

SYSTEMS DATA

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SECTION 2

SUBSECTION 2.10

CAUTION AND WARNING SYSTEM

2.10.1 INTRODUCTION.

The caution and warning system (C&WS) monitors critical parameters of most of the systems in the CM and SM. When a malfunction or out-of-tolerance condition occurs in any of these systems, the crew is immediately alerted in order that corrective action may be taken.

2.10.2 FUNCTIONAL DESCRIPTION.

Upon receipt of malfunction or out-of-tolerance signals, the C&WS simultaneously identifies the abnormal condition and alerts the crew to its existence. Each signal will activate the appropriate systems status indicator and a master alarm circuit. The master alarm circuit visually and aurally attracts the crew's attention by alarm indicators on the MDC and by an audio tone in the headsets. Crew acknowledgment of an abnormal condition consists of resetting the master alarm circuit, while retaining the particular systems status malfunction indication. The capability exists for the crew to select several modes of observing systems status and master alarm indicators and of monitoring CM or SM systems.

2.10.3 MAJOR COMPONENT/SUBSYSTEM DESCRIPTION.

The C&WS consists of one major component, the detection unit. It is located behind MDC-3, and therefore is neither visible nor accessible to the crew during the mission. The balance of the system is made up of visual indicators, aural alerting and associated circuits, and those switches required to control the various system functions. Visual indicators include the two uppermost fuel cell electromechanical event devices on MDC-3, as well as all systems status and master alarm lights.

The detection unit circuits consist of comparators, logic, level detectors, lamp drivers, and a master alarm and tone generator. Also incorporated are two redundant power supplies that furnish regulated +12 and -12 dc voltages for the electronics.

Inputs to the detection unit consist of both analog and event-type signals. The analog signals are in the 0- to 5-volt d-c range. Alarm limits for these signals trigger voltage comparators, which, in turn, activate logic and lamp-driver circuits. This causes activation of the master alarm circuit and tone generator, illumination of applicable systems status lights on MDC-2, and for certain measurements, activation

C&WS

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CAUTION AND WARNING SYSTEM

SYSTEMS DATA

of applicable electromechanical event indicators on MDC-3. Several event inputs are monitored by the C&WS detection unit. These signals originate from solid state and mechanical switch closures in malfunction sensing devices. Certain signals will directly illuminate applicable system status lights and, through logic circuitry, activate the master alarm circuit and tone generator. Other event signals directly illuminate the system status lights, but require level detectors to activate the master alarm circuit. One event signal, originating within the detection unit, directly illuminates the C/W light, but activates only the MASTER ALARM switch lights of the master alarm circuit. One event signal, referred to as "CREW ALERT," originates from ground stations and enters through the UDL portion of the communications system. This system status light can only be extinguished by a second signal originating from the ground.

The master alarm circuit alerts crewmembers whenever abnormal conditions are detected. This is accomplished visually by the illumination of remote MASTER ALARM switch-lights on MDC-1 and -3, and the MASTER ALARM switch-light on LEB-122. An audio alarm tone, sent to the three headsets, aurally alerts the crew. The output signal of the tone generator is a square wave that is alternately 750 and 2000 cps, changing at a rate of 2.5 times per second. Although the tone is audible above the conversation level, it does not render normal conversation indistinct or garbled. When the crew has noted the abnormal condition, the alarm lights and the tone generator are deactivated and reset by pressing any one of the three MASTER ALARM switch-lights. This action leaves the systems status lights illuminated and resets the master alarm circuit for alerting the crew if another abnormal condition should occur. The individual systems status lights will remain illuminated until the malfunction or out-of-tolerance condition is corrected.

The C&WS power supplies include sensing and switching circuitry that ensure unit self-protection should high-input current, or high- or low-output voltage occur. Any of these conditions will cause the illumination of the master alarm lights and the C/W system status light. The tone generator, however, will not be activated because of requiring the 12-volt output from the malfunctioned power supply for its operation. The crew must then manually select the redundant power supply to return the C&WS to operation. This is accomplished by repositioning the CAUTION/WARNING-POWER switch on MDC-2. In so doing, the C/W status light is extinguished, but the master alarm circuit remains activated, thus requiring it to be reset.

