

OBJECTIVE

- TO DEFINE A CABIN ATMOSPHERE THAT SATISFIES
FLAMMABILITY AND PHYSIOLOGICAL CRITERIA
WITHOUT COMPROMISING CREW PROCEDURES

cc2e

ISSUES ASSOCIATED WITH 60% O₂/40% N₂

PHYSIOLOGICAL LIMITS

- IN EARTH ORBIT, A 60/40 ATMOSPHERE IS SAFE FOR HELMET REMOVAL. (CONTINGENCY)
- IF A CABIN DECOMPRESSION OCCURS AND CREW MUST RETURN TO SUIT - HYPOXIA WILL OCCUR.
- SHOULD THIS CASE BE CONSIDERED?
- IF SO WE MUST GO TO 80/20
- HOW DO WE MEASURE 80/20?
PPO₂ SENSOR
CALCULATIONS (TIME BASE)

FLAMMABILITY LIMITS

A 60/40 IS APPROXIMATELY EQUIVALENT TO 6.2 PSI O₂

METHOD OF DILUENT REMOVAL

- TIME TO REACH 80/20
- CREW PROCEDURES
- CONSUMABLES

AREAS REQUIRING RESOLUTION

● PHYSIOLOGICAL LIMITS

- PPO₂ REQUIRED FOR CONTINGENCY AT EARTH ORBIT INSERTION (45/55)
- PPO₂ REQUIRED TO MINIMIZE PHYSIOLOGICAL PROBLEMS (80/20)

● FLAMABILITY LIMITS (60/40)

● METHOD OF DILUENT REMOVAL TO REACH (80/20) PURGE

● LOADING PROCEDURES

● TEST AND CHECKOUT

● ● RECOMMENDATION

- USE 60% O₂ /40% N. ON THE PAD

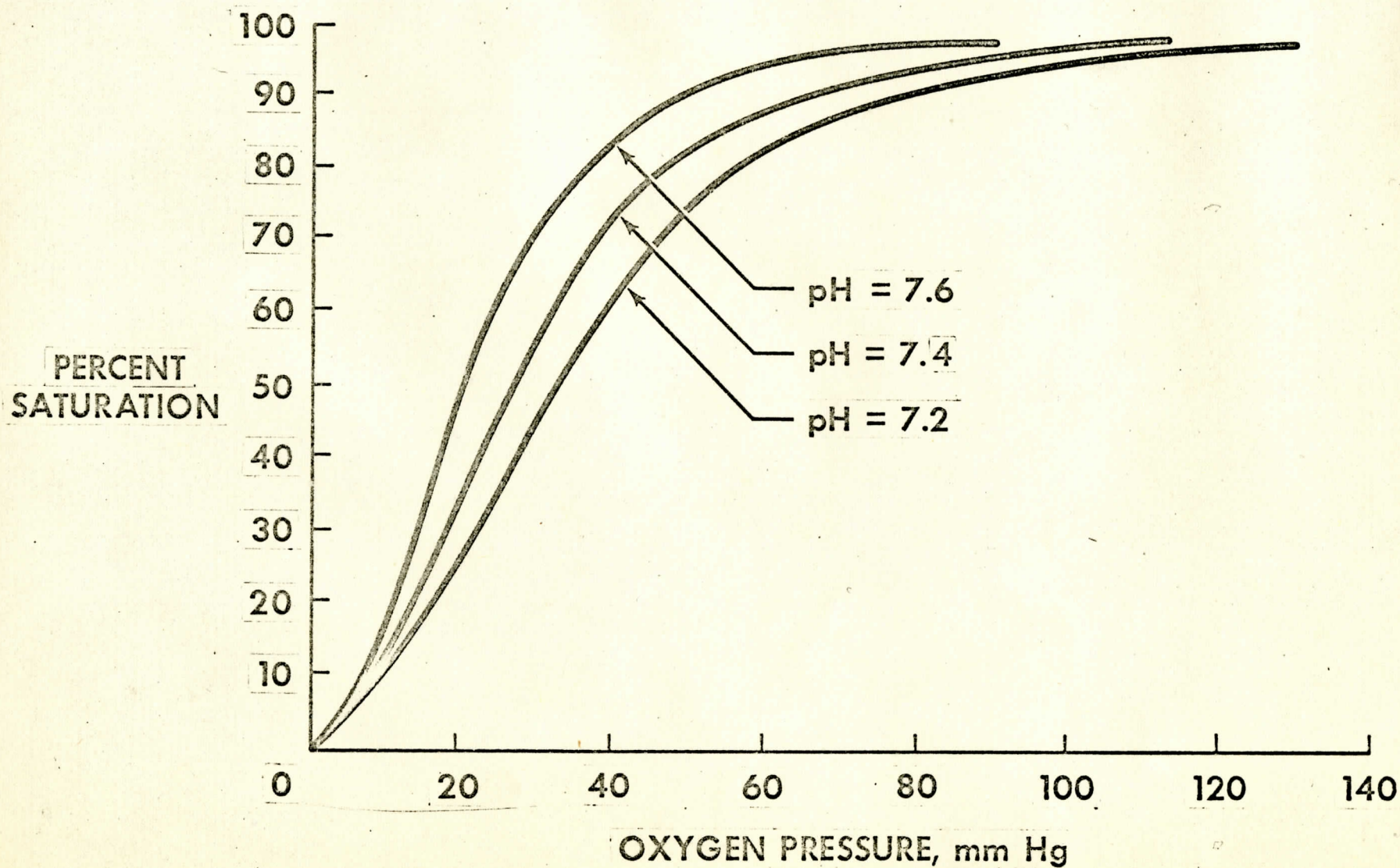
PHYSIOLOGIC GROUND RULES

- ACCEPTABLE MISSION CABIN ATMOSPHERE
SEA LEVEL EQUIVALENT PA_{O_2} (OR HIGHER) (100 mm Hg +)
CONTINGENCY PA_{O_2} (AT $3.75 \pm .25$ PSIA) OF 60 mm Hg
- ACCEPTABLE SUIT LOOP ATMOSPHERE FOR PLANNED EVA
95 PERCENT AT $3.7 \pm .25$ PSIA ($PA_{O_2} = 82$ mm Hg =
3,000 FT AIR EQUIVALENT)
- IF CABIN AT ORBITAL INSERTION VIOLATES RULE 1,
CREW MUST REMAIN ON SUIT LOOP UNTIL RULE 1 VALUES
ARE OBTAINED
- ANY ATMOSPHERE USED MUST NOT SUBJECT CREW TO PA_{O_2}
LESS THAN 60 mm Hg AS RESULT OF SINGLE POINT FAILURE
(52 PERCENT O_2 AT 4.8 PSIA, 45 PERCENT O_2 AT 5.6 PSIA)
- OXYGEN PREBREATHING TIME PRIOR TO LAUNCH = 4+ HOURS

