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TEST AND EVALUATION OF 18,000 BTUH/100 CFM INTEGRATED CHEMICAL FILTER AND ENVIRONMENTAL CONTROL EQUIPMENT (ICE) UNIT

VSE Corporation
2550 Huntington Avenue
Alexandria, VA 22303-1499

30 September 1986

Final Report for Period 19 November 1985 - 30 September 1986

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Prepared for:

U.S. Army Belvoir Research, Development and Engineering Center (BRDEC)
Environmental Control Division
Fort Belvoir, VA 22060-5606

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A prototype 18K/100 ICE Unit was tested, modified, evaluated and had a Level 1 drawing package updated according to task order requirements. The results of this effort yielded seven pretest and six post-test hardware modifications, a proposed operator and maintenance manual, and 34 recommended changes to be incorporated into a production ICE unit. If adopted, these 34 changes will give an estimated savings of 22 pounds, 0.2 cubic feet, and $4,000.00 per unit. VSE Corporation recommended that the changes be adopted and the proposed manual be fully developed for future use.

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SUMMARY

One prototype 18,000 BTUH/100 CRM Integrated Chemical Filter and Environmental Control Equipment (ICE) Unit was built for the U.S. Army Belvoir Research, Development and Engineering Center (BRDEC) by the VSE Corporation under Task Order 0166 to BRDEC Contract DAAK70-81-D-0109. This unit, known as the 18K/100 ICE Unit, combined the separate chemical filter equipment and the environmental control equipment into a single unit. Task Order 0190 was for a follow-on effort to test, evaluate, modify, redesign, and update Level 1 drawings for the prototype unit. Results of this effort provided for improved performance, maintainability and reliability, and reductions in weight, volume and cost.

A pretest ICE Unit evaluation resulted in seven hardware modifications before tests began. Following tests and data evaluations concerned with cooling, heating, and airflow capacities, and acoustic signature, VSE made an additional six hardware modifications. Hardware modifications resulted in improved unit performance, maintainability and reliability.

During the test period, VSE developed a proposed operator and maintenance manual for subsequent ICE Unit operation. The manual, in its earlier working draft form, was very useful during the test of the ICE Unit.

After completing unit tests, evaluations, hardware modifications, and Level 1 drawing updates, VSE again evaluated the unit's design. This evaluation yielded 34 design changes which were recommended for incorporation in a production unit design package. These changes provided for an estimated unit reduction of:

- weight - 22 pounds.
- volume - 0.2 cubic feet.
- cost - $4,000.00.

PREFACE

This report was prepared by authority of Task Order C190 to BRDEC Contract DAAK70-81-D-0109. Contract 0109 requires VSE to provide engineering and technical support for a range of R & D projects being performed by the U.S. Army Belvoir Research, Development and Engineering Center. Task Order 0190 provided for test, evaluation, modification, and redesign of the prototype 18K/100 ICE Unit which was built for BRDEC by VSE under Task Order 0166.

The authors of this report wish to acknowledge the very valuable guidance and contributions provided by Mr. Robert A. Rhodes, Jr. of BRDEC (STRBE-FE).

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1. INTRODUCTION

1.1 Background. The U.S. Army Belvoir Research, Development and Engineering Center (BRDEC) is developing the 18K/100 ICE Unit. This unit, which uses a new General Motors V-5 automotive compressor, is protected from Electromagnetic Interference ('"MI) and will withstand chemical decontamination treatments. It will operate . worldwide climate conditions ranging from hot-dry through severe cold as described in Army Regulation (AR) 70-38, Research, Development, Test and Evaluation of Materiel for Extreme Climatic Conditions.

1.2 Unit Description

1.2.1 Nomenclature. This unit is known as the 18K/100 ICE Unit or 18,000 BTUH/100 CFM Integrated Chemical Filter and Environmental Control Unit. As the name implies, it is an 18,000 BTUH air conditioner/heater combined with a 100 CFM chemical/biological filter, all in one enclosure.

1.2.2 Size. Basic unit dimensions are 33.5" deep (front to back), 29.6" wide and 25.8" high, not including screw heads and control projections.

1.2.3 Enclosure. The 18K/100 ICE Unit has a painted, welded aluminum frame, aluminum skin enclosure. The face of the unit which contains the control panel is identified as the front, and other faces are defined in relation to the front.

1.2.4 Weight and lifting. The prototype unit, as developed, weighs 315 pounds and can be lifted with a crane and a four-leg sling using the four lifting rings near each of the top corners. If extreme caution is used to prevent damaging the bottom skin, a fork lift can also be used to lift the unit.

1.2.5 Electric power. The 18K/100 ICE Unit operates on a 208 volt, 3-phase, 4-wire, 60 Hertz electrical supply. The power supply should be capable of sustaining a 7500 watt load with a 21-ampere current. The power supply should be protected by three 30-amp slow-blow fuses or a circuit breaker.

1.2.6 Unit capacitites. The 18K/100 ICE Unit nominal capacities are as follows:

Cooling: 18,000 BTUH
Heating: 24,000 BTUH
Chemical-Biological (CB) Filtered Fresh Air: 100 CFM
Normal Fresh Air Intake: 40 CFM
Conditioned Air Discharge: 650 CFM @ .25 ESP

1.3 Statement of problem. To improve performance and reduce the weight, volume, and cost of a government furnished prototype 18,000 BTUH/100 CFM Integrated Chemical Filter and Environmental Control (18K/100 ICE) Unit.

1.4 Approach to problem. Task Order 0300.0190 of Contract DAAK70-81-D-0109 required VSE Corporation to provide engineering evaluation, prototype manufacturing, testing, and documentation services in support of the 18K/100 ICE Unit. This support consisted of testing and evaluating the unit, performing a design evaluation, redesigning and modifying the unit, and updating the "as built" Level 1 engineering drawings.

1.5 Reference to related work. U.S. Army Belvoir Research, Development and Engineering Center (BRDEC) Contract DAAK70-81-D-0109, Task Order 0300.0166, required VSE to design and produce a prototype 18K/100 ICE Unit. This unit was constructed, tested, and delivered to BRDEC per task order. The current task, 0300.0109, is a follow-on effort to improve performance and reduce weight, volume, and cost of the previously delivered BRDEC prototype unit.

1.6 Purpose of report. To document the results of an equipment modification and test program to improve performance and reduce weight, volume, and cost of a prototype 18K/100 ICE Unit.

2. INVESTIGATION

2.1 General. Between 19 November 1985 and 30 September 1986 VSE tested, evaluated, and modified the government furnished prototype 18K/100 ICE Unit. Additional modifications for incorporation into the production unit were identified. And, the "as built" prototype drawing package was upgraded to DOD-D-1000 Level 1 requirements.

2.2 Work accomplished. Work accomplished in support of this task included:

- evaluating the prototype design.
- making prototype pretest modifications.
- testing the prototype.
- evaluating test data.
- making prototype post-test modifications.
- evaluating the prototype post-test design.
- identifying additional modifications for use in production units.
- estimating reductions for weight, volume, and cost.
- upgrading "as built" drawings.

Details of work accomplished are discussed in Section 3.

3. DISCUSSION

3.1 Pretest design evaluation. The pretest design evaluation of the prototype ICE Unit showed that some pretest modifications would improve the performance, reliability, and maintainability of the unit. These modifications were made before unit tests began. They consisted of:

- Slowing the compressor to 1539 rpm. Early government furnished compressor data required 2000 rpm, but subsequent government tests showed that 2000 rpm was excessive. The manufacturer's data was used to select 1539 rpm.

- Changing from a serviceable bearing idler to a permanently lubricated sealed bearing to minimize required maintenance.

- Installing a removeable hinge pin in the clean air duct so that duct can be easily removed to facilitate maintenance in the compressor area.

- Rerouting refrigerant lines near the lower rear of the unit to provide better access to the compressor mounting bolts.

- Relocating the support strut for the CB cradle to provide better access to compressor and motor.

- Changing the fastener layout to reduce the number of return air filter fasteners (without jeopardizing EMI protection) to reduce maintenance.

- Installing additional rivets in the bottom pan of the unit to prevent buckling.

3.2 Test and evaluation. A series of tests of the prototype ICE Unit were conducted after completion of the pretest modifications (para. 3.1). These tests provided operating experience and data directly concerned with the unit's capacity for cooling, heating, and air flow. Tests were also made for the unit's free field acoustic signature. Calculations shown later in this section are derived from the test data base shown in appendix A. Evaluations were made using test data, test results, and personal experience from operating the ICE Unit.

3.2.1 Cooling capacity tests. Cooling capacity testing was accomplished by the psycnrometric method using: a hot wire anemometer survey to measure average air flows in temporarily connected ducts; a slant-tube manometer to determine static pressure; service set gauges to measure refrigerant pressures; and, thermocouple grids for measuring temperatures. Barometric pressure and relative humidities were obtained from telephone recorded local weather reports. These tests were approved by the BRDEC Technical Advisor for this task order.

3.2.1.1 Cooling capacity - wet coil conditions. With a sensible capacity of 18,537 BTUH, and a latent capacity of 1303 BTUH the ICE Unit produced 19,840 BTUH during this test. Conditions which existed during the test were:

- outside temperature - 120°F
- inside dry-bulb temperature - 90°F
- inside wet-bulb temperature - 73°F
- external evaporator static pressure - 0.25 inch w.g.

Calculations, shown in appendix A, page A-7, were made using data shown in pages A-1 through A-6.

3.2.1.2 Cooling capacity - dry coil conditions. The calculated dry coil cooling capacity of the ICE Unit is 18,455 BTUH. This value compares favorably with the 18,000 BTUH required cooling capacity. Conditions which existed during the test were:

- o outside temperature - 120°F
- o inside dry-bulb temperature - 90°F
- o inside wet-bulb temperature - 61°F
- o external evaporator static pressure - 0.25 inch w.g.

Calculations, shown in appendix A, page A-8, were made using data shown in pages A-1 through A-6.

3.2.2 Heating capacity tests. Heating capacity data were also obtained psychrometrically. Calculations for both high and low heat capacities used data shown in appendix A, pages A-1 through A-6 and page A-10. The curve on page A-10 was developed before the heating capacities were calculated. Resulting values were justified using the electrical power input as measured during these tests.

3.2.2.1 High heat capacity. The calculated heating capacity in the High Heat mode is 23,976 BTUH. Electrical verification of this value, using an estimated system efficiency, yielded 23,927 BTUH.

A theoretical calculation based on the number of heating elements and their estimated wattage at the applied voltage gave 23,962 BTUH. Specified heat was 24,000 BTUH which would be attained at 208 volts. Calculations are shown in appendix A, page A-9.

3.2.2.2 Low heat capacity. The calculated low heat capacity is 11,968 BTUH at 205 volts. Required capacity was 12,000 BTUH. This would have been attained at 208 volts. Calculations are shown in appendix A, page A-9.

3.2.3 Air flow capacity tests

3.2.3.1 Recirculated air flow. The graph of recirculated air flow in appendix A, page A-10, represents the evaporator air flow volume available from the unit at various external static pressures. This curve was based on air flow test measurements, as represented by data sheets in appendix A, pages A-11 through A-18.

3.2.3.2 Fresh air intake air flow. The fresh air intake air volume was approximately 49 CFM over the range of 0" to 0.25" w.g. (evaporator) external static pressure. This determination was made based on air measurements as documented in appendix A, pages A-19 and A-20. The specified minimum fresh air intake volume was 40 CFM.

3.2.3.3 CB system air flow. The Chemical-Biological (CB) filter element is a GFE military M-48 filter combining activated charcoal and particulate filters in one package. It is sized for about 100 CFM. The GFE filter fan employed in the 18K/100 ICE Unit is from a new 100 CFM filter being developed by the Chemical Research and Development Center at Edgewood Arsenal, MD. It is a variable speed fan, electronically controlled to maintain a specific pressure (0.5" w.g.) within the conditioned shelter. Maximum CB air flow into the unit under various unit operating modes and external evaporator pressures (from 0" to 0.25" w.g.) was 144 to 149 CFM. Specified minimum CB air flow was 100 CFM. Appendix A, pages A-21 through A-23, shows data for the CB system air flow capacity test.

3.2.3.4 Reverse air flow CB filter. The CB filter air flow enters the evaporator section after the evaporator fan. When the CB fan is not operating, the evaporator fan imposes a positive pressure in the area of the CB discharge, causing a slight reverse air flow through the CB filter system. The air volume varies from about 9 to 15 CFM with external evaporator static pressure between 0" and 0.25" w.g. We believe that this is an unacceptable air loss from the evaporator compartment during normal (non-CB) operation. Therefore, we have included a proposed modification to the unit (para. 3.4) to prevent this leakage, using a check valve in the CB filter discharge (clean air) duct. Appendix A, pages A-24 and A-25, shows data for the reverse air flow test.

3.2.4 Free field acoustic signature test. This test of the 18K/100 ICE Unit was designed to provide free field sound level data from both the condenser and evaporator sides of the unit. Data taken while the unit was operating concerned:

- maximum cooling mode alone.
- maximum cooling with CB fan mode.
- CB fan only mode.
- evaporator side fan and in vent mode only.

After data reduction, a comparison between similarly acquired data for the 18K BTUH Horizontal Air Conditioner was made. The comparison shows the 18K/100 ICE Unit to quickly rise to its maximum sound pressure levels at 250 Hertz and drop off thereafter, while the 18K Horizontal Unit quickly peaks at 125 Hertz and drops off above that.

On the condenser side, the condenser fan is a prime candidate for sound generation. And, on the evaporator side, the noise is probably transmitted from the condenser fan by the unit frame.

Appendix B is a report of the free field acoustic signature test.

3.2.5 Post-test evaluation and prototype modifications. During the testing of the 18K/100 ICE Unit, VSE test and engineering personnel observed that a few additional modifications would immediately improve the unit's performance, maintainability, and reliability. These modifications, shown as follows, were made and the unit checked out O.K.

- Installed a reoriented face plate over the GFE CB System Control Module (control panel) to facilitate reading the panel and also to change design and wording for clarity and HFE considerations.

- Installed sound attenuation material inside the CB air intake duct.
- Installed six mounting inserts in the bottom of the unit.
- Changed to a 35 blade pitch condenser fan to increase air flow and reduce head pressure.
- Installed a directional air flow sign on the partition beside the CB filter to assure correct orientation.
- Ground flats on the rotary damper solenoid shaft to prevent coupling from rotating on the shaft.

3.3 Post-test design evaluation. Many proposed changes were made as result of VSE's effort relating to its pretest design evaluation, test and evaluations, post-test evaluations and hardware modifications. A final post-test design evaluation of all data and observations showed that the following changes would be beneficial if incorporated into a production 18K/100 ICE Unit:

- Extend the body length of the fresh air inlet duct slightly to properly compress the gasket on the return air frame.
- Consolidate harnesses with wires running in the same locations.
- Check for proper heater overtemperature switch settings and change if needed.
- Soft mount the motor and compressor to reduce conducted noise.
- Include a pilot type overtemperature switch in the motor windings to protect the motor.
- Provide spade type terminals on the motor to improve maintainability.
- Provide a jacking type arrangement between the compressor and the motor to facilitate tightening the belt.
- Change to spade type terminals on the condenser fan clutch and rotary solenoid.
- Provide EMI type sealing compound behind lifting rings, for both EMI and environmental seal.
- Install a sealing cap behind each lifting ring pivot to minimize EMI and air leakage.
- Rivet the partition in place rather than welding to prevent warpage. Bed the partition in sealing compound.

- Revise the CB fan mount to correct slight misalignment and use a fixed clip at the back fan mounts for easier maintenance.

- Provide automatic belt adjustment mechanisms to minimize need for maintenance.

- Delete the standing seam on all panels. It appears that these are unneeded and only add weight.

- Install Teflon surfaces on CB filter cradle to allow filter to be slid into place on the cradle.

- Install a check valve in the clean air duct to prevent evaporator air loss backwards through the filter system.

- Add a small sponge rubber block to the top panel in the condenser section to retain the filter belt clamp.

- Provide a second flat on the condenser fan shaft to accept the second set screw in the fan hub.

- Specify EMI sealing compound where the bottom skin is installed against the frame for EMI integrity.

- Remove the suction line accumulator/drier and install a filter-drier and receiver. We probably don't need the accumulator with TXV's, but without a receiver excess refrigerant charge raises the head pressure.

- Use precision belts to minimize noise in the belt-idler area.

- Review Riv-nut locations to prevent interference between screws at corners and edges.

- Use stainless steel Riv-nuts where possible and minimize the use of Pem-nuts. Pem-nuts can easily be dislodged.

- Use surface mounted heads on Riv-nuts wherever possible. Installation is cheaper than with countersunk heads and countersinking in 1/16" metal doesn't provide enough material for good grip.

- Use zinc or cadmium plated mild steel screws and bolts. SS screws with SS nuts often gall, ruining threads.

- Provide a 2" x 2" EMI window over the sight glass. The 1" x 2" window installed in the prototype makes it difficult to see refrigerant conditions.

- Install a 3" x 3" window near the motor pulley for checking rotation direction of the motor.

- Redesign the clean air duct for easier opening and closing.

- Provide a smaller hole in the dirty air duct where the filter inlet penetrates, so that the filter cannot be installed backwards.
- Install a directional air flow sign near the CB filter so that the installer will place the filter correctly in its cradle.
- Consider a redesign of the control panels to eliminate overlaps so that the air conditioner panel can be opened for servicing without first having to remove the CB control panel.
- Investigate the proposed General Motors electronic control valve for the V-5 compressor to see if it might be practical for the ICE Unit.
- Fabricate a block-off panel with pass-through MS connectors so that the control panel can be remoted and attached to the unit through a remote cable.
- Eliminate the very expensive CB fan and electronic control system and substitute a clutch activated CB blower, belt driven from the main motor, with damper controls to maintain proper shelter pressure. This change could drop the CB fan costs to about 1/3 of the present $6,000.00 price.

3.4 Estimated weight, volume, and cost reductions. Taking into account the pretest, post-test, and proposed prototype unit modifications, VSE developed estimates for reduction in unit weight, volume, and cost.

3.4.1 Estimated weight reduction. VSE estimates that the original 320.5 pound prototype unit can be reduced to 298.5 pounds. This 22 pound weight reduction can be achieved as follows:

Change	Reduction
Smaller compressor drive pulley	0.8
Motor	7.0
Transformer	3.0
Compressor clutch	0.5
Metal grilles (6): reduce frame material from .064 to .050, and mesh from .125 to .090	3.0
Housing: reduce all 1" square tubing to 3/4"; all 1 1/2" x 1" and 2" x 1" tubing from 1/8" wall to 1/16" wall; other miscellaneous changes	5.0
Panels: remove reverse standing flanges from all panels	1.0
Hardware: reduce screw length	0.3
Use aluminum pulleys	1.4
WEIGHT REDUCTION	22.0

3.4.2 Estimated volume reduction. VSE estimates that a 0.2 cu ft volume reduction of the prototype unit can be made by incorporating all pretest and post-test modifications and proposed changes (para. 3.3) for the production unit. Each dimension of the unit would be slightly reduced.

