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HANDLING**

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✓ missing  
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**ROUGH DRAFT**

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26 Jan 1967  
33 Pages  
copy 1 of 1

ACOUSTIC AND VIBRATION TESTING

5 Jan 67

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QUESTIONS TO BE ADDRESSED

- WHAT SHOULD THE OVERALL VIBRATION/ACOUSTIC TESTING PROGRAM BE FOR MOL?
- IS THERE A REQUIREMENT FOR AN ACOUSTIC FACILITY AT EKC FOR MOL?

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TEST OBJECTIVES

- DEVELOPMENT TESTING  
ENGINEERING TEST TO PROVIDE COMPONENT ENVIRONMENTAL  
DESIGN AND QUALIFICATION TEST DATA, AND TO VERIFY  
STRUCTURAL DESIGN
- QUALIFICATION TESTING  
PROVE DESIGN IS ADEQUATE FOR EXPECTED ENVIRONMENT  
WITH MARGIN
- ACCEPTANCE TESTING  
PROVE PARTICULAR ARTICLE IS BUILT TO SPECIFICATIONS  
AND READY FOR FLIGHT.

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PRESENT TEST PLAN

SYSTEM		SEGMENT			COMPONENT		
		LM	TMB	COAB	LM	TMB	COAB
DEVELOP.	0	ACOUSTIC (QUAL. STRUC.)	ACOUSTIC (EKC)		VIBR. AND ACOUS.	VIBR.	VIBRATION & ACOUSTIC
QUAL.	0	----	VIBR.	ACOUSTIC (EKC)	VIBR. AND ACOUS.	VIBR.	VIBRATION & ACOUSTIC
ACCEP.	0	----	VIBR.				

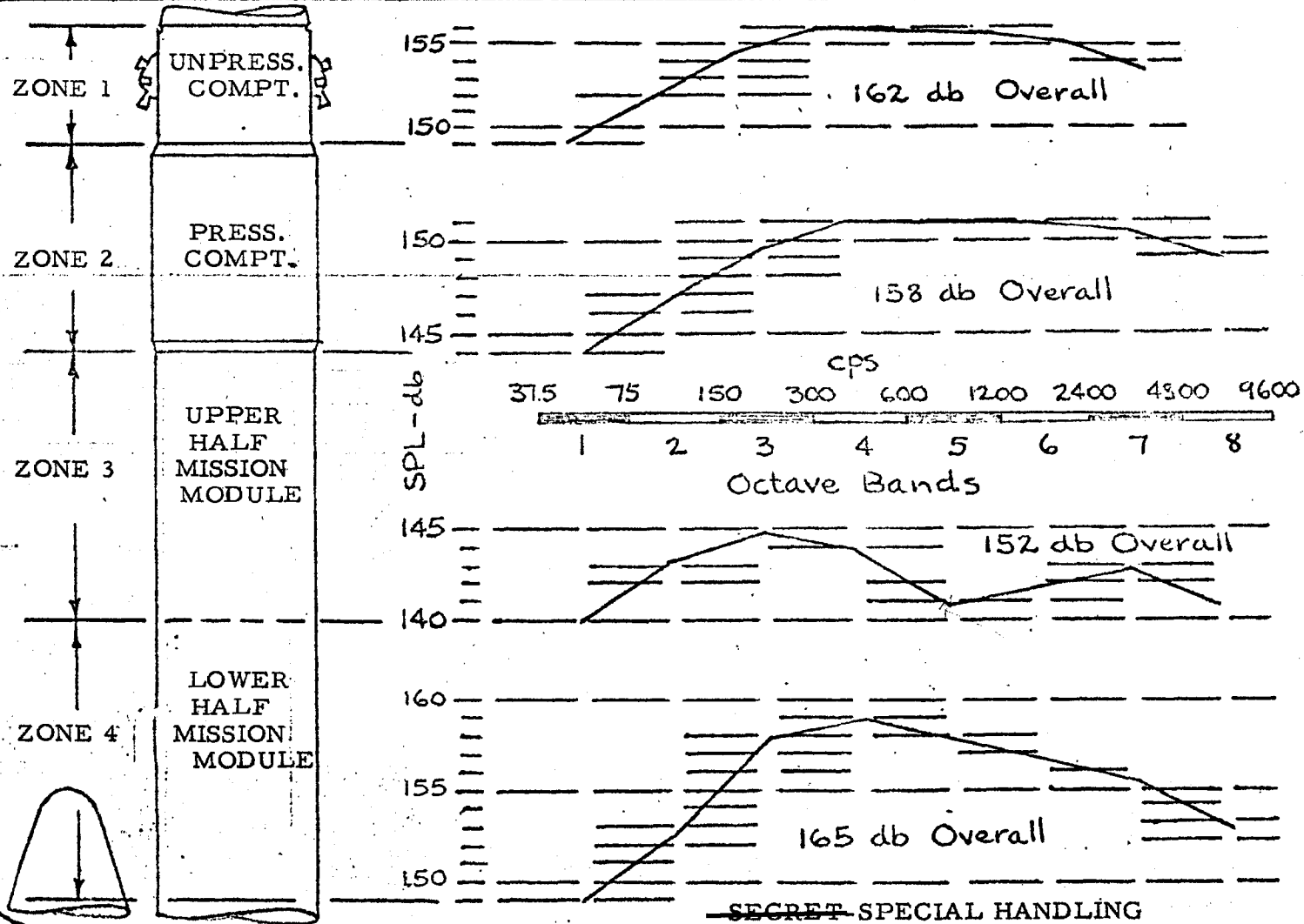
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# External Sound Pressure Levels

