TABLE 4.2
GROUND TEST INSTRUMENTATION

MEASUREMENT NUMBER *	MEASUREMENT NAME	RANGE	BIT VALUE
SC2120X **	FC 1 Bus A	——	——
SC2121X **	FC 2 Bus A	——	——
SC2122X **	FC 3 Bus A	——	——
SC2125X **	FC 1 Bus B	——	——
SC2126X **	FC 2 Bus B	——	——
SC2127X **	FC 3 Bus B	——	——
SC0092X	Pressure low O_2 tanks 1 & 2	Normal - Low	Event
SC0093X	Motor Switch Close O_2 tanks 1&2	Open - Close	Event
SC0094X	Pressure low H_2 tanks 1 & 2	Normal - Low	Event
SC0095X	Motor Switch Close H_2 Tanks 1&2	Open - Close	Event
SC0360V	Fan Motor Oper Tank 1 O_2	——	——
SC0361V	Fan Motor Oper Tank 2 O_2	——	——

* See note, page A-160

** Data also displayed to crew

TABLE 4.2
GROUND TEST INSTRUMENTATION (Continued)

MEASUREMENT NUMBER *	MEASUREMENT NAME	RANGE	VALUE
SC0362V	Fan Motor Oper Tank 1 H_2	——	——
SC0363V	Fan Motor Oper Tank 2 H_2	——	——
SC2075X	FC H_2 Inline Htr ON	ON	Event
SC2076X	FC H_2 Inline Htr OFF	OFF	Event
SC2116V	FC 1 DC Volts Out	25-40 volts	0.059
SC2117V	FC 2 DC Volts Out	25-40 volts	0.059
SC2118V	FC 3 DC Volts Out	25-40 volts	0.059
SC2130X	FC 1 H_2 Purge Valve Oper	Close - Open	Event
SC2131X	FC 2 H_2 Purge Valve Oper	Close - Open	Event
SC2132X	FC 3 H_2 Purge Valve Oper	Close - Open	Event

* See note, page A-160

TABLE 4.2
GROUND TEST INSTRUMENTATION (Continued)

MEASUREMENT NUMBER *	MEASUREMENT NAME	RANGE	BIT VALUE
SC2133X	FC 1 O_2 Purge Valve	Close - Open	Event
SC2134X	FC 2 O_2 Purge Valve	Close - Open	Event
SC2135X	FC 3 O_2 Purge Valve	Close - Open	Event
SC2326X **	FC 1 O_2/H_2 Shutoff Valve Open Hold	Off - Hold	Event
SC2327X **	FC 2 O_2/H_2 Shutoff Valve Open Hold	Off - Hold	Event
SC2328X **	FC 3 O_2/H_2 Shutoff Valve Open Hold	Off - Hold	Event
GC5000V	FC 1 Htr Voltage Zone 1	0-120 vrms	0.472
GC5001V	FC 1 Htr Voltage Zone 2		
GC5002V	FC 1 Htr Voltage Zone 3		

* See note, page A-160

** Data also displayed to crew

TABLE 4.2
GROUND TEST INSTRUMENTATION (Continued)

MEASUREMENT NUMBER *	MEASUREMENT NAME	RANGE	BIT VALUE
GC5003V	FC 2 Htr Voltage Zone 1	0-120 vrms	0.472
GC5004V	FC 2 Htr Voltage Zone 2		
GC5005V	FC 2 Htr Voltage Zone 3		
GC5006V	FC 3 Htr Voltage Zone 1	0-120 vrms	0.472
GC5007V	FC 3 Htr Voltage Zone 2		
GC5008V	FC 3 Htr Voltage Zone 3		
GC5009C	FC 1 Htr Current Zone 1	0-5 arms	0.0197
GC5010C	FC 1 Htr Current Zone 2	0-50 arms	0.197
GC5011C	FC 1 Htr Current Zone 3	0-5 arms	0.0197

* See note, page A-160

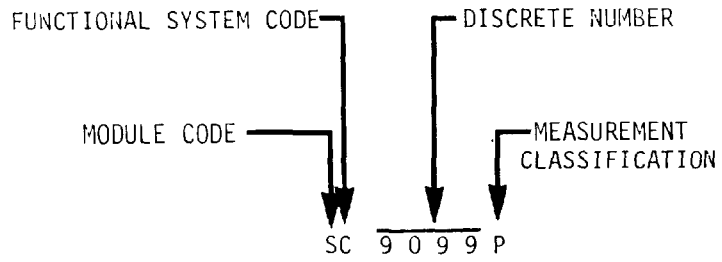
TABLE 4.2
GROUND TEST INSTRUMENTATION (Continued)

MEASUREMENT NUMBER *	MEASUREMENT NAME	RANGE	BIT VALUE
GC5012C	FC 2 Htr Current Zone 1	0-5 arms	0.0197
GC5013C	FC 2 Htr Current Zone 2	0-50 arms	0.197
GC5014C	FC 2 Htr Current Zone 3	0-5 arms	0.0197
GC5015C	FC 3 Htr Current Zone 1	0-5 arms	0.0197
GC5016C	FC 3 Htr Current Zone 2	0-50 arms	0.197
GC5017C	FC 3 Htr Current Zone 3	0-5 arms	0.0197
GC5019E	FC 1 Htr Power	0-5000 watts	19.7
GC5020E	FC 2 Htr Power		
GC5021E	FC 3 Htr Power		

* See note, page A-160

TABLE 4.1 NOTE

The measurement identification used in Table 4.1 consists of seven characters: two letters followed by four numbers and one letter as shown below.



Module Code

The first letter designates the measurement location by module:

C	Command Module
G	GSE Auxiliary and Checkout Equipment
S	Service Module

Function Subsystem Code

The second letter denotes the subsystem within which the measurement originates:

C	Electrical Power

Discrete Number

Characters three through six are discrete numbers listed sequentially within each system.

Measurement Classification

The seventh character, a letter, denotes measurement classification or type:

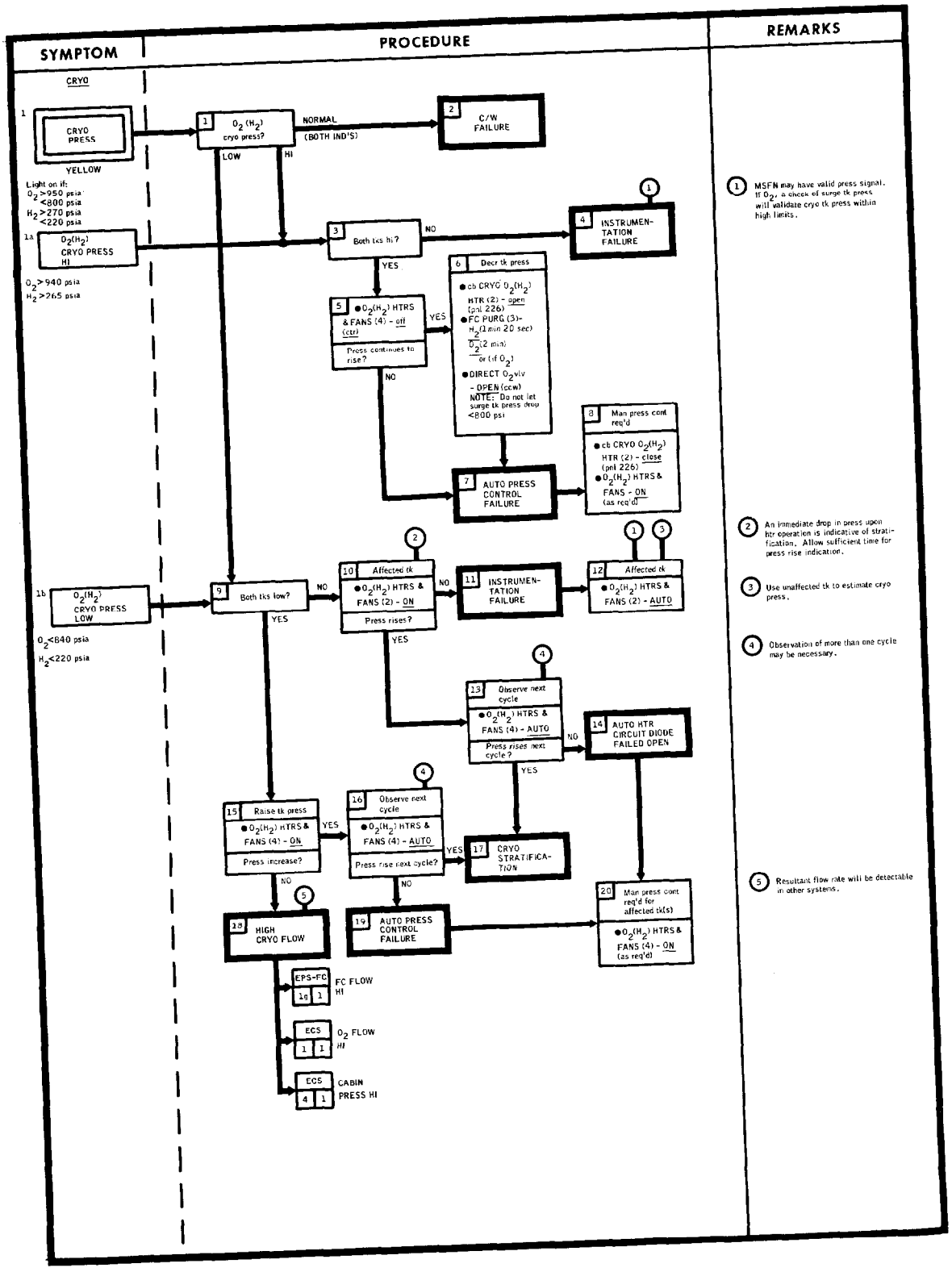
C	Current	R	Rate
E	Power	T	Temperature
P	Pressure	V	Voltage
Q	Quantity	X	Discrete Event

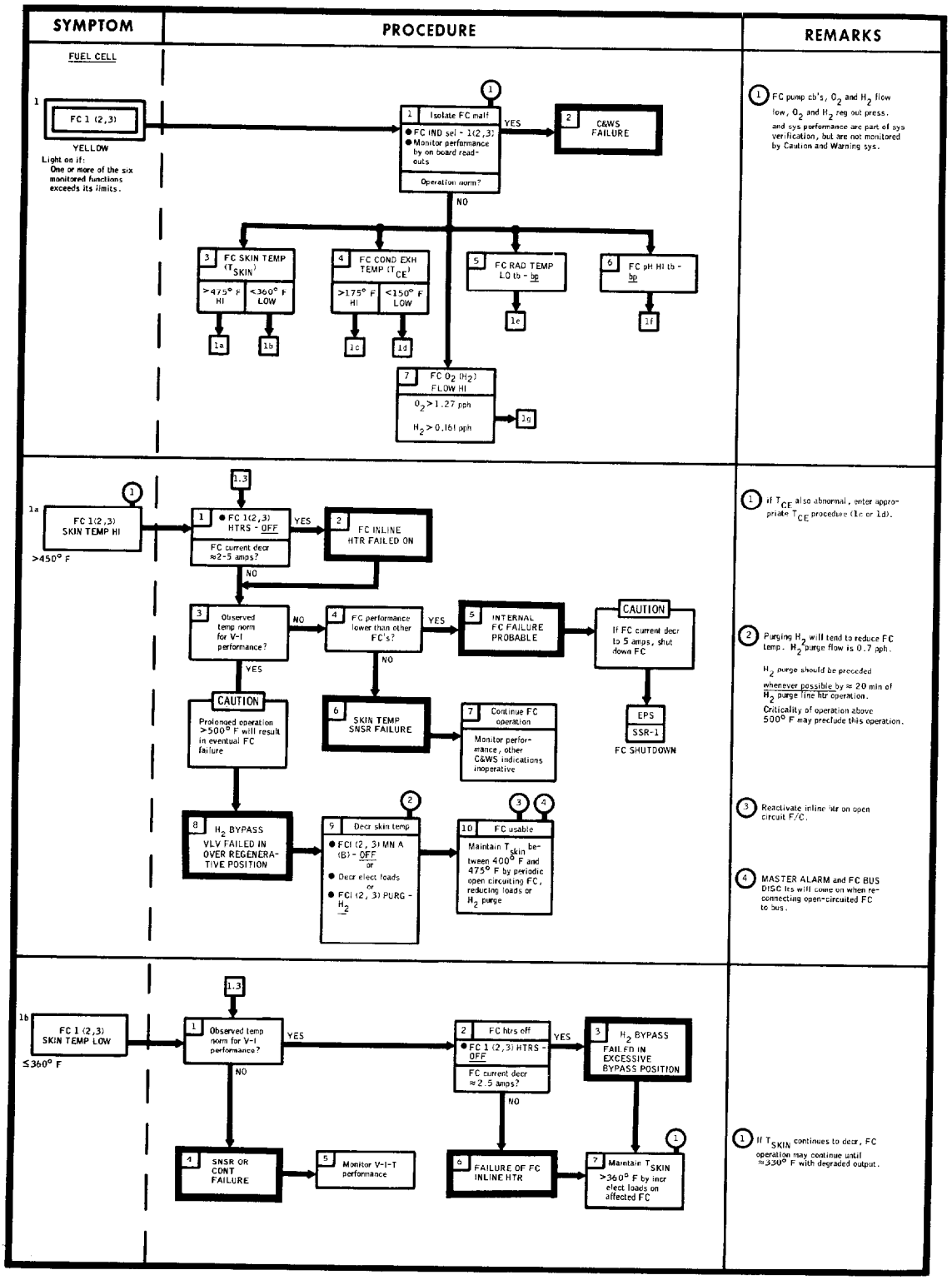
5.0 FUEL CELL/CRYOGENIC SUBSYSTEM MALFUNCTION PROCEDURES

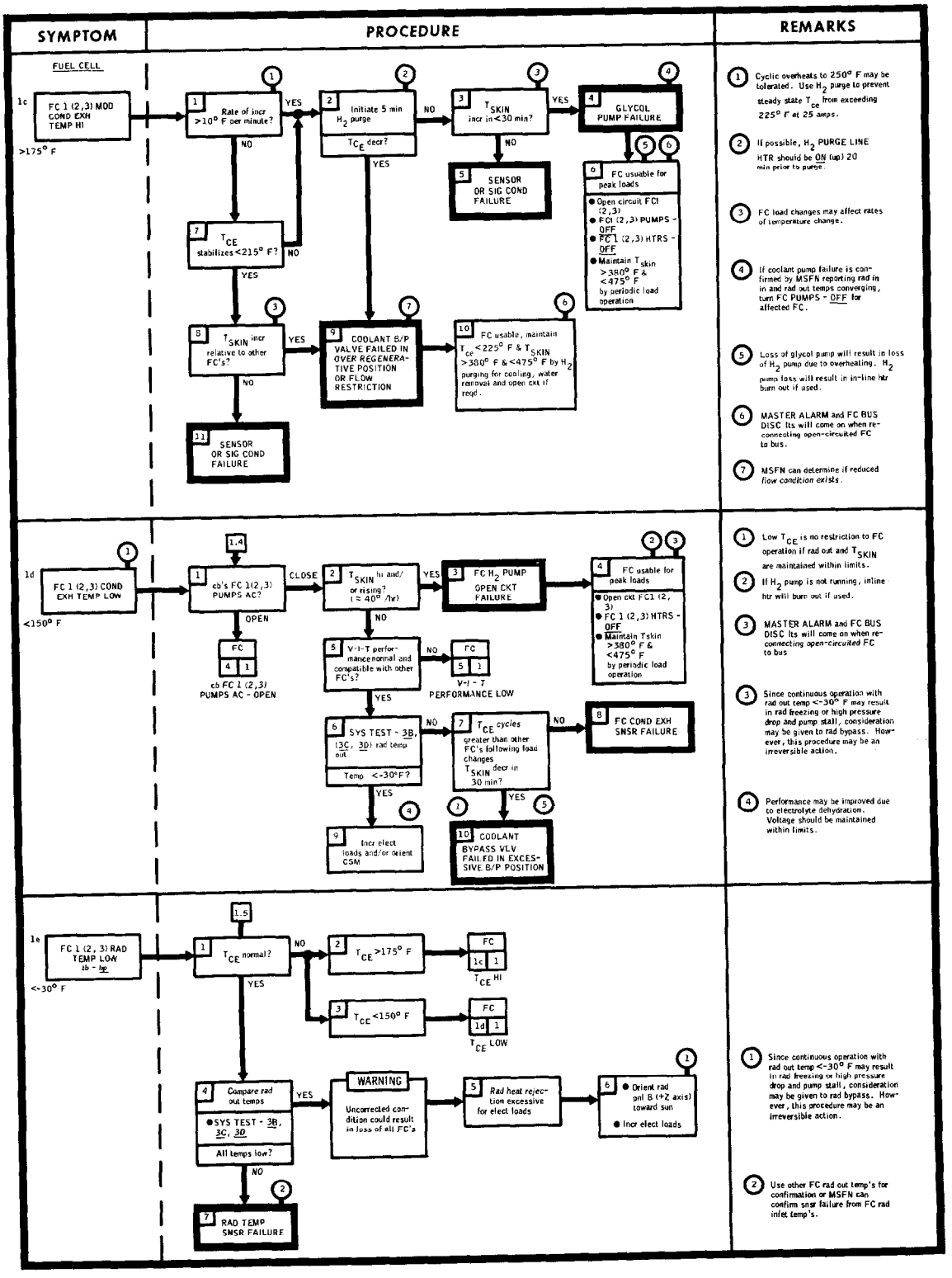
The procedures describe the proper order and nature of emergency steps the crew must perform to determine the source of a fuel cell or cryogenic storage system problem/malfunction. A Caution and Warning alarm and light or abnormal instrumentation indication is evaluated by a malfunction procedure logic diagram. The logic diagrams enable the crew to determine the source of the problem and corrective actions, if required. Fuel cell shutdown and bus short isolation (not related to Caution and Warning) procedures are also presented as part of the malfunction procedures.