3.4.3 Estimated cost reduction. A major unit cost reduction can be obtained by changing the CB fan and electronic control system to a clutch activated CB blower. This change will reduce the CB fan cost by at least 67% of the present $6,000.00 cost.

3.5 Updated drawings. The original Level 1 prototype unit drawings have been changed to the current post-test "as built" condition. These drawings, updated to DOD-D-1000 requirements, do not include any proposed modifications (para 3.3). All drawings were provided separately to BRDEC (STRBE-FE).

3.6 Prototype unit manual. During the operational tests of the unit, test personnel recognized the need for some form of an operator and maintenance manual. Consequently, such a manual was developed in draft form. This manual, shown in appendix C, provides the equipment user with readily accessible information pertinent to any further unit operation, test, and maintenance actions.

4. CONCLUSIONS

As a result of performing prototype operational tests, analyzing test data, and evaluating the initial 18K/100 ICE Unit design, VSE concludes that:

- the prototype weight can be reduced by 22.0 pounds if all modifications and proposed changes are incorporated into the production unit design.
- an estimated 0.2 cu ft unit volume reduction can be achieved if all changes are incorporated into the production unit design.
- an estimated unit cost reduction of $4,000.00 can be obtained by changing the prototype CB fan and electronic control system to a clutch activated CB blower.
- the draft operator and maintenance manual shown in appendix C will assist in further tests of the 18K/100 ICE Unit. This manual can also be expanded for use with production units.

5. RECOMMENDATIONS

VSE recommends that:

- modifications and proposed changes be incorporated into the production model of the 18K/100 ICE Unit.
- the draft operator and maintenance manual (appendix C) be expanded and used for further prototype tests and for production units.

APPENDIX A

TEST DATA
18K/100 ICE UNIT

18K/100 ICE TEST DATA

DATA TAKEN BY: Sherfy/Hicks

TIME	10:13	10:37	10:50	11:16	11:29	11:48
BAROMETER PRESSURE		29.81			29.88	
RELATIVE HUMIDITY		48%			50%	
DATE (1986)	5/28	5/30	5/30	5/30	5/30	5/30
OPER. MODE/TEMP. CONTROL*	C/C	C/C	C/C	C/C	C/C	C/C
VOLTS PHASE A	208	206	206	206	206	203
PHASE B	208	208	208	208	208	203
PHASE C	208	207	208	207	208	203
AMPS LINE A	9.8	12.6	12.5	12.6	12.6	12.5
LINE B	9.9	12.5	12.4	12.5	12.6	12.5
LINE C	9.9	12.5	12.5	12.5	12.7	12.5
NEUTRAL	0.0	0.7	0.7	0.7	0.7	0.7
AIR SP - EVAP OUTLET	.25	.23	.25	.25	.25	.25
VOLUME - EVAP INLET AIR		613	613	613	613	613
EVAP INLET AIR TEMP 1	89	91	91	92	91	90
EVAP INLET AIR TEMP 2	89	92	91	92	91	91
EVAP OUTLET AIR TEMP 3	68	64	64	64	64	63
COND OUTLET AIR VOLUME	1276	1276	1276	1276	1276	1276
COND OUTLET AIR TEMP 4	137	148	149	148	148	147
COND INLET AIR TEMP 5	120	123	124	123	123	122
COND INLET AIR TEMP 6	117	121	122	121	121	121
REFRIG. HEAD PRESSURE	211	267	267	270	267	263
REFRIG. SUCT PRESSURE •	40	49.5	49.5	49.5	49.5	48.5
CONDENSATE OUT (GMS)		0.0	YES	YES	YES	YES
SIGHT GLASS	CLR	CLR	CLR	CLR	CLR	CLR
STOP RUN	10:57					

*C = COOL OR COOLER. W = WARMER

18K/100 ICE TEST DATA

DATA TAKEN BY: Sherfy

TIME	1:31	1:58	2:10	2:24	3:25	3:37
BAROMETER PRESSURE					29.81	
RELATIVE HUMIDITY					35%	
DATE (1986)	5/30	5/30	5/30	5/30	Restart-ed at	5/30
OPER. MODE/TEMP CONTROL	C/C	C/C	C/C	C/C	70# and 200#	C/W
VOLTS PHASE A	206	202	202	202	after	202
VOLTS PHASE B	208	202	202	202	fullload	202
VOLTS PHASE C	206	201	201	201	shutdown for 10	202
AMPS LINE A	12.2	12.5	12.5	12.5	sec.	6.9
AMPS LINE B	12.3	12.5	12.6	12.5	Turned	7.1
AMPS LINE C	12.2	12.5	12.3	12.5	to warm-	7.2
AMPS NEUTRAL	0.7	0.7	0.7	0.7	er, shut off load	0.6
AIR SP - EVAP OUTLET	.25	.25	.25	.25	& opened	.29
VOLUME - EVAP INLET AIR	613	613	613	613	doors.	
EVAP INLET AIR TEMP 1	91	90	90	89	80	79
EVAP INLET AIR TEMP 2	91	91	90	89	80	79
EVAP OUTLET AIR TEMP 3	63	63	62	62	63	63
COND OUTLET AIR VOLUME	1276	1276	1276	1276	1276	1276
COND OUTLET AIR TEMP 4	147	147	146	144	121	118
COND INLET AIR TEMP 5	123	123	122	120	109	107
COND INLET AIR TEMP 6	120	120	120	116	107	103
REFRIG. HEAD PRESSURE	262	263	261	254	182	175
REFRIG. SUCT PRESSURE	48.0	48.5	48.0	47.0	28.0	28.5
CONDENSATE OUT (GMS)	YES	YES	YES	2117	YES	SLOW DRIP
SIGHT GLASS	CLR	OCCAS BUBBLE	OCCAS BUBBLE	OCCAS BUBBLE	CLR	CLR
STOP RUN				2:27		

18K/100 ICE TEST DATA

DATA TAKEN BY: Sherfy

TIME	3:46	3:55	4:00	4:03	4:08	4:12
BAROMETER PRESSURE						
RELATIVE HUMIDITY						
DATE (1986)	5/30	5/30	5/30	5/30	5/30	5/30
OPER. MODE/TEMP. CONTROL*	C/W	C/W	VENT	HI HEAT	LO HEAT	OFF
VOLTS PHASE A	202	205	203	205	205	END
PHASE B	203	205	205	203	205	OF
PHASE C	202	205	203	203	205	TEST
AMPS LINE A	6.9	6.8	3.9	20.5	11.3	
LINE B	7.2	7.2	4.2	20.5	11.5	
LINE C	7.2	7.2	3.9	20.0	10.6	
NEUTRAL	0.6	0.6	0.6	0.6	0.7	
AIR SP - EVAP OUTLET	*.31	.32	.33	.34	.34	
VOLUME - EVAP INLET AIR						
EVAP INLET AIR TEMP 1	79	79	82	93	97	
EVAP INLET AIR TEMP 2	79	79	82	93	97	
EVAP OUTLET AIR TEMP 3	64	65	79	123	112	
COND OUTLET AIR VOLUME	1276	1276				
COND OUTLET AIR TEMP 4	117	116				
COND INLET AIR TEMP 5	105	104				
COND INLET AIR TEMP 6	104	103				
REFRIG. HEAD PRESSURE	175	173				
REFRIG. SUCT PRESSURE	28.5	28.5				
CONDENSATE OUT (GMS)	SLOW DRIP	ALMOST NO DRIP	NONE	NONE	NONE	NONE
SIGHT GLASS	CLR	CLR				
STOP RUN						

*CONDENSATE EVAPORTING FROM COIL CAUSING INCREASED AIR FLOW AND HIGHER ESP AT DISCHARGE DUCT.

18K/100 TEST DATA
EVAPORATOR AIR FLOW

450	460	500	500	510	470	390
470	510	480	460	480	470	420
450	470	480	460	480	470	460
430	470	450	430	420	430	430
410	450	420	440	450	440	420
380	440	430	460	420	430	420
330	370	380	400	400	430	380

TIME: 2:30

DATE: 5/30/86

AVG VEL = 440.82 FPM

DATA TAKE BY: SHERFY

SP = 0.25"

AIR VOLUME INTO EVAPORATOR = 44082 X 1.39 FT^2 = 612.73 CFM

18K/100 ICE TEST DATA
EVAPORATOR AIR FLOW

250	600	590	730	730	880	350
350	600	1000	1150	1100	1200	620
420	630	1000	1130	1000	1100	820
420	650	880	950	1000	1250	920
470	750	820	980	1100	1400	1000
450	700	800	950	1050	1400	900
400	540	630	800	850	1150	650

TIME: 2:50

DATE: 5/30/86

AVG VEL = 818.57 FPM

DATA TAKE BY: SHERFY

SP = 0.0"

AIR VOLUME INTO EVAPORATOR= 818.57 X 1.56 = 1276 CFM

18K/100 ICE TEST DATA

DATA TAKEN BY: SHERFY/HICKS

TIME		1:00	1:40	1:51	2:05
BAROMETER PRESSURE		30.33			
RELATIVE HUMIDITY		32%			
DATE (1986)			6/3	6/3	6/3
OPER. MODE/TEMP. CONTROL			COOL	COOL	COOL
THERMOSTAT SETTING			COOLER	COOLER	COOLER
WATTS			4100	4150	4100
VOLTS	PHASE 1		204.5	205	205
	PHASE 2		205	205	205
	PHASE 3		205	205	205
AMPS	LINE A		12.3	12.7	12.4
	LINE B		12.8	13.0	12.7
	LINE C		12.8	13.2	12.7
	NEUTRAL		1.0	0.9	0.8
AIR SP - EVAP OUTLET			.25	.25	.25
VOLUME - EVAP INLET AIR			613	613	613
EVAP INLET AIR TEMP 1			89	90	89
EVAP INLET AIR TEMP 2			89	90	89
EVAP OUTLET AIR TEMP 3			65	66	65
COND OUTLET AIR VOLUME			1276	1276	1276
COND OUTLET AIR TEMP 4			144	146	144
COND INLET AIR TEMP 5			119	121	120
COND INLET AIR TEMP 6			120	122	120
REFRIG. HEAD PRESSURE			250	251	250
REFRIG. SUCT PRESSURE			51	50.5	49
CONDENSATE OUT (GMS)			NONE	NONE	NONE
SIGHT GLASS			CLR	CLR	CLR
MOTOR RPM					1685
COMPRESSOR RPM					1481
COND FAN RPM					
STOP RUN			1:43	1:59	2:10

18K/100 ICE UNIT

COOLING CAPACITY AT WET COIL CONDITIONS
120°F OUTSIDE, 90 /73 INSIDE, 0.25" E.S.P
FROM 5/30/86 DATA.

Sensible cooling = 1.08 X CFM Xdt
= 1.08 x 613 (28°) = 18,537 BTUH

Latent cooling: $\frac{2177 \text{ gms}}{3.83 \text{ hrs}} = \frac{553 \text{ gms/hr}}{454 \text{ gms/lb}}$

= 1.219 lbs of condensate collected
Enthalpy of condensed water: hg = 1100 BTU/lb @ 90 F, hf = 31 BTU/lb @ 63 F. Diff = 1069 BTU/lb

Latent = 1.219 x 1069 = 1303 BTUH
Electrical input = 4100 watts x 3.413 = 13,993 BTUH

Condenser heat rejection
= 1.08 x 1276 (25) = 34,452 BTUH

Energy in =	18,537	sensible
	1303	latent
	13,993	electrical
	33,833	BTUH
Energy out =	34,452	
Difference =	619	

% agreement = $\frac{619}{33,833}$ = .018 = 2%

18K/100 ICE UNIT

COOLING CAPACITY AT DRY COIL CONDITIONS
120°F outside, 90 /61 inside, 0.25" E.S.P
FROM 6/3/86 Data (no condensate)

Sensible cooling = 1.08 X CFM Xdt
= 1.08 x 712 (89° - 65°)
= 1.08 x 712 x 24°
= 18,455 BTUH

Condenser heat rejection
= 1.08 x 1276 (144° - 120°)
= 1.08 x 1276 x 24°
= 34,074 BTUH

Electrical energy in 4100 watts x 3.413 = 13,993 BTUH

Energy in =	18,455	cooling
	13,993	electrical
	32,448	BTUH
Energy out =	33,074	BTUH
Difference =	626	BTUH

$$\% \text{ agreement} = \frac{626}{32,448} = .02 = 2\%$$

HEATING CAPACITY CALCULATIONS

Tests performed 5/30/86

High Heat (QHH):

Temp. diff. = t out - t in = 123° - 93° = 30°F
Air flow at 0.34" SSP = 740 CFM (from curve)
QHH = 1.08 x CFM x dt
+ 1.08 x 740 x 30° = 23,976 BTUH

Power input check =
Approx. watts input = I x E x $\sqrt{3}$ x eff.
= 20.3 x 203.7 x 1.73 x .98 (est)
= 7011 watts
Heat equiv. of watts in =
7011 x 3.413 = 23,927 BTUH

With 12 heaters at 585 watts ea. x 3.413
Q Theoretical = 12 x 585 x 3.413 = 23,962 BTUH at 203.7 volts

Low Heat (QLH):

Temp. diff. = 112 - 97 = 15 F
Air flow at 0.34" SP = 740 CFM (from curve)
OLH = 1.08 x 740 x 15 = 11,988 BTUH

Power check =
watts in = 11.13 x 205 x 1.73 x .94 (est)
= 3710 watts
= 3.413 = 12,664 BTUH

VSE CORPORATION

PJO NO. ______ SHEET ____ OF ____

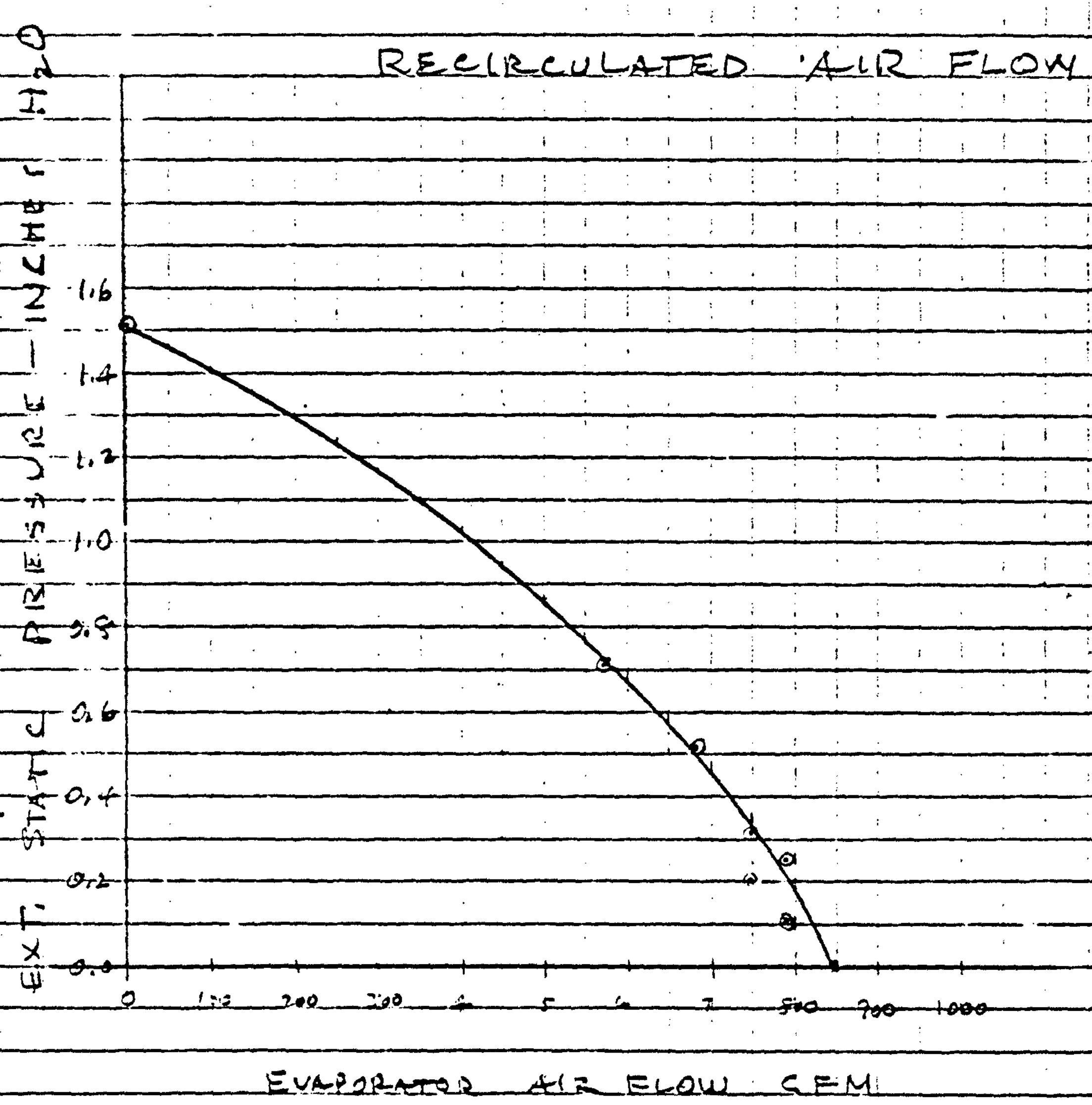
CLIENT ______

PROJECT TITLE ______

SUBJECT ______

PREPARED BY RAL DATE ______ CHECKED BY ______ DATE ______

18K/100 ICE UNIT PROTOTYPE
OPERATED IN VENT MODE
WITH CB & FRESH AIR
OPENINGS SEALED



18K/100 ICE TEST DATA

DATA TAKEN BY: HICKS

DATE	6/4/86	6/4/86	6/5/86	6/5/86	6/5/86	6/5/86	6/5/86
TIME	3:15	4:15	8:15	9:20	10:15	11:15	1:4[illegible]
BAROMETER PRESSURE	30.17	30.17	30.06-	30.07	30.05	30.05-	30.[illegible]
RELATIVE HUMIDITY	54%	54%	81%	66%	62%	57%	52%
SWITCH MODE	VENT	VENT	VENT	VENT	VENT	VENT	VENT
OPER. MODE/TEMP. CONTROL							
THERMOSTAT SETTING							
OUTSIDE AIR TEMP	77°	77°	68°	74°	77°	81°	85°
WATTS	400	400	450	450	400	400	
VOLTS PHASE 1	205	205	207	208	205	205	
PHASE 2							
PHASE 3							
AMPS LINE A							
LINE B							
LINE C							
NEUTRAL							
AIR SP - EVAP OUTLET	.00	.11	.22	.32	.51	.71	1.5[illegible]
VOLUME - EVAP INLET AIR	845	787	747	749	678	573	[illegible]
EVAP INLET AIR TEMP 1							
EVAP INLET AIR TEMP 2							
EVAP OUTLET AIR TEMP 3							
COND OUTLET AIR VOLUME							
COND OUTLET AIR TEMP 4							
COND INLET AIR TEMP 5							
COND INLET AIR TEMP 6							
REFRIG. HEAD PRESSURE							
REFRIG. SUCT PRESSURE							
CONDENSATE OUT (GMS)							
SIGHT GLASS							
MOTOR RPM							
COMPRESSOR RPM							
COND FAN RPM							
STOP RUN	3:20	4:20	8:20	9:25	10:25	11:20	1:45

