

Space Program Operations Contract

Caution and Warning

C&W 21002

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Final Version

**This document has been reviewed and updated.
No subsequent updates to this document are anticipated or required due to the
approaching shuttle program closure.**

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**Caution and Warning
C&W 21002**

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PREFACE

The content of this document was provided by the Systems Training Group, Systems Training Branch, Space Transportation Vehicle Division, Mission Operations Directorate (MOD), Lyndon B. Johnson Space Center (JSC), National Aeronautics and Space Administration (NASA). Technical documentation support was provided by Bastion Technologies, Inc. Any technical questions concerning this training manual or any recommendations should be directed to the training manual book manager, John Kennard/USH-4713 at 281-244-2334; all other questions should be directed to the document controller, Tina Pompilio/USH-44713 at 281-244-7679.

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A Training Materials Evaluation is included at the end of this document. Inputs on this sheet will be used to evaluate the lesson material. You do not need to sign the sheet.

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1.0 INTRODUCTION

This book is organized into sections. Each section has objectives listed for the key learning points followed by an overview that highlights the section's content. Material is further divided into general information and technical information for a more detailed discussion. Review questions are provided after many sections, with the answers in Appendix B. These questions will check your understanding of the material and help reinforce the objectives.

The Flight Data File (FDF) procedures printed in this training manual are examples only and should not be used as a source of operational data. Current FDF procedures are available electronically on the JSC Web. Copies of the Reference Data Book, Orbit Operations Checklist, and cue cards may be available within your department; check with your FDF representative.

The acronyms, abbreviations, and symbols used in this manual are listed in Appendix A. The acronyms are defined when they are first used in the manual.

2.0 ALARM CLASSES

2.1 OBJECTIVES

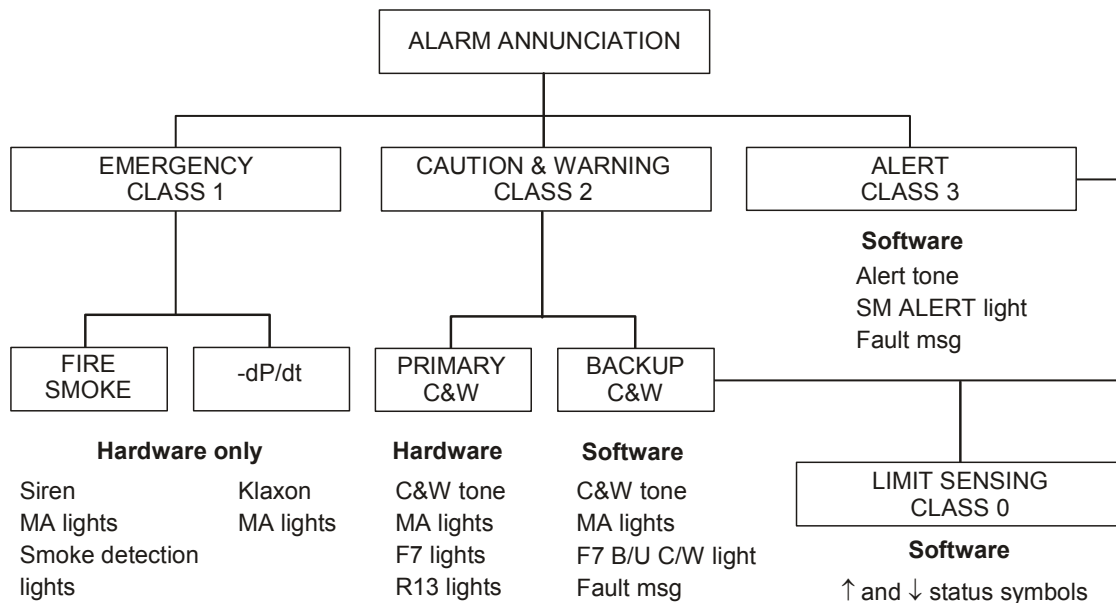
After reading this section, the student should be able to

- Identify the different alarm classes
- Identify which systems are software systems
- Identify which systems are hardware systems
- Define some common terms used in discussions about the Caution and Warning (C&W) system

2.2 SYSTEM OVERVIEW

Figure 2-1 is a diagram of the four alarm classes that make up the C&W system. Note the unique tone corresponding to each alarm class. Figure 2-2 and Figure 2-3 illustrate the crew interfaces with the alarm systems.

Table 2-1 describes the alarm tones with each frequency range generated.



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Figure 2-1. C&W diagram

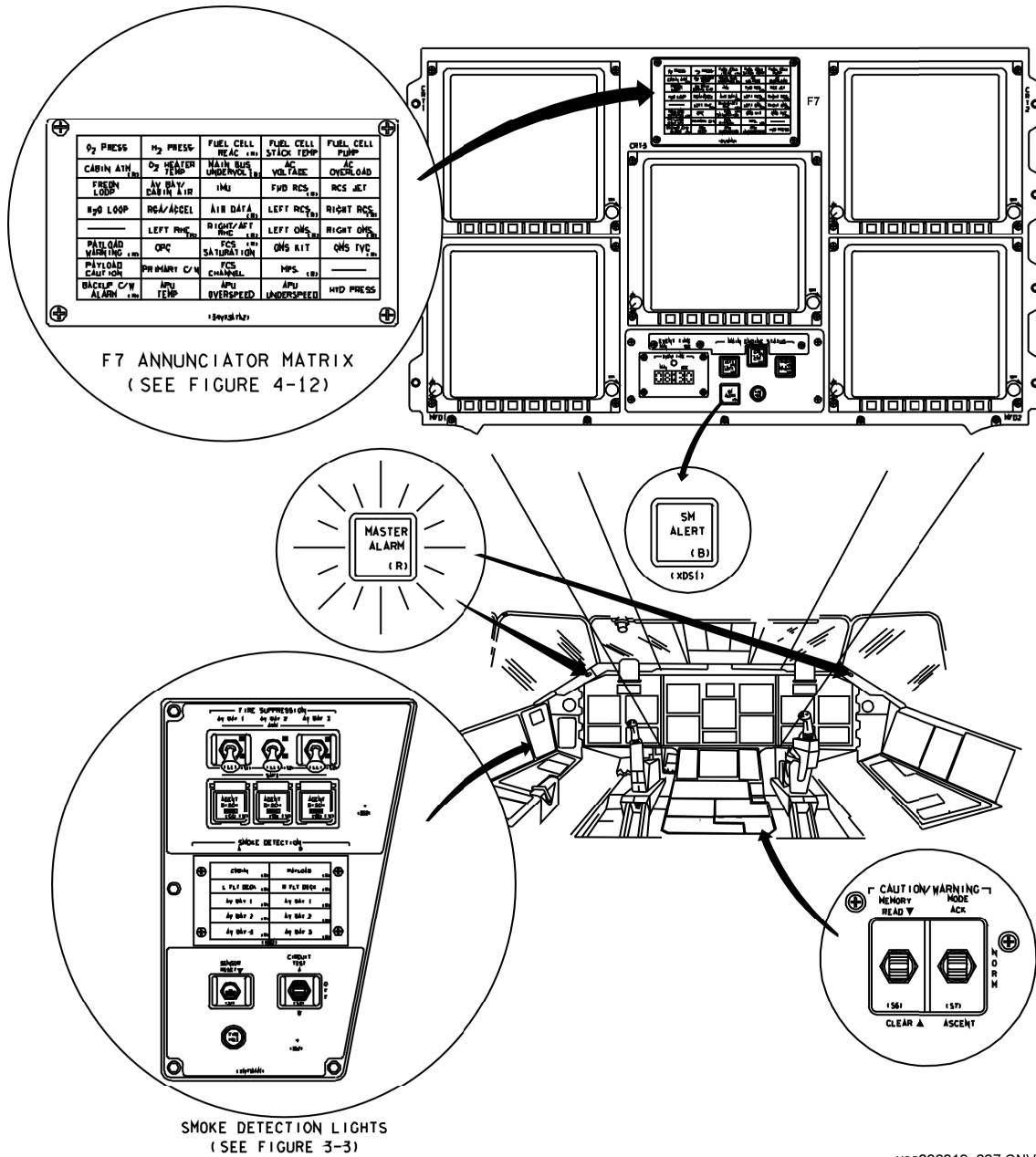
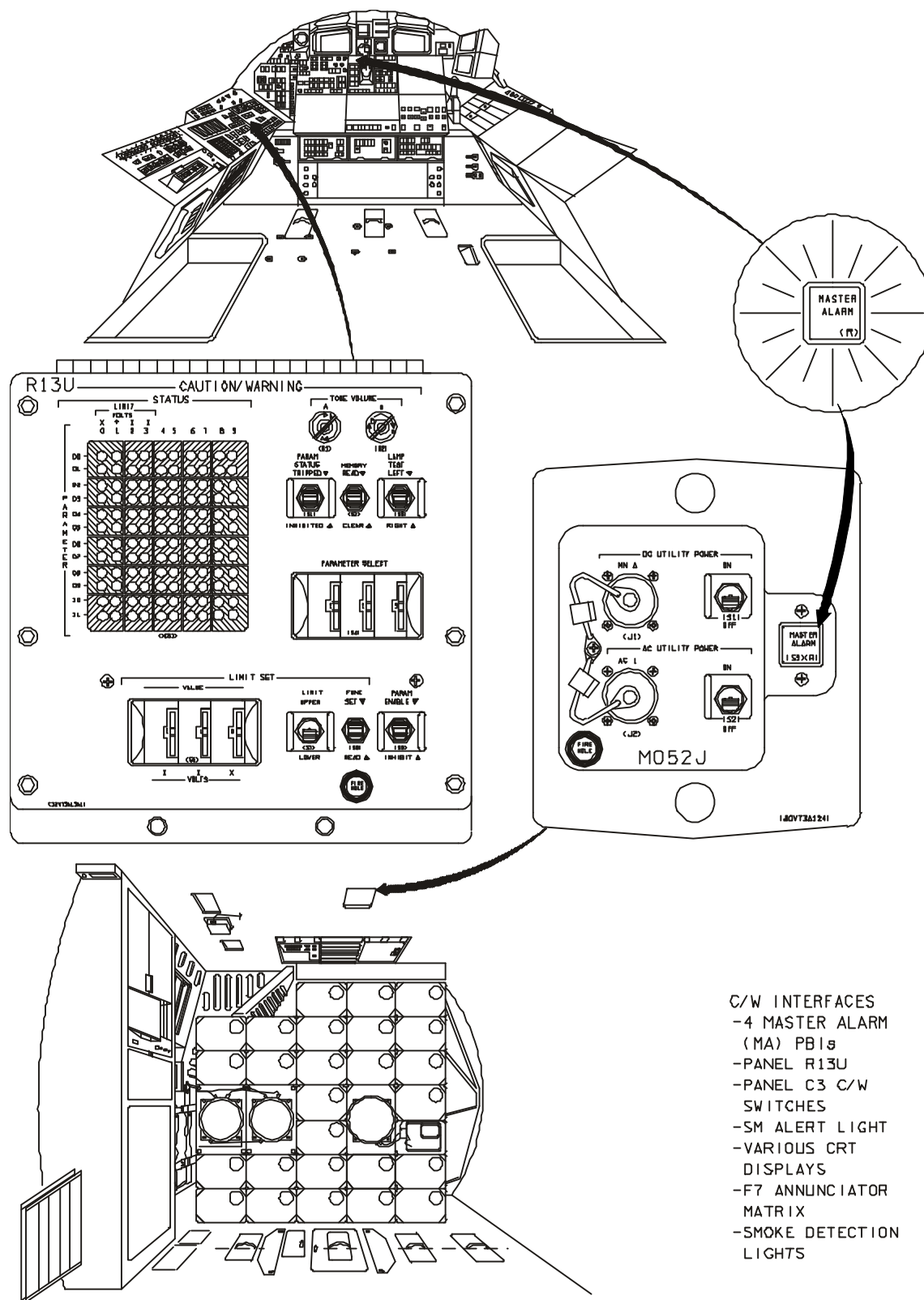


Figure 2-2. Alarm interfaces forward flight deck

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Figure 2-3. Alarm interfaces aft flight deck/middeck

The C&W system provides visual and aural warnings to the crew for failures that could create a hazard to the orbiter and/or crew. The crew must evaluate the indications and under certain situations perform time-critical procedures (under 5 minutes) to correct the problem. The C&W system receives parameter inputs for 120 channels, such as temperature, pressure, and flow rates, and is also activated by the Fault Detection and Annunciation (FDA) software system in the General Purpose Computers (GPCs). If any parameter value exceeds its set limits, a visual and aural alarm will be generated.

The crew interfaces with the C&W system through Panel R13U, the C&W switches on Panel C3, Data Processing System (DPS) displays, Panel F7 annunciator matrix, the Master Alarm (MA) Pushbutton Indicators (PBIs) (Panels F2, F4, A7, and M052J), the Systems Management (SM) alert light, and the smoke detection lights on Panel L1 (Figure 2-2 and Figure 2-3).

The C&W system uses audio and visual alerts to inform the crew of out-of-limit conditions, emergency situations, and events.

The C&W system discussion in this document includes the primary C&W hardware system, the Backup (B/U) C&W software system, the SM alert system, the fire and smoke emergency system, and the rapid delta pressure emergency system.

The C&W system has the responsibility of alerting the crew to out-of-limit conditions or improperly configured systems. When one of these conditions is detected, the C&W system alerts the crew with an alarm or group of alarms.

The visual cues consist of the following:

- a. MA lights
- b. Parameter status lights
- c. C&W system annunciation lights
- d. B/U C&W light
- e. SM alert light
- f. Smoke detection lights
- g. Fault messages on DPS displays
- h. Status symbols (↓ or ↑) on DPS displays

The audio alarms consist of

- a. Siren
- b. Klaxon

- c. C&W tone
- d. SM alert tone

Alarm annunciation to inform the crew of out-of-limits conditions in the orbiter is provided by the following systems:

- a. Emergency systems sense smoke in the pressurized volumes and rapid loss of cabin pressure and set off emergency alarms (siren and klaxon).
- b. A hardware system and an independent FDA software system in the GPCs generate C&W tones. In many cases, the hardware system and the software system sense the same parameter. Both systems trigger alarms for out-of-limits conditions. There are many parameter inputs sensed only by the hardware system or only by the software system. A majority of the software sensing for C&W limit violations is accomplished by the SM system within the computer; however, the Guidance, Navigation, and Control (GNC) software also provides inputs to generate alarms and messages.
- c. SM alert tones are triggered by software only (FDA or GNC software) for out-of-limit conditions, indicating possible abnormal system operation.

The C&W system interfaces with and monitors the listed parameters from the following systems:

- a. Auxiliary Power Unit (APU) pressures, temperatures, quantities, discretes, speed, and events
- b. Communication System (COM) temperatures, Communications Security (COMSEC) and Network Signal Processor (NSP) events, Ground Control Interface Logic (GCIL) configuration
- c. DPS GPC fail flags
- d. Environmental Control and Life Support System (ECLSS) pressures, temperatures, quantities, flow rates, speed discretes, and dP/dT pressure change rate
- e. Electrical Power System (EPS) bus currents and voltages, cryo temperatures and pressures, fuel cell temperatures, valve positions, cell performance monitor, and events
- f. Flight Control System (FCS) discrete events
- g. Guidance and Navigation (G&N) Inertial Measurement Unit (IMU) discrete output by the GNC computers
- h. Hydraulic (Hyd) pressures, temperatures, and quantities

- i. Main Propulsion System (MPS) pressures
- j. Reaction Control System (RCS) pressures and temperatures and fail discretes
- k. Orbital Maneuvering System (OMS) temperatures, pressures, and discretes
- l. Payload input channels for six discretes
- m. Payload Deployment and Retrieval System joint limitations

At this point it is useful to define some commonly used terms.

- a. Limits A set of limits (upper and lower) defines a normal/acceptable operating range. "Out-of-limits" means the parameter is outside its normal/acceptable operating range.
- b. Inhibited A parameter that is inhibited no longer annunciates an alarm if it has gone out-of-limits.
- c. Tripped A tripped parameter is one that has gone out-of-limits; in other words, exceeded its limit range.
- d. Hardware system Pertaining to our context, a hardware system is one that uses hardware, such as switches, to work with parameters. It has its own hardware electronics unit that monitors parameters and issues alarms.
- e. Software system A software system relies on software to issue an alarm, to monitor parameters, and to work with parameters.

2.3 C&W CLASSES

Four alarm classes makeup the C&W system (Figure 2-1).

2.3.1 Class 1 - Emergency

Class 1 emergency has two types of alarms, smoke detection/fire suppression and rapid cabin depressurization. Class 1 alarms are generated only by the hardware system and normally receive the highest priority for resolution.

Smoke detectors are located throughout the crew compartment. Alarm signals and smoke particle concentration readings are provided to the crew. Once the crew confirms a fire, they can extinguish the fire by actuating the permanently mounted fire bottles if the fire is in an avionics bay or by using a handheld extinguisher if the fire is on the flight deck or middeck.

The cabin pressurization rate, also called delta pressure/delta time (dP/dT), senses the rate at which atmospheric pressure in the orbiter is changing with respect to time (in psi/min). An alarm is issued only for a rapid cabin depressurization (in other words, only for negative dP/dT).

2.3.2 Class 2 - C&W

Class 2 C&W consists of two subclasses, primary C&W, which is generated by the hardware components, and B/U C&W, which is generated by the software system.

Primary C&W uses Panel R13U and the C&W switches on Panel C3 to access the system.

B/U C&W is accessed through SM SPEC 60, SM TABLE MAINT, which can be displayed on a selected DPS display.

2.3.3 Class 3 - Alert

Class 3 alerts are only provided through the software system.

This system is accessed through SM SPEC 60, SM TABLE MAINT, which can be displayed on a selected DPS display.

2.3.4 Class 0 - Limit Sensing

Class 0 is part of the FDA software system to aid crews in identifying which parameter is out-of-limits. It consists of up and down arrows (\uparrow , \downarrow) displayed on the DPS display next to a parameter. Please note that the "Class 0" function does not activate alarm lights or tones.

A down arrow (\downarrow) indicates that the low limit for that parameter has been violated. In addition, the down arrow is used to indicate a state that does not agree with the nominal state. For example, a down arrow would be displayed next to a fan that is off but nominally is on, like the humidity separator fan.

An up arrow (\uparrow) indicates that the upper limit for that parameter has been exceeded.

Limit sensing uses either the B/U C&W or the alert software limits. For cases where a parameter is monitored by both FDA software limits, the alert limits will drive the arrows.

Table 2-1. Alarm tone description

Tone	Actual and SPEC	Description
Siren	ACTUAL	Varying frequency from 666 cycles per second (Hz) to 1470 Hz and return with a period of 5 seconds
	SPEC	Varying frequency from 666 ± 66 Hz to 1470 ± 147 Hz and return with a period of a 5 ± 0.5 seconds
Klaxon	ACTUAL	2560 Hz with a period of 2.1 ms ON and 1.6 ms OFF mixed with a 256 Hz tone with a period of 215 ms ON and 70 ms OFF
	SPEC	2500 ± 250 Hz with a period 2.1 ± 0.2 ms on and 1.6 ± 0.2 ms OFF mixed with a 270 ± 27 Hz tone with a period of 215 ± 21 ms ON and 70 ± 7 ms OFF
C&W tone	ACTUAL	Alternating signal of 400 Hz and 1024 Hz at a 2.5 Hz rate. (In other words, it is 400 Hz for 0.4 seconds, then 1024 Hz for 0.4 seconds)
	SPEC	Alternating signal of 375 ± 37.5 Hz and 1000 ± 100 Hz at a 2.5 ± 0.25 Hz rate
Alert tone	ACTUAL	Continuous tone of 512 Hz
	SPEC	Continuous tone of 550 ± 55 Hz

2.4 QUESTIONS

1. List the C&W alarm classes and their titles.
2. Which alarm class generally receives the highest priority? Why?
3. Define the phrase “out-of-limits.”
4. How many of the classes contain software systems? Name the classes.

3.0 CLASS 1 EMERGENCY

3.1 OBJECTIVES

After reading the material about the fire and smoke subsystem, the student should be able to

- a. State the alarm annunciation, both audio and visual
- b. Identify the location of each smoke detector, fire bottle, and portable fire extinguisher
- c. Describe how the smoke detectors and fire bottles operate
- d. Identify relevant data on the DPS display, SM SYS SUMM 1
- e. Identify and describe the function of relevant switches and circuit breakers (cb's) on Panels L1, O14, O15, and O16
- f. Explain the purpose of the fire ports
- g. Summarize facts about Halon 1301

After reading the material about the cabin dP/dT subsystem, the student should be able to

- a. State alarm annunciation, both aural and visual
- b. Identify the relevant meter on Panel O1
- c. Identify the relevant data on DPS displays SM SYS SUMM 1 and SPEC 66
- d. Describe the normal cabin dP/dT for ascent, orbit, and entry
- e. Explain the alarm difference between +dP/dT and -dP/dT

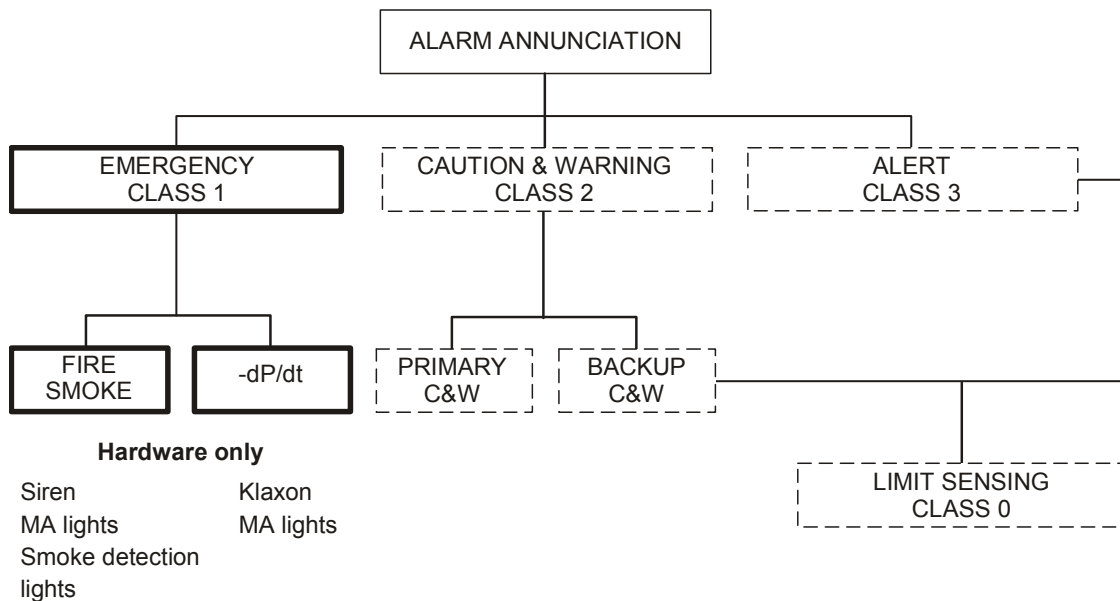
3.2 OVERVIEW

The class 1 emergency alarms are generated only by the hardware system. It consists of two subsystems: fire and smoke subsystem, which includes fire detection and suppression, and -dP/dT subsystem, which monitors cabin depressurization (Figure 3-1). Each subsystem provides a unique audio alarm to alert the crew, in addition to providing visual warning lights.

Fire detection capability is provided by smoke detectors located in the cabin and in each of three avionics bays.

Fire suppression is accomplished with three handheld extinguishers for the cabin. Access ports in panels, allows fire agent to be applied behind panels to the source of a fire/smoke. These handheld extinguishers are available as B/Us for the avionics bay extinguishers. The three avionics bay extinguishers are remotely controlled through Panel L1. All extinguishers are charged with Halon 1301.

The cabin dP/dT indication is provided by one dP/dT sensor located in the orbiter. The class 1 emergency alarm is triggered only for a decrease in pressure (-dP/dT) and is not triggered for an increase in cabin pressure (+ dP/dT).



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Figure 3-1. Class 1 alarm diagram

3.3 FIRE AND SMOKE SUBSYSTEM

3.3.1 Annunciation

The fire and smoke subsystem uses audio and visual signals to alert the crew. These cues include

- a. Visual cues
 1. MA lights on Panels F2, F4, A7, and MO52J (Figure 2-2 and Figure 2-3)
 2. Panel L1 - Smoke detection light matrix

- b. Audio cue

Siren tone - Varying frequency from 666 to 1470 Hz and return at a 5-sec/cycle rate. The siren can be silenced by pressing any MA PBI.

Note: The B/U C&W system (see Section 4.5.2) will annunciate a C&W alarm (class 2) for high smoke concentration.

3.3.2 Fire Detection

3.3.2.1 Smoke Detector Locations

Nine smoke detectors are monitored by the emergency system and are located throughout the cabin and avionics bays (Figure 3-2). Payload smoke detection can be added for mission specific requirements. The detectors are divided into two groups, A and B.

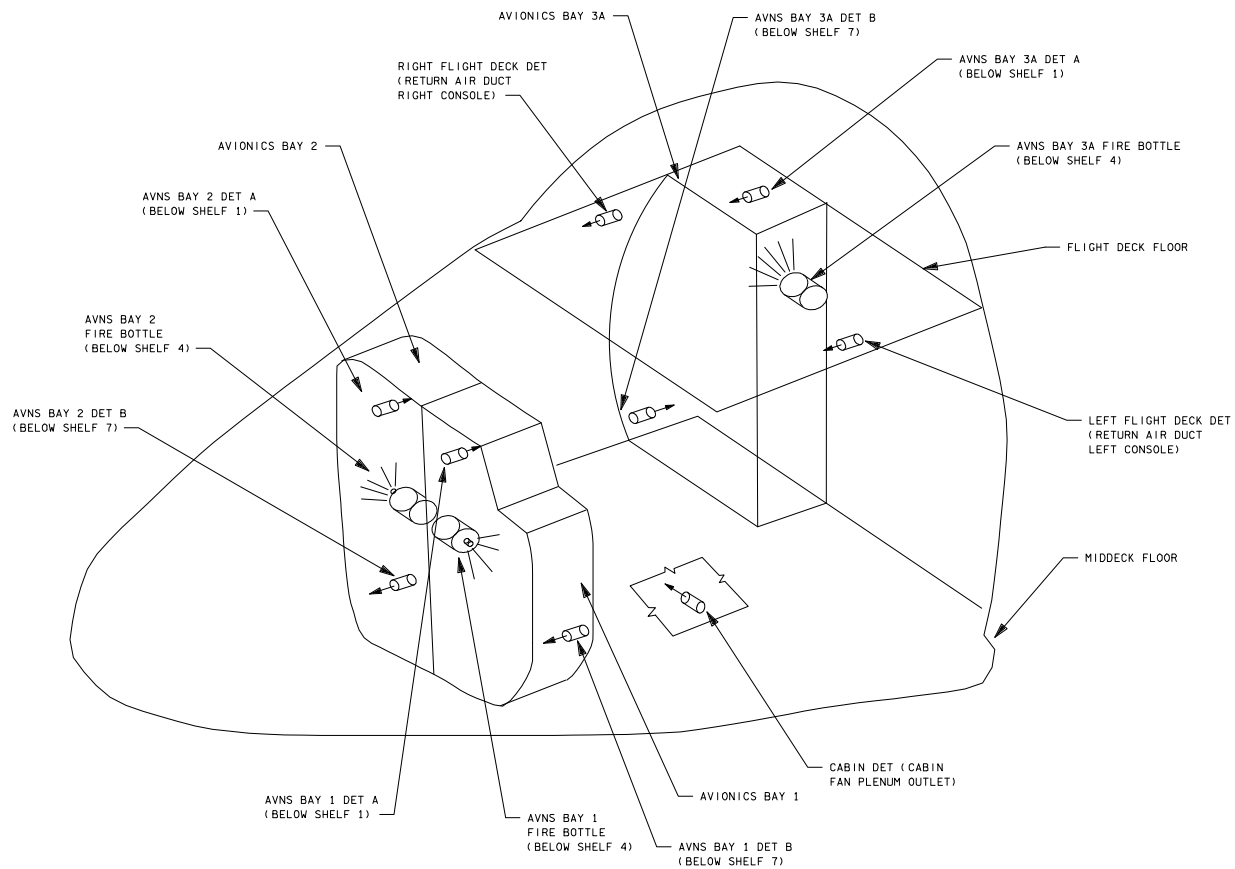
- a. Group A detectors include
 - 1. One on the cabin fan outlet
 - 2. One on the left return air duct of the flight deck
 - 3. One in each of the three avionics bays
- b. Group B detectors include
 - 1. One on the right return air duct of the flight deck
 - 2. One in each of the three avionics bays
 - 3. Payload smoke detection system input (Mission specific)

3.3.2.2 Smoke Detection

Each smoke detector will issue an alarm if either of the following two cases is violated:

- a. Smoke particle concentration of $2000 \pm 200 \mu\text{g}/\text{m}^3$ (for two consecutive counts; counts are 2.5 seconds apart)
- b. Rate of increase in concentration of $22 \mu\text{g}/\text{m}^3$ per second for eight consecutive counts (which takes 20 seconds)

If a fire occurs in an avionics bay, each smoke detector in that bay should detect the fire and illuminate its corresponding smoke detection light on Panel L1. Refer to Section 3.3.1 for a complete description of the alarm annunciation. The avionics bay detectors are located near the top and bottom of each bay, with the Halon bottle located near the middle.



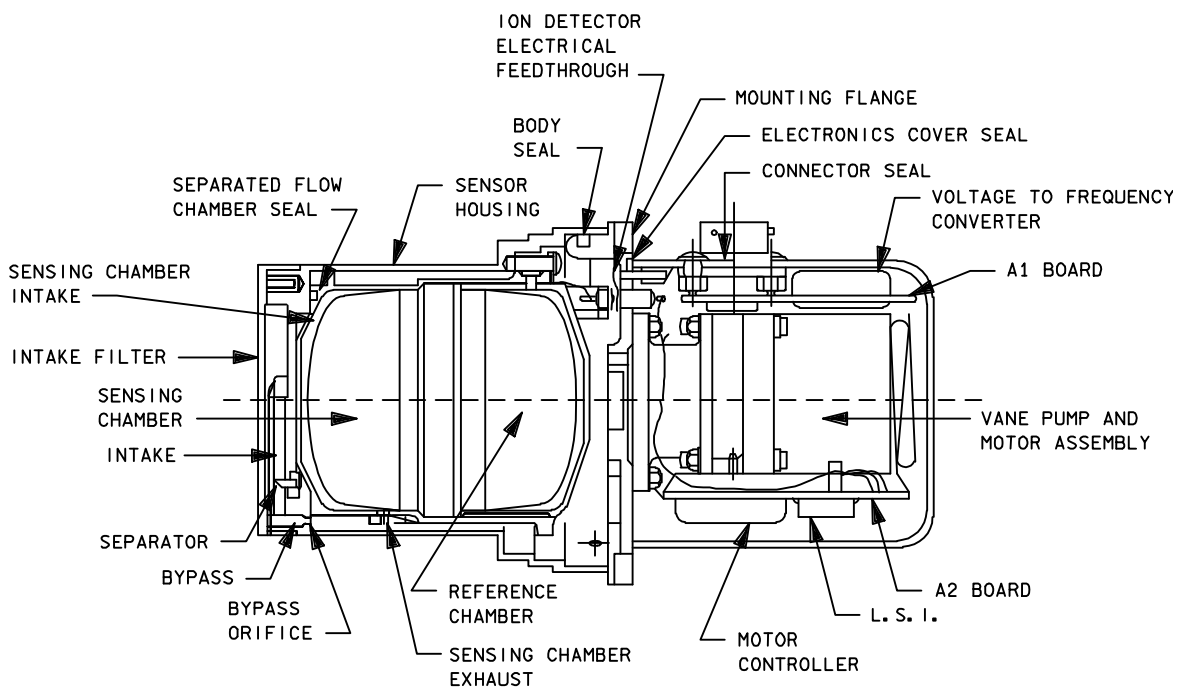
TD4020302. ART. 2

Figure 3-2. Smoke detector and fire bottle locations

Once the alarm system has been triggered, it remains latched until a reset signal is input to the detector from Panel L1 (see Figure 3-3). While the system is latched, the emergency alarm system will not activate a second siren alarm (class 1) for another fire indication. However, the appropriate Panel L1 smoke detection light, and the smoke concentration on SM SYS SUMM 1 will provide valid indications. The B/U C&W software will trigger a C&W tone (class 2). Note: the group A detectors are independent from the group B detectors and could generate a second emergency alarm if only one group was previously activated and latched. The crew should reset the Fire Detection circuits at the earliest opportunity.

The smoke detectors are sensitive to submicron particles and will annunciate an alarm for a presmoke state of a potential fire condition. These particles are emitted from materials that have been subject to abnormal energy, such as wire bundle heating due to excessive current.

Figure 3-3 shows the smoke detector used by the orbiter. It requires approximately 6.5 Watt (W) of power to run. The detector uses a positive displacement pump (fan) to draw a continuous air sample into the inlet filter. The inlet filters out particles larger than 40 microns. The flow, once through the intake, is turned to pass the separator inlet.



TD4020304. ART, 1

Figure 3-3. Smoke detector

The separator allows particles of 2 microns or less to enter. This is accomplished by flowing the air sample across the separator inlet. The kinetic energy of the air flow is great enough that the larger particles continue past the separator inlet and exit from the detector. The smaller particles, 2 microns or less, are drawn into the separator and enter the sensing chamber. The reference chamber is filled with a sample of static air

and is not recharged unless a pressure differential occurs in the surrounding atmosphere. Therefore, the reference chamber provides a semi static sample of air as a reference. However, the sensing chamber is constantly recycled and uses the static air sample in the reference chamber for a comparison.