ALVEOLAR PO_2 AT SEA LEVEL

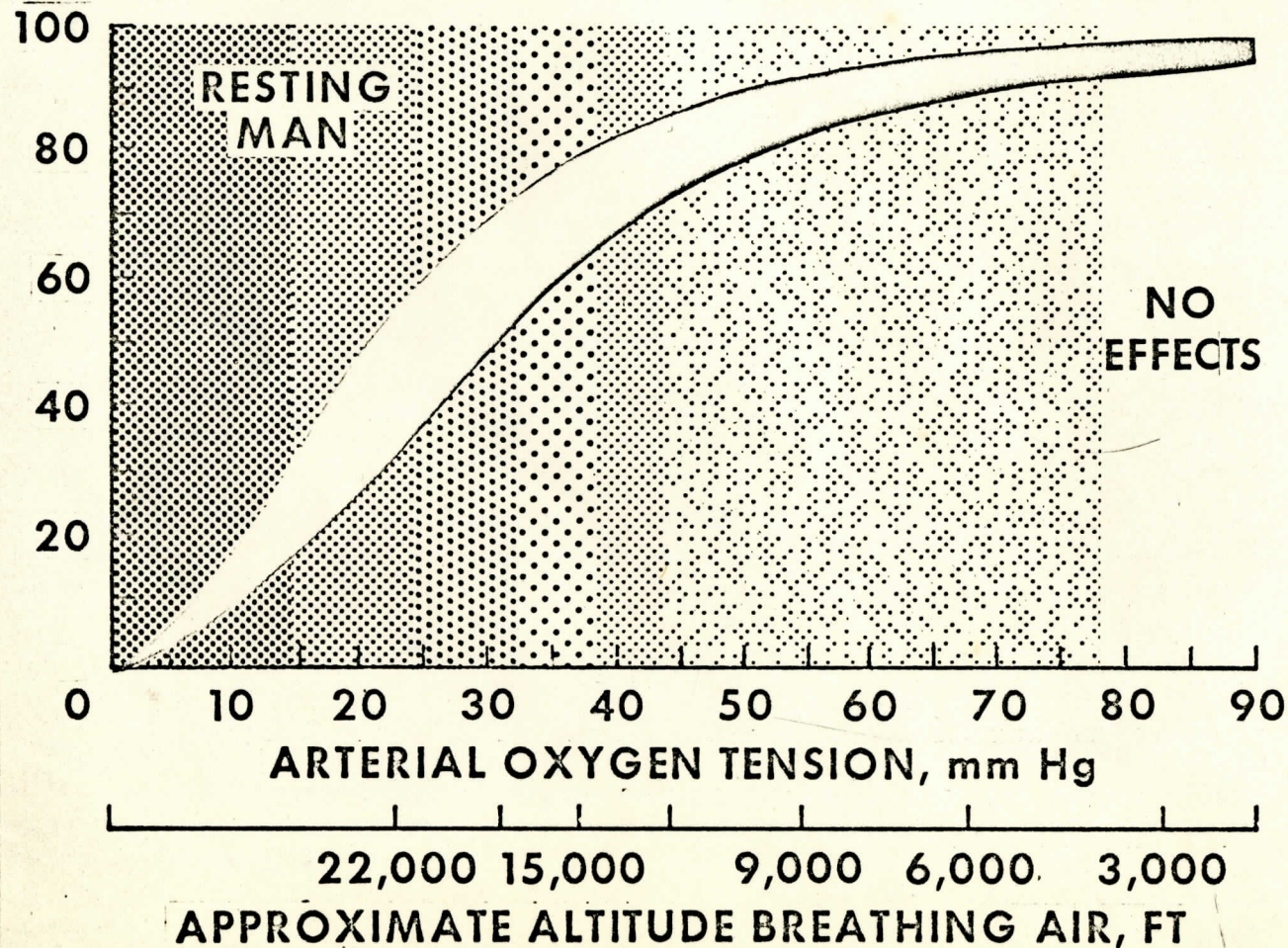
$$\begin{aligned} PAO_2 &= FIO_2 (PB - PA_{H_2O}) - PACO_2 \left[FIO_2 + \frac{1 - FIO_2}{R} \right] \\ &= .21 (760 \text{ mmHg} - 47 \text{ mmHg}) - 40 \left[.21 + \frac{1 - .21}{R} \right] \\ &= 104 \text{ mmHg} \end{aligned}$$

OXYGEN DISSOCIATION CURVE OF THE BLOOD FOR DIFFERENT pH CONDITIONS



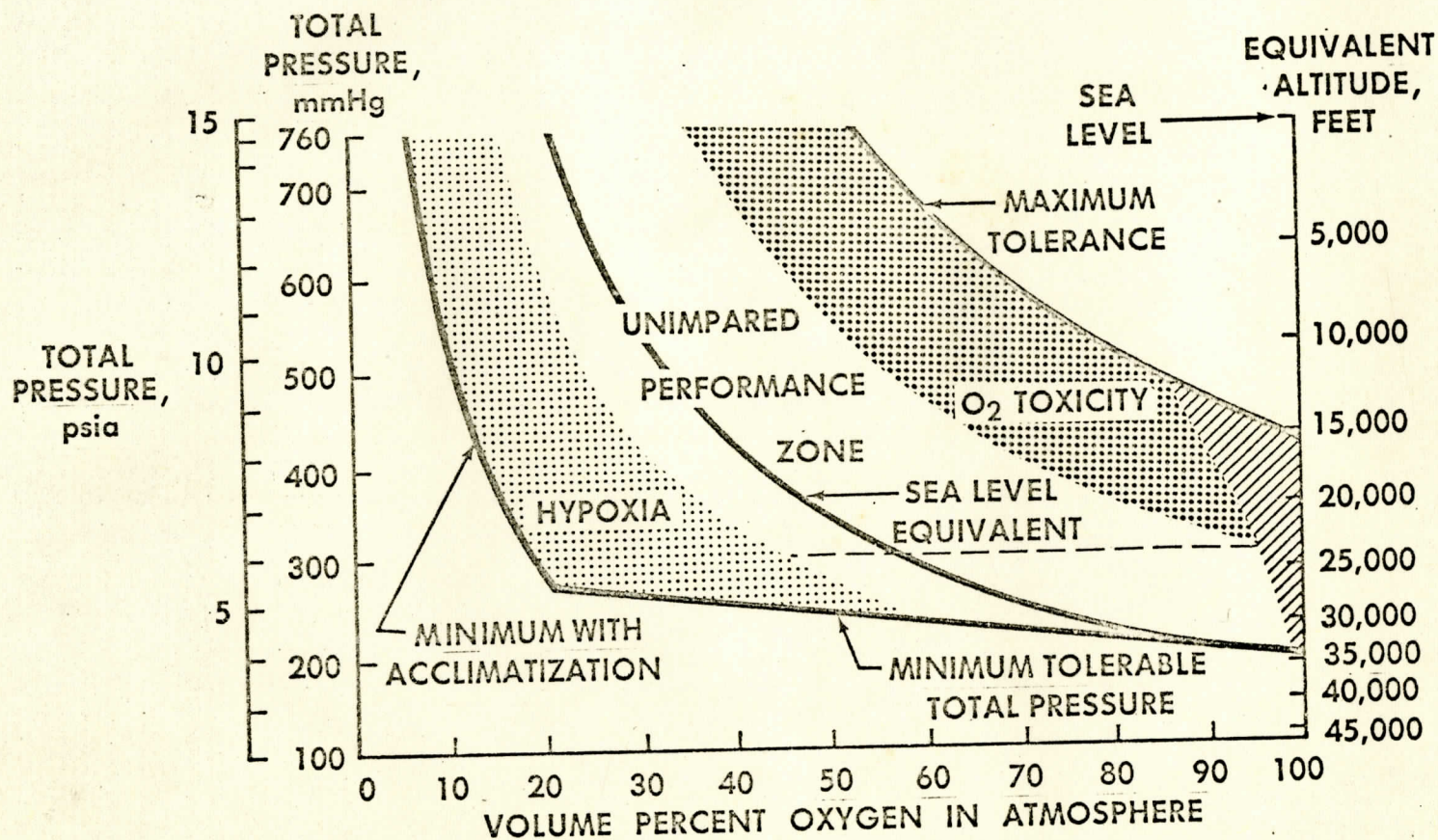
GENERAL EFFECTS OF HYPOXIA ON ARTERIAL SATURATION AND BODY FUNCTION

ARTERIAL
OXYGEN
SATURA-
TION, %



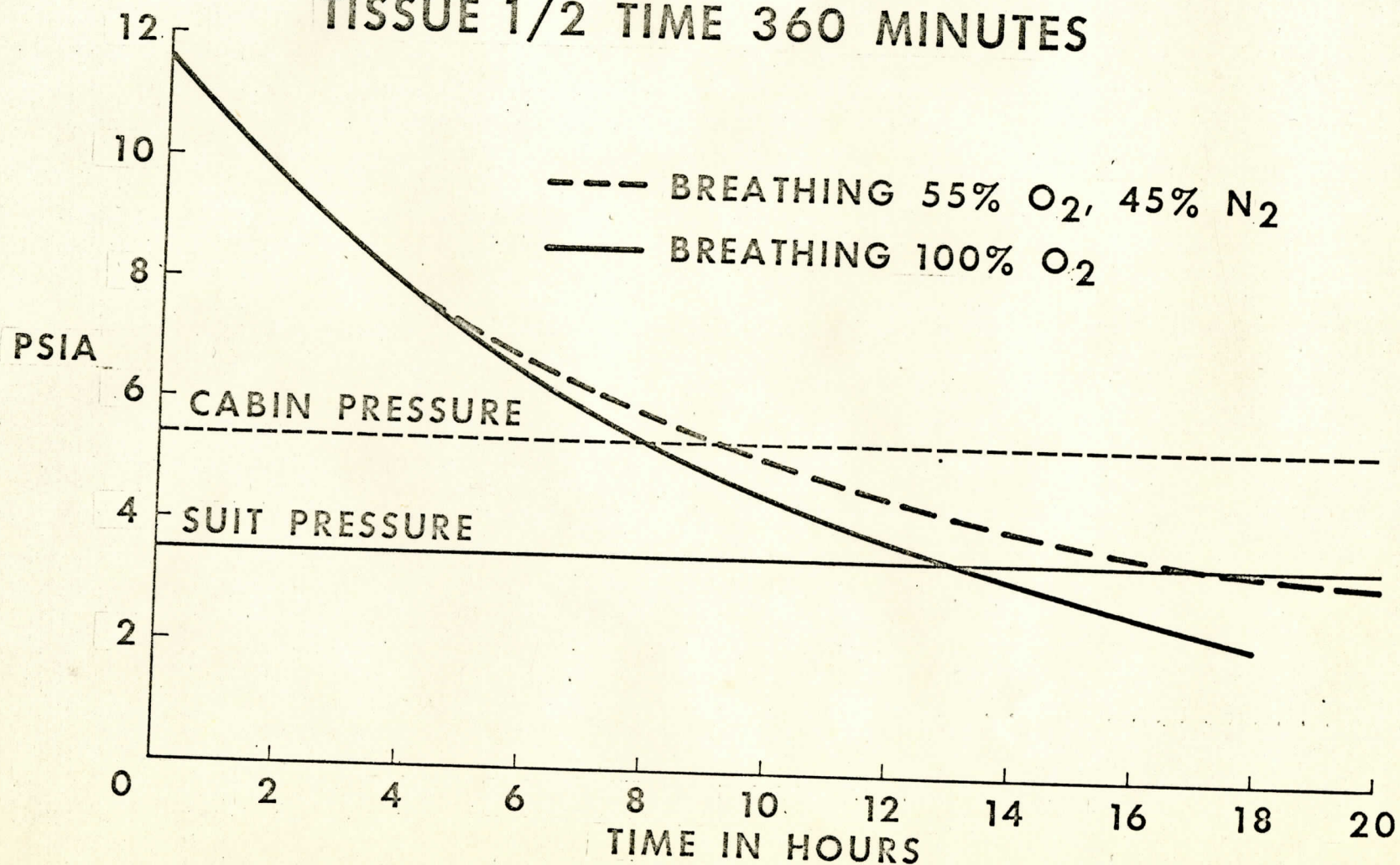
- UNCONSCIOUSNESS IN SECONDS
- UNCONSCIOUSNESS IN MINUTES
- UNCONSCIOUSNESS IN HOURS
- ALTERED JUDGMENT
IMPAIRED COORDINATION
- IMPAIRED
RECENT MEMORY
AND CALCULATION
- DECREASED NIGHT
(SCOTOPIC)
VISUAL SENSITIVITY
- NO EFFECTS
- RANGE OF
OXYGEN SATURATION

