TEST AND BALANCE REPORT
CONTRACT N62470-86-B-9517
CAMP LEJEUNE, NORTH CAROLINA

CONTRACT N62470-86-B-9517

NAVFAC SPECIFICATION
No. 05-86-9517

RENOVATE BUILDING 2615

AT THE

MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA

DESIGNED BY:

THE SMITH SINNETT ASSOCIATES, P.A.
110 WIND CHIME COURT
RALEIGH, NORTH CAROLINA 27615

SPECIFICATION PREPARED BY:

Architect: The Smith Sinnett Associates, P.A.
Structural: Bigger & Agnew
Mechanical: Jim Cheatham, P.E.
Electrical: Shelton Adcock, P.E.
Fire Protection: Jim Cheatham, P.E.

Submitted by: Ronald J. Little, AIA Date:6-15-87

CONSTRUCTION WORK PREFORMED BY:

LONESTAR GENERAL CONTRACTORS
P.O. BOX 7881
TYLER, TEXAS 75711

CONSTRUCTION TECHNOLOGY, INC.
MECHANICAL CONTRACTORS
1324 PARK PLACE, SUITE 225
HURST, TEXAS 76053

TEST & BALANCE ENGINEER:
BILL M. LONG P.E.
1324 PARK PLACE, SUITE 225
HURST, TEXAS 76053

FOREWORD

The work described in these documents was performed in accordance with the requirements set forth in Sections 15996 of the specification for contract No. N62470-86-B-9517 "Renovate Building 2615" at the Marine Corps Base, Camp LeJeune North Carolina.

All testing and balancing procedures were done in accordance with the NEBB Standards. The work performed was done under the supervision of Bill M. Long P.E., a registered professional engineer, who was approved by ROIC for this phase of the work.

Bill M. Long 10/27/88

Bill M. Long

NORTH CAROLINA
REGISTERED
SEAL
6882
ENGINEER
BILL M. LONG

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DESCRIPTION:

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Eval of Compliance

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Eval of Compliance

I. EVALUATION OF COMPLIANCE

A. GENERAL

The testing and balancing goals as set forth in the TAB Agenda (see appendix) and the contract specifications have not been obtained to the extend desired. In general the systems served by the new air handling equipment have been balanced satisfactorily but those systems served by existing equipment are considerably short of air.

The areas served by existing air handling units AHU-1, AHU-2, AHU-3 and AHU-7 were proportionally balanced with the air supplies available and when those systems do produce the design CFM then they should continue to be balanced.

The areas served by existing AHU-4, AHU-5 and AHU-6 are not proportionally balanced due to air restrictions existing in the systems. Example: AHU-6 is suppose to deliver 3015 CFM to the Federal Lobby but can only delivery 250 CFM (9% of design) even though the unit is delivering 47% of it's total capacity. The reheat coil serving the Lobby is completely covered with dirt and dust film and until it is cleaned any attempts at air balancing is futile. A similar condition exists in the LeJeune Room Lobby (served from AHU-4) where the air flow is only 29% of design.

The following is a recap of the air readings as they now exist:

Equipment	Area Served	Test Results as % of Design
New AHU-1:	Dry Storage 67	102%
New AHU-2:	Womens Dress. Rm. 81	96%
	Womens Toilet 82	100%
	Mens Toilet 80	100%
	Mens Dress. Rm. 83	96%
	Snack Bar 84	99%
Exist. AHU-1:	International Bar 19	63%
Exist. AHU-2:	Den Bar 30	64%
Exist. AHU-3	Carolina Rm. 42	51%
	Dining Rm. 43	42%
	Cafeteria 44	44%
	Service Corr. 41	unchg.
Exist. AHU-4	LeJeune Lobby 35	29%
	LeJeune Rm. 36	63%
	LeJeune Bar 37	47%

Exist. AHU-5	OCW Room 18	61%
	Regimental Rm. 24	99%
Exist. AHU-6	Federal Lobby 01	9%
	Corridor 07	162%
	Cashier 09	89%
	Cashier 10	63%
	Mens Toilet 20	102%
	Womens Lounge 16	66%
	Womens Toilet 19	77%
	Board Room 14	84%
Exist. AHU-7	Office 28	67%
	Office 29	65%
	Corridor 26	82%
Exist. AHU-8	Tower Room 201	N/A

B. New AHU-1 and AHU-2:

These units are performing as intended and have been balanced. No additional TAB work on these units or duct systems is required.

C. Existing AHU-1:

This unit serves the International Bar 19 and is producing approximately 63% of the design CFM. This system has a charcoal filter bank located in the main supply duct and it was suspected that this was the cause for the reduced air flows. However, these filters were taken out and while they do need cleaning, they only altered the total air flow by 15%. The CFM readings used in this report are with the charcoal air filters installed. From the field readings taken it is evident that the changes made in the duct system are not the cause of the reduced air flows. The total AHU static pressure was measured at 2.57" and of that only 1.15" was in the supply air duct system of which the charcoal filters accounted for 48%(0.55"). This would indicate that the fan speeds will have to be increased in order to obtain the design air flows. All air outlets have been proportionally balanced and it appears that there is sufficient air flow to satisfy the needs of this area. There is however, a large percentage of outside air being introduced into this system which could effect it's performance during extreme conditions.

D. Existing AHU-2: This unit serves the Den Bar and is producing approximately 64% of the designed CFM. This unit also has a charcoal filter bank and the CFMs used in this report are with the filters installed. The filters do need cleaning but this would not account for the differences between the scheduled air quantities and those actually measured. The air outlets were proportionally balanced and

if the unit should ever produce the scheduled air flow, the system should remain balanced. The outside air quantities have been checked and do not appear to be excessive.

E. Existing AHU-3:

This unit serves the Carolina Room, Dining Room and Cafeteria areas and is delivering approximately 52% of the scheduled CFM air supply. There are charcoal filters in each of the zone supplies and the CFMs used in this report are with the filters in place. The air outlets have been proportionately balanced so the increased air flows should not change the performance of the system. It appears that there is approximately 38% outside air being introduced into the system, which may or may not be excessive, and is included herein for information purposes only.

F. Existing AHU-4:

This unit serves the LeJeune Lobby, LeJeune Room and LeJeune Bar. It is delivering approximately 47% of the design CFM but the air distribution is unbalanced. The LeJeune Lobby is scheduled for 3015 CFM but is only receiving 250 CFM because the reheat coil in this duct needs cleaning. Field measurements show 0.45" pressure drop across this coil with only 250 CFM of air flow and until this coil is cleaned there is no use in trying to balance the air to any zone. There are charcoal filters in each supply duct which are contributing to the low air flows but these are not restricting proportional balancing like the reheat coil is.

G. Existing AHU-5:

This unit serves the OWC and Regimental Rooms and is delivering 78% design air, but it is unbalanced. The Regimental Room is within 99% of the design CFM but the OWC Room is only 61% of design. The reason is because the charcoal filters were removed from the duct supplying the Regimental Room and if these filters were reinstalled the air percentage would decrease in the Regimental Room, increase in the OCW Room, decrease in overall air delivery and in essence balance out. The outside air is approximately 21% of the supply and should not seriously effect the performance of the unit under extreme conditions.

H. Existing AHU-6

This unit serves the Federal Lobby, Board Room, Men and Womens Lounges and the Cashier Areas. It is delivering approximately 52% of the scheduled air but it is unbalanced. The Federal Lobby is scheduled for 2730 CFM but is only getting 250 CFM. This area, like the LeJeune Lobby, is suffering from a stopped up reheat coil and until it is cleaned all balancing attempts are futile.

Existing AHU-7:

This unit serves the offices and corridors and is delivering approximately 69% of design CFM. All outlets have been proportionally balanced and if the system should ever deliver the scheduled CFMs the system should remain balanced.

Existing AHU-8:

This unit was relocated to the second floor and reconnected. No TAB work was specified for this unit and none was done except to verify that it was operational.

Fan and Coil Units Nos. 1 thru 5:

No provisions such as flow sensors, circuit setters, thermometers, or pressure gages were provided for the fan and coil units. All testing and balancing was done using strap on thermostats and digital thermometers to read water and air temperatures. The units were tested for operation and proper sequencing of controls.

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Tab report

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TAB Report

RENOVATE BUILDING 2615
MARINE CORPS BASE,
CAMP LEJEUNE, NORTH CAROLINA

TEST AND BALANCE REPORT
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CON·TECH

CONSTRUCTION TECHNOLOGY, INC.

CERTIFICATION

PROJECT RENOVATE BUILDING 2615 - CONTRACT NO. N62470-86-B-9517

ADDRESS CAMP LEJEUNE, NORTH CAROLINA

THE DATA PRESENTED IN THIS REPORT IS AN EXACT RECORD OF SYSTEM PERFORMANCE AND WAS OBTAINED IN ACCORDANCE WITH NEBB STANDARD PROCEDURES. ANY VARIANCES FROM DESIGN QUANTITIES WHICH EXCEED NEBB TOLERANCES ARE NOTED THROUGHOUT THIS REPORT.

THE AIR DISTRIBUTION SYSTEMS HAVE BEEN TESTED & BALANCED AND FINAL ADJUSTMENTS HAVE BEEN MADE IN ACCORDANCE WITH NEBB "PROCEDURAL STANDARDS FOR TESTING—ADJUSTING-BALANCING OF ENVIRONMENTAL SYSTEMS" AND THE PROJECT SPECIFICATIONS.

TAB CONTRACTOR CONSTRUCTION TECHNOLOGY, INC.

REG. NO. NONE CERTIFIED BY BILL M. LONG, P.E. (Air TAB Supervisor) DATE OCTOBER 27, 1988

THE HYDRONIC DISTRIBUTION SYSTEMS HAVE BEEN TESTED & BALANCED AND FINAL ADJUSTMENTS HAVE BEEN MADE IN ACCORDANCE WITH NEBB "PROCEDURAL STANDARDS FOR TESTING—ADJUSTING-BALANCING OF ENVIRONMENTAL SYSTEMS" AND THE PROJECT SPECIFICATIONS.

TAB CONTRACTOR CONSTRUCTION TECHNOLOGY, INC.

REG. NO. NONE CERTIFIED BY BILL M. LONG, P.E. (Hydronic TAB Supervisor) DATE OCTOBER 27, 1988

SUBMITTED & CERTIFIED BY:

TAB CONTRACTOR CONSTRUCTION TECHNOLOGY, INC.

TAB SUPERVISOR BILL M. LONG, P.E.

REG. NO. * 6882

DATE OCTOBER 27, 1988

*Professional Engineer Registration North Carolina

NORTH CAROLINA REGISTERED SEAL 6882 ENGINEER BILL M. LONG

Bill M. Long 10/27/88

PRELIMINARY TAB PROCEDURES

FIGURE 3-3 Systems Ready to Balance
CHECK LIST

	Ready Yes	Ready No	Date Corrected
1. HVAC Units and Built-up Units			
a) *General*	X		
Louvers installed	X		
Manual dampers open and locked	X		
Automatic dampers set properly	X		
Housing construction-leakage	X		
Access doors-leakage	X		
Condensate drain piping and pan	X		
Free from dirt and debris	X		
Nameplate data	X		
b) *Filters*			
Type and size	X		
Number	X		
Clean	X	①	
Frame-leakage	X		
c) *Coils (Hydronic)*			
Size and rows	X		
Fin spacing and condition	X		
Obstructions and/or debris	X	②	
Airflow and direction	X		
Piping leakage	X		
Correct piping connections and flow	X		
Valves open or set	X		
Airvents or steam traps	X		
Provisions made for TAB measurements	X	③	
d) *Coils (Electric)*	N/A		
Size and construction	N/A		
Airflow direction	N/A		
Duct connections	N/A		
Safety switches	N/A		
Obstructions	N/A		
Free from debris	N/A		
Contactors and disconnect switches	N/A		
Electrical service and connections	N/A		
Nameplate data	N/A		
e) *Fans*			
Rotation	X		
Wheel clearance and balance	X		
Bearing and motor lubrication	X		
Drive alignment	X		
Belt tension	X		

	Ready Yes	Ready No	Date Corrected
e) *Fans (continued)*			
Drive set screws tight	X		
Belt guard in place	X		
Flexible duct connector alignment	X		
Starters and disconnect switches	X		
Electrical service and connections	X		
Nameplate data	X		
f) *Vibration Isolation*			
Springs and compression	X		
Base level and free	X		
2. Duct Systems			
a) *General*			
Manual dampers open and locked	X		
Access doors closed and tight	X		
Fire dampers open and accessible	N/A		
Terminal units open and set	N/A		
Registers and diffusers open and set	X		
Turning vanes in square elbows	X		
Provisions made for TAB measurements	X		
Systems installed as per plans		④	
Ductwork sealed as required	X		
b) *Architectural*			
Windows installed and closed	X		
Doors closed as required	X		
Ceiling plenums installed and sealed	X		
Access doors closed and tight	X		
Air shafts and openings as required	X		
3. Pumps			
a) *Motors*			
Rotation	X		
Lubrication	X		
Alignment	X		
Set screws tight	X		
Guards in place	X		
Tank level and controls	X		
Starters and disconnect switches	X		
Electrical service and connections	X		
Nameplate data	X		
b) *Piping*			
Correct flow	X		
Correct connections	X		

NOTES:

① THE INTAKE AIR FILTERS ON ALL OF THE EXIST. AIR HANDLING UNITS WERE REPLACED BY CON TECH PERSONNEL BUT THE CHARCOAL AIR FILTERS IN THE SUPPLY DUCTS ARE DIRTY AND NEED NEW CHARCOAL MEDIA.