The sensing and reference chambers are separated by Americium 241. The Americium 241 is a radiation source that discharges alpha particles into both chambers. The air molecules become ionized by the radiation field and are attracted to the outer cover of the chamber. The cover acts as an electrode, thus creating current flow. The submicron particles present in the sensing chamber are attracted by and become attached to the ionized air molecules. This reduces their mobility and causes a drop in current flow. The difference in current flow between the sensing and the reference chamber, which does not see the submicron particles, is processed to provide the alarm and analog concentration outputs. The air exits the sensing chamber and mixes with the bypassed flow. The mixture then exits the detector through the fan.

3.3.2.3 Smoke Detection Circuit Test

The smoke detection system includes a test circuit that tests the light circuitry, pump motors, and proper function of rate alarm and concentration alarm processing circuits. Figure 3-4 shows a functional diagram of the avionics bay fire suppression and circuit test system.

When testing a detector, the circuit test switch selects either all A or all B detectors. When the test switch on Panel L1 is placed in the A (or B) position, power is applied to the Annunciator Control Assembly (ACA) channels. The agent discharge lights illuminate immediately. Approximately 20 seconds later, the smoke detection A (or B) lights (PAYLOAD light is mission specific) illuminate and the siren is triggered. Following this indication, when the circuit test switch is taken to off, the agent discharge lights are extinguished. If the circuit test switch is taken to off between 5 and 10 seconds after being placed in A (or B), the agent discharge lights go out, the smoke detection A (or B) lights illuminate, and the siren is triggered. Note: The Payload light is part of the B detectors. It is mission specific and tested via other procedures, but it is normally disconnected.

The siren can be interrupted by pressing an MA PBI. The smoke detection A and B lights are extinguished by taking the sensor switch to reset and releasing the momentary switch. All detectors are reset with the sensor reset switch. If there is a switch failure, and the detector is stuck in the reset or self-test position, the analog concentration output still responds to changes in smoke level.

The Smoke Detection Circuit Test procedure is found in the ECLSS section of the Orbit Operations (ORB OPS) Checklist (C/L). Refer to a copy of this C/L for the current procedure. The procedure is normally performed during the first day in orbit.

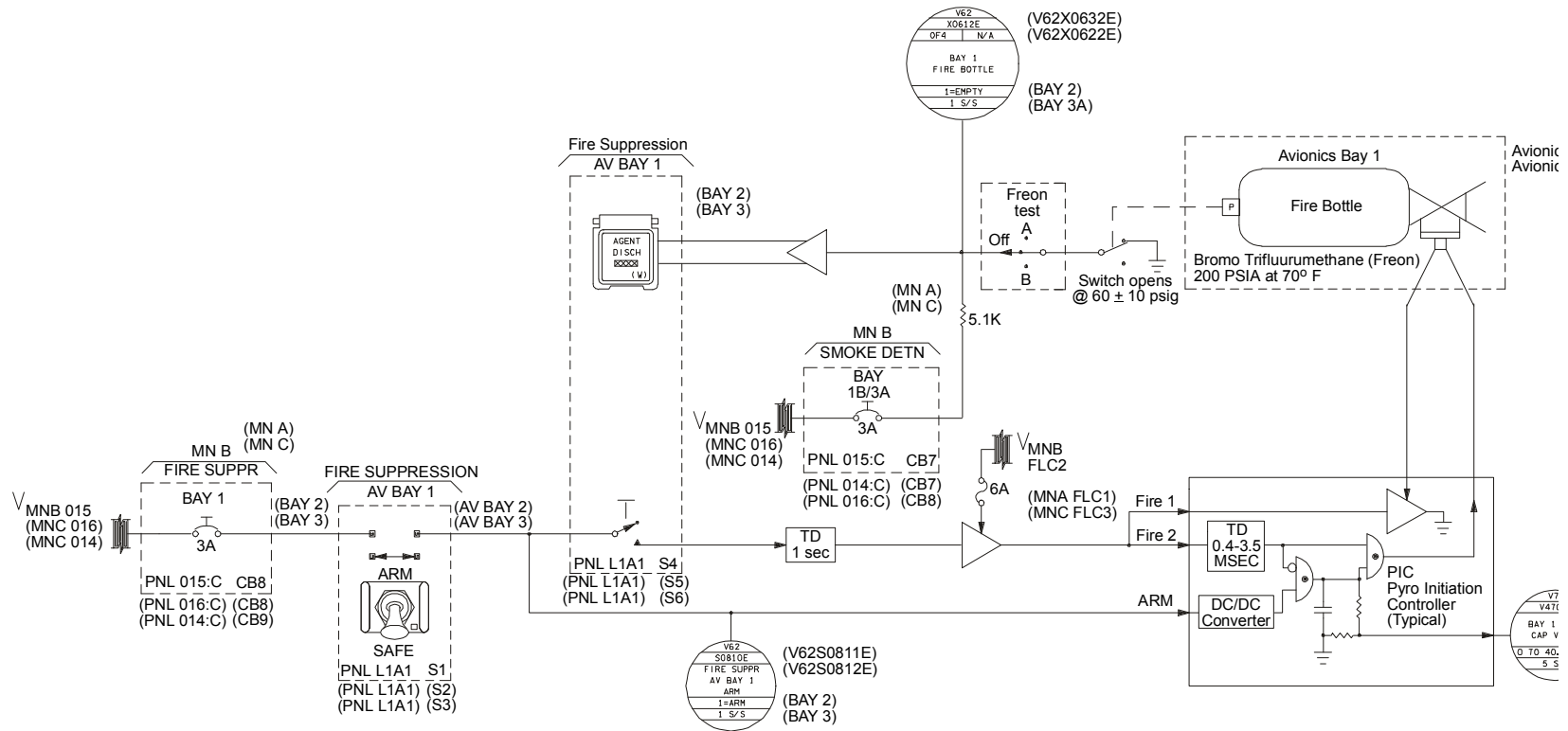


Figure 3-4. Avionics bay fire suppression and circuit test system

3.3.2.4 Performance Monitoring

The smoke concentration is monitored by SM SYS SUMM 1 (SPEC 78) in the Backup Flight System (BFS) for Operational Sequence (OPS) 1 and 3 and Primary Avionics Software System (PASS) for OPS 2 (Figure 3-5). The values displayed are sent from the respective smoke detectors.

The normal reading from the detectors on the DPS display is -0.5 to + 0.5 mg/m³. A reading of 2.0 mg/m³ triggers the B/U C&W alarm annunciation. (mg/m³ = milligrams per cubic meter)

3.3.2.5 Troubleshooting False Alarms

After an alarm and a reset of the detector, the following conditions may be observed:

- a. If the alarm returns immediately, the concentration readouts should be observed on SM SYS SUMM 1 in the affected location. If concentrations are normal, the alarm is false.
- b. If the alarm does not return, perform self-test. If available, check concentrations on SM SYS SUMM 1.

0001/ /078		SM SYS SUMM 1		5 000/03:13:09 BFS 000/00:00:00		
SMOKE	1/A 2/B	DC VOLTS	1/A 2/B 3/C			
CABIN	- 0.9	FC	31.1 31.1 31.1			
L/R FD	- 0.4 0.2	MAIN	31.0 31.1 31.0			
AV BAY	1 - 1.2 - 0.0	ESS	29.8 29.8 29.8			
	2 - 0.6 - 0.3			A-----B-----C-----A		
	3 - 0.1 - 0.9	CNTL	1 29.3 29.3 29.3			
CABIN			2 29.3 *00.0↓ 29.3			
RESS	14.7		3 29.3 29.3 29.3			
dP/dT	+0.00	AC				
BU/EQ	-0.00 +0.00	VOLT	φA 117 117 117			
PPO2	3.02 3.02		φB 117 117 117			
FAN DP	5.79		φC 117 117 117			
HX OUT T	49	AMPS	φA 4.4 4.1 2.7			
O2 FLOW	0.0 0.0		φB 3.9 4.2 3.2			
N2 FLOW	0.0 0.0		φC 2.4 3.2 4.8			
IMU FAN DP	4.62	FUEL CELL PH				PH↓
DV FC1 FC2 FC3		AMPS	172 167 178			
SS1 15 18 18		REAC VLV	OP OP OP			
SS2 16 20 11		STACK T	+204 +203 +203			
SS3 22 26 26		EXIT T	150 150 151			
TOTAL AMPS	510	COOL P	61 61 61			
KW	15	PUMP				ΔP↓

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(a) BFS

2011/ /078		SM SYS SUMM 1		4 000/14:44:12 000/00:00:00		
SMOKE	1/A 2/B	DC VOLTS	1/A 2/B 3/C			
CABIN	0.0	FC	30.6 30.1 31.0			
L/R FD	0.0 0.0	MAIN	30.6 30.1 31.0			
AV BAY	1 0.3 0.3	ESS	29.6 29.6 29.3			
	2 0.3 0.4			A-----B-----C-----A		
	3 0.3 0.3	CNTL	1 29.4 29.4 29.6			
CABIN			2 29.4 29.4 29.4			
PRESS	14.0		3 29.4 29.4 29.4			
dP/dT-EQ	+0.00 +0.000	AC				
O2 CONC	21.4	VOLT	φA 118 118 117			
PPO2	3.00 3.00		φB 117 117 118			
FAN ΔP	5.00		φC 117 117 118			
HX OUT T	46	AMPS	φA 4.3 6.3 2.1			
O2 FLOW	0.0 0.0		φB 5.5 6.6 2.2			
N2 FLOW	0.0 0.0		φC 3.1 5.0 3.2			
IMU FAN A B* C		FUEL CELL				
AV FC1 FC2 FC3		AMPS	180 232 146			
SS1 22 21 22		REAC VLV	OP OP OP			
SS2 22 22 23		STACK T	+202 +206 +200			
SS3 23 21 21		EXIT T	150 152 149			
TOTAL AMPS	557	COOL P	61 60 61			
KW	17	PUMP				

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(b) PASS

Figure 3-5. SMS SYS SUMM 1 (SPEC 78)

3.3.3 Fire Suppression

3.3.3.1 Portable Fire Extinguishers

The portable fire extinguishers can be used to suppress fires in open areas as well as closed areas. One extinguisher is on the flight deck and two are on the middeck (Figure 3-6). The portable extinguishers are pressurized to 380 psig and are slightly smaller than the avionics bay fire bottles. The fire extinguisher nozzle should be inserted into the fire hole and actuated for about 90 seconds to complete the discharge. Ninety percent of the bottle will be discharged within the first 30 seconds.

3.3.3.2 Fire Ports

Fire ports, sized to fit the extinguisher nozzles, are present throughout the flight deck and middeck (Figure 3-7). The ports are of two types, a 1/2-inch diameter hole covered with a marked label or a 1/2- to 1/4-inch diameter tapered hole. To suppress a fire behind a panel or within an avionics bay, the extinguisher nozzle is inserted into the fire port and the actuating mechanism is depressed for at least 15 seconds for an individual panel or till empty for the Av Bay.

3.3.3.3 Avionics Bay Fire Bottles

The avionics bay fire suppression system consists of three permanent fire suppressant (Halon) bottles. The fire bottles are mounted in avionics bays 1, 2, and 3A (Figure 3-7 (concluded)).

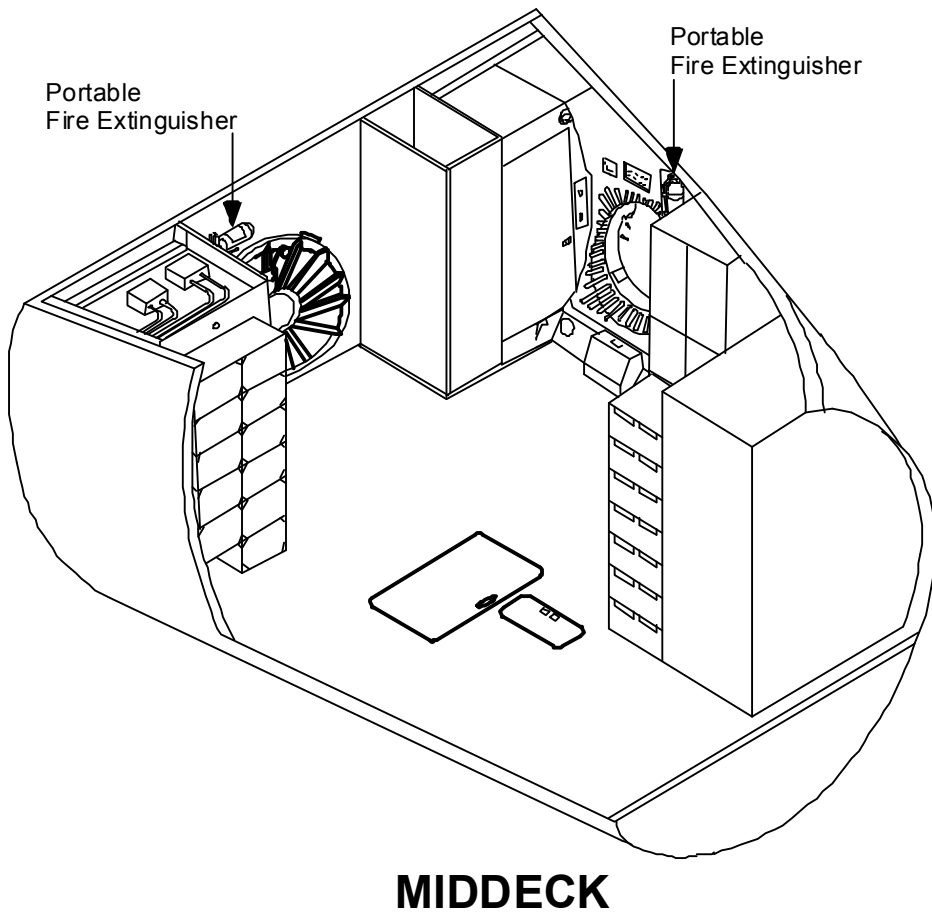
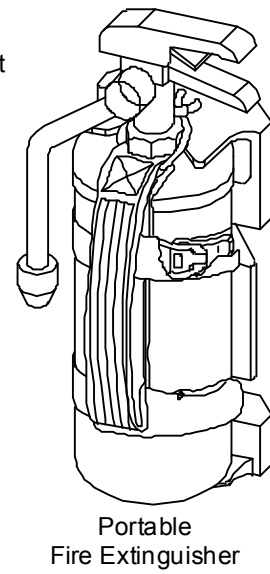
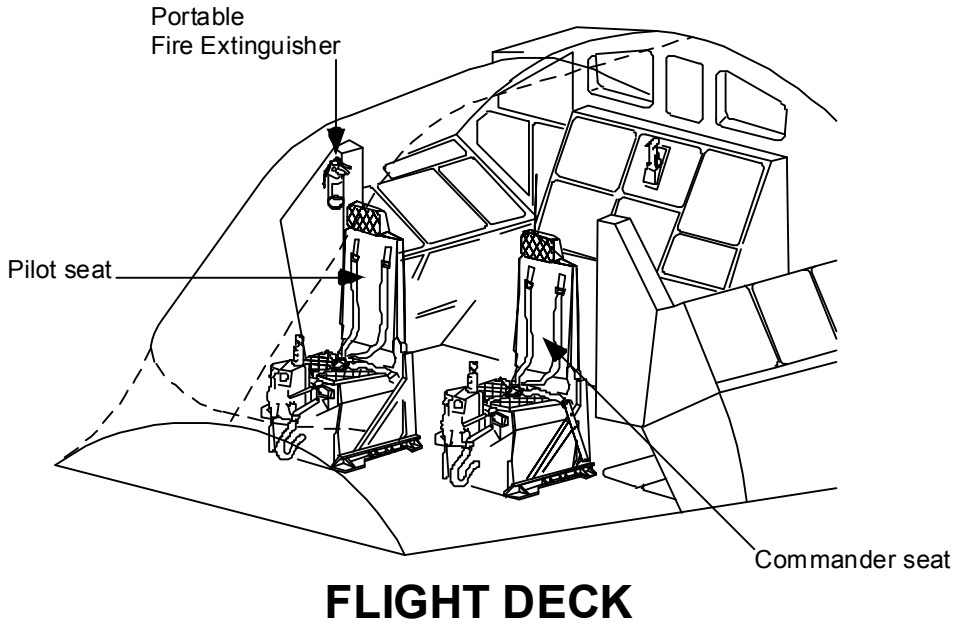
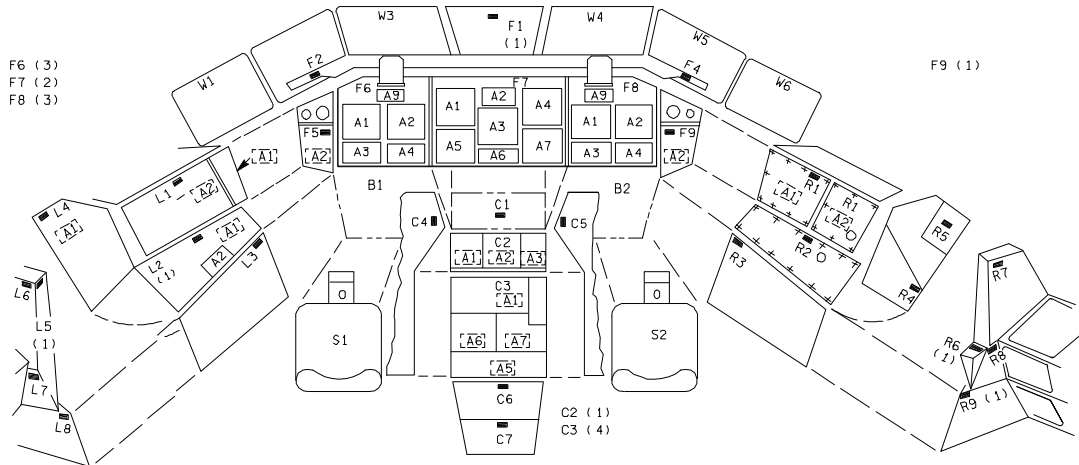
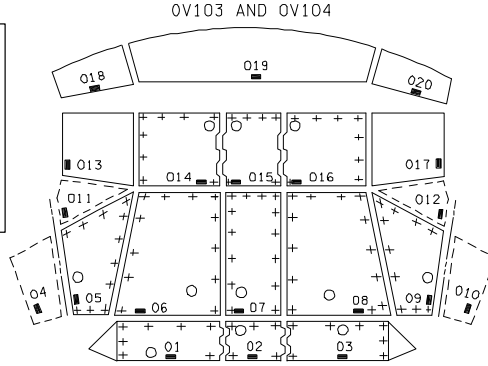
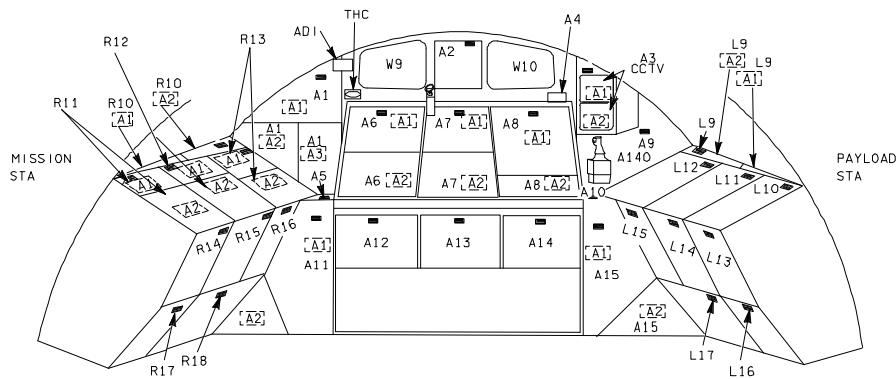


Figure 3-6. Portable fire extinguisher locations

- NOTES**
- FIRE PORTS PROVIDE ACCESS TO AREAS BEHIND CONTROL AND DISPLAY PANELS
 - FIRE PORTS ARE SIZED TO FIT PORTABLE FIRE EXTINGUISHER NOZZLE
 - PANELS CONTAINING FIRE PORTS ARE SHADED AND IDENTIFIED BY PANEL NUMBER
- R1 = PANEL NUMBER
(1) = NUMBER OF FIRE PORTS ON PANEL

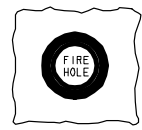


FLIGHT STATION



AFT STATION

OBRITER PANEL CONFIGURATION

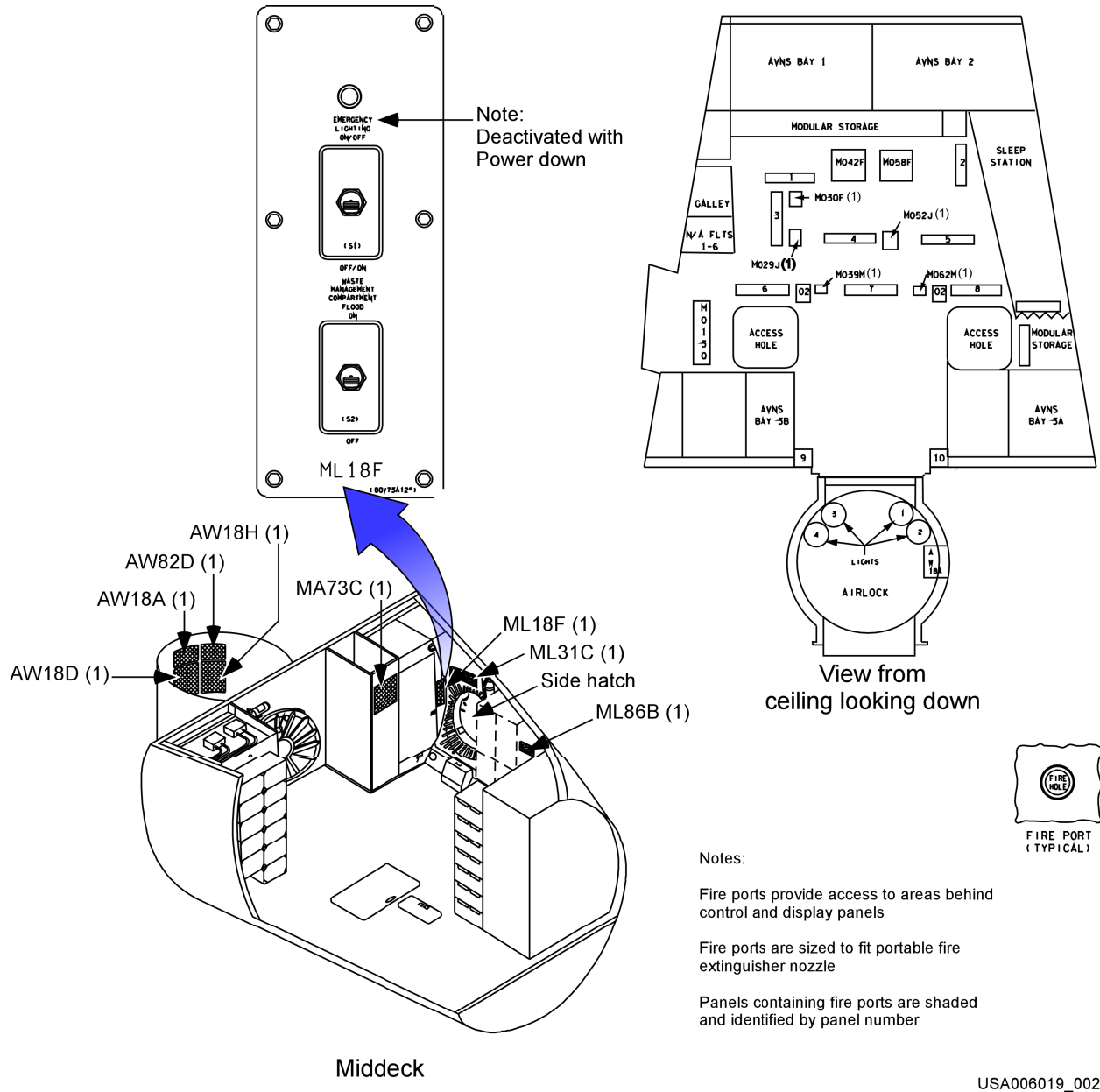


FIRE PORT
(TYPICAL)

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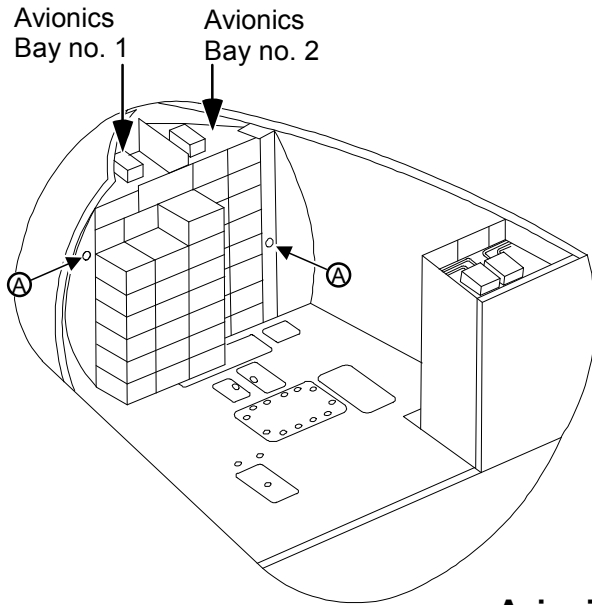
(a) Flight and aft stations

Figure 3-7. Fire port locations



(b) Middeck

Figure 3-7. Fire port locations (continued)

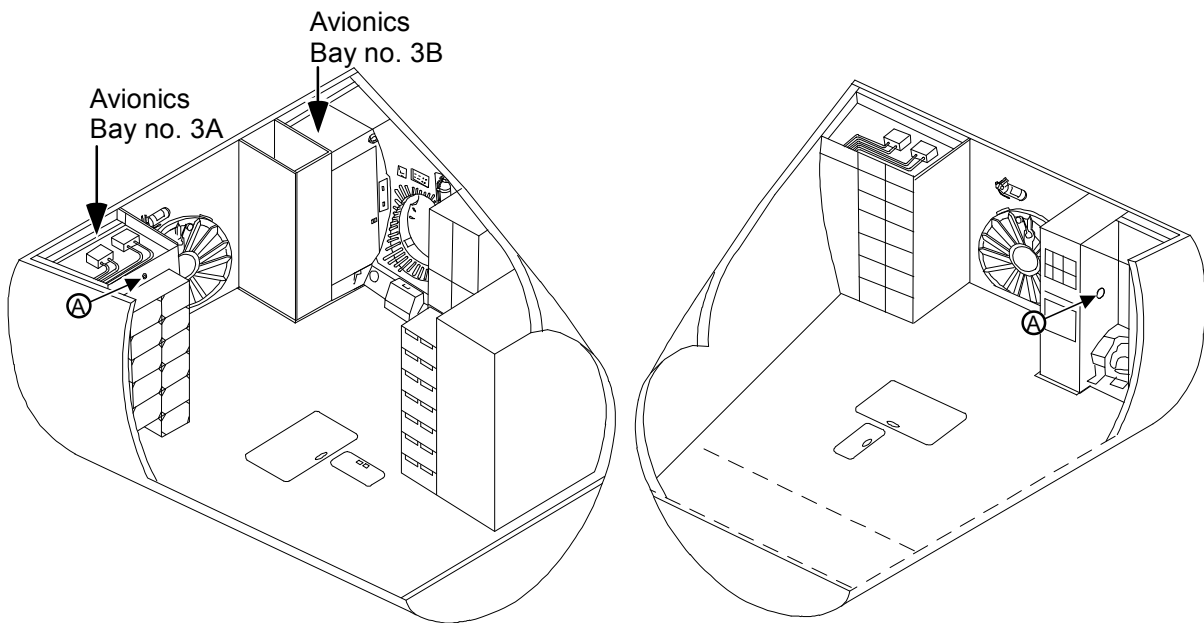


Notes:

- Fire ports provide access to avionics bays
- Fire ports are sized to fit portable fire extinguisher nozzle

Ⓐ Fire port/guide (typical)

Avionics bays 1 and 2



Avionics bays 3A and 3B

(c) Avionics bays

Figure 3-7. Fire port locations (concluded)

3.3.3.4 Fire Bottle Discharge Procedure

The fire bottles in the avionics bays 1, 2, and 3A are electronically discharged by performing the following actions on Panel L1 (Figure 3-8):

FIRE SUPPRESSION - ARM

FIRE SUPPRESSION pb - DISCH (push until lit)

Placing the switch in the ARM position provides power to the AGENT DISCHARGE PBI, which is guarded by a cover. Once the AGENT DISCHARGE PBI is depressed, there is a 1-second time delay before power is applied. The time delay is designed to prevent accidental discharge. The PBI needs to be held for approximately 2 seconds to ensure activation of the Fire Bottle. The time delay then routes main electrical power to the Pyro Initiation Controller (PIC). The PIC opens the valve on the fire suppression bottle. When the pressure in the bottle drops to about 60 (± 10) pounds per square inch gauge (psig), the AGENT DISCHARGE light illuminates.

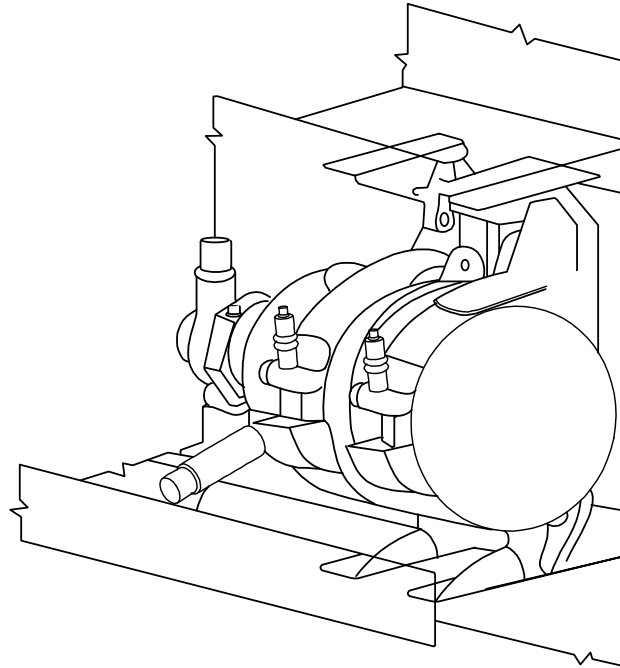
The discharge of the bottle in the avionics bay gives a Halon concentration of 7.5 to 9.5 percent and then slowly decrease over time. A 4 to 5 percent concentration is required to suppress a fire. Portable bottles are considered backups to the avionics bay bottles for avionics bay fires and will provide a Halon concentration of 6 to 7 percent.

The FIRE/SMOKE cue card contains the fire suppression procedures for ascent and entry on one side, and orbit on the opposite side. The cue card is mounted to the left of the fire suppression switches on Panel L1.

3.3.3.5 Fire Bottle Operation

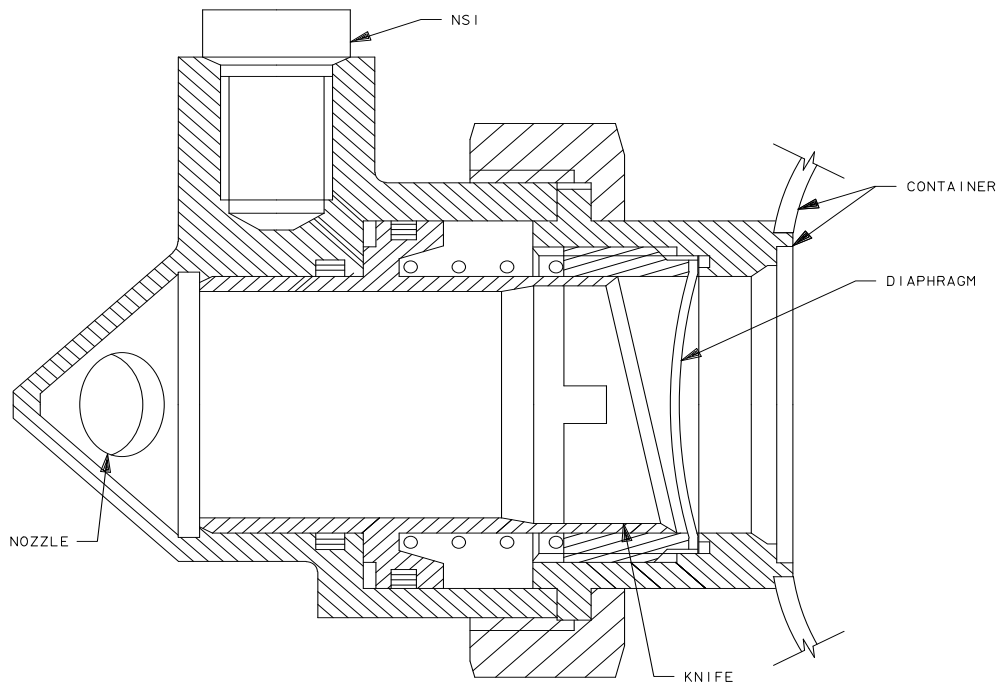
The fire bottle consists of a nozzle assembly, pressure switch, and pressure vessel (Figure 3-8 and Figure 3-9).