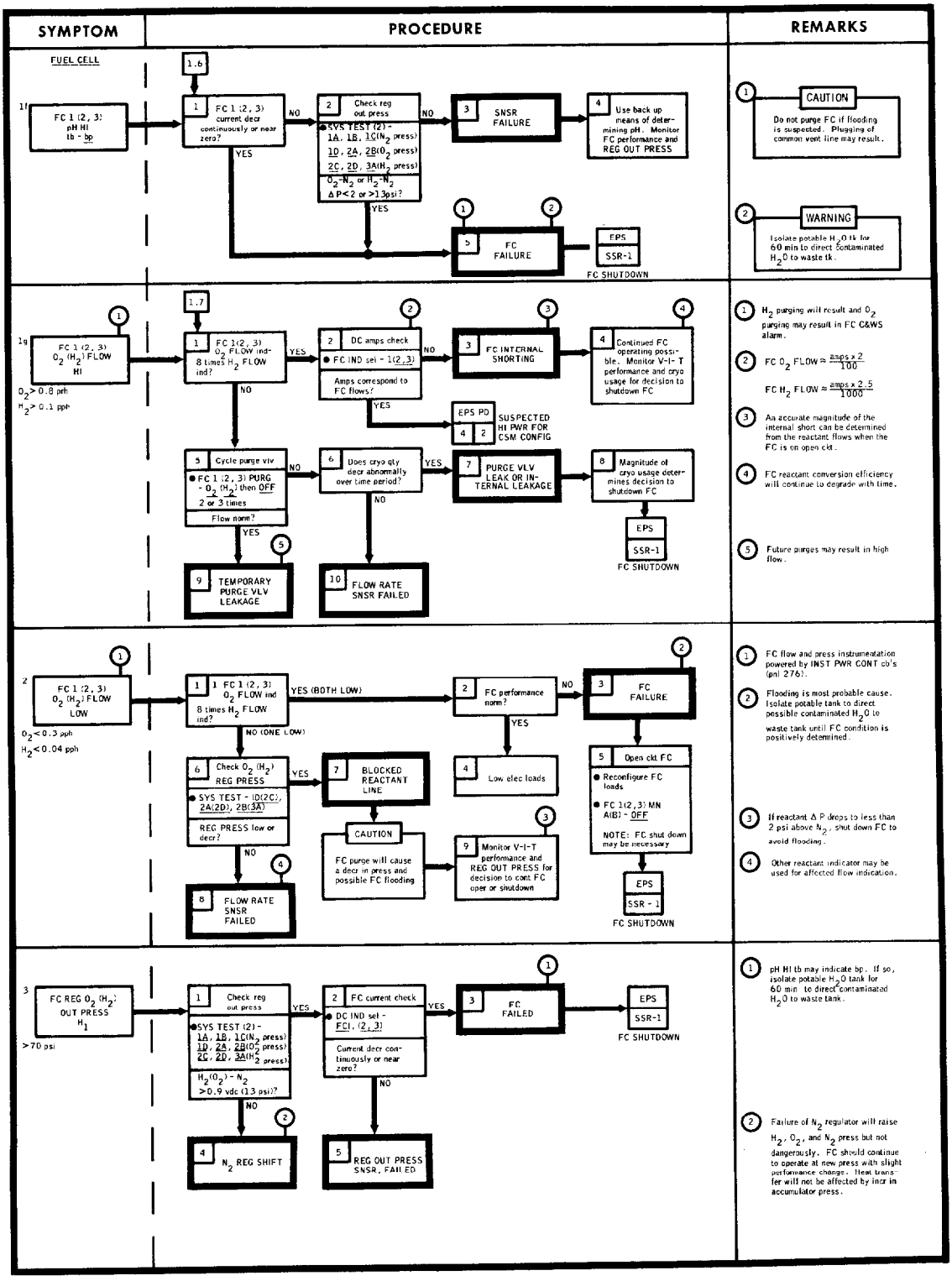
The procedures are primarily used as a guide for the flight crew to locate a problem and are presented for the flight monitor as a guide to the crew actions.

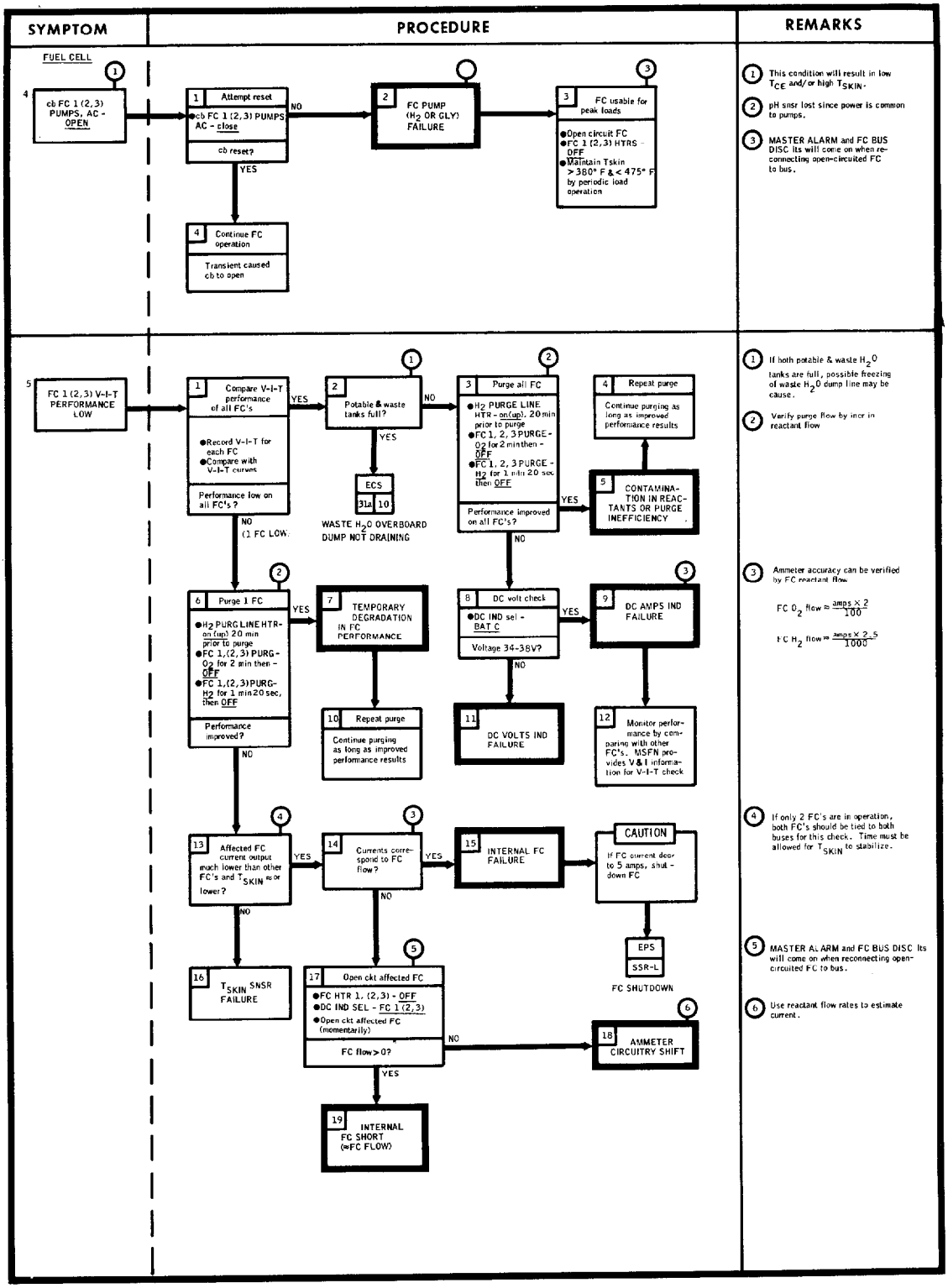
The source of the data was CSM 108 (Apollo 12) Flight Malfunction Procedures.

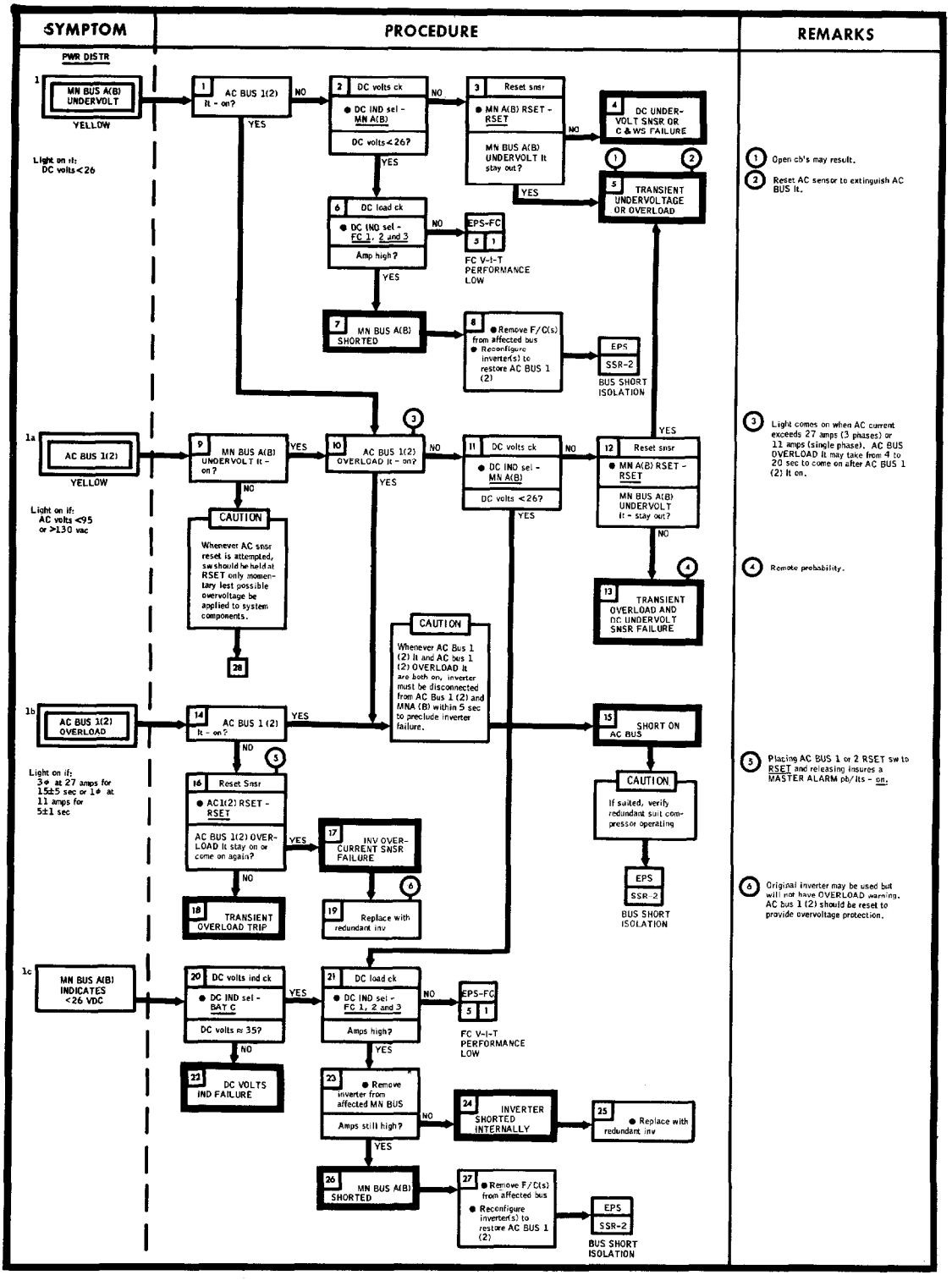

SYMPTOM
PROCEDURE
REMARKS
CRYO
1 CRYO PRESS YELLOW
Light on if:
O_2 >950 psia
<800 psia
H_2 >270 psia
<220 psia
1a $O_2(H_2)$ CRYO PRESS HI
O_2 >940 psia
H_2 >265 psia
1b $O_2(H_2)$ CRYO PRESS LOW
O_2 <840 psia
H_2 <220 psia
1 O_2 (H_2) cryo press?
NORMAL (BOTH IND'S)
2 C/W FAILURE
LOW
HI
3 Both tks hi?
NO
4 INSTRUMENTATION FAILURE
YES
5 ● $O_2(H_2)$ HTRS & FANS (4) - off (ctr)
Press continues to rise?
YES
NO
6 Decr tk press
● cb CRYO $O_2(H_2)$ HTR (2) - open (grd 226)
● FC PURG (3)- H_2 (1 min 20 sec) O_2 (2 min) or (if O_2)
● DIRECT O_2 v/v - OPEN (ccw)
NOTE: Do not let surge tk press drop <800 psi
7 AUTO PRESS CONTROL FAILURE
8 Man press cont req'd
● cb CRYO $O_2(H_2)$ HTR (2) - close (grd 226)
● $O_2(H_2)$ HTRS & FANS - ON (as req'd)
9 Both tks low?
NO
YES
10 Affected tk
● $O_2(H_2)$ HTRS & FANS (2) - ON
Press rises?
NO
YES
11 INSTRUMENTATION FAILURE
12 Affected tk
● $O_2(H_2)$ HTRS & FANS (2) - AUTO
13 Observe next cycle
● $O_2(H_2)$ HTRS & FANS (4) - AUTO
Press rises next cycle?
NO
YES
14 AUTO HTR CIRCUIT DIODE FAILED OPEN
15 Raise tk press
● $O_2(H_2)$ HTRS & FANS (4) - ON
Press increase?
YES
NO
16 Observe next cycle
● $O_2(H_2)$ HTRS & FANS (4) - AUTO
Press rise next cycle?
YES
NO
17 CRYO STRATIFICATION
18 HIGH CRYO FLOW
19 AUTO PRESS CONTROL FAILURE
20 Man press cont req'd for affected tk(s)
● $O_2(H_2)$ HTRS & FANS (4) - ON (as req'd)
EPS-FC 16 1 FC FLOW HI
ECS 1 1 O_2 FLOW HI
ECS 4 1 CABIN PRESS HI
1 MSFN may have valid press signal. If O_2, a check of surge tk press will validate cryo tk press within high limits.
2 An immediate drop in press upon htr operation is indicative of stratification. Allow sufficient time for press rise indication.
3 Use unaffected tk to estimate cryo press.
4 Observation of more than one cycle may be necessary.
5 Resultant flow rate will be detectable in other systems.

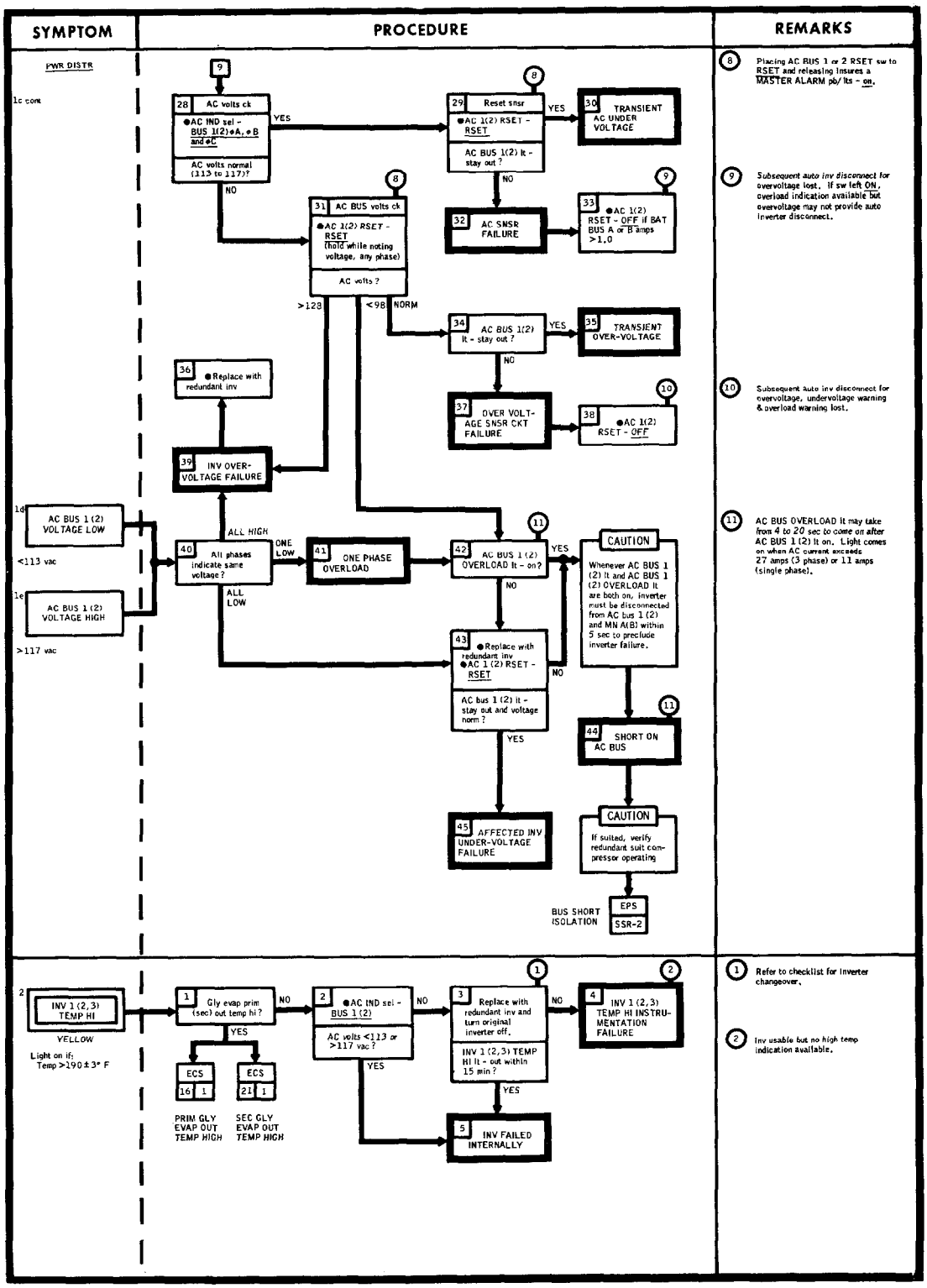

SYMPTOM
PROCEDURE
REMARKS
FUEL CELL
1
FC 1 (2,3)
YELLOW
Light on if:
One or more of the six monitored functions exceeds its limits.
1 Isolate FC malf
● FC IND sel - 1(2,3)
● Monitor performance by on board read-outs
Operation norm?
YES
2 C&WS FAILURE
NO
3 FC SKIN TEMP (T_{SKIN})
>475° F HI
<360° F LOW
4 FC COND EXH TEMP (T_{CE})
>175° F HI
<150° F LOW
5 FC RAD TEMP LO tb - bp
6 FC pH HI tb - bp
1a
1b
1c
1d
1e
1f
7 FC O_2 (H_2) FLOW HI
O_2 > 1.27 pph
H_2 > 0.161 pph
1g
1 FC pump cb's, O_2 and H_2 flow low, O_2 and H_2 reg out press. and sys performance are part of sys verification, but are not monitored by Caution and Warning sys.
1a
FC 1(2,3) SKIN TEMP HI
>450° F
1 ● FC 1(2,3) HTRS - OFF
FC current decr ≈2-5 amps?
YES
2 FC INLINE HTR FAILED ON
NO
3 Observed temp norm for V-I performance?
NO
4 FC performance lower than other FC's?
YES
5 INTERNAL FC FAILURE PROBABLE
CAUTION
If FC current decr to 5 amps, shut down FC
EPS
SSR-1
FC SHUTDOWN
YES
CAUTION
Prolonged operation >500° F will result in eventual FC failure
NO
6 SKIN TEMP SNSR FAILURE
7 Continue FC operation
Monitor performance, other C&WS indications inoperative
8 H_2 BYPASS VLV FAILED IN OVER REGENERATIVE POSITION
9 Decr skin temp
● FCI (2, 3) MN A (B) - OFF
or
● Decr elect loads
or
● FCI (2, 3) PURG - H_2
10 FC usable
Maintain T_{skin} between 400° F and 475° F by periodic open circuiting FC, reducing loads or H_2 purge
1 If T_{CE} also abnormal, enter appropriate T_{CE} procedure (1c or 1d).
2 Purging H_2 will tend to reduce FC temp. H_2 purge flow is 0.7 pph.
H_2 purge should be preceded whenever possible by ≈ 20 min of H_2 purge line htr operation.
Criticality of operation above 500° F may preclude this operation.
3 Reactivate inline htr on open circuit F/C.
4 MASTER ALARM and FC BUS DISC lts will come on when reconnecting open-circuited FC to bus.
1b
FC 1 (2,3) SKIN TEMP LOW
≤360° F
1 Observed temp norm for V-I performance?
YES
NO
2 FC htrs off
● FC 1 (2,3) HTRS - OFF
FC current decr ≈2.5 amps?
YES
NO
3 H_2 BYPASS FAILED IN EXCESSIVE BYPASS POSITION
4 SNSR OR CONT FAILURE
5 Monitor V-I-T performance
6 FAILURE OF FC INLINE HTR
7 Maintain T_{SKIN} >360° F by incr elect loads on affected FC
1 If T_{SKIN} continues to decr, FC operation may continue until ≈330° F with degraded output.