OXYGEN-PRESSURE EFFECTS



CRITICAL TISSUE NITROGEN ELIMINATION CURVE

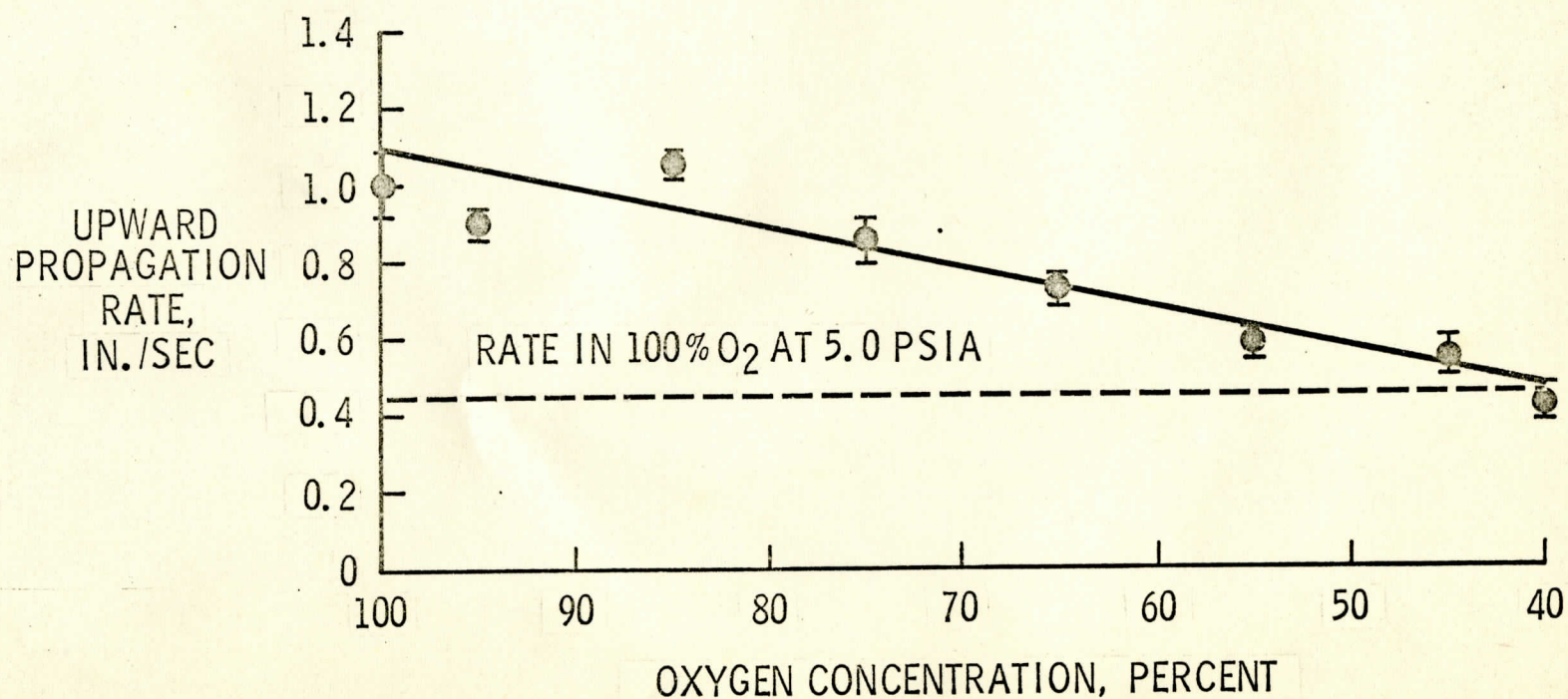
TISSUE 1/2 TIME 360 MINUTES



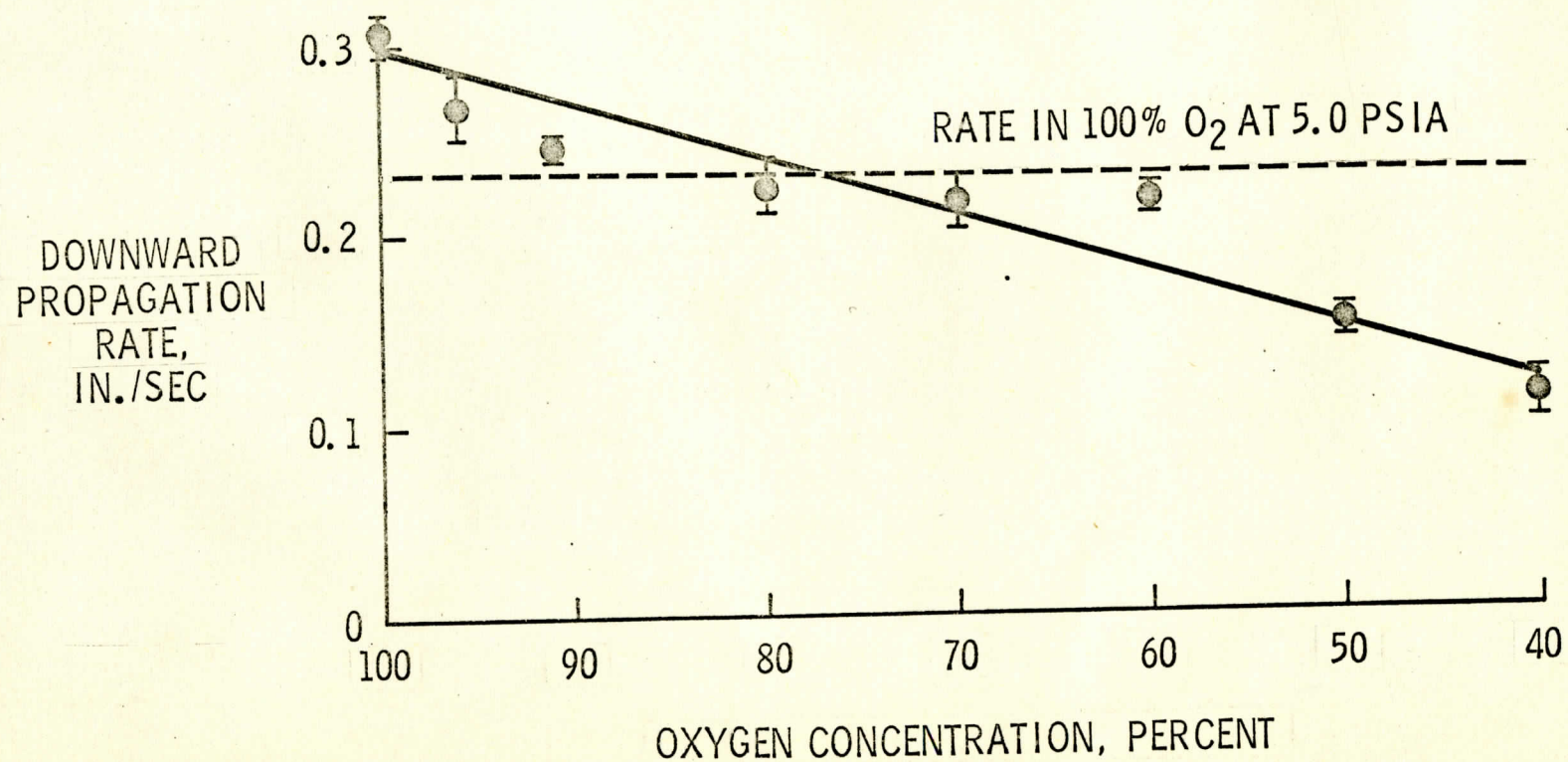
LUNG (ALVEOLAR) OXYGEN PARTIAL PRESSURES AND OXY-HEMOGLOBIN SATURATIONS AT VARYING OXYGEN MIXTURES AND VARYING ATMOSPHERIC PRESSURES