The nozzle assembly consists of a 1.5-inch nozzle, a PIC, a spring, and a hollow cylindrical knife. The PIC provides an explosion when the agent discharge button on Panel L1 is depressed. This explosion compresses the spring, which drives the knife into the pressure vessel diaphragm. The diaphragm ruptures and releases the Halon. Before being fired, an avionics bay bottle pressure is 185 psig at 65° F. When the pressure drops to 60 \pm 10 psig, the pressure switch sends a signal to Panel L1 and illuminates the agent discharge light. The pressure inside the avionics bay momentarily rises approximately 1 psia when the avionics bottle is discharged. Bottle discharge may be heard by the crew, and tests have shown that the overall sound pressure level may reach 143 dB (decibel).



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Figure 3-8. Fire bottle and mount



TD4020312. ART: 2

Figure 3-9. Fixed fire extinguisher nozzle assembly

3.3.3.6 Performance Monitoring

Once the fire bottle in an avionics bay has been discharged, the smoke concentration caused by the fire will stabilize. However, the smoke detectors will see a concentration spike of about $6000 \mu\text{g}/\text{m}^3$ (handheld extinguisher) or about $7500 \mu\text{g}/\text{m}^3$ (avionics bay fire bottle) when the Halon is discharged. Within about 90 to 120 seconds, the smoke concentration values on SM SYS SUMM 1 will have more or less returned to the stable smoke particle concentration remaining from the fire (See Space Shuttle Systems Handbook (SSSH) 5.1-1).

The Halon is effective in the cabin and within the orbiter panels only if the cabin fan is turned off. As a note for comparison, if all three handheld extinguishers are discharged in the cabin with air circulation, the Halon concentration will be less than one percent (four percent minimum required to be effective). The Cabin Fire procedures call for the cabin fan to be off a "maximum of 20 minutes" due to equipment cooling. This will ensure the Halon concentrations remain high enough to extinguish the fire, help localize toxic byproducts, and minimize any oxygen introduction to the fire. Once the cabin fan is turned back on, the concentration of Halon is dispersed evenly throughout the cabin and is not sufficient to suppress fires. Halon concentrations in the cabin will decrease with time. If another fire occurs, another handheld fire bottle discharge is required to suppress the fire. The Halon is effective in an avionics bay for 50 hours, even with the avionics bay fan operating.

3.3.4 Controls

The primary controls for observing and activating the fire systems is Panel L1. (See Figure 3-10) The cb's that control the fire and smoke subsystem are located on Panels O14, O15, and O16 (Figure 3-11, Figure 3-12 and Figure 3-13).

3.3.4.1 Panel L1

The forward portion of Panel L1 contains the crew smoke detection indication lights, the controls to activate the Avionic Bay fire bottles, and the ability to test and reset the fire detection circuits. To operate the fire suppression, the crew will observe a fire indication, determine its location, and confirm the fire/smoke indications are real. Activating the ARM switch will provide power to the circuit. Lifting the protective cover and depressing the AGENT DISCHARGE button will fire the fire bottle PIC and dispense Halon into the selected Avionics Bay. The button must be held for 2 seconds and will only light up after the fire bottle pressure falls below 60 psig.

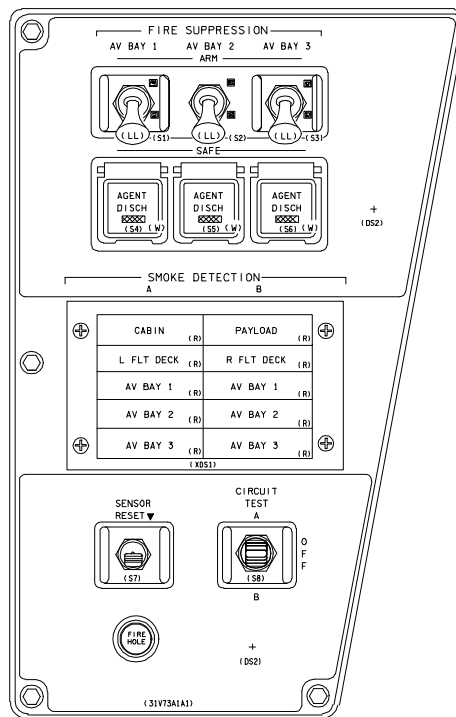


Figure 3-10. Panel L1

Table 3-1. Displays and controls

Panel	Type	Nomenclature/ position	Function	Remarks
L1	2-pos lever lock	FIRE SUPPRESSION AV BAY 1 (2, 3) SAFE/ARM	Controls power from main electrical bus B (MNB) (C, A) to the avionics bay 1 (2, 3) AGENT DISCH PBI and fire bottle PIC arm circuit	3 switches
L1	Pushbutton indicator	FIRE SUPPRESSION AV BAY 1 (2, 3) AGENT DISCH	Connects direct current (dc) power from the main bus to the PIC to activate the fire bottle discharge pyros. Also, illuminates when the fire bottle has discharged to 60 ± 10 psig	3 switches
L1	5 by 2 light display	SMOKE DETECTION A/B	Illuminates when the smoke detector connected to that light detects $2000 \mu\text{g}/\text{m}^3$ of smoke particles or a rate change of $22 \mu\text{g}/\text{m}^3$ per sec for 20 seconds	
L1	2-pos momentary	SENSOR RESET	Resets the smoke detector logic circuitry, which extinguishes the smoke-detection lights and allows for the next siren tone warning	
L1	3-pos toggle	CIRCUIT TEST A/B	Applies 28 Volt (V) power from CNTL BUS BC3 to the A or B smoke detectors to test the lights and 20-second time delay. Also, breaks the ground circuit to the AGENT DISCH light allowing the lights to illuminate	

3.3.4.2 Panel O14: C

- a. cb **MNA SMOKE DETN L/R FLT DK** - Applies power to the left and right flight deck smoke detectors.
- b. cb **MNA SMOKE DETN BAY 2A/3B** - Applies power to the avionics bay 2 sensor A and bay 3 sensor B smoke detectors, provides power for the sensor reset function of the L/R FLT DK, and 2A/3B detectors, and powers the avionics bay 3 agent discharge light.
- c. cb **MNA FIRE SUPPR BAY 3** - Supplies power to the avionics bay 3A fire suppressant bottle PIC.
- d. cb **MNA ANNUN FWD ACA 1** - Supplies power to the ACA 1 electronics and annunciator lights, including the brightness control and test function.

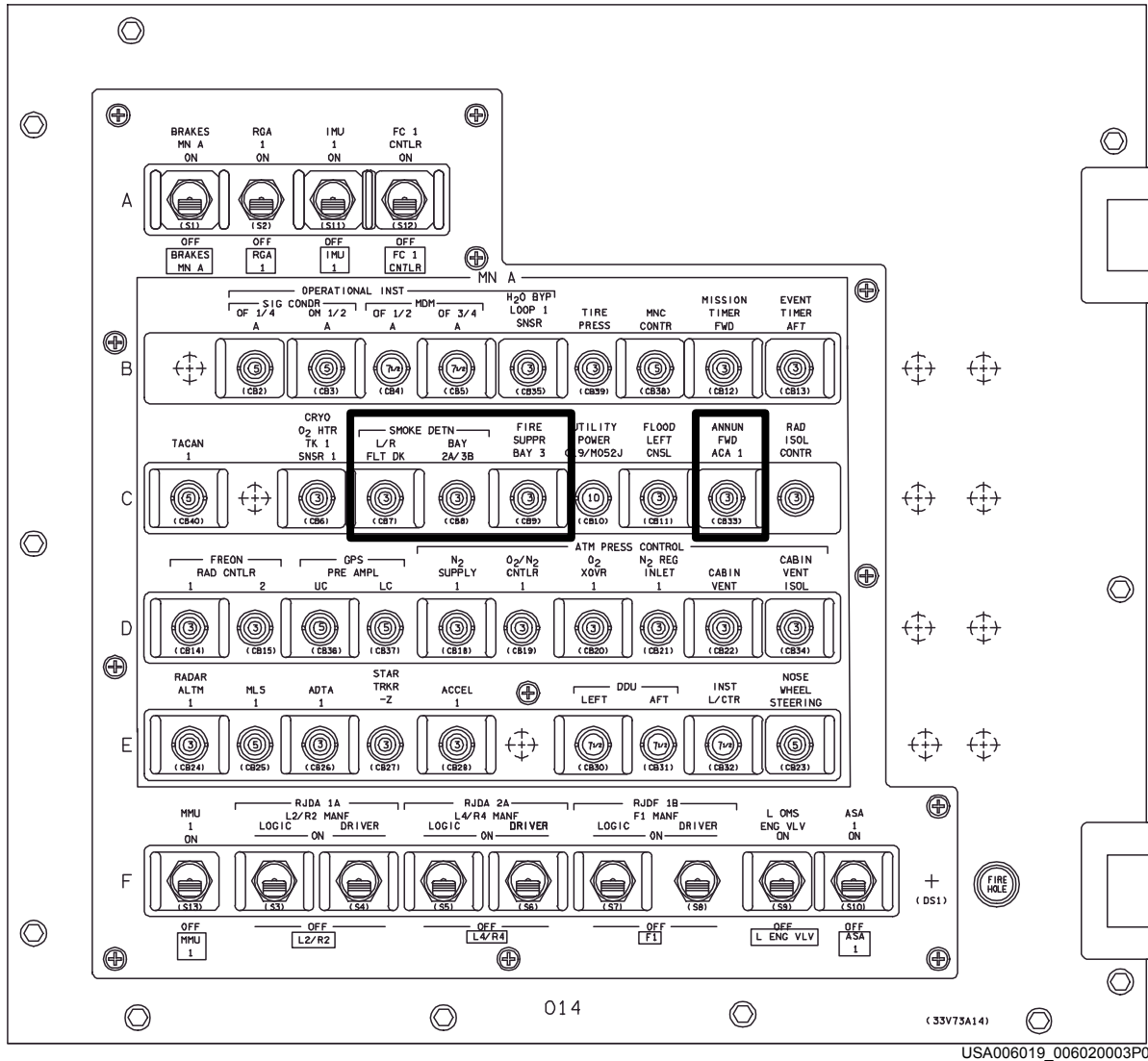


Figure 3-11. Panel O14

3.3.4.3 Panel O15: C

See Figure 3-12.

- a. cb **MNB SMOKE DETN BAY 1B/3A** - Applies power to the avionics bay 1 sensor B and bay 3 sensor A smoke detectors, provides power for the sensor reset function of the 1B/3A detectors, and powers the avionics bay 1 agent discharge light.
- b. cb **MNB FIRE SUPPR BAY 1** - Supplies power to the avionics bay 1 fire suppressant fire bottle PIC.
- c. cb **MNB ANNUN FWD ACA 1** - Supplies power to the ACA 1 electronics and annunciation lights, including the brightness control and test function.
- d. cb **MNB ANNUN FWD ACA 2/3** - Supplies power to ACA 2 and 3 electronics and annunciation lights, including the brightness control and test function.
- e. cb **MNB ANNUN AFT ACA 4/5** - Supplies power to the ACA 4 and 5 electronics and annunciation lights, including the brightness control and test function.
- f. cb **MNB PPO₂C CABIN DP/DT** - Provides power for the PPO₂C and cabin dP/dT sensors.

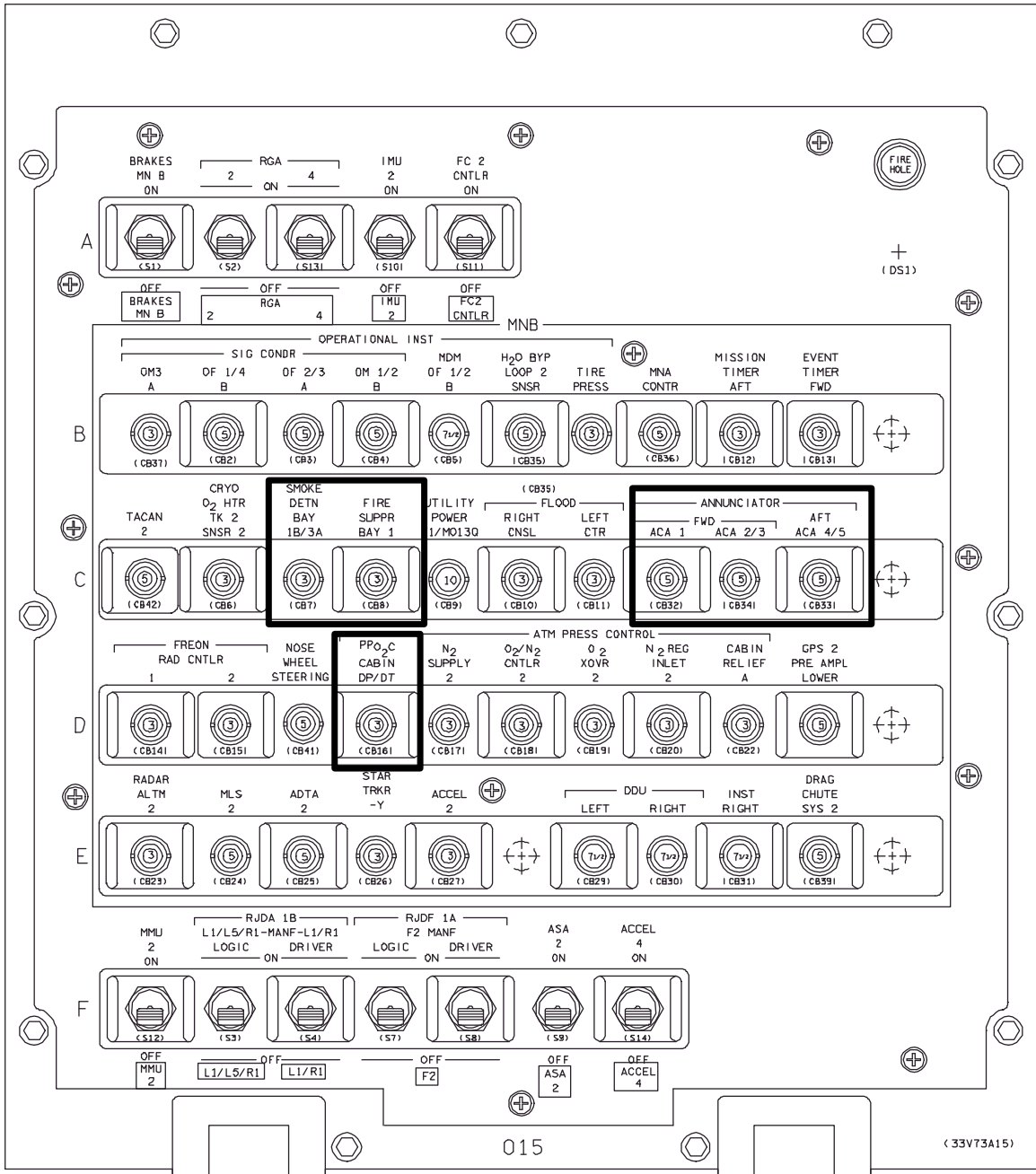


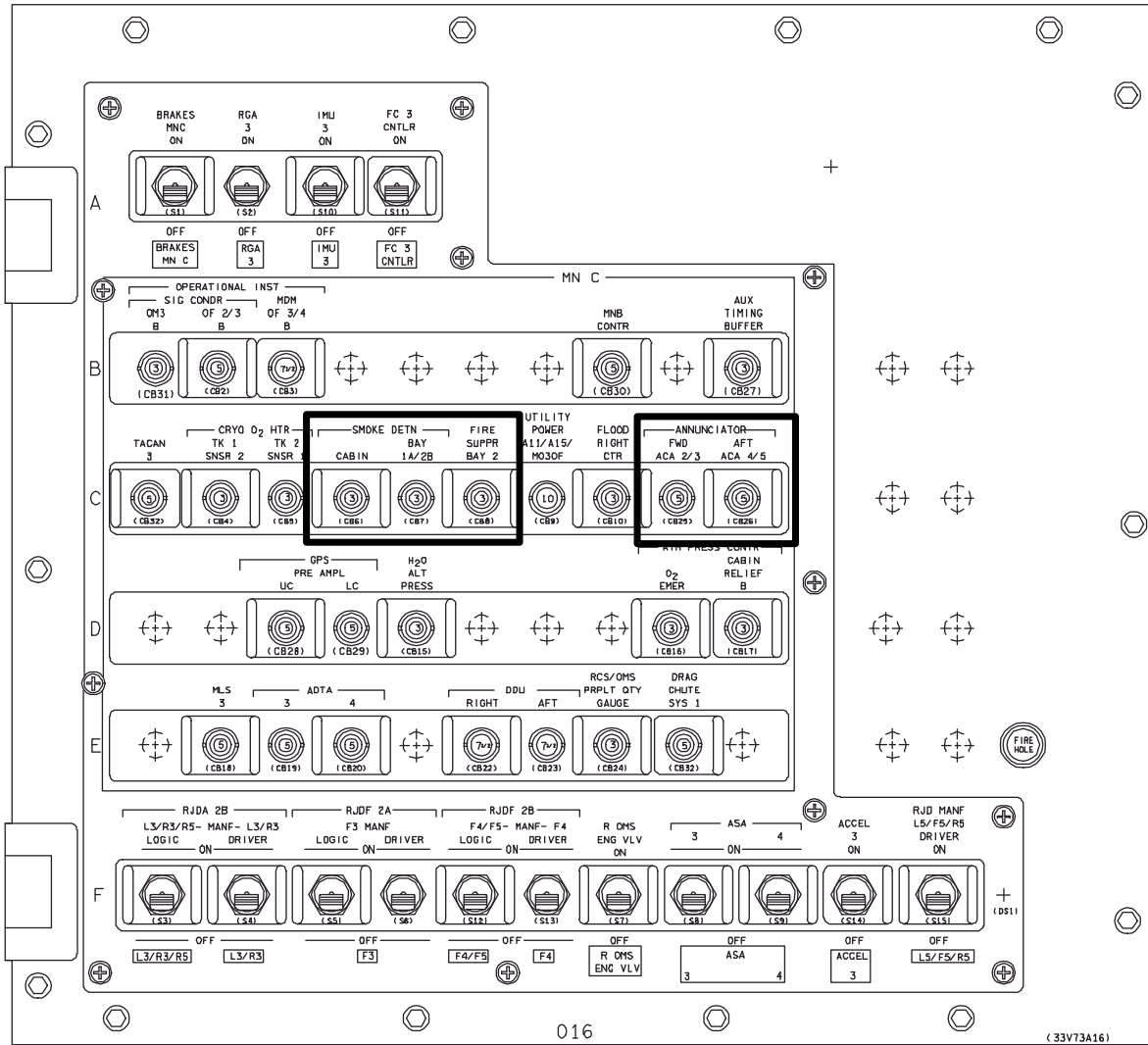
Figure 3-12. Panel O15

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3.3.4.4 Panel O16: C&D

See Figure 3-13.

- a. cb **MNC SMOKE DETN CAB** - Applies power to the CABIN smoke detector, enabling the sensor.
- b. cb **MNC SMOKE DETN BAY 1A/2B** - Applies power to the avionics bay 1 sensor A and bay 2 sensor B smoke detectors, provides power for the sensor reset function of the CABIN & 1A/2B detectors, and powers the avionics bay 2 agent discharge light.
- c. cb **MNC FIRE SUPPR BAY 2** - Supplies power to the avionics bay 2 fire suppressant bottle PIC.
- d. cb **MNC ANNUN FWD ACA 2/3** - Supplies power to the ACA 2 and 3 electronics and annunciation lights, including the brightness control and test function.
- e. cb **MNC ANNUN AFT ACA 4/5** - Supplies power to the ACA 4 and 5 electronics and annunciation lights, including the brightness control and test function.



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(33V73A16)
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Figure 3-13. Panel O16

3.3.5 Halon 1301

Halon 1301 is used as the extinguishing agent for all fire suppression devices. Halon 1301 is colorless, odorless, and electrically nonconductive. Discharge of the agent may create a light mist in the vicinity of the discharge nozzle, but visibility is not adversely affected. Once the Halon is discharged into an enclosure, it is difficult to detect its presence through normal human senses.

Exposure to Halon in the 5 to 7 percent range produces little, if any, noticeable physiological effect. At levels between 7 and 10 percent, mild Central Nervous System (CNS) effects such as dizziness and tingling in the extremities have been reported. Above 10 percent, some subjects report a feeling of impending unconsciousness after a few minutes, although test subjects exposed to as much as 14 percent for 5 minutes have not lost consciousness. These types of CNS effects are completely reversible upon removal from exposure.

It is considered good practice to avoid all unnecessary exposure to Halon 1301 and to limit exposures to the following times:

- a. Seven percent and below - 15 minutes
- b. Seven to 10 percent - 1 minute
- c. Ten to 15 percent - 30 seconds
- d. Above 15 percent - Prevent exposure

Anyone suffering from toxic effects of Halon 1301 should immediately move or be moved to fresh air. In treating persons suffering toxic effects, the use of epinephrine (adrenaline) and similar drugs must be avoided. These drugs may produce cardiac arrhythmias, including ventricular fibrillation.

3.3.6 Post-Fire Contaminants

One theory holds that Halon must decompose before it is effective in suppressing fire. The decomposition takes place on exposure to a flame or to a hot surface of approximately 900° F. Although Halon 1301 has a low toxicity, its decomposition can be hazardous. These products have a characteristically sharp acrid odor, even in minute concentrations of only a few parts per million. This smell provides a warning system but at the same time creates a noxious, irritating atmosphere. Depending on the severity of the fire, length of time Halon is exposed to flame, and concentration of Halon, the decomposition products may be extensive. Immediate action in the early stage of fire/smoke detection, coupled with rapid discharge rate of Halon can minimize the quantity of the toxic gases produced. Expeditious clean up will minimize the crew's exposure. The toxic products can be scrubbed from the atmosphere; however, Halon concentrations cannot be determined nor can they be removed. After a fire, the Compound Specific Analyzer - Combustion Products (CSA-CP) can be used to determine the levels of four of the contaminants in the cabin air (Table 3-2).

**Table 3-2. Compound specific analyzer - combustion products measurements
(ppm)**

Contaminant	7-day SMAC¹	TLV²	IDLH³	CSA-CP range
Carbon monoxide (CO)	10	25	1500	1 to 1000
Hydrogen cyanide (HCN)	1	10	60	1 to 100
Hydrogen chloride (HCl)	1	5	100	1 to 100
Hydrogen fluoride (HF)	0.1	3	20	1 to 100

¹SMAC - Spacecraft Maximum Allowable Concentrations

²TLV - Threshold Limit Value* (8-hr limit)

³IDLH - Immediate Danger to Life and Health

3.4 CABIN DP/DT SUBSYSTEM

3.4.1 dP/dT Annunciation

The cabin dP/dT system is designed to alert the crew to a rapid cabin depressurization.

Cabin dP/dT is measured by a sensor (Figure 3-14). The value of this sensor is read in the dP/dT field of the DPS displays and the Panel O1 meter. This sensor generates the class 1 emergency alarm when a value of -0.08 psi/min is exceeded.

a. Visual cue

MA lights on Panels F2, F4, A7, and MO52J (Figure 2-2 and Figure 2-3).

b. Aural cue

Klaxon - 2560 Hz tone with a period of 2.1 ms on and 1.6 ms off mixed with a 256 Hz tone with a period of 215 ms on and 70 ms off. The klaxon can be silenced by depressing any MA PBI.

The cabin dP/dT is presented on two DPS displays and on a meter located on Panel O1. The DPS displays are DISP 66 ENVIRONMENT and DISP 78 (SM SYS SUMM 1). The SM1 SYS SUMM 1 display is available in both PASS and BFS.

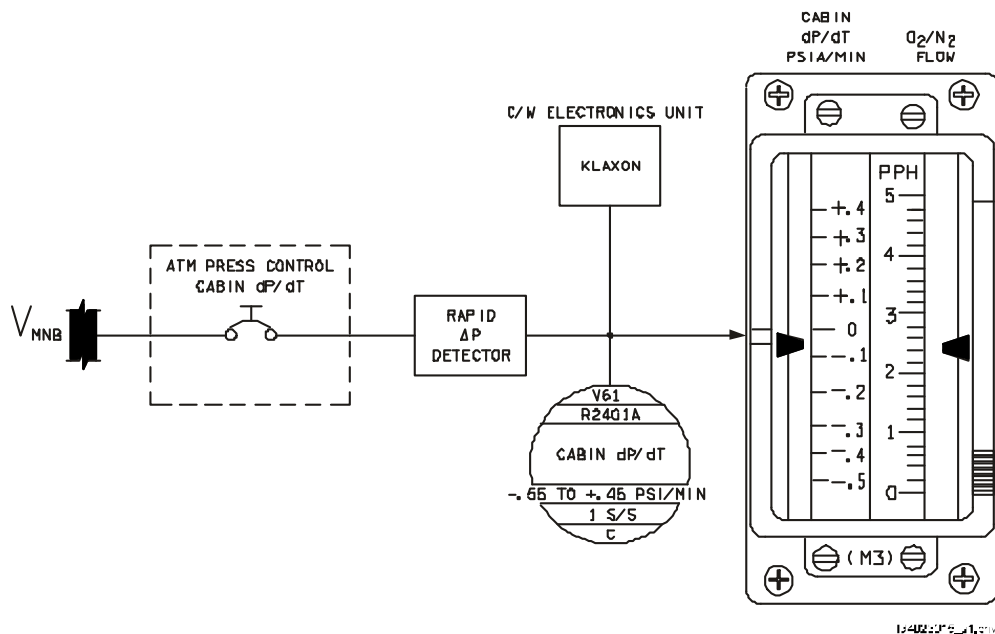


Figure 3-14. Cabin rapid ΔP

3.4.2 Other Cabin Leak Annunciation

Two calculated parameters, B/U dP/dT (BFS) and equivalent (EQ) dP/dT (PASS and BFS), will only generate class 3 alerts if the LOW limit is exceeded. These parameters are not part of the class 1 emergency alarm system.

B/U dP/dT uses the cabin pressure sensor to calculate the rate of change of cabin pressure. Simplified, the B/U dP/dT calculation uses a 30 second difference of the Cabin Pressure sensor readings sampled every 5 seconds. The software filters the final value to avoid large changes in B/U dP/dT due to cabin pressure bit flips. The equation used is $dP/dT = (0.6065307) * 2(P_{30} - P_0)_{T-1} + (0.39346931) * 2(P_{30} - P_0)_T$.

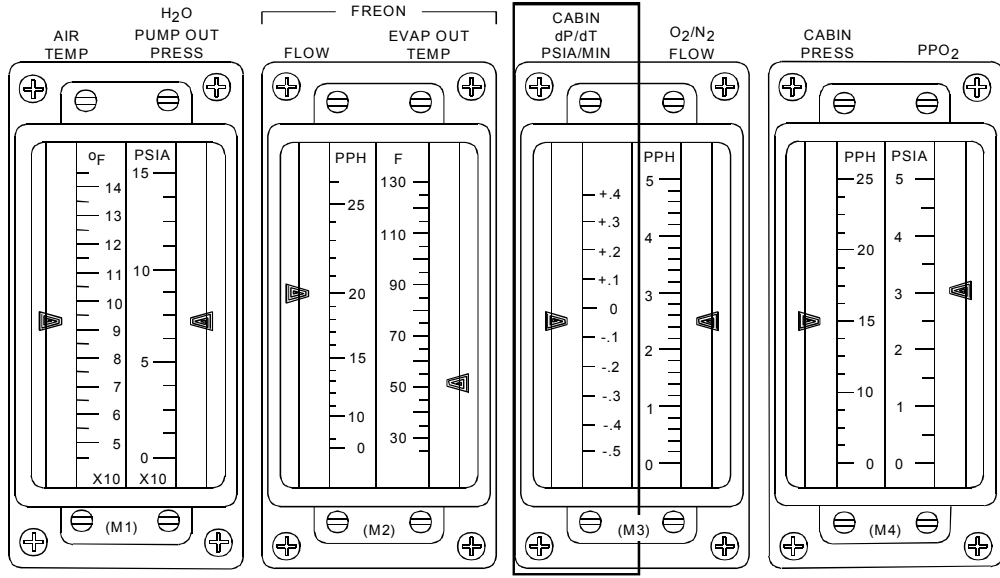
EQ dP/dT uses both the dP/dT and cabin pressure sensors to calculate a normalized dP/dT adjusted back to a 14.7 psia cabin pressure. The equation used is:

$$EQ \text{ dP/dT} = 14.7 \times \left(\frac{dP/dT}{\text{Cabin P}} \right)$$

If a cabin leak occurs, numerous class 2 C&W and class 3 alert alarms will be annunciated when each limit is exceeded. Alarms may include EQ dP/dT, B/U dP/dT, CABIN PRESS (when lower limit is violated), nitrogen (N₂) flow, and oxygen (O₂) flow (if flowing to maintain cabin pressure). As cabin pressure decreases, cooling fans lose cooling capability and alarms occur when each lower limit is exceeded.

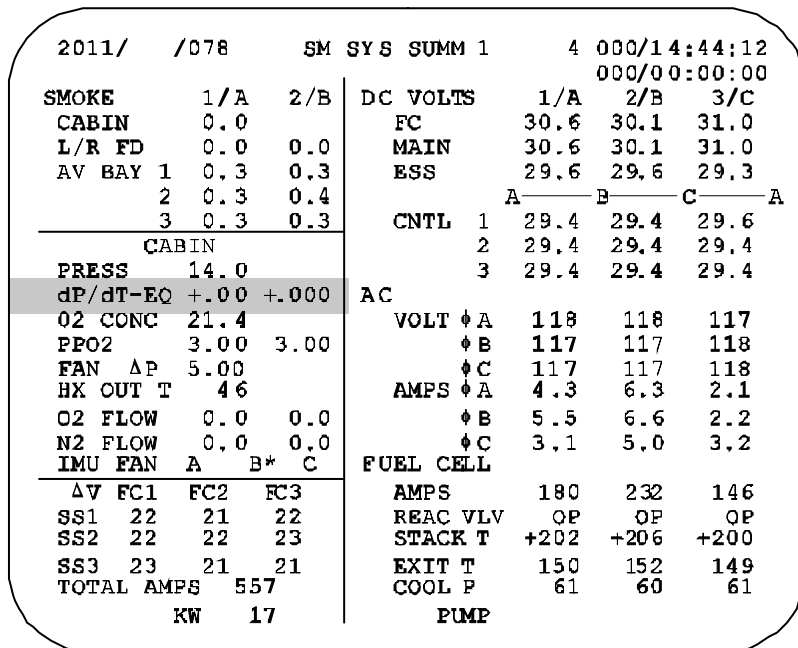
3.4.3 Performance Monitoring

The value of cabin dP/dT sensor is displayed on a meter on Panel O1. See Figure 3-15. The cabin dP/dT sensor, along with EQ dP/dT and B/U dP/dT, are displayed on the following DPS displays: PASS and BFS SM SYS SUMM 1 and PASS SPEC 66. See Figure 3-16, Figure 3-17, and Figure 3-18.



td402_013.cv5

Figure 3-15. Panel O1 meters



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Figure 3-16. SM SYS SUMM 1 (PASS)

0001/ /078		SM SYS SUMM 1		5 000/03:13:09		
				BFS 000/00:00:00		
				1/A 2/B 3/C		
SMOKE	1/A	2/B	DC VOLTS			
CABIN	-0.9		FC	31.1	31.1	31.1
L/R ED	-0.4	0.2	MAIN	31.0	31.1	31.0
AV BAY	1-1.2	-0.0	ESS	29.8	29.8	29.8
	2-0.6	-0.3				
	3-0.1	-0.9				
CABIN			CNTL	1 29.3	29.3	29.3
PRESS	14.7			2 29.3	*00.0	29.3
dP/dT	+0.00			3 29.3	29.3	29.3
H/EQ	-0.00	+0.00	AC			
PPO2	3.02	3.02	VOLT	ΦA 117	117	117
FAN DP	5.79			ΦB 117	117	117
HX OUT T	49			ΦC 117	117	117
O2 FLOW	0.0	0.0	AMPS	ΦA 4.4	4.1	2.7
N2 FLOW	0.0	0.0		ΦB 3.9	4.2	3.2
IMU FAN DP	4.62			ΦC 2.4	3.2	4.8
DV FC1	FC2	FC3	FUEL CELL PH			
SS1 15	18	18	AMPS	172	167	178
SS2 16	20	11	REAC VIV	OP	OP	OP
SS3 22	26	26	STACK T	+204	+203	+203
TOTAL AMPS	510		EXIT T	150	150	151
KW	15		COOL P	61	61	61
			PUMP		ΔP	

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Figure 3-17. SM SYS SUMM 1 (BFS)

2011/ /066		ENVIRONMENT		4 000/02:33:38		
				000/00:00:00		
CABIN		AV BAY	1	2	3	
dP/dT +.01	CABIN P 14.7	TEMP	90	90	78	
PPO2	AIRLK P 14.8	FAN ΔP	3.80	3.77	3.92	
A 3.04	FAN ΔP 5.55	SUPPLY H2O				
B 3.04	HX OUT T 45L	QTY A	67	PRESS	32	
C 3.04	CABIN T 71	B	18	DMP LN T	77	
PPCO2 1.9		C	94	NOZ T A	64	
		D	94	B	64	
O2 FLOW	1 0.0L	2 0.0L	WASTE H2O			
REG P	100	100	QTY 1	15	PRESS	17
N2 FLOW	0.0L	0.0L	DMP LN T 58			
REG P	202	202	NOZ T A 82			
O2/N2 CNTL VLV	N2	O2	B 82			
H2O TK N2 P	17	17	VAC VT NOZ T 224			
N2 QTY	131	131	CO2 CNTLR 1 2			
EMER O2 QTY	1		FILTER P 0.00L			
REG P	4L		PPCO2 -0.0L			
			TEMP 32.0L			
	A B C ΔP		BED A PRESS 0.0L 0.0L			
IMU FAN	* *	4.5	B PRESS 0.0L 0.0L			
HUMID SEP	*		ΔP 0.00L 0.00L			
			VAC PRESS 0.0L			

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Figure 3-18. SM SPEC 66

The nominal dP/dT on orbit and entry is 0 ± 0.01 psi/min. During the first 2 minutes of ascent (launch to Solid Rocket Booster (SRB) separation), the dP/dT can be as high as -0.07 psi/min because of cabin stretch. The class 1 emergency alarm annunciates when the $dP/dT \geq -0.08$ psi/min. Positive dP/dT values will not cause a class 1 emergency alarm.

