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INVESTIGATION

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NAVAL CIVIL ENGINEERING LABORATORY
PORT HUENEME, CALIFORNIA 93043

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METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

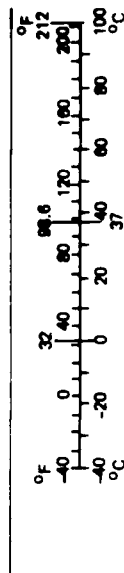
Symbol	When You Know	Multiply by	To Find	Symbol
in ft yd mi	inches feet yards miles	2.5 30 0.9 1.6	centimeters	cm
			centimeters	cm
			meters	m
			kilometers	km
in ² ft ² yd ² mi ²	square inches square feet square yards square miles acres	6.5 0.09 0.8 2.6 0.4	square centimeters	cm ²
			square meters	m ²
			square meters	m ²
			square kilometers	km ²
oz lb	ounces pounds short tons (2,000 lb)	28 0.45 0.9	grams	g
			kilograms	kg
			tonnes	t
tsp Tbsp fl oz c pt qt gal ft ³ yd ³	teaspoons tablespoons fluid ounces cups pints quarts gallons cubic feet cubic yards	5 15 30 0.24 0.47 0.95 3.8 0.03 0.76	milliliters	ml
			milliliters	ml
			milliliters	ml
			liters	l
			liters	l
			liters	l
			liters	l
			cubic meters	m ³
			cubic meters	m ³
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	
			°C	

Approximate Conversions from Metric Measures

When You Know	Multiply by	To Find	Symbol
millimeters centimeters meters kilometers	0.04 0.4 3.3 1.1 0.6	inches	in
		inches	in
		feet	ft
		yards	yd
square centimeters square meters square kilometers hectares (10,000 m ²)	0.16 1.2 0.4 2.5	square inches	in ²
		square yards	yd ²
		square miles	mi ²
		acres	
grams kilograms tonnes (1,000 kg)	0.035 2.2 1.1	ounces	oz
		pounds	lb
		short tons	
milliliters liters liters cubic meters cubic meters	0.03 2.1 1.06 0.26 35 1.3	fluid ounces	fl oz
		pints	pt
		quarts	qt
		gallons	gal
		cubic feet	ft ³
		cubic yards	yd ³
°C	9/5 (then add 32)	Fahrenheit temperature	
		°F	



*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS
 Spec. Publ. 288, Units of Weights and Measures, Price \$2.25, SD Catalog No. C13.10-288.



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HANGAR DESTRATIFICATION INVESTIGATION, by J. Ashley

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1. Energy conservation

2. Stratification

I. ZO829-01-111C

Measurements made in military hangars indicated that stratification, the existence of a layer of hot air in a structure's overhead, is a typical phenomenon. Five destratification concepts (three commercial and two Navy-developed) were evaluated to determine the effectiveness and the adaptability of each concept for hangar applications. Only the Navy-developed concepts were found practical for hangar applications. Destratifier design and application guidelines were developed and are presented in the report.

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INTRODUCTION

Measurements made in five hangars (two U.S. Air Force and three U.S. Navy) indicated that stratification, the existence of a layer of hot air in the structure's overhead, is a typical phenomenon in heated hangars (Ref 1). This phenomenon results in increases in energy consumption because of the following:

- the increased temperature difference across the roof and upper wall surfaces increases the amount of heat transferred from inside a structure to the outside
- chimney effect increases the structure's air infiltration rate
- unused heat is wasted heat

Five destratification concepts (three commercial, one developed by NCEL and one suggested by the Naval Facilities Engineering Command Atlantic Division*) were evaluated to determine the effectiveness and adaptability of each concept for hangar applications. This report presents the design criteria for the NCEL destratification concept and the results of the evaluations of all the concepts.

DESTRATIFICATION CONCEPTS

The five destratification concepts evaluated are as follows:

- Destratification tube - commercial (Figure 1): The unit consists of a small blower mounted on top of a tube or duct which transverses from floor to ceiling. The fan blows hot ceiling level air down through the duct to the floor level where the hot air mixes with the cooler floor level air.
- Ceiling fan - commercial (Figure 2): A fan, mounted at the ceiling level, blows hot air down toward the floor where it is mixed with the cooler floor level air.
- Floor blower - commercial (Figure 3): A blower placed at the floor level blows cool floor level air upward toward the ceiling where it mixes with the hot ceiling level air.

*LANTDIV.



Figure 1. Destratification tube.

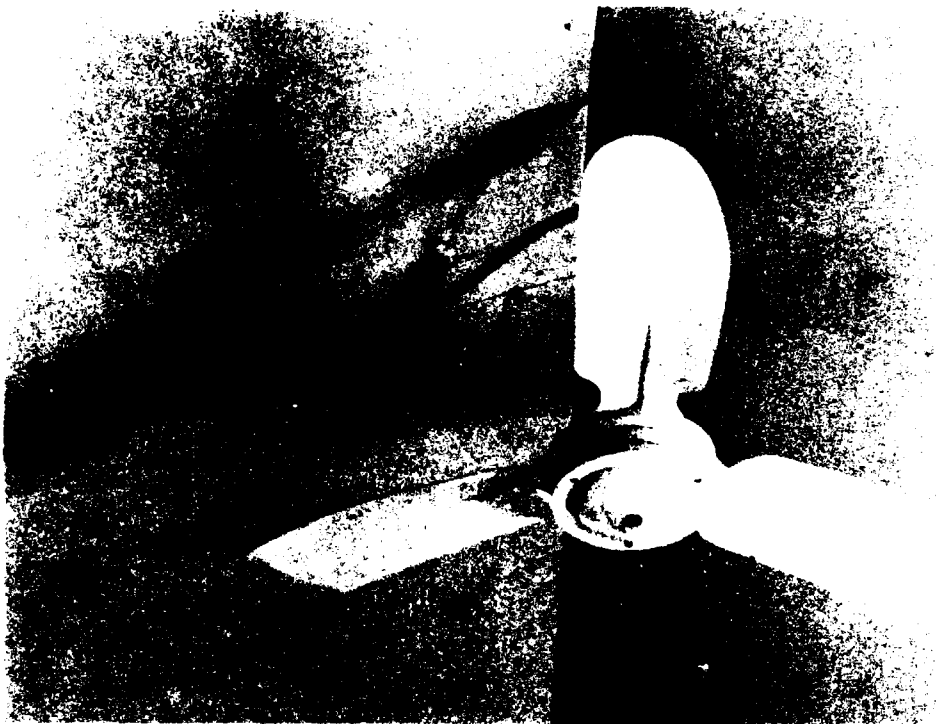


Figure 2. Ceiling fan.

- Cold air jet - NCEL (Figure 4): A blower sucks cool floor level air through a duct and injects this air as a high velocity air jet near the ceiling where it mixes with the hot ceiling level air. The design criteria for the NCEL cold air jet destratifier are presented in the Appendix.
- Heating system modification - LANTDIV (Figure 5): Hot ceiling level air is used as the intake air for the heating system's heating coils. The intake air can be routed to the heating system via a duct, or the heating coil's air intake can be located within the hot ceiling level air.

EVALUATION

Preliminary Evaluation of Commercial Destratifiers

The three commercial destratification units were evaluated at NCEL to determine their adaptability for use in hangars. All three were installed in a shop building at the laboratory and their effectiveness measured. The results of the evaluation are provided in Tables 1, 2, and 3 for the destratification tube, ceiling fan, and cold air blower, respectively. Figure 6 shows where the data were taken and the location of the destratifier within the building. As can be readily noted from the tables, while neither the ceiling fan nor the destratification tube produced any significant changes in the building's stratification characteristics, the cold air blower rapidly destratified the building.

