AD-A081 006 ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND ABERD--ETC F/G 19/3
SUMMARY OF M113A1 ARMORED PERSONNEL CARRIER (APC) LEAKAGE TESTI--ETC(U)
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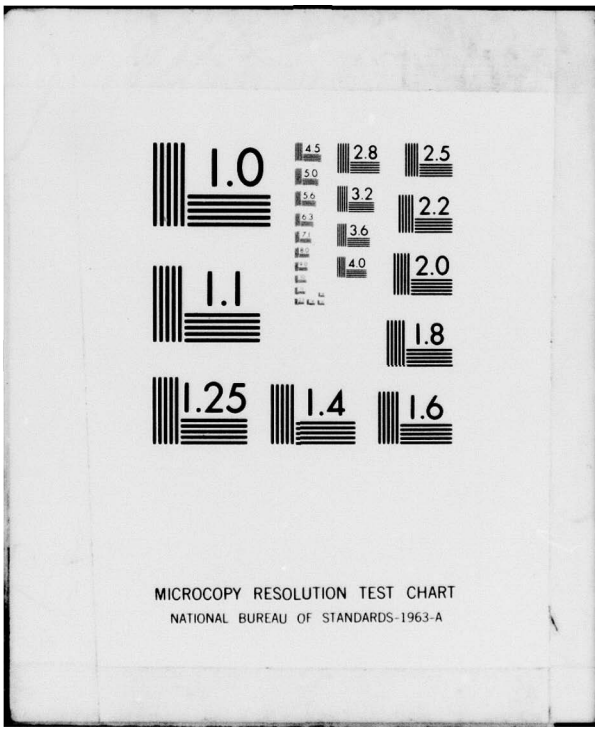
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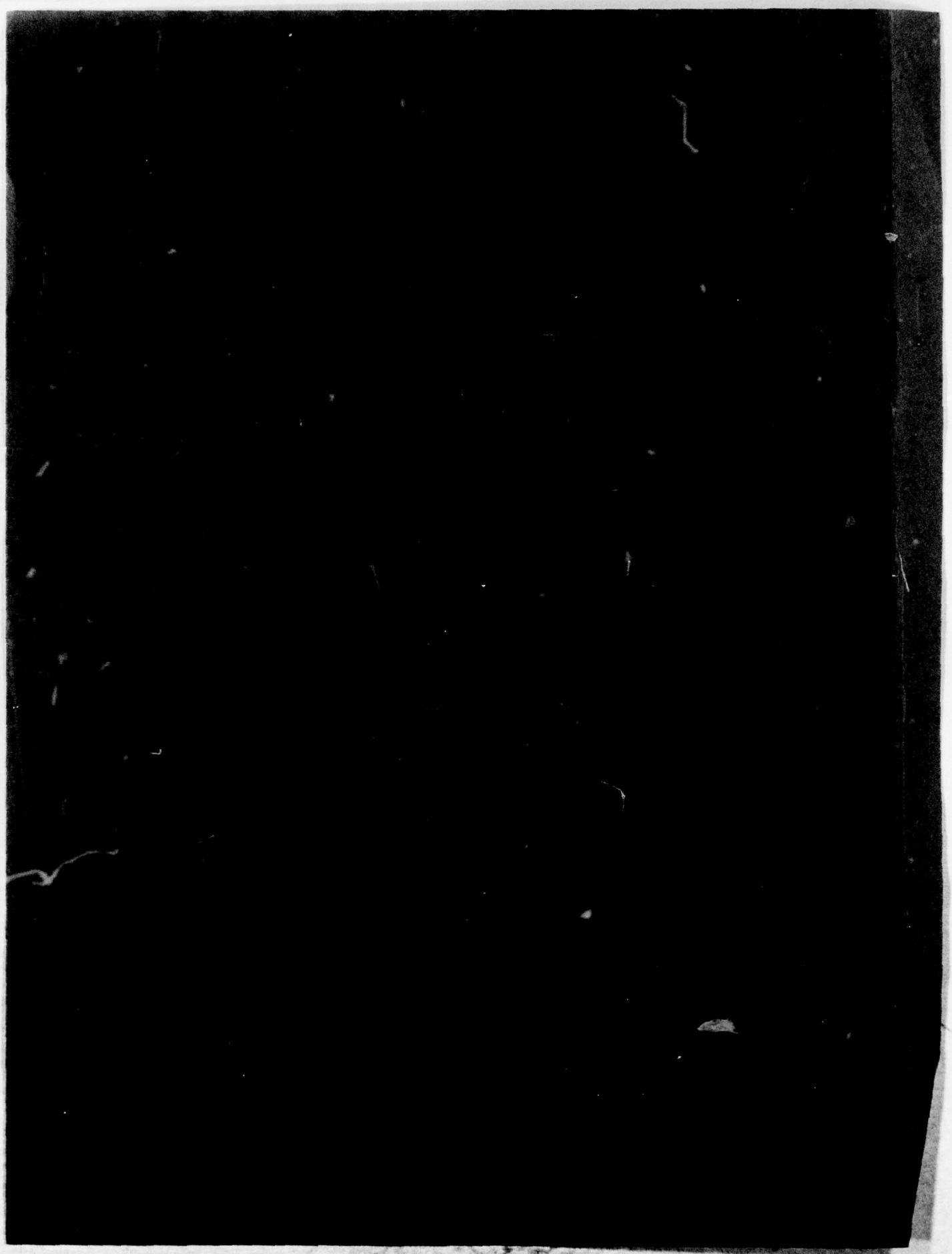