3.4.4 Controls

Panel O15: D (Figure 3-12)

The PPO₂C CABIN dP/dT cb provides power from main B to the dP/dT sensor. This cb also provides power to the PPO₂C sensor.

3.5 QUESTIONS

1. Which DPS display shows concentration of smoke in the avionics bays?
 - a. SPEC 66
 - b. SM SYS SUMM 1
 - c. SM SYS SUMM 2
 - d. GNC SYS SUMM 1
2. If the emergency smoke alarm system is latched (sensor reset has not been performed) and a fire occurs in another location, which of the following indications will NOT occur?
 - a. Illumination of corresponding Panel L1 smoke detection light(s)
 - b. Increase in corresponding SM SYS SUMM 1 smoke concentration(s)
 - c. Siren
3. The smoke detectors check for concentrations and rate increase of concentrations; which of the following is true?
 - a. $2000 \pm 200 \mu\text{g}/\text{m}^3$ for 5 seconds and/or $22 \mu\text{g}/\text{m}^3$ per second for eight consecutive counts in 70 seconds
 - b. $2000 \pm 200 \mu\text{g}/\text{m}^3$ for eight consecutive counts in 20 seconds and/or $22 \mu\text{g}/\text{m}^3$ per second for 5 seconds
 - c. $2000 \pm 200 \mu\text{g}/\text{m}^3$ for 5 seconds and/or $22 \mu\text{g}/\text{m}^3$ per second for eight consecutive counts in 20 seconds
4. What actions are needed to discharge a fire bottle into an avionics bay?
5. True or False. For avionics bay fires, portable extinguishers are considered backups to the avionics bay bottles.

6. The class 1 emergency annunciation for a cabin rapid dP/dT consists of
 - a. MA lights, siren, and Panel L1 light
 - b. MA lights, klaxon, and Panel L1 light
 - c. MA lights and siren
 - d. MA lights and klaxon
7. The alarm system will sound when the dP/dT equals or exceeds
 - a. 0.08 psi/min
 - b. -0.02 psi/sec
 - c. -0.08 psi/min
 - d. either A or C
8. The nominal dP/dT during orbit is
 - a. ± 0.07 psi/sec
 - b. ± 0.07 psi/min
 - c. ± 0.01 psi/min
 - d. ± 0.01 psi/sec
9. The cabin pressure and dP/dT can be referenced on which of the following:
 - a. Panel L1, Panel O1, and SPEC 66
 - b. Panel O1, SPEC 66, and SM SYS SUMM 1
 - c. Panel O1, SPEC 55, and SM SYS SUMM 1
 - d. Panel L1, Panel O1, and SM SYS SUMM 1
10. Where are the fire extinguishers located?
 - a. One on the middeck and two on the flight deck
 - b. Two on the middeck and two on the flight deck
 - c. Two on the middeck and one on the flight deck
 - d. One on the middeck and one on the flight deck

11. True or False. Both the sensing and reference chambers in the smoke detectors are constantly recycled.
12. True or False. The separator of the smoke detector allows only particles 2 microns or less to enter the sensing chamber.
13. True or False. The radiation source used by the smoke detectors is Americium 241.
14. True or False. The fire bottles use a PIC to provide an explosion in the nozzle assembly.
15. The nozzle assembly consists of the following:
 - a. A 1/2-inch nozzle, a PIC, a valve, and a chain
 - b. A 1/4-inch nozzle, a valve, and a hollow cylindrical knife
 - c. A 1/2-inch nozzle, a valve, and a hollow cylindrical knife
 - d. A 1/2-inch nozzle, a PIC, a spring, and a hollow cylindrical knife
16. True or False. The diaphragm of the fire bottle is ruptured by use of a knife.
17. True or False. The pressure switch on the fire bottle sends a signal to Panel L1 to illuminate the AGENT DISCH light when the pressure in the bottle drops to 60 ± 10 psi.
18. How many smoke detectors are in each avionics bay?
 - a. One
 - b. Two
 - c. Three
 - d. Four
19. True or False. Once the alarm system is triggered by a smoke detector, the entire system remains latched until reset by Panel L1.
20. When performing a circuit test on Panel L1, how long is it until the siren sounds after the test switch is placed in A or B position?
 - a. Approximately 5 seconds
 - b. Approximately 10 seconds
 - c. Approximately 15 seconds
 - d. Approximately 20 seconds

21. How long is the Halon effective as a fire suppressant after fire bottle discharge into an avionics bay?
 - a. 24 hours
 - b. 72 hours
 - c. 24 hours
 - d. 50 hours
22. True or False. All detectors are reset with the sensor reset switch on Panel L1.
23. True or False. All fire ports are located on the flight deck.
24. True or False. The fire bottles in the avionics bays are empty when the AGENT DISCH light goes off.
25. True or False. The emergency alarm system annunciates for either +dP/dT or -dP/dT

4.0 CLASS 2 CAUTION AND WARNING

4.1 OBJECTIVES

After reading this section, the student should be able to

- Differentiate between primary C&W and B/U C&W
- Specify which software supports B/U C&W
- State the aural and visual indications for
 - Primary C&W
 - B/U C&W
- Describe the crew response to primary and B/U C&W annunciation
- Explain the purpose of the following:
 - Upper and lower limits
 - Enable/inhibit status
 - Noise filter value (B/U C&W)
- Describe the capabilities of Panel R13U
- Correctly answer the questions at the end of the section

4.2 OVERVIEW

The C&W system (Figure 4-1) monitors parameters associated with many orbiter systems. The C&W system consists of two subsystems, primary C&W (a hardware system) and B/U C&W (a software system).

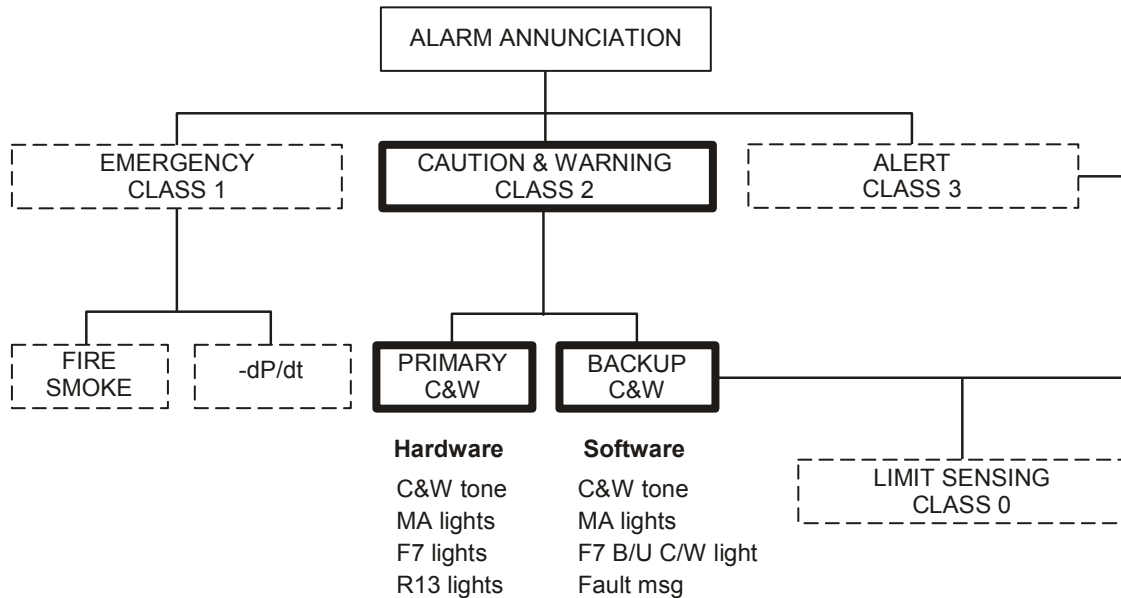


Figure 4-1. Class 2 C&W diagram

4.3 PRIMARY C&W

The primary C&W system is a hardware system. The system has the capacity to monitor 120 inputs, most of which are received from transducers through signal conditioners. A few inputs are received from GPCs through Flight Forward (FF) Multiplexer/Demultiplexers (MDMs). The primary C&W system is sometimes referred to as the hardware C&W system.

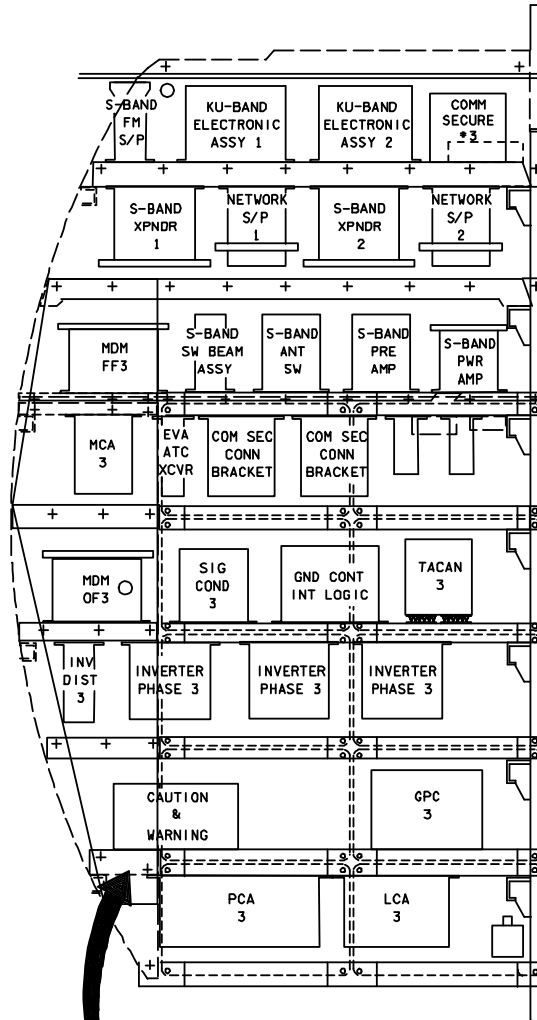
The 120 inputs are fed into a multiplexing system. Of these 120 inputs, 98 are directly from transducers, 5 are from GPC input/output processors, 15 are from MDMs, and 2 are spares. These inputs can be either analogs or discretes. The analog signals are 0 to 5 V dc; the discretes can be either 0, 5, or 28 V dc. All the inputs are designed to provide high, low, or both high- and low-limit detection. There are an additional eight input channels utilized by the C&W electronics for internal self-testing purposes. Each input parameter is sampled at 80 Hz and is then compared against its stored upper and lower limit values. If the parameter limits are exceeded during any eight consecutive samples (out of limits for 100 ms), the C&W tone will sound, the MA lights illuminate, the appropriate indicator on the F7 annunciator panel will light, and the tripped parameter number will be stored in memory. If the parameter status switch on Panel R13 is held in the TRIPPED position, the current out-of-limit parameters will illuminate on the status parameter matrix.

The additional eight self-test parameters mentioned above are generated within the C&W electronics and used as a self-test. Should the self-test fail, the primary C&W light will illuminate on the Panel F7 annunciator light array.

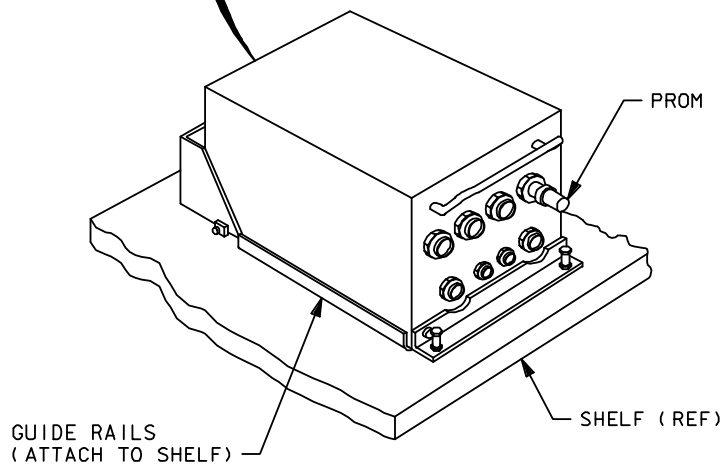
The computers utilize the hardware C&W master alarm tone logic circuitry to activate alarm tones and lights via 12 discrete inputs through the MDMs. Six of these discretes are used to activate the B/U C&W light on Panel F7 and generate the C&W tone (class 2). The other six discretes are used to activate the SM alert tone (class 3). The SM alert light is separate from the C&W circuitry and is controlled by six additional discretes from the computers. One additional discrete input allows the ground the ability to reset the MA lights and tone through the Launch Forward (LF) MDM available pre-launch only.

The C&W electronics unit (Figure 4-2) is located in avionics bay 3A. Internally, there are two systems (SYS A and SYS B) powered by separate sources. SYS A controls the Hardware portion of the electronics necessary to perform limit comparisons, alarm annunciation, and other primary C&W functions. SYS B controls the software activation of the Back Up C/W light on the F7 panel. The tone generator card for each system receives both hardware and software inputs to activate the proper alarms and lights.

A Programmable Read-Only Memory (PROM), which is connected to the C&W electronics unit (Figure 4-2), contains preset (default) limits. The crew can change these limits through Panel R13U. However, if power is lost to the C&W electronics, the system reverts (defaults) to the PROM values. Upon reapplication of power, the crew must re-enter any changes made during the flight. Unlike the B/U C&W and alert software systems, Mission Control Center (MCC) cannot uplink changes to the hardware primary C&W system limits.



COMPONENT LOCATIONS - BAY 3A



006019005. ART# 1

Figure 4-2. Primary C&W electronics unit

4.4 ANNUNCIATOR LIGHT MATRIX

A 40-light annunciator matrix is located on Panel F7 (Figure 4-3).

Each light is driven by one or more parameters. With the exception of the B/U C&W ALARM light, once a lamp has been illuminated, it will not be extinguished until all parameters driving that light are back within limits or the out-of-limit parameter is inhibited. The intensity of the lights is adjustable by the crew through the bright/variable switch and the variable intensity knob on Panel O6 (Figure 9-3). Each lamp assembly has two bulbs, wired in parallel for redundancy and can be easily replaced. Power for the annunciator light matrix is routed through the ESS 1BC C&W A cb on Panel O13A (Figure 4-4).

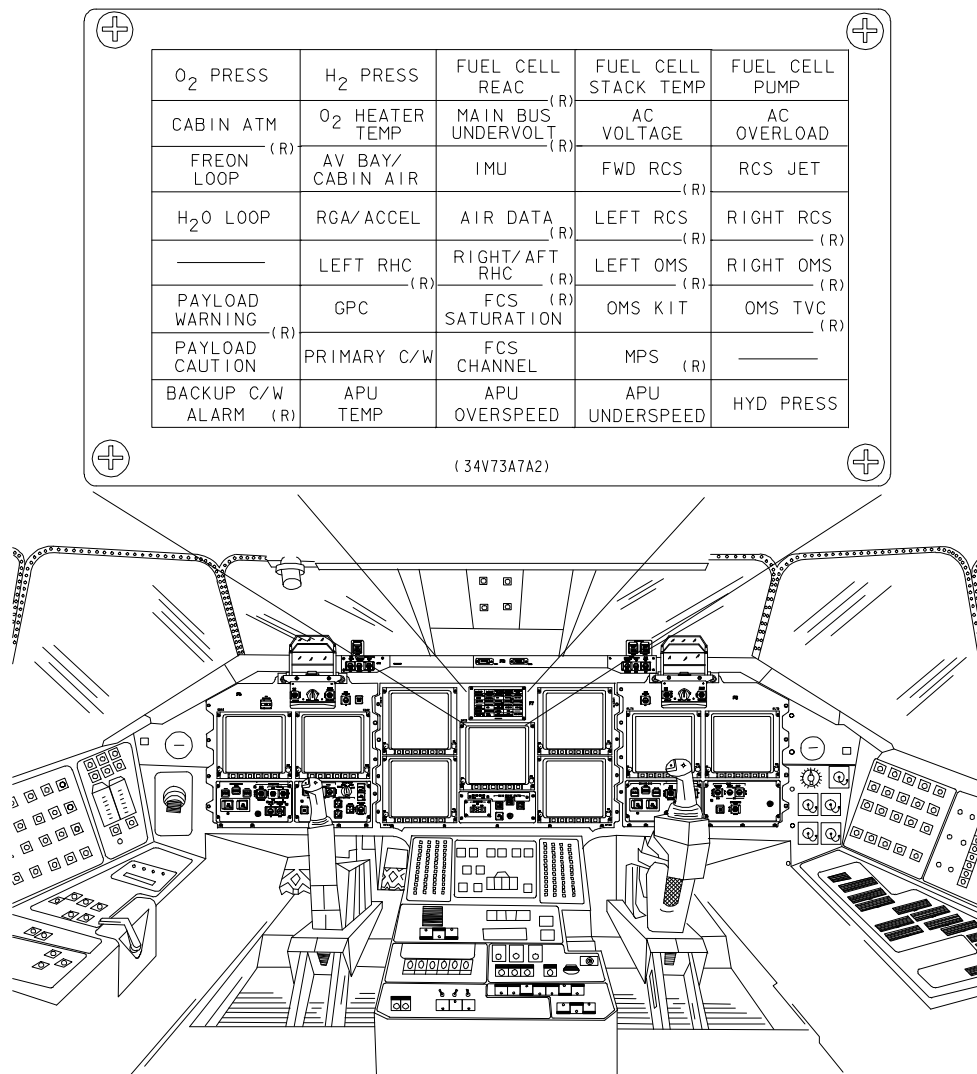
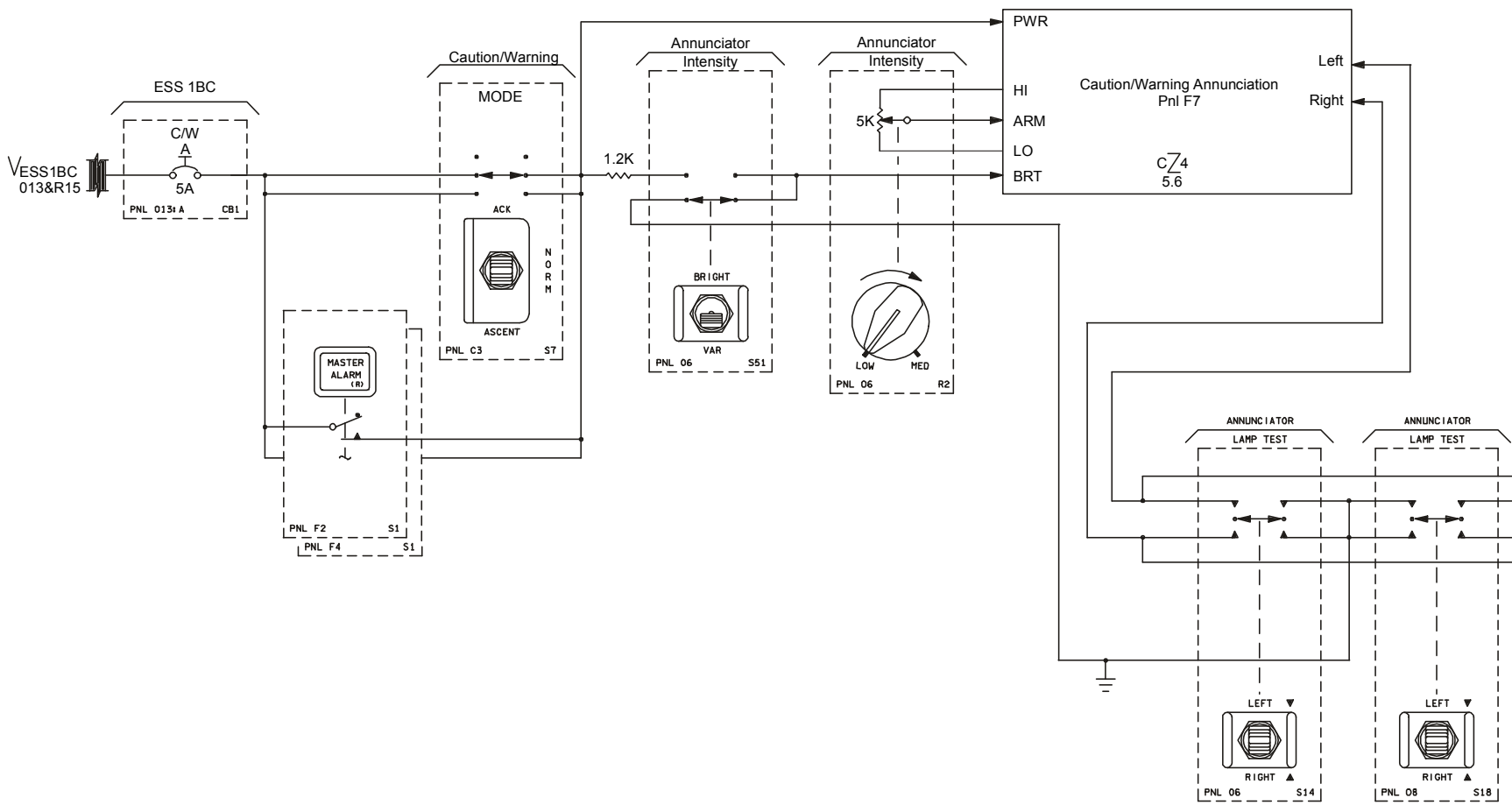


Figure 4-3. Panel F7 annunciator light matrix



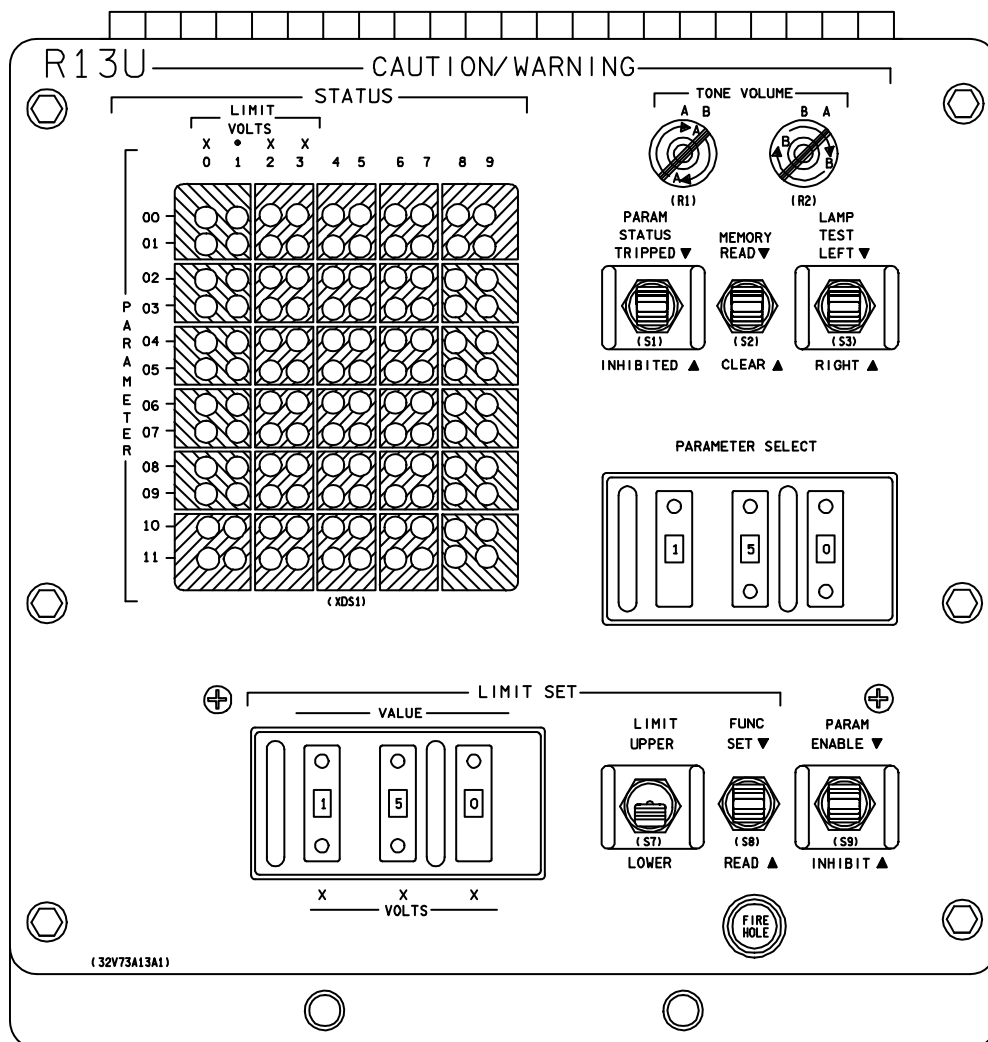
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Figure 4-4. Annunciator light schematic

4.4.1 Panel R13U

Panel R13U is the crew interface with the primary C&W system. Controls on this panel allow the crew to verify and change primary C&W limits, inhibit and enable primary C&W parameters, check the tripped or inhibited status of primary C&W parameters, and access the primary C&W memory (Figure 4-5).

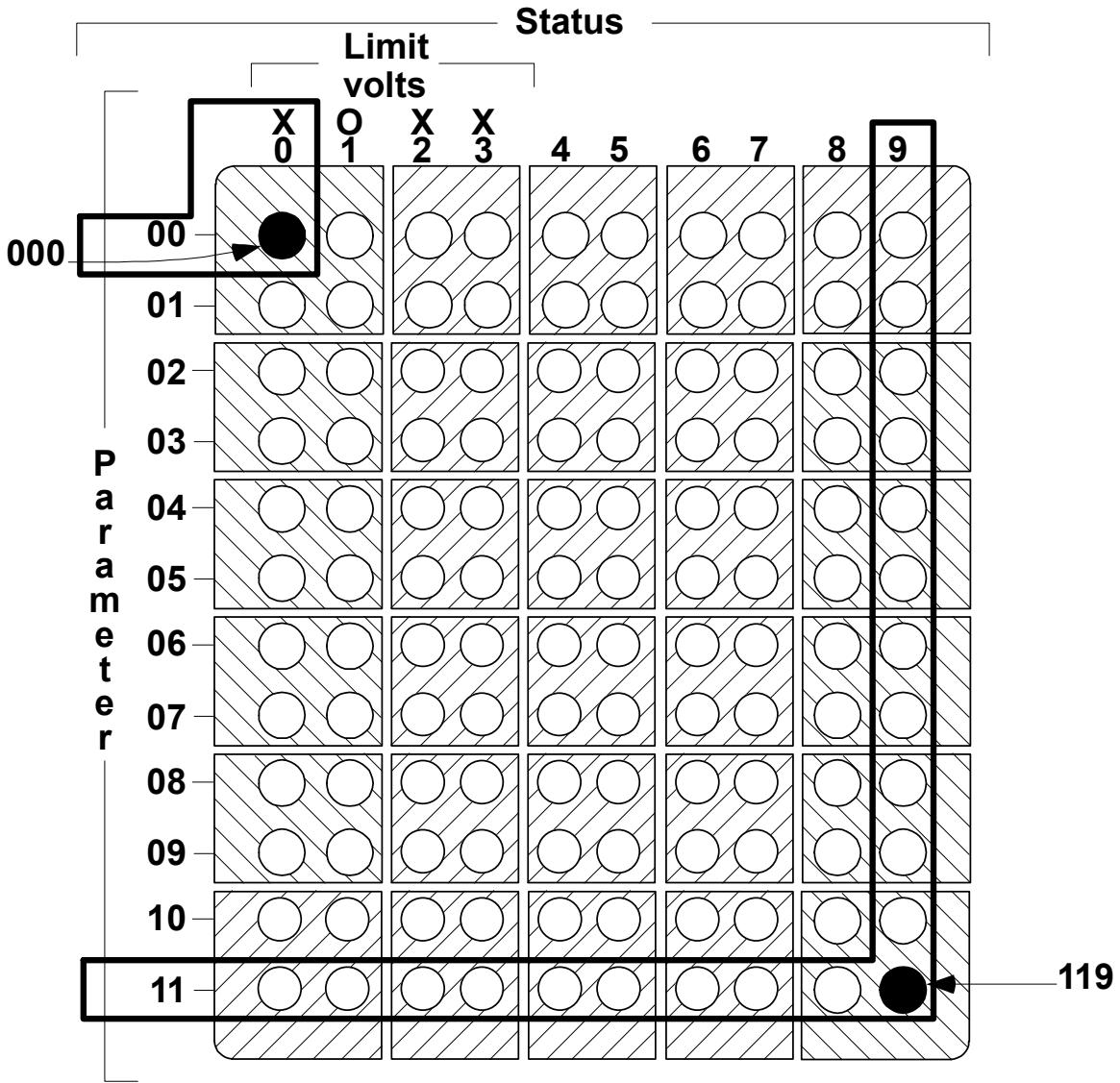
Starting at the upper right-hand corner of Panel R13U, there are two TONE VOLUME control potentiometers. When turned clockwise, the potentiometer increases the volume of the siren, klaxon, C&W tone, and alert tone to the Audio Central Control Unit (ACCU). There is one potentiometer for each of the two tone generators. Audio annunciation control is discussed further in Section 9.3.



006019004. PNL, 1

Figure 4-5. Panel R13U

In the top left of Panel R13U is the (parameter) STATUS light matrix (Figure 4-6). This matrix is used to check the status of the parameters and also to check the limits set for a particular parameter. When used to check the status of parameters, the numbers down the left side are read first, then the number on the top is read to obtain parameter number. The matrix has the capability to display all 120 parameters available to the primary C&W system. The 120 parameters are numbered from 000 to 119.



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Figure 4-6. STATUS matrix

The STATUS light matrix also is used to read the limits for each parameter in terms of volts (Figure 4-7). The key at the top of the matrix shows how the first four columns of the parameter status light matrix are used to read the voltage for a particular limit. The second column is always blank and is used as the decimal place (X.XX volts). During development of the C&W electronics, it was desired to have a single engineering measurement to represent all the parameters. At the time, programs used transducers with signals from 0 to 5 V dc; thus, voltage was chosen as the single measurement to establish limits. The input transducer ranges were rescaled to match 0 volts as the minimum value and 5 volts the maximum value. Therefore, the wide variety of measurements with many differing ranges (temperature, pressure, rates, speed, single discretets, etc.) could be represented with one measurement (0 to 5 V). The Reference Data Book, which is discussed in Section 7.0, contains the calibration scales to convert between voltages and the appropriate engineering units.

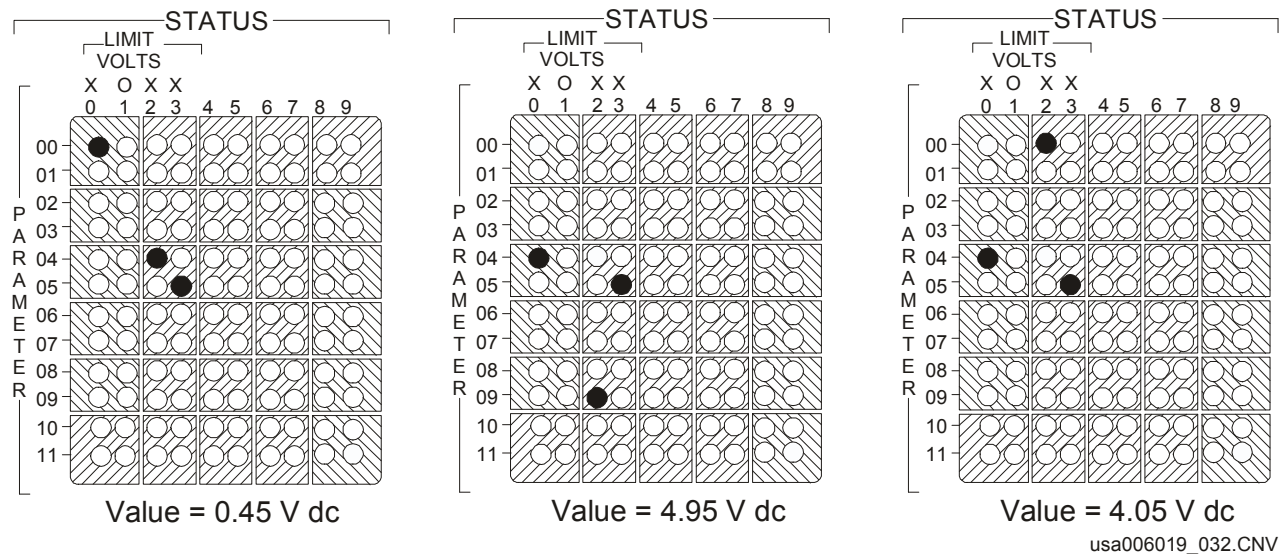


Figure 4-7. Limit values

The LAMP TEST switch is used to test the continuity of the 120 lamps on the STATUS light matrix. The left position illuminates the left 60 lamps, and the right position illuminates the right 60 lamps.