OXYGEN MIXTURE	CONTINGENCY MODE MINIMUM PRESSURE		NOMINAL MINIMUM PRESSURE		PURGE MODE MINIMUM PRESSURE	
	2.8 psi (145 mm Hg)	3.5 psi (181 mm Hg)	4.8 psi (248 mm Hg)	5.6 psi (290 mm Hg)		
	PAO ₂ mm Hg	OXY-HGB CONCEN %	PAO ₂ mm Hg	OXY-HGB CONCEN %	PAO ₂ mm Hg	OXY-HGB CONCEN %
AIR (20.93% O ₂) (79.07% N ₂)			-16.2	0	-3.6	0
50% O ₂ /50% N ₂			23.4	40	56.9	87
60% O ₂ /40% N ₂			37.6	70	77.8	91
70% O ₂ /30% N ₂			51.0	80	98.3	94
80% O ₂ /20% N ₂			92.6	95	129.4	98
100% O ₂ /0% N ₂	48	80			152.8	100

UPWARD PROPAGATION OF 0.005 INCH TEFLON
IN VARIOUS O_2/N_2 MIXTURES AT A TOTAL
PRESSURE OF 16.5 PSIA

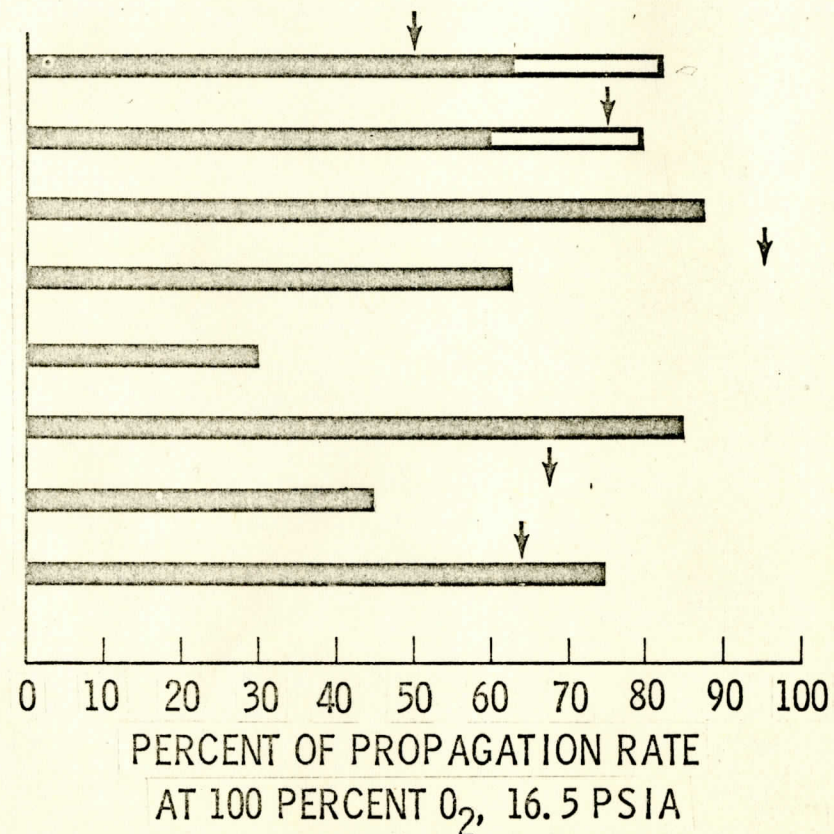


DOWNWARD PROPAGATION OF 0.005 INCH NOMEX
IN VARIOUS O₂/N₂ MIXTURES AT A TOTAL
PRESSURE OF 16.5 PSIA



COMPARISON OF DOWNWARD PROPAGATION RATES IN 100% O₂; 60% O₂/40% N₂; AND 80% O₂/20% N₂ AT 16.5 PSIA

TEFLON SHEET, 0.005 IN.
NOMEX SHEET, 0.005 IN.
NYLON CLOTH, MIL-C-7219C
HOLLAND CLOTH, MIL-C-17564
VELCRO PILE
POLYETHYLENE, MIL-P-3803
TRILOCK PLASTIC SHEET NO. 6027
MYLAR SHEET TYPE 7506A



NOTE: BLACK BAR INDICATES RATE IN 60 PERCENT O₂ / 40 PERCENT N₂
WHITE BAR INDICATES RATE IN 80 PERCENT O₂ / 20 PERCENT N₂
ARROW INDICATES RATE IN 100 PERCENT O₂ AT 6.2 PSIA

PRESENTATION WILL ADDRESS PERIOD FROM LIFTOFF THROUGH
CABIN PURGE

FOLLOWING AREAS WILL BE DISCUSSED

- METHODS AVAILABLE TO REMOVE DILUENT
- ADVANTAGES AND DISADVANTAGES OF EACH METHOD
- A SELECTED GAS MIXTURE AND THE RECOMMENDED
PROCEDURES FOR REMOVING N_2 FROM THE CABIN

- TO OBTAIN AN UNDERSTANDING OF THE TRADEOFFS TO BE MADE IN SELECTING A PROCEDURE TO REMOVE THE DILUENT FROM THE CABIN AFTER ORBITAL INSERTION, THE FOLLOWING CASES WERE CONSIDERED
 - CASE I 80 PERCENT O_2 , 20 PERCENT N_2 - A GAS MIXTURE AT LAUNCH WHICH PROVIDES A CABIN ENVIRONMENT AFTER ORBITAL INSERTION SUITABLE FOR NORMAL OPERATIONS
 - CASE II 60 PERCENT O_2 , 40 PERCENT N_2 - A GAS MIXTURE AT LAUNCH WHICH PROVIDES A CABIN ENVIRONMENT AT ORBITAL INSERTION WHICH IS ACCEPTABLE FOR CONTINGENCY OPERATIONS
 - CASE III 20 PERCENT O_2 , 80 PERCENT N_2 - A GAS MIXTURE AT LAUNCH WHICH RESULTS IN A LETHAL CABIN ENVIRONMENT AT ORBITAL INSERTION BUT IS OPTIMUM FROM A FLAMMABILITY VIEWPOINT

- GUIDELINES FOR STUDY

- PROCEDURES SELECTED FOR REMOVING DILUENT MUST SATISFY THE LUNAR MISSION CASE
- EITHER THE SURGE TANK OR THE EMERGENCY OXYGEN SUPPLY (EOS) IS SUITABLE FOR USE DURING REENTRY
- ONLY ONE OF THE TWO EMERGENCY O₂ SYSTEMS SHOULD BE DEPLETED AT ANY GIVEN TIME (NOMINALLY)
- CABIN DUMP CANNOT BE INITIATED UNTIL AFTER 2-1 GO / NO GO
- CABIN PURGE MAY BEGIN ANY TIME AFTER ORBITAL INSERTION

- THREE BASIC METHODS AVAILABLE TO REMOVE DILUENT AFTER ORBITAL INSERTION
 - NORMAL LEAKAGE (.2 LB / HR SPEC)
 - CONTINUOUS CABIN PURGE
 - COMPLETE OR PARTIAL CABIN DUMP FOLLOWED BY REPRESSURIZATION
- PRESENT HARDWARE IS CAPABLE OF SUPPORTING THE THREE BASIC METHODS AND COMBINATIONS

- AFTER ORBITAL INSERTION AND DURING REMOVAL OF N_2 FROM THE CABIN, TWO CONDITIONS ARE DEFINED
 - PERCENT O_2 AT A GIVEN CABIN PRESSURE WHEN THE CABIN CAN BE USED AS A BACKUP TO THE SUIT LOOP
 - PERCENT O_2 AT A GIVEN CABIN PRESSURE AT WHICH TIME HELMET CAN BE REMOVED .