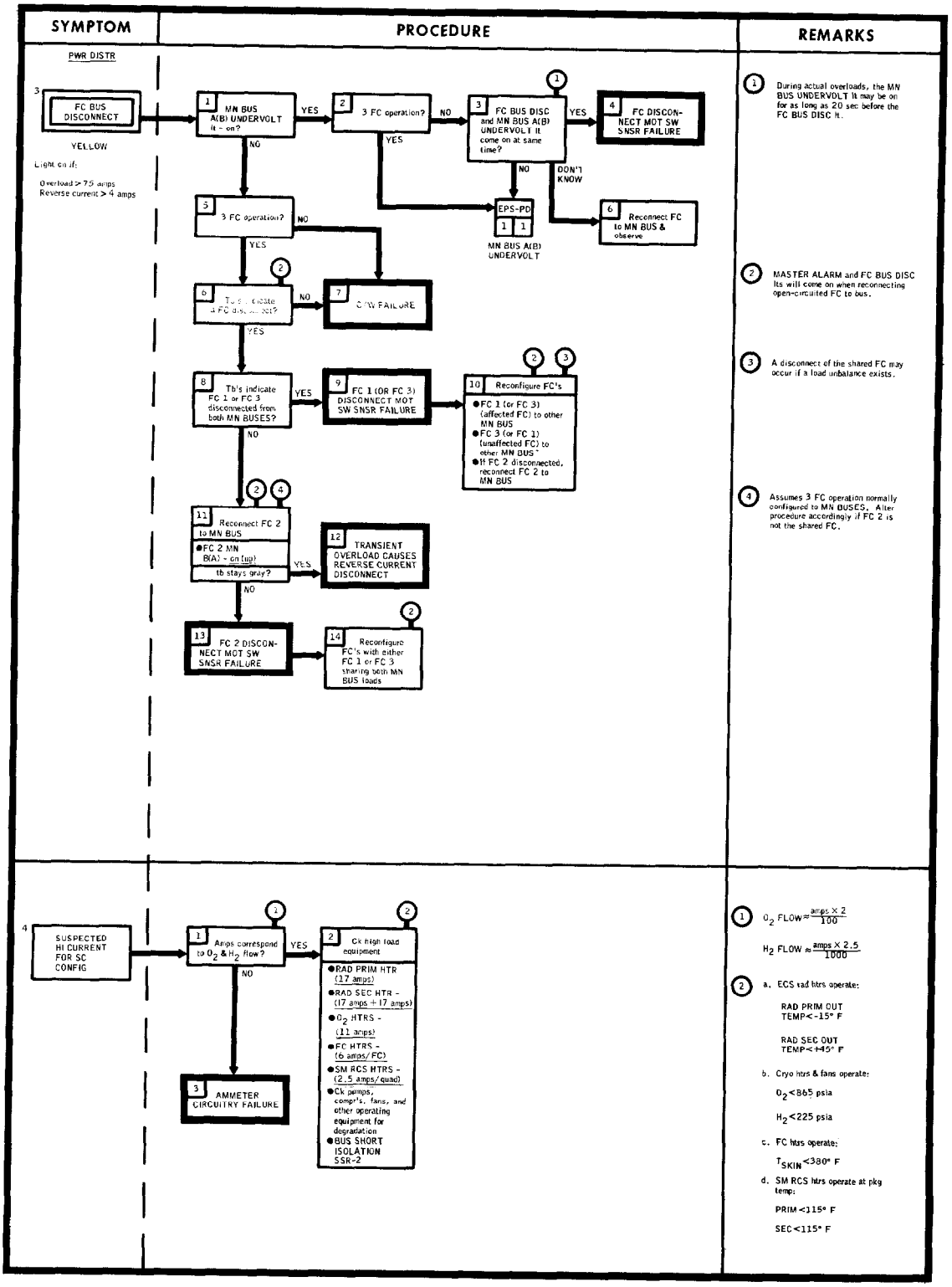

SYMPTOM
PROCEDURE
REMARKS
FUEL CELL
1c
FC 1 (2,3) MOD COND EXH TEMP HI
>175° F
1 Rate of incr >10° F per minute?
YES
NO
2 Initiate 5 min H_2 purge
T_{CE} decr?
NO
YES
3 T_{SKIN} incr in <30 min?
YES
NO
4 GLYCOL PUMP FAILURE
5 SENSOR OR SIG COND FAILURE
6 FC usable for peak loads
● Open circuit FC1 (2,3)
● FC1 (2,3) PUMPS - OFF
● FC1 (2,3) HTRS - OFF
● Maintain T_{skin} >380° F & <475° F by periodic load operation
7 T_{CE} stabilizes <215° F?
NO
YES
8 T_{SKIN} incr relative to other FC's?
YES
NO
9 COOLANT B/P VALVE FAILED IN OVER REGENERATIVE POSITION OR FLOW RESTRICTION
10 FC usable, maintain T_{ce} <225° F & T_{SKIN} >380° F & <475° F by H_2 purging for cooling, water removal and open ckt if reqd.
11 SENSOR OR SIG COND FAILURE
1 Cyclic overheats to 250° F may be tolerated. Use H_2 purge to prevent steady state T_{ce} from exceeding 225° F at 25 amps.
2 If possible, H_2 PURGE LINE HTR should be ON (up) 20 min prior to purge.
3 FC load changes may affect rates of temperature change.
4 If coolant pump failure is confirmed by MSFN reporting rad in in and rad out temps converging, turn FC PUMPS - OFF for affected FC.
5 Loss of glycol pump will result in loss of H_2 pump due to overheating. H_2 pump loss will result in in-line htr burn out if used.
6 MASTER ALARM and FC BUS DISC lts will come on when reconnecting open-circuited FC to bus.
7 MSFN can determine if reduced flow condition exists.
1d
FC 1 (2,3) COND EXH TEMP LOW
<150° F
1,4
1 cb's FC 1(2,3) PUMPS AC?
CLOSE
OPEN
FC 4 1
cb FC 1 (2,3) PUMPS AC - OPEN
2 T_{SKIN} hi and/or rising? (= 40° /hr)
YES
NO
3 FC H_2 PUMP OPEN CKT FAILURE
4 FC usable for peak loads
● Open ckt FC1 (2, 3)
● FC 1 (2,3) HTRS - OFF
● Maintain Tskin >380° F & <475° F by periodic load operation
5 V-I-T performance normal and compatible with other FC's?
NO
FC 5 1
V-I - T PERFORMANCE LOW
YES
6 SYS TEST - 3B, (3C, 3D) rad temp out
Temp <-30°F?
NO
YES
7 T_{CE} cycles greater than other FC's following load changes
T_{SKIN} decr in 30 min?
NO
YES
8 FC COND EXH SNSR FAILURE
9 Incr elect loads and/or orient CSM
10 COOLANT BYPASS VLV FAILED IN EXCESSIVE B/P POSITION
1 Low T_{CE} is no restriction to FC operation if rad out and T_{SKIN} are maintained within limits.
2 If H_2 pump is not running, inline htr will burn out if used.
3 MASTER ALARM and FC BUS DISC lts will come on when reconnecting open-circuited FC to bus
3 Since continuous operation with rad out temp <-30° F may result in rad freezing or high pressure drop and pump stall, consideration may be given to rad bypass. However, this procedure may be an irreversible action.
4 Performance may be improved due to electrolyte dehydration. Voltage should be maintained within limits.
1e
FC 1 (2, 3) RAD TEMP LOW 4b - 4g
<-30° F
1,5
1 T_{CE} normal?
NO
YES
2 T_{CE} >175° F
FC 1c 1
T_{CE} HI
3 T_{CE} <150° F
FC 1d 1
T_{CE} LOW
4 Compare rad out temps
● SYS TEST - 3B, 3C, 3D
All temps low?
YES
NO
WARNING
Uncorrected condition could result in loss of all FC's
5 Rad heat rejection excessive for elect loads
6 ● Orient rad pnl B (+Z axis) toward sun
● Incr elect loads
7 RAD TEMP SNSR FAILURE
1 Since continuous operation with rad out temp <-30° F may result in rad freezing or high pressure drop and pump stall, consideration may be given to rad bypass. However, this procedure may be an irreversible action.
2 Use other FC rad out temp's for confirmation or MSFN can confirm snsr failure from FC rad inlet temp's.

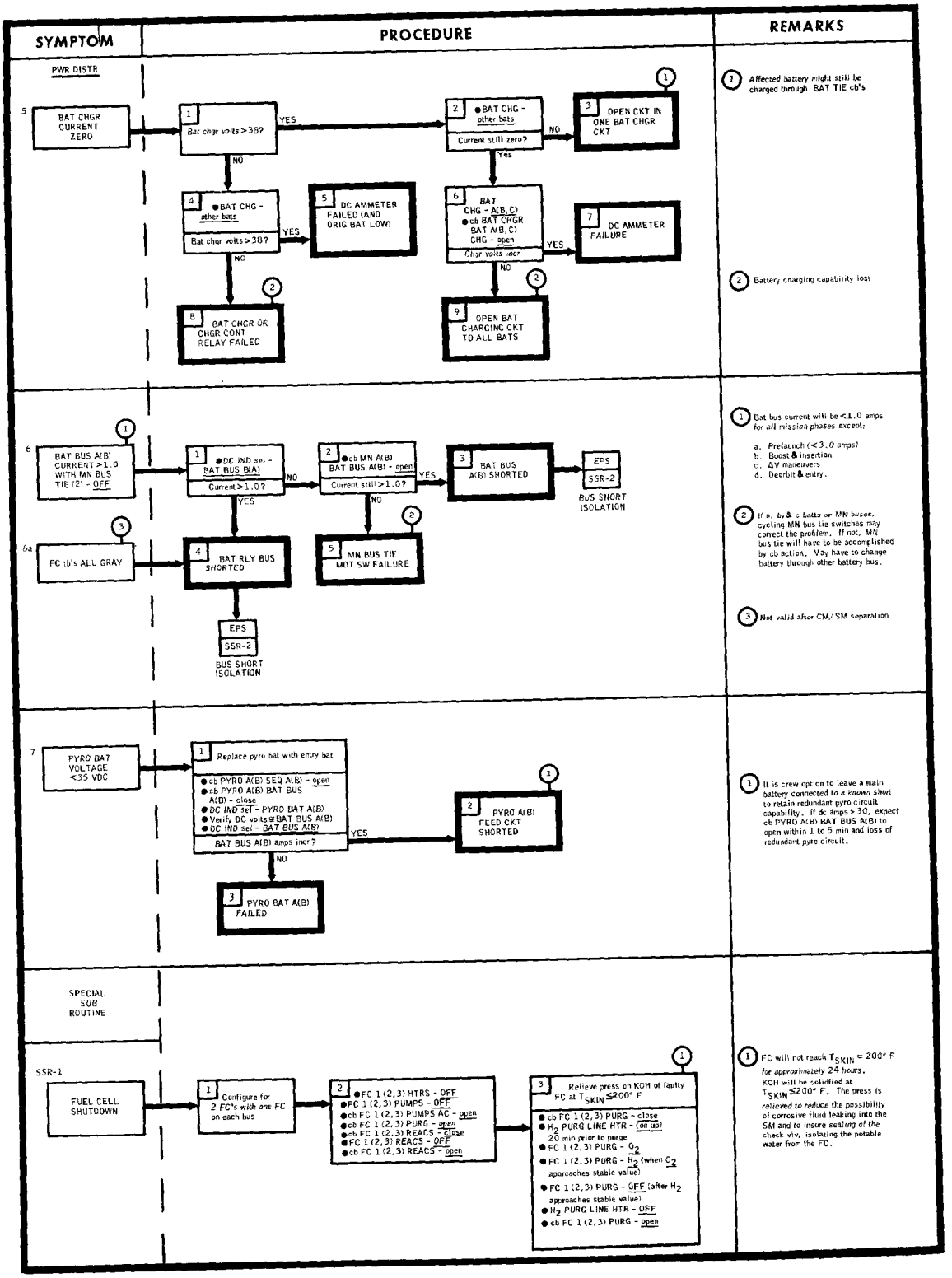

SYMPTOM
PROCEDURE
REMARKS
FUEL CELL
1f
FC 1 (2, 3) pH HI tb - bp
1.6
1 FC 1 (2, 3) current decr continuously or near zero?
NO
YES
2 Check reg out press
SYS TEST (2) - 1A, 1B, 1C(N2 press) 1D, 2A, 2B(O2 press) 2C, 2D, 3A(H2 press)
O2-N2 or H2-N2 ΔP<2 or >13psi?
YES
NO
3 SNSR FAILURE
4 Use back up means of determining pH. Monitor FC performance and REG OUT PRESS
5 FC FAILURE
EPS
SSR-1
FC SHUTDOWN
1g
FC 1 (2, 3) O2 (H2) FLOW HI
O2 > 0.8 pph
H2 > 0.1 pph
1.7
1 FC 1(2, 3) O2 FLOW ind- 8 times H2 FLOW ind?
YES
NO
2 DC amps check
FC IND sel - 1(2,3)
Amps correspond to FC flows?
YES
NO
3 FC INTERNAL SHORTING
4 Continued FC operating possible. Monitor V-I-T performance and cryo usage for decision to shutdown FC
EPS PD
4 2
SUSPECTED HI PWR FOR CSM CONFIG
5 Cycle purge vlv
FC 1 (2, 3) PURG - O2 (H2) then OFF 2 2 2 or 3 times
Flow norm?
YES
NO
6 Does cryo qty decr abnormally over time period?
YES
NO
7 PURGE VLV LEAK OR INTERNAL LEAKAGE
8 Magnitude of cryo usage determines decision to shutdown FC
EPS
SSR-1
FC SHUTDOWN
9 TEMPORARY PURGE VLV LEAKAGE
10 FLOW RATE SNSR FAILED
2
FC 1 (2, 3) O2 (H2) FLOW LOW
O2 < 0.3 pph
H2 < 0.04 pph
1 FC 1 (2, 3) O2 FLOW ind 8 times H2 FLOW ind?
YES (BOTH LOW)
NO (ONE LOW)
2 FC performance norm?
NO
YES
3 FC FAILURE
4 Low elec loads
5 Open ckt FC
Reconfigure FC loads
FC 1(2,3) MN A(B) - OFF
NOTE: FC shut down may be necessary
EPS
SSR-1
FC SHUTDOWN
6 Check O2 (H2) REG PRESS
SYS TEST - 1D(2C), 2A(2D), 2B(3A)
REG PRESS low or decr?
YES
NO
7 BLOCKED REACTANT LINE
CAUTION
FC purge will cause a decr in press and possible FC flooding
8 FLOW RATE SNSR FAILED
9 Monitor V-I-T performance and REG OUT PRESS for decision to cont FC oper or shutdown
3
FC REG O2 (H2) OUT PRESS H1
>70 psi
1 Check reg out press
SYS TEST (2) - 1A, 1B, 1C(N2 press) 1D, 2A, 2B(O2 press) 2C, 2D, 3A(H2 press)
H2(O2) - N2 >0.9 vdc (13 psi)?
YES
NO
2 FC current check
DC IND sel - FC1, (2, 3)
Current decr continuously or near zero?
YES
NO
3 FC FAILED
EPS
SSR-1
FC SHUTDOWN
4 N2 REG SHIFT
5 REG OUT PRESS SNSR, FAILED
1 CAUTION
Do not purge FC if flooding is suspected. Plugging of common vent line may result.
2 WARNING
Isolate potable H2O tk for 60 min to direct contaminated H2O to waste tk.
1 H2 purging will result and O2 purging may result in FC C&WS alarm.
2 FC O2 FLOW ≈ amps x 2 / 100
FC H2 FLOW ≈ amps x 2.5 / 1000
3 An accurate magnitude of the internal short can be determined from the reactant flows when the FC is on open ckt.
4 FC reactant conversion efficiency will continue to degrade with time.
5 Future purges may result in high flow.
1 FC flow and press instrumentation powered by INST PWR CONT cb's (pnl 276).
2 Flooding is most probable cause. Isolate potable tank to direct possible contaminated H2O to waste tank until FC condition is positively determined.
3 If reactant Δ P drops to less than 2 psi above N2, shut down FC to avoid flooding.
4 Other reactant indicator may be used for affected flow indication.
1 pH HI tb may indicate bp. If so, isolate potable H2O tank for 60 min to direct contaminated H2O to waste tank.
2 Failure of N2 regulator will raise H2, O2, and N2 press but not dangerously. FC should continue to operate at new press with slight performance change. Heat transfer will not be affected by incr in accumulator press.