The MEMORY read switch accesses the C&W memory. When placed in the READ position, any parameter, which was out-of-limits since the last time the memory was cleared, will be illuminated on the STATUS light matrix. When the switch is taken to the CLEAR position, the C&W memory is cleared, but any parameter currently out-of-limits will be rewritten to memory. Because this switch position (CLEAR) provides no feedback, a prudent course of action is to take the switch to the READ position to verify that the C&W memory was cleared.

The parameter (PARAM) STATUS switch, when taken to the TRIPPED position, illuminates on the light matrix those parameters that are presently tripped. The INHIBITED position illuminates those parameters that are presently inhibited.

The PARAMETER SELECT pushbuttons (thumbwheels are used in the Single System Trainers (SSTs)) are used to select the number of the desired parameter. Once selected, the parameter's limits can be adjusted using the PARAM and LIMIT SET switches.

The PARAM switch, when moved to the INHIBIT position, inhibits the selected parameter, which will also extinguish the appropriate F7 annunciator light. The ENABLE position enables the selected parameter, which allows it to trigger the primary C&W alarm when out-of-limits.

The LIMIT SET switches work together either to read or to change a limit of the selected parameter.

The VALUE pushbuttons (thumbwheels are used in the SSTs) are used for entering the value, in volts, for the limit of the selected parameter. The valid voltage range is 0.00 to 5.00 in increments of 0.05.

The LIMIT switch is used to choose either the upper or the lower limit for a selected parameter.

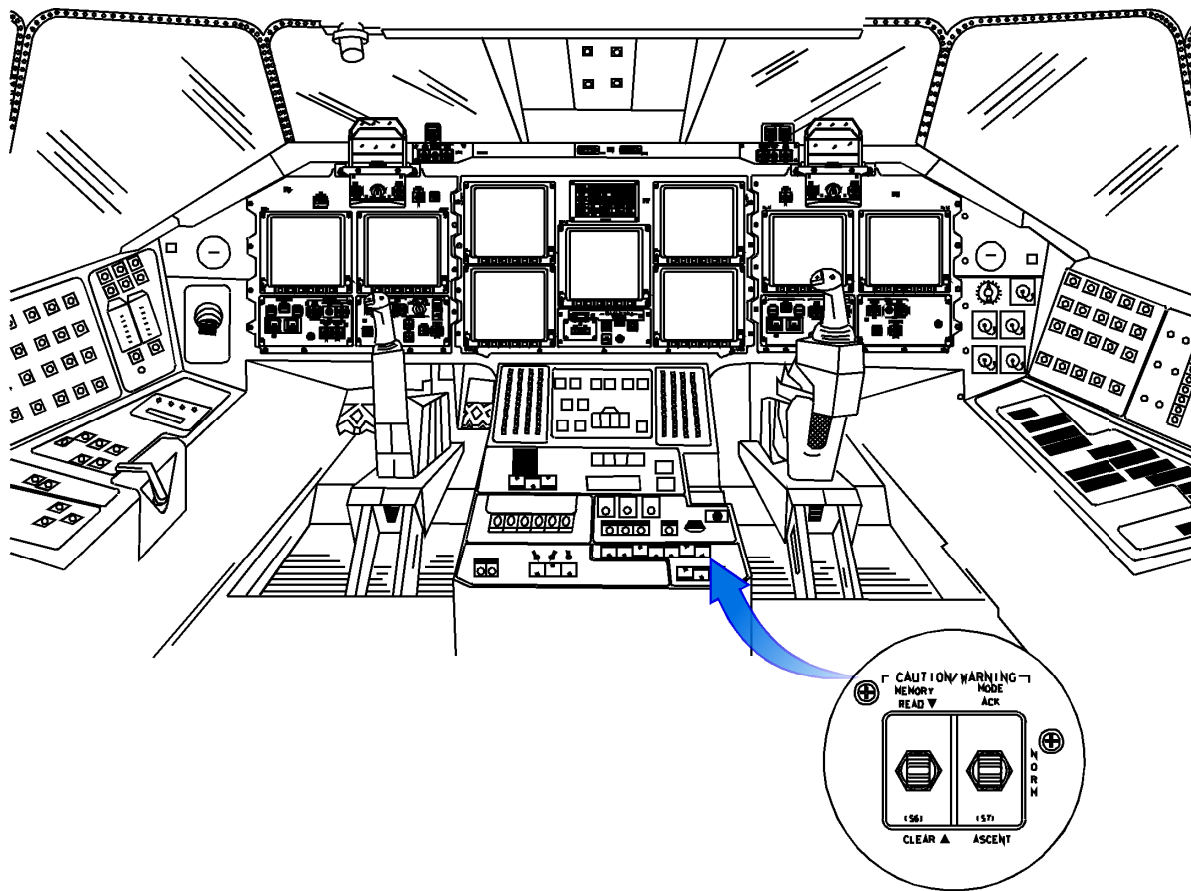
When placed in the READ position, the function (FUNC) switch displays the current voltage limit of the selected parameter on the STATUS light matrix. The SET position sets the selected limit for the selected parameter to the voltage value that is entered on the VALUE pushbuttons. Because the set position does not illuminate the value on the STATUS light matrix, it is prudent to verify that the desired value has been entered by moving the switch to the READ position after setting a limit.

When not in use, the PARAMETER SELECT pushbuttons should be left at a value higher than 119 to prevent inadvertent inhibits, enables, and limit changes.

When setting either the PARAMETER SELECT number or the LIMIT SET VALUE (or any similar pushbuttons on the shuttle), care should be taken to avoid pushing the increment and decrement pushbuttons at the same time. Pressing both simultaneously may jam the mechanism. It may be possible to correct a jam by pulling out on the pushbuttons. Additionally, one should not rapidly change the direction (increment to decrement or vice versa) because the previous pushbutton may be sticking a little. If (when changing direction) the pushbutton will not go in, pull out on the other pushbutton, then try again.

4.4.2 Panel C3

The MEMORY switch located on Panel C3 (Figure 4-8) accesses the same memory and operates the same as the MEMORY switch on Panel R13U. The CLEAR position clears the C&W stored memory of all the previously tripped parameters. However, the READ position illuminates the annunciators on the F7 panel matrix, instead of the parameters on the R13U status matrix. When placed in the READ position, any annunciator having a parameter, which was out-of-limits since the last time the memory was cleared, will be illuminated on the F7 annunciator matrix.



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Figure 4-8. MEMORY switch on Panel C3

The MODE switch has three positions, allowing the crew to select how the C&W lights are illuminated. The positions are acknowledge (ACK), normal (NORM), and ASCENT. The MODE switch is usually placed in the NORM position throughout the entire flight.

The normal position allows for all normal annunciation of the C&W system.

The acknowledge position removes power from the Panel F7 C&W annunciator light matrix, thereby preventing the lights from illuminating when an alarm is issued. The F7 lights are illuminated by pressing and holding the MA PBI on either Panel F2 (commander's side) or F4 (pilot's side). The MA PBI completes the electrical circuit and applies power to the Panel F7 C&W light matrix. This position is used when the crew desires to avoid sudden distractions or excessive glare from the F7 matrix. For example, this position can be used for night landings.

The ascent position removes power to the bulbs in the commander (CDR) MA PBI on Panel F2; however, the button still functions properly when depressed. It is thought that early engineering designs placed the MA and Aborts lights close together and the ascent position was intended to keep the CDR from confusing the MA light with the abort light. However, the abort light was placed on Panel F6, which avoids the potential confusion. The ascent position is not used.

4.4.2.1 Primary C&W Alarm Annunciations

When a primary C&W parameter violates either its upper limit or lower limit, a primary C&W alarm will be issued if the parameter is enabled. The normal annunciations received when a primary C&W alarm is issued are

a. Aural

C&W tone - This is an alternating signal of 400 Hz and 1024 Hz at a 2.5-Hz rate (400 Hz for 0.4 seconds then 1024 Hz for 0.4 sec). The same tone is generated for B/U C&W alarms (software). Depressing an MA PBI will silence the C&W tone.

b. Visual

1. Lamp illuminated on the Panel F7 annunciator matrix. This light corresponds to the hardware parameter that is out-of-limits. (The B/U C&W alarm lamp will only illuminate if a corresponding software limit is exceeded).
2. MA PBIs illuminated on Panels F2, F4, A7, and MO52J.
3. Lamp illuminated on Panel R13U PARAMETER STATUS light matrix when the STATUS switch is held in the TRIPPED position.

Refer to Figure 2-2 and Figure 2-3 for the locations of the C&W interfaces.

4.4.3 Power Supply

The primary C&W system is composed of a system A and a system B, each receiving power from an independent source through an internal power supply. C&W System A is powered by power supply A, which receives Essential (ESS) Bus 1BC power through the “C&W A” cb on Panel O13. C&W system B is powered by power supply B, which receives ESS Bus 2CA power through the “C&W B” cb also on Panel O13. Each power supply powers the logic circuitry for its respective tone generator. (See Figure 4-9 and Section 9.3) Power supply A additionally supports all the hardware logic, memory, and functions to include Panel R13U. Power supply B supports the logic to activate the “Back Up C&W” F7 light when software FDA limits are exceeded.

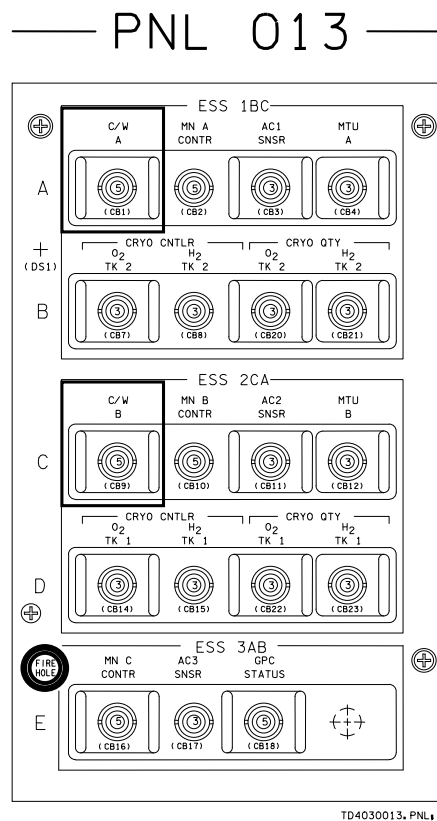


Figure 4-9. Panel O13

A loss of power supply A causes the loss of primary C&W. All lights will illuminate on Panel F7 except for the B/U C&W light. It also causes a loss of Panel R13U status lights and functions; siren for “A” smoke detectors, C&W MEMORY READ switch, two of four bulbs of the MA light (except for lamp test); primary C&W limit sensing; and ACCU bypass tones to the middeck. Reference Data FDF provides a quick summary for the loss of the power supply (Figure 4-10).

C&W POWER SUPPLY FAILURE	
PRIMARY C&W light ON plus:	
<u>SYS A PWR SPLY</u>	<u>SYS B PWR SPLY</u>
All F7 annun lts ON except B/U C&W lt	B/U C&W light ON (no reset)
Loss of:	Loss of:
<ul style="list-style-type: none"> • C&W status pnl lts' and function (R13U) • Smoke detection siren test CKT A • C&W memory read • Lower bulbs MA light except for lamp test • Primary C&W limit sensing • ACCU Bypass tones to MIDDK SMU 	<ul style="list-style-type: none"> • Upper bulbs MA light except for lamp test • Smoke detection siren test CKT B • Sleep station headset tones

Figure 4-10. C&W power supply loss matrix

A loss of power supply B causes the B/U C&W light on Panel F7 to fail on in addition to the primary C&W light. It also causes a loss of the siren for the "B" smoke detectors, two of four bulbs of the MA lights (except during a lamp test), and sleep station headset tones.

The effects of power loss from the ESS buses to the power supplies versus a failure of the power supply are similar, with one addition. The failure of ESS 1BC power source unpowers all annunciator lights for the F7 matrix.

Temporary loss of power (cycling C&W A cb, power supply A or ESS 1BC temporary loss) to C&W system A will cause all hardware parameter limits to reset (default) back to their original PROM values. Any inhibited parameters would be enabled and alarms would result from any out-of-limit condition. The crew must re-enter any parameter inhibits and limit values that differ from the default values. The software C&W program Fault Detection and Annunciation (FDA) is not affected and will still provide expected warnings.

An In-Flight Maintenance (IFM) procedure is available to regain power redundancy for the C&W system. If ESS bus power is lost, the IFM will repower the C&W system affected resulting in full recovery. If a power supply fails, that C&W system is lost. The IFM will provide redundant power to the remaining C&W system. With the failure of one C&W system, C&W alarms are critical to the remaining ESS bus power. Should the ESS bus fail, no alarms would be generated and the appropriate fuel cell would fail within 9 minutes. However, the software FDA still functions and will provide the normal display messages. Therefore the crew must continually monitor the fault summary messages for failures until the IFM is complete. (See IFM C/L, C&W Electronics Unit Contingency Power)

4.4.4 Self-Test

C&W system A has eight dedicated parameters numbered 120 through 127, which are utilized during self-test to ensure parameter limits are being compared correctly. When a parameter fails the self-test, a “PRI C&W” F7 light, MA light, and C&W tone is generated. Normally the crew cannot access or change the limits of these eight parameters.

Each self-test parameter has upper and lower limits established by the PROM. Their output from the timing unit is inhibited to the primary C&W trigger to prevent an MA every time a parameter is tested. Parameter numbers 120 through 123 are low-limit tested at 0.1 V below parameter values, while 124 through 127 are high-limit tested at 0.1 V above parameter values. Many things can cause a self-test to fail (e.g., a timing unit failure, an internal limit shift, or a power failure).

4.5 BACKUP C&W

4.5.1 System Description

The B/U C&W system is a software system and is commonly referred to as the software C&W system. Software programs contained in the GPCs monitor parameters, detect out-of-limit conditions, and initiate B/U C&W annunciation. A fault message will be displayed on the DPS display and the GPC sends a signal via the forward and/or payload MDMs to both C&W system A and B to trigger the MA light, B/U C&W light, and C&W alarm tone.

C&W alarm signals are generated by the Fault Detection and Annunciation (FDA) software or GNC software when set limits are exceeded. Parameters monitored by the FDA software have limits that can be changed by the crew through the SM TABLE MAINTENANCE display (SPEC 60, PASS only) or accessed by a memory read/write procedure in BFS. These limits are displayed in engineering units and do not need to be converted to voltage (0.00-5.00) like the hardware C&W system. Parameters monitored by GNC software are accessed through GPC Memory Read/Write procedures. The fault messages generated and the FDA parameter limits are listed in the FDF REF DATA book as an easy reference source.

4.5.2 B/U C&W and Alert Software Support

The B/U C&W system and the alert system are supported by the SM and GNC major functions of both the PASS and the BFS software. All orbiter software except the payload major function is included.

4.5.2.1 Primary Avionics Software System

The PASS has the following three types of applications software, called major functions.

- a. SM - This major function is active on orbit. The software module within SM that monitors parameters and initiates alarms is called FDA.
- b. GNC - This major function is active during all flight phases. When GNC software detects an out-of-limit condition, a signal is sent to the Guidance, Navigation, and Control Annunciation Interface (GAX). The GAX software determines the appropriate response and initiates an alarm, if required.
- c. Payload (PL) - This major function does not contain alarm annunciation software.

4.5.2.2 Backup Flight Software

The BFS contains both GNC and SM major functions. The BFS is normally used only during ascent and entry. When the BFS is in run, the BFS alarm annunciation depends on the BFS engage status.

- a. Pre-engaged = SM C&W, SM alerts
- b. Engaged = SM C&W, SM alerts, GNC C&W, GNC alerts

When the BFS is in STANDBY, alarm annunciation consists of only DPS display fault messages and status indicators. No lights or tones are annunciated because the BFS does not have control of the payload buses in standby.

4.5.2.3 Crew and Mission Control Center Software Interface

- a. PASS SM Parameters - SPEC 60, SM Table Maintenance (Section 8.0), provides a crew interface with the PASS SM parameters so that their limits, noise filter value, and enable/inhibit status may be read or changed. MCC may also make these changes through an uplinked Table Maintenance Block Update (TMBU) (Section 8.7). Information about these parameters and the procedures for using SPEC 60 are located in the FDF Reference Data Book and in the SM Flight Systems Software Requirements (FSSR) document.
- b. PASS GNC, BFS GNC, and BFS SM Parameters - To change the way these parameters are monitored, a memory read/write procedure must be performed by the crew or uplinked from MCC. The Display and Control (D&C) FSSR contains information about these parameters.

Further information about the DPS, DPS software, and memory read/write procedures can be found in the Crew Software Interface (CSI) 2102, DPS OV 2102, DPS PRINC 2102, and DPS Hardware/Software 2102 training manuals.

4.5.3 Requirements for B/U C&W Annunciation

4.5.3.1 Limits

Each B/U C&W parameter has either an upper limit, a lower limit, or both. For each parameter, the GPC software compares the present value with the limit set. If either the upper or lower limit is violated, the parameter is out of limits.

For parameters that are monitored by both B/U C&W and primary C&W, the limits for each system are set at the same value (Flight Rule 9.1.4-10). This will result in simultaneous primary and B/U C&W annunciation for these parameters.

The C&W and FDA tables of the Reference Data Book provide a comprehensive listing of all limit-sensed parameters that can result in a class 2 or 3 alarm. The crew can use the information to verify preflight limit values or alter desired limits (Section 7.0).

4.5.3.2 Noise Filter Value

For an alarm to be annunciated, the parameter must be out-of-limits for a certain number of consecutive samples. This number, "n," is the parameter noise filter value. It has a range of 1 through 15. A parameter cannot annunciate a subsequent alarm until it has been back within limits for at least "n" consecutive samples and once again out of limits for "n" consecutive samples.

A noise filter value of greater than 1 helps avoid nuisance alarms caused by a transient signal or a signal that is fluctuating around a limit value. Thus, larger noise filter values delay alarm annunciation, while smaller filter values provide earlier warnings with greater potential for nuisance alarms. The B/U C&W noise filter value is typically set at 2 to provide rapid annunciation of class 2 B/U C&W alarms. Alert values are typically 15, 7, or 2. All BFS parameters have a noise filter value of 2.

Typical SM GPC data acquisition rates for FDA parameters are 1.04 Hz (once a second) and 0.52 Hz (once every other second). Most B/U C&W parameters are sampled every second. Alert parameters are sampled every 1 or 2 seconds.

- a. Example 1: A parameter is sampled once every second (1.04 Hz) and has a filter value of 2. It must be out-of-limits for 2 seconds before annunciating an alarm. It would then have to be back within limits for at least 2 seconds and out-of-limits again for 2 seconds before a subsequent alarm would be annunciated for the parameter. (This is typical for B/U C&W parameters.)
- b. Example 2: A parameter is sampled once every 2 seconds (0.52 Hz) and has a filter value of 15. It must be out-of-limits for 30 seconds before annunciating an alarm. It would then have to be back within limits for at least 30 seconds and out-of-limits again for 30 seconds before a subsequent alarm would be annunciated for the parameter. (This is common for alert parameters.)

Noise filter values and GPC data acquisition rates are specified in the SM FSSR and are not carried onboard the shuttle.

4.5.3.3 B/U C&W Parameter Annunciation Enable/Inhibit Status

For each parameter, alarm annunciation is either enabled or inhibited. A parameter must be enabled in order for annunciation to occur. An inhibited parameter that goes out-of-limits does not generate B/U C&W annunciation. The class 0 limit sensing arrows will still be displayed next to the out-of-limit parameter on the DPS display for inhibited parameters.

4.5.4 B/U C&W Annunciation

Annunciation occurs when an enabled parameter that is out of limits has satisfied its noise filter value requirement. Regardless of the type of software (SM or GNC) that initiated the alarm, B/U C&W annunciation consists of the following indications:

a. Aural

Generation of the C&W tone - This is an alternating signal of 400 Hz and 1024 Hz at a 2.5-Hz rate (400 Hz for 0.4 seconds then 1024 Hz for 0.4 seconds). The same tone is generated for primary C&W (hardware) alarms.

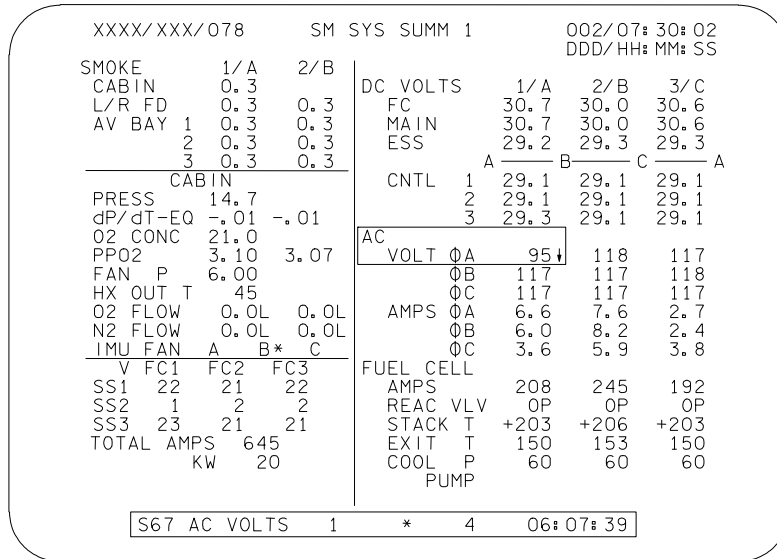
b. Visual

1. Illumination of the red MA lights on Panels F2, F4, A7, and MO52J (Figure 2-2 and Figure 2-3).
2. Illumination of the red B/U C&W ALARM light in the lower left corner of the Panel F7 C&W annunciator matrix (Figure 4-3).
3. Display of the appropriate fault message on
 - (a) DPS display fault message line (Figure 4-11) - If the fault message line already contains a message, the queue number at the right of the message is incremented.
 - (b) Fault summary (SPEC 99) - Maintains a chronological record of fault messages (Section 9.1).

Note: The fault messages are defined in the Fault Message section of the FDF Reference Data Book (Section 7.0).

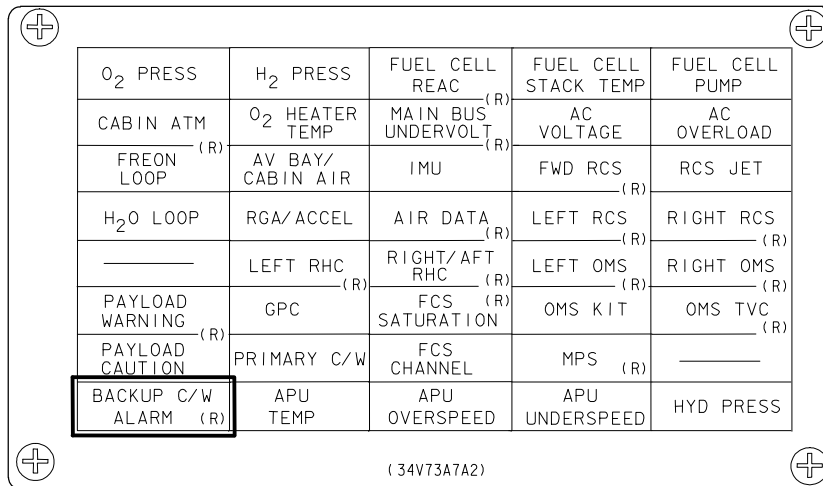
4. An up or down arrow, which is generated by class 0 limit sensing, is displayed beside the parameter on each SPEC page that contains the parameter (Figure 4-11) (Section 6.0). When a parameter is monitored by both B/U C&W and Alert FDA, the class 0 limit sensing arrows appear when the alert limits are violated.

The C&W tone, the MA lights, and the B/U C&W alarm light (Figure 4-12) are generated by the primary C&W electronics unit (hardware), but are activated by a discrete from the B/U C&W system (software).



TD4020410. CRT; 3

Figure 4-11. B/U C&W fault message example



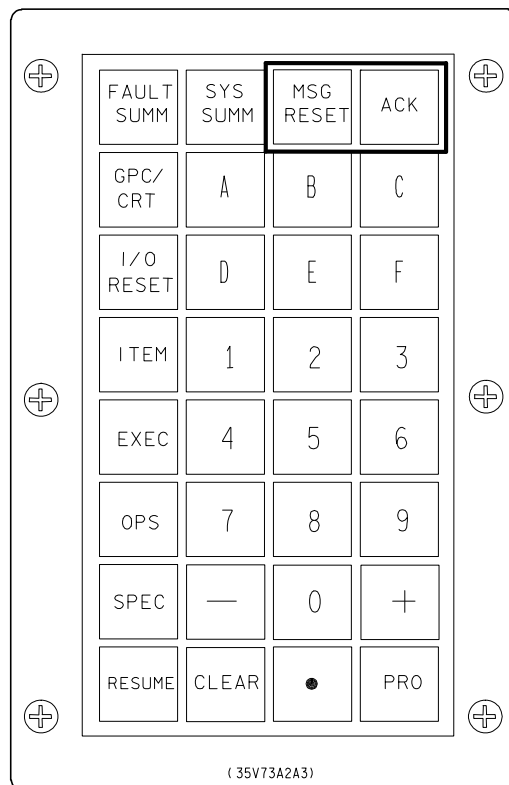
TD4020414. PNL; 2

Figure 4-12. B/U C&W alarm light

4.5.5 Crew Response to B/U C&W Annunciation

The crew response to a B/U C&W alarm may include the following actions:

- a. Depress the MASTER ALARM PBI - This extinguishes the MA light and silences the C&W tone.
- b. Depress the ACK key on the keypad (Figure 4-13) - Fault message stops flashing and becomes stationary. This step is unnecessary if the crewmember can examine the message while it is flashing.
- c. Read fault message on fault message line of DPS display - If subsequent messages have occurred, as noted by a queue number on the DPS display, look at the fault summary display (Section 9.1) or scroll through them using the ACK key.
- d. Depress the MSG RESET key on the keypad (Figure 4-13) - This clears the fault message line and extinguishes the B/U C&W alarm light on Panel F7. The light is extinguished regardless of the status of the parameter that caused the annunciation. This differs from the primary C&W Panel F7 system lights that remain lit until the parameter is either within limits or inhibited.
- e. Consult appropriate FDF procedure for actions to be performed.



TD4020415, PNL 2

Figure 4-13. Keypad

4.6 QUESTIONS

Answer the following questions by either filling in the blank or selecting the appropriate answer.

1. The primary C&W system is class ____; the B/U C&W system is class ____.
2. True or False. Both primary C&W and B/U C&W are software systems.
3. True or False. Both PASS and BFS support B/U C&W.
4. Which of the following major functions support B/U C&W?
 - a. GNC
 - b. SM
 - c. Both GNC and SM
5. True or False. Flight rules do not require that the B/U C&W and primary C&W limits be the same.
6. Limits for the following systems are in which units?

____ Primary C&W	a. Volts dc
	b. Engineering units
____ B/U C&W	c. Imaginary units
7. Preflight limit values are available to the crew in the ____ section of the FDF _____ Book.
8. The R13 C&W panel allows the crewmember to interact with the ____ system(s).
 - a. Primary C&W
 - b. B/U C&W
 - c. a and b
9. Panel R13 is used to _____ for the primary C&W system.
 - a. Read and change parameter limits
 - b. Enable and inhibit parameters
 - c. Change parameter filter values
 - d. a and b
 - e. a, b, and c

10. The Panel R13 light matrix is used to
 - a. Determine which parameters are tripped
 - b. Determine which parameters are inhibited
 - c. Read the upper or lower limit of a parameter
 - d. a and b
 - e. a, b, and c
11. True or False. The Panel R13 and Panel C3 MEMORY switches access the same C&W memory.
12. The Panel F7 annunciator matrix contains
 - a. Primary C&W system lights
 - b. The B/U C&W alarm light
 - c. a and b
13. The fault summary maintains a record of _____ fault messages
 - a. Primary C&W
 - b. B/U C&W
 - c. a and b
14. C&W annunciation - Place an "X" in the appropriate positions to indicate the annunciation for the enabled and inhibited states of both primary and B/U C&W.

	Primary C&W		B/U C&W	
	Enabled	Inhibited	Enabled	Inhibited
MA lights illuminated				
Panel F7 B/U C&W alarm light illuminated				
Panel F7 system light illuminated				
Panel R13 status light illuminated while the PARAM STATUS switch is in the TRIPPED position				
Panel R13 status light illuminated while the PARAM STATUS switch is in the INHIBITED position				
C&W tone				
Fault message on DPS display				
Class 0 limit sensing up and down arrows on DPS displays				

15. Crew response to annunciation - Place an "X" in the appropriate positions to indicate the crew response to the various types of primary and B/U C&W annunciation.

	Press MA PBI	Press ACK	Press MSG RESET	Not possible by any of these actions
Extinguish MA lights				
Extinguish Panel F7 B/U C&W alarm light				
Extinguish Panel F7 system lights				
Extinguish Panel R13 parameter light				
Make DPS display fault message stationary				
Erase DPS display fault message				
Interrupt C&W tone				

5.0 CLASS 3 ALERT

5.1 OBJECTIVES

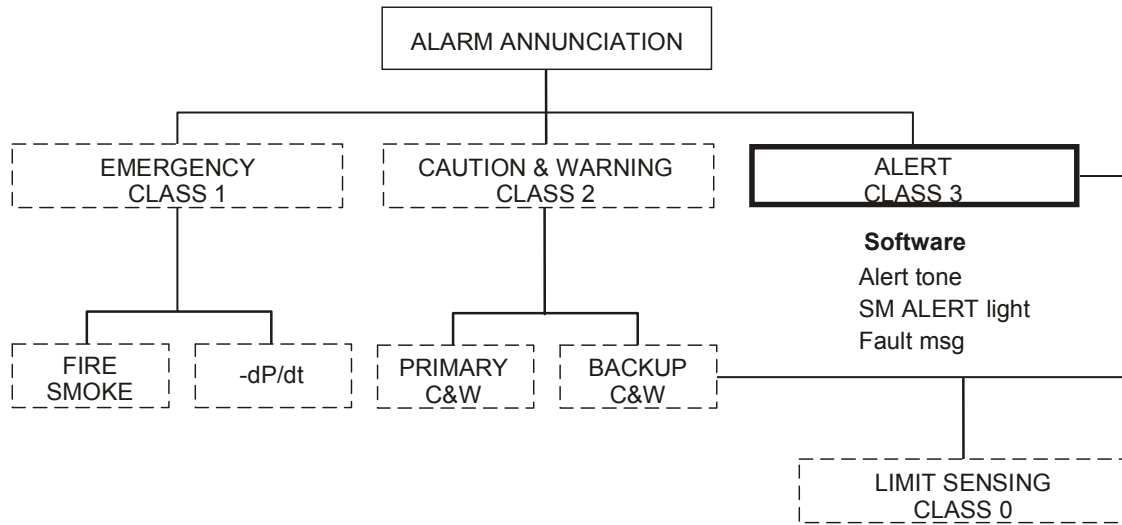
After reading this section, the student should be able to

- Specify which software supports alerts
- State the aural and visual indications of alert annunciation
- Describe the crew response to alert annunciation
- Explain the purpose of
 - Upper and lower limits
 - Enable/inhibit status
 - Noise filter value
 - Preconditioning
- Correctly answer the questions at the end of the section

5.2 OVERVIEW

The alert system is a software system ONLY (Figure 5-1). The FDA software monitors parameters, detects out-of-limit conditions, and initiates alert annunciation.

The alert system monitors parameters associated with many orbiter systems. Many of these parameters are also monitored by the C&W system, which typically have broader C&W limits than the alert limits.



USA006019_008

Figure 5-1. Class 3 alert diagram

5.2.1 Alert Software Support

The alert system is supported by the same software as the B/U C&W system. This includes the SM and GNC major functions of both the PASS and the BFS software. (Refer to Section 4.5.2 for details.)

SPEC 60, SM Table Maintenance (Section 8.0), provides the crew interface to read or change PASS SM parameter limits, noise filter values, and annunciation enable/inhibit status. Changes to a PASS GNC or a BFS parameter requires a memory read/write procedure (see the DPS Hardware/Software 2102 training manual for details).

5.2.2 Requirements for Alert Annunciation

5.2.2.1 Limits

Each alert parameter has either one, two, or three sets of limits. Each set of limits may consist of an upper limit, a lower limit, or both. The GPCs sample the present value of each parameter and compare it to the parameter limits to determine whether an upper or lower limit is violated.

The C&W and FDA tables of the Reference Data Book provide a comprehensive listing of all limit-sensed parameters that can result in a class 2 or 3 alarm with information which can be used by the crew to alter limits (see Section 7.4).

5.2.2.2 Preconditioning

Only one set of alert limits is active at any one time. Alert parameters with multiple sets of limits have precondition steering, which is used to determine the appropriate set of limits. Simply stated, a sensor input or system status is used in the logic to select which set of limits will be used.

Each set of limits has a corresponding set of conditions. The GPC software selects the appropriate set of limits based on the conditions. This selection is typically based on the operating level or the switch configuration of an orbiter system. For example, the water (H₂O) loop 2 pump out pressure parameter uses preconditioning that is based on system configuration (Figure 5-2). If the pump is on, the limits will detect a failed pump. If the pump is off, the limits will detect a system leak. The fuel cell stack temperature preconditioning is based on the fuel cell power level (Figure 5-2), the higher the power, the higher the temperature range. Preconditionings are listed in the FDF REF Data Book (C&W & FDA Table) and discussed in Section 7.4 of this training manual.