18K/100 ICE TEST DATA
EVAPORATOR AIR FLOW

500	580	620	600	600	620	600
480	580	650	620	580	600	550
550	650	620	650	680	600	580
580	620	550	650	550	600	650
600	700	680	650	650	620	630
600	650	620	650	600	580	650
500	580	680	650	650	550	550

TIME: 3:15 AVG VEL = 607.55 FPM

DATE: 6/04/86

DATA TAKEN BY: Derwin Hicks

EVAPORATOR AIR VOLUME AT 0.00 ESP
(IN VENT MODE) = 607.55 X 1.39 = 844.5 CFM

18K/100 ICE TEST DATA
EVAPORTOR AIR FLOW

550	620	580	620	680	570	600
620	700	650	620	580	620	580
650	680	680	560	550	580	560
580	600	550	600	550	520	500
580	600	620	500	550	480	500
520	580	580	550	480	450	480
480	520	580	520	450	480	480

TIME: 4:15

AVG VEL = 566.33 FPM

DATE: 6/04/86

DATA TAKE BY: Derwin Hicks

EVAPORATOR AIR VOLUME AT 0.11" ESP
(IN VENT MODE) = 566.33 X 1.39 = 787.2 CFM

18K/100 ICE TEST DATA
EVAPORATOR AIR FLOW

550	620	620	600	580	550	480
580	650	580	580	550	550	550
600	620	550	550	450	500	520
580	600	550	480	480	520	580
550	580	600	520	480	450	450
550	620	620	550	450	450	480
450	550	580	520	420	450	400

TIME: 8:15

AVG VEL = 537.55 FPM

DATE: 6/05/86

DATA TAKE BY: Derwin Hicks

EVAPORATOR AIR VOLUME AT 0.22" ESP
(IN VENT MODE) = 537.55 X 1.39 = 747.2 CFM

18K/100 ICE TEST DATA
EVAPORATOR AIR FLOW

550	580	680	600	580	480	450
600	650	620	600	550	520	480
580	650	600	550	520	550	520
580	600	580	520	520	480	480
550	600	580	520	550	480	500
550	580	520	500	480	480	420
450	520	580	520	450	480	420

TIME: 9:20 AVG VEL = 538.77 FPM

DATE: 6/05/86

DATA TAKEN BY: Derwin Hicks

EVAPORATOR AIR VOLUME AT 0.32" ESP
(IN VENT MODE) = 538.77 X 1.39 = 748.9 CFM

18K/100 ICE TEST DATA
EVAPORATOR AIR FLOW

480	550	580	550	520	500	480
550	580	520	480	550	480	480
580	520	550	520	480	450	430
520	580	480	480	450	480	500
520	500	520	450	480	500	420
400	450	480	480	480	450	380
420	520	500	420	450	400	350

TIME: 10:15 AVG VEL = 487.55 FPM

DATE: 6/05/86

DATA TAKEN BY: Derwin Hicks

EVAPORATOR AIR VOLUME AT 0.51" ESP
(IN VENT MODE) = 487.55 X 1.39 = 677.7 CFM

18K/100 ICE TEST DATA
EVAPORATOR AIR FLOW

480	520	550	480	420	400	380
480	500	450	480	450	400	400
420	500	420	440	400	400	420
400	480	420	420	380	420	400
420	480	420	380	320	400	320
380	450	420	380	350	320	330
350	400	420	350	380	330	300

TIME: 11:15

AVG VEL = 412.45 FPM

DATE: 6/05/86

DATA TAKEN BY: Derwin Hicks

EVAPORATOR AIR VOLUME AT 0.71" ESP
(IN VENT MODE) = 412.45 X 1.39 = 573.3 CFM

18K/100 ICE TEST DATA
EVAPORATOR AIR FLOW

550	620	650	580	520	580	520
520	580	600	620	550	580	620
580	650	620	580	550	520	600
520	650	620	580	550	520	550
580	620	550	580	520	550	600
580	620	580	550	520	550	550
500	520	580	520	520	500	500

TIME: 11:15

AVG VEL = 566.73 FPM

DATE: 6/05/86

DATA TAKEN BY: Derwin Hicks

EVAPORATOR AIR VOLUME AT 0.25" ESP
(IN VENT MODE) = 566.73 X 1.39 = 787.8 CFM

18K/100 ICE TEST DATA
FRESH AIR FLOW

165	150	190	150
180	175	200	190
150	180	200	190
175	160	180	175
150	170	180	170
150	180	180	175
170	190	160	190

TIME: 3:10 AVG VEL = 174.11 FPM

DATE: 6/05/86

DATA TAKEN BY: Derwin Hicks

FRESH AIR CFM AT 0.25" ESP (IN VENT MODE) = 174.11 X .28 = 48.8 CFM

18K/100 ICE TEST DATA
FRESH AIR FLOW

140	170	170	180
150	170	190	200
170	150	190	190
170	180	160	190
170	18C	150	190
170	170	180	190
170	160	180	180

TIME: 10:30 AVG VEL = 173.57 FPM

DATE: 6/06/86

DATA TAKEN BY: Derwin Hicks

FRESH AIR CFM AT 0.0" ESP (IN VENT MODE) = 173.57 X .28 = 48.6 CFM

18K/100 ICE TEST DATA
CB AIR FLOW

600	480	500	400	380	380
520	500	480	420	380	280
580	580	520	450	420	350
580	600	580	550	480	400
550	600	580	550	480	420
550	580	580	550	500	400

TIME: 9:15 AVG VEL = 493.05 FPM

DATE: 6/06/86

DATA TAKEN BY: Derwin Hicks

CB AIR WITH A/C IN VENT MODE, CB FAN ON AND WITH
0.25 ESP AIR FLOW = 493.05 X .293 = 144.5 CFM

8K/100 ICE TEST DATA
CB AIR FLOW

520	480	500	480	400	350
520	480	550	480	420	380
580	580	550	520	500	420
520	620	600	580	480	450
580	600	580	550	520	450
580	550	520	580	450	400

TIME: 10:50 AVG VEL = 508.88 FPM

DATE: 6/06/86

DATA TAKEN BY: Derwin Hicks

CB AIR WITH A/C IN VENT MODE, CB FAN ON AND WITH
0.0 ESP AIR FLOW = 508.88 X .293 = 149.1 CFM

18K/100 ICE TEST DATA
CB AIR FLOW

480	520	580	450	420	280
450	480	500	520	420	380
520	580	600	580	520	430
480	520	580	600	550	500
380	550	600	580	520	440
380	480	580	520	480	380

TIME: 11:05 AVG VEL = 495.3 FPM

DATE: 6/06/86

DATA TAKEN BY: Derwin Hicks

CB AIR WITH A/C UNIT EVAP. FAN OFF AND
0.0 ESP WITH CB FAN ON: AIR FLOW = 495.3 X .293 = 145.1 CFM

18K/100 ICE TEST DATA
EVAPORATOR AIR LEAKAGE THROUGH CB SYSTEM

55	57	50	40	30	20
55	60	60	50	45	30
60	65	60	55	40	40
65	70	65	55	47	37
60	65	60	55	50	30
55	50	50	45	40	35

TIME: 8:40 AVG VEL = 50.16 FPM

DATE: 6/06/86

DATA TAKEN BY: Derwin Hicks

AIR OUT OF CB INTAKE (LEAKAGE) AT 0.25 ESP
IN VENT MODE: AIR FLOW = 50.16 X .293 = 14.7 CFM

18K/100 ICE TEST DATA
EVAPORATOR AIR LEAKAGE THROUGH CB SYSTEM

45	45	40	40	30	32
50	47	45	40	37	35
45	45	40	35	38	35
35	38	40	30	35	30
25	30	25	20	23	20
20	17	20	12	15	18

TIME: 10:40 AVG VEL = 32.69 FPM

DATE: 6/06/86

DATA TAKEN BY: Derwin Hicks

AIR OUT OF CB INTAKE (LEAKAGE) AT 0.0 ESP
IN VENT MODE: AIR FLOW = 32.69 X .293 = 9.6 CFM

APPENDIX B

FREE FIELD ACOUSTICAL SIGNATURE TEST
18K/100 ICE UNIT

SECTION I

INTRODUCTION

1.1 Purpose of the Report. The purpose of this report is to present the acoustical test data gathered for the 18,000 Btuh/100 CFM Integrated Chemical Filter and Environmental Control Unit, designed and assembled by VSE Corporation. This unit is also called the 18K/100 ICE Unit.

1.2 Purpose of the Test. The primary purpose for sound level testing of the subject unit is to establish a valid free field acoustical signature of noise data pertaining to both the evaporator and condenser sides. This information provides a substantial data base by which the ICE Unit can be compared to the previously tested horizontal unit (reference Acoustical Test Report for the 18,000 BTUH Horizontal Air Conditioner Type II Size B of November 1985) and evaluated in terms of noise attenuation characteristics.

1.3 Scope. The data contained herein is intended to provide sound level information from both the condenser and evaporator sides of the subject unit when in operation in the maximum cooling mode alone, maximum cooling with CB fan mode, with the CB fan only mode, with the evaporator side fan and in vent mode only.

1.4 Sound Level Meter Equipment. Readings were taken using the General Radio (GEN RAD) Model 1988 Precision Integrating Sound Level Meter and Analyzer; a Perpendicular-Incidence, Electret Condenser microphone, GEN RAD Model 1988-9710; Preamplifier, 60 foot extension cable, and windscreen. All equipment was calibrated in November 1985 and is calibrated on a yearly basis, with interim calibrations being performed prior to each use of the equipment using a GEN RAD Sound Level Calibrator, Model 1987 producing 1 kHz at either 94 or 114 dB. All equipment conforms to ANSI S1.4 Type I and ANSI S1.11 Type E, Class II.

1.5 Test Location and Personnel. All readings were taken at the VSE Corporation parking area located on Huntington Avenue by Mr. L. Lawrence, and Mr. R. Sherfy of VSE. An early Sunday morning (0600-0800) time was chosen to ensure an acceptable background vs sound source noise differential.

1.6 Type of Test. A free-field test was performed on the subject air conditioner. The unit was placed on a 1/2" thick rubber mat to reduce the transmission of structure borne noise, and then on a moveable metal tool/parts bench. No buildings, hills or other reflecting surfaces were within 50 feet of the test area. The parking lot surface is flat and predominantly asphalt.

SECTION II

TESTING CRITERIA

2.1 Microphone Locations. All recordings were accomplished using a single microphone. The microphone positions for both evaporator and condenser sides of the unit are shown in Figure 1. Microphone positions conform to standards as required in MIL-A-52767B, Paragraph 4.6.3.26, Amendment 3, a copy of which is attached.

2.2 Recording of Data. The data recorded included dB(A) weighted, dB(C) weighted, and the following octave band center frequency pressure levels: 31.5 Hz,63, 125, 250, 500, 1000, 2000, 4000 and 8000 Hz. All data was recorded on the Acoustical Test Data sheet as provided in MIL-STD-1474B, Figure 7. Recorded data is presented in Table 1 of this report.

2.3 Test Unit Operating Conditions. The subject air conditioner was run continuously throughout the test in various modes as described in Table 1.

2.4 Calibration. Calibration of the sound measuring equipment in the "as used" configuration was accomplished prior to beginning recordation. It included the influence of microphones, extension cables, preamplifier and analyzer. Calibration was accomplished prior to testing each side of the subject unit. A GEN RAD, Model 1987, Sound Level Calibrator producing 1 kHz at 94 dB was used for field calibration.

2.5 Instrument Settings. For taking actual readings, the following sound level meter settings were used:

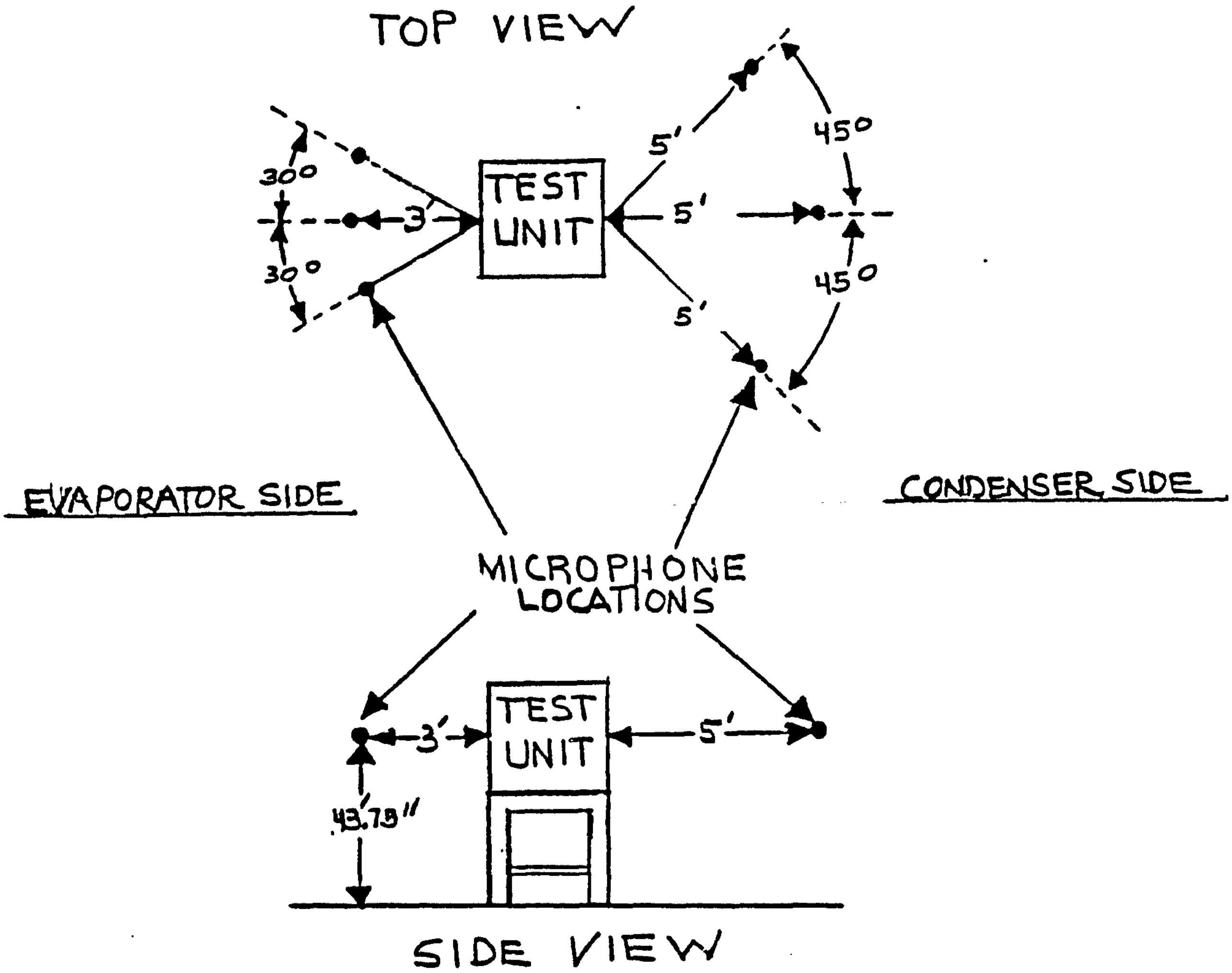
1) The preamplifier "OFF/200V" switch was set to "OFF"; the gain was set to "X1".

2) The 60-foot microphone extension cable was attached to the preamplifier and the sound level meter.

3) A 1/2" Electret Condenser-Perpendicular Incidence microphone was attached to the preamplifier.

4) The sound level meter's controls were set as follows:

POWER: On
DISPLAY: dB
INTEGRATION: SPL (Leg)
MODE: Maximum
DETECTOR: Slow
WEIGHTING: A and C to measure weighted values
OCTAVE FILTER FREQ HZ: 31.5 - 8,000



NOTE: Center microphone was located in the geometric center of the test unit, with all other microphone positions being at the same height, and at the angles shown.