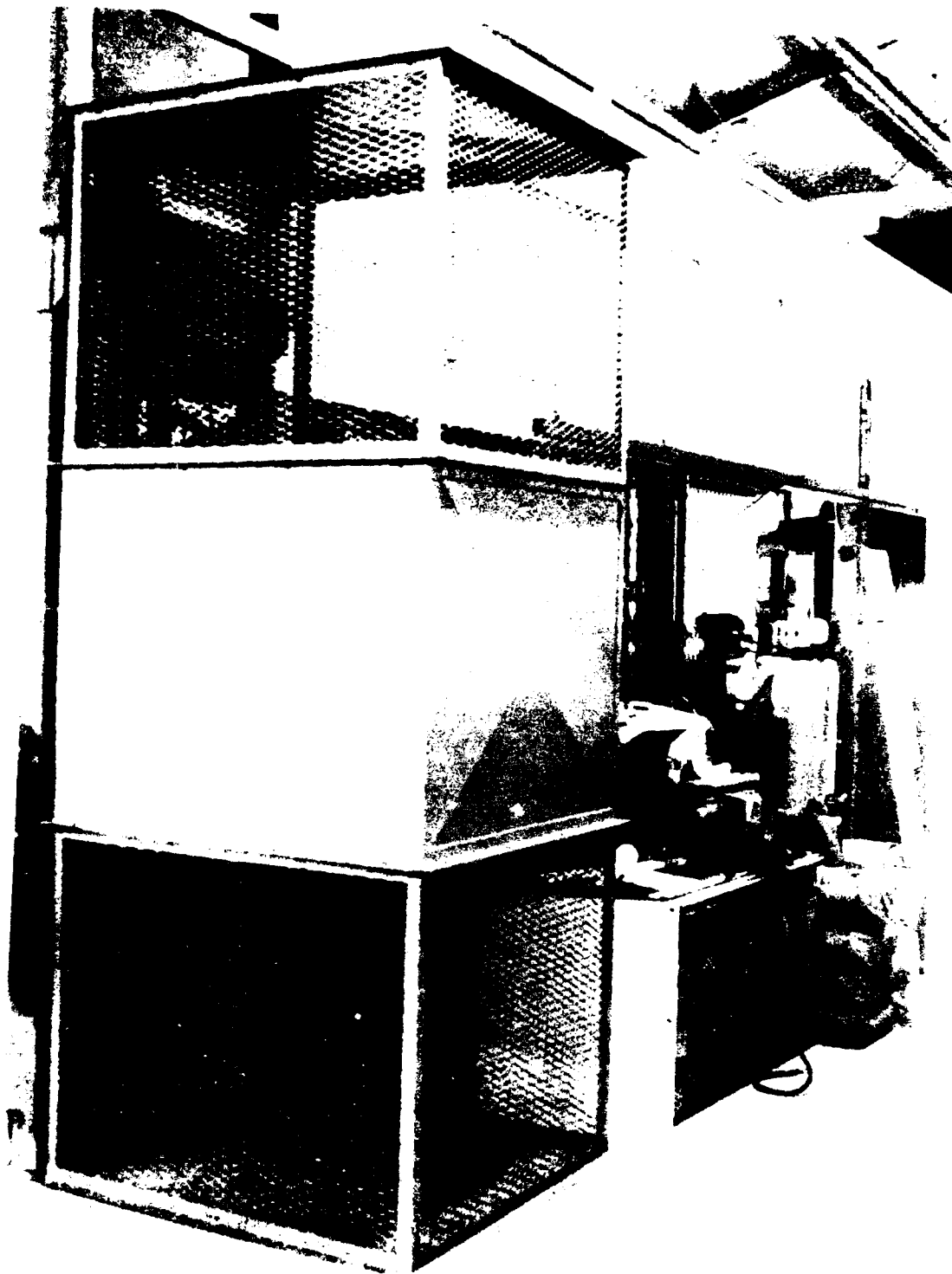
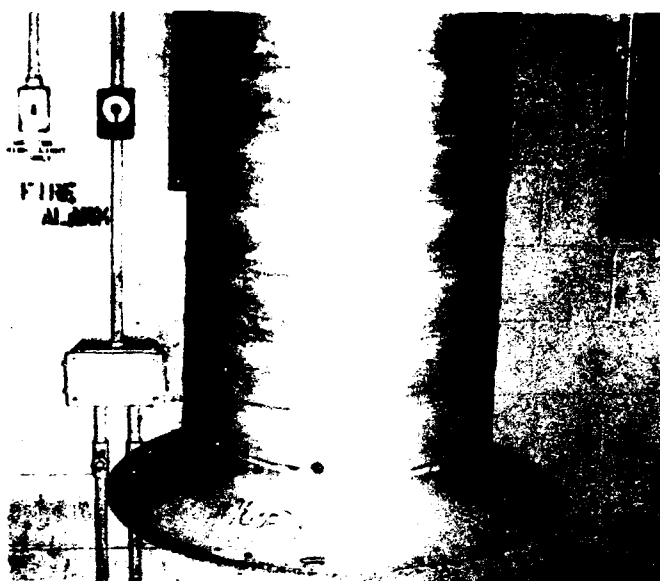


Figure 3. Floor blower.

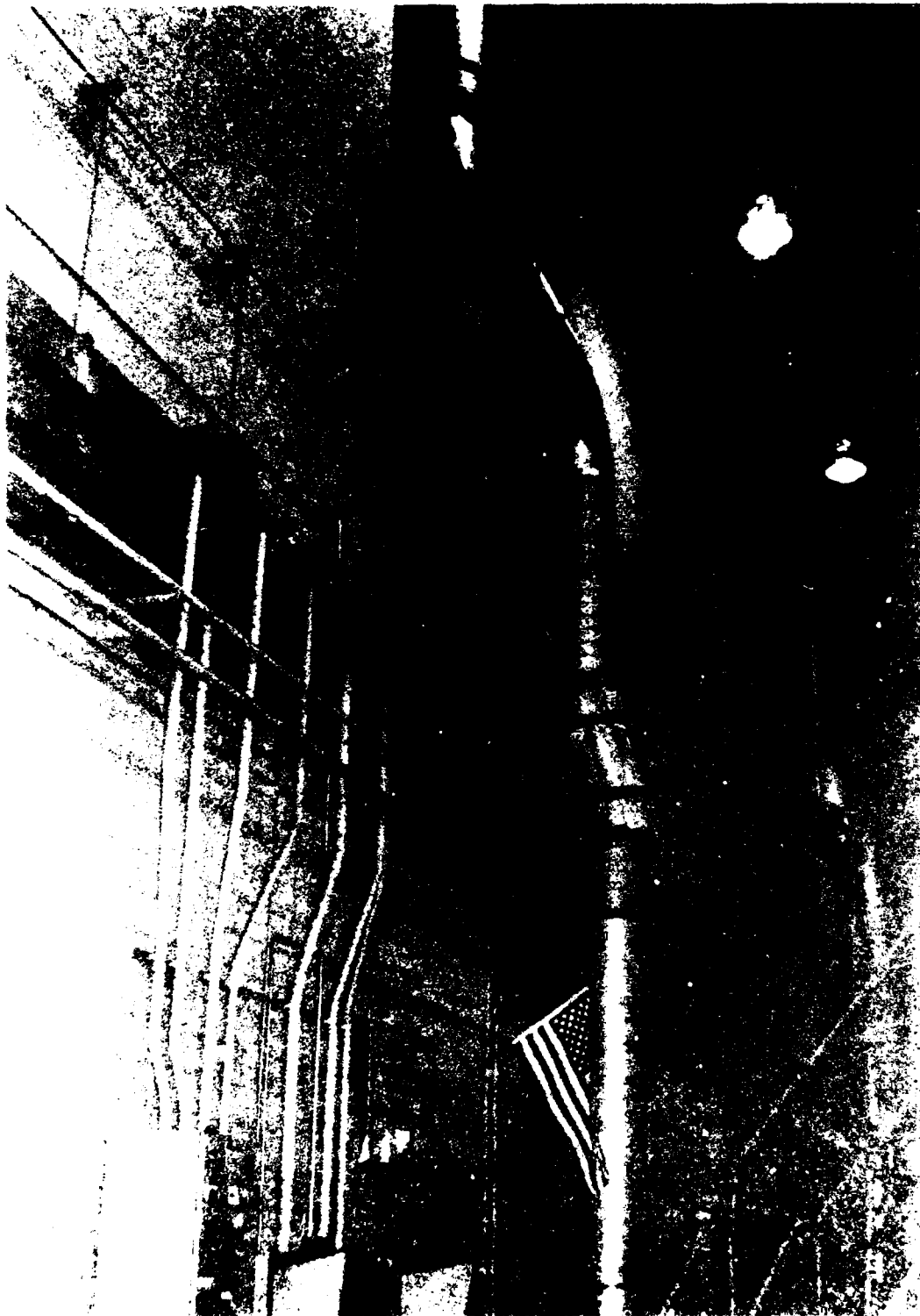


(a) Duct near floor level.