Each limit set has a corresponding logic statement consisting of one to four discretized or limit-sensed analogs. The logic statement defines the conditions for which the limit set is used. If no logic statement is satisfied, the first set of limits is selected as the default set. The preconditioning logic statements for alerts generated by the SM major function are located in the SM FSSR.

The crew cannot directly select which set of limits is active. If the crew alters the system configuration (turns on a pump, for example) or changes the system performance (decreases the loads on the fuel cell, thereby changing its power output, for example), the software may select a different limit set since a different precondition may be met. However, the crew or MCC could change the value of constants (Section 8.0, SPEC 60) that is used in the preconditioning process, which would affect the conditions selected, but this is rarely done.

H₂O Loop 2 Pump Out Pressure

<u>Alert limits</u>		Precondition*
Low	High	
50.0	75.0	ON or GPC with “pump ON” command issued
20.0	None	OFF or GPC with “pump ON” command not present

*The precondition is loop 2 pump switch position (ON, OFF, or GPC).

Fuel Cell Stack Temp

<u>Alert limits</u>		Precondition*
Low	High	
180	212	$\leq 3.5 \text{ kW}$
190	222	$3.5 < \text{kW} < 7.5$
198	238	$\geq 7.5 \text{ kW}$

*The precondition is fuel cell power output.

Figure 5-2. Preconditioning

Some alert parameters have a time delay that is invoked when the GPC software selects a new limit set. The time delay must expire before fault detection can occur. For example, a temperature parameter may have a time delay that will cause the software to wait a certain number of minutes (or seconds) after an associated heater is turned on. The time delay values are listed in the SM FSSR and are not carried onboard.

5.2.2.3 Noise Filter Value

The alert noise filter provides false alarm avoidance in the same manner as the B/U C&W noise filter. (Refer to Section 4.5.3.2)

Typical values for the alert noise filter are 15, 7, and 2. All BFS parameters have a noise filter value of 2. Alert parameters are sampled every second or every 2 seconds. It is common for alert parameters to have a filter value of 15 and be sampled every 2 seconds. For such parameters, annunciation will occur no earlier than 30 seconds after the parameter initially violates a limit.

5.2.2.4 Alert Parameter Annunciation Enable/Inhibit Status

For each parameter, alarm annunciation is either enabled or inhibited. An enabled parameter that goes out of limits can annunciate an alert, where an inhibited parameter cannot. The class 0 limit sensing remains active for inhibited parameters.

5.2.3 Alert Annunciation

Annunciation occurs when an enabled parameter that is out of limits has satisfied its noise filter value requirement. Alert annunciation consists of the following indications (regardless of the type of software which initiated the alert):

a. Aural

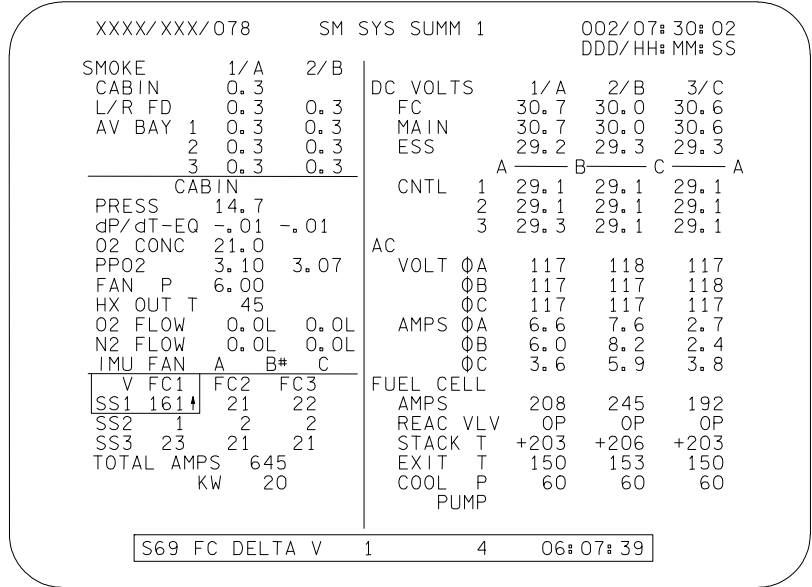
Generation of the alert tone - This is a continuous tone at 512 Hz. It is generated by the primary C&W electronics unit but is driven by a discrete from the alert system.

b. Visual

1. Illumination of the blue SM ALERT light on Panel F7 (Figure 2-2).
2. Display of the appropriate fault message on
 - (a) DPS display fault message line (Figure 5-3) - If the fault message line already contains a message, the queue number at the right of the message is incremented.
 - (b) Fault summary (SPEC 99) - Maintains a chronological record of fault messages (Section 9.1).

Note: The fault messages are defined in the Fault Message section of the FDF Reference Data Book (Section 7.0).

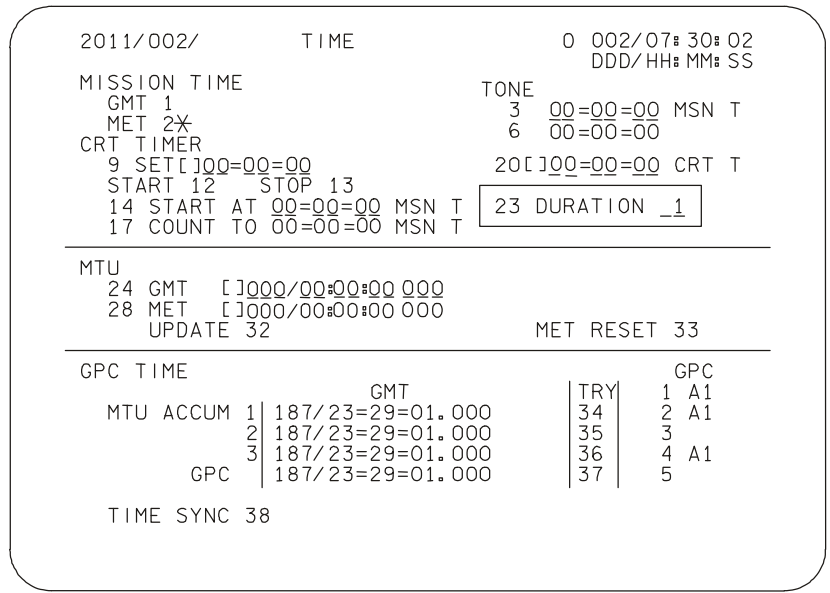
3. An up or down arrow, which is generated by class 0 limit sensing, is displayed beside the parameter on each SPEC that contains the out of limit parameter (Figure 5-3) (Section 6.0).



TD4020503. CRT; 3

Figure 5-3. Alert fault message example

The duration of the alert tone is adjustable from 0 to 99 seconds. The crew can read and change the duration (item 23) on SM SPEC 2, TIME (Figure 5-4). A value of 1 (second) is typical. Setting the duration to “0” will prevent the tone from annunciating (this is not typically done). The crew normally changes the duration pre-sleep and post-sleep to provide a longer tone during crew sleep periods. If the tone is not acknowledged, it will halt when the duration has been satisfied.



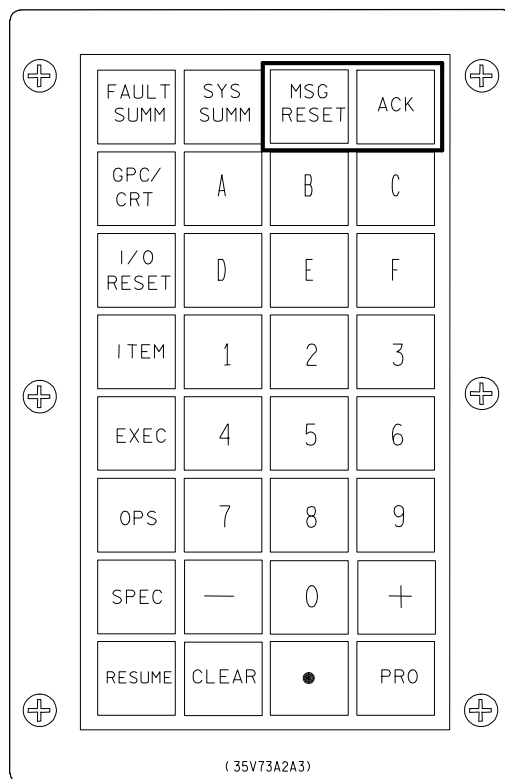
usa006019_021

Figure 5-4. SPEC 2, TIME with alert duration highlighted

5.2.4 Crew Response to Alerts

The crew response to an alert may include the following actions:

- a. Optional: Depress the MASTER ALARM PBI - This interrupts the alert tone if the duration has not already timed out.
- b. Depress the ACK key on the keypad (Figure 5-5) - Fault message stops flashing and becomes stationary. This also interrupts the alert tone and extinguishes the blue SM ALERT light on Panel F7. This step is unnecessary if the crewmember can examine the message while it is flashing and if the alert tone duration has already timed out.
- c. Read fault message - If subsequent messages have occurred, as noted by a queue number on the DPS display, look at the fault summary display (Section 9.0) or scroll through them using the ACK key.
- d. Depress the MSG RESET key on the keypad - This action clears the fault message line and extinguishes the blue SM ALERT light on Panel F7. This also silences the alert tone if the duration has not timed out.
- e. Consult the appropriate FDF procedure for actions to be performed.



TD4020520, PNL, 1

Figure 5-5. Keypad

5.3 QUESTIONS

Answer the following questions by either filling in the blank or selecting the appropriate answer.

1. The alert system is class ____.
2. True or False. Both PASS and BFS support alerts.
3. Which of the following major functions support alerts?
 - a. GNC
 - b. SM
 - c. Both GNC and SM
4. An alert parameter may have up to ____ sets of limits.
5. Alert limits are in which of the following units?
 - a. V DC
 - b. Engineering units
6. The duration of the alert tone may be adjusted by an item ____ entry on SPEC ____.
7. True or False. When the alert tone is activated and not interrupted, it will stop when it has timed out.
8. True or False. Alert parameters with one set of limits are preconditioned.
9. Preflight limit values are available to the crew in the _____ section of the _____ (FDF).
10. Alert annunciation - Place an "X" in the appropriate positions to indicate the annunciation for the enabled and inhibited states of alerts.

	Alert	
	Enabled	Inhibited
SM ALERT light illuminated		
MA light illuminated		
Alert tone		
C&W tone		
Fault message on DPS display		
Class 0 limit sensing (up and down arrows on DPS displays)		

11. Crew response to annunciation - Place an "X" in the appropriate positions to indicate the crew response to the various types of alert annunciation.

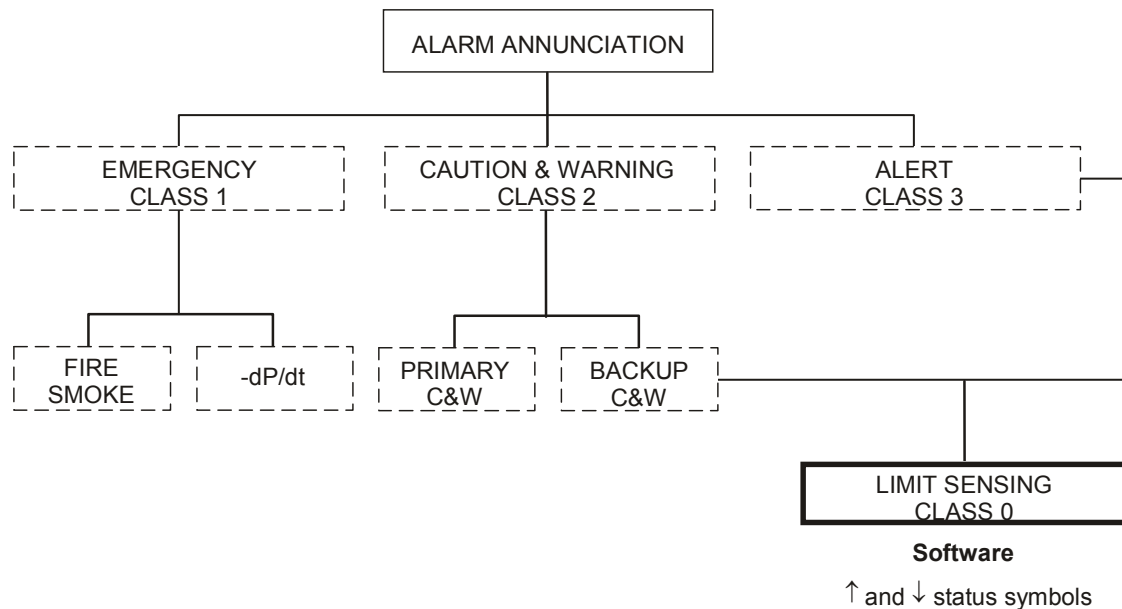
	Press MA PBI	Press ACK	Press MSG RESET	Not possible by any of these actions
Extinguish SM alert light				
Make DPS display fault message stationary				
Erase DPS display fault message				
Interrupt C&W tone				

*Alert tone will time out if no action is performed.

6.0 CLASS 0 LIMIT SENSING

6.1 OBJECTIVES

After completing this section, the student should understand how limit sensing is annunciated and the interrelationship to the other FDA software (C&W and alert systems) (Figure 6-1).



USA006019_009

Figure 6-1. Class 0 limit sensing diagram

6.2 OVERVIEW

The sole purpose for class 0 limit sensing is to provide crewmembers a quick way to identify out-of-limit parameters on often cluttered DPS displays. It is part of the FDA software system, but unlike the others, provides no aural annunciation, preconditioning, or special purpose limit-sensing capabilities. This is accomplished by displaying an appropriate status symbol next to the out-of-limit parameter.

6.3 STATUS SYMBOLS

There are seven specially defined parameter status indicators. They are displayed in “overbright” intensity directly to the right of the affected parameter and are listed in Table 6-1.

Table 6-1. Status symbols

Symbol	Definition
M	This symbol indicates missing data. The parameter value may be blank or the last value received by the GPC may be displayed. If data is missing for a parameter that has no numerical value associated with it, then an M is used to indicate the parameter status
H	This symbol indicates that a parameter is off-scale high. The transducer limit has been reached, and the scale is registering at its highest possible value. The actual parameter being measured may, in fact, be higher than the recorded data, but the instrument in use does not have the capacity to measure the value
L	This symbol indicates off-scale low parameters. This means that the parameter value is the lowest possible reading due to transducer limitations. The actual value of the parameter may be lower than the displayed value, but the range of the hardware cannot accommodate this reading
?	This symbol indicates a Redundancy Management (RM) dilemma. That is, if two hardware units measuring the same parameter disagree and the software cannot isolate which of the two is failed, a “?” will be displayed in both places
↑	This symbol indicates a parameter driven out-of-limits high. The value displayed is a true reading but has equaled or exceeded the operational high limit established by the software. When the parameter value exceeds both the transducer limit and the operational limit, the H symbol overrides the ↑ symbol
↓	<p>This symbol is the counterpart to the ↑ symbol. It indicates that a parameter value is equal to or less than the operational lower limit established by software. The value displayed is a true reading. When the parameter value exceeds both the transducer limit and the operational limit, the L symbol overrides the ↓ symbol.</p> <p>In addition, the ↓ symbol is used to indicate a discrete state that does not agree with the nominal state. For example, a cryogenic oxygen valve feeding the fuel cells is normally open; if it closes, a ↓ is displayed next to the parameter.</p> <p>The ↓ also is used to indicate that a hardware unit has been declared failed by a GPC</p>
*	This symbol indicates an active state, or to show the selected item of mutually exclusive items

6.4 LIMIT-SENSING INDICATIONS

The class 0 alarm generates two of the seven status symbols. The symbols are “↑” and “↓.”

The remaining five status symbols are not generated by this alarm class. They are provided by subroutines separate from the FDA software.

SM FDA is a subroutine which monitors the operational low and high limits of all parameters listed in the C&W & FDA Table. The table contains operational limits for B/U C&W (class 2), alert (class 3), and limit sensing (class 0) systems.

When a limit is violated, the appropriate ↑ or ↓ status symbol is shown next to the parameter on all DPS displays on which the parameter is listed. No fault message, tone, or light is associated with this alarm class.

If a parameter is monitored by both B/U C&W (class 2) and alert (class 3), class 0 limit sensing uses the alert limits to trigger the status symbol.

Class 0 limit sensing remains active for a parameter even if B/U C&W and/or alert annunciation is inhibited for that parameter.

The GNC software provides a similar function for GNC parameters.

7.0 FDF REFERENCE DATA BOOK

7.1 OBJECTIVES

After completing this section, the student should be able to identify and use the information available in the fault message table and the three C&W tables in the FDF Reference Data Book.

7.2 OVERVIEW

This section discusses the following tables from the FDF Reference Data Book:

- a. Fault Message table
- b. C&W & FDA table
- c. Hardware C&W table
- d. Primary-to-Backup C&W Analog Parameter Calibration table

7.3 FAULT MESSAGES TABLE

The fault messages table provides a reference to crewmembers on all software-generated fault messages.

Table 7-1 is an example of a typical fault message table. The following is a list of the information contained in the table:

- a. Message The message column notes the exact message annunciated on a DPS display. PASS and BFS messages may not be identical for the same failure, which are identified in the table.
- b. OPS availability This column is broken into two subcolumns: PASS and BFS. Under each subcolumn is a list of GPC OPS in which a particular message can be received.
- c. Cause This column lists the operational causes that drive the associated messages.

d. Comments

The comments column provides crewmembers with clarification notes to aid procedures and trouble shoot the failure.

(1) Expands on exactly what condition must be present for a message to be annunciated. For example, an F_RCS LEAK message will be generated for an OX/FU Δ QTY > 9.5 percent. (The C&W & FDA Table identifies this as a bilevel discrete.)

(2) NO MAL: Identifies that the message has no corresponding long form malfunction procedure.

(3) Identifies the correct procedure to be consulted. This is done in those cases where the general procedure titles contained in the PKT C/L are too generic for proper identification and use. For example, the RCS LEAK ISOL PKT C/L procedure should be used for an F_RCS He P msg.

(4) Identifies impacts on the system. Examples include "quantity calculation suspended" and "cause termination of auto sequence."

Table 7-1. Typical fault message table

MESSAGE		OPS AVAIL		CAUSE	COMMENTS
		PASS	BFS		
F RCS (Cont.)	RJET	G1,2,3,6,8		• F RIGHT JET 2(4,5) FAIL ON/OFF/LK	• FAIL OFF DETECTION NOT PERFORMED IN MM101 & 102 FOR PASS
	UJET	G1,2,3,6,8		• F UP JET 1(2,3) FAIL ON/OFF/LK	
	He P LEAK	G2,8	G1,3,6	• F He (FU OR OX) TK P 2 LOW	• PKT C/L - RCS LEAK ISOL
		G2,3,8	G1,3,6	• PROP/He LEAK	• OX/FU Δ QTY > 9.5%
	PVT	G2,3,8		• LOSS OF P OR T DATA FOR RCS QTY CALC	• NO MAL • QTY CALC SUSPENDED
	TK P	G2,8	G1,3,6	• FWD RCS (FU OR OX) TK ULL PRESS HI/LOW	• QTY CALC SUSPENDED
S69 FC AMPS SM1 FC AMPS 1(2,3)	1(2,3)	S2,4		• FC AMPS $\uparrow\downarrow$	
			SM		
S69 FC COOL P SM1 FC COOL P 1(2,3)	1(2,3)	S2,4		• FC COOL P $\uparrow\downarrow$	
			SM		
S69 FC DELTA V SM1 FC DELTA V 1(2,3)	1(2,3)	S2,4		• FC SUBSTACK $\Delta V > 150$ MV	
			SM		
S69 FC EXIT T SM1 FC EXIT T 1(2,3)	1(2,3)	S2,4		• FC EXIT T $\uparrow\downarrow$	
			SM		
S69 FC H2 FLOW	1(2,3)	S2,4		• FC H2 FLOW \uparrow	
S69 FC H2 PUMP	1(2,3)	S2,4		• FC H2 PUMP STATUS $\uparrow\downarrow$	

7.4 C&W AND FDA TABLE

The C&W and FDA table provides a comprehensive alphabetical listing of limit-sensed parameters and their respective annunciation limits for the hardware primary C&W and SM software B/U C&W and the SM alert systems. Only a few GNC parameters are listed. The table also provides information that can be used by the crew to alter limits and to eliminate nuisance alarms when necessary.

Table 7-2 is an example of one page out of the C&W and FDA table. The table columns are organized as follows:

- a. **Parameter name** The parameter name is consistent with the parameter title on the DPS display as much as possible; these names are alphabetically arranged. If the first words of a parameter are identical to the parameter(s) above it, they are not repeated.

PASS, BFS, and/or GNC are specified only when the limits are unique to a given software system. Footnotes attached to the parameter name typically indicate the OPS, Major Mode (MM), major function (GNC or SM), and/or flight system (PASS or BFS) that the parameter is available.
- b. **C&W CH** The C&W channel column gives the channel number of the parameter (from 000 to 119) to be used on Panel R13U for the PARAMETER SELECT pushbuttons and the STATUS MATRIX.

This channel number corresponds only to the primary C&W system (class 2 hardware).
- c. **H/W C&W** The H/W C&W column presents the high and low primary C&W limits (class 2) in V dc. In the cases where hardware limits are not backed up by identical software limits, the value in engineering units is printed in parentheses below the value in V dc.
- d. **SOFTWARE ID** This column gives the parameter Identification (ID) to be used when altering parameter fault detection via PASS Table Maintenance, SM SPEC 60. Software IDs for BFS SM limits also are given, although at the present time there is no BFS equivalent to the Table Maintenance SPEC. GNC limit-sensed parameters cannot be changed except by memory read/write; I-load identification numbers are provided for selected parameters.
- e. **PASS SPEC** This column lists the specific SPEC or DISP number on which the parameter appears.

- f. SM ALERT The SM alert column contains the low and high alert limits (class 3) in engineering units. The column title is misleading because some GNC parameter limits are included as well as limits for SM parameters.
- g. B/U C&W The B/U C&W column provides crewmembers with the high and low B/U C&W (class 2) limits in engineering units.
- h. Precondition (P) and/or bilevel state (BL) The last column identifies precondition characteristics when applicable.
It also describes the circumstances that generate the bilevel change of state and subsequent alarm. Bilevel (BL) means two possible states exist for a given parameter (for example, an APU has either experienced an underspeed or it has not). Bilevel comments give the state, which triggers alarm annunciation.
Also listed in this column are default values for the primary C&W system. Refer to Section 2.0 for a discussion of PROM defaults.
In addition, a few notes describe unusual cases.

As a final note: These tables are for class 2 and class 3 limit sensed parameters. The Class 1 alarms for Fire/Smoke or Cabin dP/dT are hardware only and not part of these tables.

Table 7-2. C&W FDA table

PARAMETER NAME	C/W CH	H/W C/W		SOFTWARE ID	PASS SPEC	SM ALERT		B/U C/W		PRECONDITION (P) AND/OR BILEVEL STATE (BL)
		LOW	HIGH			LOW	HIGH	LOW	HIGH	
APU SPEED % 2 (BFS)				0460235			112.0			<ul style="list-style-type: none"> • APU 2 ON & NOT IN HIGH SPD MODE (P) • APU 2 ON (P) • APU 2 IN INJ COOL FOR 3.5 MIN CONTINUOUS MINS AND SPD <80% (P) • APU 3 ON & NOT IN HIGH SPD MODE (P) • APU 3 ON (P) • APU 3 IN INJ COOL FOR 3.5 MIN CONTINUOUS MINS AND SPD <80% (P)
3 (BFS)				0460335		80.0	112.0	80.0	122.0	
TEMP EGT 1 ^a	8		4.20	0460142						
2 ^a	18		4.20	0460242						
3 ^a	28		4.20	0460342						
UNDERSPEED 1	98		5.00							
2	108		5.00							
3	118		5.00							
AV BAY FAN ΔP 1				0612642	66	2.5	4.3			
2				0612647	66	2.5	4.3			
3				0612658	66	2.5	4.3			
3 ^b				0612658	66	4.5	7.8			
TEMP 1	84		4.25	0612645	66				130.0	
2	94		4.25	0612650	66				130.0	
3	104		4.25	0612661	66				130.0	

^aH/W C/W channels are inhibited

^bUpgraded AV Bay Fan

7.5 HARDWARE C&W TABLE

The hardware C&W table provides crewmembers with a quick way to associate primary C&W channel numbers with their respective parameter names (Table 7-3).

Table 7-3. Hardware C&W table

C&W CH	PARAMETER NAME	C&W CH	PARAMETER NAME	C&W CH	PARAMETER NAME	C&W CH	PARAMETER NAME	C&W CH	PARAMETER NAME
0	CRYO O2 P TK1	25	GPC 3	50	CRYO H2 P TK1	*75		100	L RHC
1	CRYO O2 HTR1 TK1	26	RCS LEAK/TK P - F	51	CRYO O2 HTR 2 TK3	76	RCS TK P FU - R	101	FCS SATURATION
2	FC1 REAC O2	27	OMS ENG - L	52	FC3 REAC H2	*77		102	FC2 COOL PUMP
3	DC VOLT MAIN A	28	APU 3 EGT	53	AC3 VOLT (A, B, C)	78	APU 2 OVERSPEED	103	IMU
4	CAB PRESS	29	MPS HE TK P - R	54	CAB N2 FLOW 1	79	MPS MANF P LH2	104	AV BAY 3 TEMP
5	GPC 1	30	CRYO O2 P TK 4/5	*55		80	CRYO H2 P TK 4/5	105	H2O LOOP 1 PUMP OUT P
6	RCS TK P OX - F	31	CRYO O2 HTR 2 TK2	56	RCS LEAK/TK P - L	81	CRYO O2 HTR 1 TK5	106	FREON LOOP 1 FREON FLOW
7	OMS TK P OX - L	32	FC2 REAC H2	57	OMS ENG - R	82	FC3 STACK T	107	FREON LOOP 1 EVAP OUT T
8	APU 1 EGT	33	AC1 VOLT (A, B, C)	58	APU 3 OIL T	83	AC3 OVLD	108	APU 2 UNDERSPEED
9	MPS HE TK P - C	34	CAB PPO2 A	59	MS HE REG P - R	84	AV BAY 1 TEMP	109	HYD 2 P
10	CRYO O2 P TK2	35	GPC 4	60	CRYO H2 P TK2	*85		110	R/AFT RHC
11	CRYO O2 HTR 2 TK1	36	RCS TK P OX - L	61	CRYO O2 HTR 1 TK4	86	RCS LEAK/TK P - R	111	FCS CH BYPASS
12	FC1 REAC H2	37	OMS TK P OX - R	62	FC1 STACK T	*87		112	FC3 COOL PUMP
13	DC VOLT MAIN B	38	APU 1 OIL T	63	AC1 OVLD	88	APU 3 OVERSPEED	*113	
14	CAB O2 FLOW 1	39	MPS HE REG P - C	64	CAB N2 FLOW 2	*89		114	CAB HX OUT T
15	GPC 2	40	CRYO O2 P TK5	*65		90	CRYO H2 P TK5	115	H2O LOOP 2 PUMP OUT P
16	RCS TK P FU - F	41	CRYO O2 HTR 1 TK3	66	RCS TK P OX - R	91	ADTA	116	FREON LOOP 2 FREON FLOW
17	OMS TK P FU - L	42	FC3 REAC O2	67	OMS TVC	92	FC1 COOL PUMP	117	FREON LOOP 2 EVAP OUT T
18	APU 2 EGT	43	AC2 VOLT (A, B, C)	68	APU 1 OVERSPEED	93	RGAAA	118	APU 3 UNDERSPEED
19	MPS HE TK P - L	44	CAB PPO2 B	69	MPS MANF P L O2	94	AV BAY 2 TEMP	119	HYD 3 P
20	CRYO O2 P TK3	45	GPC 5	70	CRYO H2 P TK3	95	PL WARNING		
21	CRYO O2 HTR 1 TK2	46	RCS TK P FU - L	71	CRYO O2 HTR 2 TK4	96	RCS JET		
22	FC2 REAC O2	47	OMS TK P FU - R	72	FC2 STACK T	97	PL CAUTION		
23	DC VOLT MAIN C	48	APU 2 OIL T	73	AC2 OVLD	98	APU 1 UNDERSPEED		
24	CAB O2 FLOW 2	49	MPS HE REG P - L	74	CAB FAN ΔP	99	HYD 1 P		

* Channel not used

td402_010.doc

7.6 PRIMARY-TO-BACKUP C&W ANALOG PARAMETER CALIBRATION TABLE

This calibration table is used in conjunction with the primary C&W system. Because the primary C&W system uses voltage for limits, a conversion from engineering units to voltage and voltage to engineering units is necessary (Table 7-4).

The first operation in using this table is to locate the name and bubble number of a parameter. As an example, the parameter scale for APU exhaust gas temperature is bubble 11. The first column (bubble 1) is also the volt conversion column from 0.0 to 5.0 V. If there is a multiplying factor or vehicle identifier, it will be listed by the parameter name.

After identifying an associated bubble for the parameter, read across the top of the table until reaching the column that matches the parameter bubble. The next step is to proceed down the column until the desired value, in engineering units, is located. Next, read across (row) to the left to the first column. The value that appears in the first column is the corresponding voltage to the engineering value that has been selected (column). Several parameters may be listed for a specific conversion scale and may require an appropriate multiplying factor.

If a limit value had been read for a particular parameter using the primary C&W system (Panel R13U matrix), and it is desired to convert this voltage to its corresponding engineering unit, the same table is used. Locate the voltage value in the first column, then read across to the appropriate column to determine the engineering value.

As an example, refer to Table 7-4. If we want to set an upper limit of 15.5 psia for the cabin pressure on Discovery, Orbiter Vehicle (OV)-103, the first step is to locate the correct bubble. In this case, it is bubble 5b. Proceed down column 5b until the value 15.5 is located. You will notice that there is no value corresponding exactly to 15.5, so the value of 15.40 is substituted (use the conservative lower value in this case).

Moving to the left to the first column, we see that the corresponding voltage value is 3.85. This is the value needed for the primary C&W system. Then set this value as per the C&W Parameter Limit Read/Change procedure in REF DATA.

Conversely, if we read the primary C&W lower limit for cabin pressure and find it to be 3.65 V, the corresponding pressure can be found. First, we identify which column corresponds to cabin pressure (column 5b). Then, we locate 3.65 in column 1, the C&W limit volts column. Next, we move to the right to column 5b. The value found in column 5b, 14.60, is the engineering unit (psia) that corresponds to 3.65 V.