CASE I 80% O₂, 20% N₂

- CONDITIONS AT INSERTION
 - 5.6 PSIA IN CABIN
 - 4.48 PO₂ → 153 MM HG (PAO₂)
 - CABIN SUITABLE FOR HELMET OFF OPERATIONS
- ADVANTAGES
 - NO SPECIAL PROCEDURES REQUIRED
 - NO ADDITIONAL O₂ IS REQUIRED
 - CABIN CAN BE USED AS SUIT BACKUP
- DISADVANTAGES
 - NOT OPTIMUM FROM FLAMMABILITY VIEWPOINT

CASE II 60% O₂, 40% N₂

- CONDITIONS AT ORBITAL INSERTION
 - 5.6 PSIA IN CABIN
 - 3.36 PO₂ → 103 MM HG (PAO₂) EQUIVALENT TO SEA LEVEL
 - CABIN SUITABLE BACKUP TO SUIT LOOP
- WITH 3.5 PSIA IN CABIN
 - 2.1 PO₂ → 38 MM HG (PAO₂) EQUIVALENT TO 15,000 FT

60% O₂, 40% N₂ DILUENT REMOVAL

- NORMAL LEAKAGE

- WILL REQUIRE MINIMUM OF 50 HOURS TO REACH 80 PERCENT IN CABIN ASSUMING LEAK RATE OF .2 LB / HR

- DISADVANTAGES

- CREW MUST REMAIN SUITED FOR EXCESSIVE TIME
- SC MAY HAVE LEAK RATE LOWER THAN SPECIFICATION VALUE
- NO POSITIVE CONTROL OF TIME TO REMOVE DILUENT

60% O₂, 40% N₂ DILUENT REMOVAL CABIN PURGE

- FOUR METHODS AVAILABLE TO PURGE CABIN
 - DISCHARGE SURGE TANK WITH PRESS TO TEST BUTTON
 - USE EOS
 - USE O₂ FROM CYROGENIC STORAGE TANKS BY OPENING
MANUAL REPRESS VALVE
 - DISCHARGE SURGE TANK THROUGH USE OF DIRECT O₂ VALVE
- EOS NOT RECOMMENDED
 - DISCHARGES IN CLOSE VICINITY OF CABIN RELIEF VALVE
 - DISCHARGE IN ONE MINUTE
 - INSUFFICIENT MIXING OF GAS
- DISCHARGING SURGE TANK THROUGH USE OF DIRECT O₂ VALVE
NOT RECOMMENDED
 - DIRECT O₂ VALVE DUMPS WITHIN 2 FEET OF CABIN RELIEF
VALVE INTO AN ENCLOSED AREA
- CABIN PURGE PROCEDURE LIMITED TO USE OF SURGE TANK
AND / OR MANUAL REPRESS VALVE

60% O₂, 40% N₂ DILUENT REMOVAL CABIN PURGE (CONT)

- TYPICAL PROCEDURE
 - CHECK PLSS VALVE CLOSED
 - DEPRESS 'PRESS TO TEST' BUTTON ON EMERGENCY CABIN PRESSURE REGULATOR UNTIL PRESSURE DROPS TO 125 PSI
 - CONTINUE PURGE WITH O₂ FROM CYROGENIC STORAGE TANKS BY
 - OPENING MANUAL REPRESS VALVE ON THE CABIN PRESSURE REGULATOR
 - CLOSE MANUAL REPRESS VALVE WHEN DESIRED CABIN CONDITIONS ARE REACHED

60% O₂ 40% N₂ DILUENT REMOVAL

- WILL REQUIRE 77 MINUTES FROM START OF PURGE TO INSURE 80 PERCENT O₂ AT CABIN PRESSURE OF 5 PSIA
- WILL REQUIRE APPROXIMATELY 11 POUNDS OF ADDITIONAL OXYGEN (3.1 POUNDS IN TANK) (.1 POUND / MINUTE FROM CYRO TANK)
- ADVANTAGES
 - SOLE RELIANCE ON SUIT LOOP NEVER REQUIRED. (NOMINALLY)
 - SUITABLE FROM A FLAMMABILITY VIEW POINT
 - CABIN SUITABLE BACKUP TO SUIT AT ORBITAL INSERTION
- DISADVANTAGES
 - CREWMAN MUST LEAVE COUCH TO DISCHARGE SURGE TANK
 - CREWMAN MUST HOLD PRESS TO TEST BUTTON FOR APPROXIMATELY FIVE (5) MINUTES
 - REQUIRES USE OF SURGE TANK
 - CREWMAN MUST LEAVE COUCH TO OPEN AND CLOSE MANUAL REPRESS VALVE
 - CREW MUST REMAIN IN HELMETS UNTIL PURGE COMPLETED

60% O₂ 40% N₂ DILUENT REMOVAL (CONT)

- CABIN DUMP
 - NOT RECOMMENDED
 - NULLIFIES BENEFIT OF 60 / 40 MIXTURE IN THAT DUMP
PROCEDURE WILL ELIMINATE THE CABIN AS A SUIT
BACKUP FOR SOME PERIOD OF TIME

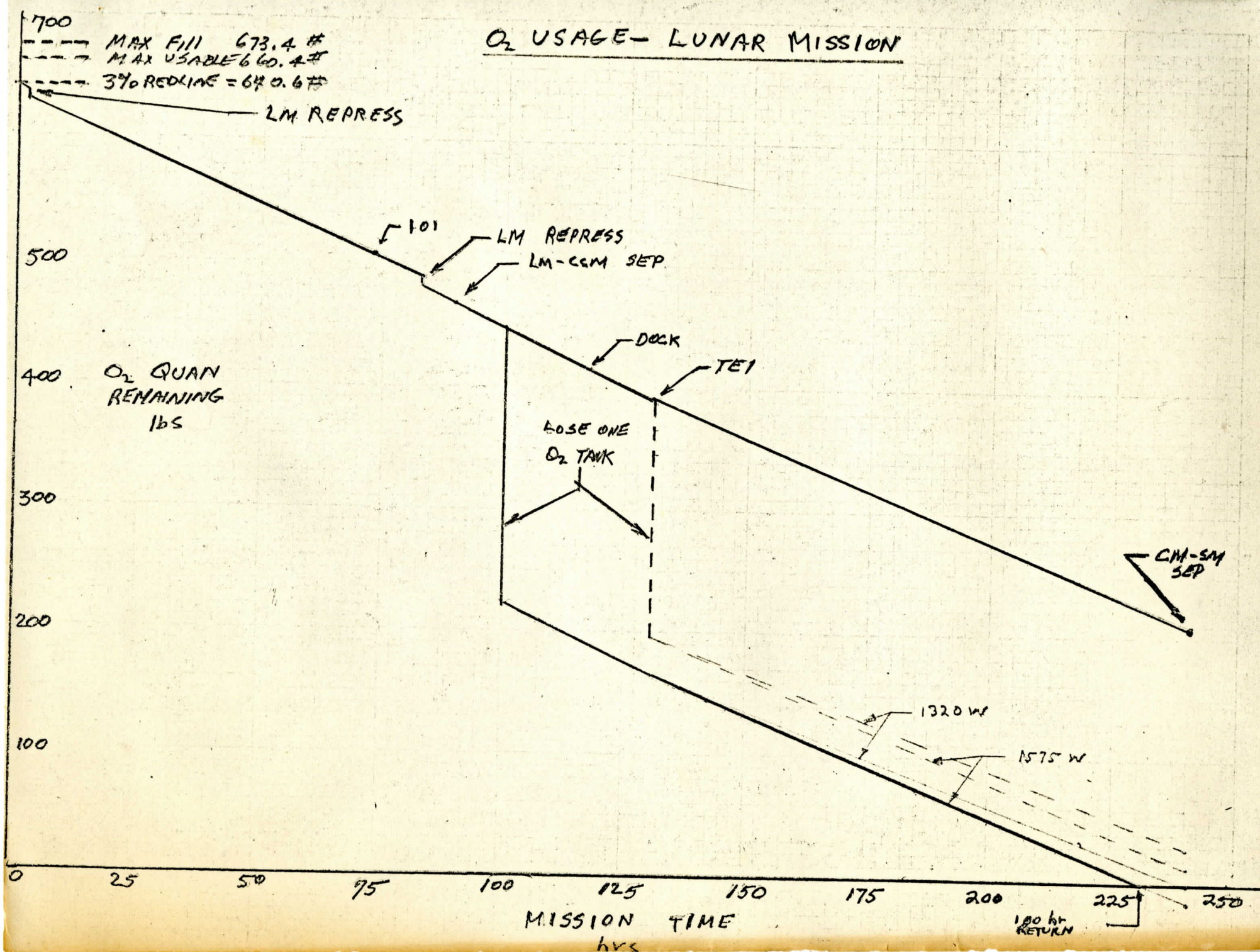
80% N₂ 20% O₂ DILUENT REMOVAL

- CONDITIONS AT INSERTION
 - 5.6 PSIA IN CABIN 1.12 PO₂ → -3.6 MM HG (PAO₂)
 - CABIN NOT SUITABLE AS A BACKUP TO SUIT LOOP
- NORMAL LEAKAGE
 - NOT RECOMMENDED, TIME REQUIRED TO REACH ACCEPTABLE CABIN ENVIRONMENT IS EXCESSIVE (GREATER THAN 80 HOURS)
- CABIN PURGE
 - NOT RECOMMENDED, TIME REQUIRED TO INSURE ACCEPTABLE CABIN ENVIRONMENT IS GREATER THAN 2 1 / 2 HOURS
- CABIN DUMP
 - NOT RECOMMENDED, SOLE RELIANCE ON SUIT LOOP UNTIL CABIN REPRESSURIZED
 - SERIOUSLY EFFECT CREW TIME LINE

