psia, a relief valve to protect the H2O storage tank, and a crew controlled GN2 shut-off valve to isolate GN2 supply on-orbit. The software limits in Table _____ apply only if BLR N2 Supply is selected (Panel ON or if MCC inputs the limits via TMBU after the transition to OPS2. High regulated pressure may indicate excessive temperature or transducer shift. Low regulated pressure may indicate a GN2 leak or H2O leak. When BOILER CNTLR PWR/HTR - B is selected, REG P will indicate OL since this parameter is not provided by controller B.
- 24) BYP VLV - This display indicates the position of the hydraulic bypass valve. There are two motors (one for each W/B controller (A&B) which open or close the bypass valve, allowing hydraulic fluid to either bypass the water spray boiler (W/B) or go through the W/B for cooling. The valve position (BYP or W/B) is controlled thermostatically. When the temperature of the hydraulic fluid is $\leq 190^{\circ}$ F, the bypass valve opens, allowing the fluid to bypass the W/B and return to the hydraulic reservoir. If the temperature of the fluid is $\geq 210^{\circ}$ F, the bypass valve closes and allows the fluid to go through the W/B for cooling. When BOILER CNTL PWR/HTR - B is selected, the valve will operate normally, but the display indication will be invalid (will probably indicate BVP). Bypass valve position is also displayed on the SM SYS SUMM 2 display.
- 25) VENT T - This is the measurement of the water boiler steam vent temperature. The vent system is designed to vent steam from the water boiler overboard. Steam vent heaters, controlled by the BOILER CNTLR switch, reduce the risk of steam vent ice buildup. The normal operating temperature of the steam vent is $\geq 130^{\circ}$ F, and the vent heaters are thermostatically controlled from 150°-175° F. There are two vent temperature sensors--one for water

boiler controller A and one for controller B. The displayed temperature depends upon which controller (A or B) is selected. No temperature is displayed if BOILER CNTLR is selected OFF. There are no software limits and no fault display for vent temperature. Vent temperature high ($>175^{\circ}$ F) indicates vent heaters failed ON and low vent temperature ($<130^{\circ}$ F) indicates vent heaters failed OFF.

26 TANK T - This is the measurement of the water boiler H₂O storage tank temperature. The H₂O storage tank is part of the water spray boiler feed system. This parameter is used by the GPC for H₂O storage tank quantity computations. H₂O tank heaters, controlled by the BOILER CNTLR PWR/HTR switch, prevent the tank from icing. The normal operating range of the tank is 45-160° F with the heaters thermostatically controlled at 50-55° F. When BOILER CNTLR PWR/HTR - B is selected, TANK T will indicate off-scale low since this parameter is not provided by controller B. When another controller (A or B) is selected, software limits are reset (see Table ____). If TANK T is still out-of-limits upon reselection of controller A, the fault message will reoccur after 5 minutes. Low H₂O tank temperature (on-orbit) indicates tank heaters failed OFF.

27 BLR T - This is the measurement of the internal boiler system temperature. The boiler provides for the cooling of hydraulic fluid and APU lube oil. There are two boiler modes: a pool mode for ascent and entry for heavy heat loads, and a spray mode (valve pulses) for lower heat loads on-orbit. Hydraulic fluid and APU lube oil are cooled by water in the pool mode during prelaunch, launch and ascent. As orbit is approached, the temperature at which water boils has decreased, which decreases the internal boiler water level by evaporation. The boiler remains empty on-orbit, requiring the system to be in the spray mode during operation

of the APII/hydraulic system for deorbit rehearsal and at deorbit prior to descent. The boiler will be in the spray mode during descent until the pool level of the boiler is sufficient to take care of the cooling demanded by the hydraulic fluid and APU lube oil. The normal operating range of the boiler is 50-120° F with the heaters thermostatically controlled from 50-55° F. There are two boiler temperature sensors, one for water boiler controller A and one for controller B. The displayed temperature depends upon which controller (A or B) is selected. No temperature is displayed if BOILER CNTLR is selected OFF. When another controller (A or B) is selected, software limits are reset (see Table ____). If BLR T is still out of limits upon reselection of controller A, fault message will reoccur after 2 minutes. High boiler temperature (on-orbit) indicates boiler heaters failed ON and low boiler temperature (on-orbit) indicates boiler heaters failed OFF.

28. SW VLV - The switching valve (SW VLV) matrix displays the hydraulic switching valve position for each applicable flight control surface. The format consists of horizontal rows listing the flight control surfaces, the column headings (PR, S1, S2), indicating the switching valve configuration (Primary, Secondary 1, Secondary 2) and the designated hydraulic system (1, 2, 3). A switching valve assembly basically consists of two spools, an ACTIVE and a PASSIVE STANDBY spool, that route fluid to the surface actuators from the different hydraulic systems. The exact switching valve configuration is determined by establishing the position of each spool based on bi-level position measurements. Associated with each switching valve configuration is a designated hydraulic system that actively feeds a particular control surface actuator as long as that switching valve configuration is maintained. An "*" by the appropriate

flight control surface actuator indicates which hydraulic system is active for the actuator. The determination is performed through comparison of active and passive/standby spool positions, while actual designation of hydraulic systems is by hydraulic system pressure.

For example, if all three hydraulic systems are pressurized, the SW VLV matrix would appear as follows:

SW VLV	PR	S1	S2
ELEV L OB	3*	1	2
IB	2*	1	3
R IB	3*	1	2
OB	2*	1	3
RUD/SPD BK	1*	2	3

If Hydraulic Systems 1 and 3 are pressurized, the display appears as:

SW VLV	PR	S1	S2
ELEV L OB	3*	1	2
IB	2	1*	3
R IB	3*	1	2
OB	2	1*	3
RUD/SPD BK	1*	2	3

If Hydraulic Systems 1 and 2 are pressurized, the display appears as:

SW VLV	PR	S1	S2
ELEV L OB	3	1*	2
IB	2*	1	3
R IB	3	1*	2
OB	2*	1	3
RUD/SPD BK	1*	2	3

If Hydraulic Systems 2 and 3 are pressurized, the display appears as:

SW VLV	PR	S1	S2
ELEV L OB	3*	1	2
IB	2*	1	3
R IB	3*	1	2
OB	2*	1	3
RUD/SPD BK	1	2*	3

If only Hydraulic System 1 is pressurized the display appears as:

SW VLV	PR	S1	S2
ELEV L OB	3	1*	2
IB	2	1*	3
R IB	3	1*	2
OB	2	1*	3
RUD/SPD BK	1*	2	3

If only Hydraulic System 2 is pressurized the display appears as:

SW VLV	PR	S1	S2
ELEV L OB	3	1	2*
IB	2*	1	3
R IB	3	1	2*
OB	2*	1	3
RUD/SPD BK	1	2*	3

If only Hydraulic System 3 is pressurized, the display appears as:

SW VLV	PR	S1	S2
ELEV L OB	3*	1	2
IB	2	1	3*
R IB	3*	1	2
OB	2	1	3*
RUD/SPD BK	1	2	3*