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Code tester	M577	Command post carrier
Anemometer	M113A1	Leakage reduction
Leakage	Armored personnel carrier	Vehicle leakage

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report summarizes three sets of M113A1 Armored Personnel Carrier (APC) leakage data which were acquired from Aerophysics Company, Donaldson Company, and Research Division, Chemical Systems Laboratory. The average leakage value for the M113A1 APC is 458 ft^3/min at 1.5-inches water gage. Six leakage reduction measures are suggested that have a potential of reducing the M113A1 APC leakage value to 110 ft^3/min at 1.5-inches water gage. Areas where leakage reduction is possible include the commander's turret ring, scupper valve, air ventilator control, air inlet valve, hatches/doors, and bilge pump discharge line.

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PREFACE

The work described in this report was authorized under Project 1M263721D604, Collective Protection for Combat Vehicles. It was begun in September 1977 and finished at the end of June 1978.

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SUMMARY OF M113A1 ARMORED PERSONNEL CARRIER (APC) LEAKAGE TESTING

I. INTRODUCTION.

To ensure that the current combat vehicle fleet has adequate nuclear, biological and chemical (NBC) protection, the Army established an armored-vehicle program managed by US Army Tank Automotive Research and Development Command (TARADCOM). The central effort of this program is at Chemical Systems Laboratory (CSL), Aberdeen Proving Ground. To characterize a vehicle's vulnerability to NBC agents, physical parameters are defined and a series of challenge tests are conducted to quantify the data base. Vehicle leakage enables modeling of air exchange between the vehicle and its environment: Air exchange determines the concentration of NBC agent that infiltrates the vehicle. The purpose of this report is (1) to summarize three sets of M113A1 Armored Personnel Carrier (APC) leakage data which has been acquired from Aerophysics Company, Donaldson Corporation, and Research Division, CSL and (2) to prepare preliminary modification for major leak areas.

II. TEST PROCEDURES.

Test methodologies were reviewed in a previous report* and it was recommended that a standardized-leakage-testing procedure be utilized. A standardized-vehicle-leakage test procedure enables comparison of leakage data generated by different sources. A short description of each test procedure is provided.

CSL supplies air through commander's hatch with a centrifugal blower and measures the flow rate with a calibrated-axial-vane anemometer immediately before discharge into the vehicle. The exterior and/or interior of the vehicle is then examined (generally by feel) to locate sources of air leakage which are then sealed with duct seal or tape. Once all accessible leaks are sealed, the unaccounted leakage is measured. Next, each individual leak is unsealed, and each associated leakage measured at several differential static pressures. Each leakage measurement is then repeated. The leak area is resealed prior to measuring the next leak area.