(b) Duct joint and blower.

Figure 4. Cold air jet.



(c) Overall configuration.

Figure 4. Continued

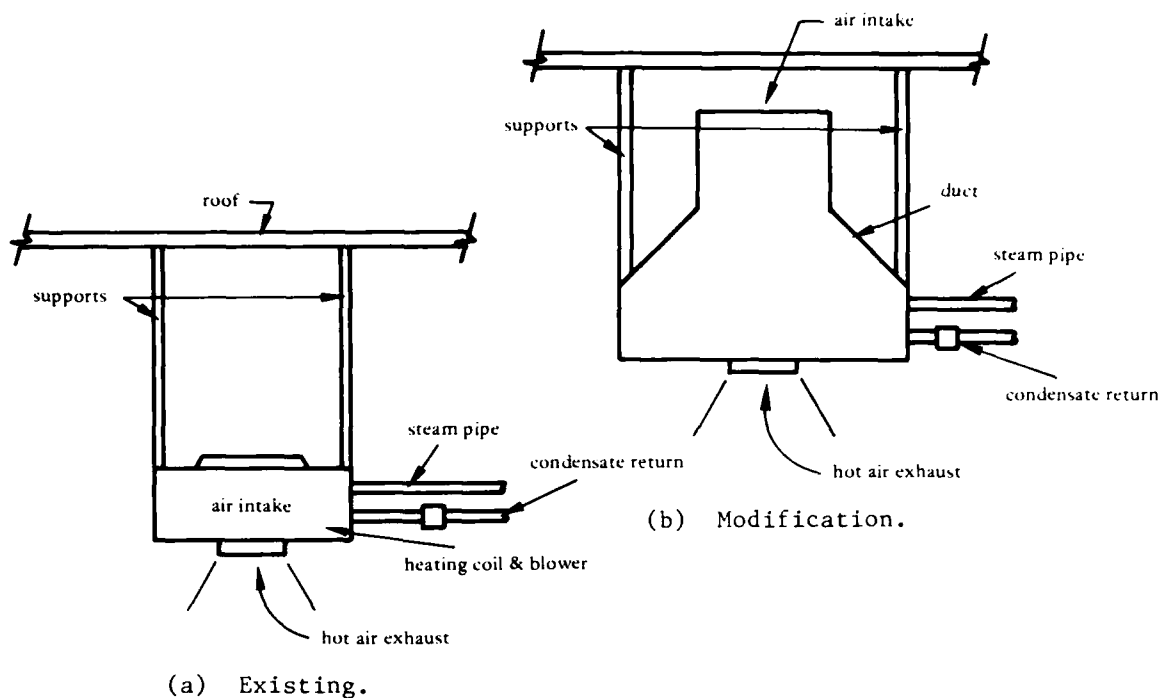


Figure 5. LANTDIV heating system modification.

Table 1. Destratification Tube Evaluation, Building 564

Time	Data Point	Temperature (°F) at following Test Numbers				Avg
		1	2	3	4	
Ambient temperature 60°F; weather, cloudy; destratification tube placed in operation at 0917; floor/ceiling temperature difference, 26°F.						
0830	Floor	68	69	68	68	68
	Loft	73	74	72	74	73
	Ceiling	95	94	89	92	93
Ambient temperature, 62°F; weather, cloudy; data not taken at 10-ft level; floor/ceiling temperature difference, 26°F.						
1240	Floor	67	68	69	68	68
	Loft	--	--	--	--	--
	Ceiling	95	94	93	94	94

Table 2. Ceiling Fan Evaluation, Building 564

Time	Data Point	Temperature (°F) at following Test Numbers				Avg
		1	2	3	4	
Destratification tube secured; ceiling fan placed in operation; floor/ceiling tempera- ture difference, 25°F.						
1240	Floor	67	68	69	68	68
	Loft	--	--	--	--	--
	Ceiling	95	94	93	94	94
Ambient temperature, 63°F; weather cloudy; floor/ceiling temperature difference, 21°F.						
1330	Floor	73	72	74	73	73
	Loft	77	77	76	76	77
	Ceiling	97	95	93	89	94

Table 3. Floor Air Blower Test Results, Building 564

Time	Data Point	Temperatures (°F) at Following Test Numbers					Avg
		1	2	3	4	5	
Ambient temperature 53°F; weather, rain. Destratifier not in operation; floor/ceiling temperature difference, 12°F.							
1000	Floor	76	76	76	75	74	75
	10-ft high	77	81	78	77	74	77
	Ceiling	88	94	94	84	74	87
Ambient temperature, 53°F; weather, rain. Destratifier in operation at 1015; electric power consumption, 850 watts; floor/ceiling temperature difference, 1°F.							
1025	Floor	77	77	79	76	77	77
	10-ft high	75	76	80	75	77	77
	Ceiling	76	76	84	75	80	78

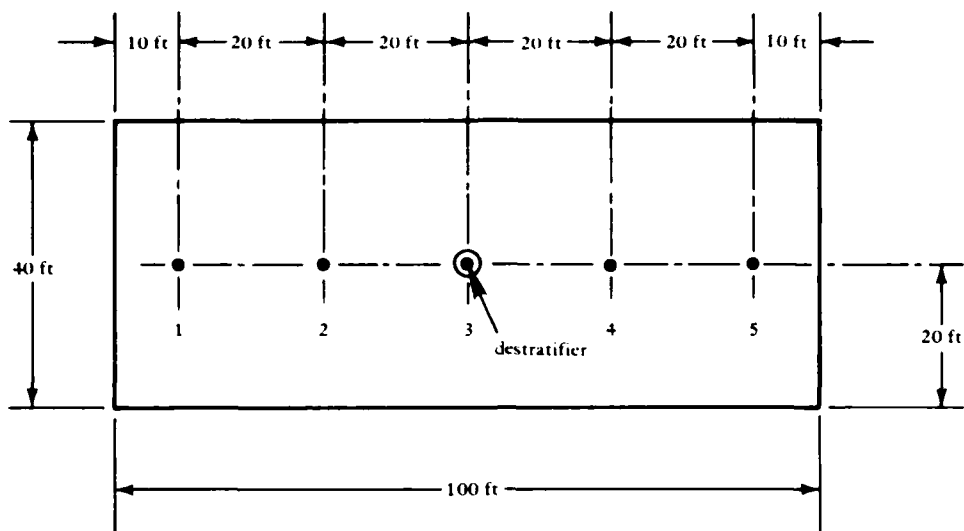


Figure 6. Location of data points and destratifier in test hangar.

The destratification tube and ceiling fan were then installed in a test chamber in order to determine if their effectiveness and installation criteria could be established. Tables 4 and 5 and Figures 7 and 8 provide the results of the chamber evaluation for the destratification tube and the ceiling fan, respectively. One installation parameter not measured at the evaluations conducted at NCEL was a maximum ceiling height. Although all three commercial concepts can destratify a structure, to varying degrees, and can save energy if properly installed, only the cold air blower indicated that it might be practically used to destratify a hangar. The number of units, height, and destratification effectiveness would have to be determined.

Installation and Evaluation for Chosen Systems

Destratifiers based upon the NCEL, LANTDIV, and cold air blower concepts were installed in Navy hangars and evaluated.

NCEL. The NCEL-designed destratifier, the cold air jet, was installed at the Navy Air Rework Facility, Norfolk, Va., in one of two bays in hangar V-147. Steam consumption was measured for both bays. Thermostat settings for both bays were kept at 55°F. Table 6 presents the reduction in steam consumption for the destratified bay versus the stratified bay. Based upon measurements made during parts of two heating seasons, the destratified bay consumed 29% less heating-related energy.