② THE EXISTING HEATING COILS SERVING THE FEDERAL LOBBY AND THE LEJEUNE LOBBY ARE STOPPED UP AND NEED CLEANING BEFORE ANY TAB WORK CAN BE ATTEMPTED.

③ NO PROVISIONS FOR BALANCING VALVES OR FLOW SENSORS HAVE BEEN PROVIDED FOR THE FAN COIL UNITS.

④ THE HVAC PIPING SYSTEM AND DUCT SYSTEMS FOR AHU #1 AND #2 WERE ESSENTIALLY INSTALLED AS ORIGINALLY SHOWN ON THE CONTRACT DRAWINGS BUT THE REMAINDER OF THE HVAC DUCT SYSTEM WAS ALTERED CONSIDERABLY AS THE CONTRACT DRAWINGS DID NOT MATCH THE EXISTING INSTALLATION.

FIGURE 3-3 Systems Ready to Balance (Continued)

CHECK LIST

	Ready Yes	Ready No	Date Corrected
b) *Piping (continued)*			
Leakage	X		
Valves open or set	X		
Strainer clean	X		
Air vented	X		
Flexible connectors	X		
Provisions made for TAB measurements	X	5	
Cavitation possibilities		X	
c) *Bases*	X		
Vibration isolation	X		
Grouting	X		
Leveling	X		
4. Hydronic Equipment			
a) *Boilers* -DEAERATOR			
Operating controls and devices			
Safety controls and devices	X		
Lubrication of fans and pumps	X		
Draft controls and devices	N/A		
Piping connections and flow	X		
Valves open or set	X		
Water make-up provisions	X		
Blowdown provisions	X		
Electrical connections	X		
Nameplate data	X		
b) *Heat Exchangers*			
Correct flow and connections	X		
Valves open or set	X		
Airvents or steam traps	X		
Leakage	X		
Provisions made for TAB measurements	X	5 6	
Nameplate data	X		
c) *Cooling Towers/ Evaporative Condensers*	N/A		
Correct flow and connections	N/A		
Valves open or set	N/A		
Leakage	N/A		
Provisions made for TAB measurements	N/A		
Sump water level	N/A		
Spray nozzles	N/A		
Fan/pump rotation	N/A		
Motor/fan lubrication	N/A		
Drives and alignment	N/A		
Guards in place	N/A		

	Ready Yes	Ready No	Date Corrected
c) *Cooling Towers/ Evaporative Condensers (continued)*	N/A		
Starters and disconnect switches	N/A		
Electrical connections	N/A		
Nameplate data	N/A		
5. Refrigeration Equipment			
Crankcase heaters energized	X		
Operating controls and devices	X		
Safety controls and devices	X		
Valves open	X		
Piping connections and flow	X		
Flexible connectors	X		
Oil level and lubrication	X		
Alignment and drives	X		
Guards in place	X		
Vibration isolation	X		
Starters, contactors and disconnect switches	X		
Electrical connections	X		
Nameplate data	X		
6. Hydronic Piping Systems			
Leak tested	X		
Fluid levels and make-up	X		
Relief or safety valves	X		
Compression tanks and air vents	X		
Steam traps and connections	X		
Strainers clean	X		
Valves open or set	X		
Provisions made for TAB measurements	X	5	
Systems installed as per plans	X		
7. Control Systems			
Data centers	N/A		
Outdoor/return Air/reset	N/A		
Economizer	N/A		
Static pressure	N/A		
Room controls	X		
8. Other Checks			
a) *Other trades or personnel notified of TAB work requirements*	X		
b) *Preliminary data complete*	X		
c) *Test report forms prepared*	X		

NOTES:

5 NO BALANCING VALVES OR FLOW SENSORS WERE PROVIDED ON THE STEAM HOT WATER CONVERTORS OR RUN OUTS TO FAN COIL UNITS.

6 NO FLOW ORFICES OR METERING DEVICES WERE PROVIDED ON ANY STEAM OR CONDENSATE SUPPLIES.

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CONSTRUCTION TECHNOLOGY, INC.

AIR APPARATUS TEST REPORT

PROJECT Renovate Building 2615 SYSTEM/UNIT AHU-1

LOCATION Seth Williams St. Paradise Point Camp Lejeune, NC

UNIT DATA	
Make/Model No.	TRANE CLCH-3A
Type/Size	DRAW THRU
Serial Number	K88C07825
Arr./Class	1/1
Discharge	HORIZONTAL
Make Sheave	N/A
Sheave Diam/Bore	5" 1/2"
No. Belts/make/size	(1) 4L380
No. Filters/type/size	(2) 16"x25"x2"

MOTOR DATA	
Make/Frame	CENTURY M43-T
H.P./RPM	1/3 - 1750 rpm
Volts/Phase/Hertz	120/1 ph/60 Hz.
F.L. Amps/S.F.	7.2 Amps/ 1.35
Make Sheave	BROWNING #828
Sheave Diam/Bore	3.75" 3/4"
Sheave ℄ Distance	13 7/8"

TEST DATA	DESIGN	ACTUAL
Total CFM	800	825
Total S.P. (in. H2O)	N/A	0.67"
Fan RPM	1200	1022
Motor Volts T_1T_2 T_2T_3 T_3T_1	120	125
Motor Amps T_1 T_2 T_3	7.2	6.0
Outside Air CFM	100	130
Return Air CFM	700	705

TEST DATA	DESIGN	ACTUAL
Discharge S.P.	N/A	0.22"
Suction S.P.	N/A	0.45"
Reheat Coil Δ S.P.	N/A	N/A
Cooling Coil Δ S.P.	N/A	0.35"
Preheat Coil Δ S.P.	N/A	combined
Filters Δ S.P.	N/A	0.10"
Total ESP (1)	0.35"	0.30"
Vortex Damp. Position	N/A	N/A
Out. Air Damp. Position	As Req'd	90% Open
Ret. Air Damp. Position	As Req'd	

REMARKS:

(1) ESP does not include filters.

TEST DATE Sept. 7, 1988 READINGS BY James Glenn

CON·TECH

CONSTRUCTION TECHNOLOGY, INC.

AIR APPARATUS TEST REPORT

PROJECT Renovate Building 2615 SYSTEM/UNIT AHU-2

LOCATION Seth Williams St. Paradise Point Camp Lejeune, NC

UNIT DATA	
Make/Model No.	TRANE CLCH3A
Type/Size	DRAW THRU
Serial Number	K88B06357
Arr./Class	1/1
Discharge	HORIZONTAL
Make Sheave	N/A
Sheave Diam/Bore	4 3/4"x3/4"
No. Belts/make/size	(1) BROWNING 4L415
No. Filters/type/size	20"x25"x2"

MOTOR DATA	
Make/Frame	MARATHON 143T
H.P./RPM	1 Hp - 1730 rpm
Volts/Phase/Hertz	208V/3ph/60 Hz
F.L. Amps/S.F.	4.3/1.35
Make Sheave	BROWNING K90411B
Sheave Diam/Bore	5" x 3/4"
Sheave ℄ Distance	14 1/4"
Serial No.	UVA143TTDR5327AA

TEST DATA	DESIGN	ACTUAL
Total CFM ②	1600	1795
Total S.P.	N/A	0.43
Fan RPM	1650	1608
Motor Volts T_1T_2, T_2T_3, T_3T_1	208	210-215-215
Motor Amps T_1 T_2 T_3	4.3	4.1-4.2-4.5
Outside Air CFM	740	720
Return Air CFM	860	1075

TEST DATA	DESIGN	ACTUAL
Discharge S.P.	N/A	0.15
Suction S.P.	N/A	1.35
Reheat Coil ^ S.P.	N/A	-----
Cooling Coil ^ S.P.	N/A	combined
Preheat Coil ^ S.P.	N/A	1.20"
Filters ^ S.P.	N/A	0.10"
TOTAL ESP ①	0.35"	0.48"
Vortex Damp. Position	N/A	N/A
Out. Air Damp. Position	As Req'd	95% Open
Ret. Air Damp. Position		

REMARKS:

① ESP does not include filters

② Print Design CFM - 1800

TEST DATE Sept. 2, 1988 READINGS BY James Glenn

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CONSTRUCTION TECHNOLOGY, INC.

APPARATUS COIL TEST REPORT

PROJECT Renovate Building 2615, Camp LeJeune, N.C.

COIL DATA	COIL NO. HW-1		COIL NO. CW-1		COIL NO. HW-2		COIL NO. CW-2	
System Number	AHU-1		AHU-1		AHU-2		AHU-2	
Location	Attic Space		Attic Space		Attic Space		Attic Space	
Coil Type	Heating Water		Cooling Water		Heating Water		Cooling Water	
No. Rows-Fins/In.	1/131		6/80		2/111		8/120	
Manufacturer	Trane		Trane		Trane		Trane	
Model Number	WC		WL		M		WL	
Face Area, Sq. Ft.	2.08		2.08		3.13		3.13	
TEST DATA	DESIGN	ACTUAL	DESIGN	ACTUAL	DESIGN	ACTUAL	DESIGN	ACTUAL
Air Qty., CFM	800	825	800	825	1600	1795	1600	1795
Air Vel., FPM	N/A	400	600	400	N/A	575	600	575
Press. Drop, In.	N/A	0.10	2.0	0.40	N/A	0.33	2.0	1.26
Out. Air DB/WB	N/A	80.2	N/A	87.5/74.0	N/A	81.0	N/A	81.0/71.6
Ret. Air DB/WB	N/A	82.4	N/A	71.2/61.0	N/A	95.8	N/A	66.4/60.2
Ent. Air DB/WB	62 DB	82.0	78.2/66.8	73.8/63.0	47.2 DB	89.9	83.6/71.5	72.2/65.0
Lvg. Air DB/WB	N/A	110.8	58.1/57.1	66.7/59.2	N/A	108.8	53/52.9	63.2/59.2
Air Δ T	N/A	28.8	20.1	12.9	N/A	18.9	30.6	9
Water Flow, GPM	3	3.3	5.0	5.0	11.0	10.6	19.1	19.0
Press. Drop, PSI	4.3	1.0	6.49	1.0	4.3	1.0	6.49	5.0
Ent. Water Temp.	180	180	45	50.0	180	180	45	50
Lvg. Water Temp.	160	164.5	55	54.1	160	173	55	53.4
Water Δ T	20	15.5	10	4.1	20	11	10	3.4
Exp. Valve/Refrig.	N/A		N/A		N/A		N/A	
Refrig. Suction Press.	N/A		N/A		N/A		N/A	
Refrig. Suction Temp.	N/A		N/A		N/A		N/A	
Inlet Steam Press.	N/A		N/A		N/A		N/A	

REMARKS:

DATE Sept. 7, 1988 READINGS BY James Glenn

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CONSTRUCTION TECHNOLOGY, INC.

FAN TEST REPORT

PROJECT Renovate Building 2615 Camp Lejeune, NC

FAN DATA	FAN NO. F-1	FAN NO. F-2	FAN NO. F-3
Location	Roof	Roof	Roof
Service	Baths 83-84	Ice Room	Baths 53-54
Manufacturer	Loren Cook	Loren Cook	Loren Cook
Model Number	90C15D	120C35	90C15D
Serial Number	S22589-00-2/88	S22589-00-2/88	s22589-00-2/88
Type/Class	Centrifugal	Centrifugal	Centrifugal
Motor Make/Style	Fasco	Marathon	Fasco
Motor H.P./RPM/Frame	1/8 Hp/NA	1/4/1725/48Z	1/8 Hp/NA
Volts/Phase/Hertz	115/1/60	120/1/60	115/1/60
F.L. Amps/S.F.	1.7 Amps/NA	5.0 - 5.5 amps/NA	1.7/NA
Motor Sheave Make/Model	Direct Drive	---------	Direct Drive
Motor Sheave Diam./Bore	N/A	3.0"/1/2"	N/A
Fan Sheave Make	N/A	---------	N/A
Fan Sheave Diam./Bore	N/A	4.0"/0.75"	N/A
No. Belts/Make/Size	N/A	(1)Browning 4L200	N/A
Sheave ℄ Distance	N/A	5 1/2" ℄	N/A

TEST DATA	F-1 DESIGN	F-1 ACTUAL	F-2 DESIGN	F-2 ACTUAL	F-3 DESIGN	F-3 ACTUAL
CFM	380	630	1150	1100	470	435
Fan RPM	1300	1600	1490	1165	1300	1600
S.P. In/Out	N/A	0.23/0.01	N/A	0.30/0.01	N/A	0.44/0.01
Total S.P.	0.125	0.24	0.20	0.31	0.125	0.45
Voltage T_1T_2 T_2T_3 T_3T_1	115	125	120	125	120	125
Amperage T_1 T_2 T_3	1.7	0.6	5.0	4.8	1.7	0.75

REMARKS:

TEST DATE Sept. 26, 1988 READINGS BY James Glenn

CON·TECH

CONSTRUCTION TECHNOLOGY, INC.