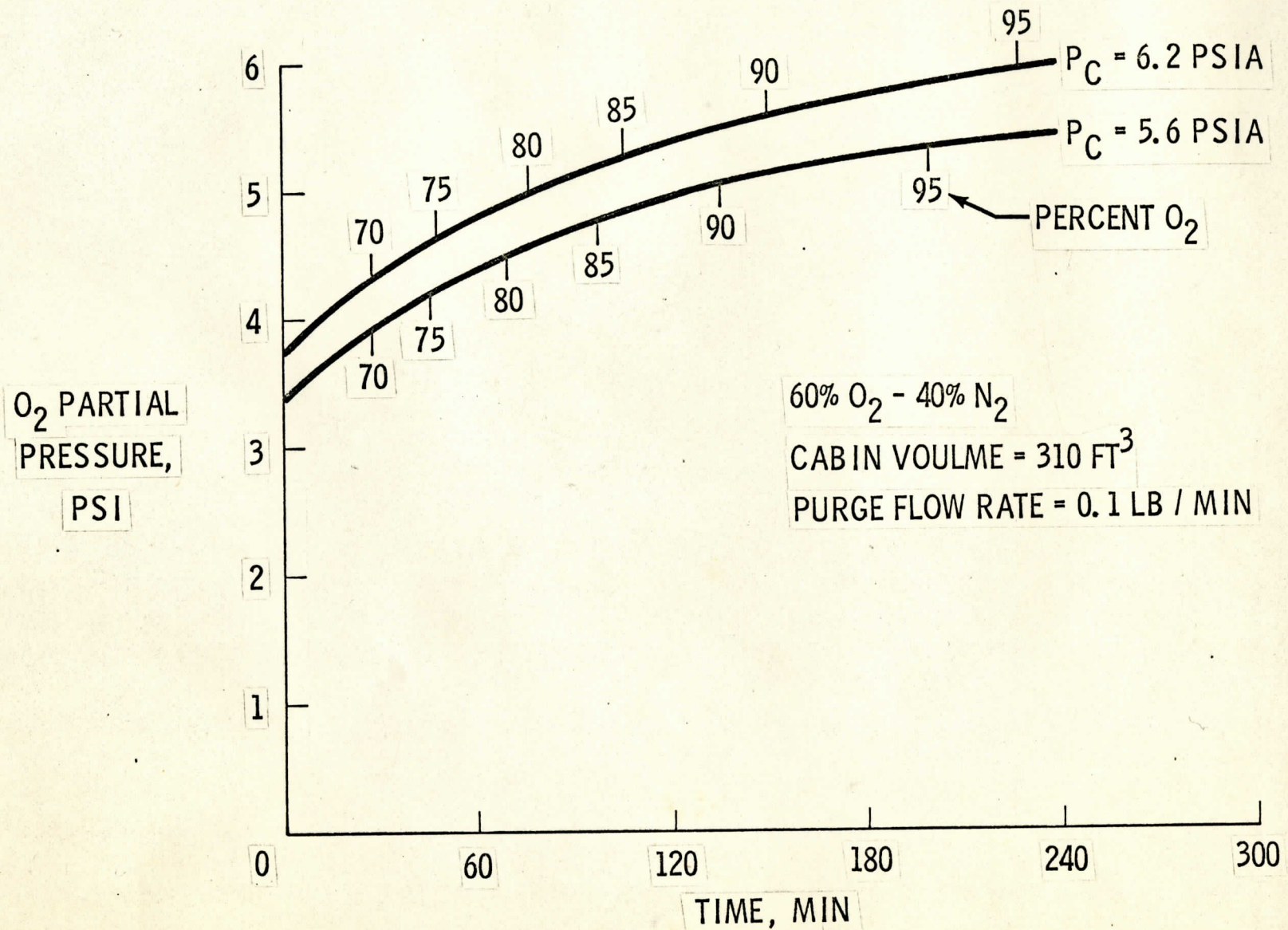
RECOMMENDED GAS MIXTURE AND PROCEDURES TO REMOVE DILUENT

- USE 60 PERCENT O₂, 40 PERCENT N₂
- USE PURGE METHOD TO REMOVE DILUENT
- MAINTAIN CABIN PRESSURE AT $6 \pm \frac{2}{4}$ PSIA BY OPENING MANUAL REPRESSURIZATION VALVE AT ORBITAL INSERTION
- CLOSE MANUAL REPRESSURIZATION VALVE APPROXIMATELY 2 HOURS AFTER PURGE INITIATION
- REMOVE HELMET AT SOME POINT DURING PURGE (TO BE DETERMINED)
- ADVANTAGES
 - MINIMUM IMPACT ON CREW TIME LINE
 - EMERGENCY O₂ NOT USED
 - DEPENDING ON TIME AT WHICH HELMETS ARE REMOVED, WILL NOT EFFECT LUNAR MISSION CASE
- DISADVANTAGES
 - 12 POUNDS OF ADDITIONAL O₂ REQUIRED
 - PRESENCE OF N₂ IN CABIN WILL REQUIRE A MORE DETAILED ANALYSIS OF PO₂ SENSOR ACCURACY AND VALIDATION OF THE RESULTING ATMOSPHERE WITH ABOVE PROCEDURES DURING 2TV-1 TESTS
 - CREWMAN MUST LEAVE COUCH TO OPEN AND CLOSE MANUAL REPRESSURIZATION VALVE