FIGURE 1

TESTING CONFIGURATION

ACOUSTICAL TEST DATA

TIME: ~~1100~~ 0600	**DATE:** 8 JUNE 1986 ~~Nov. 20, 1985~~		
TEST ITEM: 18K/100 INTEGRATED CHEMICAL AND ENVIRONMENTAL (ICE) UNIT	**STATION:**	**TEST CONDUCTED BY:** LAWRENCE R SHELBY	**TEST ITEM OPERATOR:** R SHELBY
RFG/MODEL NO: VSE PROTOTYPE	**SERIAL NO:**	**ODOMETER:** / **HOUR METER:**	**TEST ITEM CONDITION:** NEW
TEMPERATURE: 66°F	**HUMIDITY:** 48%	**TEST SITE:** VSE PARKING LOT	**SURFACE:** GRAVEL/MAR · **SEA STATE:** — · **TERRAIN:** FLAT
BAROMETRIC PRESSURE: 30.62 R	**SKY COVER:** CLEAR	**STATIONARY OPERATION:** ☒	**HIGHWAY DRIVING:** ☐ · **DRIVE BY:** ☐
WIND DIRECTION: VRBL	**WIND VELOCITY:** 2-3 MPH	**MICROPHONE:** 1/2" PERPENDICULAR INCIDENT	**SOUND LEVEL METER:** GEN RAD MOD #: 1988 · **OCTAVE ANALYZER:** SAME
INTERIOR: ☐	**EXTERIOR:** ☐	**MICROPHONE LOCATION:** AS PER FIGURE I	**TAPE RECORDER:** NA · **TAPE NO:** NA

BACKGROUND 53.7dBA	dbA	dbB	dbC	ALL PASS	31.5	63	125	250	500	1,000	2,000	4000	8000	REMARKS
CONDENSER SIDE 0°	79.1		90.5		81.5	74.9	73.4	82.9	76.8	71.5	65.3	62.8	57.2	ON MAX COOL
45° LEFT	78.7		83.8		65.3	65.8	71.9	82.0	75.9	72.5	68.6	64.4	60.1	MODE; WITH CB
45° RIGHT	80.4		83.5		62.7	65.9	72.8	80.3	76.6	75.0	72.6	70.5	67.2	FAN RUNNING
0°	72.0		73.9		63.8	70.9	63.7	63.9	66.5	68.7	65.1	61.5	56.4	WITH CB FAN ONLY
45° LEFT	69.6		72.6		63.8	65.4	62.0	60.9	65.3	65.2	62.4	59.9	53.1	
45° RIGHT	79.7		79.7		63.7	64.8	65.9	68.0	70.3	73.3	75.0	72.0	67.4	
0°	77.9		89.9		83.6	77.3	74.6	82.1	75.9	68.1	62.3	57.9	56.3	COOLING MODE ONLY,
45° LEFT	77.9		83.9		67.7	66.8	73.3	81.9	76.1	71.7	65.4	63.4	51.7	CB FAN OFF
45° RIGHT	76.8		81.0		65.9	66.5	71.9	79.9	75.8	[illegible]	64.8	[illegible]	[illegible]	
														CONTINUED ON NEXT PAGE

TABLE 1

ACOUSTICAL TEST DATA

TIME: 0710	DATE: 8 JUNE 1986		
TEST ITEM: ICE UNIT -	STATION:	TEST CONDUCTED BY:	TEST ITEM OPERATOR:
RFG/MODEL NO: VSE PROTOTYPE	SERIAL NO:	ODOMETER:	HOUR METER:
TEST ITEM CONDITION:			
TEMPERATURE: 73°	HUMIDITY: 46%	TEST SITE:	SURFACE:
SEA STATE:	TERRAIN:		
BAROMETRIC PRESSURE: 30.63 R	SKY COVER: CLEAR	STATIONARY OPERATION: ☐	HIGHWAY DRIVING: ☐
DRIVE BY: ☐			
WIND DIRECTION: VRBL	WIND VELOCITY: 3-4 MPH	MICROPHONE:	SOUND LEVEL METER:
OCTAVE ANALYZER:			
INTERIOR: ☐	EXTERIOR: ☐	MICROPHONE LOCATION: AS PER FIGURE 1	TAPE RECORDER:
TAPE NO:			

BACKGROUND 53.8	dbA	dbB	dbC	ALL PASS	31.5	63	125	250	500	1,000	2,000	4000	8000	REMARKS
CONDENSER SIDE 0°	61.0		71.5		62.9	65.7	67.7	62.6	60.4	52.7	48.9	46.8	39.5	WITH VENT FAN
45° LEFT	61.3		71.5		63.3	65.0	68.4	62.9	60.8	54.9	51.1	48.8	39.6	ONLY
45° RIGHT	60.5		70.9		63.2	66.8	66.3	61.9	59.8	51.9	48.0	46.4	38.7	
EVAPORATOR SIDE 0°	72.8		79.4		68.6	67.5	70.9	74.8	70.9	67.3	63.9	59.4	53.5	ON MAX COOL;
30° LEFT	78.1		80.3		67.7	66.9	71.4	74.5	71.3	70.6	74.3	68.4	60.8	WITH CB FAN
30° RIGHT	73.7		79.4		68.2	66.3	70.8	76.5	70.8	67.8	63.6	58.7	51.9	RUNNING.
0°	70.5		72.9		63.9	64.9	61.9	66.8	63.8	64.3	66.0	61.0	48.9	WITH CP FAN ONLY
30° LEFT	79.7		78.8		68.7	67.7	61.0	66.3	66.9	70.4	75.6	71.4	62.0	
30° RIGHT	70.4		75.0		68.8	66.9	63.8	66.1	65.6	64.9	63.8	59.6	48.3	
														CONTINUED ON NEXT PAGE

TABLE 1

ACOUSTICAL TEST DATA

TIME: 0135	DATE: 8 JUNE 1986		
TEST ITEM: ICE UNIT	STATION:	TEST CONDUCTED BY:	TEST ITEM OPERATOR:
RFG/MODEL NO: VSE PROTOTYPE	SERIAL NO:	ODOMETER:	HOUR METER:
TEST ITEM CONDITION:			
TEMPERATURE: 75°	HUMIDITY: 46 %	TEST SITE: VSE PACKING LOT	SURFACE: GRAVEL/TAR
SEA STATE: —	TERRAIN: —		
BAROMETRIC PRESSURE:	SKY COVER:	STATIONARY OPERATION: ☐	HIGHWAY DRIVING: ☐
DRIVE BY: ☐			
WIND DIRECTION: VRBL	WIND VELOCITY: 3-4 MPH	MICROPHONE:	SOUND LEVEL METER:
OCTAVE ANALYZER:			
INTERIOR: ☐	EXTERIOR: ☐	MICROPHONE LOCATION: AS PER FIGURE 1	TAPE RECORDER:
TAPE NO:			

BACKGROUND 53.0	dbA	dbB	dbC	ALL PASS	31.5	63	125	250	500	1,000	2,000	4000	8000	REMARKS
EVAPORATOR SIDE 0°	71.3		78.7		66.7	67.2	72.1	74.7	70.3	65.3	59.1	56.8	53.1	COOLING MODE ONLY,
30° LEFT	71.1		78.3		66.5	67.7	71.9	74.9	69.8	64.5	58.6	55.0	50.5	CB FAN OFF
30° RIGHT	72.3		78.8		67.2	67.5	71.9	75.9	70.5	66.6	60.6	56.1	51.3	
0°	68.4		77.8		66.5	68.3	71.4	73.5	66.3	60.4	57.3	56.4	51.7	WITH VENT FAN
30° LEFT	68.5		77.2		64.8	67.9	71.8	73.4	65.6	58.7	56.3	55.2	49.7	ONLY
30° RIGHT	68.2		76.7		66.4	67.5	70.3	72.6	65.9	60.7	56.8	54.7	49.8	

TABLE 1

SECTION III

RESULTS

3.1 Acoustical Test Data. Table 1 presents all sound level data taken during the described test procedings. Table 2 presents all sound level measurements previously taken for the 18,000 BTUH Horizontal Air Conditioner.

3.2 Comparison of Data. To aid in understanding the value of the recorded data, Figures 2 and 3 graphically compare established Noise Criteria (NC) characteristics with recorded sound level measurements. The solid line represents those measurements taken on the 18,000 BTUH horizontal air conditioner when operating in the maximum cooling mode, and the dashed lines represent measurements taken on the 18K/100 ICE Unit when operated in a similar mode (CB fan not running).

In general, NCs were constructed and developed to relate noise levels to speech interference properties. However, they also are applicable for conditions of human hearing comfort. As such, it is generally agreed that sound levels below approximately NC-30 generally are considered quiet. Those above approximately NC-50 are considered noisy.

No NC criterion has been established for the subject unit and, as a result, this information should be used only for general comparative purposes. Additional information concerning NCs may be found in the 1977 ASHRAE Fundamentals Handbook and Noise Control by L. L. Beranek, published in January, 1957.

Figures 2 and 3 each consist of three individual graphs depicting the recordings taken from the center, left and right positions for both the evaporator and condenser sides respectively. Instrument settings for recording data in each position are described in Section II, Paragraph 2.5.

ACOUSTICAL TEST DATA

TIME: 1100
DATE: November 20, 1985

TEST ITEM: 18,000 BTU Horizontal Air Conditioner
STATION: Evaporator and Condenser Sides
TEST CONDUCTED BY: Lou Lawrence and Nat'l. Testing Services
TEST ITEM OPERATOR: N/A

MFG/MODEL NO: FSN: 4120-01-136-9836 Tiernay Manufact.
SERIAL NO: 267
ODOMETER: N/A
HOUR METER: N/A
TEST ITEM CONDITION: Production Model, Fair to Good

TEMPERATURE: 63°
HUMIDITY: 77%
TEST SITE: NTS Facilities
SURFACE: Work Bench
SEA STATE: N/A
TERRAIN: Open

BAROMETRIC PRESSURE: 30.06 Falling
SKY COVER: Scattered high cirrus and cumulus
STATIONARY OPERATION: X
HIGHWAY DRIVING:
DRIVE BY:

WIND DIRECTION: SE
WIND VELOCITY: 6-8 MPH
MICROPHONE: General Radio 1962-9611
SOUND LEVEL METER: General Radio Model 1988
OCTAVE ANALYZER: Same

INTERIOR:
EXTERIOR:
MICROPHONE LOCATION: As per paragraph 4.6.3.26 of MIL-A-52767B, Amend. 3
TAPE RECORDER: N/A
TAPE NO: N/A

EVAPORATOR SIDE	dbA	dbB	dbC	ALL PASS	31.5	63	125	250	500	1,000	2,000	4000	8000	REMARKS
CENTER	70.9		85.0		72.1	76.2	83.9	69.3	67.7	66.3	59.2	55.0	46.7	MIC positioned in geometric center of AC, 36" away
LEFT OF CENTER	74.0		85.0		62.7	69.2	84.6	70.9	68.6	67.7	60.2	57.3	50.5	MIC placed 30° from geometric center
RIGHT OF CENTER	70.4		84.6		73.5	74.3	83.6	69.4	68.2	62.0	59.5	54.6	48.4	MIC placed 30° from geometric center
CONDENSER SIDE														
CENTER	79.1		79.4		62.4	71.0	76.1	70.6	75.2	68.7	65.5	64.8	58.7	MIC positioned in geometric center of AC 60" away
LEFT OF CENTER	75.1		80.1		56.2	70.8	75.2	68.8	71.7	67.8	68.0	67.4	61.9	MIC placed 45° from geometric center.
RIGHT OF CENTER	75.8		81.6		63.9	69.7	75.1	67.3	70.2	70.6	68.0	69.0	64.5	MIC placed 45° from geo metric center.
BACKGROUND NOISE	44.9													NOTE: A windscreen was used on the MIC for all readings.

TABLE 2

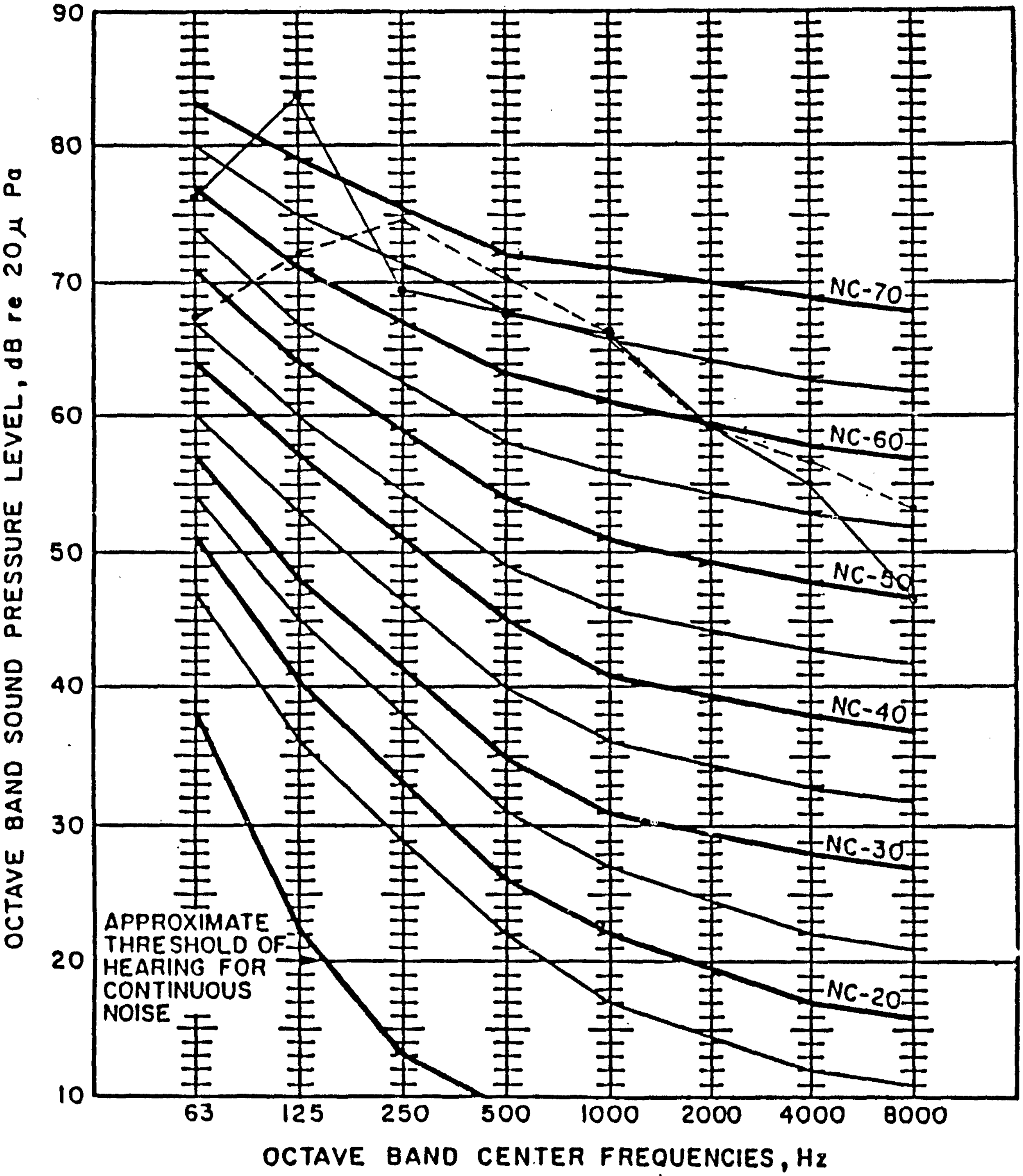


FIGURE 2

EVAPORATOR SIDE MEASUREMENTS, CENTER (Page 1 of 3)

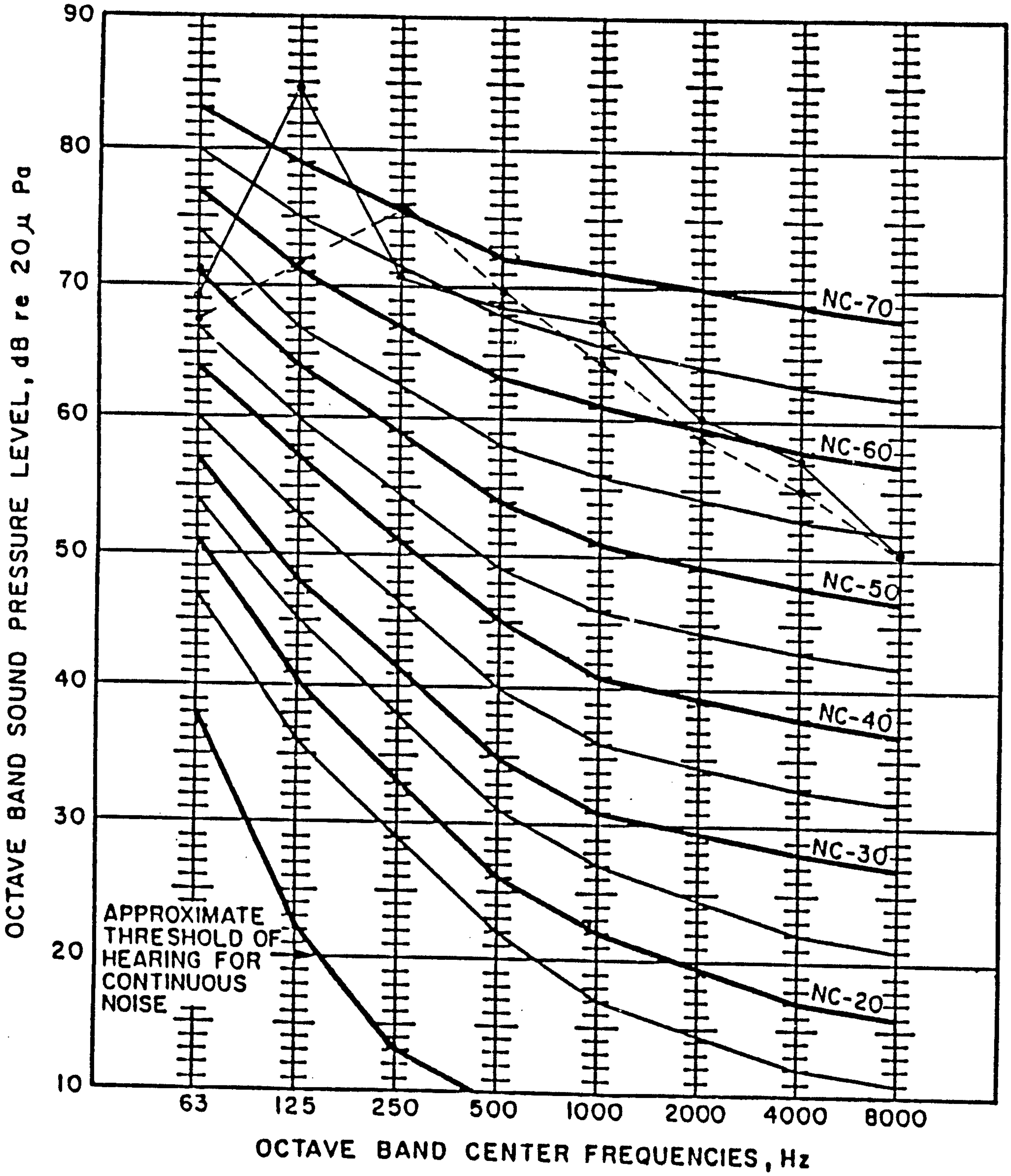


FIGURE 2

EVAPORATOR SIDE MEASUREMENTS, LEFT (Page 2 of 3)