FAN TEST REPORT

PROJECT Renovate Building 2615 , Camp Lejeune, NC

FAN DATA	FAN NO. F-4	FAN NO. F-5	FAN NO.
Location	Roof	Roof	
Service	Boiler Room	Boiler Room	
Manufacturer	Loren Cook	Loren Cook	
Model Number	195C3B	195C3B	
Serial Number	S225589-00-2/88	S225589-00-2/88	
Type/Class	Centrifugal	Centrifugal	
Motor Make/Style	Marathon	Marathon	
Motor H.P./RPM/Frame	1/4 Hp/1725 rpm/48Z	1/4 Hp/1725 rpm/48Z	
Volts/Phase/Hertz	120/1 Ph/60 Hz	120/1 Ph/60 Hz	
F.L. Amps/S.F.	5.0 - 5.5	5.0 - 5.5	
Motor Sheave Make/Model	N/A	N/A	
Motor Sheave Diam./Bore	3.0"/0.5"	3.0"/0.5"	
Fan Sheave Make	N/A	N/A	
Fan Sheave Diam./Bore	7.0"/0.75"	7.0"/0.75"	
No. Belts/Make/Size	(1) Browning 4L300	(1)Browning 4L300	
Sheave ℄ Distance	6 3/4"	6 5/8"	

TEST DATA	DESIGN	ACTUAL	DESIGN	ACTUAL	DESIGN	ACTUAL
CFM	2500	2700	2500	3000		
Fan RPM	700	707	700	734		
S.P. In/Out (in. H2O)	N/A	0.28/0.01	N/A	0.20/0.01		
Total S.P. (in. H2O)	0.125	0.29	0.125	0.21		
Voltage T_1T_2 T_2T_3 T_3T_1	120	125	120	125		
Amperage T_1 T_2 T_3	5.0	4.75	5.0	4.75		

REMARKS:

TEST DATE Sept. 26, 1988 READINGS BY James Glenn

CON·TECH

CONSTRUCTION TECHNOLOGY, INC.

FAN TEST REPORT

PROJECT Renovate Building 2615 Camp Lejeune, NC

FAN DATA	FAN NO. MA-1	FAN NO.	FAN NO.
Location	Attic - Snack Bar		
Service	Exhaust Hood Make-up		
Manufacturer	Loren Cook		
Model Number	10DB		
Serial Number	S225589-01		
Type/Class/Diam	FC x 1 x 11"		
Motor Make/Style	Marathon		
Motor H.P./RPM/Frame	1/3 Hp/1725 rpm/48Z		
Volts/Phase/Hertz	120/1Ph/60 Hz		
F.L. Amps/S.F.	6.1/1.35		
Motor Sheave Make/Model	-----		
Motor Sheave Diam./Bore	3" x 7/16"		
Fan Sheave Make	------		
Fan Sheave Diam./Bore	7" x 3/4"		
No. Belts/Make/Size	(1) Browning 4L400		
Sheave ℄ Distance	11 3/4"		
Motor Serial No.	UVA48S17D2056EP		

TEST DATA	DESIGN	ACTUAL	DESIGN	ACTUAL	DESIGN	ACTUAL
CFM	1440	1435				
Fan RPM	661	725				
S.P. In/Out	N/A	0.25/0.16				
Total S.P.	0.25"	0.41"				
Voltage T_1T_2, T_2T_3, T_3T_1	120	125				
Amperage T_1 T_2 T_3	6.1	4.5				

REMARKS:

TEST DATE Sept. 7, 1988 READINGS BY James Glenn

CON·TECH

CONSTRUCTION TECHNOLOGY, INC.

TERMINAL UNIT COIL CHECK REPORT

PROJECT Renovate Building 2615 Camp Lejeune SYSTEM Fan & Coil Units MANUFACTURER Trane

ROOM NO.	RISER NO.	UNIT SIZE (cfm)	DESIGN GPM	WATER PRESSURES DESIGN ΔP	WATER PRESSURES ENT. WTR. PR.	WATER PRESSURES LVG. WTR. PR.	WATER TEMPERATURES DESIGN ΔT	WATER TEMPERATURES EWT deg. F	WATER TEMPERATURES LWT deg. F	COIL AIR TEMPERATURES DESIGN ΔT	COIL AIR TEMPERATURES EAT deg. F	COIL AIR TEMPERATURES LAT deg. F	ΔP	ΔT deg. F
57	FC-1	300	2.2	14.5	N/A	N/A	10 F	50.0	55.1	N/A	70	51.8	N/A	18.2
60	FC-2	200	1.4	4.1	N/A	N/A	10	50.0	52.3	N/A	66.9	50.2	N/A	16.7
47	FC-3	800	5.1	7,6	N/A	N/A	10	50.0	54.1	N/A	66.6	52.7	N/A	13.9
48	FC-3	800	5.1	7.6	N/A	N/A	10	50.0	54.6	N/A	68.2	53.6	N/A	14.6
103	FC-4	200	1.4	4.1	N/A	N/A	10	50.0	53.7	N/A	69.6	51.3	N/A	18.3
27	FC-5	600	4.0	10.7	N/A	N/A	10	52.0	57.0	N/A	67.5	55.2	N/A	12.3

NOTE: USE ONE OF THE ABOVE ALTERNATE METHODS

REMARKS: WATER SUPPLY TEMP. 50 deg. F OUT. AIR TEMP. 71.0 deg. F

1. No provisions were made for measuring the water pressures across the coils.
2. All air temperatures are dry bulb readings.
3. No provisions were made to measure GPM flows.

TEST DATE Sept. 26, 1988 READINGS BY James Glenn

CON·TECH

CONSTRUCTION TECHNOLOGY, INC.

PUMP TEST REPORT

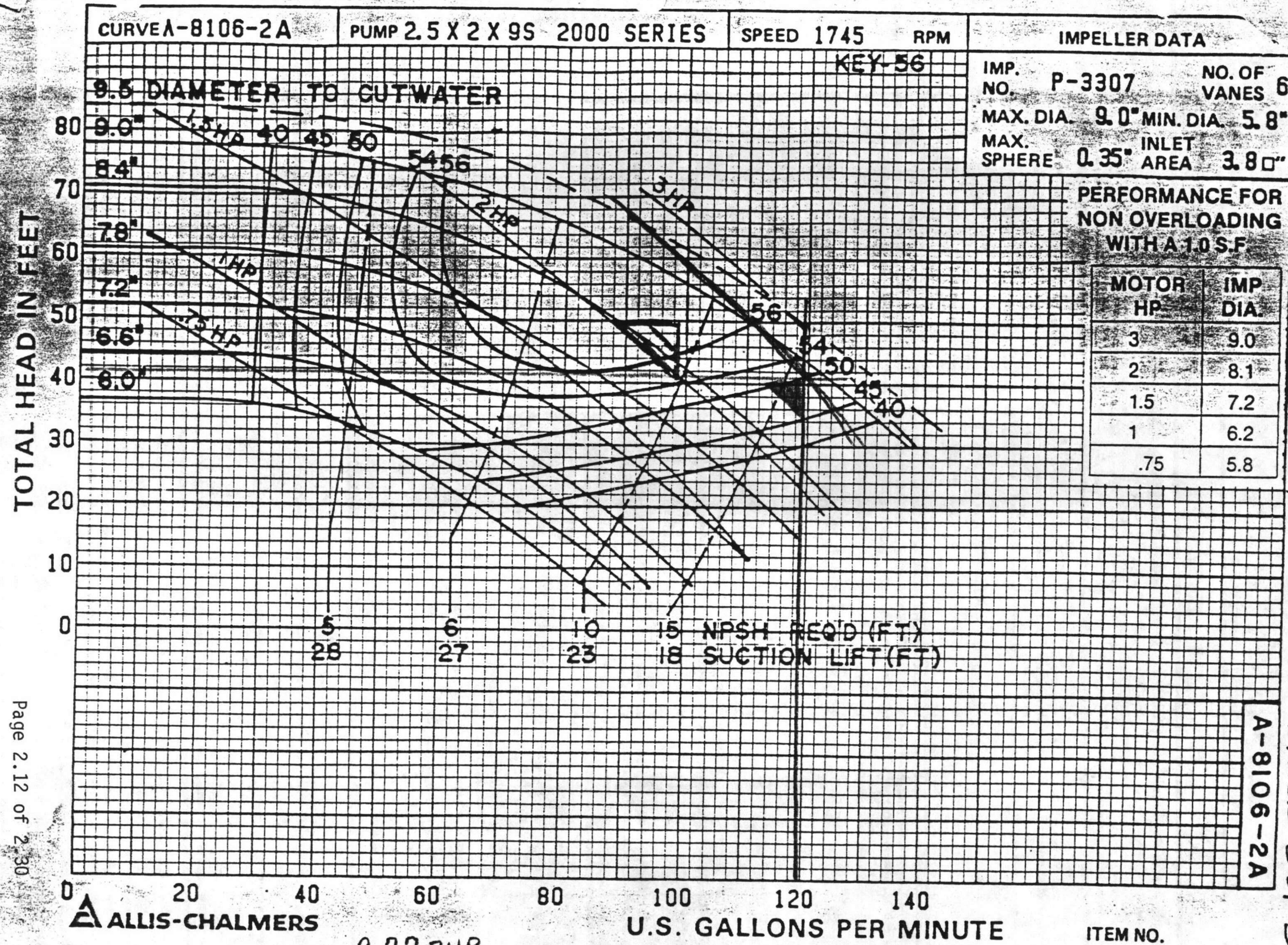
PROJECT Renovate Building 2615 Camp Lejeune, NC

	DATA	PUMP NO. P-1	PUMP NO.	PUMP NO.	PUMP NO.	PUMP NO.
DESIGN	Location	Room #87				
	Service	Heating Water				
	Manufacturer	Allis Chalmers				
	Model Number	150				
	Serial Number	881-62550-01-1				
	GPM/Head	99 / 50				
	Req. NPSH	15				
	Pump RPM	1750 rpm				
	Impeller Diam.	8.80				
	Motor Mfr./Frame	Marathon				
	Motor HP/RPM	3 / 1750				
	Volts/Phase/Hertz	460/3/60				
	F.L. Amps/S.F.	4.5/1115				
	Seal Type	Mechanical				
ACTUAL	Pump Off Press.	13.5 psi				
	Valve Shut Diff.	33.0 psi				
	Act. Impeller Diam.	8.80"				
	Valve Open Diff.	17.5 psi				
	Valve Open GPM	120				
	Final Dischg. Press.	30.0 psi				
	Final Suction Press.	11.7 psi				
	Final ∆ P	18.3 psi				
	Final GPM	118				
	Voltage T_1-T_2 T_2-T_3 T_3-T_1	510 510 510				
	Amperage T_1 T_2 T_3	4.5 4.0 4.0				

REMARKS:

1. No provisions made to measure GPM flows.

TEST DATE Sept. 27, 1988 READINGS BY James Glenn



2.77 BHP
40.425 Ft Hd
HP
GPM 118

Page 2.12 of 2.30

ITEM No 1 PAGE 3 OF 3

CON·TECH

CONSTRUCTION TECHNOLOGY, INC.

HEAT EXCHANGER/CONVERTER TEST REPORT

PROJECT Renovate Building 2615 Camp LeJeune, NC

UNIT DATA	UNIT NO. 1		UNIT NO.		UNIT NO.	
Location	Mechanical Room #87					
Service	Hot Water Heater					
Rating, BTU/Hr.	1,339,600 (2)					
Manufacturer	TACO					
Model Number	Type S					
Serial Number						
TEST DATA	**DESIGN**	**ACTUAL**	**DESIGN**	**ACTUAL**	**DESIGN**	**ACTUAL**
Steam — Pressure, PSI	45 psi	38 psi				
Steam — Flow, Lbs./Hr.	1341	885 (3)				
Steam		165/180				
Primary Water — Ent./Lvg. Temp.	152.8/180	165/180				
Primary Water — Temp. Δ T	27.2	15				
Primary Water — Ent./Lvg. Press.	(1)	(1)				
Primary Water — Press. Δ P	(1)	(1)				
Primary Water — GPM	98.5	118				
Primary Water						
Secondary Water						
Secondary Water — Ent./Lvg. Temp.	N/A	N/A				
Secondary Water — Temp. Δ T	N/A	N/A				
Secondary Water — Ent./Lvg. Press.	N/A	N/A				
Secondary Water — Press. Δ P	N/A	N/A				
Secondary Water — GPM	N/A	N/A				
Control Set Point						
Exchanger Circuiting						

REMARKS:

(1) Pressure drops were not required by specs or drawings.

(2) Ratings are manufacture ratings.

(3) Steam control valve was modulating.