Aerophysics supplies the air through the air intake port using a "code tester" built in accordance with the Joint Air Moving and Conditioning Association, Inc. – American Society of Heating, Refrigerating, and Air Conditioning Engineers' specifications published in April 1975. The "code tester" has the capability to measure airflow up to 6000 ft^3/min. The air mover is a variable-speed centrifugal fan, controlled by a variable voltage-variable frequency "varidyne" electric generator. Initial leak identification is made by feel. After all accessible leaks are sealed with duct tape, the unaccounted leakage is measured. Next, each leak is unsealed and the associated leakage measured at several differential static pressures.

Donaldson Corporation leakage data was extracted from a report.** It is assumed that the data was measured by a similar procedure.

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* Ferriter, J. M., and Beeson, L. J. ARCSL-TR-79041. Summary of M60A1 Tank Leakage Testing. June 1979.

** Krisko, W. J., Camplin, H. R., and Schoen, D. W. Donaldson Corporation. Contract DAAK-11-78-C-0020. Final Report. Investigative Study of Positive Pressure Collective Protection for Combat/Armored Vehicles. August 1978.

III. LEAKAGE DATA RESULTS.

The data from the three sources are collected in the table. CSL and Aerophysics* conducted their tests on the same M113A1 APC's. The Donaldson Corporation data are from an unknown vehicle. Some of the Donaldson data are estimated from M577 Command Post Carrier (CPC) leakage data.

IV. DISCUSSION OF RESULTS.

Total leakage and individual leakage points are reported and are compared where applicable. All data are reported in standard cubic feet per minute at 1.5-inch water-gage static pressure.

A. Total Vehicle Leakage.

	Aerophysics		CSL		Donaldson
Serial No.	69569	55469	69569	55469	–
ft^3/min	347	422	403	474	555.9

Aerophysics supplied air through the air inlet valve and did not measure a recordable leak at the driver's hatch. Leakage for firewall auxiliary blower was not measured on the vehicles tested by Aerophysics and CSL. If the data are corrected to reflect similar leak points, the comparative values are as follows:

	Aerophysics		CSL		Donaldson
Serial No.	69569	55469	69569	55469	–
ft^3/min	414	487	403	474	513.8

B. Commander's Turret Ring.

	Aerophysics		CSL		Donaldson
Serial No.	69569	55469	69569	55469	–
ft^3/min	116	149	92	141	157

This is a major leak area.

* Jackson, W. P., Foshag, W. F., and Boehler, G. D. Aerophysics Company. Contract DAAK11-78-M-0013. Final Report. Static Air Leakage on Two M113A1 Full Tracked Armored Personnel Carriers. August 1978.

Table. M113 APC Leakage - Comparison of Results

Leak location	Aerophysics 12B55469	Aerophysics 12C69569	CSL 12B55469	CSL 12C69569	Donaldson
	std ft ^{3}/min at 1.5 in wg*				
Vehicle as received	422	347	474	403	555.9
Commander's turret ring	149	116	141	92	157**
Ventilator control (closed)	103	56	109	67	39
Rear door	43		33	1	0
Grommets to engine		3		3	6.9
Scupper valve	40	93	44	100	183
Ramp	17	8	0	3	
Torsion bars	12	24	16	28	
Bilge pump	15	15	11	13	7.4
Driver's periscope cover	11	9	12	9	6
Cargo hatch	2	1	0	0	4**
Engine access door	2	1	3	4	1**
Unaccounted leakage	28	21	11	9	25**
Firewall auxiliary blower					42**
Driver's hatch					5.5**
Air inlet valve (closed)			65	67	

* Wg = water gage pressure
** Projected data

C. Ventilator Control (closed).

	Aerophysics		CSL		Donaldson
Serial No.	69569	55469	69569	55469	–
ft^3/min	56	103	67	109	39

Good agreement is obtained between Aerophysics and CSL. This leak value may depend on the tolerances of the valve.

D. Scupper Valve.

	Aerophysics		CSL		Donaldson
Serial No.	69569	55469	69569	55469	–
ft^3/min	93	40	100	44	183

Leakage of the scupper depends on the position of valve.

E. Rear Door.

	Aerophysics		CSL		Donaldson
Serial No.	69569	55469	69569	55469	–
ft^3/min	–	43	1	33	0

The rear door on vehicle 55469 was warped.