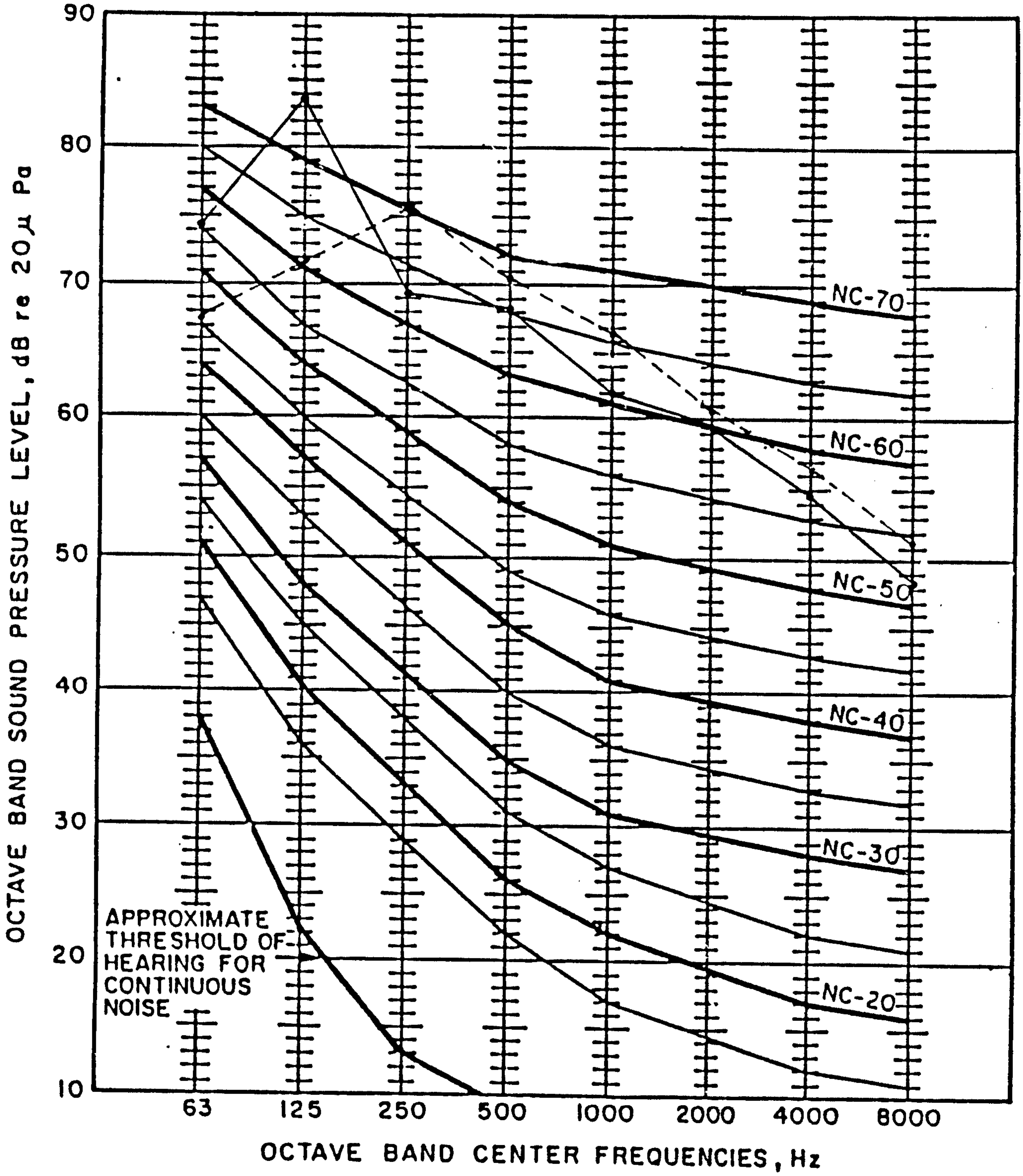


FIGURE 2

EVAPORATOR SIDE MEASUREMENTS, RIGHT (Page 3 of 3)

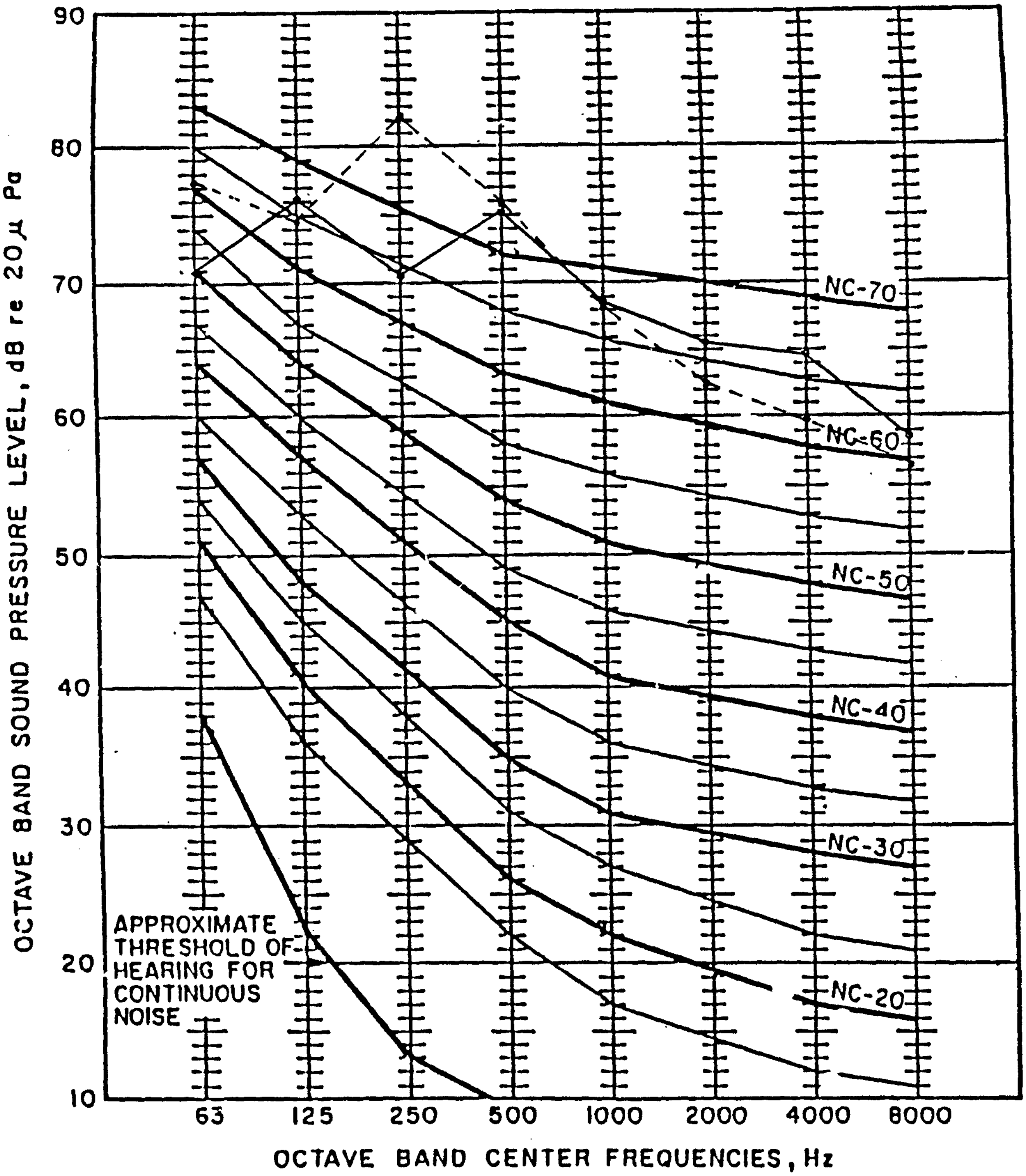


FIGURE 3

CONDENSER SIDE MEASUREMENTS, CENTER (Page 1 of 3)

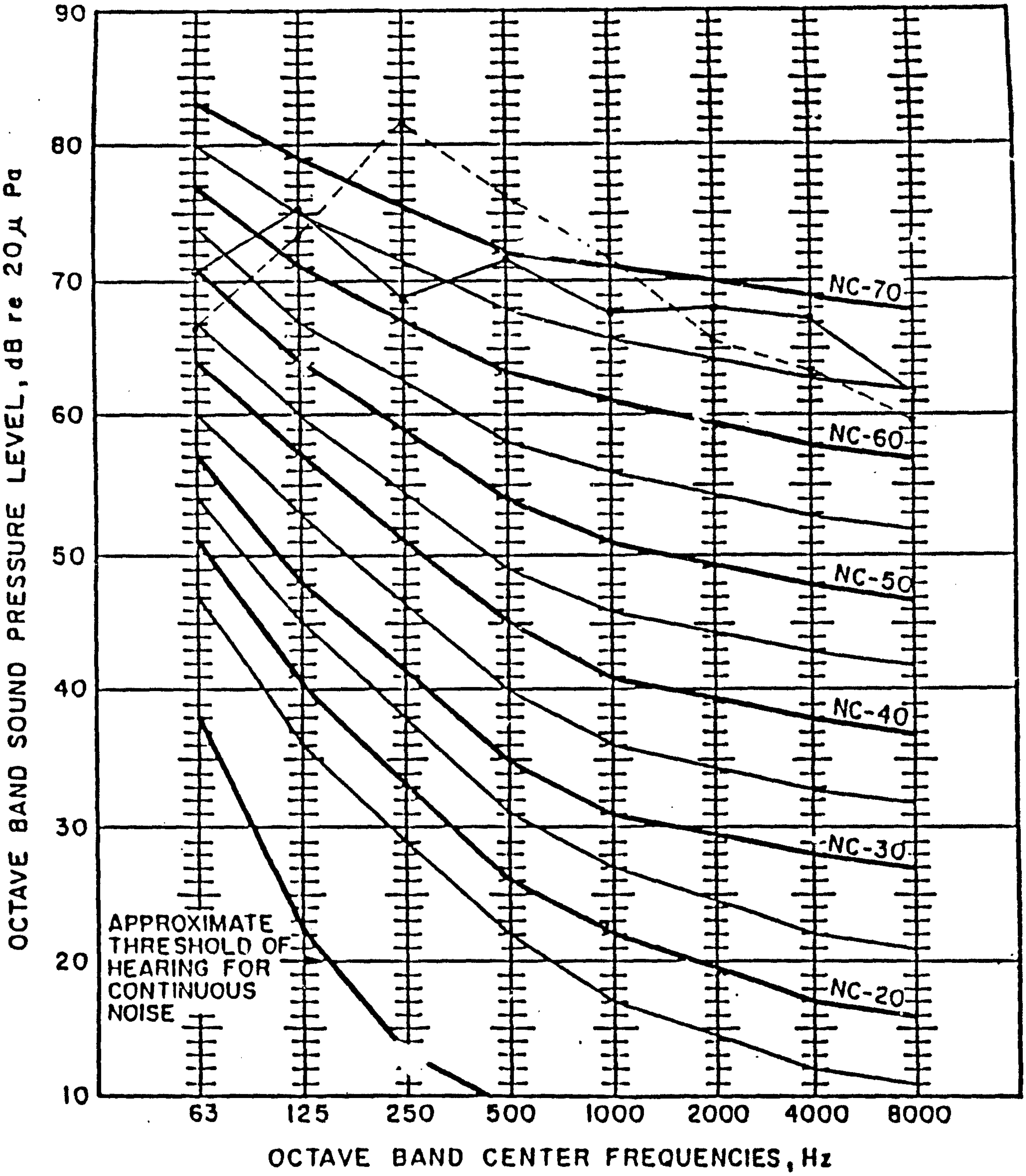


FIGURE 3

CONDENSER SIDE MEASUREMENTS, LEFT (Page 2 of 3)

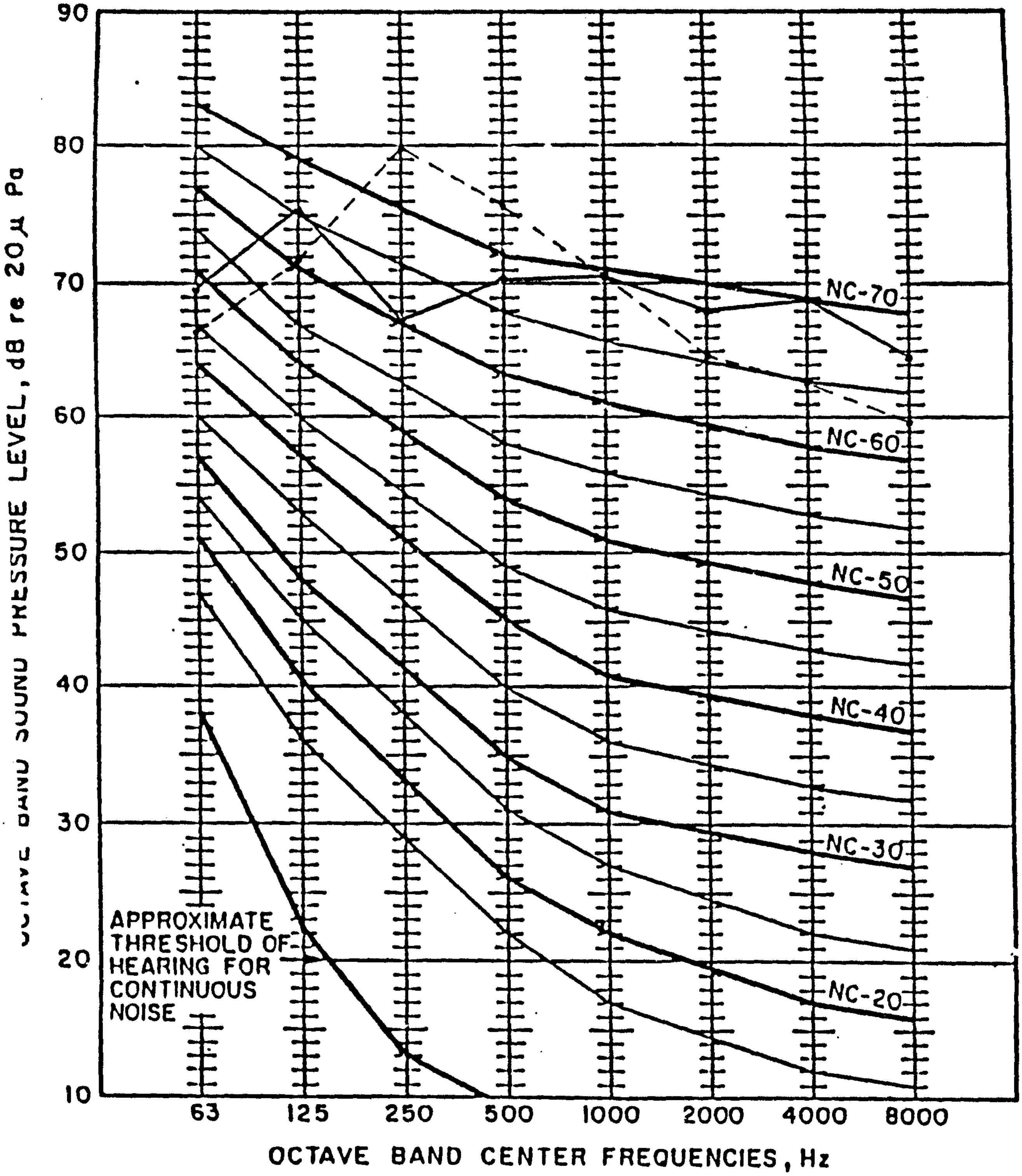


FIGURE 3

CONDENSER SIDE MEASUREMENTS, RIGHT (Page 3 of 3)

SECTION IV

DISCUSSION

Comparison of the data when plotted on the noise criteria graphs found in the ASHRAE Fundamentals Handbook evidences a prominent characteristic which warrants discussion.

Most obvious is the distinctive rise in sound levels, expressed in dBs, in the 250 and 500 Hz mid-octave and frequency range. These are most pronounced on the condenser side as shown in Figure 3, pages 1, 2 and 3. The condenser fan would be a prime candidate for the source of noise.

On the evaporator side, a similar increase in the 250 and 500 Hz data also is evident. However, VSE engineers are of the opinion that much of what is being registered on the evaporator side in these bands is being generated from the condenser side and is being transmitted, to a larger extent, around the exterior of the unit. Much of this could be easily attenuated by the shelter wall in a proper installation.

One of the goals of the overall 18K/100 ICE Unit design efforts was to minimize the sound level as measured in the dB "A" weighted category. An examination of recorded data (reference Tables 1 and 2) reveals that on the condenser side, in max cool, the standard horizontal military 18,000 BTUH AC recorded 79.1 center, 75.1 left and 75.8 right dBA readings as compared to the 77.9 center, 77.9 left, and 76.8 right readings produced by the 18K/100 ICE Unit. Ths equates to an average of .87 dBA increase over the military unit.

On the evaporator side, the 18,000 BTUH AC recorded 70.9 center, 74.0 left and 70.4 right readings as compared to 71.3 center, 71.1 left and 72.3 right readings for the 18K/100 ICE Unit. This equates to an average .20 dB"A" decrease below the levels produced by the standard military unit.

SECTION V

CONCLUSION

The sound level measurements described herein were accomplished using the "free field" method of testing. Although this produces typically accurate data which may be used for further analysis it does not replicate the true operational scenario of the unit.

SECTION VI

RECOMMENDATION

Additional sound level tests should be accomplished with the evaporator and condenser sides separated, as would be the case in normal use. It is believed that this would provide more accurate critical noise (interior) data from which further sound attenuation decisions can be made.

APPENDIX C

OPERATOR AND MAINTENANCE MANUAL
18K/100 ICE UNIT

DRAFT

OPERATOR AND MAINTENANCE MANUAL
18K/100 ICE UNIT
(18,000 BTUH/100 CFM INTEGRATED CHEMICAL FILTER
AND ENVIRONMENTAL CONTROL UNIT)
208 VOLT, 3-PHASE, 60 HERTZ

Developed by:

VSE Corporation
2550 Huntington Avenue
Alexandria, VA 22303

Army Systems Group
Project Engineer
Robert B. Sherfy

For:

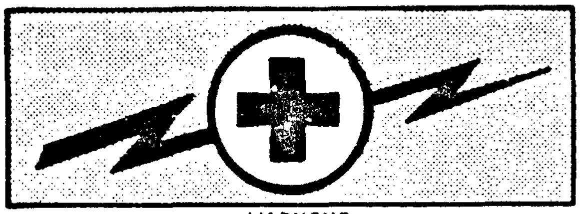
U.S. Army Belvoir Research, Development
and Engineering Center
Fort Belvoir, VA 22303

Technical Advisor:
Robert A. Rhodes

June 30, 1986

DRAFT

WARNING



WARNING

HIGH VOLTAGE

is used in the operation of this equipment.

DEATH ON CONTACT

or severe injury may result if you fail to observe safety precautions. Always disconnect the air conditioner from power source before working on it. Do not operate the air conditioner without screens, filters, covers, and grilles in place and tightly secured.

WARNING

REFRIGERANT UNDER PRESSURE

is used in the operation of this equipment.

DEATH

or severe injury may result if you fail to observe safety precautions. Never use a heating torch on any part that contains Refrigerant -- 12. Do not let liquid refrigerant touch you, and do not inhale refrigerant gas.

WARNING

When access covers are removed from this unit, moving mechanical components, such as pulleys, belts, fans and shafts, may be contacted, causing bodily injury. Always turn off power to the unit before servicing.

WARNING

Clean parts in a well-ventilated area. Avoid inhalation of solvent fumes and prolonged exposure of skin to cleaning solvent. Wash exposed skin thoroughly. Dry cleaning solvent (Fed. Spec. P-D-680) used to clean parts is potentially dangerous to personnel and property. Do not use near open flame or excessive heat. Flash point of solvent is 100 °F to 138 °F (38 °C to 59 °C). Wear eye protection when blowing solvent from parts. Air pressure should not exceed 30 psig (2.1 Kg/cm^2).