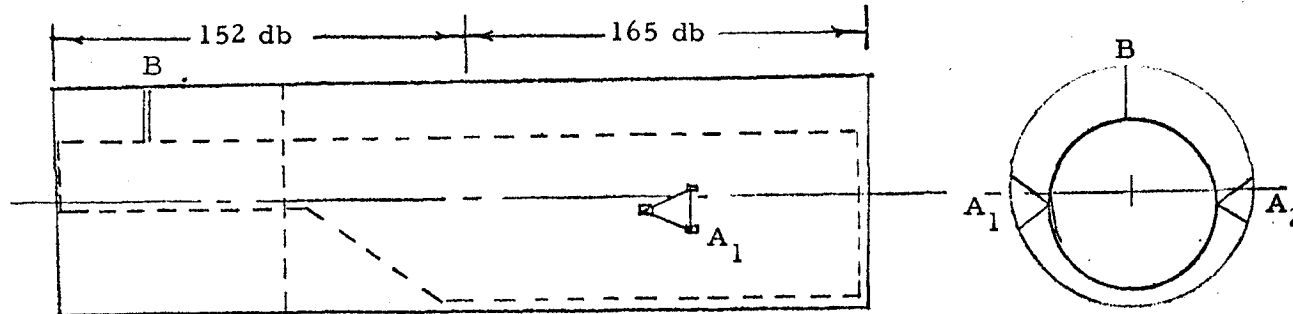


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THE MISSION MODULE PROBLEM

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o THE EXCITATION (REF: SAFSL 10003)



o THE TRANSMISSION PATHS

'A' FRAMES AT  $A_1$  &  $A_2$ ; HINGED STRAP AT B

INTERNAL ACOUSTICS

o VIBRATION TEST?

REQUIRES: TEST FIXTURES FROM SHAKERS TO ATTACH PTS  $A_1$   $A_2$  & B

- EXTENSIVE STRUCTURAL MODS AT ATTACH POINTS

A DIFFICULT TEST DESIGN PROBLEM

o ACOUSTIC TEST

SIMULATES REAL ENVIRONMENT

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**CAPABILITIES OF SOME EXISTING ACOUSTIC FACILITIES**

LOCATION	SIZE	EQUIPMENT	TEST LEVELS (OVERALL)	PROGRAM
ASD, DAYTON	150,000 ft <sup>3</sup> (42 ft high)	PURE TONE SIRENS	162 db 'QUASI' RANDOM	AIRCRAFT FATIGUE
DOUGLAS, SANTA MONICA	10,000 ft <sup>3</sup> (30 ft high)	ELECTROPNEUMATIC TRANSDUCER	158 db RANDOM	MISSILE & SPACE VEHICLES
WYLE LABS, HUNTSVILLE	100,000 ft <sup>3</sup> (36 ft high)	"	155 db RANDOM	SATURN
NORTH AMERICAN LOS ANGELES	9000 ft <sup>3</sup> (22 ft high)	"	160 db RANDOM	
JPL, PASADENA	1000 ft <sup>3</sup> (14 ft high)	"	154 db RANDOM	SPACECRAFT
NORTHROP, HAWTHORNE	170 ft <sup>3</sup>	HIGH PRESSURE AIR MODULATOR	165 db RANDOM	SPACECRAFT COMPONENTS
MARTIN, DENVER	74 ft <sup>3</sup> (5 ft high)	RANDOM SIREN	166 db 'QUASI' RANDOM	TITAN COMPONENTS
MSC - NASA	DUCT SHROUDS	ELECTRO-PNEUMATIC TRANSDUCER	169 db RANDOM	APOLLO VEHICLE

**CONCLUSIONS: DOUGLAS & WYLE FACILITIES REPRESENT CURRENT STATE OF ART.  
165 db REALIZED ONLY IN SMALL CHAMBERS, OR BY SPEC. TECHNIQUES.**



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ASD SONIC FATIGUE FACILITY

● DESCRIPTION

- LARGE ACOUSTIC CHAMBER (70X56X42 FT) - DOOR 16X16 FT
- SOUND EQUIPMENT - 36 PURE TONE SIRENS - "WARBLED"  
THROUGH 50 CPS FILL 1/2 SPECTRUM  
BELOW 2400 CPS; 1/20 SPECTRUM ABOVE  
- AIR SUPPLY - 310,000 CFM @ 14.6 PSIG
- INSTRUMENTATION - 72 ANALOG DATA CHANNELS → 342 CHANNELS  
BY (10X30) +42

● DEFICIENCIES

- DOOR SIZE
- RELIABILITY OF SIREN EQUIPMENT (FATIGUE FAILURES)
- NON CONTINUOUS SPECTRUM - POOR SIMULATION OF ACOUSTIC  
EXCITATION
- DATA ACQUISITION AND ANALYSIS SYSTEM - CUMBERSOME  
AND TIME CONSUMING

● MODIFICATIONS REQUIRED FOR MOL TESTING

- INCREASE DOOR SIZE
- PROCURE NEW (ELECTROPNEUMATIC TRANSDUCER) RANDOM  
NOISE SYSTEM
- PROVIDE HIGHER PRESSURE AIR SUPPLY
- REPLACE DATA ACQUISITION AND ANALYSIS SYSTEM WITH  
DIGITAL SYSTEM

● IMPACT

- NEW FACILITY EXCEPT FOR MODIFIED CHAMBER - COST  
APPROXIMATELY 3.7M (152/165 LOCAL)

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EK PROPOSED ACOUSTIC FACILITY

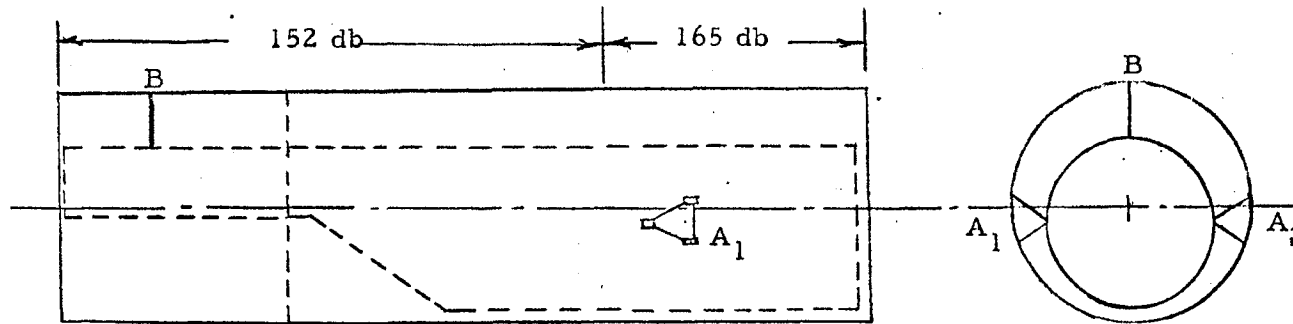
REVERBERANT ROOM	32' x 42' x 60'
ACOUSTIC LEVELS	152 DB REVERBERANT 165 DB DIRECT RADIATION (12' LONG)
RUN DURATION	2 MIN. AT FULL POWER CONTINUOUS AT 7 DB DOWN
ACOUSTIC HORNS	4 NORAIR MK VII REVERBERANT 30 LTV 94 DIRECT RADIATION
AIR SUPPLY	57,000 CU. FT. STORAGE @ 130 PSIG 12,000 CFM/3000 HP AIR COMPRESSOR
APPROXIMATE COST	\$4.9M