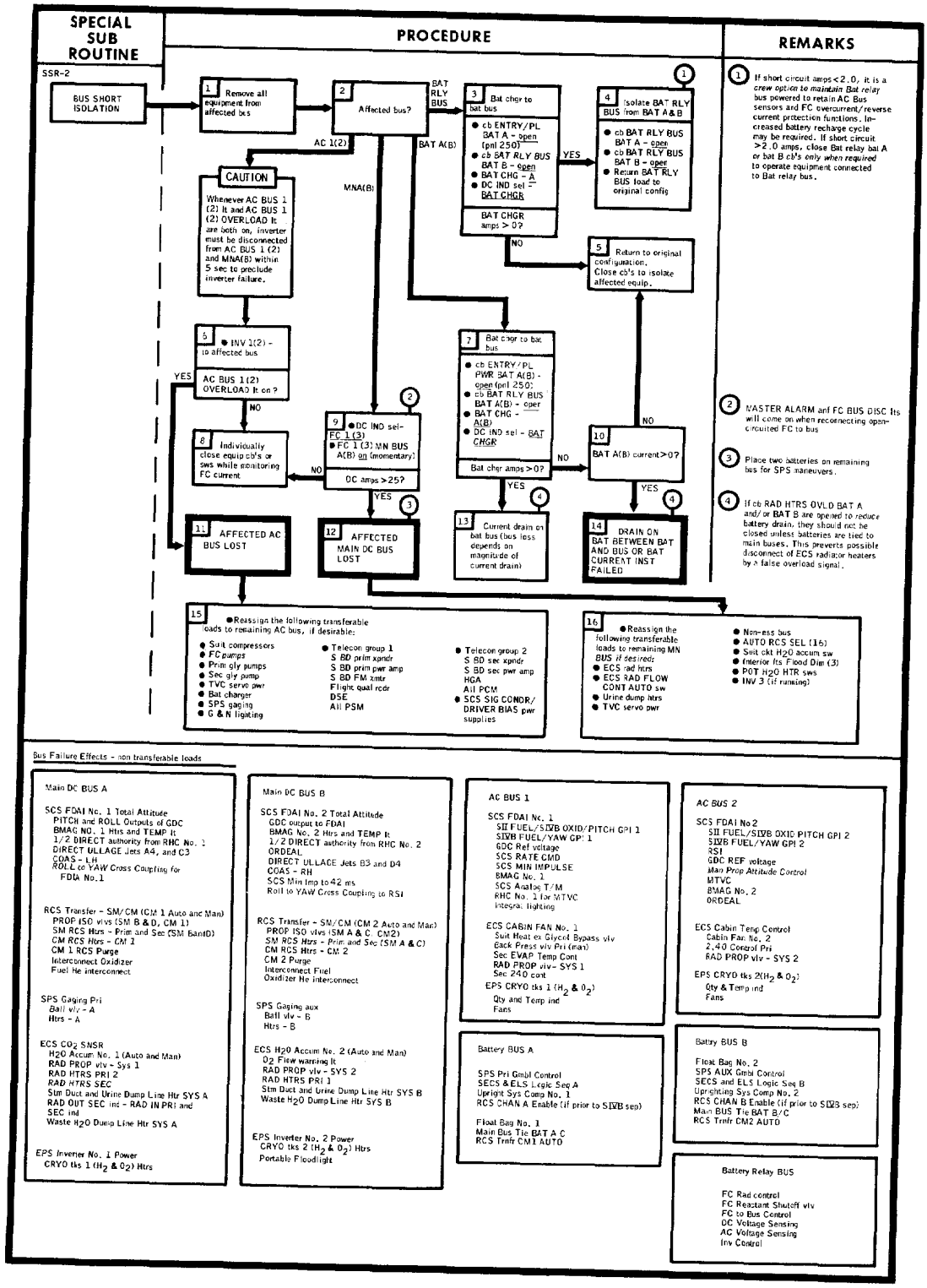

SYMPTOM
PROCEDURE
REMARKS
FUEL CELL
4
cb FC 1 (2,3) PUMPS, AC - OPEN
1
Attempt reset
cb FC 1 (2,3) PUMPS AC - close
cb reset?
NO
YES
2
FC PUMP (H_2 OR GLY) FAILURE
3
FC usable for peak loads
●Open circuit FC
●FC 1 (2,3) HTRS - OFF
●Maintain Tskin > 380° F & < 475° F by periodic load operation
4
Continue FC operation
Transient caused cb to open
1 This condition will result in low T_{CE} and/or high T_{SKIN}.
2 pH snsr lost since power is common to pumps.
3 MASTER ALARM and FC BUS DISC lts will come on when re-connecting open-circuited FC to bus.
5
FC 1 (2,3) V-I-T PERFORMANCE LOW
1
Compare V-I-T performance of all FC's
●Record V-I-T for each FC
●Compare with V-I-T curves
Performance low on all FC's?
YES
NO (1 FC LOW)
2
Potable & waste tanks full?
YES
NO
ECS
31a 10
WASTE H_2O OVERBOARD DUMP NOT DRAINING
2
3
Purge all FC
●H_2 PURGE LINE HTR - on(up), 20 min prior to purge
●FC 1, 2, 3 PURGE - O_2 for 2 min then - OFF
●FC 1, 2, 3 PURGE - H_2 for 1 min 20 sec then OFF
Performance improved on all FC's?
YES
NO
4
Repeat purge
Continue purging as long as improved performance results
5
CONTAMINATION IN REACTANTS OR PURGE INEFFICIENCY
2
6
Purge 1 FC
●H_2 PURG LINE HTR - on (up) 20 min prior to purge
●FC 1,(2,3) PURG - O_2 for 2 min then - OFF
●FC 1,(2,3) PURG - H_2 for 1 min 20 sec, then OFF
Performance improved?
YES
NO
7
TEMPORARY DEGRADATION IN FC PERFORMANCE
10
Repeat purge
Continue purging as long as improved performance results
8
DC volt check
●DC IND sel - BAT C
Voltage 34-38V?
YES
NO
9
DC AMPS IND FAILURE
11
DC VOLTS IND FAILURE
12
Monitor performance by comparing with other FC's. MSFN provides V & I information for V-I-T check
3 Ammeter accuracy can be verified by FC reactant flow.
FC O_2 flow ≈ $\frac{\text{amps} \times 2}{100}$
FC H_2 flow ≈ $\frac{\text{amps} \times 2.5}{1000}$
4
13
Affected FC current output much lower than other FC's and T_{SKIN} same or lower?
YES
NO
3
14
Currents correspond to FC flow?
YES
NO
15
INTERNAL FC FAILURE
CAUTION
If FC current decr to 5 amps, shut-down FC
EPS
SSR-L
FC SHUTDOWN
4 If only 2 FC's are in operation, both FC's should be tied to both buses for this check. Time must be allowed for T_{SKIN} to stabilize.
16
T_{SKIN} SNSR FAILURE
5
17
Open ckt affected FC
●FC HTR 1, (2,3) - OFF
●DC IND SEL - FC 1 (2,3)
●Open ckt affected FC (momentarily)
FC flow > 0?
NO
YES
6
18
AMMETER CIRCUITRY SHIFT
19
INTERNAL FC SHORT (∞FC FLOW)
5 MASTER ALARM and FC BUS DISC lts will come on when reconnecting open-circuited FC to bus.
6 Use reactant flow rates to estimate current.


SYMPTOM
PROCEDURE
REMARKS
PWR DISTR
1
MN BUS A(B) UNDERVOLT
YELLOW
Light on if: DC volts < 26
1 AC BUS 1(2) lt - on?
NO
YES
2 DC volts ck
● DC IND sel - MN A(B)
DC volts < 26?
NO
YES
3 Reset snsr
● MN A(B) RSET - RSET
MN BUS A(B) UNDERVOLT lt stay out?
NO
YES
4 DC UNDER-VOLT SNSR OR C & WS FAILURE
5 TRANSIENT UNDERVOLTAGE OR OVERLOAD
6 DC load ck
● DC IND sel - FC 1, 2 and 3
Amp high?
NO
YES
EPS-FC 5 1
FC V-I-T PERFORMANCE LOW
7 MN BUS A(B) SHORTED
8 ● Remove F/C(s) from affected bus
● Reconfigure inverter(s) to restore AC BUS 1 (2)
EPS SSR-2
BUS SHORT ISOLATION
1a
AC BUS 1(2)
YELLOW
Light on if: AC volts <95 or >130 vac
9 MN BUS A(B) UNDERVOLT lt - on?
YES
NO
10 AC BUS 1(2) OVERLOAD lt - on?
NO
YES
11 DC volts ck
● DC IND sel - MN A(B)
DC volts < 26?
NO
YES
12 Reset snsr
● MN A(B) RSET - RSET
MN BUS A(B) UNDERVOLT lt - stay out?
YES
NO
13 TRANSIENT OVERLOAD AND DC UNDERVOLT SNSR FAILURE
CAUTION
Whenever AC snsr reset is attempted, sw should be held at RSET only momentary lest possible overvoltage be applied to system components.
28
CAUTION
Whenever AC Bus 1 (2) lt and AC bus 1 (2) OVERLOAD lt are both on, inverter must be disconnected from AC Bus 1 (2) and MNA (B) within 5 sec to preclude inverter failure.
1b
AC BUS 1(2) OVERLOAD
Light on if: 3φ at 27 amps for 1±.5 sec or 1φ at 11 amps for 5±1 sec
14 AC BUS 1 (2) lt - on?
YES
NO
15 SHORT ON AC BUS
CAUTION
If suited, verify redundant suit compressor operating
EPS SSR-2
BUS SHORT ISOLATION
16 Reset Snsr
● AC1(2) RSET - RSET
AC BUS 1(2) OVERLOAD lt stay on or come on again?
YES
NO
17 INV OVER-CURRENT SNSR FAILURE
18 TRANSIENT OVERLOAD TRIP
19 Replace with redundant inv
1c
MN BUS A(B) INDICATES <26 VDC
20 DC volts ind ck
● DC IND sel - BAT C
DC volts ≈ 35?
YES
NO
21 DC load ck
● DC IND sel - FC 1, 2 and 3
Amps high?
NO
YES
EPS-FC 5 1
FC V-I-T PERFORMANCE LOW
22 DC VOLTS IND FAILURE
23 ● Remove inverter from affected MN BUS
Amps still high?
NO
YES
24 INVERTER SHORTED INTERNALLY
25 ● Replace with redundant inv
26 MN BUS A(B) SHORTED
27 ● Remove F/C(s) from affected bus
● Reconfigure inverter(s) to restore AC BUS 1 (2)
EPS SSR-2
BUS SHORT ISOLATION
1 Open cb's may result.
2 Reset AC sensor to extinguish AC BUS lt.
3 Light comes on when AC current exceeds 27 amps (3 phases) or 11 amps (single phase). AC BUS OVERLOAD lt may take from 4 to 20 sec to come on after AC BUS 1 (2) lt on.
4 Remote probability.
5 Placing AC BUS 1 or 2 RSET sw to RSET and releasing insures a MASTER ALARM pb/lts - on.
6 Original inverter may be used but will not have OVERLOAD warning. AC bus 1 (2) should be reset to provide overvoltage protection.


SYMPTOM
PROCEDURE
REMARKS
PWR DISTR
1c cont
28 AC volts ck
●AC IND sel - BUS 1(2) ●A, ●B and ●C
AC volts normal (113 to 117)?
YES
NO
29 Reset snsr
●AC 1(2) RSET - RSET
AC BUS 1(2) lt - stay out ?
YES
30 TRANSIENT AC UNDER VOLTAGE
NO
32 AC SNSR FAILURE
33 ●AC 1(2) RSET - OFF if BAT BUS A or B amps >1.0
31 AC BUS volts ck
●AC 1(2) RSET - RSET (hold while noting voltage, any phase)
AC volts ?
>128
<98
NORM
34 AC BUS 1(2) lt - stay out ?
YES
35 TRANSIENT OVER-VOLTAGE
NO
37 OVER VOLT-AGE SNSR CKT FAILURE
38 ●AC 1(2) RSET - OFF
36 ●Replace with redundant inv
39 INV OVER-VOLTAGE FAILURE
1d AC BUS 1(2) VOLTAGE LOW
<113 vac
1e AC BUS 1(2) VOLTAGE HIGH
>117 vac
40 All phases indicate same voltage ?
ALL HIGH
ONE LOW
ALL LOW
41 ONE PHASE OVERLOAD
42 AC BUS 1(2) OVERLOAD lt - on?
YES
NO
CAUTION
Whenever AC BUS 1 (2) lt and AC BUS 1 (2) OVERLOAD lt are both on, inverter must be disconnected from AC bus 1 (2) and MN A(B) within 5 sec to preclude inverter failure.
43 ●Replace with redundant inv ●AC 1 (2) RSET - RSET
AC bus 1 (2) lt - stay out and voltage norm ?
NO
YES
44 SHORT ON AC BUS
CAUTION
If suited, verify redundant suit com-pressor operating
BUS SHORT ISOLATION
EPS SSR-2
45 AFFECTED INV UNDER-VOLTAGE FAILURE
2 INV 1 (2,3) TEMP HI
YELLOW
Light on if: Temp >190 ± 3° F
1 Gly evap prim (sec) out temp hi ?
YES
NO
ECS 16 1
ECS 21 1
PRIM GLY EVAP OUT TEMP HIGH
SEC GLY EVAP OUT TEMP HIGH
2 ●AC IND sel - BUS 1 (2)
AC volts <113 or >117 vac ?
NO
YES
3 Replace with redundant inv and turn original inverter off.
INV 1 (2,3) TEMP HI lt - out within 15 min ?
NO
YES
4 INV 1 (2,3) TEMP HI INSTRU-MENTATION FAILURE
5 INV FAILED INTERNALLY
8 Placing AC BUS 1 or 2 RSET sw to RSET and releasing insures a MASTER ALARM pb/lts - on.
9 Subsequent auto inv disconnect for overvoltage lost. If sw left ON, overload indication available but overvoltage may not provide auto inverter disconnect.
10 Subsequent auto inv disconnect for overvoltage, undervoltage warning & overload warning lost.
11 AC BUS OVERLOAD lt may take from 4 to 20 sec to come on after AC BUS 1 (2) lt on. Light comes on when AC current exceeds 27 amps (3 phase) or 11 amps (single phase).
1 Refer to checklist for inverter changeover.
2 Inv usable but no high temp indication available.


SYMPTOM
PROCEDURE
REMARKS
PWR DISTR
3
FC BUS DISCONNECT
YELLOW
Light on if:
Overload > 7.5 amps
Reverse current > 4 amps
1 MN BUS A(B) UNDERVOLT lt - on?
YES
NO
2 3 FC operation?
NO
YES
3 FC BUS DISC and MN BUS A(B) UNDERVOLT lt come on at same time?
YES
NO
DON'T KNOW
4 FC DISCONNECT MOT SW SNSR FAILURE
EPS-PD
1 1
MN BUS A(B) UNDERVOLT
6 Reconnect FC to MN BUS & observe
5 3 FC operation?
NO
YES
6 This indicate a FC disc. ... ect?
NO
7 C/W FAILURE
YES
8 This indicate FC 1 or FC 3 disconnected from both MN BUSES?
YES
9 FC 1 (OR FC 3) DISCONNECT MOT SW SNSR FAILURE
10 Reconfigure FC's
●FC 1 (or FC 3) (affected FC) to other MN BUS
●FC 3 (or FC 1) (unaffected FC) to other MN BUS
●If FC 2 disconnected, reconnect FC 2 to MN BUS
NO
11 Reconnect FC 2 to MN BUS
●FC 2 MN B(A) - on (up) tb stays gray?
YES
12 TRANSIENT OVERLOAD CAUSES REVERSE CURRENT DISCONNECT
NO
13 FC 2 DISCONNECT MOT SW SNSR FAILURE
14 Reconfigure FC's with either FC 1 or FC 3 sharing both MN BUS loads
1 During actual overloads, the MN BUS UNDERVOLT lt may be on for as long as 20 sec before the FC BUS DISC lt.
2 MASTER ALARM and FC BUS DISC lts will come on when reconnecting open-circuited FC to bus.
3 A disconnect of the shared FC may occur if a load unbalance exists.
4 Assumes 3 FC operation normally configured to MN BUSES. Alter procedure accordingly if FC 2 is not the shared FC.
4
SUSPECTED HI CURRENT FOR SC CONFIG
1 Amps correspond to O2 & H2 flow?
YES
NO
2 Ck high load equipment
●RAD PRIM HTR (17 amps)
●RAD SEC HTR - (17 amps + 17 amps)
●O2 HTRS - (11 amps)
●FC HTRS - (6 amps/FC)
●SM RCS HTRS - (2.5 amps/quad)
●Ck pumps, compr's, fans, and other operating equipment for degradation
●BUS SHORT ISOLATION SSR-2
3 AMMETER CIRCUITRY FAILURE
1 O2 FLOW ≈ amps X 2 / 100
H2 FLOW ≈ amps X 2.5 / 1000
2 a. ECS rad htrs operate:
RAD PRIM OUT TEMP<-15° F
RAD SEC OUT TEMP<+45° F
b. Cryo htrs & fans operate:
O2<865 psia
H2<225 psia
c. FC htrs operate:
TSKIN<380° F
d. SM RCS htrs operate at pkg temp:
PRIM<115° F
SEC<115° F