WARNINGS

- Do not replace NBC contaminated filters without anti-contamination MOPP equipment.

Contact with NBC contamination is usually fatal.

- Do not attempt to service this unit with system power on. Severe electrical shock and burns could result.

- Do not operate this unit with any panels removed. Bodily injury or damage to the equipment could occur.

CAUTION

Attempting system repairs not specifically listed in the text can cause severe damage to the unit and possible injury to personnel. Follow operator's manual instructions when malfunctions occur and refer all other problems to the next echelon of maintenance. For further information contact:

Army Systems Group
VSE Corporation
2550 Huntington Avenue
Alexandria, Virginia 22303-1499
Phone (703) 960-4600

SAFETY NOTES

Because of the uncertainty involved in the operation of any prototype, persons working with this unit should be familiar with first aid. See FM 21-11, First Aid for Soldiers.

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FIGURES

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6. Refrigeration Schematic Diagram 24

1.0 UNIT DESCRIPTION

1.1 Nomenclature. This unit is known as the 18K/100 ICE Unit or 18,000 BTUH/100 CFM Integrated Chemical Filter and Environmental Control Unit. As the name implies, it is an 18,000 BTUH air conditioner/heater combined with a 100 cfm chemical/biological filter, all in one enclosure.

1.2 Size. Basic unit dimensions are 33.5" deep (front to back), 29.6" wide and 25.8" high, not including screw heads and control projections.

1.3 Enclosure. The 18K/100 ICE Unit uses a painted, welded aluminum frame, aluminum skin enclosure. The face of the unit which contains the control panel is identified as the front, and other faces are defined in relation to the front.

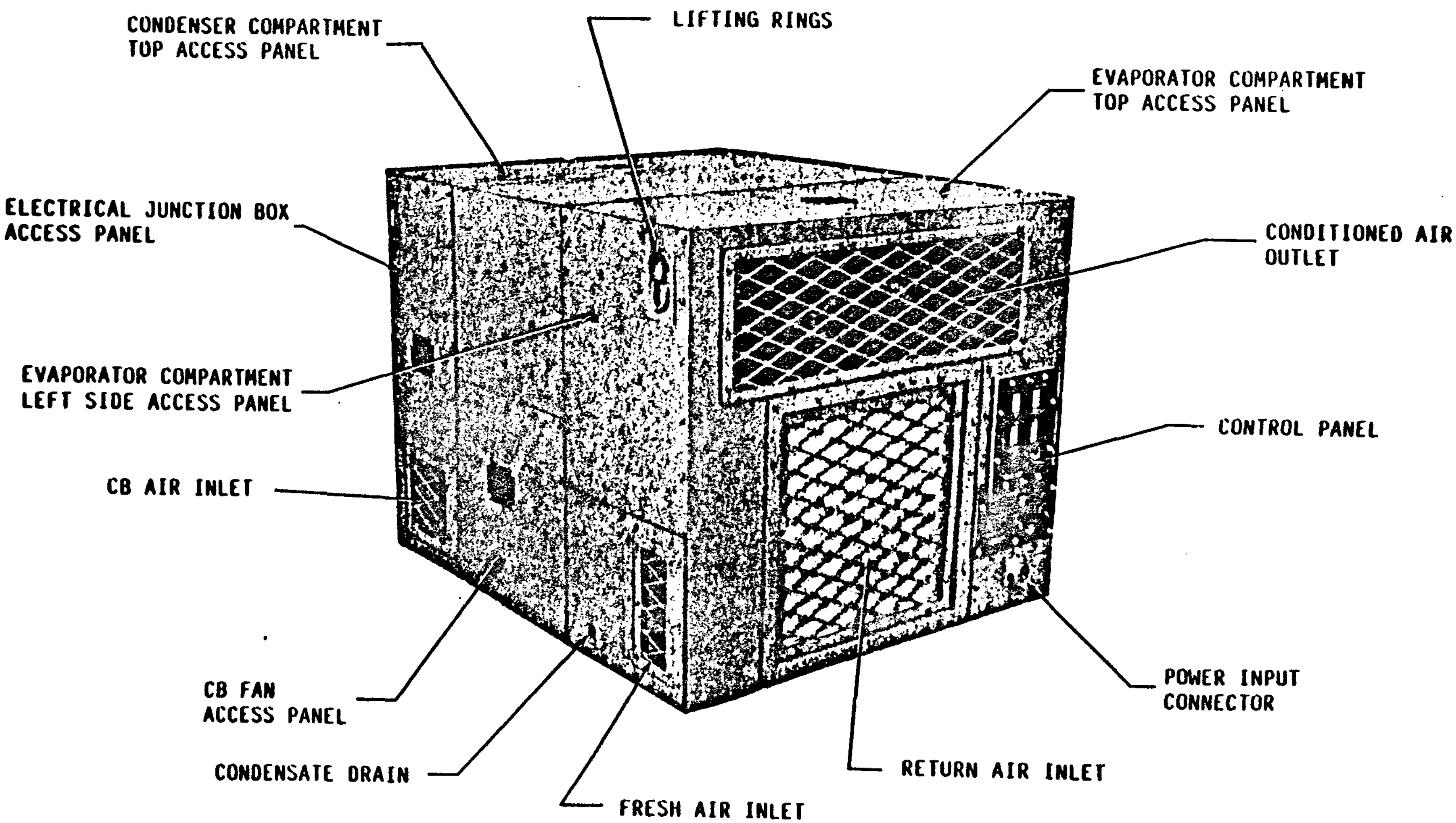
1.3.1 Air Openings. There are six air openings on the unit. Two large openings, the return air from the shelter (lower) and the discharge (conditioned) air (upper), are in the front of the unit (see Figure 1). In the left side (also shown in Figure 1) are two smaller openings; the one nearest the front being the fresh air inlet and the other, the CB air inlet. The right side of the unit (see Figure 2) contains the condenser inlet opening, and the rear face (also Figure 2) has the condenser discharge air opening.

Each of the six air openings has a protective grille and an EMI screen installed. In addition, the return air opening, the fresh air intake, and the CB air intake have air filters to remove particulate matter from the entering air. The grilles help to protect the air filters and EMI screens from physical damage. The EMI screens are part of unit's Electro-Magnetic Interference protection, which attenuates radio frequency signals which could otherwise enter or leave the unit. Such signals might damage electrical and electronic circuits within the unit if allowed to enter, or certain signals which might be generated from within the ICE Unit, if allowed to escape, might interfere with nearby radio communication.

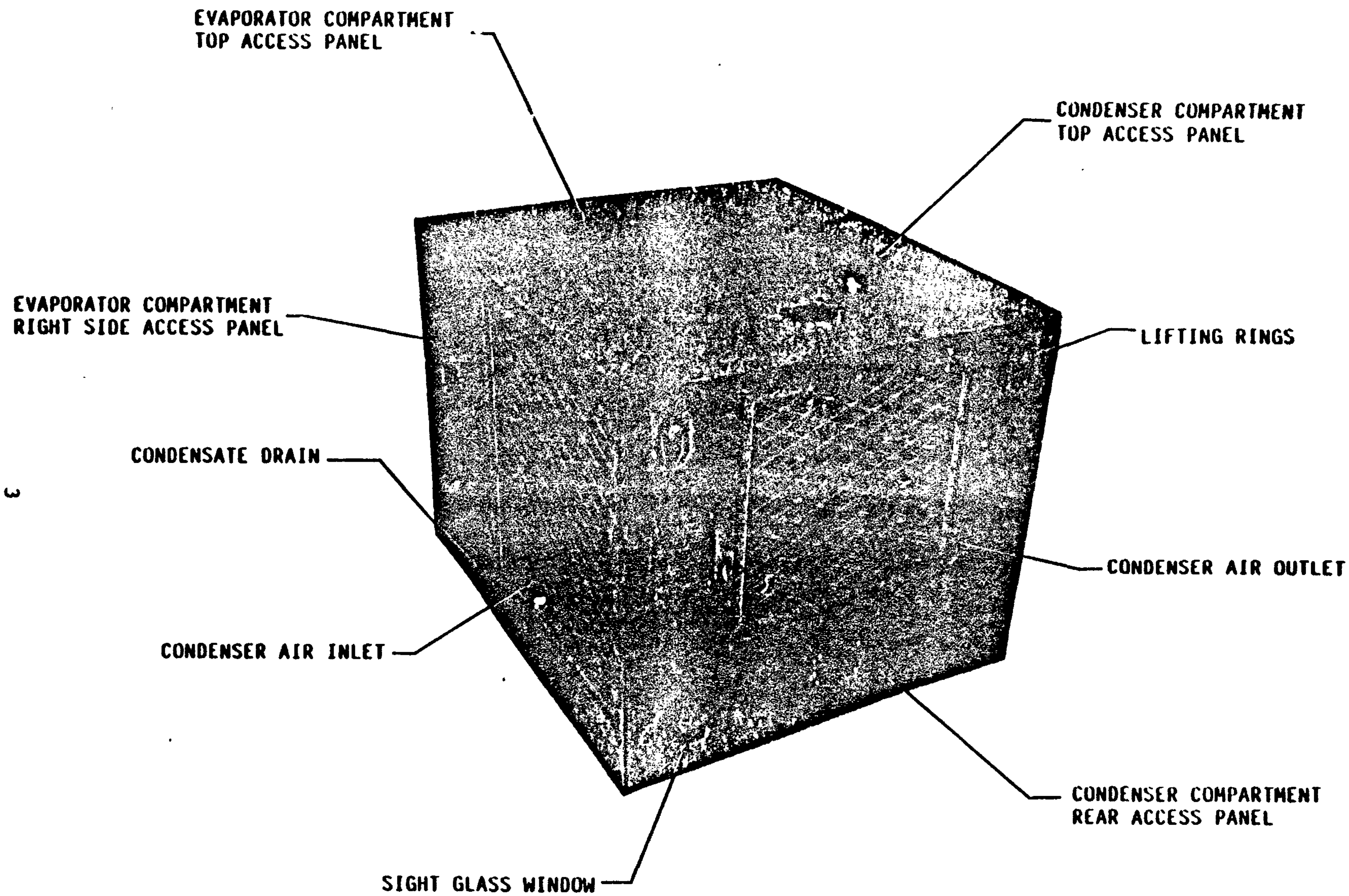
1.3.2 Other Openings. In the lower part of both the left and right sides there is a small condensate drain opening, tapped to accept a 3/8" male pipe thread fitting. This can be used with an appropriate hose to carry the water, condensed from the air by the evaporator coil, to a convenient location for disposal.

A window for viewing the refrigerant sight glass is in the lower rear panel, and in Figures 1 and 2, the four lifting rings can be seen near the top four corners.

1.3.3 Access Panels. Seven access panels are provided in the unit to facilitate servicing. These are described, along with their use, in Section 6, Servicing Procedures. Further access for servicing can be gained by removing air opening frames and assemblies, and the control panel assembly.



LEFT FRONT VIEW (FIGURE 1)



RIGHT REAR VIEW (FIGURE 2)

1.4 Lifting. The unit weighs 315 pounds and can be lifted with a crane and a four-leg sling using the four lifting rings near each of the top corners. If extreme caution is used to prevent damaging the bottom skin, a fork lift can also be used to lift the unit.

1.5 Electric Power. The 18K/100 ICE Unit operates on a 208 V, 3-phase, 4-wire, 60-hertz electrical supply. The power supply should be capable of sustaining a 7500 watt load with a 21-ampere current. The power supply should be protected by three 30-amp slow-blow fuses or a circuit breaker.

1.6 Unit Capacities. The 18K/100 ICE Unit nominal capacities are as follows:

Cooling: 18,000 BTUH
Heating: 24,000 BTUH
Chemical-Biological (CB) Filtered Fresh Air: 100 cfm
Normal Fresh Air Intake: 40 cfm
Conditioned Air Discharge: 650 cfm @ .25 ESP

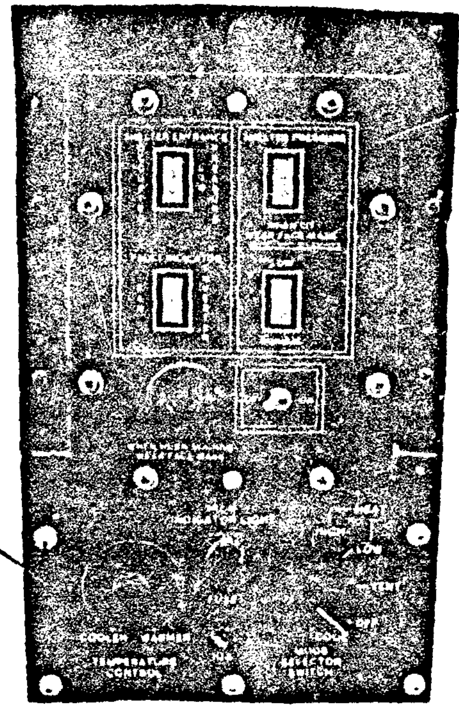
1.7 Operating Modes. The ICE Unit has it's control panel divided into two sections; one to operate the heater/air conditioner, and the other to control the CB filter fan (see Figure 3).

1.7.1 Vent. In the VENT mode, the main motor and the evaporator fan operate, recirculating room air and also bringing in approximately 40 cfm of fresh air. (This fresh air is brought in unless the CB fan is turned on. With the CB fan on, the fresh air damper is closed, so that outside air enters only through the CB fan and filter.)

1.7.2 Cool. With the mode switch in the COOL mode, the main motor runs and the evaporator fan, refrigeration compressor, and condenser fan also operate. The evaporator fan impeller is attached to the main motor shaft, so that any time the motor is running, the evaporator fan runs. Fresh air is also pulled in, except when the CB fan runs, as indicated in the paragraph above. The temperature of the room is controlled by a thermostat which senses the temperature of the return air. The room temperature can be set by rotating the temperature control to select the desired temperature.

1.7.3 Low Heat. In the LOW HEAT mode the evaporator fan runs, and half of the 12 electric heater elements may operate. They are controlled by the thermostat, which can be set for the desired temperature. The thermostat turns the six heaters on and off to maintain the set temperature in the room.

1.7.4 High Heat. With the mode switch set to HIGH HEAT, six electric heater elements are continuously energized and the other six elements are cycled on and off by the thermostat as described in the paragraph above. Since half of the heaters are on continuously, it is up to the operator to switch back to low heat if the thermostat control is set all the way to cooler, but the room is still too warm.



CONTROL PANEL (FIGURE 3)

1.7.5 CB Fan. When the ON-OFF switch in the upper panel is turned on, the CB fan will operate at the proper speed to maintain a 3/4" w.g. air pressure inside of the room. It does this by forcing CB filtered outside air into the evaporator portion of the air conditioner. A pressure sensor in the CB control panel will maintain the proper room pressure. The CB fan can operate alone, with nothing else running, or with the air conditioner/heater in any operating mode.

1.8 Features

1.8.1 EMI Protection. The 18K/100 ICE Unit is fully EMI protected. All electrical relay and solenoid coils are protected with diodes and all DC relay contacts are protected with capacitors to minimize internally generated interference. The 208 V power input line is filtered at the entrance to the unit to prevent spikes or stray signals from entering or leaving the unit and thus suppressing conducted EMI. All openings in the unit, such as evaporator air discharge and return grilles and condenser air inlet and outlet are protected by EMI screens with openings not larger than 1/8 of an inch. All removable panels and EMI screens are electrically connected to the unit chassis by EMI gasketing and screw spacing close enough to prevent gaps where radiated EMI could intrude. When replacing any removed EMI screen or panel, care should be taken to evenly tighten the scews to compress the spring-type lock washers, but not overtighten the screws. Either over or undertightening could cause poor sealing of the EMI gaskets.

1.8.2 Remote Control. The control box, including both the CB system control module and the air conditioner control panel, is designed to be remotable. If the application of the unit to a shelter is such that the front of the unit is not accessible from inside the shelter, then both the return air filter and the controls must be removed from the unit as described in paragraphs 3.3 and 3.4. Also, if a CB protective entrance is used on the shelter, the control box must be remoted and connector P5 must be connected to the protective entrance through a long cable.

2.0 OPERATION

All operator's controls are located on the 18K/100 ICE Unit's control panel (Figure 3). The panel is divided into two sections; the upper one to control the CB filter fan, and the lower to control the air conditioner/heater.

2.1 <u>CB Filter</u>. The Chemical/Biological (CB) filter can be operated by itself or along with any operating mode of the air conditioner/heater. Its purpose is to furnish up to approximately 100 cubic feet per minute (cfm) of filtered outdoor air to the shelter. It uses a filter element which removes chemical and biological contaminants from the air that passes through it. When the CB system is turned on, the CB filter fan speed is automatically controlled to maintain the proper air pressure inside the shelter. During a CB attack, a positive pressure must be maintained in the shelter so that outdoor wind cannot force contaminated air into the shelter through any cracks or leaks. If there are leaks, the positive shelter pressure will cause clean inside air to leak out, rather than allow CB-laden air to leak in.

WARNINGS

> The CB fan should only be operated when a CB attack is imminent. Unnecessary use of the filter may cause the element to fill with normal air contaminants so that no capacity is available when needed for CB use.
>
> No CB filtered air is supplied to the shelter unless the CB filter fan switch is turned on and the fan is running. This can be heard as a high pitched noise.

The CB control panel contains an on-off switch, a warning horn, and four indicator lights, some of which are multi-purpose.

2.1.1 <u>Switch</u>. Turning the CB switch to the ON position will cause the fresh air damper to close and will start the CB fan. This fan comes up to speed slowly and is automatically speed-controlled to maintain the proper air pressure inside the shelter.

2.1.2 <u>Horn</u>. With the CB switch on, the horn will sound intermittently for approximately twenty seconds any time the shelter pressure is too low. This is a warning that the pressure inside the shelter is not high enough to keep out chemical or biological contamination and each person in the shelter should put on a CB face mask. Make sure that all doors and other openings are closed tightly.

2.1.3 <u>Shelter Pressure Warning Light</u>. If the CB switch is on, the indicator light in the upper right corner of the CB control panel will light up red when the shelter pressure is not high enough. Each person in the shelter should put on a face mask. Be sure all outside shelter openings are closed tightly. It is normal for the pressure to be low when the CB system is first turned on.

2.1.4 Shelter Pressure Level Light. The indicator light in the lower right corner of the CB control panel will light up in four yellow sections to indicate whether the shelter pressure is low or normal. As the shelter pressure increases, the light sections will go out.

2.1.5 Fan/Inverter Fault Light. If there is a problem with the CB fan motor (such as excessive current), the left half of the lower left indicator light will come on. If the right half of this same indicator light comes on, it indicates that the electronic inverter feeding the CB fan motor has a problem. If either of these indicators stay on when the CB unit is turned on, call the proper maintenance personnel to repair the system.