TEST DATE Sept. 27, 1988 READINGS BY James Glenn

CON·TECH

CONSTRUCTION TECHNOLOGY, INC.

AIR OUTLET TEST REPORT

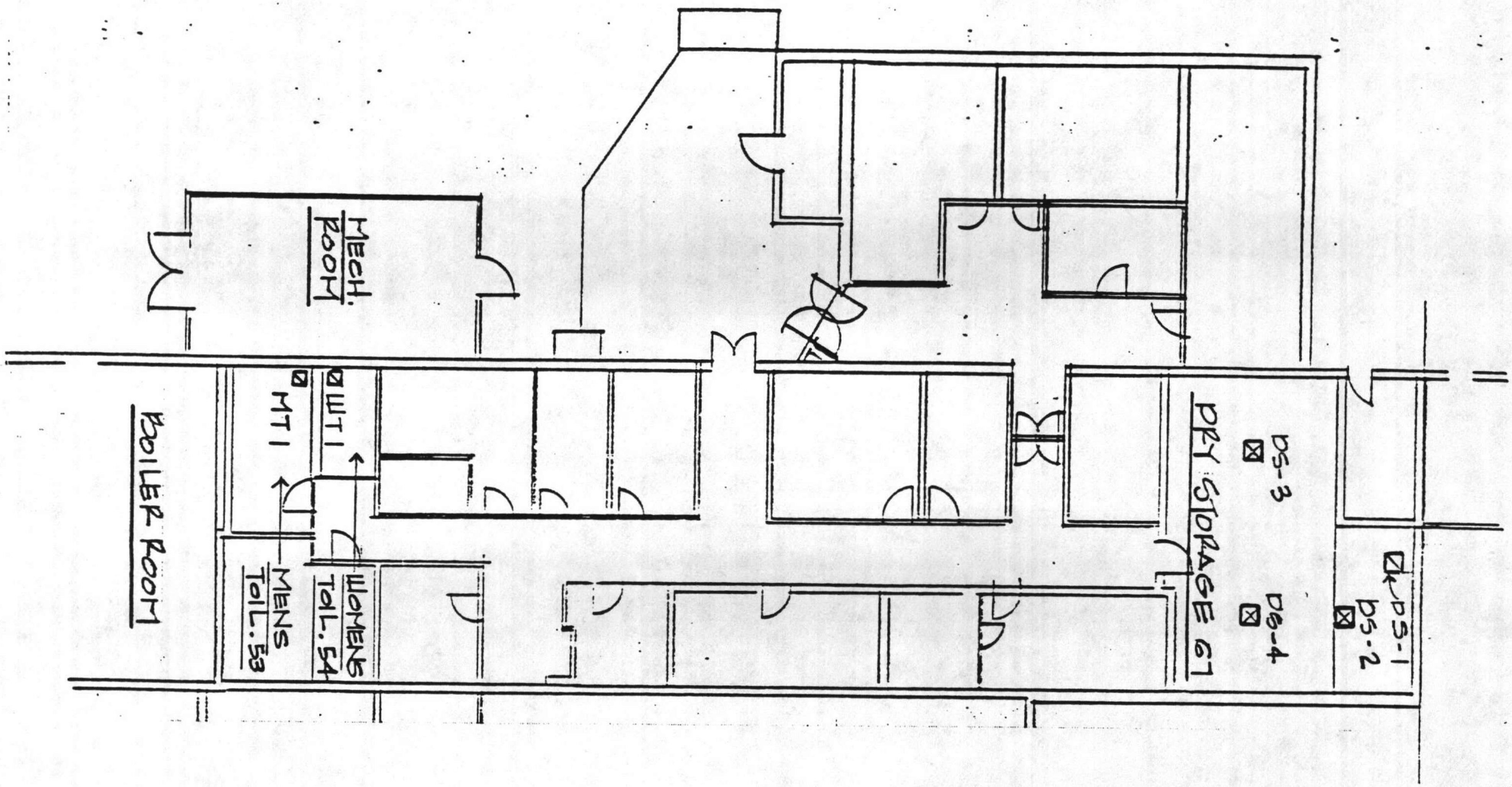
PROJECT Renovate Building 2615 Camp LeJeune SYSTEM Air Outlets - Dry Storage Mens Toilet - Womens Toilet

OUTLET MANUFACTURER Titus TEST APPARATUS Alnor Test Hood

AREA SERVED	OUTLET NO.	TYPE	SIZE	Neck	DESIGN CFM	DESIGN VEL.	Revised VEL. OR CFM	Revised VEL. OR CFM			FINAL VEL.	FINAL CFM	REMARKS
Dry Storage	DS1	RAG	18x12	18x12	N/A		N/A					700	RETURN
No. 67	DS2	CD	12x12	8	200		200					215	SUPPLY
No. 67	DS3	CD	12x12	10	300		300					310	SUPPLY
No. 67	DS4	CD	12x12	10	300		300					310	SUPPLY
Mens 53	MT1	ER	8x10	6	325		300					205	EXHAUST
Womens 54	WT1	ER	8x10	6	145		135					230	EXHAUST

REMARKS:

DATE Sept. 7, 1988 READINGS BY James Glenn



AIR OUTLET IDENTIFICATION PLAN ROOMS NOS. 53,54,67

CON·TECH

CONSTRUCTION TECHNOLOGY, INC.

AIR OUTLET TEST REPORT

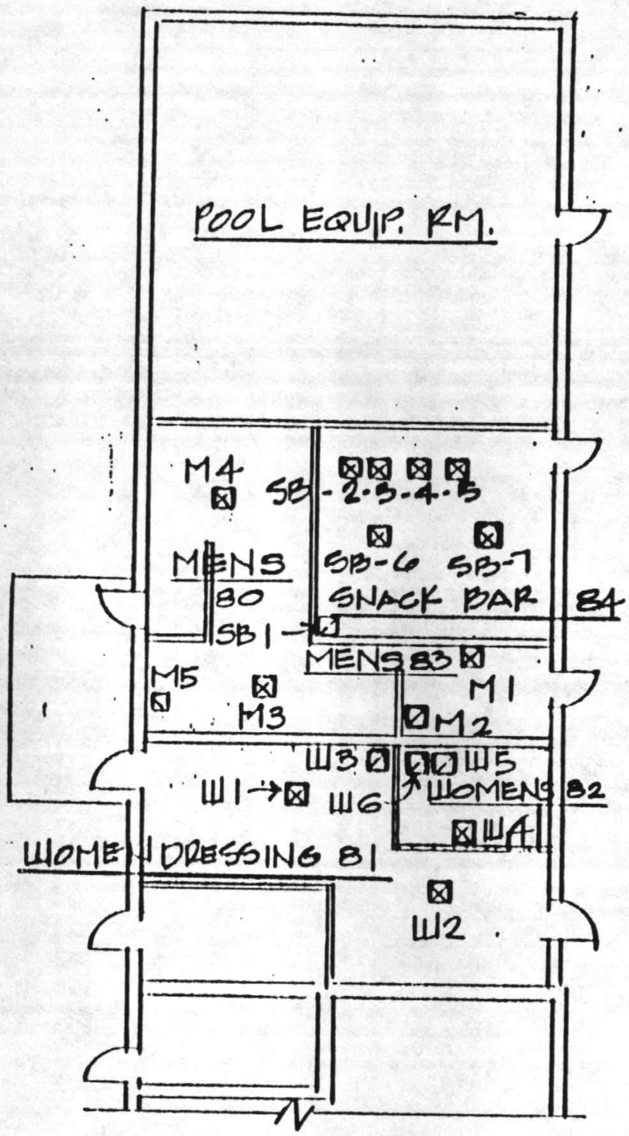
PROJECT Renovate Building 2615 Camp LeJeune SYSTEM Air Outlets - Snack Bar Dressing Rooms & Toilets

OUTLET MANUFACTURER Titus TEST APPARATUS Alnor Test Hood

AREA SERVED	OUTLET				DESIGN		PRELIMINARY				FINAL		REMARKS
	NO.	TYPE	SIZE	Neck	CFM	VEL	VEL. OR CFM	VEL. OR CFM			VEL.	CFM	
Snack Bar	SB1	RAG	24x24	12	N/A							230	RETURN
No. 84	SB2	CD	24x24	10	360							350	SUPPLY
No. 84	SB3	CD	24x24	10	360							360	SUPPLY
No. 84	SB4	CD	24x24	10	360							355	SUPPLY
No. 84	SB5	CD	24x24	10	360							370	SUPPLY
No. 84	SB6	CD	24x24	10	350							340	SUPPLY
No. 84	SB7	CD	24x24	8	175							180	SUPPLY
Mens Toilet	M1	CD	24x24	8	150							150	SUPPLY
No. 83	M2	ER	10x10	10	190							240	EXHAUST
Mens Dress.	M3	CD	24x24	8	200							200	SUPPLY
No. 80	M4	CD	24x24	10	275							255	SUPPLY
No. 80	M5	RAG	24x24	12	N/A							440	RETURN
Womens	W1	CD	24x24	8	250							250	SUPPLY
Dress No.81	W2	CD	24x24	8	250							240	SUPPLY
NO. 81	W3	RAG	24x24	12	N/A							440	RETURN
Womens Toil	W4	CD	24x24	8	150							155	SUPPLY
No] 82	W5	ER	10x6	10	190							200	EXHAUST
No. 82	W6	ER	10x6	10	-0-							200	EXHAUST

REMARKS:

DATE Sept. 7, 1988 READINGS BY James Glenn



AIR OUTLET IDENTIFICATION PLAN ROOMS NOS. 80,81,82,83,84

CON·TECH

CONSTRUCTION TECHNOLOGY, INC.

AIR OUTLET TEST REPORT

PROJECT Renovate Building 2615 Camp LeJeune, SYSTEM Air Outlets - International Bar

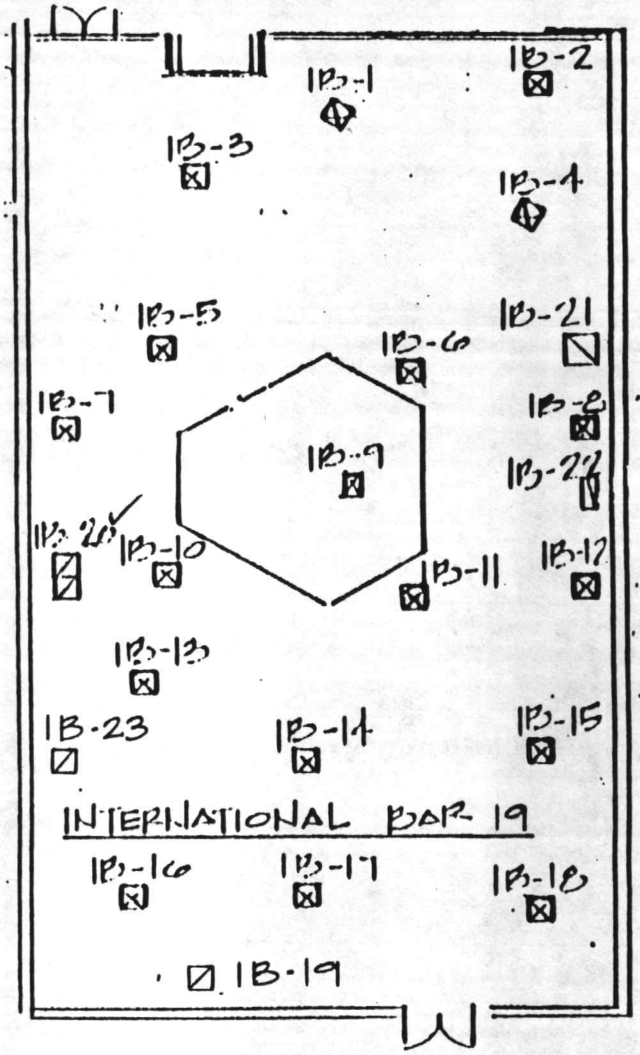
OUTLET MANUFACTURER Titus TEST APPARATUS Alnor Test Hood

AREA SERVED	OUTLET				DESIGN		Revised				FINAL		REMARKS
	NO.	TYPE	SIZE	Neck	CFM	VEL.	VEL. OR CFM	VEL. OR CFM			VEL.	CFM	
Int'l Bar	IB1	CD	24x24	12	575			361				360	SUPPLY
No. 19	IB2	CD	24x24	12	750			471				470	SUPPLY
No. 19	IB3	CD	24x24	12	545			342				340	SUPPLY
No. 19	IB4	CD	24x24	12	575			361				360	SUPPLY
No. 19	IB5	CD	24x24	12	703			442				440	SUPPLY
No. 19	IB6	CD	24x24	12	703			442				440	SUPPLY
No. 19	IB7	CD	24x24	12	545			342				345	SUPPLY
No. 19	IB8	CD	24x24	12	545			342				340	SUPPLY
No. 19	IB9	CD	24x24	10	703			442				440	SUPPLY
No. 19	IB10	CD	24x24	12	703			442				445	SUPPLY
No. 19	IB11	CD	24x24	12	703			442				440	SUPPLY
No. 19	IB12	CD	24x24	12	545			342				340	SUPPLY
No. 19	IB13	CD	24x24	12	545			342				340	SUPPLY
No. 19	IB14	CD	24x24	12	545			342				340	SUPPLY
No. 19	IB15	CD	24x24	12	545			342				380	SUPPLY
No. 19	IB16	CD	24x24	12	545			342				345	SUPPLY
No. 19	IB17	CD	24x24	12	560			352				350	SUPPLY
No. 19	IB18	CD	24x24	12	545			342				345	SUPPLY
No. 19	IB19	RAG	24x24	1	N/A			N/A				520	RETURN 1
No. 19	IB20	RAG	24x48	1	N/A			N/A				1000	RETURN 1
No. 19	IB21	RAG	24x24	1	N/A			N/A				540	RETURN 1
No. 19	IB22	RAG	12x18	1	N/A			N/A				240	RETURN 1
No. 19	IB23	RAG	12x18	1	N/A			N/A				400	RETURN 1

REMARKS:

1 Return air grilles are lay-in type; No duct connections - Above ceiling is a return air plenum - Return air duct system not changed under this contract.