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A POSSIBLE APPROACH - MISSION MODULE ACOUSTIC TESTING

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RATIONALE: THE A-FRAMES FORM THE PRIMARY TRANSMISSION PATH FOR RESPONSE EXCITED BY THE 165 DB ENVIRONMENT

- PROVIDE A BASIC ACOUSTIC EXCITATION OF 152 DB OVERALL
- ADD HORN ARRAYS TO EXCITE A-FRAME MOUNTING POINTS TO THE SPECIFIED LEVEL OF 165 DB OVERALL
- THIS APPROACH MAY REDUCE EKC FACILITY COST TO \$3.0M

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# ACOUSTIC TEST FACILITY

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27' x 38' x 50' I.D. DIMS.

AIR VENT  
WITH SOUND  
SUPPRESSION

TUBE SUPPORT  
TO PERMIT  
VERTICAL  
ADJUSTMENT

END SIMULATOR

DOOR  
15' x 45'

AIR STORAGE -  
5000 CU. FT.

6- LTV MODEL EPT-200  
ELECTRO-PNEUMATIC  
TRANSDUCERS  
3- EA SIDE

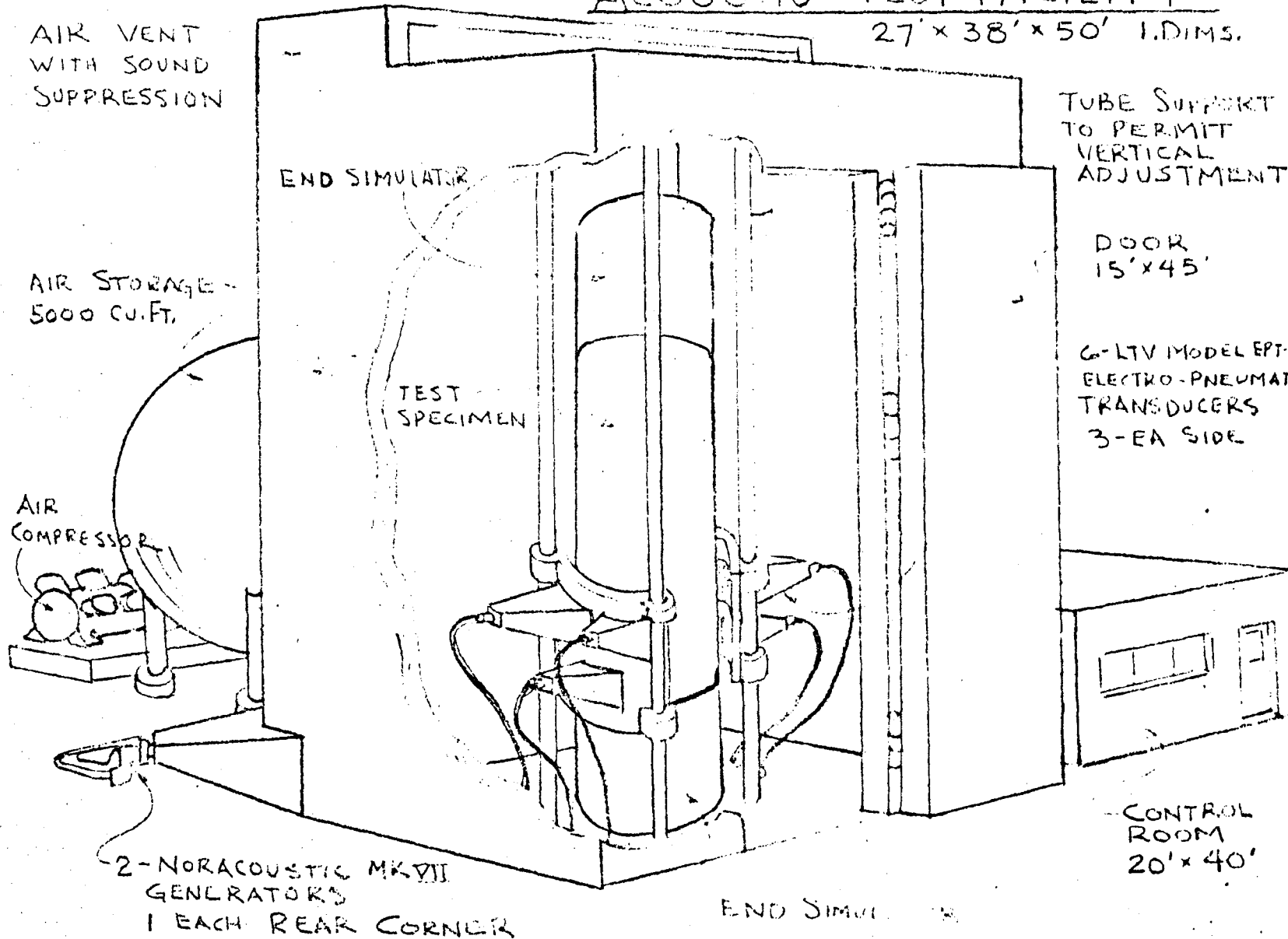
TEST  
SPECIMEN

AIR  
COMPRESSOR

2- NORAACOUSTIC MK VII  
GENERATORS  
1 EACH REAR CORNER

END SIMULATOR

CONTROL  
ROOM  
20' x 40'



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DEVELOPMENT TESTING

- o ACOUSTIC TESTING IS NEEDED TO DETERMINE ACCELERATION LEVELS RELIABLY THROUGHOUT THE VEHICLE
- o SEGMENT TESTS ARE TECHNICALLY SOUND BECAUSE OF THE NATURE OF ACOUSTIC EXCITATION
- o DEVELOPMENT TEST SHOULD BE RUN AT QUALIFICATION LEVELS
- o TEST PLANNING SHOULD NOT COUNT ON THE USE OF EKC FACILITY BECAUSE OF POTENTIAL DIFFICULTIES IN BRINGING IT ON LINE IN TIME AND MAKING AVAILABLE TO DAC
- o TWO CANDIDATES EXIST:

WYLE AT HUNTSVILLE

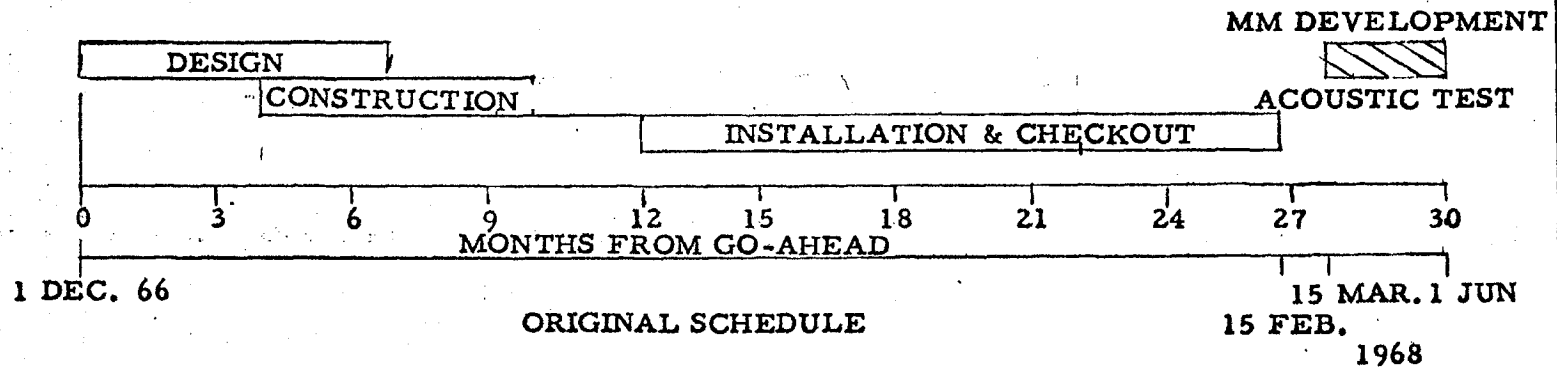
DOUGLAS AT SANTA MONICA

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EKC ACOUSTIC FACILITY SCHEDULE



SOURCE: BRIEFING BY DAVID SMITH, EKC - 28 NOVEMBER 1966

EK TWX DATED 18 NOVEMBER 1966 STATES: "LONG LEAD ITEMS  
(COMPRESSORS) FOR THE ACOUSTIC TEST FACILITY WILL  
DELAY SHIPMENT OF DSMM UNTIL 15 JUNE 1968."

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WYLE AND DAC S-M FACILITY MOD COST  
(DEVELOPMENT TESTING)

<u>WYLE</u>		<u>DAC</u>	
<u>MODS (LM &amp; MM)</u>		<u>MODS (LM ONLY)</u>	
EXCAVATE CHAMBER	.08	NEW BUILDING	.40
6 HORNS (EPT-200)	.13	3 HORNS (EPT-200)	.06
9000 CFM COMPRESSOR	.15	SHROUD	.05
MODEL TEST PROGRAM	.04	INSTRUMENTATION	.25'
AIR SYSTEM	.03	ENGINEERING	.23
MECHANICAL AGE	.12	AIR SUPPLY	.01
ENGINEERING	.54		<u>\$1.00M</u>
	<u>\$1.00M</u>		
		<u>LM AND MM</u>	
		3 HORNS (EPT-200)	.06
		COMPRESSOR	.22
		LINES	.01
		ENGINEERING	.09
			<u>\$.38M</u>
		GRAND TOTAL	\$1.38M

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QUALIFICATION TESTING

- COMPLETE LAB VEHICLE QUALIFICATION APPEARS DIFFICULT
- SEGMENT QUALIFICATION TESTS WITH PROPER INTERFACE SUBSTITUTES  
CAN ESSENTIALLY PROVIDE SATISFACTORY TEST
- DEVELOPMENT TEST PROVIDES GOOD STRUCTURAL QUALIFICATION,  
BUT ONLY GROSS COMPONENT ENVIRONMENT SIMULATION
- WYLE FACILITY REPRESENTS MOST DIFFICULT LOGISTICS PROBLEM  
FOR LM AND MM
- MODIFIED SANTA MONICA FACILITY COULD BE USED FOR BOTH LM & MM  
WITH LEASE LINE CONNECTION TO AGE IN HUNTINGTON BEACH  
(USE THERMAL VACUUM AGE INTERFACE UNITS AND VIDEO LINK)

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ACCEPTANCE TESTING CONSIDERATIONS

- TWO SCHOOLS OF THOUGHT
  - PRE- AND POST-CHECK WITH ARTICLE SUBJECTED TO FLIGHT LEVEL ENVIRONMENT (LIKE 1 MIN)
  - LOWER THAN FLIGHT LEVEL VIBRATION TESTS WITH CHECK FOR INTERMITTENT FAILURES DURING EXCITATION (UP TO MANY HOURS)
- MAJOR PROBLEM IS CHECKOUT TIME (SUMMARY CHECK OF MOST CIRCUITS)
  - LABORATORY MODULE      15 MIN > t < 60 MIN
  - TMB                              2 MIN > t < 10 MIN
  - COAB                              1 MIN

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TYPICAL ACCEPTANCE VIBRATION DEFECTS

- o LOW LEAKAGE RESISTANCE, NOISE IN RECORD PATH,  
W81 CABLE REPLACED
- o THREE SCREWS ON HEATER CONTROLLER AND TWO SCREWS  
ON TEST BOX CONNECTION LOOSENED IN VIBRATION - REPLACED
- o INTERMITTENT CPL-3 OUTPUT - WIRE WAS INTERMITTENT,  
OPEN AT LUG
- o LOOSE CONNECTING ROD ON APERTURE MASK ASSEMBLY - REPLACED
- o SCREW AND WASHER LYING IN CAMERA - BELIEVED DROPPED  
DURING ASSEMBLY
- o CAMERA ROLLER EXCESSIVE END PLAY - REPAIRED
- o PIVOT STUD BACK OUT - REPAIRED