2.1.6 Protective Entrance. If the left half of the upper left indicator light comes on, it is an indication that the protective entrance is occupied. If the right half of that light is lit, the pressure in the protective entrance is low. This is probably due to the outer door just having been opened. If the light stays on, it probably indicates that the outer door has not closed completely, which should be corrected by the next person using the protective entrance.

2.2 Air Conditioner/Heater. The air conditioning, heating, or vent functions can be operated with or without running the CB filter system. However, no CB filtered air is supplied to the shelter unless the CB fan is operating. Fresh air which has not been CB filtered is always pulled into the shelter by the evaporator fan unless the CB fan is turned on.

The lower portion of the control panel contains the controls for operating the air conditioner/heater. Located on this panel is a mode switch, a temperature control knob, a run indicator light and a fuse access cover.

2.2.1 Mode Switch. A five-position selector switch controls the operating mode of the air conditioner/heater. These positions are (in a counterclockwise direction) COOL, OFF, VENT, LOW HEAT, and HIGH HEAT.

2.2.1.1 COOL. In the COOL mode the unit operates as an air conditioner and cools the shelter air. Normally, the main motor, evaporator fan, compressor and condenser fan operate in the COOL mode. The evaporator fan is mounted to one end of the main motor shaft and therefore always turns when the main motor operates. The evaporator fan recirculates room air and brings in about 40 CFM of fresh outside air. The compressor and condenser fan are belt-driven through clutches by the main motor and will normally run all the time the unit is in the COOL mode. If the unit is operated in the COOL mode with cold outdoor temperature, an unusually low refrigerant head pressure may occur. A pressure switch in the refrigeration system will deenergize the condenser fan clutch, stopping the condenser fan.

Therefore, the refrigerant head pressure will be controlled in cold weather by the condenser fan starting and stopping automatically.

When in the COOL mode, the temperature control knob will allow selection of the desired room temperature (see Section 2.2.2).

2.2.1.2 OFF. With the mode switch in the OFF position, the main motor does not run, therefore, no heating or cooling can be obtained from the ICE Unit. However, the CB fan can be operated (see Section 2.1 above) with the mode switch in the OFF position.

2.2.1.3 VENT. In the VENT mode, the main motor and evaporator fan operate. This will recirculate room air and also draw in approximately 40 cfm of fresh outside air. No cooling or heating is possible in the VENT mode.

2.2.1.4 LOW HEAT. In the LOW HEAT mode, six electrical heaters cycle on and off to maintain the desired temperature in the room (see Section 2.2.2 for temperature setting information). The main motor and evaporator fan operate, and room air is recirculated and heated and about 40 cfm of fresh outside air is pulled in.

2.2.1.5 HIGH HEAT. In the HIGH HEAT mode the same six heaters cycle on and off to maintain room temperature at the desired set point. In addition, another six heater elements are fully on and will stay on until the mode switch is changed. Again, the evaporator fan runs to recirculate room air and about 40 cfm of fresh outside air is also brought in.

An important factor to remember in the HIGH HEAT mode is that half of the heater elements are on continually. If it gets too warm in the shelter and the temperature control is set at a normal setting, the operator must change the mode switch to the LOW HEAT position. (Likewise, if the LOW HEAT position does not produce enough heat with the temperature control at a normal setting, the operator must turn the mode switch to HIGH HEAT.)

2.2.2 Temperature Control. The temperature control knob allows the operator to select the thermostat setting and, therefore, the desired room temperature when either cooling or heating. Turning the knob pointer counterclockwise toward COOLER will allow the room temperature to decrease after a period of unit operation. When the temperature control knob pointer is turned clockwise toward WARMER, room temperature will increase over a period of time. Room temperature can be controlled with this knob in any operating mode except VENT. Note that in the HIGH HEAT mode, however, half of the heaters are on with no automatic control, while the remainder of the heaters are controlled by the temperature control knob.

When starting the ICE Unit, set the thermostat knob pointer about mid-scale (pointing straight up) or to that setting which has been found to be comfortable in the past.

It should be noted here, that the capacity of the unit is limited. In the interest of comfort and energy conservation, doors and windows in the shelter should be closed when the unit is used in either a heating or cooling mode.

2.2.3 Run Indicator Light. If the ICE Unit is connected to a source of electric power and the mode switch is turned to any operating mode, the green run indicator light should be on. With the unit connected electrically, but with the mode switch turned to OFF, the presence of control voltage can be determined by pressing in on the run indicator lamp holder and checking that the light comes on. If the light does not come on, the most likely reasons are:

a. The unit is not plugged in.

b. Power is not turned on to the power input cable.

c. The low voltage fuse is blown.

d. A fault in the internal wiring or component exists and must be repaired.

e. The run indicator bulb is burned out. A burned-out bulb can be replaced by uscrewing the lamp outer cover (knurled) counterclockwise until it comes off. Then replace the old bulb with a proper new bulb and reinstall the outer cover, turning it clockwise until snug.

2.2.4 Fuse Access Cover. The low voltage control system is protected by a 10-amp fuse, located in the lower control panel (see Figure 3). When it is suspected that this fuse is blown, it can be replaced with a good 10-amp fuse by unscrewing the fuse access cover (counterclockwise). Remove and discard the bad fuse, place a good fuse into the fuse holder and replace the cover by turning it clockwise until snug.

3.0 INSTALLATION

3.1 Bolting in Place. The 18K/100 ICE Unit is a base-mounted unit and includes six threaded inserts in the bottom so that the unit can be securely mounted to a support. Bolts with a 5/16-18 thread of proper length should be used. Bolt penetration into the unit should be not less than 5/8" or more than 7/8". One insert is located near each corner of the unit and two are under the motor. The bracket supporting the unit should be level, flat, have holes to match those in the unit, and be strong enough to support the unit during transport and cross country travel. In order to safely ground the unit and to maintain EMI resistance, special care should be taken to ground the four corner mounting bolts. Ground straps to these bolts are recommended.

3.2 Position/Location/Sealing. The unit should be mounted completely outside of the shelter but with the front face of the unit (the control panel face) showing through a properly sized and located hole in the shelter. The joint between the shelter and the ICE Unit must be gasketed or sealed to prevent leakage of air, water or contamination. If the control panel is to remain in the unit, the complete control panel, including all controls and indicator lights, must be accessible from inside the shelter through the hole in the shelter wall.

For ease of maintenance, make sure all access panels and their screws and the fresh air filter are accessible from outside the shelter. Also, the return air filter must be accessible from inside the shelter for periodic removal and cleaning.

3.3 Ducting. If return air ducting is used inside the shelter, the return air filter may have to be removed from the unit and located in an accessible location in the return duct.

3.4 Remote Controls. If the control panel is to be remoted, a block-off panel with pass-through connectors properly connected must be used to cover the hole in the unit front where the panel was removed. Control cables must connect the remoted panel with these connectors in the block-off panel. For proper CB filter control, the red hose connection on the back of the control panel must be connected with a hose to sense the outdoor air pressure. The control panel must be remoted if the ICE unit is mounted so that the control panel is not completely accessible from inside the shelter. Also, if a protective entrance is used on the shelter, the control panel must be remoted for ready access to connector P5 which must be connected, through a long cable, to the protective entrance.

3.5 Condensate Drains. There is a 3/8" pipe thread tap in each side of the air conditioner to drain condensate removed from the air during the cooling process. A 3/8" pipe nipple should be screwed into each of the two tapped holes and hoses attached to the nipples to conduct the condensate water to a satisfactory location. Remember that this water drains by gravity and therefore the hoses must run downhill from the unit.

3.6 Electrical Connections. Electrical power input to the unit must be 208 volt, 3-phase, 60 Hertz, 4-wire. Connections to the input electrical connector (MS 3102R22-22P) on the front of the unit, should be as follows:

208 V line 1 to pin A
208 V line 2 to pin B
208 V line 3 to pin C
Neutral to pin D

WARNING: Be sure that neutral is never connected to any pin but pin D. This will assure that the 120 V CB fan is not connected to higher voltage.

WARNING: Before connecting the electric power supply to the unit, be sure that the unit is grounded to a good electrical ground. This will help to prevent an electric shock hazard.

CAUTION: The electric power supply phasing must be correct or various components within the ICE unit will run backwards, which may cause damage or malfunction. See the following paragraph for procedures to assure correct phase connection.

3.7 Correct Phasing. Each time that a new electrical connection is made to an ICE Unit, a check should be made to assure that the electrical phasing is correct so that the main motor is rotating in the proper direction (see caution above). The two methods for checking this are as follows:

a. The recommended method is to start the ICE Unit in the COOL mode and immediately go to the rear of the unit (the condenser end, where the small sight glass window is). Air should be coming out of the large square grille above the sight glass window. If air IS coming OUT of the grille, the unit is electrically phased correctly, and no correction is needed.

However, if air is going IN through this grille, immediately stop the unit and use the following methods to correct this problem.

WARNING: Turn off all electrical power to the cable furnishing electrical power to the ICE Unit. The 208 V used to operate this unit can cause a severe shock and possibly death.

Shut off power to the ICE Unit's power cable. At the point where this cable connects to the electric power source, exchange wires A and B. (That is, disconnect wire A from its terminal and connect wire B in its place. Then connect wire A where wire B used to be connected.) Turn the power back on and make the above air flow test again. If air is now coming OUT of the rear grille, you have corrected the phasing problem.

WARNING: The following procedure will expose the operator to rotating machinery which could cause bodily injury. Use caution!

b. The second method for checking motor rotation is to remove the lower rear panel (with the small sight glass window in it).

Then start the unit in the VENT mode and make sure that the motor is turning CLOCKWISE. If the motor pulley is turning CLOCKWISE, the electrical phasing is correct. If the motor turns COUNTERCLOCKWISE, use the procedure in paragraph a above to correct the phasing problem. Replace the removed panel after this operation.

3.8 Obstructions. Make certain that the unit is installed in an area and in such a manner that air can circulate freely into and out of all outside openings in the ICE Unit. There should be nothing blocking the air flow. Remove any other pieces of equipment blocking the air flow and dirt or trash on or around the grilles.

4.0 PREVENTIVE MAINTENANCE

4.1 Inspection. Inspection should be performed daily to assure that the unit is in proper condition to operate. The inspection procedure is as follows:

a. Make sure that the unit is clean and free from mud, debris, and excess dirt. Cleaning can be done with a soft broom, a water hose, or a sponge or rag with soap and water followed by a water rinse.

b. Look through the EMI screens at the particulate air filters on the left side of the unit to be sure that they are clean and free of debris. Clean them if they are dirty. See paragraph 4.2.

c. Be sure that all outside air openings are clean and free of dirt, leaves, lint and trash, or anything which might prevent a full flow of air into or out of the air openings in the unit.

d. If the unit is operating in the COOL mode, check the sight glass on the back of the unit (it is covered by a glass window) to be sure that the dot in the center of the glass is a dark green, and that bubbles do not continuously move past the glass. If the spot turns yellow, or if bubbles are continuously seen in the sight glass, contact the next echelon of maintenance for repairs.

e. Check to be sure that nothing has plugged the two condensate drains. If hoses are attached, it is generally sufficient to check only the outlet ends of the hoses.

f. Be sure that any air or water seals around the unit, where it is attached to the shelter, are properly in place.

g. Check to be sure that there is not evidence of major damage to the unit. If major damage is found, contact the next echelon of maintenance for repairs.

h. Inside the shelter, push the PRESS-TO-TEST cover on the air conditioner run indicator light to assure that the bulb is good and that power is connected to the unit. The light should go on if the unit is running in any mode except CB Filter only, or when the lamp cover is pushed in. See Section 2.2.3, Run Indicator Light.

i. Check for major damage to all exposed parts of the unit and control panel inside the shelter.

j. Check the return air filter in the return air inlet. (This may be remotely located if ducts are used.) It should be clean and free from lint and trash. See paragraph 4.2 for removal and cleaning instructions.

k. Check to see if the desired temperature exists inside the shelter. If it does not, and if the unit is operating in the correct mode, check to see if changing the temperature control knob in the proper direction will correct the problem. (Give the unit time to change the conditions.) If this does not correct the situation, call the next echelon of maintenance for repairs.

NOTE: If any of these preventive maintenance items are continually found to be in good condition, with no need for correction, then the frequency of inspections for those items only can be lengthened. Most or all of these checks might regularly show conditions are O.K. and the inspection for these items could be done, perhaps, only once a month. Experience will determine how often inspection is necessary.

See paragraph 4.3 for CB filter replacement and precautions.

No preventive lubrication is required on this unit.

4.2 Particulate Air Filters. There are three particulate filters in this unit, not including an integral particulate filter in the CB filter element. One is in the return air opening, and filters the return air from the shelter, and two are on the outside of the unit (on its left side) and filter fresh air as it is brought into the system (see Figure 1). The CB air inlet filter is only used during operation of the CB system. The fresh air inlet filter is used in all operating modes except during CB system operation. Each of these three filters should be inspected on a regular basis, depending on use of the unit and experience of the operating and maintenance personnel (see paragraph 4.1, Inspection).

The particulate filters (called this because they remove some of the dirt particles from the air) are of the metal mesh, cleanable type. To clean one of these filters, remove the grille and filter retaining screws using a #2 phillips head screwdriver. Do not lose these screws, as they must all be replaced for proper system operation. Remove the grille and carefully pry out the filter element. The filter can be washed in soapy water followed by a rinse in clean water. Shake out the majority of the remaining water and replace the filter, grille and screws. Do not overtighten screws. Also note that a directional arrow is printed on the edge of each filter to indicate air flow direction. Be sure each filter is installed with the arrow pointing into the unit.

4.3 CB Filter. The chemical-biological filter element is installed in the condenser compartment and is accessible by removing the condenser compartment top access panel.

WARNING

If there is any possibility that the CB filter might contain chemical or biological contamination, you MUST use the proper anti-contamination MOPP equipment and procedures.

Contact with any CB agent is usually fatal.

To remove and replace the CB filter element, turn off power to the unit and remove the condenser compartment top access panel using a #2 phillips head screwdriver. Save all screws to properly fasten the panel when re-installing it.

With the top panel removed, open the clamp-type buckle on the strap holding the filter in place, unhook the belt hook from the buckle and move both ends of the belt (with buckle) out of the way. Move the hinged clean air duct away from the filter element, reach into the filter outlet with one hand and lift, then lift the filter clear of the unit with both hands. Dispose of the filter in accordance with proper CB procedures.

Remove a new CB filter from its carton and place it into the filter cradle in the unit so that the air directional arrows on the filter match that on the unit partition beside the filter. Make sure the filter is all the way into the duct opening on the left side of the unit, and swing the clean air duct over the discharge end of the filter. Hook the left belt hook on the buckle and close the buckle. The belt should hold the filter and clean air duct tightly in place. The right belt can be adjusted in or out of the buckle (before closing the buckle) to tighten or loosen the belt assembly. Make sure the belt ends are fastened well out of the way of any rotating or moving components in the condenser compartment. Replace the condenser compartment top cover and screws. Do not overtighten screws. Overtightened screws will bend the cover, causing a gap between the cover EMI gasket and the unit housing.

5.0 SPECIFIC CORRECTIVE MAINTENANCE PROCEDURES

Although the following maintenance functions should be accomplished by competent service personnel above the operator level, these procedures are included here as an aid to servicing the unit.

5.1 Changing Belts. Both the General Motors V-5 compressor and the condenser fan are V-belt driven from the main motor. To change these two belts, use the following steps:

a. Disconnect power from the unit to prevent the unit from being started while you are working on it.

b. Remove the condenser compartment top access panel and the condenser compartment rear access panel.

c. Remove the CB filter element as explained in paragraph 4.3.

d. Loosen the bolt holding the condenser fan belt idler pulley tensioning arm in place. Swing the arm out of the way so that the belt is loose.

e. Remove the condenser fan belt. (NOTE: Because of the method of fabrication of the prototype condenser fan shaft bracket, this bracket and fan may have to be loosened or removed for clearance to slip belts in and out of the unit.)

f. Loosen the two lower bolts holding the compressor to the lower frame, one bolt at each end of the compressor.

g. Loosen the two bolts holding the compressor side ears to the adjusting braces.

h. Rotate the compressor slightly toward the motor and remove the belt.

i. Replace the belts and reassemble the unit in the opposite order.

j. When tensioning belts, about 1/2" of belt movement should be possible when pushing the belt with a finger, half way between pulleys. Excess belt tension will prematurely wear bearings. Belts too loose may slip, wear quickly and make excessive noise.

5.2 Remove Motor. Use the following steps to remove the main motor:

a. Disconnect power from the unit.

b. Loosen the two V-belts, using the appropriate part of the procedure in paragraph 5.1.

c. Remove the screws holding the fresh air inlet on the left side of the unit. Move the inlet assembly out about 1/2".

d. Remove the return air inlet grille and filter.

e. Remove the return air inlet assembly and set it outside the unit, leaving wires attached.

f. Using the proper size allen wrench, loosen the evaporator fan wheel set screws. Pull the fan impeller off of the motor shaft.

g. Remove the loose parts of the shaft seal, noting in what order they go on the shaft.

h. Remove the insulated round cover plate behind the fan wheel.

i. Disconnect the motor electrically, noting which harness wires are connected to which motor wires for correct assembly later.

j. Remove the four motor mounting bolts and carefully remove the motor through the front of the unit.

k. Using the proper size allen wrench, remove the pulleys from the motor shaft. Note the exact position and hub direction of these pulleys for proper reinstallation later.

l. Reverse these procedures to reinstall the motor, noting the following hints.

1. Slip the belts over the motor pulleys just before the motor is in its final position.

2. Install the four motor mounting bolts but leave them loose until final motor position is verified.

3. There should be approximately 1/4" between the rear face of the evaporator fan and the insulation of the panel behind it.

4. After installing the return air inlet assembly, adjust the motor location so that equal clearance exists between the evaporator fan impeller and the inlet orifice.

5. Tighten the four motor mounting bolts and again check for proper clearance between the fan impeller and the inlet orifice. Spin the motor shaft to assure adequate clearance.

6. Continue with the reverse order installation. Use the belt tensioning procedures from paragraph 5.1.

5.3 Remove CB Fan. The following steps are used to remove the CB fan assembly:

a. Disconnect power from unit.

b. Remove the CB fan access panel on the left side of the unit.

c. Remove the condenser compartment top access panel and the CB filter element as described in paragraph 4.3.

d. Disconnect the two CB fan assembly MS connectors.

e. Loosen the intake air hose clamp and pull the hose off of the CB air inlet assembly.

f. Loosen the discharge air hose clamp and pull the hose off of the CB air discharge duct.

g. Loosen the two rear bolts (farthest from the access panel) holding down the CB fan assembly.