F. Ramp.

	Aerophysics		CSL		Donaldson
Serial No.	69569	55469	69569	55469	–
ft^3/min	8	17	3	0	

Leakage appears to depend on how securely the ramp is closed.

G. Air Inlet Valve.

	Aerophysics		CSL		Donaldson
Serial No.	69569	55469	69569	55469	–
ft^3/min	–	–	67	65	–

H. Torsion Bars.

	Aerophysics		CSL		Donaldson
Serial No.	69569	55469	69569	55469	–
ft^3/min	24	12	28	16	–

I. Bilge Pump.

	Aerophysics		CSL		Donaldson
Serial No.	69569	55469	69569	55469	–
ft^3/min	15	15	13	11	7.4

J. Driver's Periscope Cover.

	Aerophysics		CSL		Donaldson
Serial No.	69569	55469	69569	55469	–
ft^3/min	9	11	9	12	6

V. LEAK REDUCTION MEASURES.

Proposed leakage reduction modifications were suggested by Donaldson Corporation, Aerophysics, and CSL. The following leakage reduction measures were suggested by Donaldson Corporation; however, Aerophysics Company and CSL had similar recommendations.

A. The commander's turret ring could use a grease or a felt/"bristle pad" seal.

B. A manual scupper valve device, as installed in the M577A1 CPC for NBC operation, would be advantageous.

C. The combination of a gasket and fasteners should reduce the leakage for the air ventilator control and air inlet valve.

D. A more pliable and wider gasket for hatches and doors could be used.

E. The installation of a manual valve in the bilge pump discharge line should be considered.

F. Grommets could be located at points where cables pass through the firewall.

VI. CONCLUSIONS.

A. M113A1 APC leakage data indicates the possibility for leakage reduction in the following areas: commander's turret ring, scupper valve, hatches, doors, air ventilation control, air inlet valve, and bilge pump.

B. The average leakage value for the M113A1 APC is 458 ft^3/min at 1.5-inches water gage.

VII. RECOMMENDATIONS.

The six leakage reduction suggestions mentioned above ought to be examined. Incorporation of the suggested-leakage-reduction measures has a potential of reducing the M113A1 APC leakage value to 110 ft^3/min at 1.5-inches water gage.

Table A-1. M113 Armored Personnel Carrier (12B55469)

Aerophysics Company

Leakage areas	Leakage rates at the internal static pressure (in water, gage) immediately below							
	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0
	ft^3/min							
Cupola	120	177	227	259	293	327	357	391
Ventilator (closed)	83	123	149	171	191	213	239	261
Rear door	34	52	66	81	94	109	122	137
Scupper valve	32	48	59	68	78	88	97	109
Ramp	13	20	25	26	28	32	34	40
Torsion bars	10	14	17	18	18	19	15	17
Bilge pump	12	17	21	23	25	29	29	31
Driver's periscope cover	8	14	18	20	21	24	23	27
Main hatch	1	2	2	2	2	2	3	4
Engine access doors	16	3	2	2	1	1	0	0
Sealed tank	22	33	43	51	60	66	76	81
Total (measured)	341	495	616	719	817	905	996	1094
Total (added)	351	503	629	721	811	910	995	1098

Table A-2. M113 Armored Personnel Carrier (12C69569)
Aerophysics Company

Leakage areas	Leakage rates at the internal static pressure (in water, gage) immediately below							
	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0
	ft^3/min							
Cupola	94	138	171	202	228	258	290	318
Ventilator (closed)	45	66	82	93	108	116	127	138
Grommets (engine/driven)	3	3	3	3	4	4	5	5
Scupper valve	77	109	134	155	171	187	202	215
Ramp	7	9	9	9	9	9	10	11
Torsion bars	19	29	35	39	43	47	50	53
Bilge pump	12	18	21	23	25	28	30	33
Driver periscope cover	7	10	12	12	12	13	14	14
Main hatch	0	1	1	1	1	1	1	1
Engine access doors	1	1	2	2	3	3	3	4
Wire channel	1	3	3	1	1	1	1	1
Sealed tank	17	25	32	40	45	50	54	58
Total (measured)	267	397	493	572	645	717	778	843
Total (added)	283	412	505	580	650	717	787	851