Table 4. NCEL Test Chamber Results, Destratification Tube

Item	Measurement
ΔT_s (floor/ceiling temperature difference, stratified)	38°F
ΔT_d (floor/ceiling temperature difference, destratified)	31°F
Destratification efficiency, $\frac{(\Delta T_s - \Delta T_d) \times 100}{\Delta T_s}$	18.5%
Test chamber volume, V	2,500 ft ³
Destratifier fan air movement, Q	6,300 ft ³ /hr
Destratifier flow to volume ratio, Q/V	2.5
Destratifier electric power consumption, p	100 watts
Number of destratifier units required for installation in a building	$\frac{\text{Volume of building (room)}}{2.5 \times Q}$

Table 5. NCEL Test Results, Ceiling Fan

Characteristic	Test Number				
	1	2	3	4	5
Fan speed, rpm	240	160	120	90	60
Fan flow, ft ³ /min, q	1,990	1,328	996	747	498
Fan flow, ft ³ /hr, Q	119,000	79,680	59,760	44,820	29,880
ΔT_s , °F	32	29	29	29	32
ΔT_d , °F	6	10	17	27	32
Destratification efficiency, %	81	66	41	1	0
Test chamber volume, V	2,500	2,500	2,500	2,500	2,500
Q/V	47.5	32	24	18	12
Power, watts	173	150	138	127	115

Table 6. Comparison of Destratified (NCEL Concept) and Stratified Hangar, Building VI47 at NARF Norfolk, Va.

[Electric power consumption: 240 VAC @ 3.2 amps/unit
(7 units x 240 x 3 x 2 x 24 hr/day x 35 day/1,000 =
4,516 kWh); central steam plant efficiency = 68%;
electric generation heat rate = 11,600 Btu/kWh;
steam savings = 30%; net energy savings = 29%]

Date	Temperature, °F					Steam Consumption, MBtu		Steam Savings (MBtu)
	Outside	Destratified Bay		Stratified Bay		Destratified Bay	Stratified Bay	
		Floor	Ceiling	Floor ^a	Ceiling			
2/18/82	54	66	74	65	80	-- ^b	--	--
2/19/82	54	66	80	65	83	213	292	79
2/25/82	47	65	74	65	86	889	792	<97>
2/26/82	35	69	74	65	86	280	430	150
3/3/82	42	69	74	65	82	999	1,259	260
3/5/82	44	68	74	65	82	298	229	<69>
3/8/82	32	67	76	65	88	341	715	374
1/14/83	48	68	--	--	--	--	--	--
1/18/83	51	69	--	--	--	138	621	483
1/20/83	43	65	--	--	--	244	606	362
1/24/83	48	71	--	--	--	1,447	2,076	629
1/27/83	46	62	--	--	--	545	443	<102>
1/31/83	50	66	--	--	--	672	1,213	541
Total						6,066	8,676	2,610

^a Stratified bay floor level temperature was not measured, assumed to equal thermostat setting.

^b --- = data not available.

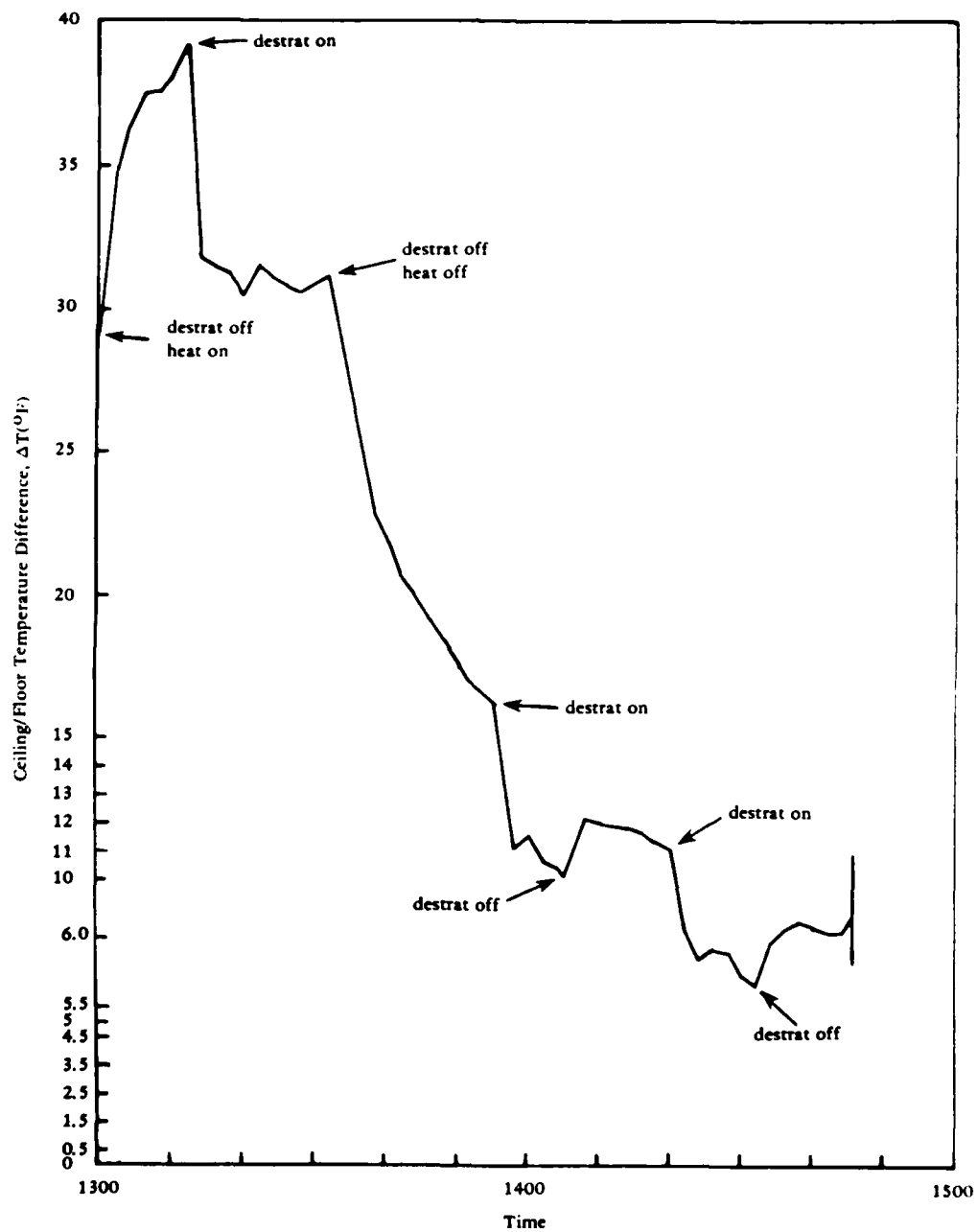


Figure 7. Destratification tube test chamber results.

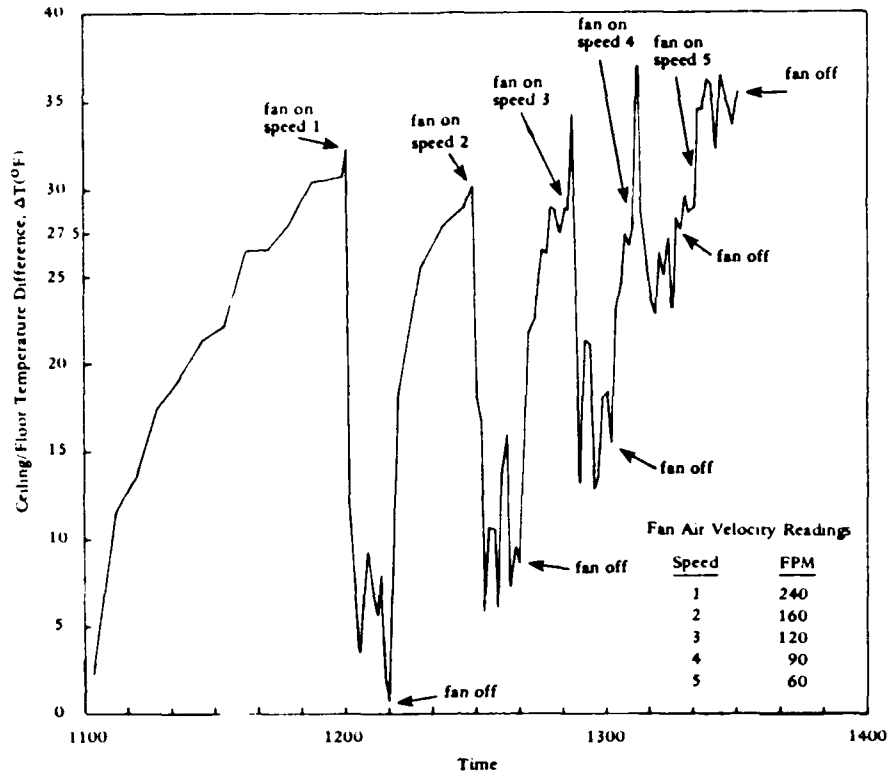


Figure 8. Ceiling fan test chamber results.