SYMPTOM
PROCEDURE
REMARKS
PWR DISTR
5
BAT CHGR CURRENT ZERO
1 Bat chgr volts > 38?
YES
NO
2 ●BAT CHG - other bats
Current still zero?
NO
Yes
1
3 OPEN CKT IN ONE BAT CHGR CKT
4 ●BAT CHG - other bats
Bat chgr volts > 38?
YES
NO
5 DC AMMETER FAILED (AND ORIG BAT LOW)
6 BAT CHG - A(B,C)
●cb BAT CHGR BAT A(B,C) CHG - open
Chgr volts incr
YES
NO
7 DC AMMETER FAILURE
2
8 BAT CHGR OR CHGR CONT RELAY FAILED
9 OPEN BAT CHARGING CKT TO ALL BATS
2
1 Affected battery might still be charged through BAT TIE cb's
2 Battery charging capability lost
6
1
BAT BUS A(B) CURRENT > 1.0 WITH MN BUS TIE (2) - OFF
1 ●DC IND sel - BAT BUS B(A)
Current > 1.0?
NO
YES
2 ●cb MN A(B) BAT BUS A(B) - open
Current still > 1.0?
YES
NO
3 BAT BUS A(B) SHORTED
EPS
SSR-2
BUS SHORT ISOLATION
6a
3
FC cb's ALL GRAY
4 BAT RLY BUS SHORTED
5 MN BUS TIE MOT SW FAILURE
2
EPS
SSR-2
BUS SHORT ISOLATION
1 Bat bus current will be < 1.0 amps for all mission phases except:
a. Prelaunch (< 3.0 amps)
b. Boost & insertion
c. ΔV maneuvers
d. Deorbit & entry.
2 If a, b, & c batts on MN buses, cycling MN bus tie switches may correct the problem. If not, MN bus tie will have to be accomplished by cb action. May have to change battery through other battery bus.
3 Not valid after CM/SM separation.
7
PYRO BAT VOLTAGE < 35 VDC
1 Replace pyro bat with entry bat
●cb PYRO A(B) SEQ A(B) - open
●cb PYRO A(B) BAT BUS A(B) - close
●DC IND Sel - PYRO BAT A(B)
●Verify, DC volts = BAT BUS A(B)
●DC IND sel - BAT BUS A(B)
BAT BUS A(B) amps incr?
YES
NO
1
2 PYRO A(B) FEED CKT SHORTED
3 PYRO BAT A(B) FAILED
1 It is crew option to leave a main battery connected to a known short to retain redundant pyro circuit capability. If dc amps > 30, expect cb PYRO A(B) BAT BUS A(B) to open within 1 to 5 min and loss of redundant pyro circuit.
SPECIAL SUB ROUTINE
SSR-1
FUEL CELL SHUTDOWN
1 Configure for 2 FC's with one FC on each bus
2 ●FC 1 (2,3) HTRS - OFF
●FC 1 (2,3) PUMPS - OFF
●cb FC 1 (2,3) PUMPS AC - open
●cb FC 1 (2,3) PURG - open
●cb FC 1 (2,3) REACS - close
●FC 1 (2,3) REACS - OFF
●cb FC 1 (2,3) REACS - open
3 Relieve press on KOH of faulty FC at $T_{SKIN} \leq 200°$ F
1
●cb FC 1 (2,3) PURG - close
● H_2 PURG LINE HTR - (on up) 20 min prior to purge
●FC 1 (2,3) PURG - O_2
●FC 1 (2,3) PURG - H_2 (when O_2 approaches stable value)
●FC 1 (2,3) PURG - OFF (after H_2 approaches stable value)
● H_2 PURG LINE HTR - OFF
●cb FC 1 (2,3) PURG - open
1 FC will not reach $T_{SKIN} \leq 200°$ F for approximately 24 hours. KOH will be solidified at $T_{SKIN} \leq 200°$ F. The press is relieved to reduce the possibility of corrosive fluid leaking into the SM and to insure sealing of the check v/v, isolating the potable water from the FC.


SPECIAL SUB ROUTINE
PROCEDURE
REMARKS
SSR-2
BUS SHORT ISOLATION
1 Remove all equipment from affected bus
2 Affected bus?
BAT RLY BUS
AC 1(2)
BAT A(B)
MNA(B)
3 Bat chgr to bat bus
● cb ENTRY/PL BAT A - open (pnl 250)
● cb BAT RLY BUS BAT B - open
● BAT CHG - A
● DC IND sel - BAT CHGR
BAT CHGR amps > 0?
YES
NO
4 Isolate BAT RLY BUS from BAT A & B
● cb BAT RLY BUS BAT A - open
● cb BAT RLY BUS BAT B - open
● Return BAT RLY BUS load to original config
5 Return to original configuration. Close cb's to isolate affected equip.
CAUTION
Whenever AC BUS 1 (2) lt and AC BUS 1 (2) OVERLOAD lt are both on, inverter must be disconnected from AC BUS 1 (2) and MNA(B) within 5 sec to preclude inverter failure.
5 ● INV 1(2) - to affected bus
AC BUS 1(2) OVERLOAD lt on?
YES
NO
6 Individually close equip cb's or sws while monitoring FC current
7 Bat chgr to bat bus
● cb ENTRY/PL PWR BAT A(B) - open (pnl 250)
● cb BAT RLY BUS BAT A(B) - oper
● BAT CHG - A(B)
● DC IND sel - BAT CHGR
Bat chgr amps > 0?
9 ● DC IND sel - FC 1 (3)
● FC 1 (3) MN BUS A(B) on (momentary)
DC amps > 25?
10 BAT A(B) current > 0?
11 AFFECTED AC BUS LOST
12 AFFECTED MAIN DC BUS LOST
13 Current drain on bat bus (bus loss depends on magnitude of current drain)
14 DRAIN ON BAT BETWEEN BAT AND BUS OR BAT CURRENT INST FAILED
15 ● Reassign the following transferable loads to remaining AC bus, if desirable:
● Suit compressors
● FC pumps
● Prim gly pumps
● Sec gly pump
● TVC servo pwr
● Bat charger
● SPS gaging
● G & N lighting
● Telecon group 1
S BD prim xpndr
S BD prim pwr amp
S BD FM xmtr
Flight qual recdr
DSE
All PSM
● Telecon group 2
S BD sec xpndr
S BD sec pwr amp
HGA
All PCM
● SCS SIG CONDR/ DRIVER BIAS pwr supplies
16 ● Reassign the following transferable loads to remaining MN BUS if desired:
● ECS rad htrs
● ECS RAD FLOW CONT AUTO sw
● Urine dump htrs
● TVC servo pwr
● Non-ess bus
● AUTO RCS SEL (16)
● Suit ckt H2O accum sw
● Interior lts Flood Dim (3)
● POT H2O HTR sws
● INV 3 (if running)
1 If short circuit amps < 2.0, it is a crew option to maintain Bat relay bus powered to retain AC Bus sensors and FC overcurrent/reverse current protection functions. Increased battery recharge cycle may be required. If short circuit > 2.0 amps, close Bat relay bat A or bat B cb's only when required to operate equipment connected to Bat relay bus.
2 MASTER ALARM and FC BUS DISC lts will come on when reconnecting open-circuited FC to bus
3 Place two batteries on remaining bus for SPS maneuvers.
4 If cb RAD HTRS OVLD BAT A and/or BAT B are opened to reduce battery drain, they should not be closed unless batteries are tied to main buses. This prevents possible disconnect of ECS radiator heaters by a false overload signal.
Bus Failure Effects - non transferable loads
Main DC BUS A
SCS FDAI No. 1 Total Attitude
PITCH and ROLL Outputs of GDC
BMAG NO. 1 Htrs and TEMP lt
1/2 DIRECT authority from RHC No. 1
DIRECT ULLAGE Jets A4, and C3
COAS - LH
ROLL to YAW Cross Coupling for FDA No.1
RCS Transfer - SM/CM (CM 1 Auto and Man)
PROP ISO vlvs (SM B & D, CM 1)
SM RCS Htrs - Prim and Sec (SM BandD)
CM RCS Htrs - CM 1
CM 1 RCS Purge
Interconnect Oxidizer
Fuel He interconnect
SPS Gaging Pri
Batt vlv - A
Htrs - A
ECS CO2 SNSR
H2O Accum No. 1 (Auto and Man)
RAD PROP vlv - Sys 1
RAD HTRS PRI 2
RAD HTRS SEC
Stm Duct and Urine Dump Line Htr SYS A
RAD OUT SEC ind - RAD IN PRI and SEC ind
Waste H2O Dump Line Htr SYS A
EPS Inverter No. 1 Power
CRYO tks 1 (H2 & O2) Htrs
Main DC BUS B
SCS FDAI No. 2 Total Attitude
GDC output to FDAI
BMAG No. 2 Htrs and TEMP lt
1/2 DIRECT authority from RHC No. 2
ORDEAL
DIRECT ULLAGE Jets B3 and D4
COAS - RH
SCS Min Imp to 42 ms
Roll to YAW Cross Coupling to RSI
RCS Transfer - SM/CM (CM 2 Auto and Man)
PROP ISO vlvs (SM A & C, CM 2)
SM RCS Htrs - Prim and Sec (SM A & C)
CM RCS Htrs - CM 2
CM 2 Purge
Interconnect Fuel
Oxidizer He interconnect
SPS Gaging aux
Batt vlv - B
Htrs - B
ECS H2O Accum No. 2 (Auto and Man)
O2 Flow warning lt
RAD PROP vlv - SYS 2
RAD HTRS PRI 1
Stm Duct and Urine Dump Line Htr SYS B
Waste H2O Dump Line Htr SYS B
EPS Inverter No. 2 Power
CRYO tks 2 (H2 & O2) Htrs
Portable Floodlight
AC BUS 1
SCS FDAI No. 1
SII FUEL/SIVB OXID/PITCH GPI 1
SIVB FUEL/YAW GPI 1
GDC Ref voltage
SCS RATE CMD
SCS MIN IMPULSE
BMAG No. 1
SCS Analog T/M
RHC No. 1 for MTVC
Integral lighting
ECS CABIN FAN No. 1
Suit Heat ex Glycol Bypass vlv
Back Press vlv Pri (man)
Sec EVAP Temp Cont
RAD PROP vlv - SYS 1
Sec 240 cont
EPS CRYO tks 1 (H2 & O2)
Qty and Temp ind
Fans
Battery BUS A
SPS Pri Gmbl Control
SECS & ELS Logic Seq A
Upright Sys Comp No. 1
RCS CHAN A Enable (if prior to SIVB sep)
Float Bag No. 1
Main Bus Tie BAT A C
RCS Trnfr CM1 AUTO
AC BUS 2
SCS FDAI No 2
SII FUEL/SIVB OXID PITCH GPI 2
SIVB FUEL/YAW GPI 2
RSI
GDC REF voltage
Man Prop Attitude Control
MTVC
BMAG No. 2
ORDEAL
ECS Cabin Temp Control
Cabin Fan No. 2
2,40 Control Pri
RAD PROP vlv - SYS 2
EPS CRYO tks 2(H2 & O2)
Qty & Temp ind
Fans
Batry BUS B
Float Bag No. 2
SPS AUX Gmbl Control
SECS and ELS Logic Seq B
Uprighting Sys Comp No. 2
RCS CHAN B Enable (if prior to SIVB sep)
Main BUS Tie BAT B/C
RCS Trnfr CM2 AUTO
Battery Relay BUS
FC Rad control
FC Reactant Shutoff vlv
FC to Bus Control
DC Voltage Sensing
AC Voltage Sensing
Inv Control

7.0 FUEL CELL/CRYOGENIC SUBSYSTEM HARDWARE DESCRIPTION

The fuel cell/cryogenic hardware description includes the subsystem isometric drawings, fluid schematics, component descriptions and filtration provisions.

Isometric drawings locate operational hardware; tubing runs, sizes and part numbers; and system interfaces. A schematic drawing of the Environmental Control System describes the water and oxygen system interfaces.

Fuel cell and cryogenic storage system schematics aid understanding of the system plumbing. These schematics are also used to reference to specific hardware component descriptions.

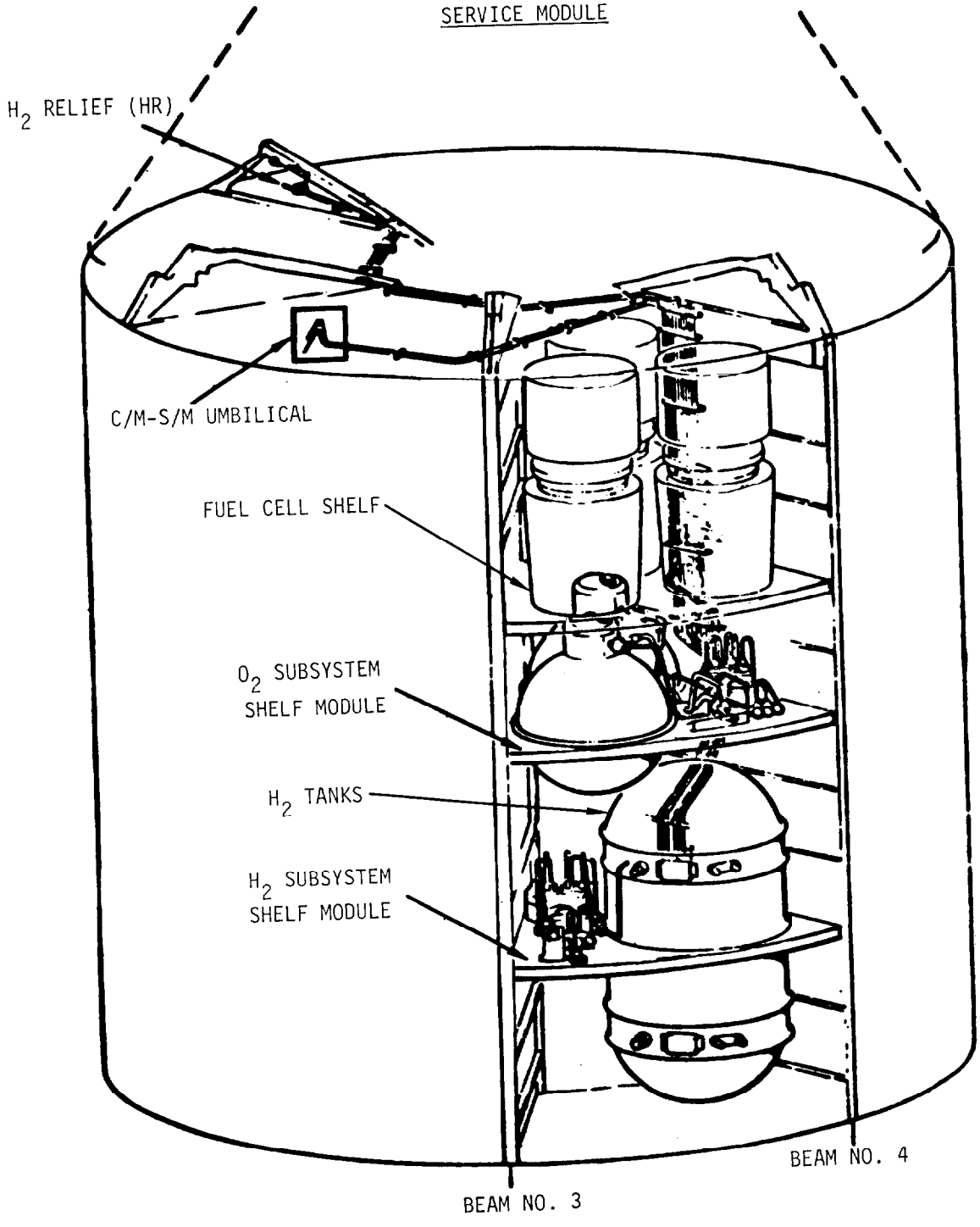
Filtration data describe the component protected, its minimum clearances and the filters rating, size, location and type.

Hardware descriptions are intended for rapid reference to the specific physical hardware affected as a result of a malfunction. Fuel cell/cryogenic subsystem interactions with interfacing components and subsystems are clarified by this background information.

The sources of the data included North American Rockwell Operational Checkout Procedures (OCP's), Pratt and Whitney Aircraft Fuel Cell Electrical Power Supply-PC3A-2 Support Manual, dated February 1, 1969, Pratt and Whitney Apollo Fuel Cell Component Descriptions, and Beech Aircraft Corporation Project Apollo Cryogenic Gas Storage Subsystem Flight Support Manual, dated September 6, 1968. The descriptions are applicable through CSM-115 including identified hardware changes for CSM 112-115 . The configurations shown were current and correct as of December 1969.