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ACCEPTANCE TESTING

- AT LEAST "LOW LEVEL" TEST MANDATORY AT SEGMENT LEVEL
- SOME TYPE OF COMPLETE SYSTEM TEST NEEDED FOR REASONABLE ASSURANCE OF FLIGHT READINESS
- SEGMENT ACCEPTANCE TEST ON MM NEEDED BEFORE SHIPPING
- "BUNGEE SUPPORTED" SYSTEM TESTS USING SMALL SHAKERS AT INTER-SEGMENT POINTS APPEAR TO BE FEASIBLE

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LOW LEVEL EKC FACILITY

o ACOUSTIC FACILITY

REVERBERANT ROOM	32' x 42' x 60'
ACOUSTIC LEVEL	140 DB REVERBERANT
RUN DURATION	CONTINUOUS
ACOUSTIC HORNS	1 NOR AIR MK V
AIR SUPPLY	1200 CFM/300HP AIR COMPRESSOR
APPROXIMATE COST	\$1.8M

o VIBRATION FACILITY

TEST LEVEL	4G RMS (RANDOM)
SHAKERS	2 C-210 SYSTEMS
AMPLIFIERS	
EQUALIZERS	
CONTROLS	
LABORATORY SPACE	
APPROXIMATE COST	\$1.4M

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CONCLUSION CHART

- ACOUSTIC DEVELOPMENT TESTING NEEDED.
- SEGMENT LEVEL ACOUSTIC QUALIFICATION TEST HIGHLY DESIRABLE.
- LOW LEVEL ACCEPTANCE TEST IS A PRACTICAL NECESSITY AT BOTH SEGMENT AND SYSTEM LEVEL.
- LOW LEVEL ACOUSTIC TEST OF MM APPEARS TO BE THE SAME COST OF VIBRATION TEST.
- HIGH LEVEL MM ACOUSTIC TESTS SHOULD USE LOCALIZED HORN APPROACH.
- IF LAB MODULE QUALIFICATION IS PERFORMED, THE SANTA MONICA FACILITY SHOULD BE MODIFIED.

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ALTERNATE 1  
FULL ACOUSTIC TESTING  
DEVELOPMENT-QUALIFICATION-ACCEPTANCE

	SYSTEM	SEGMENT			COMPONENT		
		LM	TMB	COAB	LM	TMB	COAB
DEVELOP	0	ACOUSTIC*	ACOUSTIC*		VIB. & ACOUSTIC	VIB.	VIB. & ACOUSTIC
QUAL.	LOW-LEVEL INTERMITTENT	ACOUSTIC*	ACOUSTIC*		VIB. & ACOUSTIC	VIB.	VIB. & ACOUSTIC
ACCEP.	LOW-LEVEL INTERMITTENT	ACOUSTIC*	VIB.		VIB.	VIB.	VIB. & ACOUSTIC
			ACOUSTIC**				

\* TEST AT SANTA MONICA  
\*\* TEST AT EK (LOCALIZED HORNS)

<u>DAC</u>	
SPECIAL QUAL. ARTICLE	15.0M - 20M
TEST MANHOURS	.4M
SM FACILITY	1.4M
ACCEPT. TEST	.5M
	<hr/>
	17.3M - 22.3M
<b>TOTAL COST</b>	<b>19.8M - 24.8</b>

<u>EK</u>	
ACOUSTIC FACILITY	\$2.1M
TEST MANHOURS	.4
	<hr/>
	<b>\$2.5M</b>

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ALTERNATIVE NO. 2  
FULL DEVELOPMENT AND ACCEPTANCE TESTING  
SEGMENT QUALIFICATION TESTING ON LM ONLY

	SYSTEM	SEGMENT			COMPONENT
		LM	TMB	COAB	
DEVELOP	0	ACOUSTIC*	ACOUSTIC*		VIBR. & ACOUSTIC
QUAL.	LOW-LEVEL INTERMITTENT	ACOUSTIC*	VIBR.		VIBR. & ACOUSTIC
ACCE PT.	LOW-LEVEL INTERMITTENT	LOW-LEVEL INTERMITTENT	LOW-LEVEL TEST AT ONF		VIBRATION

\*TESTS AT DAC SANTA MONICA

DAC

- SM FACILITY MOD \$ 1.4M
- TEST MANHOOURS .4M
- QUAL. LM USING COMPONENTS FROM QUAL. PROGRAM 15.0M - 20.0M
- ACCEPT. TEST .5M

\$17.3 - 22.3M

EK

- LOW LEVEL FACILITY \$ .90M
- TEST MANHOOURS .40M
- USE QUAL TEST MM FOR FL. #7 -10.00M
- (SAVING) \$- 8.70M

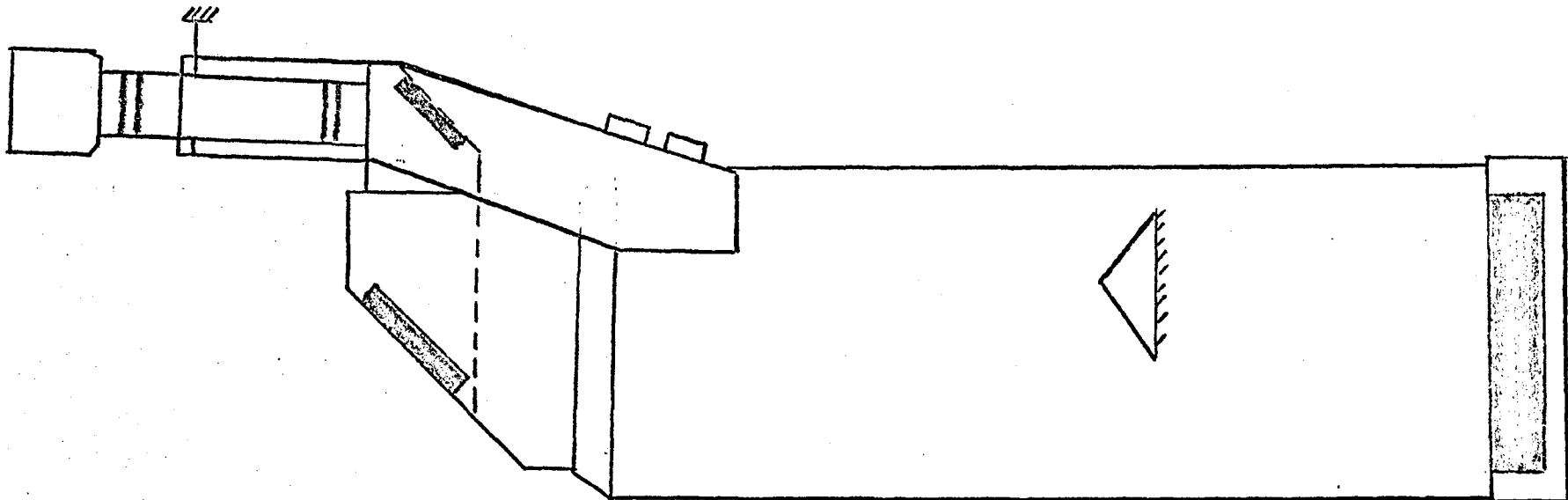
TOTAL NET COST ≈ \$8.6M - \$13.6M

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MISSION MODULE STRUCTURAL ARRANGEMENT