Incorporated into the C&WS is the capability to test the lamps of systems status and master alarm lights. Position 1 of the CAUTION/WARNING-LAMP TEST switch tests the illumination of the left-hand group of status lights on MDC-2 and the MASTER ALARM switch-light on MDC-1. Position 2 tests the MASTER ALARM switch-light

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CAUTION AND WARNING SYSTEM



SYSTEMS DATA

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on MDC-3 and the right-hand group of status lights on MDC-2. The third MASTER ALARM light is on LEB-122, and is tested by placing the CONDITION LAMPS switch on LEB-122 to TEST.

The position of the CAUTION/WARNING - CSM-CM switch (MDC-2) establishes the systems to be monitored. Before separation and entry, systems in both the CM and SM are monitored for malfunction or out-of-tolerance conditions with this switch in the CSM position. Positioning the switch to CM deactivates systems status lights and event indicators associated with SM systems.

The CAUTION/WARNING - NORMAL-BOOST-ACK switch (MDC-2) permits three modes of status and alarm light illumination. For most of the mission, the switch is set to the NORMAL position to give normal C&WS operation; that is, upon receipt of abnormal condition signals, all systems status lights and master alarm lights are capable of illumination. During the ascent phase, the switch is set to the BOOST position, so that although all other C&WS lights operate normally, the MASTER ALARM switch-light on MDC-1 will not illuminate. This prevents possible confusion on MDC-1 between the red MASTER ALARM light and the adjacent red ABORT light. The ACK switch position is selected when the crew desires to adapt their eyes to darkness, or if a continuously illuminated systems status light is undesirable. While in this mode, incoming signals will activate only the master alarm lights and the tone generator. To determine the abnormal condition, the crew must press either MASTER ALARM switch-light on the MDC. This illuminates the

C&WS

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CAUTION AND WARNING SYSTEM

SYSTEMS DATA

applicable systems status light, and deactivates and resets the master alarm circuit. The systems status light will remain illuminated only as long as the switch-light is depressed. However, it may be re-called as long as the abnormal condition exists by again pressing either switch-light.

A stowable tone booster is added to the caution and warning system to allow all three astronauts to sleep simultaneously with the headsets removed. Stowage of this unit during non-use periods will be under locker A3.

The unit consists of a power plug, tone booster, and a photo-sensitive device which can be used on the left or right side of the command module. The power connection is made to the UTILITY receptacle on MDC-15 or 16. The tone booster, which provides an audible signal, is mounted by velcro pad to the left-hand or right-hand girth shelf. The photo-sensitive device, which is sensitive only to the MASTER ALARM lamp, is mounted on the left- or right-hand crew couch so it monitors the MASTER ALARM on MDC-1 or 3.

Since the MASTER ALARM is triggered by any caution/warning monitored symptom, it will activate the tone booster until the MASTER ALARM is extinguished by a manual reset. In the event of a caution/warning system power supply failure, this unit will provide the audio alarm.

2.10.3.1 Electrical Power Distribution.

The C&WS receives power from MNA & MNB buses. (See figure 2.10-1.) Two circuit breakers are located on MDC-5. Closure of either circuit breaker will allow normal system operation.

2.10.4 OPERATIONAL LIMITATIONS AND RESTRICTIONS.

2.10.4.1 C&WS General Data.

With the CAUTION/WARNING - NORMAL-BOOST-ACK switch in the BOOST position during ascent, the MASTER ALARM switch-light on MDC-1 will not illuminate should a malfunction occur. The master alarm circuit reset capability of the light is also disabled during this time. This requires the MASTER ALARM switch-light on MDC-3 to be used exclusively for monitoring and resetting functions during boost. Several