O₂ USAGE - LUNAR MISSION



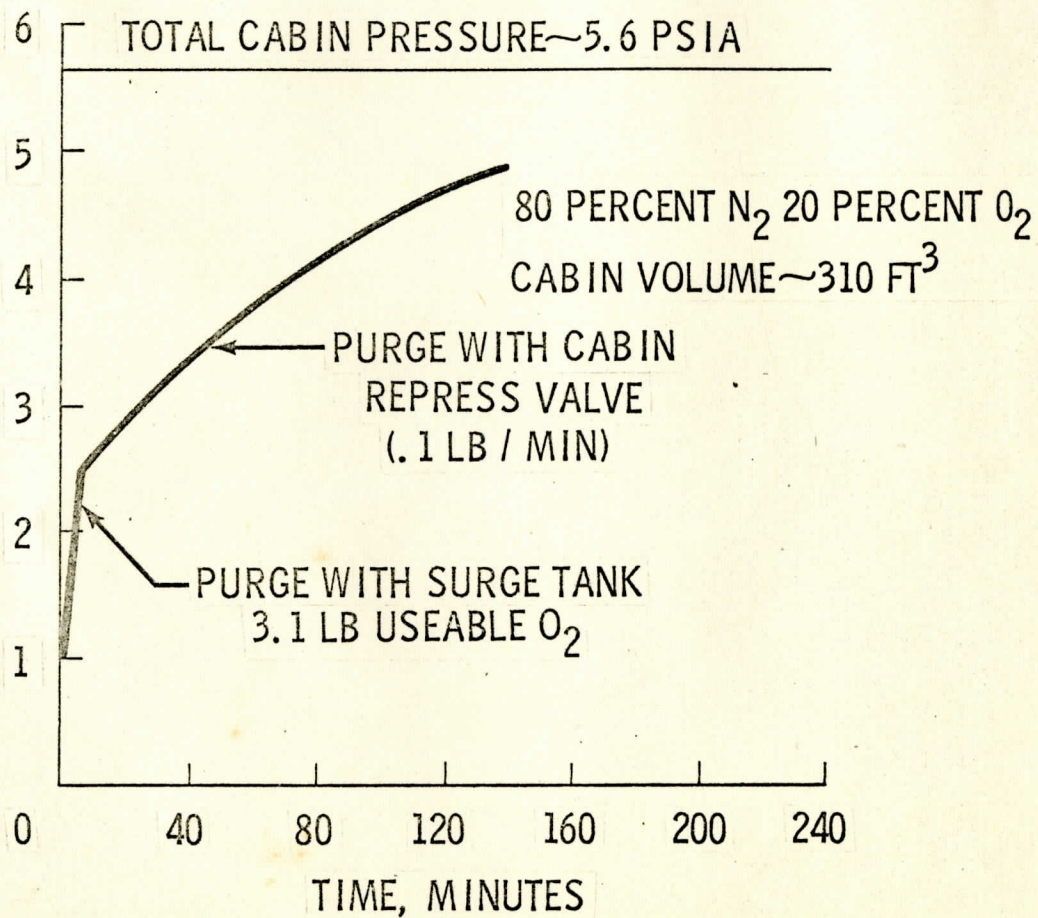
PURGE THRU CABIN REPRESS VALVE ONLY

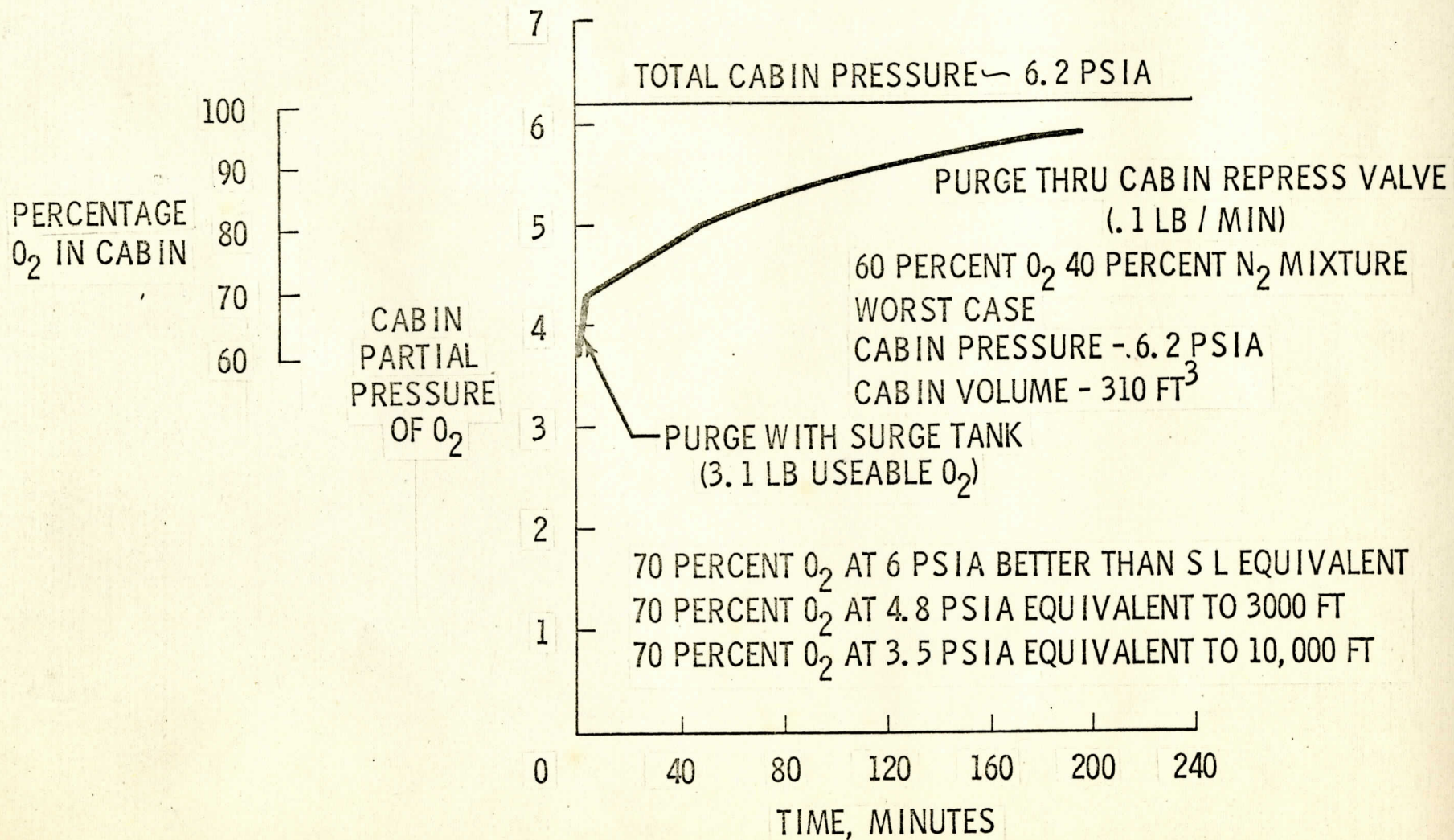


PERCENTAGE O_2
IN CABIN

90
80
70
60
50
40
30
20

CABIN
PARTIAL
PRESSURE
OF O_2





CM CABIN ATMOSPHERE

FACILITIES

- ANY CABIN ATMOSPHERE BEING CONSIDERED IS COMPATIBLE WITH GSE AND STORAGE FACILITIES AT:
 - MSC, CHAMBER 'A'
 - KSC, MSOB ALTITUDE CHAMBER
 - KSC, LC-34 AND LC-39

PROCUREMENT

- AN MSC SPECIFICATION FOR ATMOSPHERE "X" IS REQUIRED IF SELECTION IS DIFFERENT FROM:
 - BREATHING AIR, FED. SPEC. BB-A-001034
 - OR, BREATHING OXYGEN, MSFC SPEC. 399
- ALLOWABLE CONTAMINATION, ALLOWABLE TRACE ELEMENTS AND TOLERANCE FOR O₂ CONTENT SHOULD BE SPECIFIED.
- IF A MIXTURE OF STANDARD GASES IS USED, GFE-SUPPLIED MIXING VALVES AND INSTRUMENTATION MAY BE REQUIRED.
- ESTIMATED QUANTITIES ARE 1000# FOR 2TV-1 AT MSC, AND 1800# FOR S/C 101 AT KSC IN ALT. CHAMBER & ON LC-34

CM CABIN ATMOSPHERE

SAFETY CONSIDERATIONS

CREW EGRESS TIMELINES

MSC-CHAMBER A - EMERGENCY REPRESSURIZATION FROM VACUUM TO 6 PSIA IN 30 SEC. WITH EGRESS PLATFORM TO MANNED AIRLOCK AVAILABLE, WITHIN 30 SEC.

KSC-MSOB ALTITUDE CHAMBER - EMERGENCY REPRESSURIZATION FROM VACUUM TO 6 PSIA IN 30 SEC. WITH EGRESS PLATFORM TO MANNED AIRLOCK IN PLACE.

LC-34 EGRESS AVAILABLE VIA ACCESS ARM UP TO T-30 MIN. FROM T-30 MIN. UNTIL T-4 MIN., ACCESS ARM IS STAND BY POSITION 12⁰ FROM SC, AVAILABLE IN 12 SEC.

FROM T-4 MIN. UNTIL T-0, ACCESS ARM IN FULL RETRACT POSITION, AVAILABLE IN 28 SEC.

UNASSISTED EGRESS TIME FROM CM FOR 3 CREWMEN WILL BE TESTED IN MOCKUP AT KSC IN FEB. 1968. ESTIMATED EGRESS TIME FROM STRAPDOWN FOR 3 CREWMEN IS 40 SEC.

FIRE PROTECTION - WATER SPRAY EXTERNAL TO THE SC FOR FIRE EXTINGUISHING AND PERSONNEL PROTECTION IS AVAILABLE AT MSC, CHAMBER A, AND KSC, ALTITUDE CHAMBER, LC 34 & LC 39

CM CABIN ATMOSPHERE

EFFECT OF PROPOSED ATMOSPHERE CHANGE ON CHECKOUT

DOWNEY OPERATIONS - NOT AFFECTED NR USES AIR IN CABIN.

MSC-CHAMBER A-2TV-1 - AFFECTS CABIN ATMOSPHERE AND PROCEDURES
ATMOSPHERE 'X' TO BE USED FOR MANNED CABIN
CLOSEOUT & SIMULATED MISSIONS.

KSC-MSOB-ALTITUDE CHAMBER, S/C 101

EMERGENCY EGRESS PRACTICE, PRIME AND BACKUP
CREWS, USE AIR.

- OCP K-5023 CABIN LEAK TEST TO 5.6 PSIG UNMANNED,
USE N₂ UP TO 4 HR.
- OCP K-0034 CABIN LEAKAGE DECAY TEST, MANNED, 10 MIN.
AT 3.5 PSIG. USE ATMOSPHERE 'X'.

KSC - LC 34, S/C 101

EMERGENCY EGRESS PRACTICE, PRIME AND BACKUP
CREWS, USE AIR (AFTER ELECTRICAL MATE, PRIOR
TO PLUGS OUT.)

- OCP K-5124 CABIN LEAK TEST TO 5.6 PSIG, UNMANNED, USE
N₂ (AFTER PLUGS OUT, PRIOR TO CDDT.) UP TO 4 HOURS.