LANTDIV. The LANTDIV heating system modification was installed in the center section of a hangar located at the Naval Air Development Center (NADC), Warminster, Pa. (Figure 9, 10, and 11). Draft curtains across the hangar divided the overhead area into three sections of equal volumes. The draft curtains provided a solid barrier 15 feet deep from the roof down toward the floor. Thermocouple arrays were placed in two of the three sections (one with the LANTDIV destratifier modification and one without). Thermocouples for each section were placed at: (1) ceiling level directly above the hot air blower; (2) hangar centerline at ceiling level - 20 feet away from the hot air blower; (3) hangar centerline - 2, 4, 8, and 12 feet below the ceiling; and (4) center wall - 1 and 10 feet above the floor.

Hourly data were obtained for 3 months and recorded on a data logger. None of the thermocouples were calibrated to each other; thus only relative temperature differences were measured. Table 7 presents a synopsis of the data. The LANTDIV heating modification resulted in an average decrease of 2°F in the destratified section.

Cold-Air Blower. Three cold air blowers were installed, according to the manufacturer's recommendations in a hangar, also located at NADC Warminster (Figure 12). A thermocouple array was installed at the following locations: (1) on the hangar centerline - at the ceiling level and 2, 4, 8, and 12 feet below the ceiling; (2) 1 and 10 feet above the floor; and (3) outside.



Figure 9. Unit heater at NADC Warminster.



Figure 10. LANTDIV modification before installation at NADC Warminster.

Table 7. Temperatures Measured Before and After LANTDIV
Modification Installation at NADC Warminster

Before Modification ^a				After Modification ^b			
Ceiling Bay No. 2	Ceiling Bay No. 3	Floor	Outside	Ceiling ^c Bay No. 2	Ceiling Bay No. 3	Floor	Outside
61	65	51	34	68	70	55	43
61	65	53	33	69	70	56	30
73	69	58	34	72	72	58	30
78	72	58	33	72	72	58	30
78	75	60	33	73	73	57	29
79	74	59	34	75	75	58	29
77	75	59	33	75	75	58	29
78	75	59	33	77	75	58	30
79	76	60	34	75	75	58	30
79	76	60	34	76	75	59	34
76	75	58	33	78	77	60	36
74	73	58	34	79	78	63	38
70	70	55	29	80	79	63	40
72	71	56	30	81	79	64	43
75	72	57	29	81	80	65	46
74	72	58	30	74	75	61	46
76	73	60	29	61	64	53	36
81	77	64	30	64	66	55	36
Average:							
74.5	72.5	57.6	32.7	73.9	73.9	58.8	33.7

^aCeiling (2)/Floor $\Delta T = 16.9^{\circ}\text{F}$
Ceiling (3)/Floor $\Delta T = 14.9^{\circ}\text{F}$
Average ceiling ΔT Bays 2/3 = 2°F

^bCeiling (2)/Floor $\Delta T = 15.1^{\circ}\text{F}$
Ceiling (3)/Floor $\Delta T = 15.1^{\circ}\text{F}$
Average ceiling ΔT Bays 2/3 = 0°F

^cModification installed in Bay No. 2.

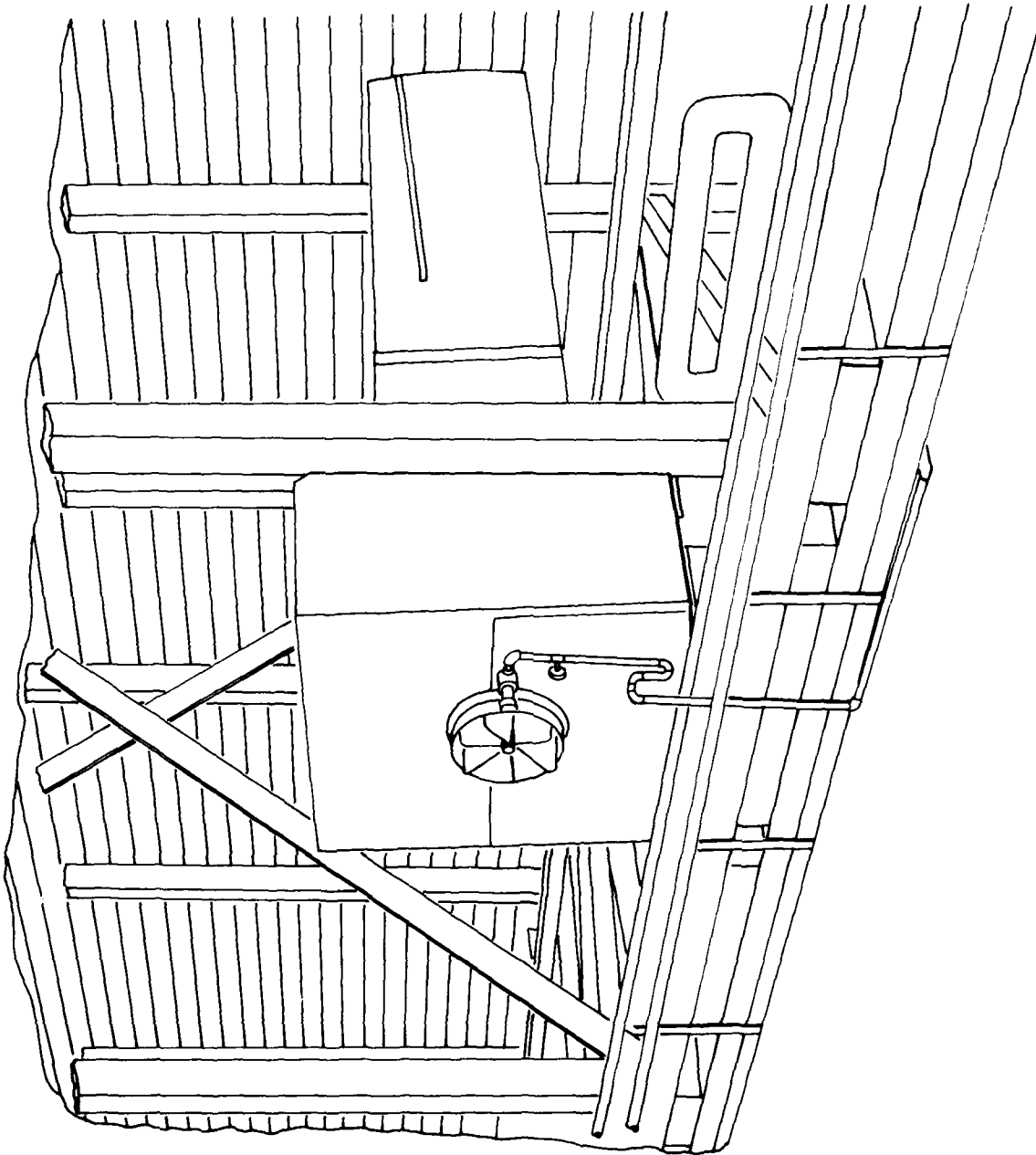


Figure 11. LANTDIV modification installed at NADC Warminster.