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ALTERNATE NO. 3  
FULL DEVELOPMENT AND ACCEPTANCE TESTING  
SEGMENT QUALIFICATION TESTING ON MM ONLY

	SYSTEM	SEGMENT			COMPONENT		
		LM	TMB	COAB	LM	TMB	COAB
DEVELOP	---	ACOUSTIC*	ACOUSTIC AT EK		VIBR. & ACOUSTIC	VIBR.	VIBR. & ACOUSTIC
QUAL.	---	---	ACOUSTIC AT EK		VIBR. & ACOUSTIC	VIBR.	VIBR. & ACOUSTIC
ACCEPT.	LOW-LEVEL INTERMITTENT VIBR. TEST	LOW-LEVEL VIBR. TEST	VIBR.	ACOUSTIC AT EK	VIBR.	VIBR.	VIBR. & ACOUSTIC

\*TEST PERFORMED AT SANTA MONICA

DAC

ACCEPT. TEST \$ .5M

TOTAL COST ≈ \$2.6M

EK

MODIFIED HIGH LEVEL  
ACOUSTIC FACILITY \$2.1M

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RECOMMENDATIONS

- ② SEGMENT LEVEL ACOUSTICAL QUALIFICATION TESTING SHOULD BE ADOPTED UNIFORMLY THROUGHOUT THE PROGRAM FOR MINIMUM RISK.
- ② LOW-LEVEL ACCEPTANCE TEST FOR WORKMANSHIP AND FUNCTIONAL CONTINUITY SHOULD BE IMPLEMENTED AT THE SEGMENT AND SYSTEM LEVEL.
- ② CONTRACTOR ASSESSMENT OF COSTS AND SCHEDULE IMPACTS OF PROPOSED ALTERNATES SHOULD BE OBTAINED.

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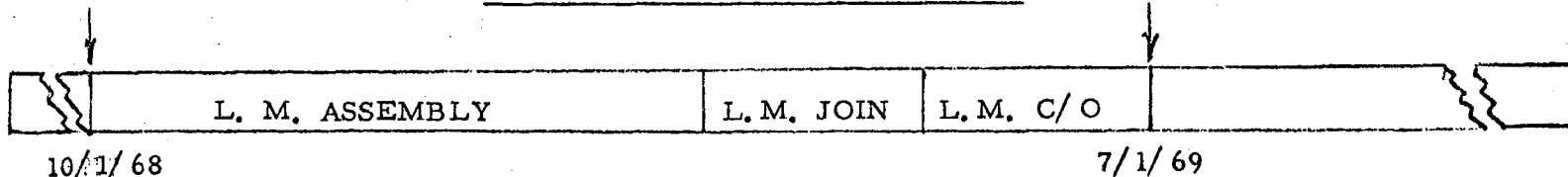
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SPECIAL TEST VEHICLE

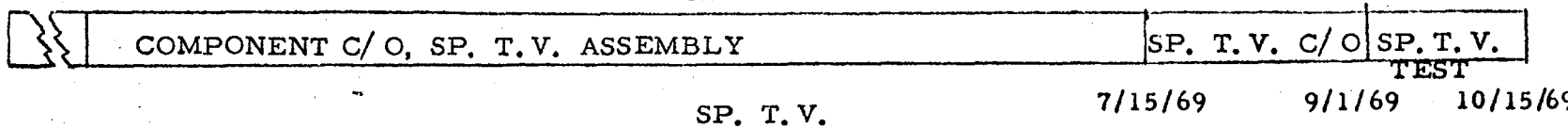
FOR

DYNAMIC QUALIFICATION TEST

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FV - 3



SP. T.V.

COST

STRUCTURE -----	2.0M
COMPONENT C/O -----	1.5
NEW ASSY. STAND -----	0.5
NEW COMPONENTS -----	6.0
FABR., C/O & TEST OF SP. TEST UNIT -----	5.5
<hr/>	
TOTAL -----	\$15.5M

- Note: (1) Extra assembly stand required to keep present production schedule.  
 (2) Checkout of new LM might delay launch of #4 by 4 to 6 weeks.

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ACOUSTIC QUALIFICATION TEST SCHEDULE ALTERNATIVES  
(USING LM-QTV FOR ALL SEGMENT QUAL. TESTS)

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INSERT QUAL. ACOUSTIC TEST INTO CURRENT SCHEDULE PRIOR TO QUAL. THERMAL  
VACUUM TEST

PRESERVES ORDERLY SEQUENCE OF QUAL. & ACCEPTANCE TESTS  
PRESERVES LOGICAL SEQUENCE OF ACOUSTIC & T/V TESTS  
SLIPS LAUNCH SCHEDULE ONE MONTH

ABOVE PLUS SPLIT QUAL. THERMAL VACUUM TEST

DELAYS QUAL. T/V AFTER ACCEPTANCE, SPLITS QUAL. T/V  
PRESERVES LOGICAL SEQUENCE OF ACOUSTIC & T/V TESTS  
NO SLIP OF LAUNCH

ADD QUAL. ACOUSTIC TEST AFTER QUAL. THERMAL VACUUM TEST

PRESERVES ORDERLY SEQUENCE OF QUAL. & ACCEPTANCE TESTS  
REVERSES LOGICAL SEQUENCE OF ACOUSTIC & T/V TESTS  
QUAL. TESTING COMPLETE PRIOR TO FV #3 SHIPMENT FROM HB  
NO SLIP OF LAUNCH

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ALTERNATE NO. 4

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FULL DEVELOPMENT AND ACCEPTANCE TESTING  
NO SEGMENT QUALIFICATION TESTING