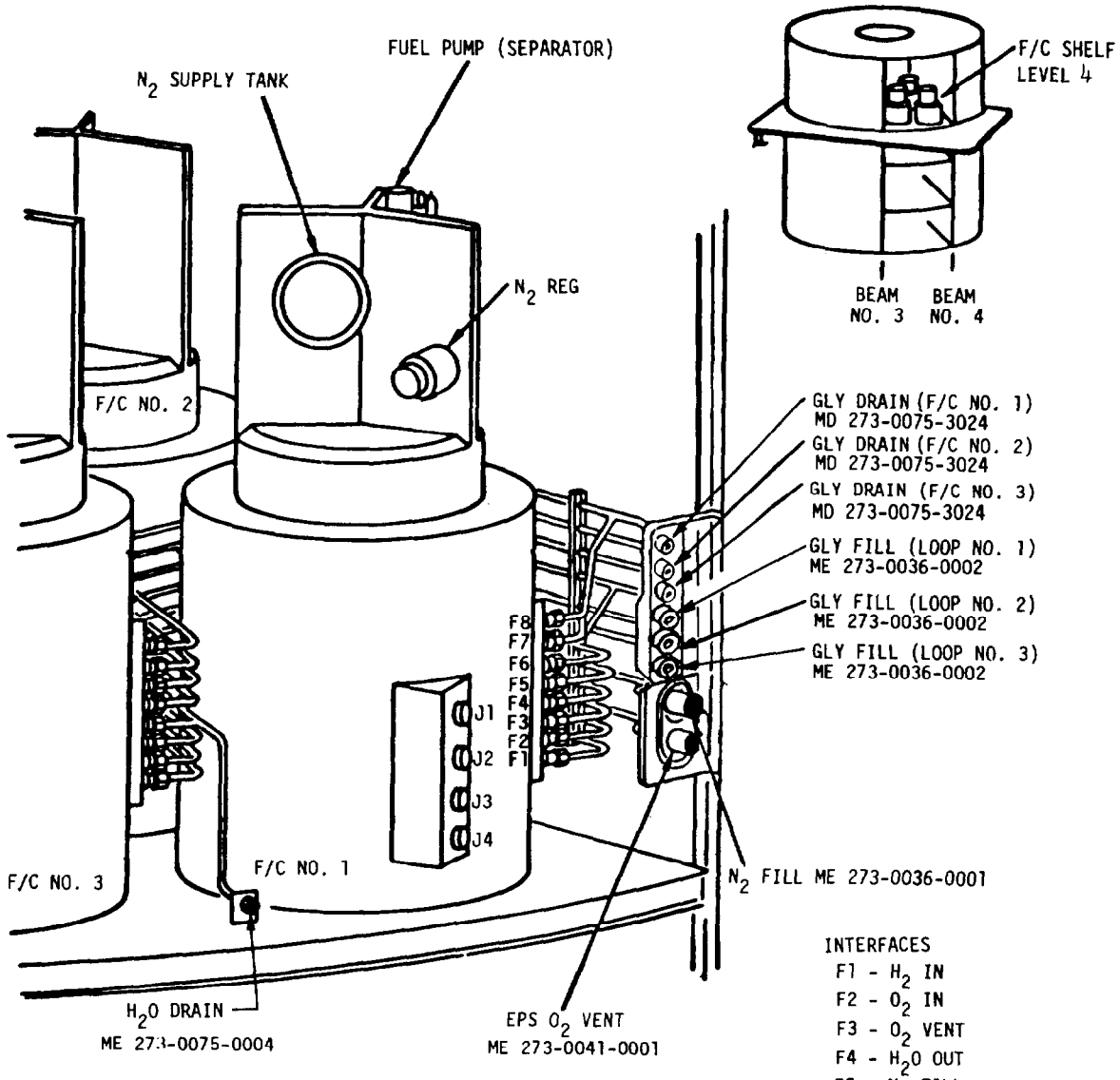
7.1 SYSTEM HARDWARE ISOMETRIC DRAWINGS AND SCHEMATIC

FUEL CELL/CRYOGENIC SUBSYSTEM LOCATION IN SERVICE MODULE

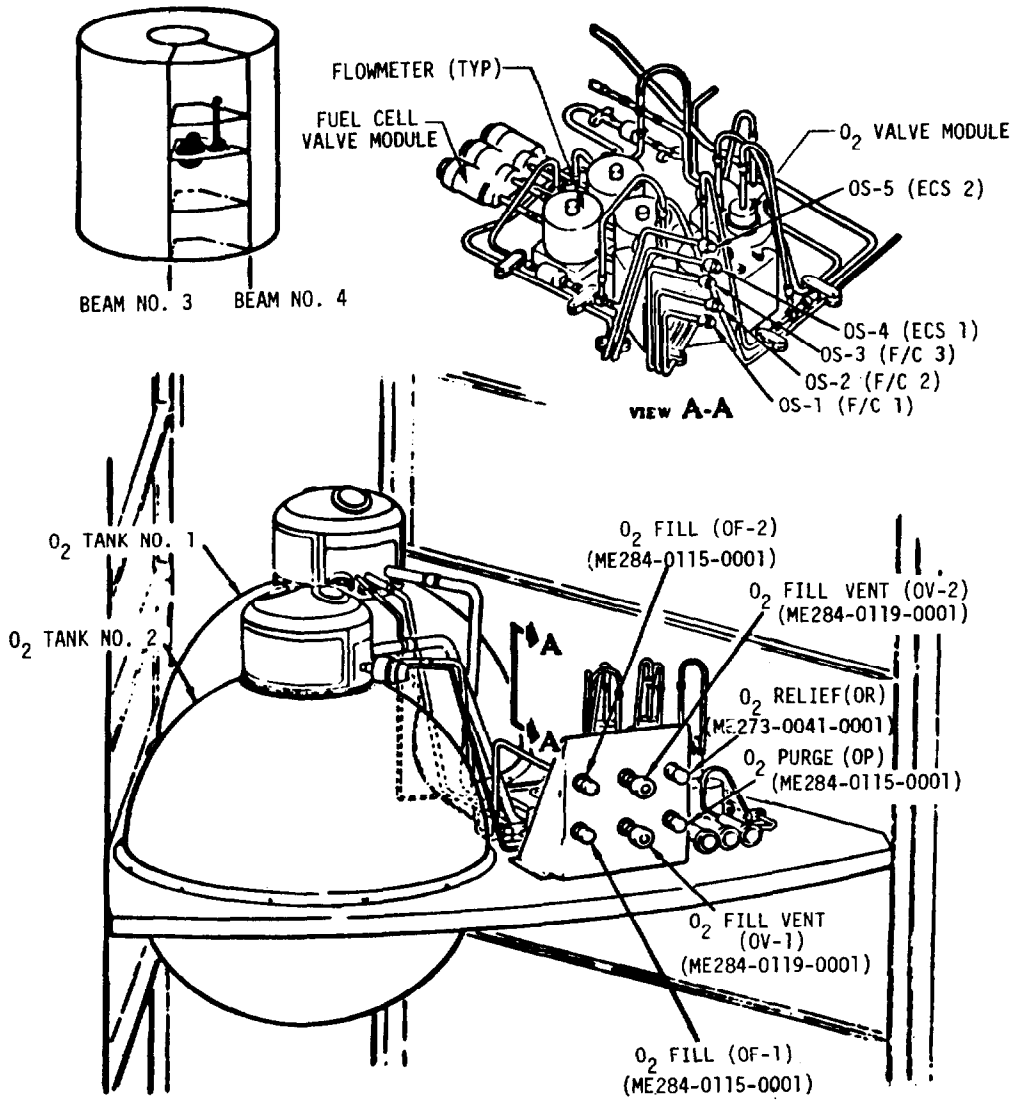


VIEW LOOKING INBOARD SECTOR IV

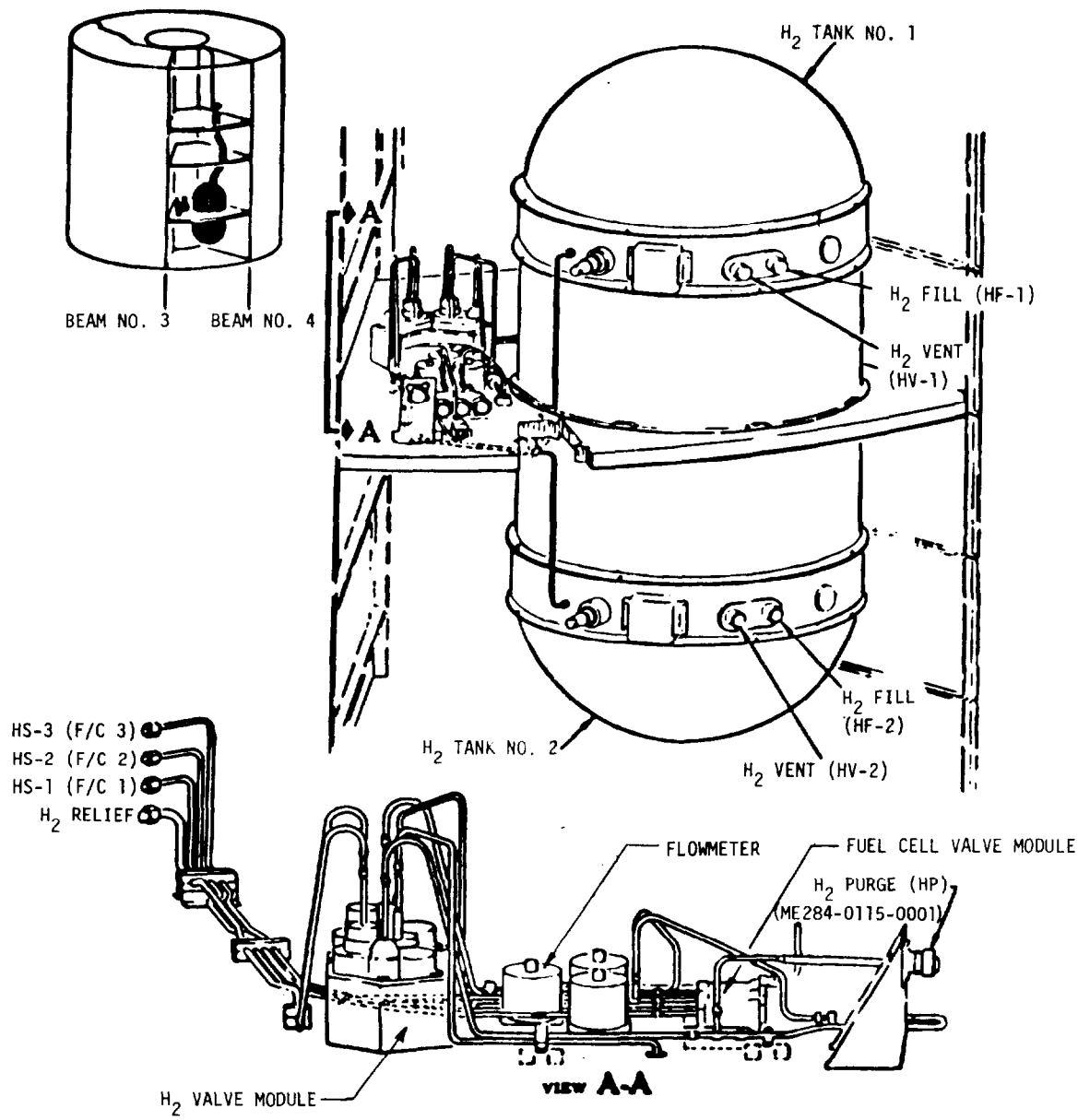
FUEL CELL SHELF INTERFACE



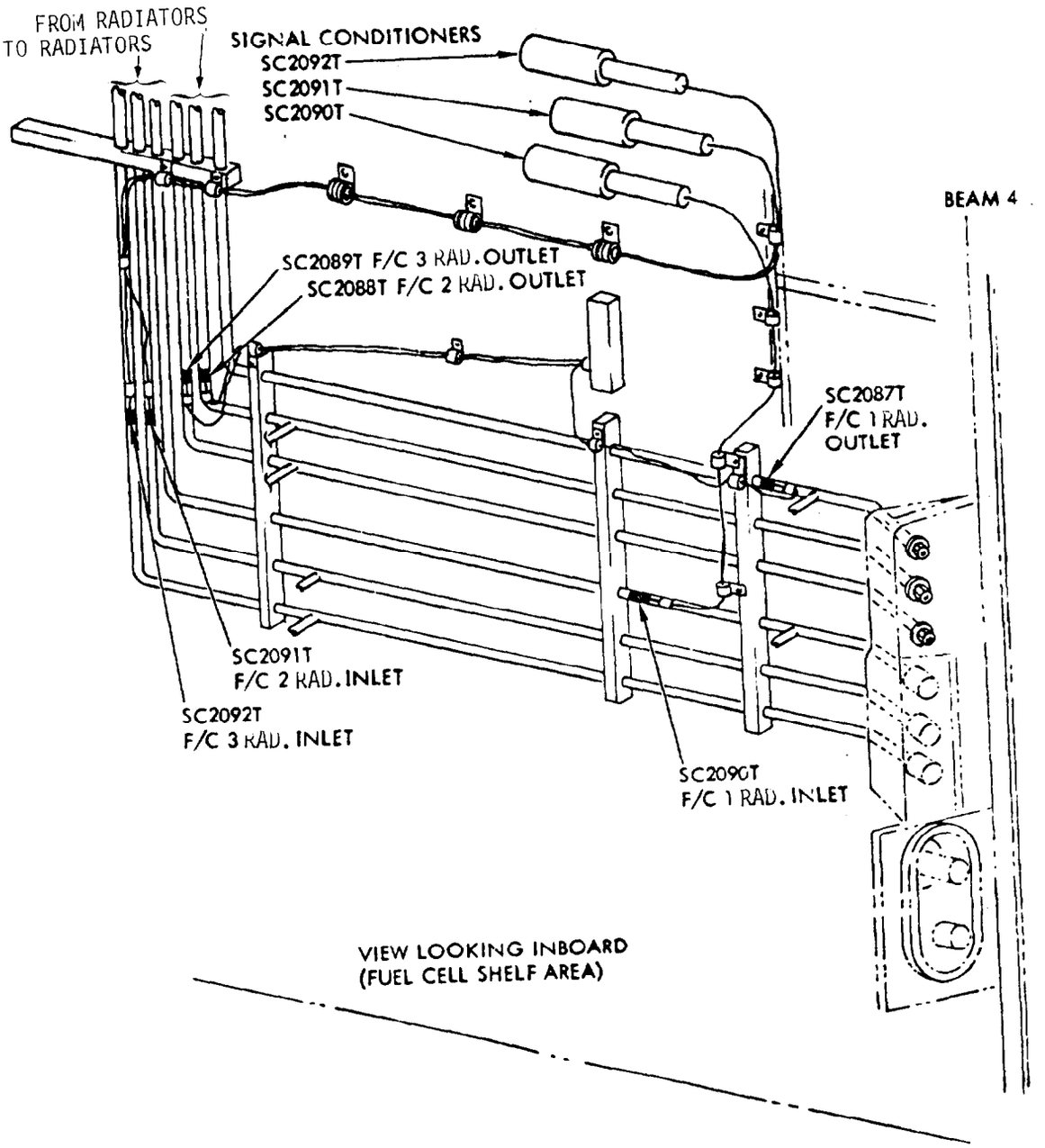
OXYGEN SUBSYSTEM SHELF MODULE



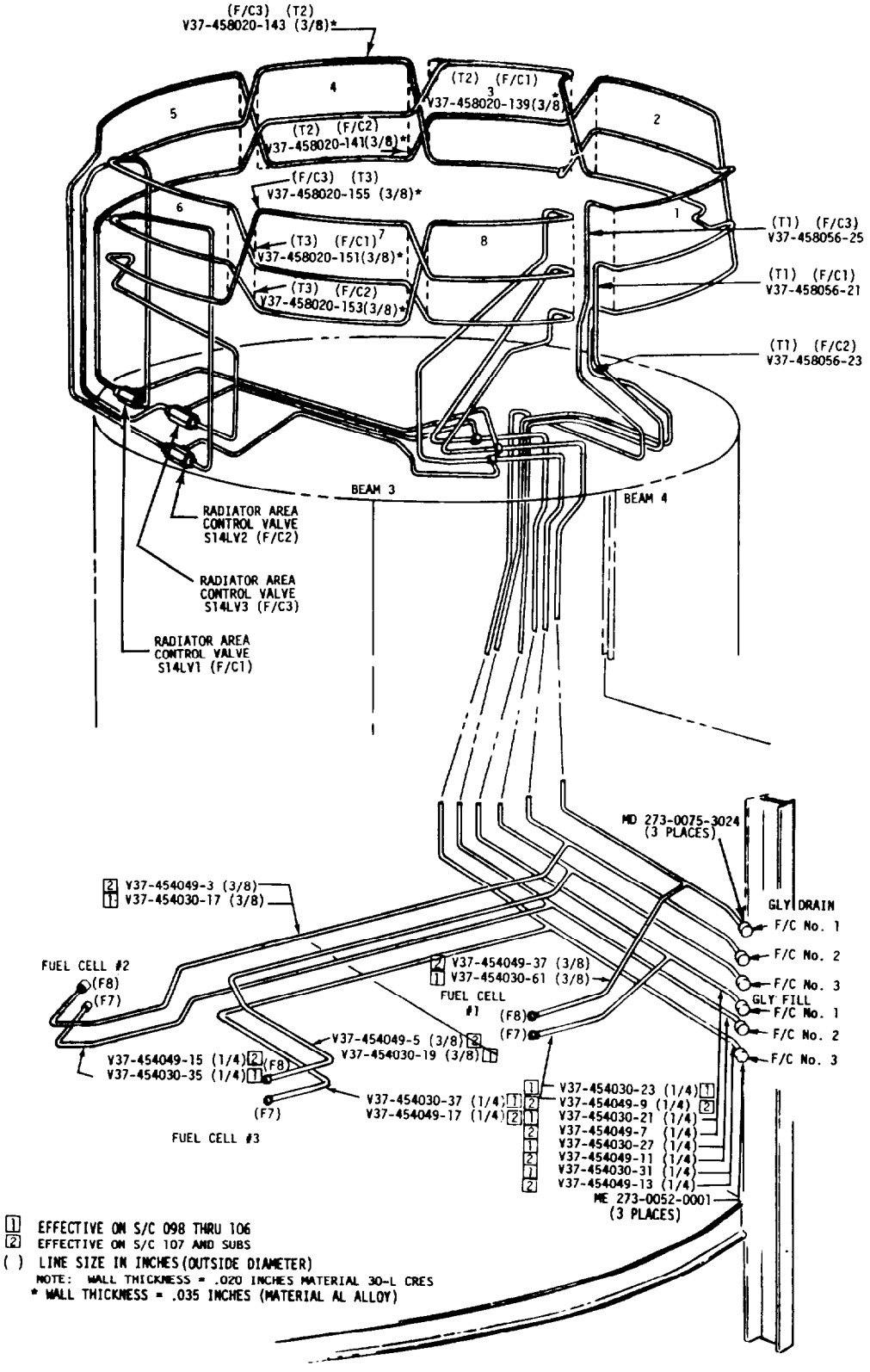
HYDROGEN SUBSYSTEM SHELF MODULE



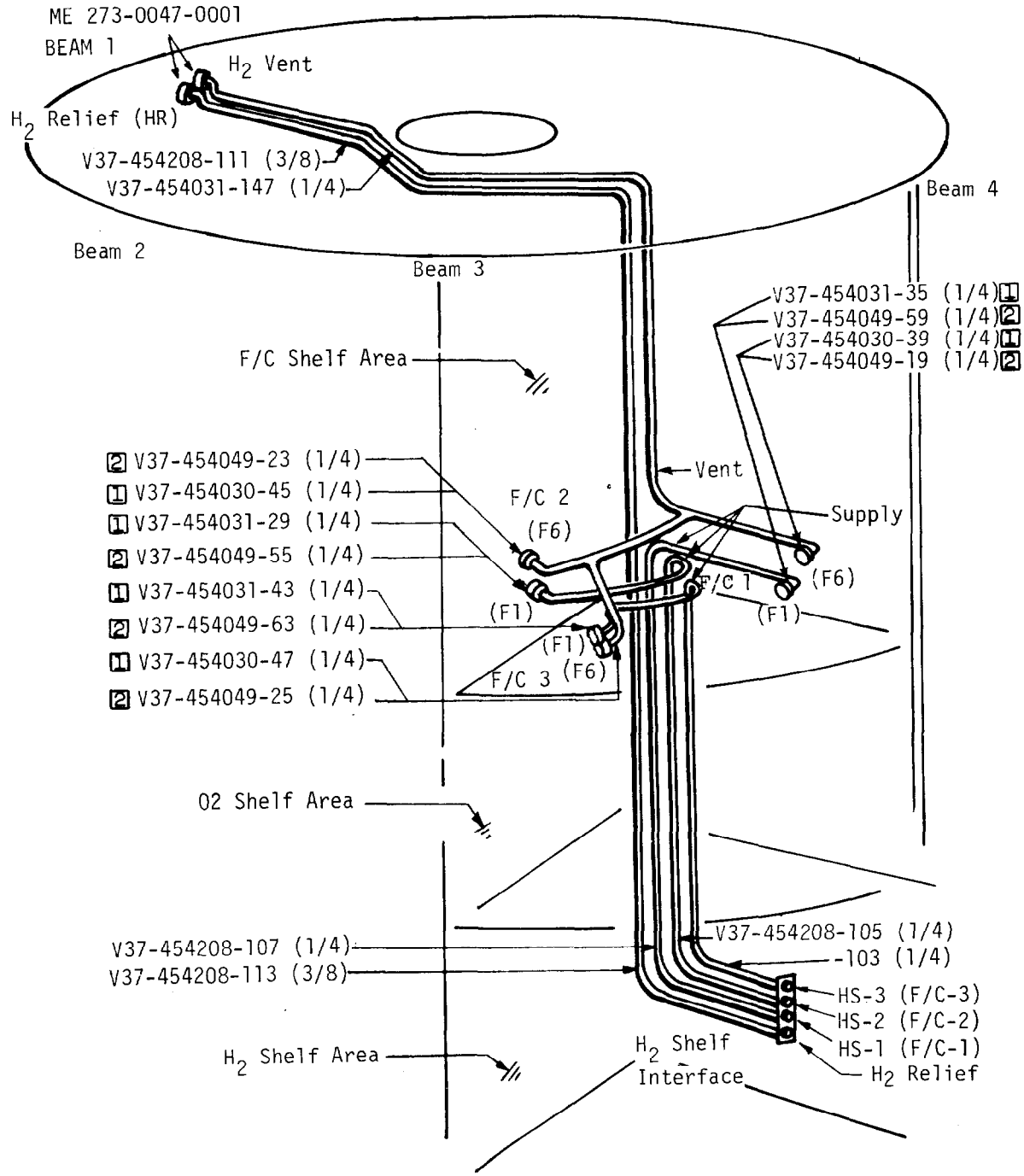
EPS WATER GLYCOL RADIATOR TEMPERATURE SENSOR LOCATION



WATER GLYCOL SERVICE MODULE LINES



CRYOGENIC HYDROGEN SERVICE MODULE LINES



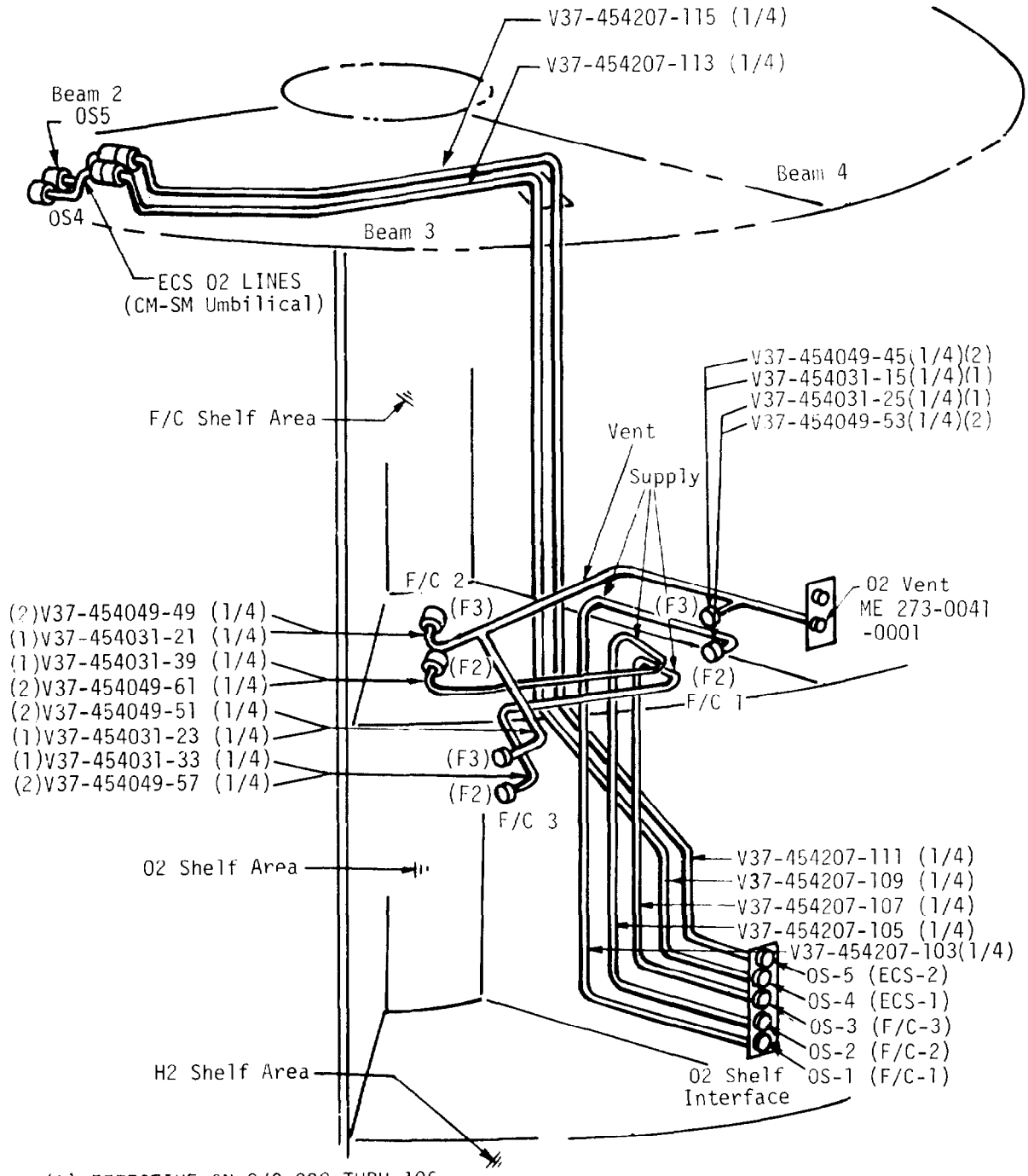