Table 7-4. Primary-to-backup C&W analog parameter calibration table

3.65 V ⇒ 14.56

① 0.00 TO 5.00	② -417 TO 468	③ -76.7 TO 298.1	④ -3.1 TO 496.8	⑤ ^a 0.11 TO 19.91	⑤ ^b 0.00 TO 20.00	⑤ ^c 0.05 TO 19.85	⑤ ^d 0.10 TO 19.92	⑥ 0 TO 8	⑦ 0 TO 40	⑧ 0 TO 100	⑨ 0 TO 150	⑩ 0 TO 300	⑪ 8 TO 1520	⑫ 24.9 TO 129.9	⑬ 45 TO 145	⑭ 145 TO 305	⑮ 515 TO 1015	⑯ 732 TO 2684
3.65	220	106.0	261.0	14.56	14.60	14.51	14.50	5.84	29.2	73	109.5	219	1112	101.5	118	261.8	880	2304
3.70	238	200.6	366.8	14.76	14.80	14.70	14.70	5.92	29.6	74	111.0	222	1127	102.6	119	263.4	885	2319
3.75	246	204.4	371.8	14.96	15.00	14.90	14.90	6.00	30.0	75	112.5	225	1142	103.6	120	265.0	890	2334
3.80	255	208.1	376.8	15.16	15.20	15.10	15.10	6.08	30.4	76	114.0	228	1157	104.7	121	266.6	895	2348
3.85	264	211.0	381.8	15.36	15.40	15.30	15.29	6.16	30.8	77	115.5	231	1172	105.7	122	268.2	900	2363
3.90	273	215.6	386.8	15.55	15.60	15.50	15.49	6.24	31.2	78	117.0	234	1187	106.8	123	269.8	905	2378
3.95	282	219.4	391.8	15.75	15.80	15.69	15.69	6.32	31.6	79	118.5	237	1202	107.8	124	271.4	910	2392
4.00	291	223.1	396.8	15.95	16.00	15.89	15.89	6.40	32.0	80	120.0	240	1217	108.9	125	273.0	915	2407
4.05	299	226.9	401.8	16.15	16.20	16.09	16.09	6.48	32.4	81	121.5	243	1233	109.9	126	274.6	920	2421
4.10	308	230.6	406.8	16.35	16.40	16.29	16.29	6.56	32.8	82	123.0	246	1248	111.0	127	276.2	925	2435
4.15	317	234.4	411.8	16.54	16.60	16.49	16.48	6.64	33.2	83	124.5	249	1263	112.0	128	277.8	930	2450
4.20	326	238.1	416.8	16.74	16.80	16.68	16.68	6.72	33.6	84	126.0	252	1278	113.1	129	279.4	935	2464
4.25	335	241.9	421.8	16.94	17.00	16.88	16.88	6.80	34.0	85	127.5	255	1293	114.1	130	281.0	940	2478
4.30	344	245.6	426.8	17.14	17.20	17.08	17.08	6.88	34.4	86	129.0	258	1308	115.2	131	282.6	945	2492
4.35	353	249.4	431.8	17.34	17.40	17.28	17.28	6.96	34.8	87	130.5	261	1323	116.2	132	284.2	950	2506
4.40	361	253.1	436.8	17.53	17.60	17.48	17.48	7.04	35.2	88	132.0	264	1338	117.3	133	285.8	955	2520
4.45	370	256.9	441.8	17.73	17.80	17.67	17.67	7.12	35.6	89	133.5	267	1354	118.3	134	287.4	960	2534
4.50	379	260.6	446.8	17.93	18.00	17.87	17.87	7.20	36.0	90	135.0	270	1369	119.4	135	289.0	965	2548
4.55	388	264.4	451.8	18.13	18.20	18.07	18.07	7.28	36.4	91	136.5	273	1384	120.4	136	290.6	970	2561
4.60	397	268.1	456.8	18.33	18.40	18.27	18.27	7.36	36.8	92	138.0	276	1399	121.5	137	292.2	975	2575
4.65	406	271.8	461.8	18.52	18.60	18.47	18.47	7.44	37.2	93	139.5	279	1414	122.5	138	293.8	980	2589
4.70	414	275.6	466.8	18.72	18.80	18.66	18.67	7.52	37.6	94	141.0	282	1429	123.6	139	295.4	985	2602
4.75	423	279.3	471.8	18.92	19.00	18.86	18.87	7.60	38.0	95	142.5	285	1444	124.6	140	297.0	990	2616
4.80	432	283.1	476.8	19.12	19.20	19.06	19.06	7.68	38.4	96	144.0	288	1459	125.7	141	298.6	995	2630
4.85	441	286.8	481.8	19.32	19.40	19.26	19.26	7.76	38.8	97	145.5	291	1475	126.7	142	300.2	1000	2643
4.90	450	290.6	486.8	19.51	19.60	19.46	19.46	7.84	39.2	98	147.0	294	1490	127.8	143	301.8	1005	2657
4.95	459	294.3	491.8	19.71	19.80	19.65	19.66	7.92	39.6	99	148.5	297	1505	128.8	144	303.4	1010	2670
5.00	468	298.1	496.8	19.91	20.00	19.85	19.86	8.00	40.0	100	150.0	300	1520	129.9	145	305.0	1015	2684

① C/W LIMIT
O2 TP

GN2 FLOW
CAB O2 FLO
X1000 = He TK P

② O2 TK HTR T

③ FCP STK T

④ APU LUBE OIL T

⑤ CABIN P
°OV102

°OV103
°OV104
°OV105

⑥ CAB FAN DP

⑦ MAIN BUS VOL
X10 = OMS
TK ULL P
X10 = RCS
TK ULL P
X100 = HYD SYS P

⑧ MPS LHZ MANF P
x10 = MPS
HE REGP

⑨ H2O LP PUMP P

⑩ MPS LO2 MANF P

⑪ APU EST

⑫ FCL EVAP
OUT T

⑬ AV BAY 7
CABMXAIR OUT T

⑭ CRYO N2 PRESS

8.0 SPEC 60, SM TABLE MAINTENANCE

8.1 OBJECTIVES

After reading this section, the student will be able to

- Specify which software contains SPEC 60
- Specify which alarm classes are associated with SPEC 60
- Read or change each of the following for a B/U C&W or alert parameter:
 - Upper and lower limits
 - Noise filter value
 - Enable/inhibit status
- Explain the function of each item on SPEC 60
- Locate the reference material and procedures for using SPEC 60
- Correctly answer the questions at the end of the section

8.2 OVERVIEW

The crew uses SPEC 60, SM Table Maintenance (Figure 8-1) to interact with the B/U C&W and alert parameters monitored by the PASS SM software.

While B/U C&W and alert parameters are supported by the GNC and SM major functions of both PASS and BFS, only the PASS SM parameters can be accessed through SPEC 60. To change the characteristics of PASS GNC, BFS GNC, and BFS SM parameters, the crew or MCC (via uplink) has to perform a GPC memory read/write procedure. (This procedure is described in the DPS Hardware/Software 2102 Training Manual.) The remainder of this section will address PASS SM parameters only.

```

2011/060/          SM TABLE MAINT          /  :  :
SM COM BUFF          /  :  :
PARAM
 1 ID -----
  VALUE=

      ALERT          LIMITS          BACKUP C W
      LOW           HI           LOW           HI
2 [ ]----- 3 [ ]----- 11 [ ]----- 12 [ ]-----
4 [ ]          5 [ ]
6 [ ]          7 [ ]
      8 FILTER --          13 FILTER --
      ENA 9           ENA 14
      INH 10          INH 15

CONSTANT
16 ID -----
17 VALUE= [ ]-----

CHECKPT 000/00:00:00  FDA
INITIATE 18          ENA 19*
STATUS              INH 20

```

TD4020801.CRT; 1

Figure 8-1. SPEC 60

Using SPEC 60, the crew can read and change the following for each PASS SM B/U C&W or alert parameter:

- a. Lower and upper limits
- b. Noise filter value
- c. Enable/inhibit status

Additionally, the crew can read and change SM program constants, initiate a checkpoint, and enable or inhibit the entire FDA software module. FDA is the PASS SM software module that monitors the B/U C&W and alert parameters and initiates alarms. FDA also drives the arrows for class 0 limit sensing.

The FDF DPS Dictionary provides the crew with a description of SPEC 60. The C&W section of the FDF Reference Data Book (Section 7.0 of this training manual) provides the crew with procedures for using SPEC 60, software IDs, preflight limit values, and other reference information.

8.3 SPEC 60 OPERATIONS

SPEC 60 is available during SM OPS 2 and SM OPS 4. When the SM Table Maintenance display is called up by its SPEC number (SPEC 60 PRO), each field is blank except CHECKPT time and FDA ENA. When SPEC 60 is recalled by pressing RESUME, the fields that were previously in use retain their data. When a legal item entry is made, the new data elements are displayed in the appropriate fields and overwrite any previous data.

8.4 BACKUP C&W AND ALERT PARAMETERS

Any (PASS SM) B/U C&W or alert parameter may be accessed by entering its software ID number in item 1. The limits, noise filter value, and enable/inhibit status of alert parameters may be accessed with items 2 through 10 (Figure 8-2). The same characteristics of B/U C&W parameters are available through items 11 to 15 (Figure 8-3). Refer to Sections 4.0 and 5.0 for details regarding the functions of noise filter values, enables, inhibits, limits, etc.

```

2011/060/          SM TABLE MAINT          /  :  :
SM COM BUFF        /  :  :
PARAM
 1 ID -----
  VALUE=

                LIMITS
ALERT          BACKUP C W
 2 [ ]----- 3 [ ]----- 11 [ ]----- 12 [ ]-----
 4 [ ]----- 5 [ ]-----
 6 [ ]----- 7 [ ]-----
                8 FILTER --                13 FILTER --
                ENA 9                ENA 14
                INH 10                INH 15

CONSTANT
16 ID -----
17 VALUE= [ ]-----

CHECKPT 000/00:00:00  FDA
INITIATE 18                ENA 19*
STATUS                INH 20
  
```

TD4020802. CRT; 1

Figure 8-2. SPEC 60 with alert items highlighted

```

2011/060/          SM TABLE MAINT          /  :  :
SM COM BUFF        /  :  :
PARAM
 1 ID -----
  VALUE=

                LIMITS
ALERT          BACKUP C W
 2 [ ]----- 3 [ ]----- 11 [ ]----- 12 [ ]-----
 4 [ ]----- 5 [ ]-----
 6 [ ]----- 7 [ ]-----
                8 FILTER --                13 FILTER --
                ENA 9                ENA 14
                INH 10                INH 15

CONSTANT
16 ID -----
17 VALUE= [ ]-----

CHECKPT 000/00:00:00  FDA
INITIATE 18                ENA 19*
STATUS                INH 20
  
```

TD4020803. CRT; 1

Figure 8-3. SPEC 60 with B/U C&W items highlighted

8.4.1 PARAM ID (Item 1) and PARAM Value

The software ID number for the desired FDA parameter is entered in item 1.

The software IDs and preflight limit values are located in the C&W and FDA table of the FDF Reference Data Book (Section 7.0).

The software ID is built from the parameter Measurement Stimulus Identification (MSID) by changing the V to a 0 and dropping the other letters. For example, the MSID for AV BAY 1 TEMP is V61T2645A and its software ID is 0612645. When entering the ID in item 1, leading zeroes may be omitted.

When a valid ID is entered, the ID number is displayed in the PARAM ID space and the current value of the parameter is displayed in the PARAM VALUE field. The status of the parameter is indicated by the presence or absence of an up or down arrow. The appropriate ALERT or B/U C&W data appear in the LIMITS portion of the SPEC (items 2 to 10 or items 11 to 15, respectively). If the parameter is monitored by both the alert and B/U C&W systems, then both sections contain the proper data (Figure 8-4). Otherwise, one of the LIMITS sections is blank (Figure 8-5). Additionally, the ALERT side will display either one, two, or three sets of limits depending on the parameter.

If the PARAM ID is not valid, all associated data fields are blank and an ILLEGAL ENTRY message is displayed.

```

2011/060/          SM TABLE MAINT          /  ::  ::
SM COM BUFF       /  ::  ::
PARAM
 1 ID 0450120
  VALUE= + 202.00

      ALERT                LIMITS                BACKUP C W
      LOW                  HI                    LOW                  HI
2 [+ ] 180.00  3 [+ ] 212.00 11 * [+ ] 172.50  12 [+ ] 243.70
4 * [+ ] 190.00  5 [+ ] 222.00
6 [+ ] 198.00  7 [+ ] 238.00
      8 FILTER  _I                    13 FILTER  _2
      ENA 9*                    ENA 14*
      INH 10                    INH 15

CONSTANT
16 ID
17 VALUE= [ ]

CHECKPT 000/00:00:00  FDA
INITIATE 18          ENA 19*
STATUS              INH 20
  
```

TD4020804. CRT; 2

Figure 8-4. SPEC 60 with FC stack T ID

```

2011/060/          SM TABLE MAINT          /  :  :
SM COM BUFF        /  :  :
PARAM
  1 ID 0450101
    VALUE= 189.00

      ALERT                LIMITS                BACKUP C W
      LOW                  HI                    LOW          HI
2*[] 54.00  3 [] 360.00 11 []----- 12 []-----
4 []----- 5 []-----
6 []----- 7 []-----
      8 FILTER  _2                13 FILTER  __
      ENA  9                    ENA 14
      INH 10                    INH 15

CONSTANT
16 ID -----
17 VALUE= []-----

CHECKPT 000/00:00:      FDA
INITIATE 18            ENA 19*
STATUS                INH 20

```

TD4020805. CRT; 1

Figure 8-5. SPEC 60 with FC amps ID

8.4.2 Limits Alert Low and Hi (Items 2 to 7)

These fields contain the upper and lower alert limits of the FDA parameter identified in item 1. The limit values are displayed in engineering units and can be changed by entering the desired data in the appropriate items.

Alert parameters that are preconditioned may have two or three limit sets. Based on the preconditions, the SM software selects which set of limits is currently active and places an asterisk next to that set (before item 2, 4, or 6). There is no item entry that allows the crew to move the asterisk to directly select which set of limits is active. This is done exclusively by software. If only one set of limits exists for the parameter, this set is displayed in the first limit set location and the asterisk is placed by item 2. If a value is entered in a limit set that does not exist for the selected parameter, an illegal entry message is displayed (see Section 5.2.2.2).

8.4.3 Limits Backup C&W Low and Hi (Items 11 and 12)

The B/U C&W limits for the FDA parameter identified in item 1 are displayed in these fields. The limit values are displayed in engineering units and can be changed by entering the new data in the desired item.

B/U C&W parameters have one set of limits. An asterisk next to item 11 indicates that a B/U C&W limit set exists for the parameter.

8.4.4 Limits Alert Filter (Item 8)

The alert parameter noise filter value can be read or changed through item 8. The range of valid values is 1 to 15 (2, 7, or 15 are common pre-initialized values).

8.4.5 Limits Backup C&W Filter (Item 13)

The B/U C&W noise filter function is similar to the alert filter (item 8) function. The major difference, in fact, is that the noise filter value is almost always pre-initialized by the flight software with a value of 2. This ensures rapid annunciation of a class 2 C&W out-of-limit conditions.

8.4.6 Limits Alert ENA or INH (Items 9 and 10)

The annunciation of an out-of-limit alert parameter may be either enabled or inhibited by executing item 9 or 10. The items are mutually exclusive, and an asterisk indicates the current annunciation status.

The class 0 status indicators (up and down arrows) and transducer data symbols (H, L, M, ?, *) are not affected by the enable or inhibited selection.

Selection of the ENA item for a previously inhibited parameter that is currently out-of-limits will not result in a fault message annunciation. Annunciation may be thought of as a “one shot” occurrence and happens only at the time of the original fault detection. Once enabled, if the parameter returns within limits (as per the noise filter value count) and then later go out-of-limits again (as per the noise filter value count), then the appropriate message will be annunciated.

8.4.7 Limits Backup C&W ENA or INH (Items 14 and 15)

The operation of these B/U C&W items is similar to the operation of alert items 9 and 10.

8.5 FDA STATUS, ENABLED, OR INHIBITED

The (PASS SM) FDA software module that monitors parameters, initiates alarms, and generates the limit sensing arrows is called FDA software.

8.5.1 FDA ENA or INH (Items 19 and 20)

All of the (PASS SM) FDA software can be either inhibited or enabled by executing the respective item (Figure 8-6). The items are mutually exclusive and an asterisk denotes the current state. The display is initialized with FDA enabled.

When FDA is inhibited, the following (PASS SM) FDA functions are disabled:

- a. FDA alarm annunciation - Includes B/U C&W (class 2), alert (class 3), and limit sensing up or down arrows (class 0)

- b. Limit sensing (class 0) - Last value displayed for each out-of-limits parameter status indicator
- c. Precondition steering
- d. False alarm avoidance noise filters

Other parameter status indicators (H, L, M, ?) are not affected because they are not generated by the FDA software (refer to Section 6.0). Also, PASS GNC alarm annunciations are not affected by the FDA software status or item entries on SPEC 60.

The FDA INH, item 20 stops all of the PASS SM FDA functions until they are reenabled via item 19. The Inhibit feature would not normally be utilized in flight, except under extraordinary circumstances.

```

2011/060/          SM TABLE MAINT          /  :  :
SM COM BUFF       /  :  :
PARAM
 1 ID -----
  VALUE=

      ALERT          LIMITS          BACKUP C W
      LOW           HI              LOW   C   W           HI
2 [ ]----- 3 [ ]----- 11 [ ]----- 12 [ ]-----
4 [ ]          5 [ ]
6 [ ]          7 [ ]
              8 FILTER --           13 FILTER --
              ENA 9                 ENA 14
              INH 10                INH 15

CONSTANT
16 ID -----
17 VALUE= [ ]-----

CHECKPT 000/00:00:00   FDA
INITIATE 18           ENA 19*
STATUS                INH 20
  
```

TD4020806. CRT; 1

Figure 8-6. SPEC 60 with constant FDA items highlighted

8.6 CONSTANTS

Many, but not all, SM constants may be accessed through items 16 and 17 (Figure 8-6). These constants are internal values utilized in the software logic or calculations and are not specifically associated with any specific parameters. They are primarily involved in SM special processes such as water loop pump cycling, alert preconditioning, and payload deployment (refer to SM Flight Systems Software Requirements (FSSR)).

8.6.1 Constant ID (Item 16)

When a constant ID number is entered in item 16, both the CONSTANT ID and VALUE fields are filled. If the ID is illegal, both data fields are blanked.

A complete list of constant IDs and values is not carried onboard the shuttle. However, the appropriate constant IDs and values are contained in the malfunction procedures when required to modify a system for failures. If a constant must be changed, the MCC either provides the crew with the data or directly changes the constant through a TMBU (see TMBU description in this section).

8.6.2 Constant Value (Item 17)

This field contains the current value of the constant identified in item 16. The constant value can be changed by entering the new data in item 17.

8.7 TABLE MAINTENANCE BLOCK UPDATE

A TMBU is the type of uplink that the MCC uses to change the following PASS SM data:

- a. Parameter limit values
- b. Parameter noise filter values
- c. Parameter annunciation enable/inhibit status
- d. SM constant values

The use of TMBUs decreases the crew's workload because the changes, that are uplinked, do not have to be manually entered on SPEC 60.

SPEC 60 operations and TMBUs are interlocked such that TMBU loads are rejected if SPEC 60 is active. If a TMBU is in progress when SPEC 60 is called, the flashing words UPLINK and UL are displayed on the SPEC 60 table (Figure 8-1). All item entries are prohibited and result in an ILLEGAL ENTRY message. As a note, while SPEC 60 is active, MCC will be unable to uplink TMBU changes.

(See the DPS PRINC 2102 and DPS HW/SW 2102 training manuals for additional information about uplinks.)

```

2011/060/          SM TABLE MAINT  UL  /  :  :
SM COM BUFF          UPLINK  /  :  :
PARAM
1 ID -----
  VALUE=

      ALERT          LIMITS          BACKUP C W
      LOW           HI           LOW           HI
2 [ ]----- 3 [ ]----- 11 [ ]----- 12 [ ]-----
4 [ ]----- 5 [ ]-----
6 [ ]----- 7 [ ]-----
           8 FILTER --           13 FILTER --
           ENA 9           ENA 14
           INH 10           INH 15

CONSTANT
16 ID -----
17 VALUE= [ ]-----

CHECKPT 000/00: 00: 00  FDA
INITIATE 18           ENA 19*
STATUS           INH 20

```

TD4020807. CRT: 2

Figure 8-7. SPEC 60 uplink indicators

8.8 UPLINK

The flashing word UPLINK is displayed in the top center of SPEC 60 to indicate that a TMBU is in progress.

8.9 UL

When any two-stage command (including a TMBU) is uplinked, a flashing UL is displayed in the upper right corner of all DPS displays associated with any GPCs that are being commanded.

8.10 CHECKPOINTS

When an SM checkpoint is performed, the following information is saved on a Mass Memory Unit (MMU):

- a. Parameter limit values
- b. Parameter noise filter values
- c. Parameter annunciation enable/inhibit status
- d. SM constant values
- e. Checkpoint timetags

The checkpoint capability is valuable because changes made through item entries on SPEC 60 affect only the SM GPC software and not the MMU software. If these changes are not saved on an MMU (via a checkpoint) and the SM GPC fails, the changes are lost and will have to be entered again (either via crew entry or uplink TMBU).

When checkpoint retrieve is enabled, the software loaded into an SM GPC from an MMU will contain the most recent checkpoint. (See the DPS HW/SW 2102 and DPS PRINC 2102 training manuals for additional information about SM checkpoint.

8.10.1 Checkpoint Initiate (Item 18), Checkpoint Status, and Time

When item 18 is executed, the STATUS field goes blank. While the checkpoint is being performed, a flashing BSY is displayed next to SM COM BUFF at the top left of SPEC 60. This indicates that the SM common buffer is in use. When the checkpoint is completed, the CHECKPT STATUS field contains GOOD. If the SM common buffer was not available, CHECKPT STATUS would be FAIL and item 18 should be executed again.

The Mission Elapsed Time (MET) of the most recent successful checkpoint is displayed as DD/HH:MM:SS in the checkpoint time field.

8.10.2 SM COM BUFF - BSY or RDY

Either a flashing BSY or a static RDY is displayed after SM COM BUFF (Figure 8-8) to indicate the status of the SM common buffer. BSY (busy) indicates that the SM COM BUFF is being used; RDY (ready) means the buffer is available.

Keypad entries on this SPEC are rejected if BSY is flashing.

Certain other mass memory related operations, besides SM checkpoint writes, also utilize the SM common buffer: SM checkpoint retrievals, telemetry format loads, decom format loads, and ground uplink MMU operations (MMU patch or crew text, both of which are rarely utilized in today's operational environment). See the communication system training manuals for further details. Note that SM roll-in SPECS do NOT utilize the SM common buffer.

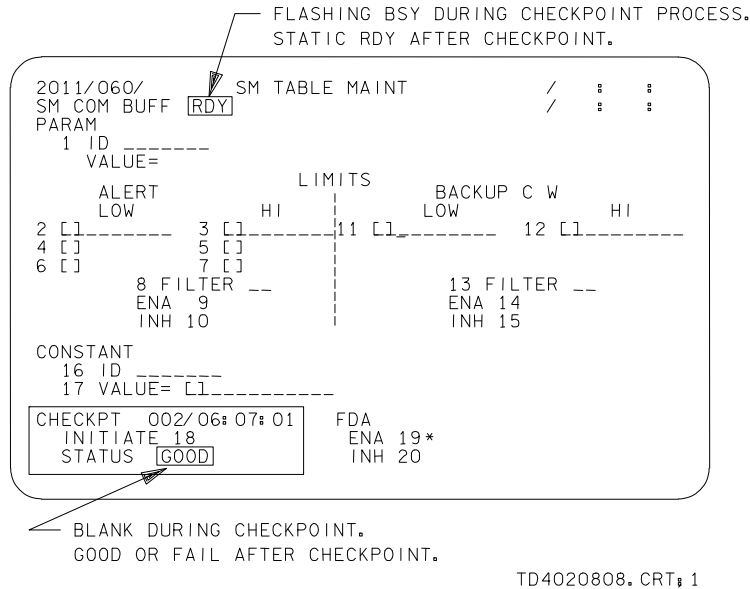


Figure 8-8. SPEC 60 after checkpoint

8.10.3 CKPT RETRV ENA (DPS Utility - SPEC 1, Item 12)

Executing this item (Figure 8-9) alternately selects or deselects CKPT RETRV ENA. An asterisk appears next to item 12 when checkpoint retrieve is enabled.

8.10.4 MMU Assignment (DPS Utility - SPEC 1, Items 3 and 4)

A checkpoint saves the changes on the MMU that is assigned to the SM software by item 3 or 4 (Figure 8-9). To save the checkpoint on both MMUS, two checkpoints must be performed (one on each MMU).

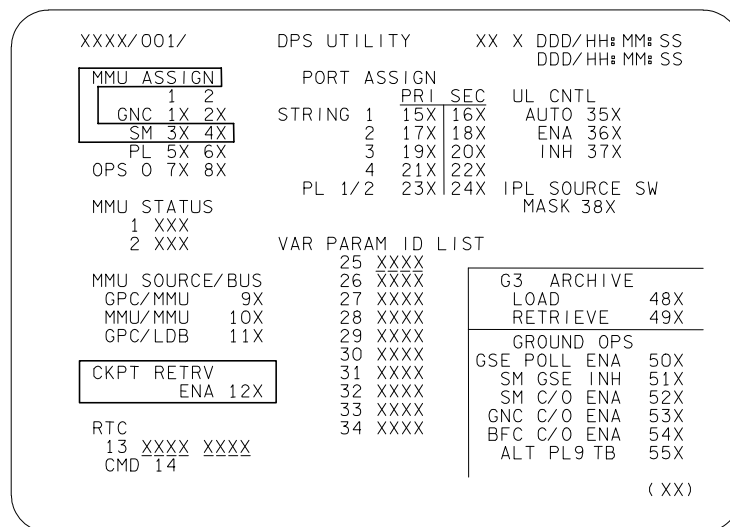


Figure 8-9. SPEC 1

8.11 QUESTIONS

Answer the following questions by either filling in the blank or selecting the appropriate answer. Refer to Figure 8-1 and Figure 8-9 as necessary.

1. SPEC 60, SM TABLE MAINT, is available in the _____ major function of OPS _____ and _____.
2. Valid software IDs and preflight limit values are available to the crew in the C&W and FDA table of the _____ Book of the FDF.
3. List the SPEC 60 item number(s) used to perform the following functions:

Enter the software ID _____

Read or Change: _____ B/U C&W lower limit

_____ Alert lower limits

_____ B/U C&W upper limit

_____ Alert upper limits

Verify or change: _____ B/U C&W noise filter value

_____ Alert noise filter value

Inhibit: _____ Alert parameter

_____ FDA software

_____ B/U C&W parameter

Enable: _____ Alert parameter

_____ FDA software

_____ B/U C&W parameter

4. True or False. After the software ID is entered, the VALUE field and the appropriate ALERT and B/U C&W fields will be filled.
5. True or False. A different set of alert limits, from the set that is currently active, may be selected by executing an item on SPEC 60.
6. The present value of the parameter whose ID is entered in item 1 is displayed in the _____ field
7. Which of the following cannot be changed by item entries on SPEC 60?
 - a. PARAM ID
 - b. PARAM VALUE
 - c. B/U C&W LIMITS, LOW and HIGH
 - d. B/U C&W FILTER

8. An alert parameter may have _____ set(s) of limits, and a B/U C&W parameter may have _____ set(s).
9. An asterisk appears next to item _____ if the second set of alert limits is selected by preconditioning software. (This asterisk cannot be moved by a crew item entry.)
10. The flight controllers can make the same changes to the SM software that the crew makes using SPEC 60 by performing a _____.
11. SM program constants can be changed by entering the constant ID in item _____ and entering the desired value in item _____.
12. To save changes made to the SM software (via SPEC 60 or a TMBU) on an MMU, a _____ must be initiated by executing item _____ on SPEC 60.
13. In order for a checkpoint to be retrieved from an MMU, CKPT RETRV ENA (item _____ on SPEC _____) must be executed.

9.0 MISCELLANEOUS

9.1 FAULT SUMMARY

A historical summary of all class 2 and class 3 fault messages is provided through the FAULT display. The PASS fault summary display consists of 15 fault message lines and the BFS 20 lines (Figure 9-1). The message lines appear in reverse chronological order, with the oldest message displayed on the bottom line. When a new fault message is generated, it appears on the first line. The other messages are pushed down and the 15th (PASS) or 20th (BFS) message disappears.

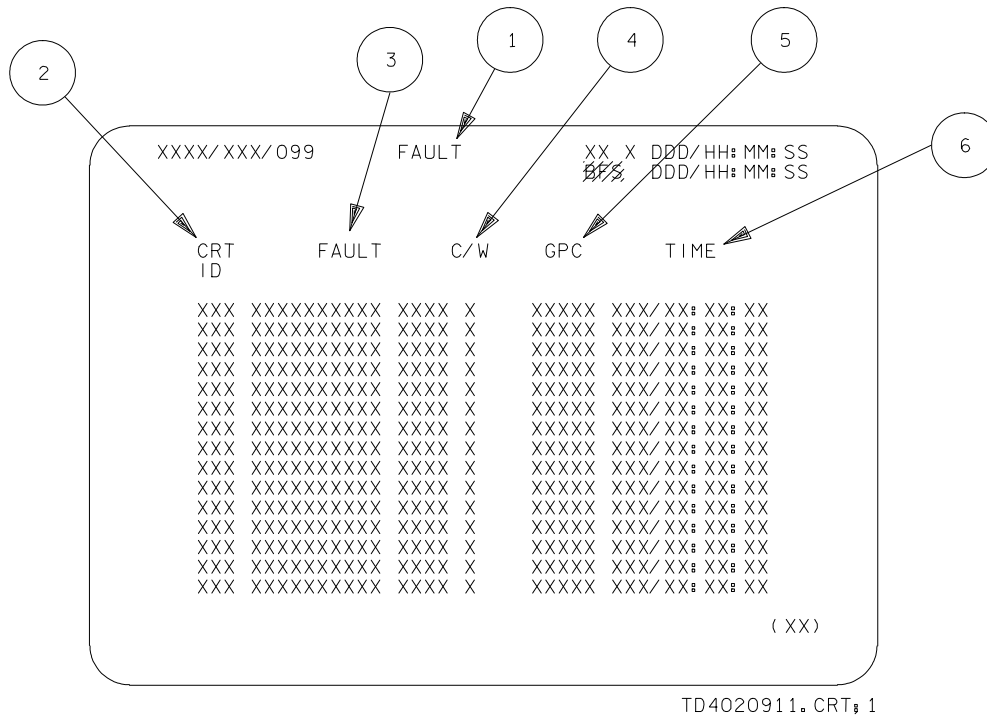
The only difference between the messages on the fault message line and the FAULT display is the TIME field. On the FAULT display, the TIME field includes days as well as hours, minutes, and seconds (DDD/HH:MM:SS).

The FAULT display is a DISP available in all OPS regardless of major function. It is selected for viewing by depression of the FAULT SUMM key or is selected by the keyboard entry SPEC 99 PRO. However, entering SPEC 99 PRO clears all fault messages from the FAULT display and the fault message lines. This capability is useful if and when the fault messages displayed are no longer significant (in other words, they are old or they have been dealt with).

Sometimes, a subsystem failure or malfunction results in the output of several fault messages, some of which may be identical. The FDA logic prevents the annunciation of identical fault messages. When a fault message is generated, its major and minor fields are compared to those of the top message of the display. If the fields are the same and if the new fault message has occurred within 4.8 seconds of the top message, the new message is inhibited.

The message displayed on the fault message line of any DPS display is not necessarily the most recent fault message. Unless the fault message line was cleared with an MSG RESET, the crewmember will not see any new messages that came in on top of the flashing or frozen message. In that case, the crewmembers can see whether a new message has been annunciated by looking at a two-character field located in the last field on the far right of the fault message line. This field is called the buffer message indicator.

The buffer message indicator serves to indicate the number of messages in the fault buffer on the FAULT display since the last MSG RESET. The currently displayed message is not included in this counter. The number is enclosed by parentheses. If there are no fault messages in the stack, this field is blank. To view any of these messages, the crewmember must look at the FAULT SUMM display or scroll through the messages using the ACK key. A MSG RESET clears the fault message line and the buffer message indicator.



NOTE: // INDICATES PARAMETERS ARE DRIVEN AND DISPLAYED ON THE BFS DISPLAYS ONLY.

- (1) **FAULT display.** A system level display available in all OPS sequences. Includes up to 15 (20 for BFS) summary messages of faults (alerts or C&W) that have occurred. The messages are ordered so that the latest fault is at the top of the page. The display is called via a dedicated key (FAULT SUMM). If the display is called via SPEC 99 PRO, the messages are cleared.
- (2) **CRT ID.** A three-character field identifying the Cathode Ray Tube (CRT) page on which the fault is displayed. The first character represents the major function (G for Guidance, Navigation, and Control (GNC), S for Systems Management (SM), P for Payload (PL)), and the last two digits are the display number. However, the CRT Identification (ID) is not included in messages that are not referenced to a CRT display page. Note: MEDS uses the CRT ID as a name of the DPS display unit referenced.
- (3) **FAULT.** Text identifying the system experiencing the fault.
- (4) **C&W.** Use only with C&W messages. The field displays an indicator (*) if a lower or an upper limit was exceeded.
- (5) **GPC.** Identification of the General Purpose Computer (GPC), which detected and identified the fault. The BFS display has a single column for indicating the BFS GPC identification.
- (6) **TIME.** The mission time (in day/hr:min:sec) at which the fault was annunciated.

Figure 9-1. FAULT summary display

If messages have been accidentally erased or scrolled off the FAULT display, crewmembers can contact the ground for required information. The last five entries of the fault summary page are included in the downlist data. Downlisting occurs automatically every 5 seconds.

9.2 ANNUNCIATOR CONTROLS

The annunciator controls allow the crew to select the power source and adjust the intensity of annunciator lights. There is also a lamp test capability.

ACAs receive command signals that tell the ACA when to illuminate each light. The ACA illuminates appropriate lights to the intensity specified by the intensity controls. It uses the power source provided by the bus select switch. The Panel F7 C&W Annunciation Matrix uses the forward annunciator controls but does not use an ACA (Figure 4-4). There are five ACAs on the orbiter. Refer to SSSH Drawing 4.3-1 and Table 4-1 for details on what each ACA powers.

Lamp tests are always performed at full intensity, regardless of the position of the bright/variable switch.

9.2.1 Panel A6U

The annunciator controls on Panel A6U are used to select the following (Figure 9-2):

- a. Bus select - Used to select either main bus B or C to power annunciation lights on aft panels.
- b. Lamp test left or right - Used to ensure that all lights are functional on aft panels.
- c. Bright/variable switch - Used to adjust intensity of the lights on aft panel; bright position illuminates lights at full intensity.
- d. Intensity dial - Used when bright/variable switch is in variable position; adjusts light intensity from low to medium.