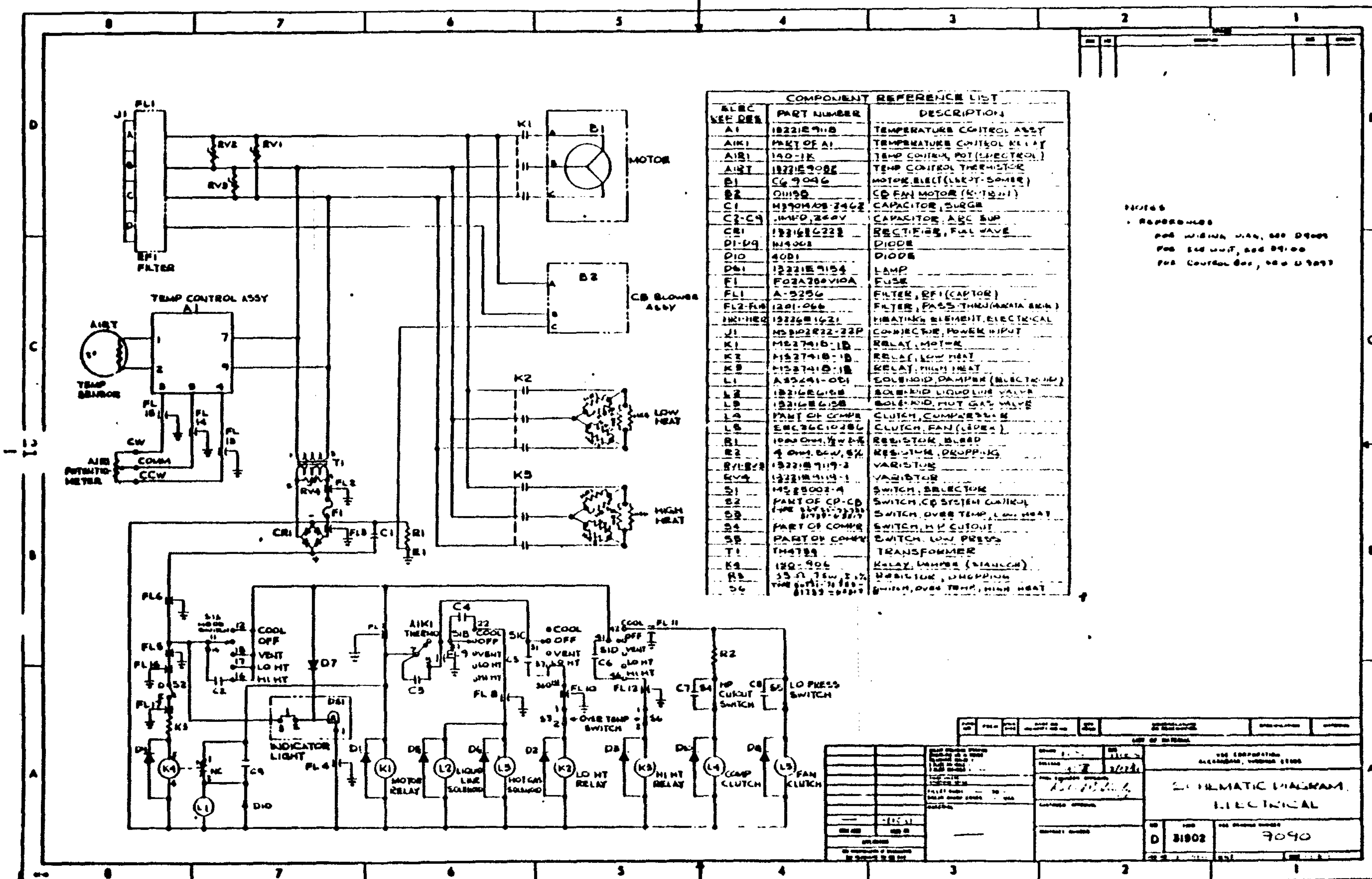
h. Remove the two front bolts holding down the CB fan assembly.

i. Remove the CB fan assembly through the access panel hole.

j. Reverse the above procedures for CB fan assembly installation and unit assembly.

6.0 OTHER SERVICING AIDS

The 18K/100 Ice Unit Electrical Schematic Diagram (Figure 4), the Wiring Diagram (Figure 5), and the Refrigeration Schematic Diagram (Figure 6) are included to facilitate higher echelon troubleshooting and corrective maintenance procedures.



COMPONENT REFERENCE LIST

ELEC REF DES	PART NUMBER	DESCRIPTION
A1	13221E9118	TEMPERATURE CONTROL ASSY
A1K1	PART OF A1	TEMPERATURE CONTROL RELAY
A1R1	140-1K	TEMP CONTROL POT (SPECTROL)
A1RT	13221E9082	TEMP CONTROL THERMISTOR
B1	CG 9046	MOTOR, ELECT (LEAR-SIEGLER)
B2	01190	CB FAN MOTOR (R-TRON)
C1	M390M/08-2462	CAPACITOR, SURGE
C2-C9	.1MFD, 240V	CAPACITOR, ARC SUP
CR1	13216E6223	RECTIFIER, FULL WAVE
D1-D9	IN4002	DIODE
D10	4001	DIODE
DS1	13221E9154	LAMP
F1	F02A250V10A	FUSE
FL1	A-5256	FILTER, RFI (CAPTOR)
FL2-FL18	1201-066	FILTER, PASS-THRU (AMATA ARM)
HR1-HR2	13226E1621	HEATING ELEMENT, ELECTRICAL
J1	MS3102R22-22P	CONNECTOR, POWER INPUT
K1	M5274:6-1B	RELAY, MOTOR
K2	M5274:8-1B	RELAY, LOW HEAT
K3	M5274:8-1B	RELAY, HIGH HEAT
L1	A35241-001	SOLENOID, DAMPER (ELECTROID)
L2	13216E6158	SOLENOID, LIQUID LINE VALVE
L3	13216E6158	SOLENOID, HOT GAS VALVE
L4	PART OF COMPR	CLUTCH, COMPRESSOR
L5	EMC36C10286	CLUTCH, FAN (LIPE)
R1	10K OHM, ½W, 5%	RESISTOR, BLEED
R2	4 OHM, 50W, 5%	RESISTOR, DROPPING
RV1-RV3	13221E9119-2	VARISTOR
RV4	13221E9119-1	VARISTOR
S1	MS25002-4	SWITCH, SELECTOR
S2	PART OF CP-CB	SWITCH, CB SYSTEM CONTROL
S3	[illegible]	SWITCH, OVER TEMP, LOW HEAT
S4	PART OF COMPR	SWITCH, H P CUTOUT
S5	PART OF COMPR	SWITCH, LOW PRESS
T1	TH4789	TRANSFORMER
K4	120-906	RELAY, DAMPER (STANCOR)
R3	35 Ω, 75W, 5%	RESISTOR, DROPPING
S6	[illegible]	SWITCH, OVER TEMP, HIGH HEAT

FIGURE 4

COMPONENT REFERENCE LIST		
ELEC REF / SS	PART NUMBER	DESCRIPTION
A1	13221E9119-1	TEMPERATURE CONTROL ASSY
A1K1	PART OF A1	RELAY, THERMOSTATIC
A1R1	140-1K	POT, TEMP CONTROL (SPECTROL)
A1RT	13221E9082	THERMISTOR, TEMP CONTROL
B1	9088	MOTOR
B2	9106	CB FAN ASSY
C1	M39014/0-2462	CAPACITOR, FILTER
C2-C9	.1 MFD, 200V	CAPACITOR, ARC SUPPRESS
CP-CB	5-19-9120	CONTROL PANEL-CB FILTER
CR1	D-39-26	RECTIFIER (EE)
D1-D9	1N4001	DIODE, BLOCKING
E1		GROUNDING SCREW
FL1	A-5256	FILTER, RFI (CAPTOR)
FL2-FL17	M15733/61-002	FILTER, EMI
HR1-HR12	13226E1621	HEATING ELEMENT, ELECTRICAL
J1	MS3102R22-22P	CONNECTOR, INPUT
J2	MS3474W14-15P	CONNECTOR
J3	MS3470W14-15S	CONNECTOR
J4	MS3106R22-22S	CONNECTOR
J5	MS3474W14-12S	CONNECTOR
J7	MS3470W14-4PW	CONNECTOR
K1-K3	MS27418-1B	RELAY
L1	A35241-051	SOLENOID DAMPER (ELECTRO...)
L2-L3	13216E6158	SOLENOID VALVE
L4	PART OF V5 COMPR	CLUTCH, COMPRESSOR
L5	SEC 26C 10286	CLUTCH, FAN (LIEVEX)
P1	MS3106R22-22S	CONNECTOR
P2	MS3475E14-15S	CONNECTOR
P3	MS3475E14-15P	CONNECTOR
P4	MS3106R22-22P	CONNECTOR
P7	MS3475E14-4SW	CONNECTOR
R1	1000Ω, 1/2W, ±5%	RESISTOR
R2	4Ω, 50W, 5%	RESISTOR
RV1-RV3	13221E9119-2	VARISTOR
RV4	13221E9119-1	VARISTOR
S1	MS25042-4	SWITCH, SELECTOR
S2	PART OF CP-CB	SWITCH, CB FILTER CONTROL
S3	[illegible]	SWITCH, OVERTEMP, LOW HEAT
S4	PART OF V5 COMPR	SWITCH, HIGH PRESS. CUTOUT
S5	PART OF V5 COMPR	SWITCH, LOW PRESS. CUTOUT
T1	TM 4759	TRANSFORMER (TRANSFORMER...)
TB2	38TE-14	TERMINAL BOARD
TB3	37TE-4	TERMINAL BOARD
XDS1	8C2 1110-0832-[illegible]	LAMPHOLDER (DIALIGHT)
XF1	342-[illegible]	FUSEHOLDER (LITTEL FUSE)
J6	MS3750BE20-41P	CONNECTOR
P6	MS3751[illegible]	CONNECTOR
D10	4001	DIODE
TP1-[illegible]	[illegible]	TERMINAL POST
TB1	31TB10	TERMINAL BOARD
R3	30Ω, 15W, ±1%	RESISTOR
S6	[illegible]	SWITCH, OVERTEMP, HIGH HEAT
K4	150-906	RELAY, DAMPER (STANCOR)

NOTES:

1. REFERENCE
   FOR SCHEMATIC, SEE D9090
2. TERMINAL [illegible] FOR A1A1, B1-B2, [illegible]

WIRING DIAGRAM

D 31902 9089

FIGURE 5

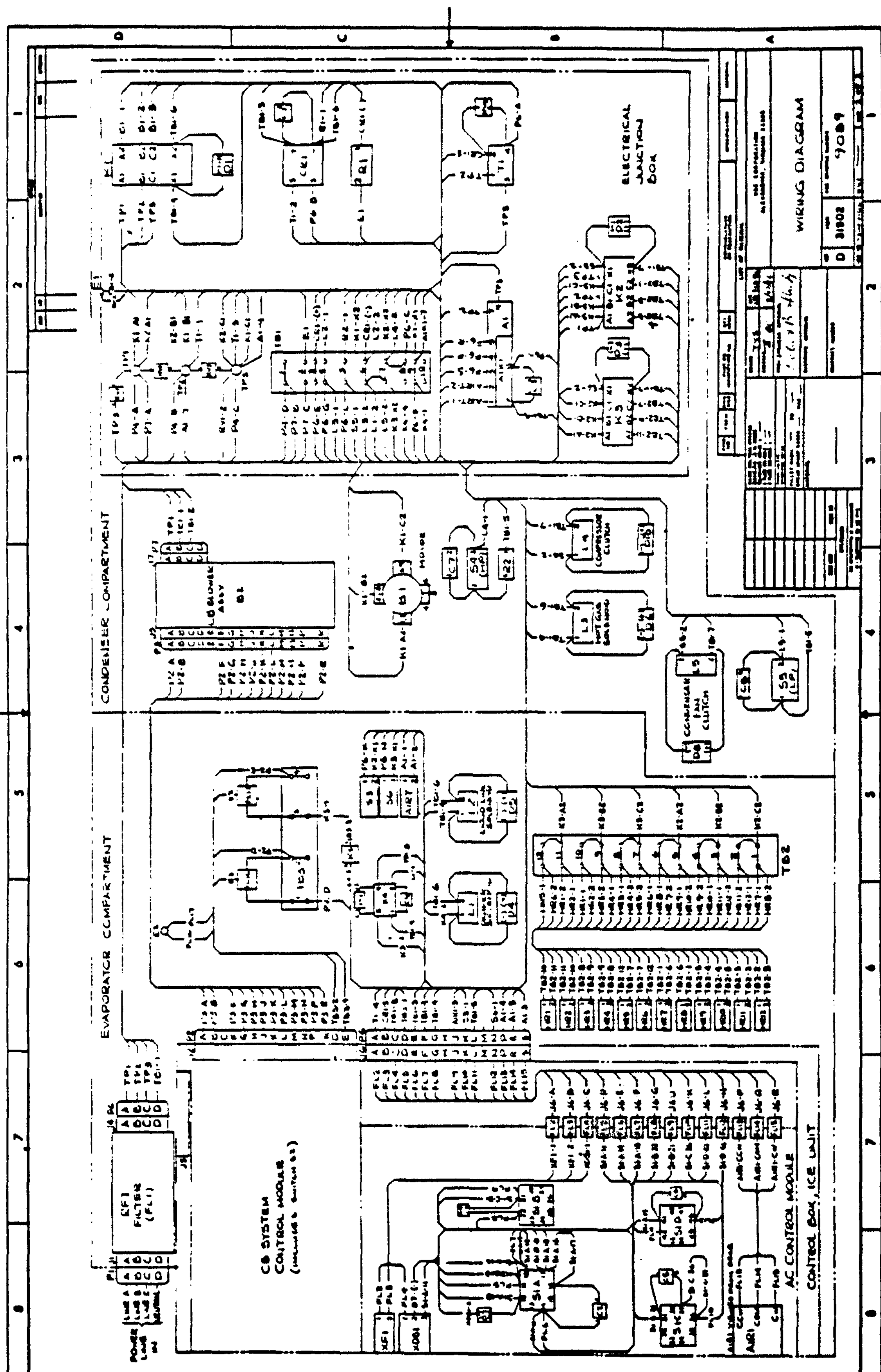

WIRING DIAGRAM
ELECTRICAL JUNCTION BOX
CONDENSER COMPARTMENT
EVAPORATOR COMPARTMENT
BLOWER ASSY
MOTOR
COMPRESSOR CLUTCH
CONDENSER FAN CLUTCH
CB SYSTEM CONTROL MODULE
AC CONTROL MODULE
CONTROL BOX, ICE UNIT
EF1 FILTER (FL1)
POWER LINE IN
TB2
9089

FIGURE 5

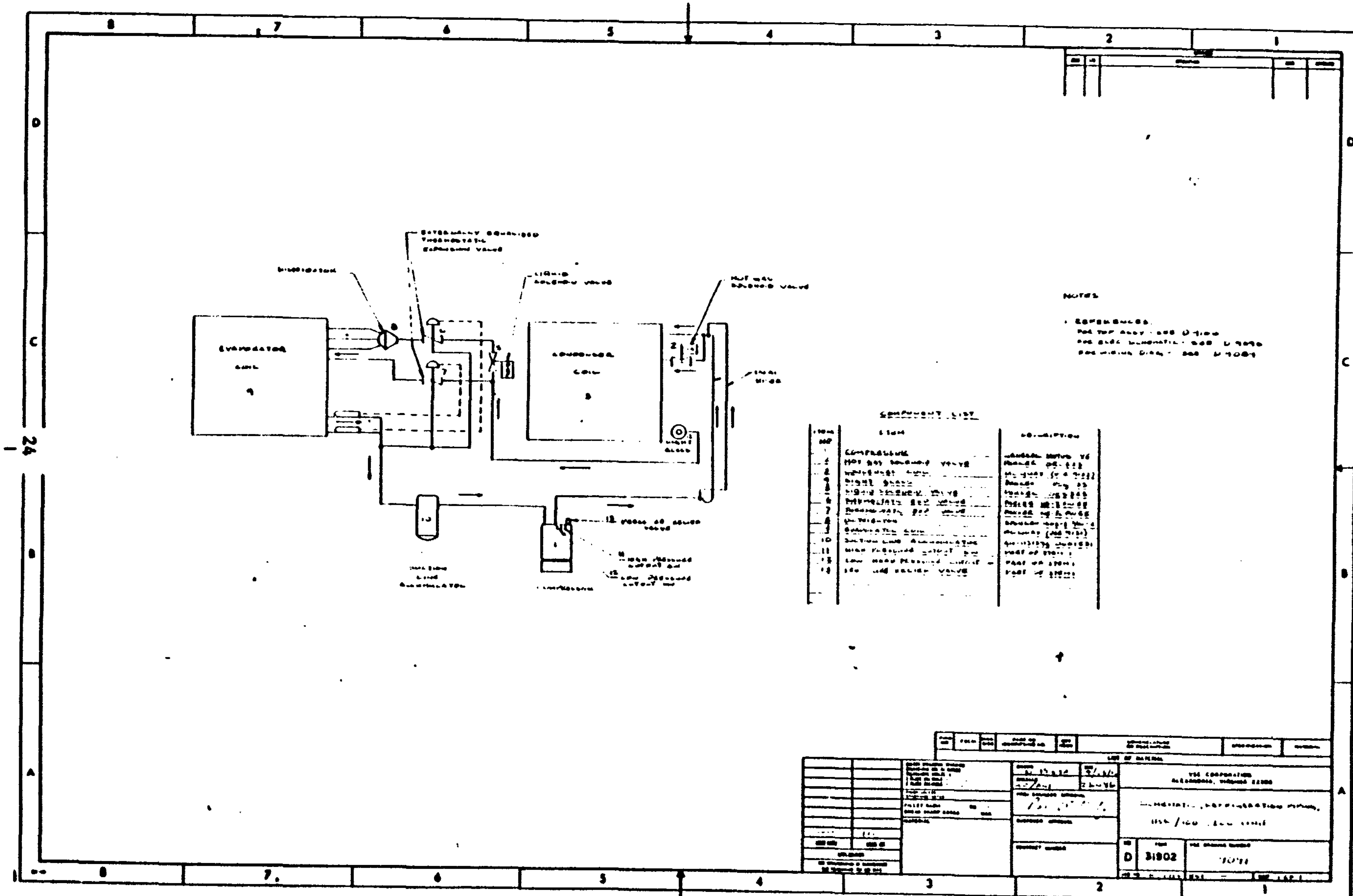

EVAPORATOR COIL
CONDENSER COIL
NOTES
COMPONENT LIST
D
31802

FIGURE 6