[1] EFFECTIVE ON S/C 098 THRU 106

[2] EFFECTIVE ON S/C 107 AND SUBS

( ) LINE SIZE IN INCHES (OUTSIDE DIAMETER)

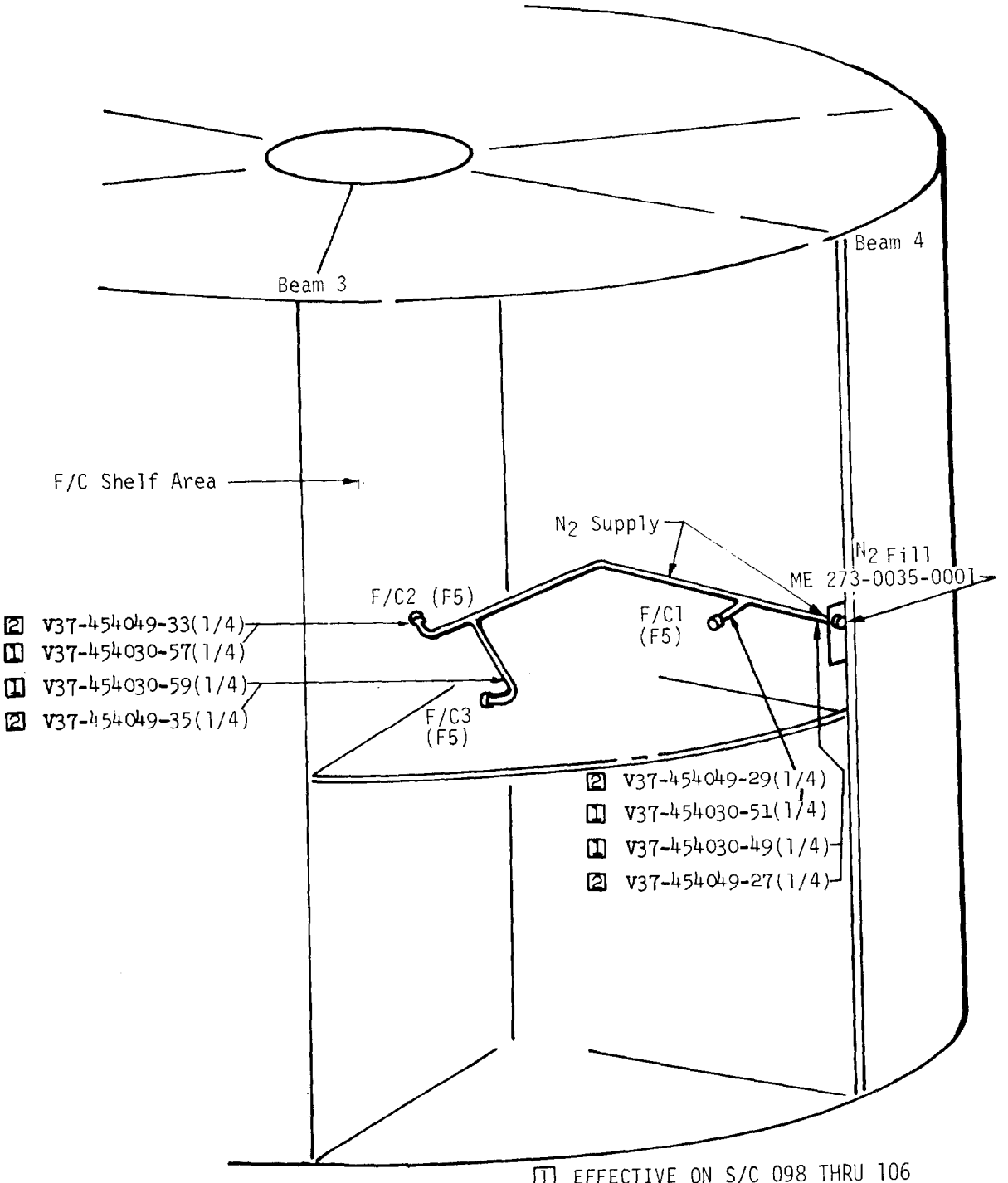
NOTE: WALL THICKNESS = .020 INCHES

CRYOGENIC OXYGEN SERVICE MODULE LINES

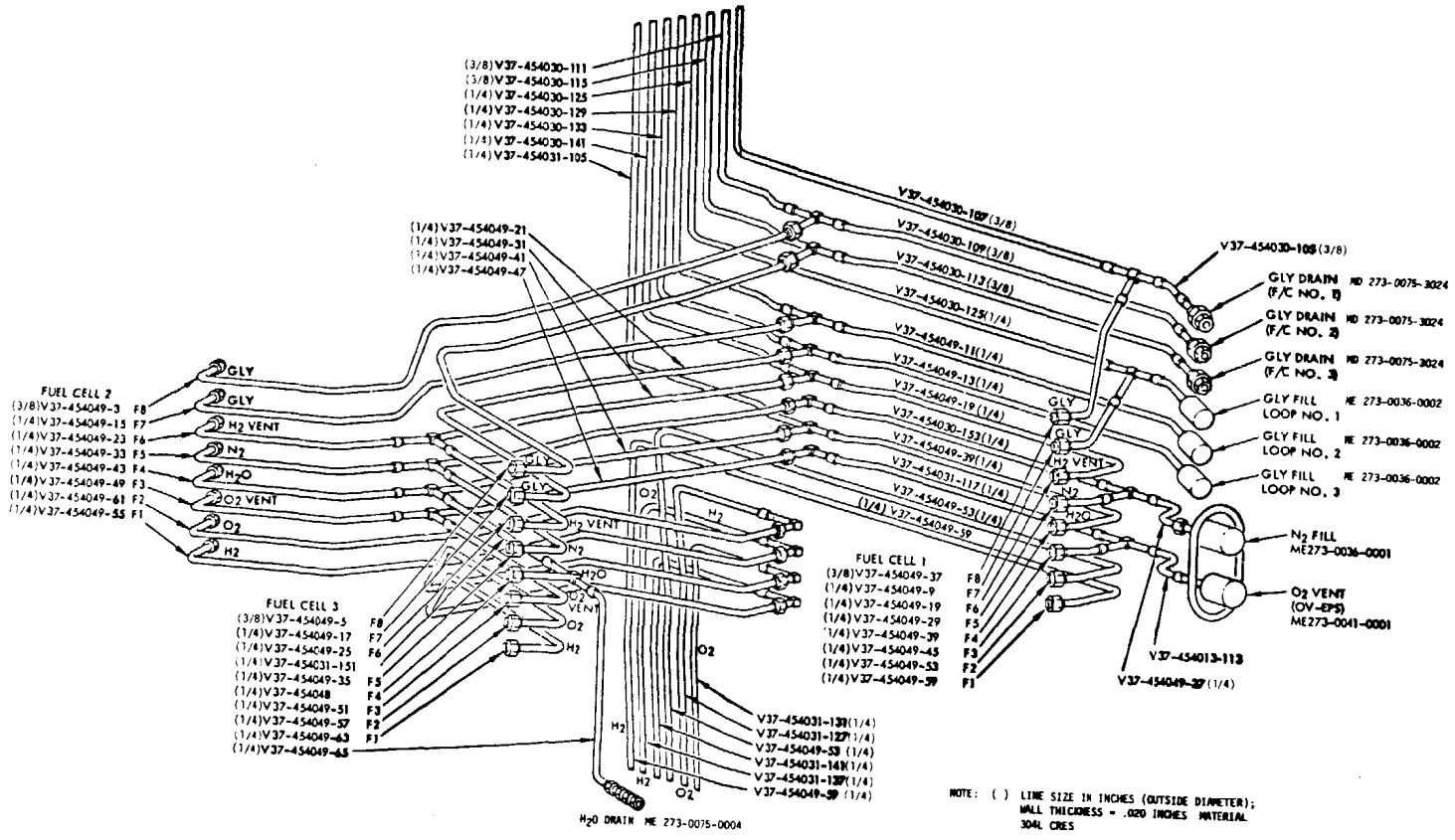


(1) EFFECTIVE ON S/C 098 THRU 106
(2 EFFECTIVE ON S/C 107 AND SUBS
( ) LINE SIZE IN INCHES (OUTSIDE DIAMETER)
NOTE: WALL THICKNESS = .020 INCHES

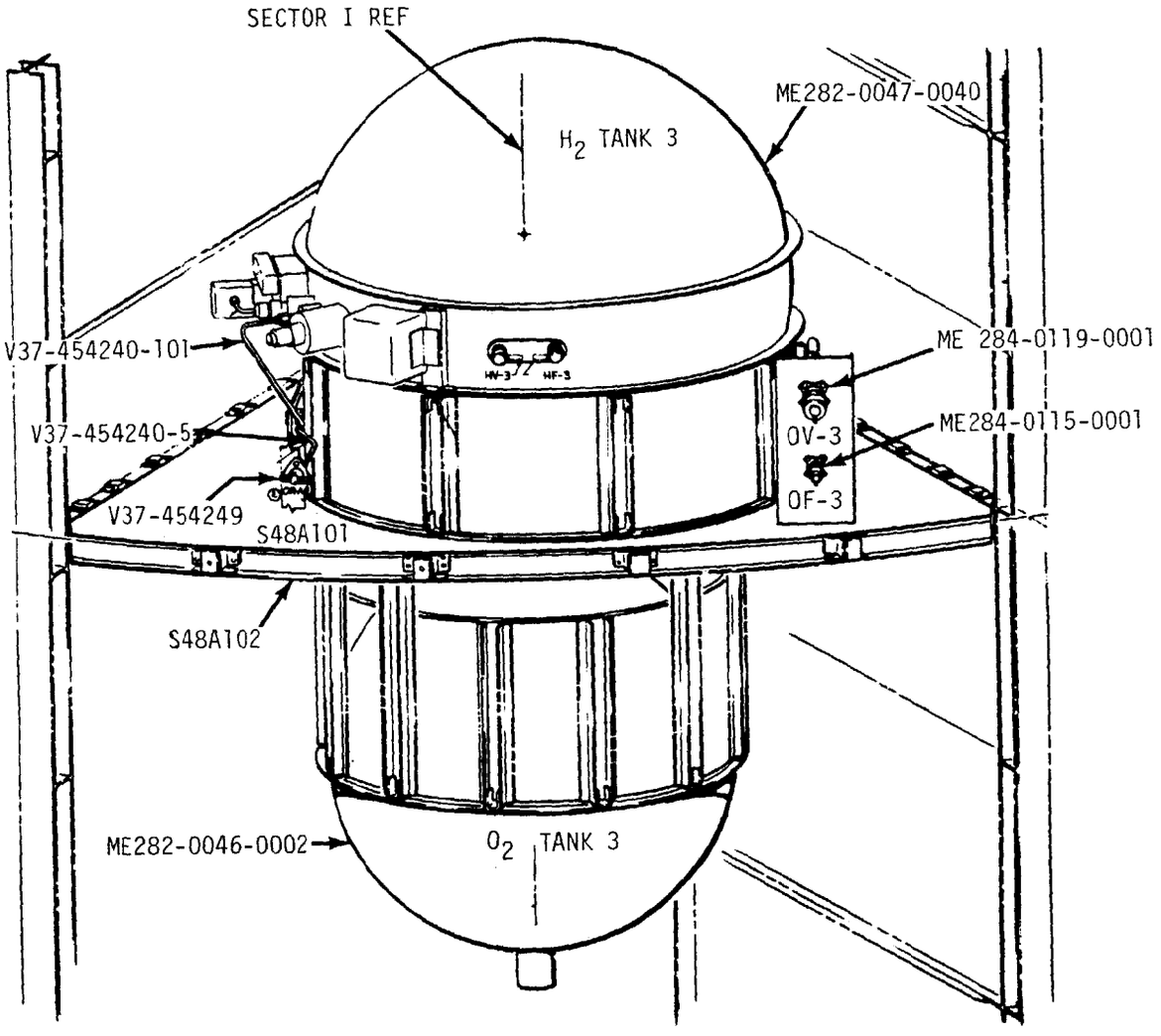
FUEL CELL NITROGEN SERVICE MODULE LINES



[1] EFFECTIVE ON S/C 098 THRU 106
[2] EFFECTIVE ON S/C 107 AND SUBS
( ) LINE SIZE IN INCHES (OUTSIDE DIAMETER)
NOTE: WALL THICKNESS = .020 INCHES