Table A-3. Research Leakage Data. Vehicle M113A1 (12C69569)

Leakage point	Leakage rates					
	Static pressure					
	0.5	1.0	1.5	2.0	3.0	6.0
	ft^3/min					
Front vent open	367	523	644	746	917	1306
Rear vent open	307	441	544	632	780	1119
Commander's turret ring	51	74	92	108	135	197
Front vent closed	41	55	67	76	92	127
Rear vent closed	30	46	59	70	91	140
Scupper valve	58	82	100	115	140	198
Rear door	0	1	1	1	1	2
Torsion bars	16	23	28	32	38	54
Driver's periscope cavity plug	2	3	4	5	6	18
Rear bilge pump outlet	7	10	13	16	20	29
Driver's infrared (IR) periscope	1	1	2	2	3	4
Unaccounted for leakage	4	7	9	11	15	25
Engine compartment bulkhead area	2	3	4	5	6	9
Ramp	2	2	3	4	5	0

Table A-4. Research Leakage Data. Vehicle M113A1 (12B55469)

Leakage point	Leakage rates					
	Static pressure					
	0.5	1.0	1.5	2.8	3.0	6.8
	ft^3/min					
Front vent open	368	523	642	743	912	1295
Rear vent open	290	413	508	587	723	1030
Commander's turret ring	75	112	141	166	218	311
Front vent closed	58	86	189	128	180	238
Rear vent closed	27	47	63	92	114	199
Scupper valve	23	34	44	52	66	99
Rear door	17	25	33	40	52	81
Torsion bars	9	13	16	19	23	34
Driver's periscope cavity plug	5	8	10	12	15	22
Rear bilge pump outlet	6	9	11	13	17	26
Driver's IR periscope	6	9	12	14	17	26
Unaccounted for leakage	5	8	11	13	17	29
Engine compartment bulkhead area	1	2	3	3	3	5
Ramp	0	0	0	0	0	0

Table A-5. Donaldson Corporation Report Data

Leakage areas	Leakage before sealing	
	1.5 in wg	7.0 in wg
	ft^3/min	
Commander's turret ring	140*	370*
Commander's hatch	3*	8*
Commander's and driver's periscopes	14	37**
Driver's hatch	5.5**	15**
Cargo hatch	4**	11**
Driver's infrared (IR) periscope	6**	15
Firewall bilge scuppers	183	510
Firewall auxiliary blower	69	228
Firewall cable openings	43**	116
Air ventilating exhaust	39	88
Bilge pump discharge	7.4	28
Firewall access panel	1**	3
Ramp door	0	1
Personnel heater	17	39
Unaccountable leakage	25**	66
Total leakage	555.9	1535

* Estimated leakage

** Extrapolated from leakage data on M113 APC or M577 CPC.

Table A-6. M577 Command Post Carrier Air Leakage

Leakage areas	Leakage rates				
	Internal static pressure as in water gage				
	0.40	1.0	3.0	5.0	7.0
	ft^3/min				
Unaccounted leaks	–	20.0	38.6	53.0	66.5
Commander's hatch	–	0,7	1.3	2.3	1.5
Driver's hatch	–	1.7	5.1	5.7	8.3
Ramp door	–	0.6	0.5	0.2	0.4
Air ventilating exhaust	–	32.0	59.5	80.8	88.3
Driver's IR periscope	3.3	4.9	12.8	17.0	15.0
Bilge pump discharge	6.0	6.5	10.0	20.0	28.0
Firewall access panels	0.3	–	5.0	–	3.0
Firewall cable openings	29.1	52.0	83.0	98.0	116.0
Firewall auxiliary blower	44.0	49.5	127.0	177.0	228.0
Firewall bilge scuppers	81.0	145.0	295.0	410.0	510.0
Total leakage	163.7	312.9	637.8	864.0	1065.0

NOTE: These tests were performed with the crew compartment pressurized and the engine compartment not pressurized. Under normal operating conditions, leakage through the firewall and bilge scuppers would not be this great.

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