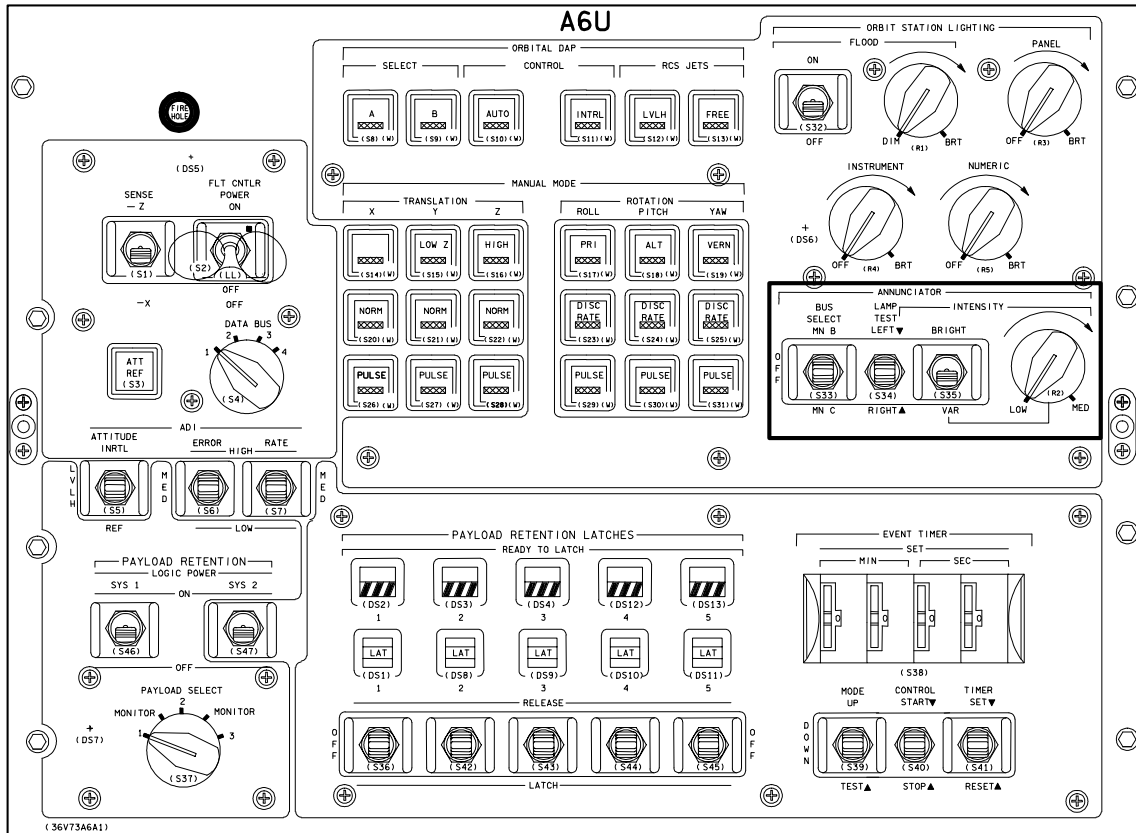
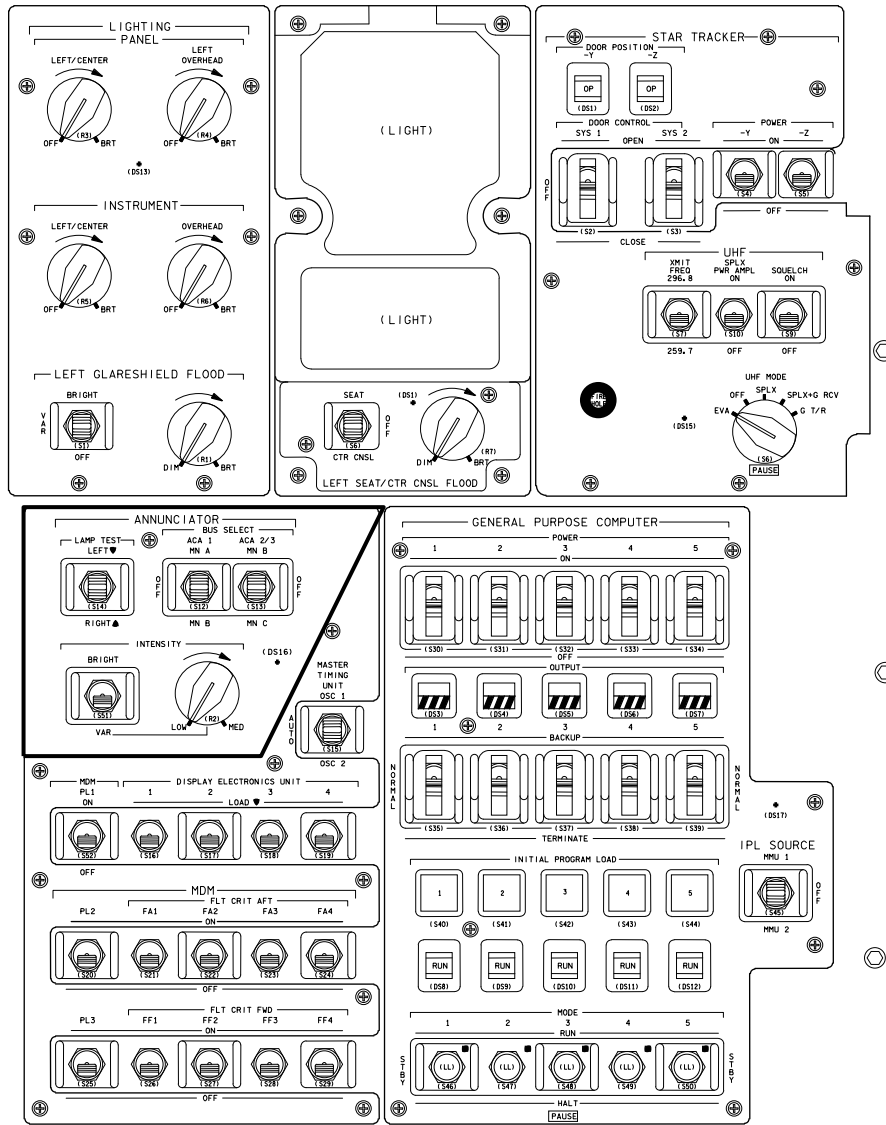


Figure 9-2. Panel A6U

9.2.2 Panel O6

The annunciator controls on Panel O6 (above the CDR's seat) are used to select the following (Figure 9-3):

- a. Bus select - Used to select the main bus to power annunciation lights on forward panels.
- b. Lamp test, left or right - Used to ensure that all lights are functional on forward panels.
- c. Bright/variable switch - Used exactly as the one on Panel A6U, except it controls the forward panels.
- d. Intensity dial - Functions like the Panel A6U dial.



TD4020903, PNL 2

Figure 9-3. Panel O6

9.2.3 Panel O8

Panel O8 (above the pilot's seat) has only the lamp test, which functions exactly the same as the lamp test on Panel O6 (Figure 9-4).

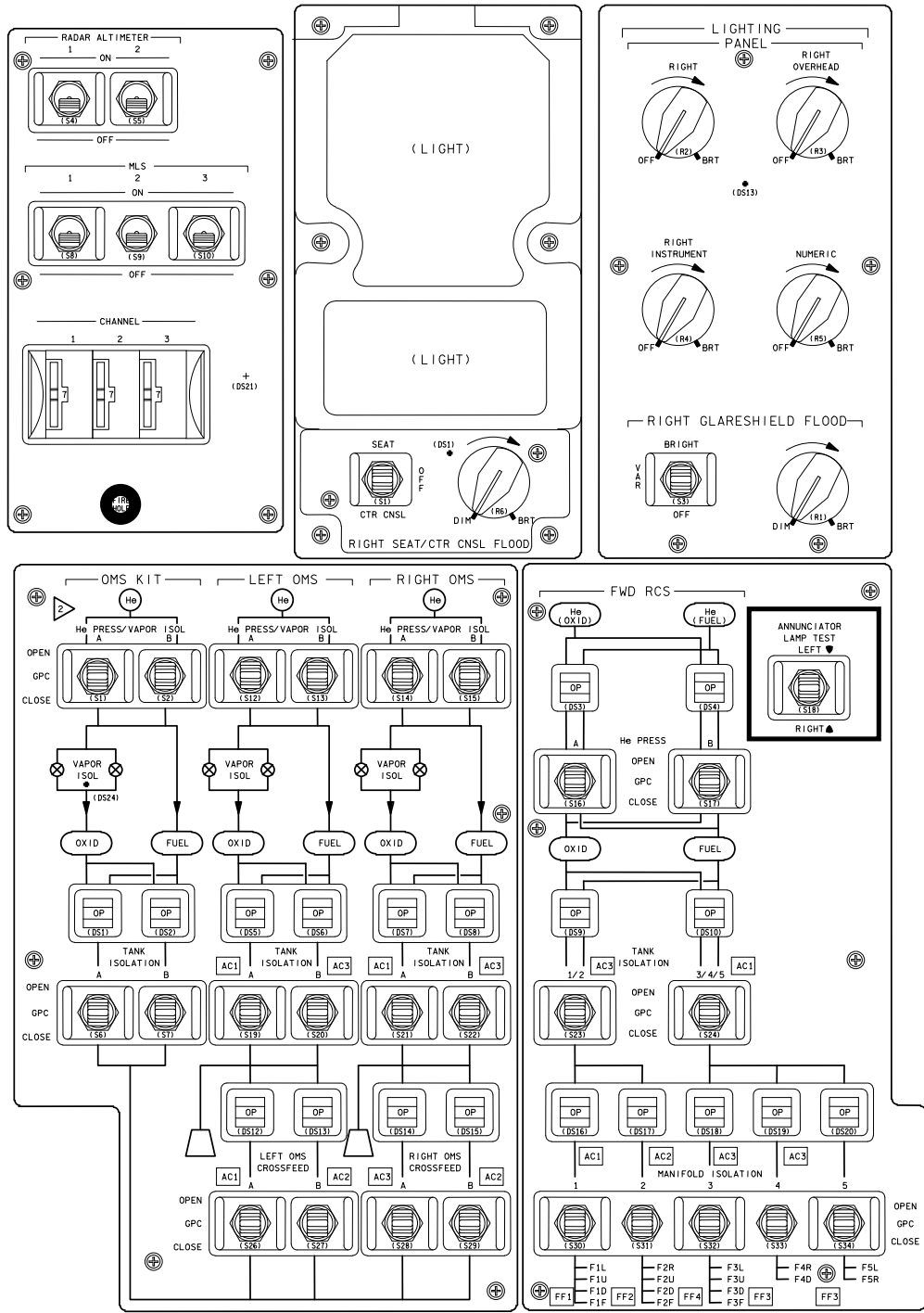


Figure 9-4. Panel O8

9.3 AUDIO ANNUNCIATION CONTROL

Because of the importance of the audio annunciation for the C&W system, there is a certain amount of redundancy within the system. Two tone generators each output all four alarm tones. All four alarm tones are routed to both headsets and speakers throughout the orbiter. This routing is performed by the orbiter communication system (AUD/UHF 2102 Training Manual).

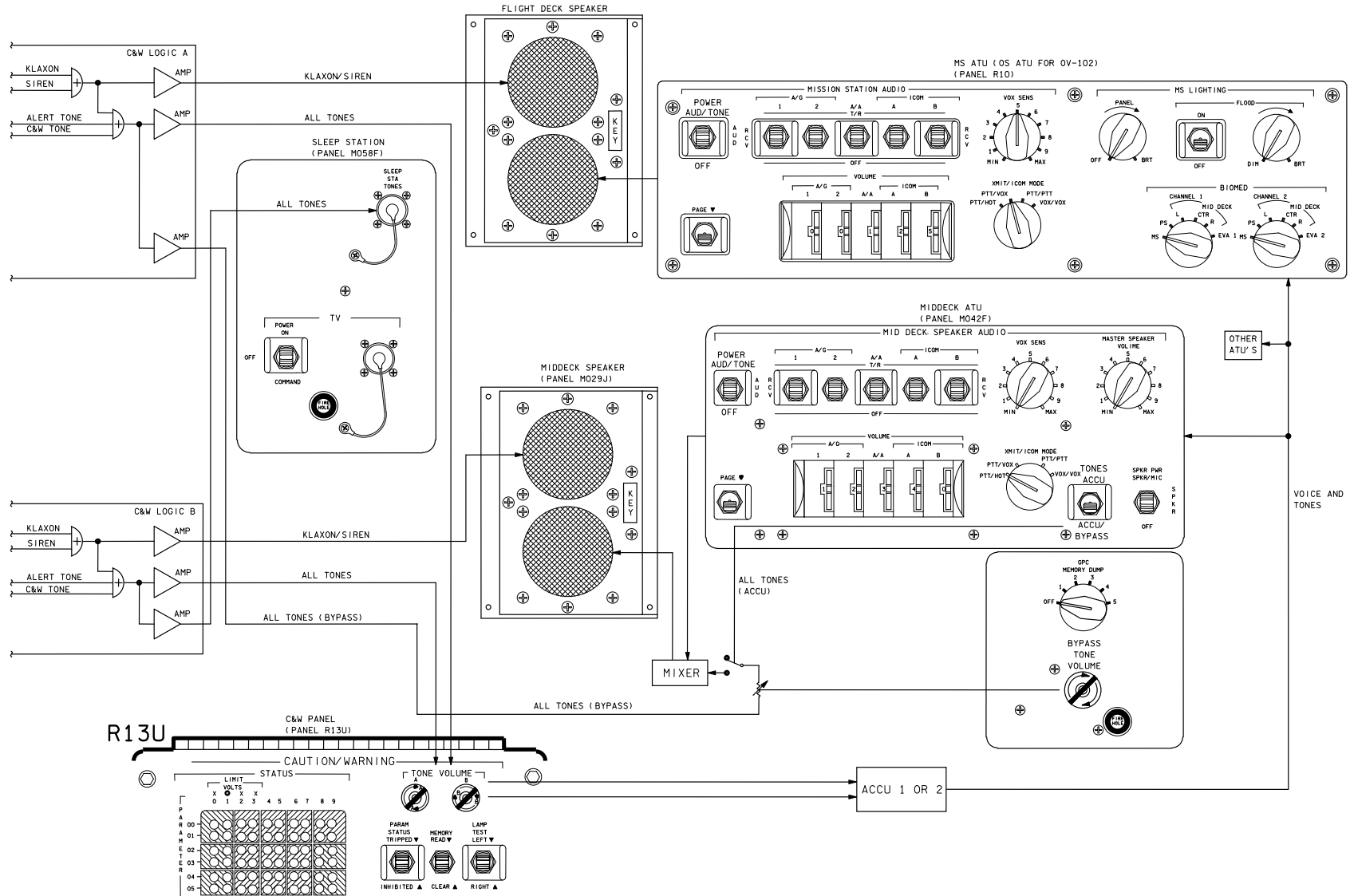
Within the primary C&W system Caution and Warning Electronics Unit (CWEU), there are two tone generators (A and B); each generates a klaxon, a siren, a C&W tone, and an alert tone. Each tone generator has three outputs (Figure 9-5).

One of the outputs from each of the tone generators sends all alarm tones through the Panel R13U tone volume control potentiometers to the ACCU, which distributes the audio alarms to the headsets, one speaker of the middeck speaker unit, and one speaker of the flight deck speaker unit (each speaker unit contains two speakers).

A second output from each of the two tone generators is used only for klaxon and siren alarms and is sent to a dedicated speaker. The A tone generator siren/klaxon direct output drives a speaker in the flight deck speaker unit. The B tone generator siren/klaxon direct output drives a speaker in the middeck speaker unit. (Note: The ACCU controls the other speaker within each speaker unit.)

The third output of the A tone generator sends all alarms to the BYPASS TONE VOLUME control, located on middeck Panel M042F. If the TONES switch is in ACCU, then all alarms are processed through the ACCU unit. If the TONES switch is in the ACCU/BYPASS position, the alarms bypass the ACCU and are sent directly to the middeck speaker used by the ACCU.

The third output of the B tone generator sends all alarms to the sleep station headset connector.



TD4020910, PNL 1

Figure 9-5. Alarm tone distribution

9.4 DISPLAYS AND CONTROLS

See Table 9-1 for a complete list of C&W switches, circuit breakers and controls.

Table 9-1. Displays and controls

Panel	Type	Nomenclature/ position	Function	Remarks
O13	Circuit breaker (Figure 4-9)	ESS 1BC C&W A	Power from Essential (ESS) bus 1BC to the A power supply, the MA A bulbs, the C&W annunciator Panel (F7) lights power supply, and the SM B/U C&W A amplifier	Row A
O13	Circuit breaker (Figure 4-9)	ESS 2CA C&W B	Power from ESS 2CA to the B power supply, the MA B bulbs, and the SM B/U C&W B amplifier	Row C
O6 and O8	3-pos momentary (Figure 9-3) (Figure 9-4)	Annunciator Lamp Test LEFT-OFF-RIGHT	Tests the "event" light bulbs on the left and right sides of the cockpit, including C&W and emergency lights	
F2 and F4	Pushbutton indicator (Figure 2-2, F2&F4)	MASTER ALARM	Displays MA any time a C&W parameter (class 1 or 2) exceeds its limits. It also acts as a switch which, when depressed, resets the master alarm tone and light logic, as well as provides an alternate path for power to the C&W annunciator (F7) power supply when the mode switch is in the ACK position	2 PBIs 2 of 4 MAs
C3	3-pos momentary (Figure 4-8)	Caution/Warning Memory READ-CLEAR	READ position illuminates lights on the C&W annunciator light matrix (F7) for all parameters that have been out of limits since the last memory clear command CLEAR position clears the recall memory in the electronics unit and affects both F7 and R13U displays	
C3	3-pos toggle (Figure 4-8)	Caution/Warning Mode ACK-NORM- ASCENT	Acknowledge (ACK) - Allows the C&W annunciator lights to illuminate only when one of the two front cockpit MA PBIs are depressed (MA on F2 or F4 panel). NORM - When an out-of-limits parameter is detected, the system will initiate an MA light and audio tone, turn on the appropriate C&W annunciator light, and set the parameter number in the recall memory and primary C&W trigger memory ASCENT - Keeps the Panel F4 master alarm PBI from illuminating when an out-of-limits condition triggers a C&W alarm	

Table 9-1. Displays and controls (continued)

Panel	Type	Nomenclature/ position	Function	Remarks
R-13	Lights (Figure 4-6)	Caution/Warning Parameter Status	A 120-light matrix with multiple functions. Each light represents a C&W input parameter. In addition, columns 0, 2, and 3 represent volt readings of parameter limits	
R-13	Screwdriver operated port	Tone Volume A	Adjusts the volume of the C&W A tones that go into the Communications Audio Central Control Unit (COMM ACCU)	
R-13	Screwdriver operated port	Tone Volume B	Adjusts the volume of the C&W B tones that go into the COMM ACCU	
R-13	3-pos momentary	Parameter Status TRIPPED- INHIBITED	TRIPPED - Illuminates lights in the C&W status light matrix corresponding to the input parameters that are currently out-of-limits, regardless of whether or not they are inhibited INHIBITED - Illuminates lights in the C&W status light matrix corresponding to the parameters that are currently inhibited	
R-13	3-pos momentary	Memory READ-CLEAR	READ - Illuminates lights on the C&W status light matrix for all enabled parameters that have been out-of-limits since the last clear command CLEAR position clears the recall memory in the electronics unit and affects both R13U and F7 displays	
R-13	3-pos momentary	Lamp Test LEFT-RIGHT	Causes the lights in the left or right halves of the status matrix to illuminate	
R-13	5-pushbuttons	Parameter Select	Identifies the parameters 000 through 119 that represent the 120 inputs to the primary C&W system	Available Ranges: 100s: 0-1 10s: 0-9 1s: 0-9
R-13	5-pushbuttons	Limit Set Value	Used to set the upper or lower limit of a specific parameter	Range 0.00 to 5.95 in increments of 0.05
R-13	2-pos toggle	Limit Set Limit UPPER-LOWER	Specifies the parameter upper or lower limit for reading or changing	

Table 9-1. Displays and controls (concluded)

Panel	Type	Nomenclature/ position	Function	Remarks
R-13	2-pos momentary	Limit Set Function SET-READ	SET - Sets the limit specified in the value thumbwheels into the selected parameter READ - Causes the limit, as specified by the parameter thumbwheels and the limit switch, to be displayed in the LIMIT VOLTS columns of the status matrix	In columns 0, 2, and 3
R13	2-pos momentary	PARAM ENABLE-INHIBIT	Enables and inhibits the out-of-limits alert portion of the parameter specified on the parameter thumbwheels	
F7	40-Light array (Figure 4-3)	Annunciator array	A 40-light module of advisory lights driven by the C&W parameters thru OR logic gates. These lights are grouped to display system or functional failures on the same light	
A7	Pushbutton indicator (Figure 2-2, Figure 2-3)	MASTER ALARM	Displays MA any time a C&W parameter (class 1 or 2) exceeds a limit. It also acts as a switch that resets the master alarm logic when depressed	1 of 4
MO52	Pushbutton indicator	MASTER ALARM	Same as the MA on Panel A7	1 of 4

APPENDIX A
ACRONYMS, ABBREVIATIONS, AND SYMBOLS

ACA	Annunciator Control Assembly
ACCU	Audio Central Control Unit
ACK	Acknowledge
APU	Auxiliary Power Unit
B/U	Backup
BFS	Backup Flight System
BL	Bilevel
C/L	Checklist
C&W	Caution and Warning
cb	circuit breaker
CDR	Commander
CH	Channel
CNS	Central Nervous System
CO	Carbon Monoxide
COM	Communication System
COMSEC	Communications Security
CRT	Cathode Ray Tube
CSA-CP	Compound Specific Analyzer-Combustion Products
CSI	Crew Software Interface
CWEU	Caution and Warning Electronics Unit
D&C	Display and Control
dB	Decibel
dc	direct current
dP/dT	delta pressure/delta time
DPS	Data Processing System
ECLSS	Environmental Control and Life Support System
EPS	Electrical Power System
EQ	Equivalent
ESS	Essential
FCS	Flight Control System
FDA	Fault Detection and Annunciation
FDF	Flight Data File
FF	Fight Forward
FSSR	Flight Systems Software Requirements
FUNC	Function
G&N	Guidance and Navigation
GAX	Guidance, Navigation, and Control Annunciation Interface
GCIL	Ground Control Interface Logic

GNC	Guidance, Navigation, and Control
GPC	General Purpose Computer
H ₂ O	Water
H/W	Hardware
HCl	Hydrogen Chloride
HCN	Hydrogen Cyanide
HF	Hydrogen Fluoride
Hyd	Hydraulic
Hz	Hertz (cycles per second)
ID	Identification
IDS	Integrated Documentation Support
IDLH	Immediate Danger to Life and Health
IFM	In-Flight Maintenance
IMU	Inertial Measurement Unit
JSC	Lyndon B. Johnson Space Center
LF	Launch Forward
MA	Master Alarm
MCC	Mission Control Center
MDM	Multiplexer/Demultiplexer
MET	Mission Elapsed Time
MM	Major Mode
MOD	Mission Operations Directorate
MMU	Mass Memory Unit
MPS	Main Propulsion System
MSID	Measurement Stimulus Identification
N ₂	nitrogen
NASA	National Aeronautics and Space Administration
NORM	Normal
NSP	Network Signal Processor
O ₂	oxygen
OMS	Orbital Maneuvering System
OPS	Operational Sequence
ORB OPS	Orbit Operations
OV	Orbiter Vehicle
PARAM	Parameter
PASS	Primary Avionics Software System
PBI	Pushbutton Indicator
PIC	Pyro Initiation Controller
PL	Payload
ppm	parts per million

PROM	Programmable Read-Only Memory
psia	pounds per square inch absolute
psig	pounds per square inch gauge
RCS	Reaction Control System
RM	Redundancy Management
S/W	Software
SM	Systems Management
SMAC	Spacecraft Maximum Allowable Concentration
SME	Subject Matter Expert
SMS	Shuttle Mission Simulator
SPOC	Space Program Operations Contract
SRB	Solid Rocket Booster
SSSH	Space Shuttle Systems Handbook
SST	Single System Trainer
TLV	Threshold Limit Value
TMBU	Table Maintenance Block Update
V	Volts
W	Watt

APPENDIX B ANSWERS

B.1 SECTION 2

1. The C&W alarm classes are class 1 emergency, class 2 caution and warning, class 3 alert, and class 0 limit sensing.
2. Class 1 emergency generally receives the highest priority because the situations that issue an alarm in this alarm class may seriously affect crew safety. Immediate action is required.
3. "Out-of-limits" means a parameter has violated a predetermined limit.
4. Three classes contain software systems: class 2 C&W, class 3 alert, and class 0 limit sensing. Remember that class 2 C&W has two subclasses, primary C&W (hardware system) and B/U C&W (software system).

B.2 SECTION 3

1. b. SM SYS SUMM 1 shows concentration of smoke in the avionics bays.
2. c. If the emergency smoke alarm system is latched and a fire occurs in another location, there will be no siren, but the appropriate light and concentration reading will work.
3. c. The smoke detector inspects for smoke particle concentration of $2000 \pm 200 \mu\text{g}/\text{m}^3$ for a period of at least 5 seconds and/or a rate increase of $22 \mu\text{g}/\text{m}^3 \text{ sec}$ for eight consecutive counts in 20 seconds.
4. To discharge a fire bottle into an avionics bay, place the FIRE SUPPRESSION ARM/SAFE switch in the ARM position, lift the cover, and press the AGENT DISCHARGE PBI.
5. True. Portable extinguishers are considered backups to the avionics bay bottles for avionics bay fires.
6. d. The class 1 emergency annunciation for a cabin rapid dP/dT consists of MA lights and the klaxon.
7. c. The alarm system sounds when the dP/dT equals or exceeds $-0.08 \text{ psi}/\text{min}$.
8. c. The nominal dP/dT during orbit is $\pm 0.01 \text{ psi}/\text{min}$.
9. b. The cabin pressure and dP/dT can be referenced on Panel O1, SPEC 66, and SM SYS SUMM 1.

10. c. Two fire extinguishers are located on the middeck; one is located on the flight deck.
11. False. Only the sensing chamber is continuously recycled. As a note, if the cabin pressure changes, the reference chamber will adjust to equalize pressure.
12. True. The separator of the smoke detector allows only particles 2 microns or less to enter the sensing chamber.
13. True. The radiation source used by smoke detectors is Americium 241.
14. True. The fire bottles use a PIC to provide an explosion in the nozzle assembly.
15. d. The nozzle assembly consists of a 1/2-inch nozzle, a PIC, a spring, and a hollow cylindrical knife.
16. True. The diaphragm of the fire bottle is ruptured by use of a knife.
17. True. The pressure switch on the fire bottle sends a signal to Panel L1 to illuminate the AGENT DISCH light when the pressure in the bottle drops to 60 ± 10 psi.
18. b. Two smoke detectors are in each avionics bay.
19. True. Once the alarm system is triggered by a smoke detector, the entire system remains latched until reset by Panel L1.
20. d. The siren sounds in approximately 20 seconds after the test switch is placed in A or B position when performing a circuit test on Panel L1.
21. d. After discharge into an avionics bay, Halon is effective as a fire suppressant for 50 hours. (Thirty-six hours from a portable fire extinguisher.)
22. True. All detectors are reset with the sensor reset switch on Panel L1.
23. False. Fire ports are provided throughout the flight deck and middeck.
24. False. The fire bottles in the avionics bays are not empty when the AGENT DISCH light goes off.
25. False. The emergency alarm system annunciates only for a $-dP/dT$.

B.3 SECTION 4

1. The primary C&W system is class 2; the B/U C&W system is class 2.
2. False. Primary C&W is a hardware system.
3. True Both PASS and BFS support B/U C&W.
4. c. Both GNC and SM support B/U C&W.
5. False. Flight rules do require that the B/U C&W and primary C&W limits be the same.
6. a. & b. For the primary C&W system, the limits are designated in volts DC. For the B/U C&W system, the limits are in engineering units.
7. Preflight limit values are available to the crew in the C&W section of the FDF Reference Data Book.
8. a. The R13 C&W panel allows the crewmember to interact with the primary C&W system.
9. d. Panel R13 is used to read and change parameter limits and enable and inhibit parameters for the primary C&W system.
10. e. The Panel R13 light matrix is used to determine which parameters are tripped, determine which parameters are inhibited, and read the upper or lower limit of a parameter.
11. True. The Panel R13 and Panel C3 MEMORY switches access the same C&W memory.
12. c. The Panel F7 annunciator matrix contains primary C&W system lights and the B/U C&W ALARM light.
13. b. The fault summary maintains a record of B/U C&W fault messages.

14. C&W annunciation.

	Primary C&W		B/U C&W	
	Enabled	Inhibited	Enabled	Inhibited
MA lights illuminated	X		X	
Panel F7 B/U C&W alarm light illuminated			X	
Panel F7 system light illuminated	X			
Panel R13 status light illuminated while the PARAM STATUS switch is in the TRIPPED position	X	X		
Panel R13 status light illuminated while the PARAM STATUS switch is in the INHIBITED position		X		
C&W tone	X		X	
Fault message on DPS display			X	
Class 0 limit sensing up and down arrows on DPS displays			X	X

15. Crew response to annunciation.

	Press MA PBI	Press ACK	Press MSG RESET	Not possible by any of these actions
Extinguish MA lights	X			
Extinguish Panel F7 B/U C&W alarm light			X	
Extinguish Panel F7 system lights				X
Extinguish Panel R13 parameter light				X
Make DPS display fault message stationary		X		
Erase DPS display fault message			X	
Interrupt C&W tone	X			

B.4 SECTION 5

1. The alert system is class 3.
2. True. Both PASS and BFS support alerts.
3. c. Both GNC and SM major functions support alerts.
4. An alert parameter may have up to three sets of limits.
5. b. Alert limits are in engineering units.
6. The duration of the alert tone may be adjusted by an item 23 entry on SPEC 2.
7. True. When the alert tone is activated and not interrupted, it will stop when it has timed out.
8. False. Alert parameters with two or three sets of limits are preconditioned.
9. Preflight limit values are available to the crew in the C&W section of the Reference Data Book.
10. Alert annunciation.

	Alert	
	Enabled	Inhibited
SM ALERT light illuminated	X	
MA light illuminated		
Alert tone	X	
C&W tone		
Fault message on DPS display	X	
Class 0 limit sensing (up and down arrows on DPS displays)	X	X

11. Crew response to annunciation.

	Press MA PBI	Press ACK	Press MSG RESET	Not possible by any of these actions
Extinguish SM alert light		X	X	
Make DPS display fault message stationary		X		
Erase DPS display fault message			X	
Interrupt C&W tone	X	X	X	

B.5 SECTION 8

1. SPEC 60, SM TABLE MAINT, is available in the SM major function of OPS 2 and 4.
2. Valid software IDs and preflight limit values are available to the crew in the C&W and FDA table of the Reference Data Book of the FDF.
3. The specific item numbers are as follows:

Enter the software ID	<u>Item 1</u>	
Read or Change:	<u>11</u>	B/U C&W lower limit
	<u>2,4,6</u>	Alert lower limits
	<u>12</u>	B/U C&W upper limit
	<u>3,5,7</u>	Alert upper limits
Verify or change:	<u>13</u>	B/U C&W noise filter value
	<u>8</u>	Alert noise filter value
Inhibit:	<u>10</u>	Alert parameter
	<u>20</u>	FDA software
	<u>15</u>	B/U C&W parameter
Enable:	<u>9</u>	Alert parameter
	<u>19</u>	FDA software
	<u>14</u>	B/U C&W parameter

4. True. After the software ID is entered, the VALUE field and the appropriate ALERT and B/U C&W fields will be filled.
5. False. A set of alert limits that is different from the set that is currently active cannot be selected by executing an item on SPEC 60.
6. The present value of the parameter whose ID is entered in item 1 is displayed in the PARAM VALUE field.
7. b. PARAM VALUE cannot be changed by item entries on SPEC 60.
8. An alert parameter may have from one to three sets of limits, and a B/U C&W parameter may have one set.
9. An asterisk appears next to item 4 if the second set of alert limits is selected by preconditioning software. (This asterisk cannot be moved by a crew item entry.)
10. The flight controllers can make the same changes to the SM software that the crew makes using SPEC 60 by performing a TMBU.

11. SM program constants can be changed by entering the constant ID in item 16 and entering the desired value in item 17.
12. To save changes made to the SM software (via SPEC 60 or a TMBU) on an MMU, a checkpoint must be initiated by executing item 18 on SPEC 60.
13. In order for a checkpoint to be retrieved from an MMU, CKPT RETRV ENA (item 12 on SPEC 1) must be executed.

Training Materials Evaluation

Please answer the following questions regarding the lesson you just completed. Your feedback will allow us to produce more effective training materials. *When complete, mail to: Systems Training Group/DS45.*

TITLE/CODE OF LESSON: Caution and Warning/C&W 21002

SIZE OF AUDIENCE/CLASS: _____

1. How well did this lesson meet its purpose?

For each statement below, mark one box on the scale:

- | | Strongly
Disagree | | | | | Strongly
Agree |
|--|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| a. <i>The lesson objectives are clearly stated.</i> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| b. <i>The lesson objectives are clearly defined.</i> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| c. <i>The lesson effectively teaches skills and information.</i> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| d. <i>The lesson meets its purpose and objectives.</i> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

2. How satisfying is the content of this lesson?

For each statement below, mark one box on the scale:

- | | Strongly
Disagree | | | | | Strongly
Agree |
|--|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| a. <i>The information is structured in a logical flow.</i> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| b. <i>The content is clear.</i> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| c. <i>The content is complete.</i> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| d. <i>The level of detail is correct for this information.</i> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| e. <i>The amount of information is effective.</i> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| f. <i>The graphics contribute to my understanding.</i> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

3. How appealing was the presentation of this lesson?

For each statement below, mark one box on the scale:

- | | Strongly
Disagree | | | | | Strongly
Agree |
|--|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| a. <i>The overall presentation is appealing.</i> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| b. <i>The visuals chosen are appropriate for the lesson.</i> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| c. <i>The visuals make the information more interesting.</i> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| d. <i>The graphics are legibly reproduced.</i> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| e. <i>The audio/visual or print quality is good.</i> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

4. How valuable is this information?

For each statement below, mark one box on the scale:

- | | Strongly
Disagree | | | | | Strongly
Agree |
|---|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| a. <i>The lesson teaches skills and information I need.</i> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| b. <i>The lesson meets my expectations.</i> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| c. <i>This information is useful for later reference.</i> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| d. <i>I would recommend this lesson to others.</i> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

**PLEASE WRITE YOUR COMMENTS/QUESTIONS ON THE BACK OF THIS FORM.
EXPLAIN ANY NEGATIVE ANSWERS IN SPECIFIC TERMS
THANK YOU IN ADVANCE FOR YOUR ASSISTANCE**

TITLE: Caution and Warning – C&W 21002

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