DATE Sept. 14, 1988 READINGS BY James Glenn



AIR OUTLET IDENTIFICATION PLAN ROOM NO. 19

CON·TECH

CONSTRUCTION TECHNOLOGY, INC.

AIR OUTLET TEST REPORT

PROJECT Renovate Building 2615 Camp LeJeune SYSTEM Air Outlets - Den Bar

OUTLET MANUFACTURER Titus TEST APPARATUS Alnor Test Hood

AREA SERVED	OUTLET NO.	OUTLET TYPE	OUTLET SIZE	Neck	DESIGN CFM	DESIGN VEL	Revised VEL OR CFM	Revised VEL OR CFM			FINAL VEL	FINAL CFM	REMARKS
Den Bar	DB1	CD	24x24	10	300			194				190	SUPPLY
No. 30	DB2	CD	24x24	14	950			605				585	SUPPLY
No. 30	DB3	CD	24x24	10	300			194				205	SUPPLY
No. 30	DB4	CD	24x24	14	350			226				230	SUPPLY
No. 30	DB5	CD	24x24	14	950			605				570	SUPPLY
No. 30	DB6	CD	24x24	14	950			605				620	SUPPLY
No. 30	DB7	CD	24x24	14	950			605				615	SUPPLY
No. 30	DB8	CD	24x24	14	950			605				610	SUPPLY
No. 30	DB9	RAG	24x48	(2)18	N/A			N/A				1950	RETURN
No. 30	DB10	RAG	24x48	(2)18	N/A			N/A				920	RETURN

REMARKS:

DATE Sept. 15, 1988 READINGS BY James Glenn

CON·TECH

CONSTRUCTION TECHNOLOGY, INC.

AIR OUTLET TEST REPORT

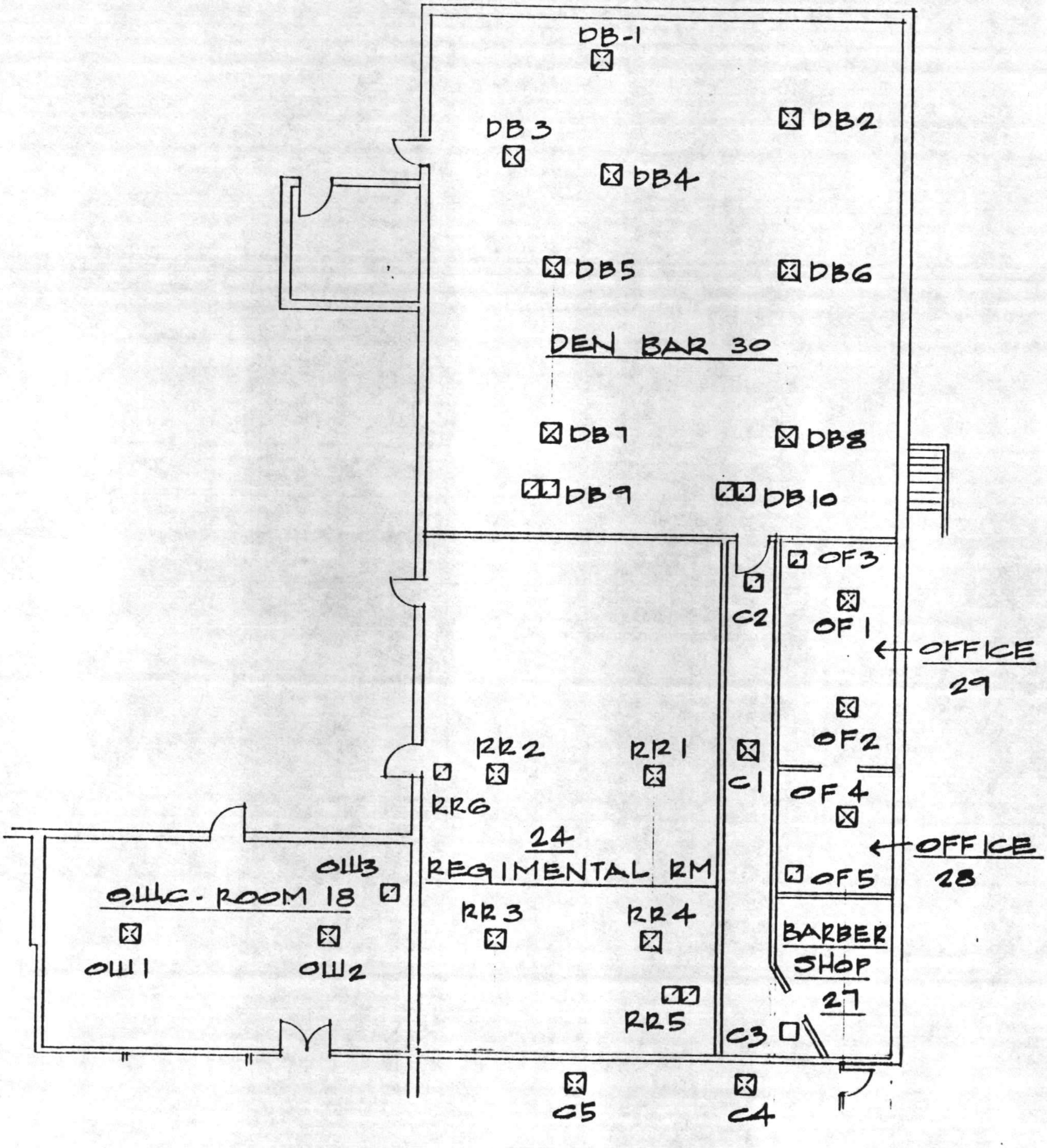
PROJECT Renovate Building 2615 Camp LeJeune SYSTEM Air Outlets - Offices - OCW Corridors - Regimental Room

OUTLET MANUFACTURER Titus TEST APPARATUS Alnor Test Hood

AREA SERVED	OUTLET				DESIGN		Revised		Prelim.		FINAL		REMARKS
	NO.	TYPE	SIZE	Neck	CFM	VEL.	VEL. OR CFM	VEL. OR CFM		CFM	VEL.	CFM	
Office 29	OF1	CD	24x24	12	583			406		360		380	SUPPLY
Office 29	OF2	CD	24x24	12;	583			406		406		380	SUPPLY
Office 28	OF3	RAG	24x24	12	N/A			N/A		700		700	RETURN
Office 28	OF4	CD	24x24	12	583			406		410		370	SUPPLY
Office 28	Of5	RAG	24x12	12	N/A			N/A		395		395	RETURN
Corridor 26	C1	CD	24x24	12	342			239		320		280	SUPPLY
Corridor 26	C2	RAG	24x12	10	N/A			N/A		270		270	RETURN
Corridor 26	C3	RAG	14x14	14	N/A			N/A		365		365	RETURN
Corridor 07	C4	CD	24x24	10	342			238		230		240	SUPPLY
Corridor 07	C5	CD	24x24	12	342			238		230		230	SUPPLY
egimental	RR1	CD	24x24	12	464			464		590		465	SUPPLY
Room No. 24	RR2	CD	24x24	12	464			464		295		465	SUPPLY
No. 24	RR3	CD	24x24	12	464			464		490		450	SUPPLY
No. 24	RR4	CD	24x24	12	464			464		470		465	SUPPLY
No. 24	RR5	RAG	24x48	(2)12	N/A			N/A		1140		1140	RETURN
No. 24	RR6	RAG	12x24	12x24	N/A			N/A		1050		1050	RETURN
OWC Room	OW1	CD	24x24	22x22	1155			700		---		705	SUPPLY
No. 18	OW2	CD	24x24	22x22	1155			700		---		695	SUPPLY
No. 18	OW3	RAG	24x30	24x30	N/A			N/A		900		1100	RETURN

REMARKS:

DATE Sept. 16, 1988 READINGS BY James Glenn



AIR OUTLET IDENTIFICATION PLAN ROOM NOS. 07,18,24,26,28,29,30

CON·TECH

CONSTRUCTION TECHNOLOGY, INC.

AIR OUTLET TEST REPORT

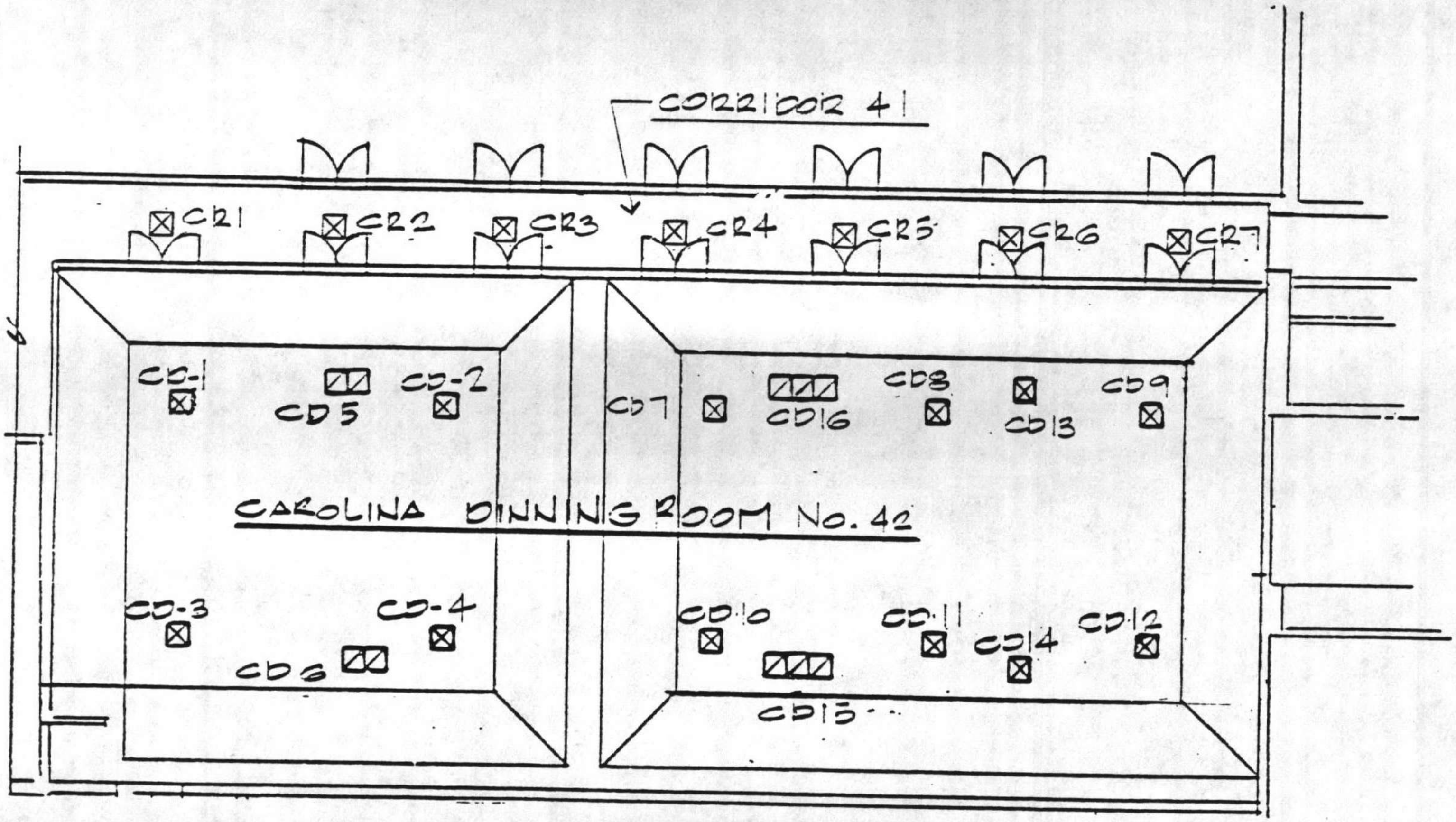
PROJECT Renovate Building 2615 Camp LeJeune SYSTEM Air Outlets - Carolina Dining