C&WS

SM2A-03-BLOCK II-(1)  
 APOLLO OPERATIONS HANDBOOK  
 SYSTEMS DATA

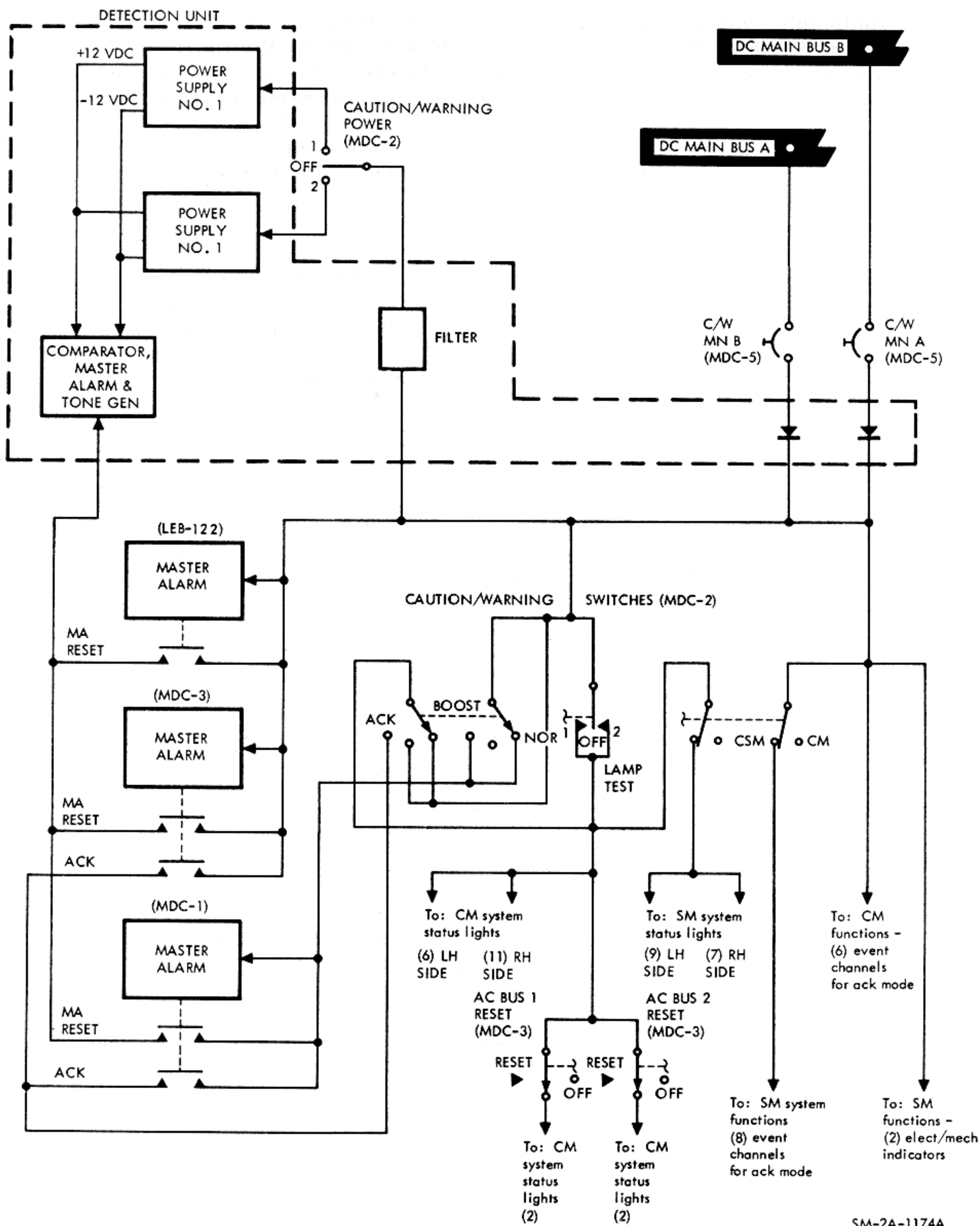


Figure 2.10-1. C&WS Power Distribution Diagram

SM-2A-1174A

CAUTION AND WARNING SYSTEM



SM2A-03-BLOCK II-(1)  
APOLLO OPERATIONS HANDBOOK

SYSTEMS DATA

peculiarities should be noted in regard to the CAUTION/WARNING - POWER switch. Whenever this switch is moved from or through the OFF position to either power supply position, the master alarm circuit is activated, which then requires it be reset. Also, switching from one power supply to another (when there is no power supply failure) may cause the C/W system status light to flicker as the switch passes through the OFF position.