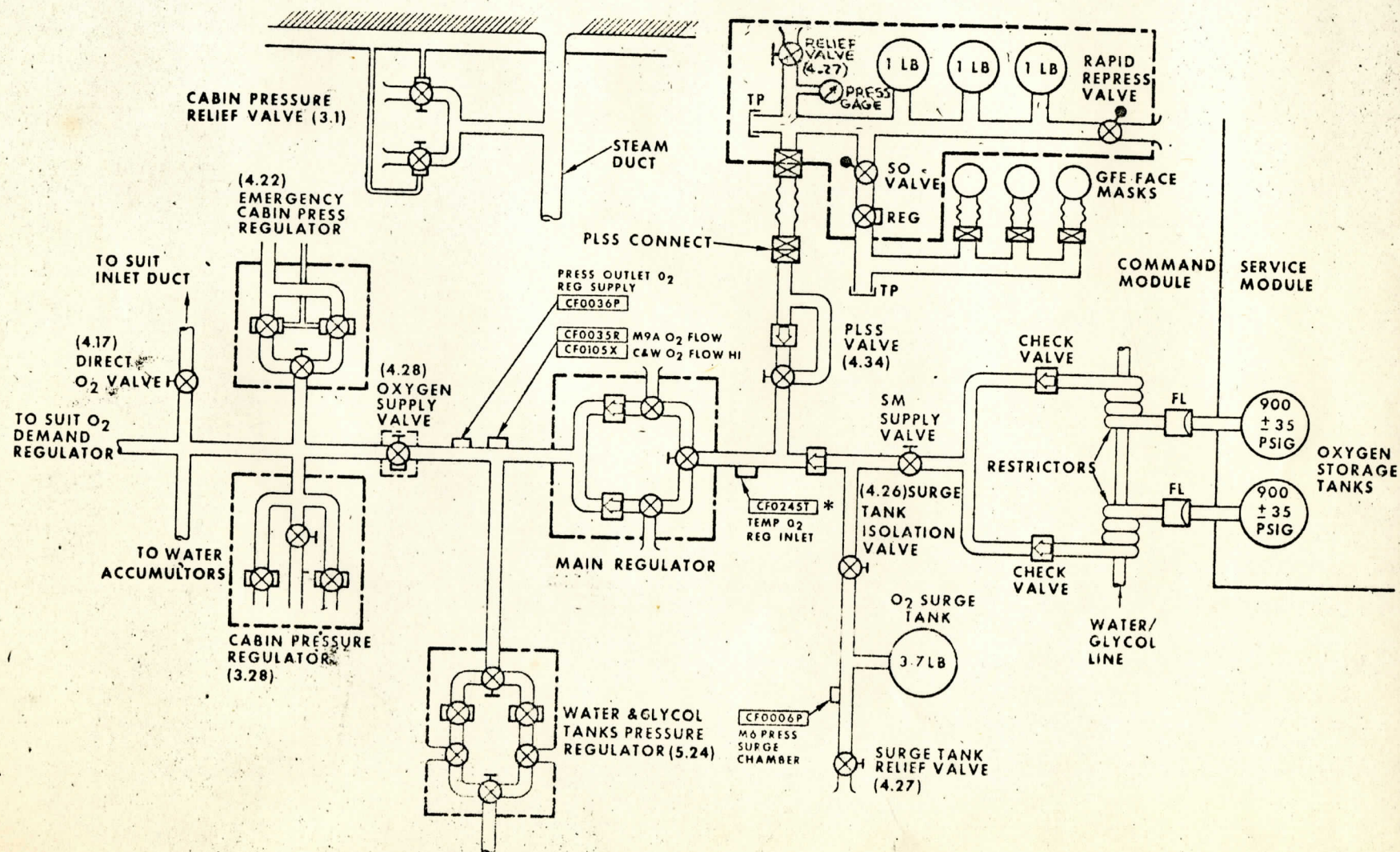
CM CABIN ATMOSPHERE

LC-34, S/C 101 CDDT (OCP K-0033) AND COUNTDOWN (OCP K-0007)

- SUIT LOOP PURGE TO 98% O₂ VERIFIED PRIOR TO LV CRYO LOADING
- LAUNCH VEHICLE CYROGENICS LOADING-CLEAR PAD
- APPROXIMATELY T-3.5 HOURS, GROUND CLOSEOUT CREW TO SC, VERIFY
VERIFY SC READY FOR FLIGHT CREW INGRESS. PURGE CABIN
COMPARTMENTS WITH ATMOSPHERE X, VERIFYING WITH PPO₂
ANALYZER (.5 TO 1.0 HR.)
- CREW INGRESS
- SUIT O₂ PURGE, AND VERIFY SUIT LOOP O₂ > 98%.
- SUIT INTEGRITY CHECK AT 4.5 PSI; DEPRESSURIZE SUIT.
- SIDE HATCH CLOSURE
- SET CABIN RELIEF VALVE TO DUMP POSITION; PURGE CABIN THRU
HATCH FITTING USING ZOO-140 ECS UNIT. PURGE WITH ATMOS-
PHERE 'X' FOR ~ 20 MIN.. USE BECKMAN ANALYZER TO ASSURE
PROPER CABIN ATMOSPHERE. CLOSE CABIN RELIEF VALVE.
- PRESSURIZE CABIN TO 3.5±.5, CHECK PRESSURE DECAY FOR 10
MIN. TO ASSURE HATCH SEAL
- DUMP CABIN PRESSURE THRU HATCH TO APPROX. .25 PSIG.
T-30 MIN., GROUND CREW LEAVES PAD.

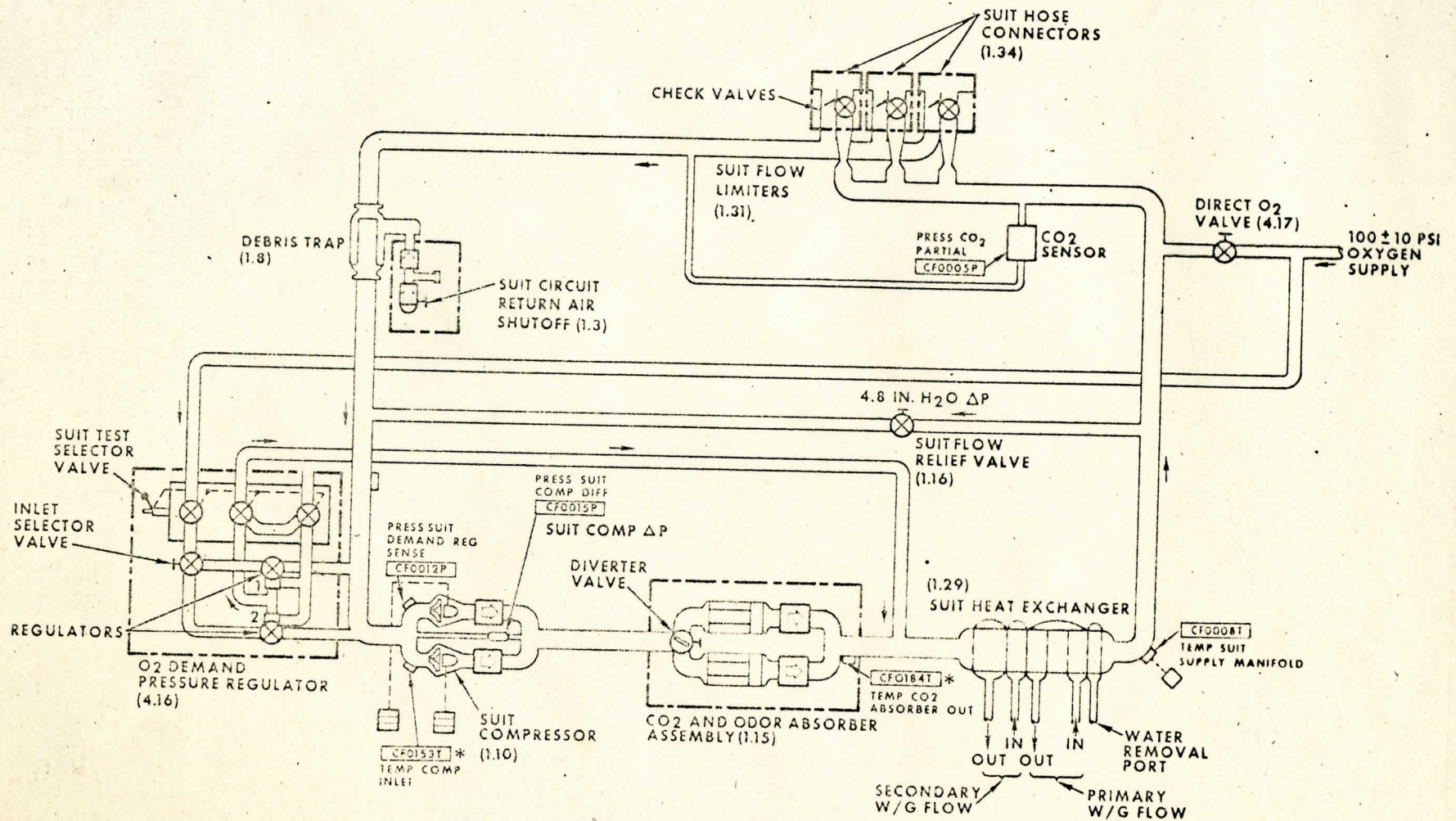
OXYGEN SUBSYSTEM

BLOCK II



SUIT CIRCUIT

BLOCK II



CM CABIN ATMOSPHERE

TOLERANCES AFFECTING MIXTURE SELECTION

● O ₂ CONTENT USED FOR FIRE TESTS	±2% FULL SCALE
● PO ₂ CABIN GAGE	±6% FULL SCALE
● CREW METABOLIC RATES	±5%
● CABIN VOLUME PURGED	±3-4%
● CABIN PURGE ATMOSPHERE	±2% FULL SCALE
● ATMOSPHERE 'X' O ₂ CONTENT	.5 TO 2%
● CABIN LEAK RATE	.2#/HR. MAX AT 6.2 PSIA.
● CABIN RELIEF VALVE SETTING	6.0 +.2 -.4 PSIG