	SYSTEM	SEGMENT			COMPONENT
		LM	TMB	COAB	
DEVELOP.	0	ACOUSTIC*			VIBRATION & ACOUSTIC
QUAL.	LOW LEVEL VIBRATION CHECK	---	---	---	VIBRATION & ACOUSTIC
ACCEPT.	LOW LEVEL VIBRATION CHECK	LOW LEVEL ACOUSTIC	VIBR. LOW LEVEL ACOUSTIC AT EK		VIBRATION

\* TESTS AT SANTA MONICA

SUPPORTING COST BREAKOUT:

<u>DAC</u>		<u>EK</u>	
FACILITY MOD	1.4M	FACILITY	.9M
TEST MAN HRS	.8M	TEST MAN HRS	.2M
ACCEPT. TEST	.5M	DELETE ONE SET HDW	-10.0M (Savings)
	<u>\$2.7M</u>		<u>- 8.9M (Savings)</u>
TOTAL COST	≈ -6.2M (Savings)		

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HISTORICAL DATA ON OTHER PROGRAMS

	QUALIFICATION		ACCEPTANCE	
	COMPONENT	SYSTEM	COMPONENT	SYSTEM
GEMINI	VIBRATION ACOUSTIC	NONE	VIBRATION	NONE (GT-3 VIB)
APOLLO	VIBRATION*	ACOUSTIC*	LOW-LEVEL VIBRATION (PARTIAL STRUCTURE TEST)	NONE
206-I	VIBRATION	NONE	VIBRATION	LOW-LEVEL VIBRATION
206-II	VIBRATION	NONE	VIBRATION	NONE

\* THEORETICALLY DETERMINED LEVELS

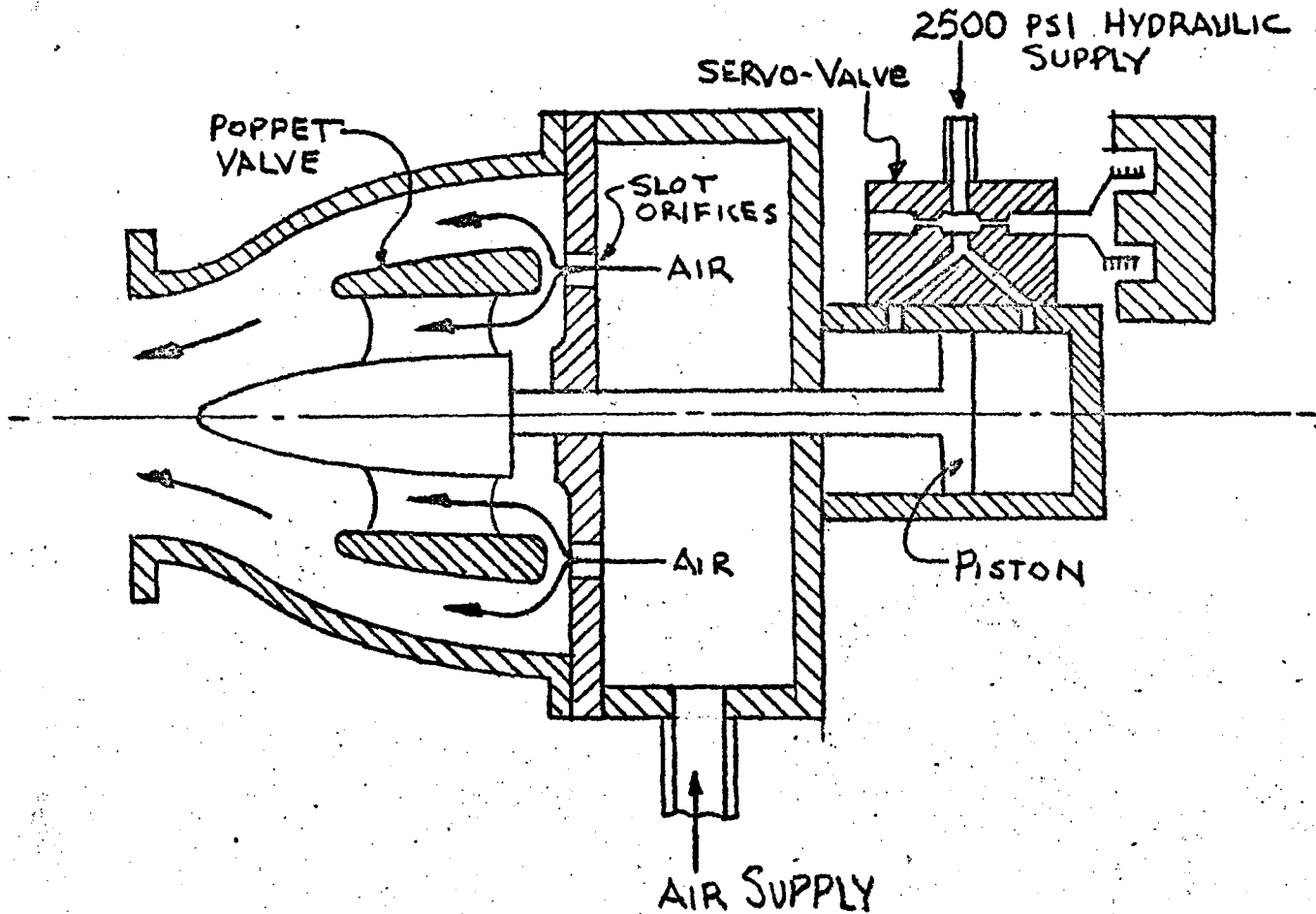
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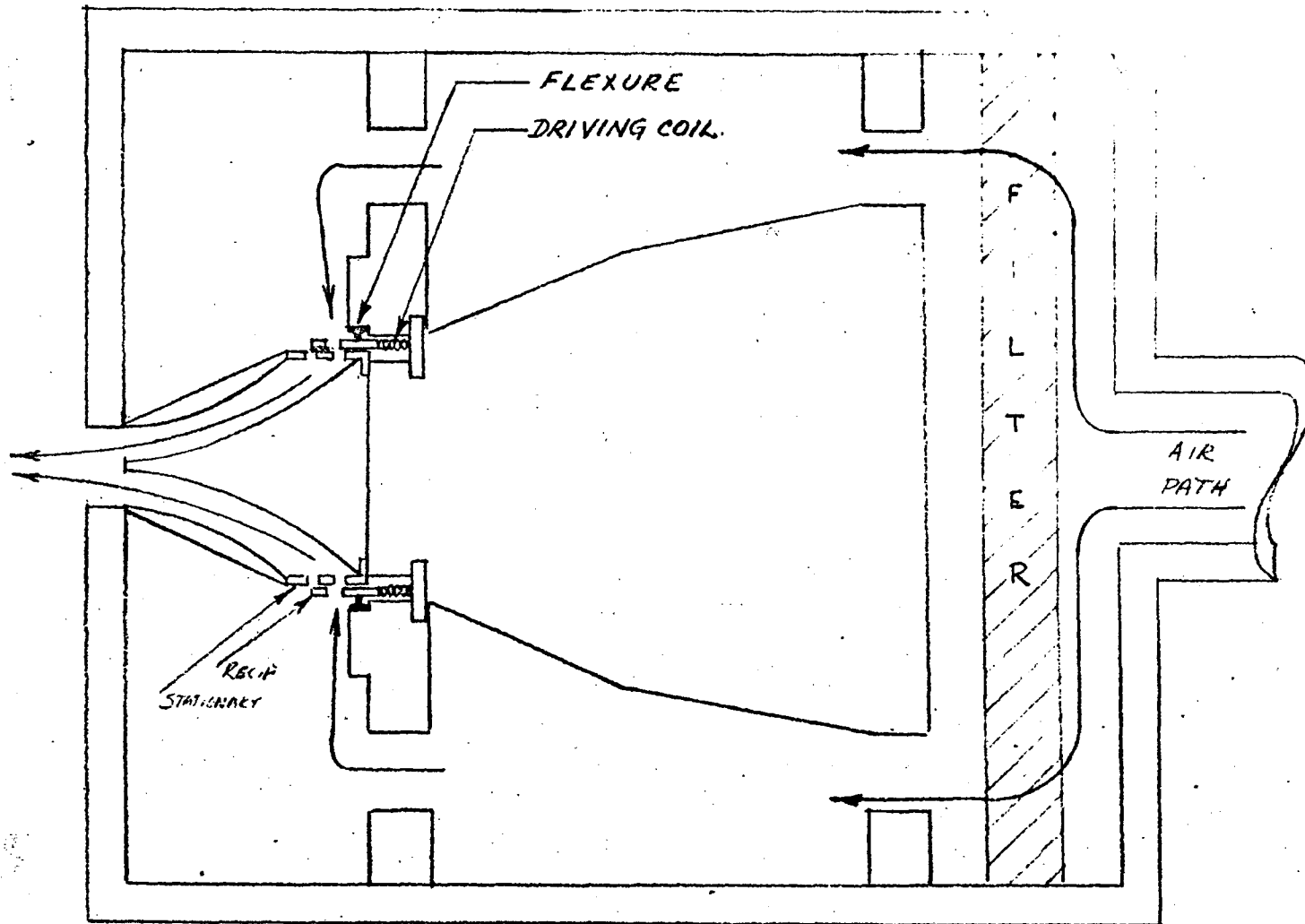
# NORAIROUSTIC GENERATOR