OUTLET MANUFACTURER Titus TEST APPARATUS Alnor Test Hood

AREA SERVED	OUTLET				DESIGN		Revised				FINAL		REMARKS
	NO.	TYPE	SIZE	Neck	CFM	VEL.	VEL. OR CFM	VEL. OR CFM			VEL.	CFM	
Carolina	CD1	CD	24x24	18	1613			819				840	SUPPLY
Dining No.42	CD2	CD	24x24	18	1613			819				860	SUPPLY
No. 42	CD3	CD	24x24	18	1613			819				880	SUPPLY
No. 42	CD4	CD	24x24	18	1613			819				885	SUPPLY
No. 42	CD5	ER	24x48	(2)18	N/A			N/A				1920	RETURN
No. 42	CD6	RAG	24x48	(2)18	N/A			N/A				2350	RETURN
No. 42	CD7	CD	24x24	18	1613			819				815	SUPPLY
No. 42	CD8	CD	24x24	18	1613			819				775	SUPPLY
No. 42	CD9	CD	24x24	18	1613			819				795	SUPPLY
No. 42	CD10	CD	24x24	18	1613			819				775	SUPPLY
No. 42	CD11	CD	24x24	18	1613			819				785	SUPPLY
No. 42	CD12	CD	24x24	18	1613			819				780	SUPPLY
No. 42	CD13	ER	24x24	12x24	1300							1	EXHAUST
No. 42	CD14	ER	24x24	12x24	1300							1	EXHAUST
No. 42	CD15	RAG	24x72	(3)18	N/A			N/A				1820	RETURN
No. 42	CD16	RAG	24x72	(3)18	N/A			N/A				1460	RETURN
Corridor	CR1	CD	Exist	10	N/A			N/A				240	SUPPLY
No. 41	CR2	CD	Exist	10	N/A			N/A				260	SUPPLY
No. 41	CR3	CD	Exist	10	N/A			N/A				290	SUPPLY
No. 41	CR4	CD	Exist	10	N/A			N/A				285	SUPPLY
No. 41	CR5	CD	Exist	10	N/A			N/A				270	SUPPLY
No. 41	CR6	CD	Exist	10	N/A			N/A				270	SUPPLY
No. 41	CR7	CD	Exist	10	N/A			N/A				285	SUPPLY

REMARKS:

DATE Sept. 19, 1988 READINGS BY James Glenn



AIR OUTLET IDENTIFICATION PLAN ROOM NOS. 41 & 42

CON·TECH

CONSTRUCTION TECHNOLOGY, INC.

AIR OUTLET TEST REPORT

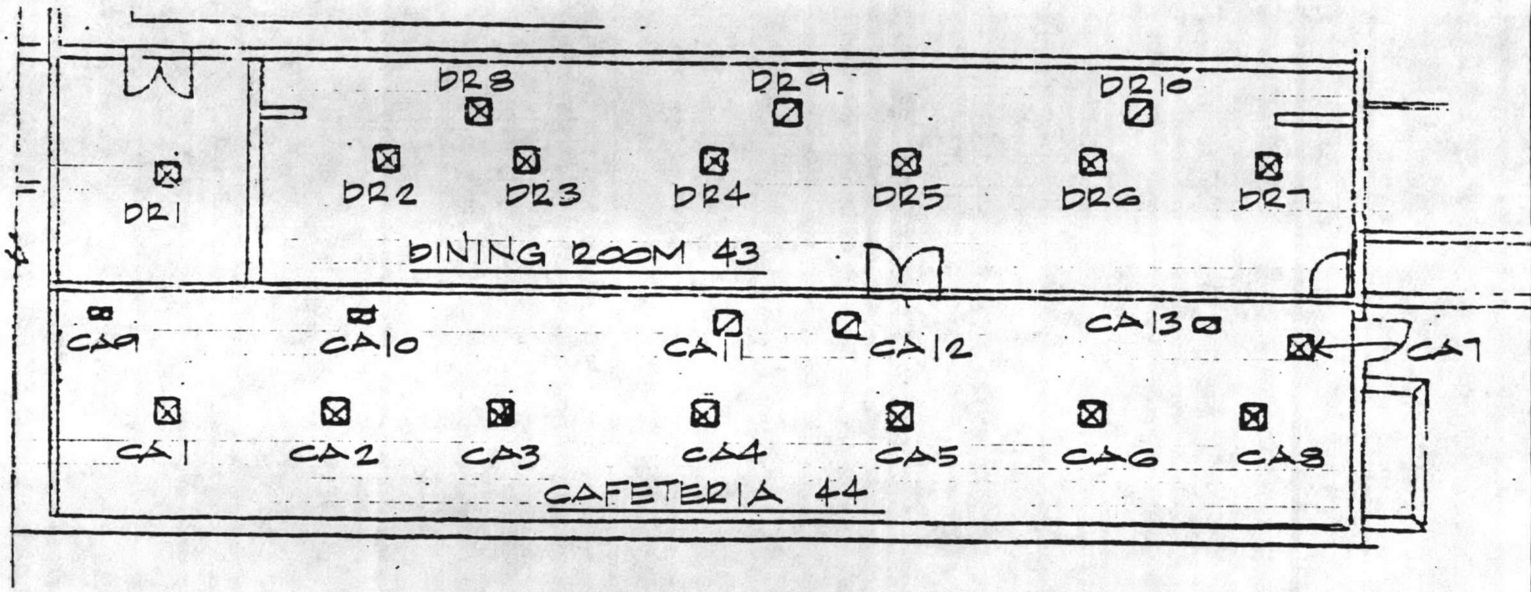
PROJECT Renovate Building 2615 Camp LeJeune SYSTEM Air Outlets - Dining Rm. & Cafeteria

OUTLET MANUFACTURER Titus TEST APPARATUS Alnor Test Hood

AREA SERVED	OUTLET NO.	OUTLET TYPE	OUTLET SIZE	Neck	DESIGN CFM	DESIGN VEL.	Revised VEL. OR CFM	Revised VEL. OR CFM			FINAL VEL.	FINAL CFM	REMARKS
Dining Rm.	DR1	CD	24x24	12	467			200				195	SUPPLY
No. 43	DR2	CD	24x24	12	467			200				195	SUPPLY
No. 43	DR3	CD	24x24	12	467			200				195	SUPPLY
No. 43	DR4	CD	24x24	12	467			200				200	SUPPLY
No. 43	DR5	CD	24x24	12	467			200				200	SUPPLY
No. 43	DR6	CD	24x24	12	467			200				200	SUPPLY
No. 43	DR7	CD	24x24	10	467			200				200	SUPPLY
No. 43	Dr8	RAG	24x24	18	N/A			N/A				1050	RETURN
No. 43	DR9	RAG	24x24	18	N/A			N/A				540	RETURN
No. 43	DR10	RAG	24x24	18	N/A			N/A				350	RETURN
Cafeteria	CA1	CD	24x24	12	481			206				175	SUPPLY
Rm. No. 44	CA2	CD	24x24	12	481			206				170	SUPPLY
No. 44	CA3	CD	24x24	12	481			206				195	SUPPLY
No. 44	CA4	CD	24x24	12	325			140				185	SUPPLY
No. 44	CA5	CD	24x24	12	325			140				185	SUPPLY
No. 44	CA6	CD	24x24	12	325			140				185	SUPPLY
No. 44	CA7	CD	24x24	10	200			86				75	SUPPLY
No. 44	CA8	CD	24x24	10	330			141				115	SUPPLY
No. 44	CA9	RAG	24x24	12	N/A			N/A				430	RETURN
No. 44	CA10	RAG	24x24	14	N/A			N/A				600	RETURN
No. 44	CA11	RAG	24x24	14	N/A			N/A				320	RETURN
No. 44	CA12	RAG	24x24	14	N/A			N/A				250	RETURN
No.44	CA13	RAG	24x24	14	N/A			N/A				110	RETURN

REMARKS:

DATE Sept. 22, 1988 READINGS BY James Glenn



AIR OUTLET IDENTIFICATION PLAN ROOM NOS. 43 & 44

CON·TECH

CONSTRUCTION TECHNOLOGY, INC.

AIR OUTLET TEST REPORT

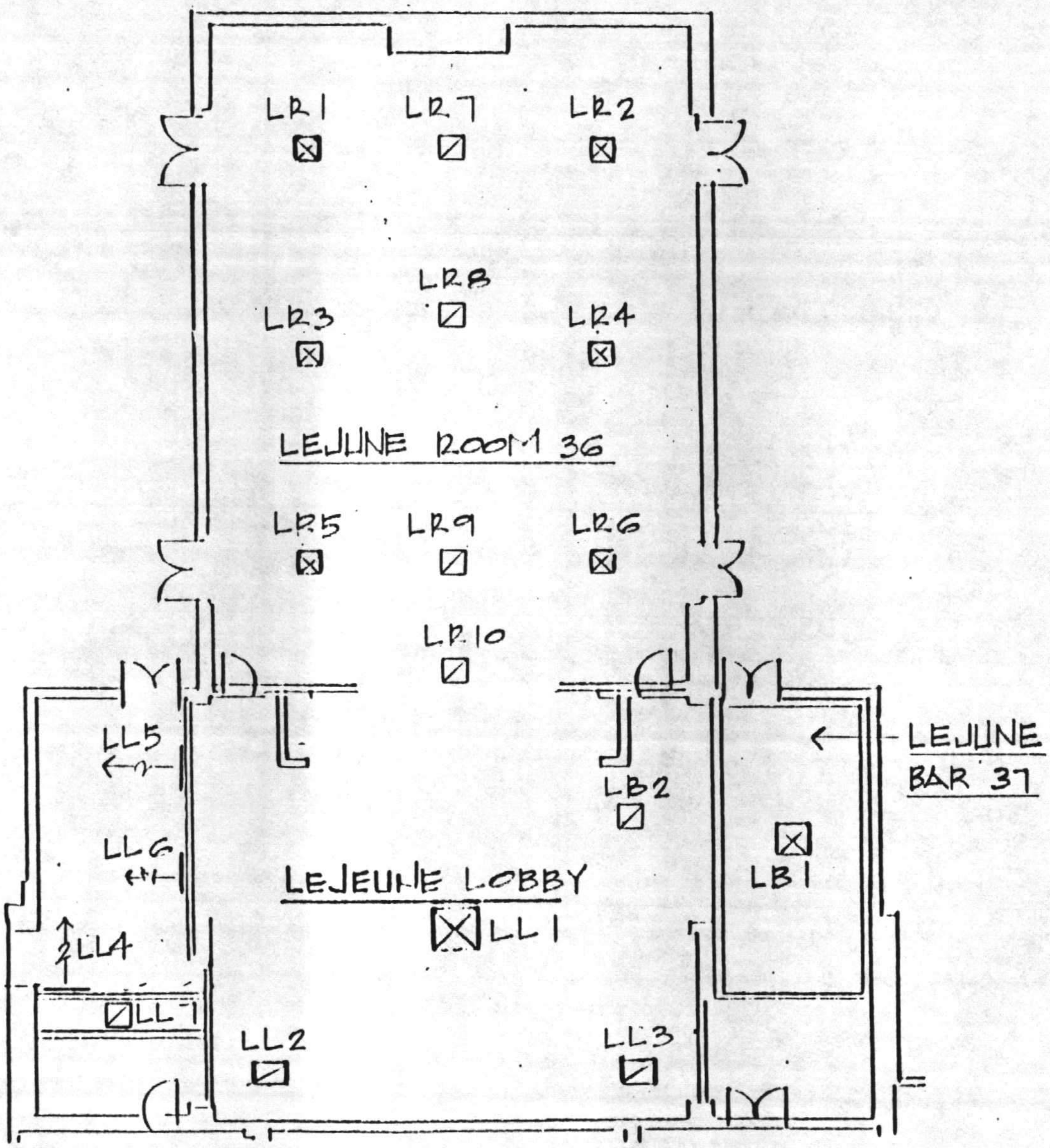
PROJECT Renovate Building 2615 CAmp LeJeune SYSTEM Air Outlets - LeJeune Room

OUTLET MANUFACTURER Titus TEST APPARATUS Alnor Test Hood

AREA SERVED	OUTLET NO.	OUTLET TYPE	OUTLET SIZE	Neck	DESIGN CFM	DESIGN VEL	Revised VEL. OR CFM	Revised VEL. OR CFM			FINAL VEL.	FINAL CFM	REMARKS
LeJeune Rm.	LR1	CD	24x24	14	770			361				480	SUPPLY
No. 36	LR2	CD	24x24	14	770			361				485	SUPPLY
No. 36	LR3	CD	24x24	14	770			361				490	SUPPLY
No. 36	LR4	CD	24x24	14	770			361				490	SUPPLY
No. 36	LR5	CD	24x24	14	770			361				475	SUPPLY
No. 36	LR6	CD	24x24	14	770			361				490	SUPPLY
No. 36	LR7	CD	24x24	14	770			N/A				270	RETURN
No. 36	LR8	RAG	24x24	18	N/A			N/A				320	RETURN
No. 36	LR9	RAG	24x24	18	N/A			N/A				440	RETURN
No. 36	LR10	RAG	24x24	18	N/A			N/A				600	RETURN
LeJeune	LL1	CD	36x36	36x36	3015			1415				250	SUPPLY
Lobby No. 35	LL2	RAG	24x30	18	N/A			N/A				1100	RETURN
No. 35	LL3	RAG	24x30	18	N/A			N/A				740	RETURN
No. 35	LL4	SWG	12x8	12x8	605			284				630	SUPPLY
No. 35	LL5	SWG	12x8	8	305			143				210	SUPPLY
No. 35	LL6	SWG	12x8	8	305			143				150	SUPPLY
No. 35	LL7	RAG	24x24	24x24	N/A			N/A				1200	RETURN
LeJeune Bar	LB1	CD	22x32	17x20	2230			1046				1050	SUPPLY
No. 37	LB2	RAG	24x28	18	N/A			N/A				440	EXHAUST

REMARKS:

DATE Sept. 28, 1988 READINGS BY James Glenn



AIR OUTLET IDENTIFICATION PLAN ROOM NOS. 35,36,37

CON·TECH

CONSTRUCTION TECHNOLOGY, INC.