Should the redundant power supply also fail, the C&WS is degraded to the extent that the complete master alarm circuit, as well as those system status lights that illuminate as the result of analog-type input signals, are rendered inoperative. This leaves only those status lights operative that require event-type input signals. They include the following SM and CM lights: CMC, ISS, BMAG 1 TEMP, BMAG 2 TEMP, SPS ROUGH ECO, PITCH GMBL 1, PITCH GMBL 2, YAW GMBL 1, YAW GMBL 2, O<sub>2</sub> FLOW HI, FC BUS DISCONNECT, AC BUS 1, AC BUS 1 OVERLOAD, AC BUS 2, AC BUS 2 OVERLOAD, MN BUS A UNDERVOLT, MN BUS B UNDERVOLT, and CREW ALERT. The C/W light will be operative only while the CAUTION/WARNING - POWER switch is in position 1 or 2.

The CAUTION/WARNING - CSM-CM switch must be in the CSM position in order to conduct a lamp test of those system status lights associated with SM systems. The status lights of CM systems may be tested with the switch in either position. Circuit design permits a complete lamp test to be conducted with the CAUTION/WARNING switch in the NORMAL or ACK position only. In the BOOST position, all lamps except those of the MASTER ALARM light on MDC-1 may be tested.

Normally, each abnormal condition signal will activate the C&WS master alarm circuit and tone generator, and illuminate the applicable systems status light. One exception to this concept is when a system status light has been activated by one of several signals and the MASTER ALARM has been reset. Any additional out-of-tolerance condition or malfunction, associated with the same system status light, will not activate the MASTER ALARM unless the first condition has been previously corrected.

Each crewmember has a power switch on his audio control panel which will enable or prevent the tone signal from entering his headset. The AUDIO-TONE position allows the signal to pass on to the headset while the AUDIO position inhibits the signal.

2.10.4.2 System Status Light Data.

The following list provides the lamp trigger values and associated information for all system status lights on MDC-2.

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CAUTION AND WARNING SYSTEM

SM2A-03-BLOCK II-(1)  
APOLLO OPERATIONS HANDBOOK

SYSTEMS DATA

System Status Lights	Trigger Values	Other Indications (Lights, Gauges, Meters, etc.)	CM or SM	Remarks
BMAG 1	1. Any BMAG <168°F 2. Any BMAG >172°F	None	CM	If activated, the BMAG POWER switch should be left in WARM UP until light is extinguished.
BMAG 2	Same as BMAG 1			
CO <sub>2</sub> PP HI	At 7.6 mm Hg	PART PRESS CO <sub>2</sub> meter (MDC-2)	CM	
PITCH GMBL 1	Overcurrent conditions dependent on time and temperature.	None	SM	
YAW GMBL 1	Same as PITCH GMBL 1	None		
PITCH GMBL 2	Overcurrent conditions dependent on time and temperature.	None	SM	
YAW GMBL 2	Same as PITCH GMBL 2	None		
CRYO PRESS	1. Tank 1 O <sub>2</sub> <800 psia 2. Tank 1 O <sub>2</sub> >950 psia 3. Tank 2 O <sub>2</sub> - Same as tank 1 O <sub>2</sub> 4. Tank 1 H <sub>2</sub> <220 psia 5. Tank 1 H <sub>2</sub> >270 psia 6. Tank 2 H <sub>2</sub> - Same as tank 1 H <sub>2</sub>	CRYOGENIC TANKS - PRESSURE-O <sub>2</sub> -1 meter (MDC-2)  CRYOGENIC TANKS - PRESSURE-O <sub>2</sub> -2 meter (MDC-2)  CRYOGENIC TANKS - PRESSURE-H <sub>2</sub> -1 meter (MDC-2)  CRYOGENIC TANKS - PRESSURE-H <sub>2</sub> -2 meter (MDC-2)	SM	
GLYCO TEMP LOW	At -30°F	ECS RADIATOR TEMP - PRIM-OUTLET meter (MDC-2)	CM	Indication is for primary water glycol system only.
CM RCS 1	1. He manf press <260 psia 2. He manf press >330 psia	CM RCS - PRESS-MANF meters (MDC-2)	CM	Light functional only when CAUTION/WARNING - CSM-CM switch is in CM position
CM RCS 2	Same as CM RCS 1			
SM RCS A	1. Pkg temp <75°F 2. Pkg temp >205°F 3. Sec fuel press <145 psia 4. Sec fuel press >215 psia	SM RCS - TEMP PKG meter (MDC-2)  SM RCS - PRESS-SEC-FUEL meter (MDC-2)	SM	
SM RCS B	Same as SM RCS A			
SM RCS C	Same as SM RCS A			