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LTV-ELECTROPNEUMATIC TRANSDUCER

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<u>PROGRAM</u>	<u>WEIGHT</u>	<u>DEVELOPMENT</u>	<u>QUALIFICATION</u>	<u>ACCEPTANCE</u>
Mercury	2.7 K	Flight V	A V	0
Gemini	8.5 K	Flight V	V	V - Future programs will
Apollo				
Command & Service Mod	27 K	A	0	0 - GE proposal all up
LEM	36 K	A V	0	0 - Acoustic taken out Future programs will
206-I	1.7 K (partial)	V	V	V
206-II	4.6 K (partial)	V	V	V
Saturn V				
S-II	50 K	)	Flight A V	0
Aft Interface	13 K			
Fwd Skirt	8 K			

V = System Vibration

A = System Acoustic

~~SECRET~~ SPECIAL HANDLING

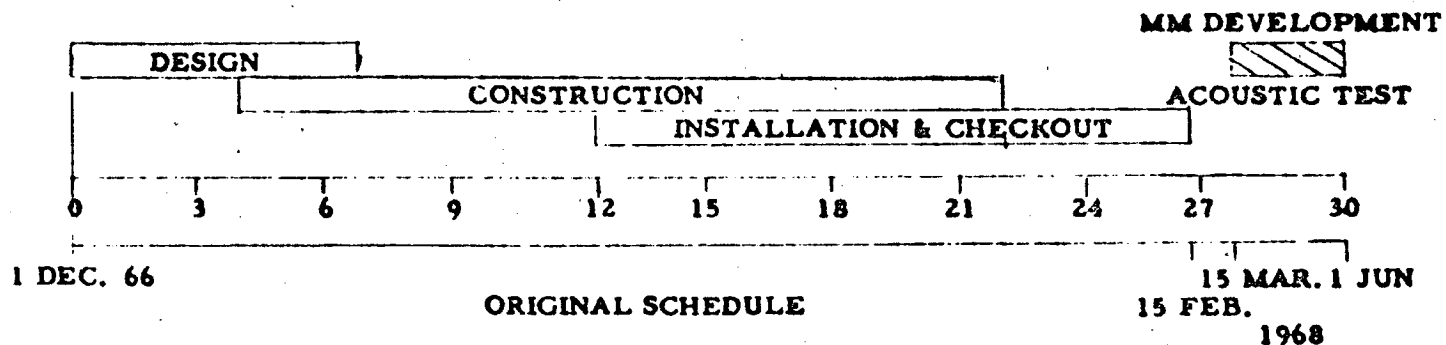
SMT-  
005 - 33  
cy1

~~SECRET~~ SPECIAL HANDLING

WHS-

WHS- 180  
p9 33

EKC ACOUSTIC FACILITY SCHEDULE



SOURCE: BRIEFING BY DAVID SMITH, EKC - 28 NOVEMBER 1966

EK TWX DATED 18 NOVEMBER 1966 STATES: "LONG LEAD ITEMS  
(COMPRESSORS) FOR THE ACOUSTIC TEST FACILITY WILL  
DELAY SHIPMENT OF DSMM UNTIL 15 JUNE 1968."

~~SECRET~~ SPECIAL HANDLING

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