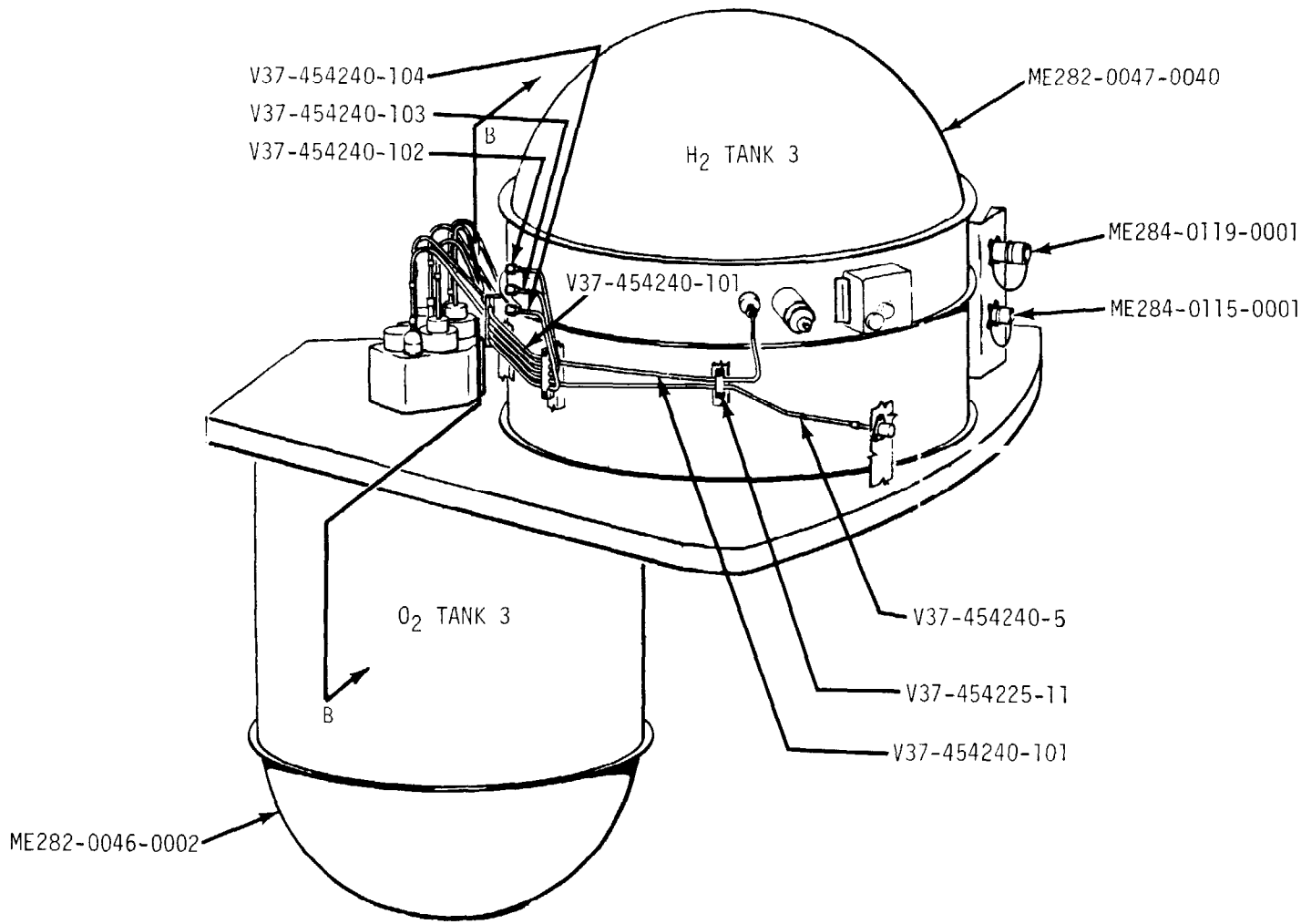


TUBING IDENTIFICATION FUEL CELL SHELF AREA



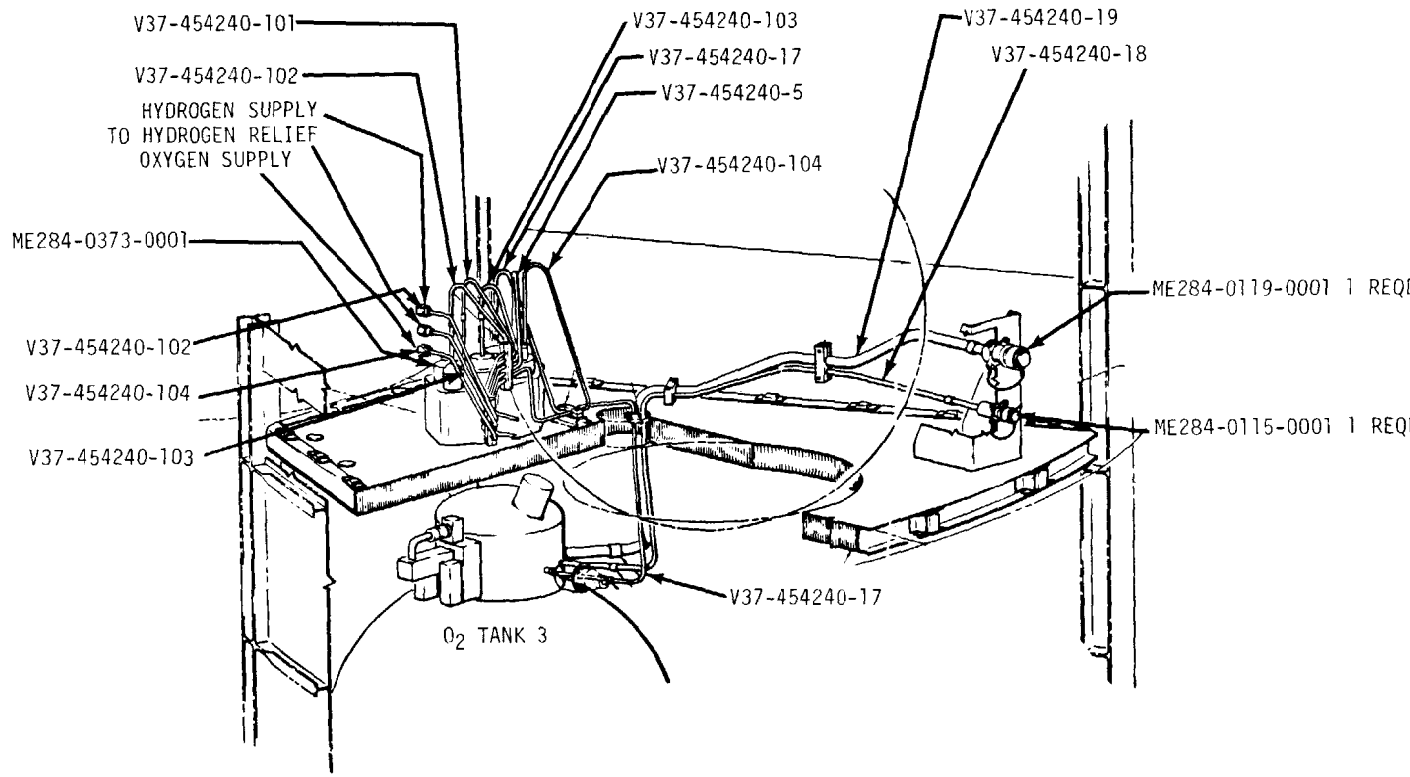
HYDROGEN/OXYGEN TANK SHELF MODULE - SECTOR I

EFFECTIVE ON CSM 112-115



HYDROGEN/OXYGEN TANK SHELF MODULE - SECTOR I (SIDE VIEW - BEAM 6 SIDE)

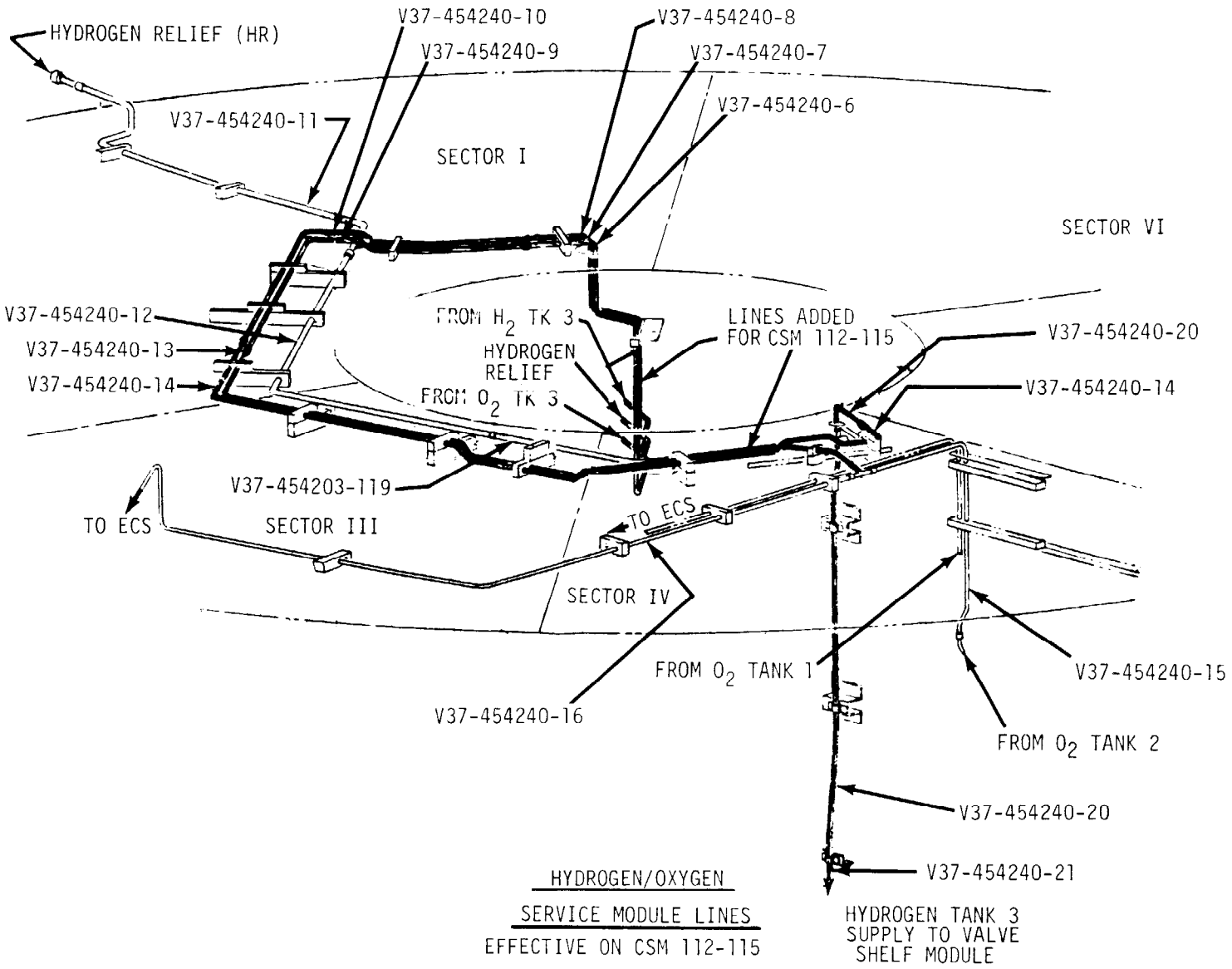
EFFECTIVE ON CSM 112-115

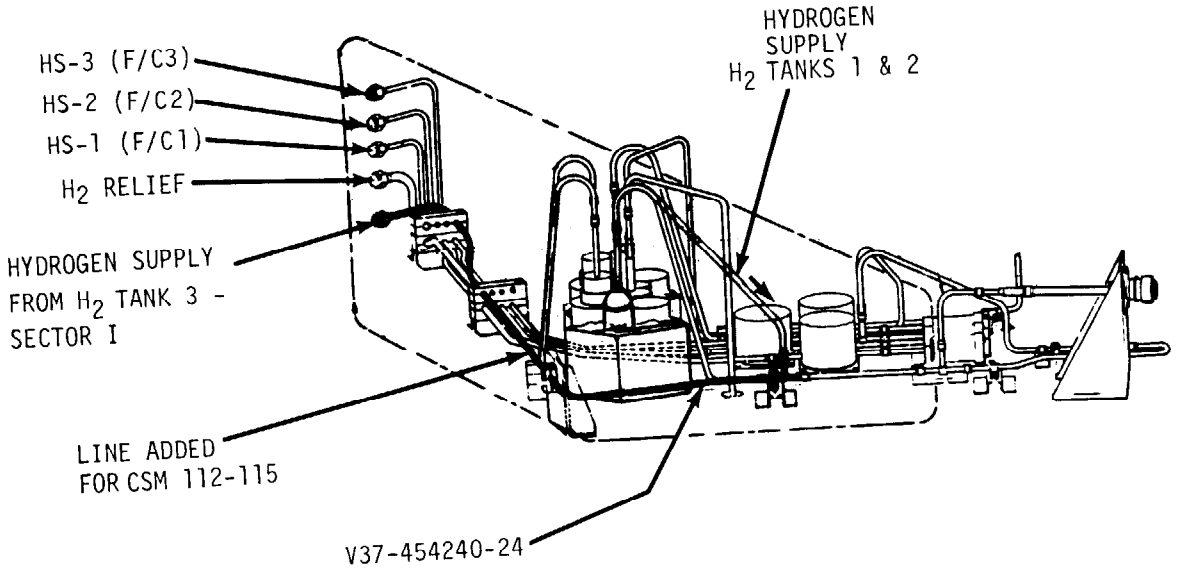


VIEW B-B

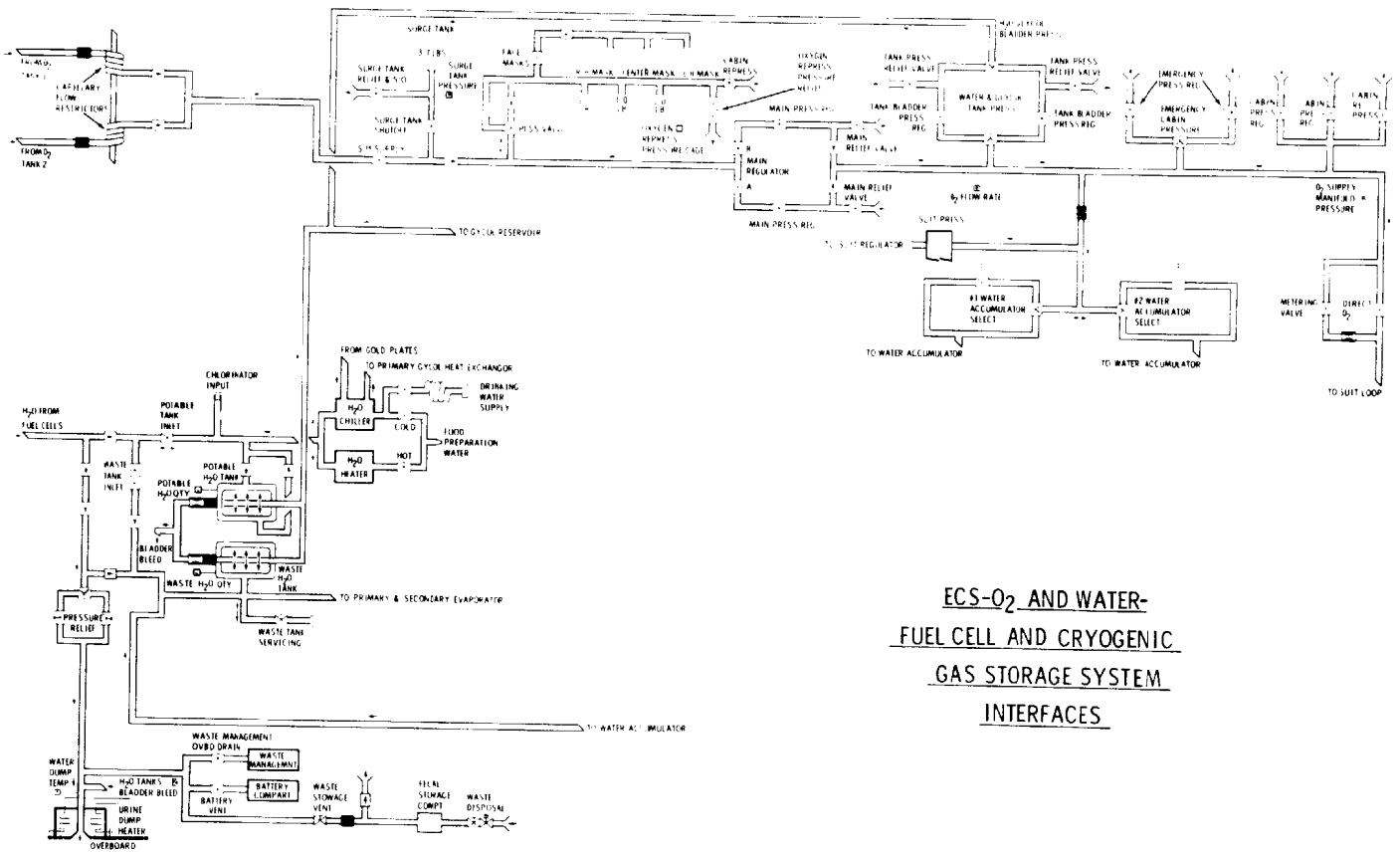
HYDROGEN/OXYGEN TANK SHELF SECTION VIEW-SECTOR I

EFFECTIVE ON CSM 112-115


HYDROGEN RELIEF (HR)
V37-454240-10
V37-454240-9
V37-454240-8
V37-454240-7
V37-454240-6
V37-454240-11
SECTOR I
SECTOR VI
V37-454240-12
V37-454240-13
V37-454240-14
FROM H_2 TK 3
HYDROGEN RELIEF
FROM O_2 TK 3
LINES ADDED FOR CSM 112-115
V37-454240-20
V37-454240-14
V37-454203-119
TO ECS
SECTOR III
TO ECS
SECTOR IV
FROM O_2 TANK 1
V37-454240-16
V37-454240-15
FROM O_2 TANK 2
V37-454240-20
V37-454240-21
HYDROGEN/OXYGEN
SERVICE MODULE LINES
EFFECTIVE ON CSM 112-115
HYDROGEN TANK 3 SUPPLY TO VALVE SHELF MODULE



HYDROGEN TANK 3 SUPPLY
INTERFACE WITH TANKS 1 & 2 - HYDROGEN
SHELF VALVE MODULE - SECTOR IV
EFFECTIVE ON CSM 112-115



ECS-O_2 AND WATER-
FUEL CELL AND CRYOGENIC
GAS STORAGE SYSTEM
INTERFACES