CAUTION AND WARNING SYSTEM

SM2A-03-BLOCK II-(1)  
APOLLO OPERATIONS HANDBOOK

SYSTEMS DATA

System Status Lights	Trigger Values	Other Indications (Lights, Gauges, Meters, etc.)	CM or SM	Remarks
SM RCS D	Same as SM RCS A			
FC 1	<ol style="list-style-type: none"> <li>1. H<sub>2</sub> flow &gt;0.16 lb/hr</li> <li>2. O<sub>2</sub> flow &gt;1.27 lb/hr</li> <li>3. Skin temp &lt;360°F</li> <li>4. Skin temp &gt;475°F</li> <li>5. Cond exh &lt;155°F</li> <li>6. Cond exh &gt;175°F</li> <li>7. At pH factor of 9</li> <li>8. Rad out temp below -30°F</li> </ol>	<p>FUEL CELL - FLOW-H<sub>2</sub>-O<sub>2</sub> indicator (MDC-3)</p> <p>FUEL CELL - MODULE TEMP-SKIN indicator (MDC-3)</p> <p>FUEL CELL - MODULE TEMP-COND EXH indicator (MDC-3)</p> <p>pH HI event indicator (MDC-3)</p> <p>FC RAD TEMP LOW event indicator (MDC-3)</p>	SM	Event indicators (elec/mech) pH HI, and FC RAD TEMP LOW are activated at lamp trigger values.
FC 2	Same as FC 1			
FC 3	Same as FC 1			
INV 1 TEMP HI	At >190°F	None	CM	
INV 2 TEMP HI	Same as INV 1 TEMP HI			
INV 3 TEMP HI	Same as INV 1 TEMP HI			
SPS PRESS	<ol style="list-style-type: none"> <li>1. Fuel tk He press &lt;157 psia</li> <li>2. Fuel tk He press &gt;200 psia</li> <li>3. Ox tk He press - Same as fuel tank He press</li> </ol>	<p>SPS PRPLNT TANKS - PRESS-FUEL meter (MDC-3)</p> <p>SPS PRPLNT TANKS - PRESS-OXID meter (MDC-3)</p>	SM	
AC BUS 1	<ol style="list-style-type: none"> <li>1. At 95±3 vac &lt;</li> <li>2. At 130±2 vac &gt;</li> </ol>	AC VOLTS meter (MDC-3)	CM	Overvoltage disconnects inverter from bus.
AC BUS 2	Same as AC BUS 1			
FC BUS DISCONNECT	<ol style="list-style-type: none"> <li>1. Forward current &gt;75 amps</li> <li>2. Reverse current &gt;4 amps for 1 to 10 seconds</li> </ol>	DC INDICATORS - FC 1, 2 & 3 (MDC-3)	SM	DC AMPS meter (MDC-3)