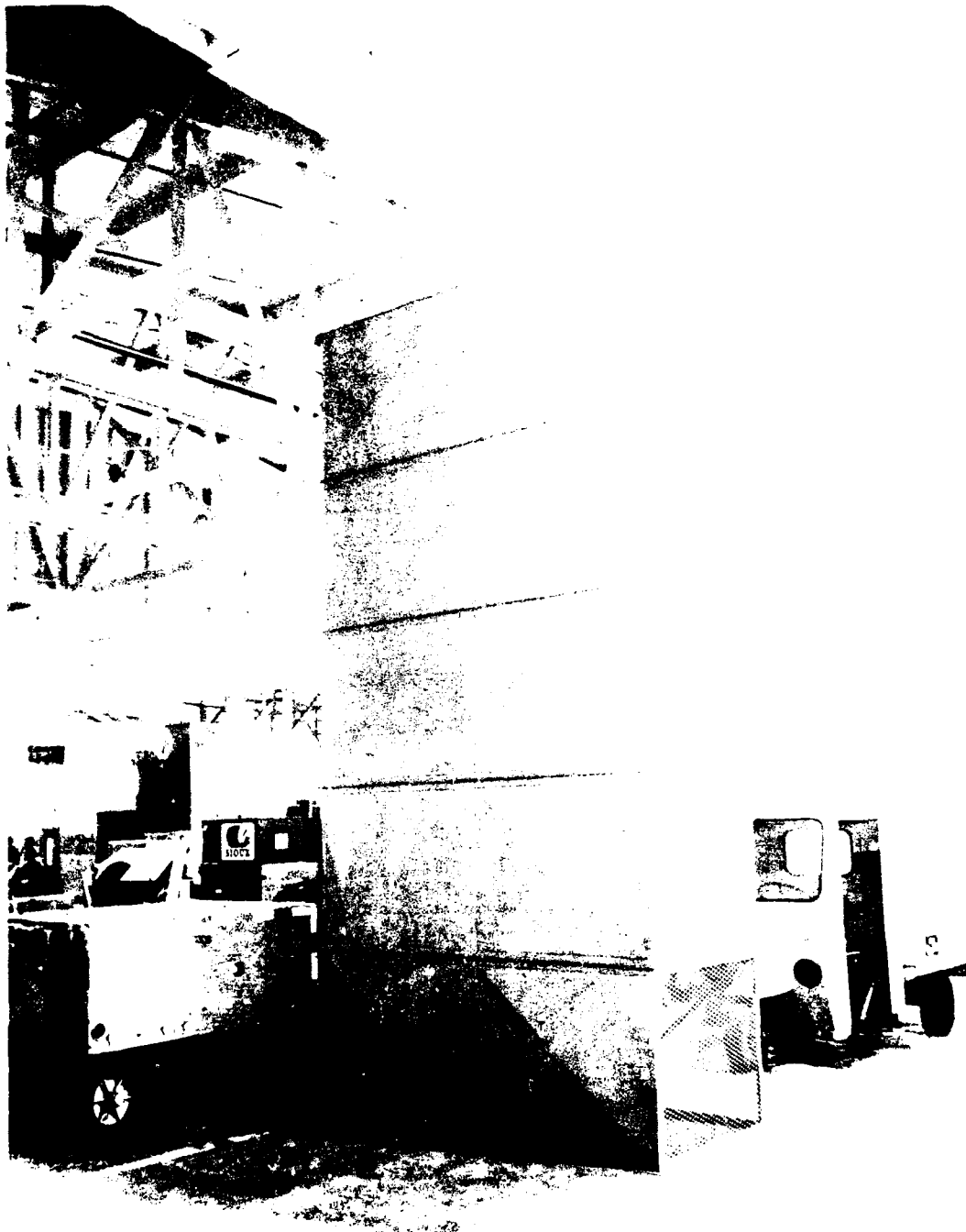


Figure 12. Cold air blower.

Hourly temperature measurements were made and recorded on a data logger during the 1982/83 winter. Data were obtained with and without the cold air blower in operation. A synopsis of the data is presented in Table 8 and Figure 13. As can be readily observed, the data are inconclusive with no definite indication of destratifier effectiveness.

CONCLUSIONS AND RECOMMENDATIONS

Of the five destratification concepts evaluated, only the NCEL cold jet destratifier and the LANTDIV modification produced meaningful results and are recommended for new and existing hangars. The cold air blower, the only commercial concept actually evaluated in a hangar, performed very well in a 25-foot-high building with the unit placed in the building's center. The hangar installation required that the units be placed along the structure's wall. Because of hangar width, height, and volume characteristics, either the cold air blower is not adaptable to hangar applications or additional units are required. Further tests are recommended to determine adaptability.

The LANTDIV heating system modification had a destratification efficiency of 11% and did save energy. Its cost (\$3,500/heater) is not much less than the more efficient NCEL unit (\$8,000/unit), therefore it is not recommended for retrofit. However, if the heating unit were located within 1 foot of the ceiling during installation of an original heating system, the additional cost required for the LANTDIV destratification would be negligible and the concept would prove most valuable during the life of the hangar. The LANTDIV concept is recommended for new hangars and for heating system replacements.

DESIGN CRITERIA FOR NCEL COLD AIR JET DESTRATIFIER

NCEL designed a cold air jet destratifier whose basis is the ability of an air jet to entrain surrounding air and to throw it across large distances. These principles are well-known and are documented in References 2 and 3. Figure 14 is a drawing of the destratifier. Design parameters are presented in Table 9 and can be used to design a destratifier for any hangar. The equations used for the destratifier system design are based upon principles stated in References 2 and 3 and are as follows:

$$Q = 0.00278 V/N \quad (1)$$

where: Q = destratifier flow, ft^3/min

V = hangar volume, ft^3

N = number of destratifiers to be installed

Table 8. Temperatures Taken With Cold Air Blower, NADC Warminster

Temperature (°F)				Floor/Ceiling Temperature Difference (°F)
Ceiling	Floor	Outside	Floor/Outside	
Destratifier Off				
76	61	34	27	15
76	61	34	27	15
76	61	34	27	15
76	61	34	27	15
76	61	33	28	15
78	68	35	33	10
79	66	27	39	13
82	75	29	46	7
84	73	33	40	11
81	71	29	42	10
81	73	27	46	8
76	67	20	47	9
73	62	18	44	11
83	74	26	48	9
89	79	33	46	10
83	75	33	42	8
83	72	44	28	11
82	72	41	31	10
77	69	45	24	8
71	62	48	14	9
73	64	44	20	9
74	68	43	25	6
75	68	43	25	7
74	67	50	17	7
73	66	57	9	7
71	63	46	17	8
Destratifier On				
75	69	52	17	6
76	64	44	20	12
79	66	38	28	13
72	68	51	17	4
74	66	43	23	8
73	62	44	18	9
75	64	44	20	11
76	64	44	20	12
77	65	43	22	12
77	65	34	31	12
78	65	36	29	13
79	65	36	29	13
80	68	43	25	12
81	69	43	26	12
76	64	43	24	12
71	67	48	19	4
74	69	50	19	5