AIR OUTLET TEST REPORT

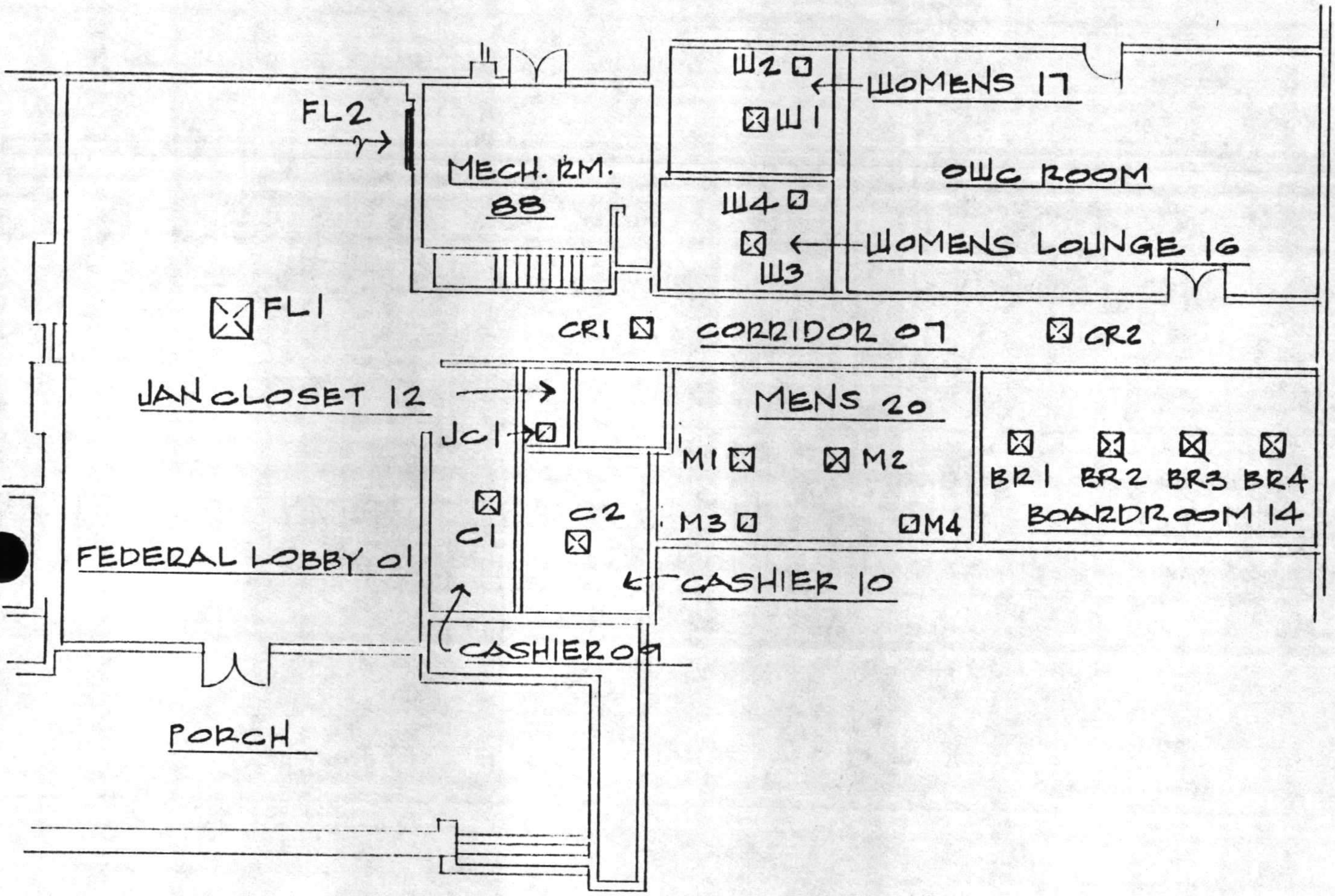
PROJECT Renovate Building 2615 Camp LeJeune SYSTEM Air Outlets - Federal Lobby Cashiers - Toilets - Board Room

OUTLET MANUFACTURER Titus TEST APPARATUS Alnor Test Hood

AREA SERVED	OUTLET NO.	OUTLET TYPE	OUTLET SIZE	Neck	DESIGN CFM	DESIGN VEL.	Revised VEL. OR CFM	Revised VEL. OR CFM			FINAL VEL.	FINAL CFM	REMARKS
Federal	FL1	CD	30x36	30x36	2730			1433				250	SUPPLY
Lobby 01	FL2	RAG	24x48	24x48	N/A			N/A				1200	RETURN
Cashier 09	C1	CD	24x24	12	285			150				320	SUPPLY
Cashier 10	C2	CD	24x24	12	285			150				180	SUPPLY
Jan Cl 12	JC1	ER	8x4	8x4	60			24				30	EXHAUST
Corridor 07	CR1	CD	24x24	10	150			79				225	SUPPLY
No. 07	CR2	CD	24x24	10	150			79				260	SUPPLY
Womens TLT	W1	CD	24x24	10	440			231				340	SUPPLY
No. 17	W2	ER	24x24	18	440			173				140	EXHAUST
Womens	W3	CD	24x24	10	440			231				290	SUPPLY
Lounge No.16	W4	ER	24x24	18	440			173				150	EXHAUST
Mens Tlt.	M1	CD	24x24	12	293			153				300	SUPPLY
No. 20	M2	CD	24x24	12	293			153				300	SUPPLY
No. 20	M3	ER	18x12	8	270			106				150	EXHAUST
No. 20	M4	ER	18x12	8	360			142				150	EXHAUST
Board Room	BR1	CD	9x9	10	155			81				130	SUPPLY
No. 14	BR2	CD	9x9	10	155			81				130	SUPPLY
No. 14	BR3	CD	9x9	10	155			81				130	SUPPLY
No. 14	BR4	CD	9x9	10	155			81				130	SUPPLY

REMARKS:

DATE Sept. 24, 1988 READINGS BY James Glenn



AIR OUTLET IDENTIFICATION PLAN
ROOM NOS.01,07,09,10,12,14,16,17,20

TAB PLACEMENT HERE

DESCRIPTION:

Appendix

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Appendix

I. TAB AGENDA

TABLE OF CONTENTS

I.1 Design Review

A. General:

A review has been made of the contract plans and specifications in an attempt to determine if all components such as balancing valves, thermometers pressure gauges, etc. have been provided in the contract documents to adequately test and balance the HVAC system(s).

B. Description of Facility:

1. This facility is an Officers Club used for recreational purposes and is complete with Club Room - Bars, Dining Areas, large kitchen, Pool-Snack Bar, Barber Shop, Office Areas and Conference Rooms. It is used for social gatherings, banquets, food and drink service, and is normally open six days a week, Tuesday through Sunday.

2. Building - This facility is a one story building with a small second floor office which is really unaffected by the TAB work. The building is basically a wood frame brick veneer structure having an underfloor crawl space and a relatively large attic space. Both the attic and crawl space are cross ventilated by natural draft ventilation and the ceilings are insulated with various types of blown in and blanket type insulations.

3. HVAC Systems - The basic system is a four pipe chilled and hot water system which is served by two centrifugal water chillers and two high pressure steam boilers along with hot water converters. The original space heating was provided by steam radiators and a couple of those still exist in this building. No new work has been performed on the chilled water system except the extension of some piping to the new AHU cooling coils. The heating piping system however was modified quite extensively because of asbestos insulation that had been used on the hot water and steam lines. A new deaerator and condensate feed water system was provided for the existing steam boilers and new steam to hot water converters and pumps were provided for generating building hot water. Two new air handling units were provided for the Snack Bar and Food Storage Areas and a new make-up air handler was provided for the existing range hood in the Snack Bar. Six new chilled - hot water

fan coil units were provided for various offices the Break Room and the Barber Shop. Six new roof exhaust fans were provided for added ventilation and the balance of the HVAC system utilizes existing AHU, fans, etc. that have been unchanged under this contract. All air distribution is from over head and most of the chilled, steam and hot water piping is below the floor in the crawl space. All controls involved in this part of the contract are pneumatic and will be reused except where specifically called for otherwise.

C. Changed Conditions:

The building was originally constructed in the forties but has been expanded and added onto on several different occasions. Consequently the HVAC systems were modified with each of these additions. During the seventies there was a major change to the HVAC system and a central chilled water system was installed and possibly the boiler plant modified. New air handling equipment was provided in most areas and the duct system was also changed. Unfortunately however all those changes were not reflected in the plans and specifications in this contract and as a result a considerable amount of actual installed conditions exist that are not shown in the contract documents. In a co-operative spirit the owner and the contractor worked together in making the necessary modifications to install the system (primarily duct work changes). In some cases air outlets were eliminated or changed while in other areas outlets were added. In any event the changes were never intended to reduce or add to the total air being delivered to a given space. The criteria emphasized by the ROIC is that the finished product produce the heating and cooling effects as designed. However, it was agreed that if necessary the air flow could very from the plan CFM as much as 15 - 20 percent if absolutely necessary, but that the TAB contractor would strive to match the CFM to $\pm$ 10 percent.

D. Assumptions:

1. It has been assumed that the existing air handling equipment which is being reused is adequate to produce the CFM as shown on the drawings.

2. It has been assumed that the filters on the reused equipment will be replaced by the owner before TAB is started.

3. It is assumed that all existing AHU coil are balanced and no work will be required on those units.
4. It is assumed that the existing pumps have the capacity and pressures required to deliver the specified flow rates to the equipment.

5. *It is assumed that all existing fan systems which were not changed under this contract will be functioning but the time the TAB operations begin.

6. *It is assumed that all existing control systems which were not changed under this contract will be functioning but the time the TAB operations begin.

7. It is assumed that the contractor shall have full access during normal working hours to all areas involved for the TAB operations.

   *The owner's maintenance personnel will have to perform some work before these systems are fully functionable.

E. Adequacy of Design:

1. General - The plans and specifications (along with on - site observations) have been reviewed for the purpose of determining the procedures and techniques required for proper TAB of the various air and water systems.** (No consideration have been given to testing steam rates, condensate flow rates, quality of steam, etc., as that is beyond this contract requirements.

   No evaluations of heating and cooling loads, air and water flows requirements, comfort conditions, etc., have been made as it is assumed these were taken into consideration by the design engineer. From our examinations we have found several pieces of equipment that have not been provided with sufficient devices to enable an accurate TAB. While close TAB can be performed, which is common in the commercial industry, the requirements to meet NEBB or AABC standards will require that additional devices be added as follows:

   a) Balancing Value and Flow Sensors on steam/hot water converter

b) Balancing Value and Flow Sensors on the Fan/Coil Units

c) Flow Orfices in the Steam supply to the hot water converter

d) Pressure Gage connections on Pumps and steam/hot water converter

e) Thermometer wells on steam/hot water converter

2. Work Strategy and Schedule:

All TAB shall be done in full accordance with the NEBB methods and procedures as hereinafter described.

It has been assumed by the TAB contractor that the existing equipment and the chilled and heating water systems were and are operating satisfactorily and performing as intended. No adjustments to any of this equipment (nor cost for same) has been included in this TAB Contractors price. Any adjustments that may be required on the existing equipment shall be performed by others or as an add to the TAB Contract.