CAUTION AND WARNING SYSTEM





SM2A-03-BLOCK II-(1)  
APOLLO OPERATIONS HANDBOOK

SYSTEMS DATA

System Status Lights	Trigger Values	Other Indications (Lights, Gauges, Meters, etc.)	CM or SM	Remarks
AC BUS 1 OVERLOAD	1. 3Ø at 27 amps for 15±5 seconds	AC VOLTS meter (MDC-3)	CM	
	2. 1Ø at 11 amps for 5±1 seconds			
AC BUS 2 OVERLOAD	Same as AC BUS 1 OVERLOAD			
CMC	1. Loss of prime power	CMC light illuminated (LEB-122)	CM	Items 5 through 11 will cause restart in the CMC.
	2. Scaler fail - if scaler stage 17 fails to produce pulses	RESTART & PGNS lights illumi- nated if restart and standby exist in CMC		
	3. Counter fail - continuous requests or fails to happen following incre- ment request			
	4. SCADBL - 100 pps scaler stage >200 pps			
	5. Parity fail - accessed word, whose address is octal 10 or greater, con- tains even number of ones			
	6. Interrupt too long or infrequent - 140 to 300 ms			
	7. TC trap - too many TC or TCF instructions, or TCF instructions too infrequent			
	8. Night watchman - computer fails to access address 67 within 64 to 1.92 seconds			
	9. V fail - 4v supply >4.4v 4v supply <3.6v 14v supply >16.0v 14v supply <12.5v 28v supply <22.6v			
	10. If oscillator stops			
	11. Stand by			
CREW ALERT	Activated by real-time command from ground stations through the UDL	None	N/A	System status light must be extinguished by ground command
MN BUS A UNDERVOLT	At 26.25±0.1 vdc	DC VOLTS meter (MDC-3)	CM	
MN BUS B UNDERVOLT	Same as MN BUS A UNDERVOLT			

CAUTION AND WARNING SYSTEM

SM2A-03-BLOCK II-(1)  
APOLLO OPERATIONS HANDBOOK

SYSTEMS DATA

System Status Lights	Trigger Values	Other Indications (Lights, Gauges, Meters, etc.)	CM or SM	Remarks
ISS	<ol style="list-style-type: none"> <li>1. IMU fail                             <ol style="list-style-type: none"> <li>a. IG servo error &gt;2.9 mr for 2 seconds</li> <li>b. MG servo error &gt;2.9 mr for 2 seconds</li> <li>c. OG servo error &gt;2.9 mr for 2 seconds</li> <li>d. 3200 cps &lt;50%</li> <li>e. 800 wheel supply &lt;50%</li> </ol> </li> <li>2. PIPA fail                             <ol style="list-style-type: none"> <li>a. No pulse during 312.5-ms period</li> <li>b. If both + and - pulses occur during 312.5-ms period</li> <li>c. If no + and - pulses occur between 1.28 to 3.84 seconds</li> </ol> </li> <li>3. CDU fail                             <ol style="list-style-type: none"> <li>a. CDU fine error &gt;1.0v rms</li> <li>b. CDU coarse error &gt;2.5v rms</li> <li>c. Read counter limit &gt;160 cps</li> <li>d. Cos (<math>\theta - \psi</math>) &lt;2.0v</li> <li>e. +14 dc supply &lt;50%</li> </ol> </li> </ol>	ISS light illuminated (LEB-122)  PIPA fail will also illuminate PGNC lights and PROGRAM light on DSKY	CM	IMU fail signal inhibited by CMC when in coarse align mode.  PIPA fail signal inhibited by CMC except during CMC controlled translation or thrusting.  CDU fail signal by CMC during CDU zero mode.
C/W	<ol style="list-style-type: none"> <li>1. At +11.7 or -11.7 vdc</li> <li>2. At +13.9 or -13.9 vdc</li> </ol>	None	CM	Alarm tone inoperative.
O <sub>2</sub> FLOW HI	1.0 lb/hr for 16 sec	O <sub>2</sub> FLOW meter (MDC-2)	CM	
SUIT COMPRESSOR	$\Delta P$ across inlet and outlet <0.22 psia	SUIT COMPR $\Delta P$ meter (MDC-2)	CM	

C&WS

CAUTION AND WARNING SYSTEM