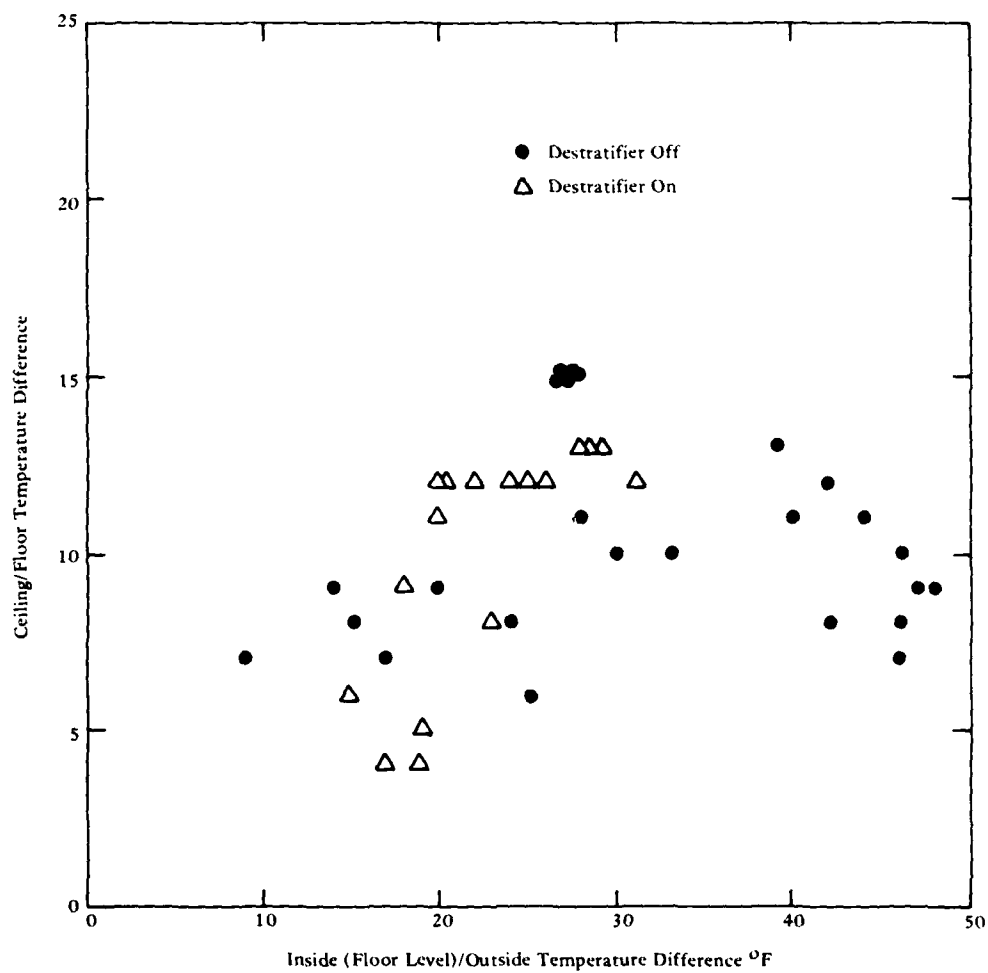


Figure 13. Cold air blower performance at NADC Warminster.

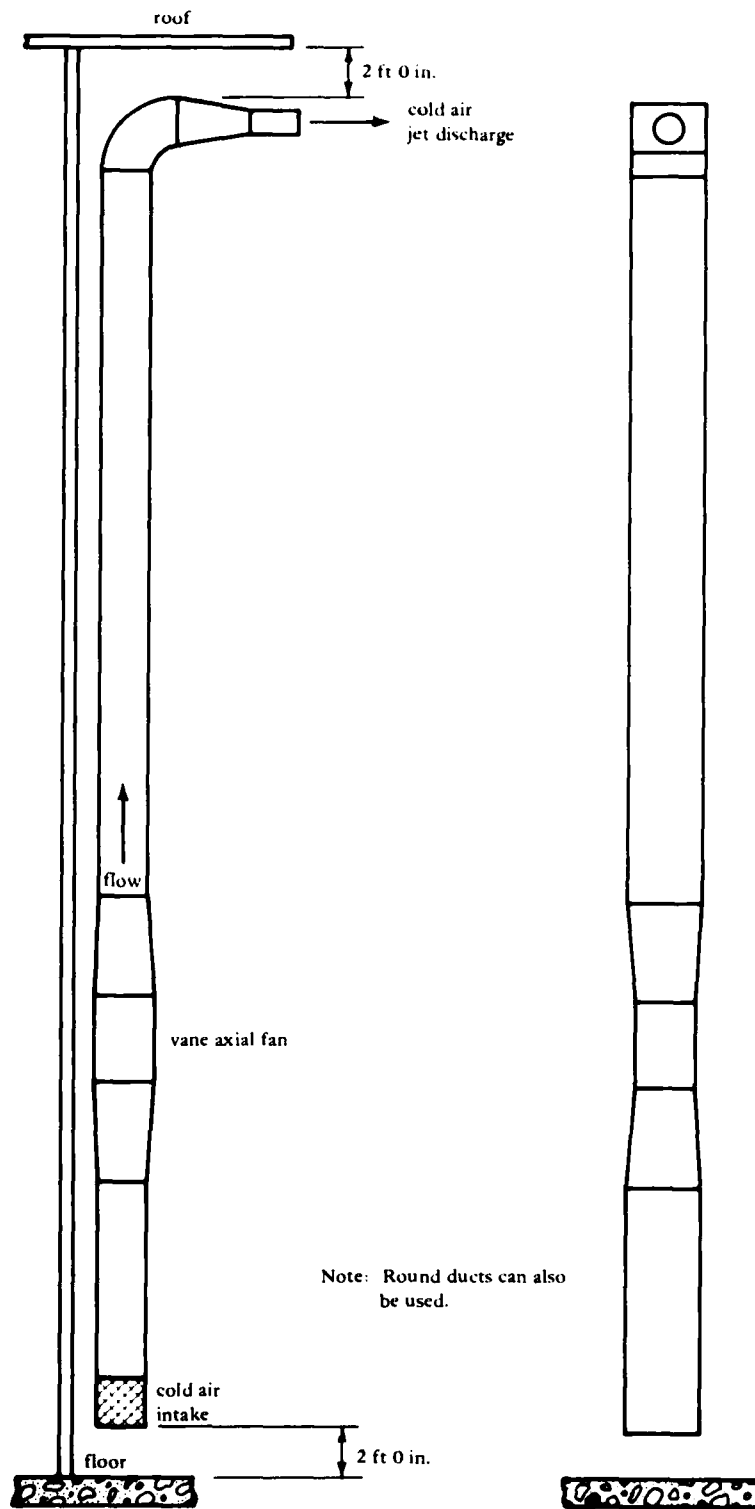


Figure 14. Cold floor air jet injection destratifier.

Table 9. Cold Air Jet Design Parameters

HANGAR VOLUME: 500000 CUBIC FEET

DESTRATIFIER PARAMETERS

HANGAR WIDTH FEET	NUMBER UNITS	FLOW CFM	DISCHARGE VELOCITY FPM	NOZZLE DIAMETER INCHES
70	4	2000	1570	15.28
80	4	2000	2050	13.38
90	4	2000	2590	11.90
100	4	2000	3200	10.71
110	4	2000	3870	9.74

HANGAR VOLUME: 750000 CUBIC FEET

DESTRATIFIER PARAMETERS

HANGAR WIDTH FEET	NUMBER UNITS	FLOW CFM	DISCHARGE VELOCITY FPM	NOZZLE DIAMETER INCHES
80	6	2000	2050	13.38
90	6	2000	2590	11.90
100	6	2000	3200	10.71
110	6	2000	3870	9.74
120	6	2000	4610	8.92
130	6	2000	5410	8.23
140	6	2000	6280	7.64

HANGAR VOLUME: 1000000 CUBIC FEET

DESTRATIFIER PARAMETERS

HANGAR WIDTH FEET	NUMBER UNITS	FLOW CFM	DISCHARGE VELOCITY FPM	NOZZLE DIAMETER INCHES
90	6	3000	1730	17.03
100	6	3000	2130	16.07
110	6	3000	2580	14.60
120	6	3000	3070	13.39
130	6	3000	3610	12.34
140	6	3000	4180	11.47
150	6	3000	4800	10.71
160	6	3000	5460	10.04

HANGAR VOLUME: 1250000 CUBIC FEET

DESTRATIFIER PARAMETERS

HANGAR WIDTH FEET	NUMBER UNITS	FLOW CFM	DISCHARGE VELOCITY FPM	NOZZLE DIAMETER INCHES
110	6	3500	2210	17.04
120	6	3500	2630	15.62
130	6	3500	3090	14.41
140	6	3500	3580	13.39
150	6	3500	4120	12.48
160	6	3500	4680	11.71
170	6	3500	5290	11.01
180	6	3500	5930	10.40

HANGAR VOLUME: 1500000 CUBIC FEET

DESTRATIFIER PARAMETERS

HANGAR WIDTH FEET	NUMBER UNITS	FLOW CFM	DISCHARGE VELOCITY FPM	NOZZLE DIAMETER INCHES
120	6	4500	2050	20.06
130	6	4500	2400	18.54
140	6	4500	2790	17.20
150	6	4500	3200	16.06
160	6	4500	3640	15.06
170	6	4500	4110	14.17
180	6	4500	4610	13.38
190	6	4500	5140	12.67
200	6	4500	5690	12.04

HANGAR VOLUME: 1750000 CUBIC FEET

DESTRATIFIER PARAMETERS

HANGAR WIDTH FEET	NUMBER UNITS	FLOW CFM	DISCHARGE VELOCITY FPM	NOZZLE DIAMETER INCHES
130	6	5000	2160	20.60
140	6	5000	2510	19.11
150	6	5000	2880	17.84
160	6	5000	3280	16.72
170	6	5000	3700	15.74
180	6	5000	4150	14.86
190	6	5000	4620	14.09
200	6	5000	5120	13.38
210	6	5000	5650	12.74
220	6	5000	6200	12.16

HANGAR VOLUME: 2000000 CUBIC FEET

DESTRATIFIER PARAMETERS

HANGAR WIDTH FEET	NUMBER UNITS	FLOW CFM	DISCHARGE VELOCITY FFM	NOZZLE DIAMETER INCHES
140	6	5500	2280	21.03
150	6	5500	2620	19.62
160	6	5500	2980	18.40
170	6	5500	3360	17.33
180	6	5500	3770	16.36
190	6	5500	4200	15.50
200	6	5500	4660	14.71
210	6	5500	5130	14.02
220	6	5500	5640	13.37
230	6	5500	6160	12.80

HANGAR VOLUME: 2250000 CUBIC FEET

DESTRATIFIER PARAMETERS

HANGAR WIDTH FEET	NUMBER UNITS	FLOW CFM	DISCHARGE VELOCITY FFM	NOZZLE DIAMETER INCHES
140	6	6500	1930	24.85
150	6	6500	2210	23.22
160	6	6500	2520	21.75
170	6	6500	2840	20.49
180	6	6500	3190	19.33
190	6	6500	3560	18.30
200	6	6500	3940	17.39
210	6	6500	4340	16.57
220	6	6500	4770	15.81
230	6	6500	5210	15.13
240	6	6500	5680	14.49
250	6	6500	6160	13.91

HANGAR VOLUME: 2500000 CUBIC FEET

DESTRATIFIER PARAMETERS

HANGAR WIDTH FEET	NUMBER UNITS	FLOW CFM	DISCHARGE VELOCITY FPM	NOZZLE DIAMETER INCHES
150	6	7000	2060	24.96
160	6	7000	2340	23.42
170	6	7000	2640	22.05
180	6	7000	2960	20.82
190	6	7000	3300	19.72
200	6	7000	3660	18.73
210	6	7000	4030	17.85
220	6	7000	4430	17.02
230	6	7000	4840	16.29
240	6	7000	5270	15.61
250	6	7000	5720	14.98
260	6	7000	6190	14.40

HANGAR VOLUME: 2750000 CUBIC FEET

DESTRATIFIER PARAMETERS

HANGAR WIDTH FEET	NUMBER UNITS	FLOW CFM	DISCHARGE VELOCITY FPM	NOZZLE DIAMETER INCHES
160	6	8000	2050	26.75
170	6	8000	2310	25.20
180	6	8000	2590	23.80
190	6	8000	2890	22.53
200	6	8000	3200	21.41
210	6	8000	3530	20.39
220	6	8000	3870	19.47
230	6	8000	4230	18.62
240	6	8000	4610	17.84
250	6	8000	5000	17.13
260	6	8000	5410	16.47
270	6	8000	5840	15.85
280	6	8000	6280	15.28

HANGAR VOLUME: 3000000 CUBIC FEET

DESTRATIFIER PARAMETERS

HANGAR WIDTH FEET	NUMBER UNITS	FLOW CFM	DISCHARGE VELOCITY FPM	NOZZLE DIAMETER INCHES
170	6	9000	2050	28.37
180	6	9000	2300	26.79
190	6	9000	2570	25.34
200	6	9000	2840	24.11
210	6	9000	3140	22.93
220	6	9000	3440	21.90
230	6	9000	3760	20.95
240	6	9000	4100	20.06
250	6	9000	4450	19.26
260	6	9000	4810	18.52
270	6	9000	5190	17.83
280	6	9000	5580	17.20
290	6	9000	5980	16.61

HANGAR VOLUME: 3250000 CUBIC FEET

DESTRATIFIER PARAMETERS

HANGAR WIDTH FEET	NUMBER UNITS	FLOW CFM	DISCHARGE VELOCITY FPM	NOZZLE DIAMETER INCHES
170	6	9000	2050	28.37
180	6	9000	2300	26.79
190	6	9000	2570	25.34
200	6	9000	2840	24.11
210	6	9000	3140	22.93
220	6	9000	3440	21.90
230	6	9000	3760	20.95
240	6	9000	4100	20.06
250	6	9000	4450	19.26
260	6	9000	4810	18.52
270	6	9000	5190	17.83
280	6	9000	5580	17.20
290	6	9000	5980	16.61
300	6	9000	6410	16.05

HANGAR VOLUME: 3500000 CUBIC FEET

DESTRATIFIER PARAMETERS

HANGAR WIDTH FEET	NUMBER UNITS	FLOW CFM	DISCHARGE VELOCITY FPM	NOZZLE DIAMETER INCHES
180	6	10000	2070	29.76
190	6	10000	2310	28.18
200	6	10000	2560	26.76
210	6	10000	2820	25.50
220	6	10000	3100	24.32
230	6	10000	3390	23.26
240	6	10000	3690	22.29
250	6	10000	4000	21.41
260	6	10000	4330	20.58
270	6	10000	4670	19.82
280	6	10000	5020	19.11
290	6	10000	5390	18.45
300	6	10000	5760	17.84
310	6	10000	6160	17.25

HANGAR VOLUME: 3750000 CUBIC FEET

DESTRATIFIER PARAMETERS

HANGAR WIDTH FEET	NUMBER UNITS	FLOW CFM	DISCHARGE VELOCITY FPM	NOZZLE DIAMETER INCHES
190	6	10500	2200	29.58
200	6	10500	2440	28.09
210	6	10500	2690	26.75
220	6	10500	2950	25.55
230	6	10500	3220	24.45
240	6	10500	3510	23.42
250	6	10500	3810	22.48
260	6	10500	4120	21.62
270	6	10500	4450	20.80
280	6	10500	4780	20.07
290	6	10500	5130	19.37
300	6	10500	5490	18.73
310	6	10500	5860	18.13
320	6	10500	6250	17.55

HANGAR VOLUME: 4000000 CUBIC FEET

DESTRATIFIER PARAMETERS

HANGAR WIDTH FEET	NUMBER UNITS	FLOW CFM	DISCHARGE VELOCITY FPM	NOZZLE DIAMETER INCHES
190	6	11000	2100	30.99
200	6	11000	2330	29.42
210	6	11000	2560	28.07
220	6	11000	2820	26.75
230	6	11000	3080	25.59
240	6	11000	3350	24.54
250	6	11000	3640	23.54
260	6	11000	3930	22.66
270	6	11000	4240	21.91
280	6	11000	4560	21.03
290	6	11000	4900	20.29
300	6	11000	5240	19.62
310	6	11000	5600	18.99
320	6	11000	5960	18.40
330	6	11000	6340	17.84

$$U = 0.022U_T^2 W^2 / Q \quad (2)$$

where: U = air exit velocity at destratifier nozzle, ft/min

U_T = residual air velocity at distance W , ft/min

W = throw distance, ft

$$D = 24 (Q/\pi U)^{1/2} \quad (3)$$

where D is the nozzle diameter, in.

For the design parameters presented in Table 9, a residual air velocity of 170 ft/min was assumed, and the hangar's width was used as the throw distance. The design data for nozzle diameter (Table 9), should be rounded to the nearest 1/4 inch. The recommended number of units is based upon moving a volume of air each hour equal to the interior volume of a hangar. Hangars, however, have their overhead areas sectionalized by draft curtains to curtail the spread of smoke and flame in case of fire. In some instances, the number of overhead sections will exceed the number of destratifier units recommended. In such circumstances, additional destratifiers are required so that at least one destratifier will be located within each section. Some older hangars have draft curtain designs which sectionalize the overhead in a shape similar to that of an egg crate. This will prevent the cold air jet destratifier from being effective. The LANTDIV heating system modification is the only concept evaluated which may be effective for an egg crate-sectionalized overhead.

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