The TAB work shall be performed on each of the air distribution systems (meaning all areas supplied by individual air handling system) as a separate TAB operation. This method will provide the least amount of disturbance to the activities of the facility while performing the TAB. However, because each air handling units serves several different rooms it will not be possible to completely balance one room at a time. The TAB work may require re-balancing each room two or three times until the entire system is balanced. The areas constituting systems are as follows:

Equipment	Area Served	TAB Time
New AHU-1: *Air Apparatus Test *Apparatus Coil Test *Air Outlet Test	Dry Storage 67	1 Day
New AHU-2: *Air Apparatus Test *Apparatus Coil Test *Air Outlet Test	Womens Dressing Room 81 Womens Toilet 82 Mens Toilet 80 Mens Dressing Room 83 Snack Bar 84	1 Day
Existing AHU-1: *Air Outlet Test	International Bar 19	2 Days
Existing AHU-2: *Air Outlet Test	Den Bar 30	1 Day
Existing AHU-3: *Air Outlet Test	Carolina Room 42 Dining Room 43 Cafeteria 44 Service Corridor 41	1 Day
Existing AHU-4: *Air Outlet Test	Lejeune Room Lobby 35 Lejeune Room 36 Lejeune Room Bar 37	2 Days

Equipment	Area Served	TAB Time
Existing AHU-5: *Air Outlet Test	OCW Room 18 Regimental Room 24	1 Day
Existing AHU-6: *Air Outlet Test	Federal Lobby 01 Corridor 07 Cashier Waiting 08 Cashier 09 Cashier 10 Passage 11 Mens Toilet 13 Women's Lounge 16 Women's Toilet 19 Board Room 14	2 Days
Existing AHU-7: *Air Outlet Test	Office 28 Office 29 Corridor 26	1 Day
Existing AHU-8: *Air Outlet Test	Tower Room 201	N/A
New FC #1: *Terminal Unit Coil Test	Office 57	1/2 Day
New FC #2: *Terminal Unit Coil Test	Office 60	1/2 Day
New FC #3: *Terminal Unit Coil Test	Breakroom 48	1/2 Day
New FC #3: *Terminal Unit Coil Test	Prep Room 47	1/2 Day
New FC #4: *Terminal Unit Coil Test	Office 103	1/2 Day
New FC #5: *Terminal Unit Coil Test	Barber Shop 27	1/2 Day
New F-1: *Fan Test	Men's Toilet 83	1/4 Day
New F-2: *Fan Test	Ice Room 49	1/4 Day
New F-3: *Terminal Unit Coil Test	Women's Toilet 54	1/4 Day
New F-4: *Fan Test	Boiler Room 51	1/4 Day

Equipment	Area Served	TAB Time
New F-5: *Fan Test	Boiler Room 51	1/4 Day
New F-6: *Fan Test	Men's Toilet 13	1/4 Day
H. W. Converter: *Heat Exchanger/Converter Test	Mechanical Room 87	1/4 Day
Htg. Water Pump *Pump Test	Mechanical Room 87	1/2 Day

*See Test Report Forms Section III for Extent of Test.

Rev. 81588

The total estimated time for the TAB work is less than three weeks (17 working days) and hopefully that can be reduced to about a week and a half. In any event there are no restrictions on the TAB work as to which systems are tested first. To accommodate the owners needs, we suggest that they select the order in which the TAB is to progress so as not to interfere with the club operations. They should keep in mind that all TAB work has been estimated on normal eight hour work days. All TAB can start as early as August 15, 1988 and hopefully no later than August 17, 1988.

The instruments that will be used for the TAB work is listed in section III.

A BASIC AIR SYSTEM PROCEDURES

"Preliminary TAB Procedures" covered the preparation work that must be done prior to the actual testing, adjusting and balancing of the HVAC systems on the job. Confirm that these preliminary procedures have been completed and check lists prepared. *Do not attempt to balance a system before installation has been completed and the system is ready to be balanced.*

The following balancing procedures are basic to all types of air systems.

1) Confirm that every item affecting the airflow of a duct system is ready for the TAB work, such as doors and windows being closed, ceiling tiles (return plenums) in place, etc.
2) Confirm that all automatic control devices will not affect TAB operations.
3) Establish the conditions for the maximum demand system airflow which generally is a cooling application with "wetted" coils.
4) After verifying that all dampers are open or set, start all related systems (return, exhaust, etc.) and the system being balanced with each fan running at the design speed (rpm). Upon starting each fan, *immediately* check the fan motor amperage. If the amperage exceeds the nameplate full load amperage, stop the fan to determine the cause or to make the necessary adjustments.
5) Again confirm that all related system fans serving each area within the space being balanced are operating. If they are not, pressure differences, and infiltration or exfiltration may adversely influence the balancing. Preliminary studies will have revealed whether or not the supply air quantity exceeds the exhaust air quantity from each area. Positive and negative pressure zones should be identified at the time.
6) If a supply fan is connected to a return air system and an outside air intake, set all system dampers and controls so that the air returned from the individual rooms or areas supplied by the fan is returned via the related return air system. Normally this will involve opening an outside air damper to the minimum position, opening the return air damper, and closing exhaust air and relief air dampers. (If the supply system is associated with a return air system and/or an independent exhaust system, make sure all systems are operating and all related dampers are set properly for the TAB work.)
7) Determine the volume of air being moved by the supply fan at design rpm by one or more of the following methods. The preferred methods are:
   a) Pitot tube traverse of main duct or ducts leaving fan discharge.
   b) Fan curves or fan performance charts. In order to determine fan performance using a fan curve or performance rating chart, it is necessary to take amperage and voltage readings. In addition, a static pressure reading across the fan must be recorded. With rpm, brake horsepower and static pressure, the fan manufacturer's data sheets may be used to determine the airflow (cfm) predicted by the manufacturer. Fan performance can deviate from the fan curves if "system effect" or other system installation defects are present.
   c) Anemometer readings across coils, filters, and/or dampers on the intake side of the fan. This is used as an approximation only.
8) If the supply fan volume is not within plus or minus 10% of the design capacity at design rpm, determine the reason by reviewing all system conditions, procedures and recorded data. Check and record the air pressure drop across filters, coils, eliminators, sound traps, etc., to see if excessive loss is occurring. Particularly study duct and casing conditions at the fan inlet and outlet.

factor prescribed by the manufacturer for use in conjunction with a particular instrument. In addition it is often necessary that the readings at grilles, registers and diffusers be taken in a position or number of positions prescribed by the manufacturer of the air terminal device.

9) Repeat the branch balancing until the system is in balance.

10) Verify the fan capacity and operating conditions again and make a final adjustment in the fan drive if necessary.

11) Verify the action of all fan shut down controls and airflow safety controls.

12) Prepare all TAB report forms and submit as required, using the NEBB TAB Report Forms

D SYSTEMS WITH ECONOMIZERS

Follow the procedures outlined for exhaust and return air systems, except that after balancing the return air system and the associated supply air system the return air damper should be closed; the interlocked relief air damper should be opened and the return air fan, static pressure and cfm should be checked again. If it is necessary to increase the system static pressure and thereby reduce the fan cfm, adjust the exhaust air damper to a maximum position less than 100% open. Recheck the supply fan airflow with the outside air damper in the full open position.

E OPTIONAL PROCEDURE— RATIO METHOD

This is one of the other methods that has been developed for the final balancing process.

1) Do all of the TAB work under Sub-Section A of this section entitled "Basic Air System Procedures."

2) Then begin balancing the supply system at the last outlet of the branch farthest from the fan (branch number 1). This is outlet number 1, number 2 is the next to the last outlet. Measure the airflow at outlet number 1 (Q_m) and compare with the design airflow for that outlet (Q_d), record the ratio (Q_m/Q_d).

3) Measure the airflow at outlet number 2 and determine the ratio (Q_m/Q_d). Compare $(Q_m/Q_d)_2$ and $(Q_m/Q_d)_1$. If these rations are not within 10% of each other, adjust outlet number 2 to bring ratios into closer agreement. DO NOT ADJUST OUTLET NUMBER 1.

   Measure and again determine $(Q_m/Q_d)_2$ and $(Q_m/Q_d)_1$ and compare. If these are within 10% of each other, no further adjustment is necessary. Proceed to outlet number 3.

4) Determine $(Q_m/Q_d)_3$ and compare with $(Q_m/Q_d)_2$. If necessary, adjust number 3 so that $(Q_m/Q_d)_3$ and $(Q_m/Q_d)_2$ do not vary by more than 10%. DO NOT ADJUST OUTLETS 1 OR 2. (Adjustment of outlet 3 automatically changes the (Q_m/Q_d) ratios of outlets 2 and 1. The ratios for all these outlets approach the same values. For this reason, once the outlet has been adjusted, it does not require further adjustment).

5) Proceed to outlet number 4 and adjust to obtain agreement between $(Q_m/Q_d)_4$ and $(Q_m/Q_d)_3$.

6) After all outlets on branch number 1 are proportionately balanced to each other, proceed to branch number 2, etc.

   Upon completion of proportionate balancing of all outlets, the branches should be proportionately balanced.

7) Select typical outlets in branches 1 and 2 ... adjust number 2 branch damper to obtain agreement of the (Q_m/Q_d) ratios for the two branches. Proceed in like manner to obtain agreement between branches 2 and 3, 3 and 4, etc.

8) Upon completion of proportionate balancing, recheck the fan capacity. Adjust the fan speed to obtain a (Q_m/Q_d) ratio of 1.0 at the fan. Since the system has been proportionately adjusted, the (Q_m/Q_d) ratio throughout the system will be approximately 1.0 and the flow from each outlet will be the design airflow rate.

9) Then continue the TAB work by following all of the steps listed under Sub-Section B—"Supply Air Systems Procedures" found earlier in this section.

10) Verify the action of all fan control dampers, shut down controls, and airflow safety controls.

11) Prepare the required report forms and submit as required. (See Section VIII report forms).

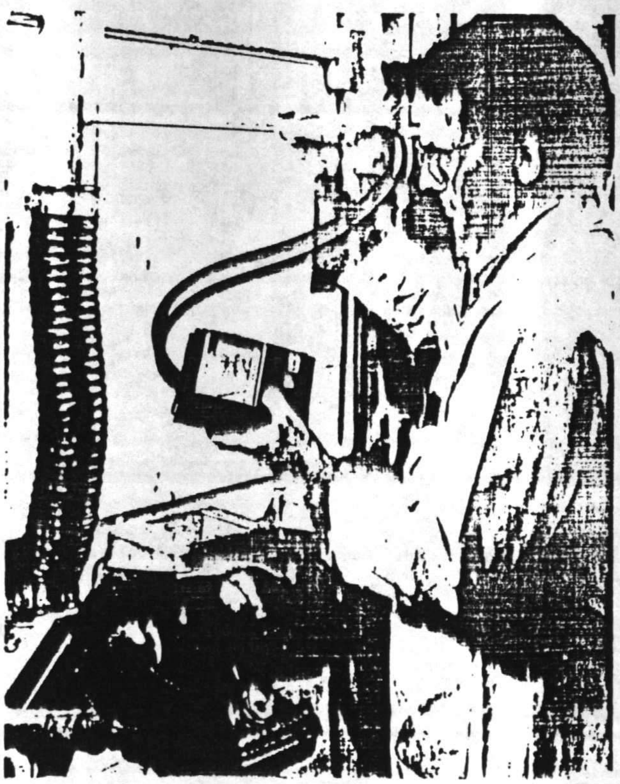
C EXHAUST AND RETURN AIR SYSTEMS

1) Follow paragraphs 1 through 6 for exhaust air fans and 1 through 7 for return air fans under Sub-Section A—"Basic Air System Procedures" in this section for return and exhaust systems.

2) Determine the volume of air being moved by the exhaust fan at design rpm by one or more of the following methods. The preferred methods are:

   a) Pitot tube transverse of the main duct or the ducts leaving the fan discharge.

   b) Fan curves or fan performance charts. In order to determine the fan performance using a fan curve or performance rating chart, it is necessary to take amperage and voltage readings and calculate the brake horsepower. In addition, a static pressure reading across the fan must be recorded.



IGURE 5-4 Obtaining an Exhaust Duct Velocity

With rpm, brake horsepower and static pressure readings, the fan manufacturers' data sheets may be used to determine the airflow (cfm) predicted by the manufacturer unless "system effect" reduces the fan performance.

3) The exhaust fan volume should be within plus or minus 10% of the design capacity if earlier procedures were followed. Check and record the air pressure drop across filters, coils, sound traps, etc., to see if any excessive loss is occurring. Particularly study duct and casing conditions at the fan inlet and outlet for possible "system effect."
Record the exhaust fan suction static pressure, fan discharge static pressure, amperage and cfm measurements. Confirm that the fan motor is not overloaded.

4) If the exhaust system is being balanced prior to the supply and/or return air systems, and if the measured cfm of any fan varies more than 10% from design, adjust the drive of each fan to obtain the approximate required cfm. Make a preliminary survey, spot checking air circulation in various areas. Then follow all procedures as outlined, after the exhaust system is balanced.

5) Make Pitot tube traverse on all main exhaust ducts to determine the air distribution. Investigate any branch that is very low in capacity to make sure that no blockage exists.

6) Adjust the volume dampers in the main ducts to the approximate airflow (cfm) requirement.

7) Without adjusting any terminal device, measure and record the airflow at each terminal in the system. Study any radical conditions and correct them. Plan the sequence of branch balancing. In making the adjustments, it is preferable to adjust the branch dampers rather than the dampers at the air terminals. If the throttling process at a terminal damper involves closing the damper to a degree that generates noise, evaluate the design cfm capacity of the branch duct.

8) Working from the branch with the highest measured capacity to the branch with the lowest measured capacity, make adjustments in each branch. Beginning with the inlet device most distant from the branch and proceeding toward the branch connection, make volume adjustments at each terminal as necessary. It is important that the balancer use the proper "k"

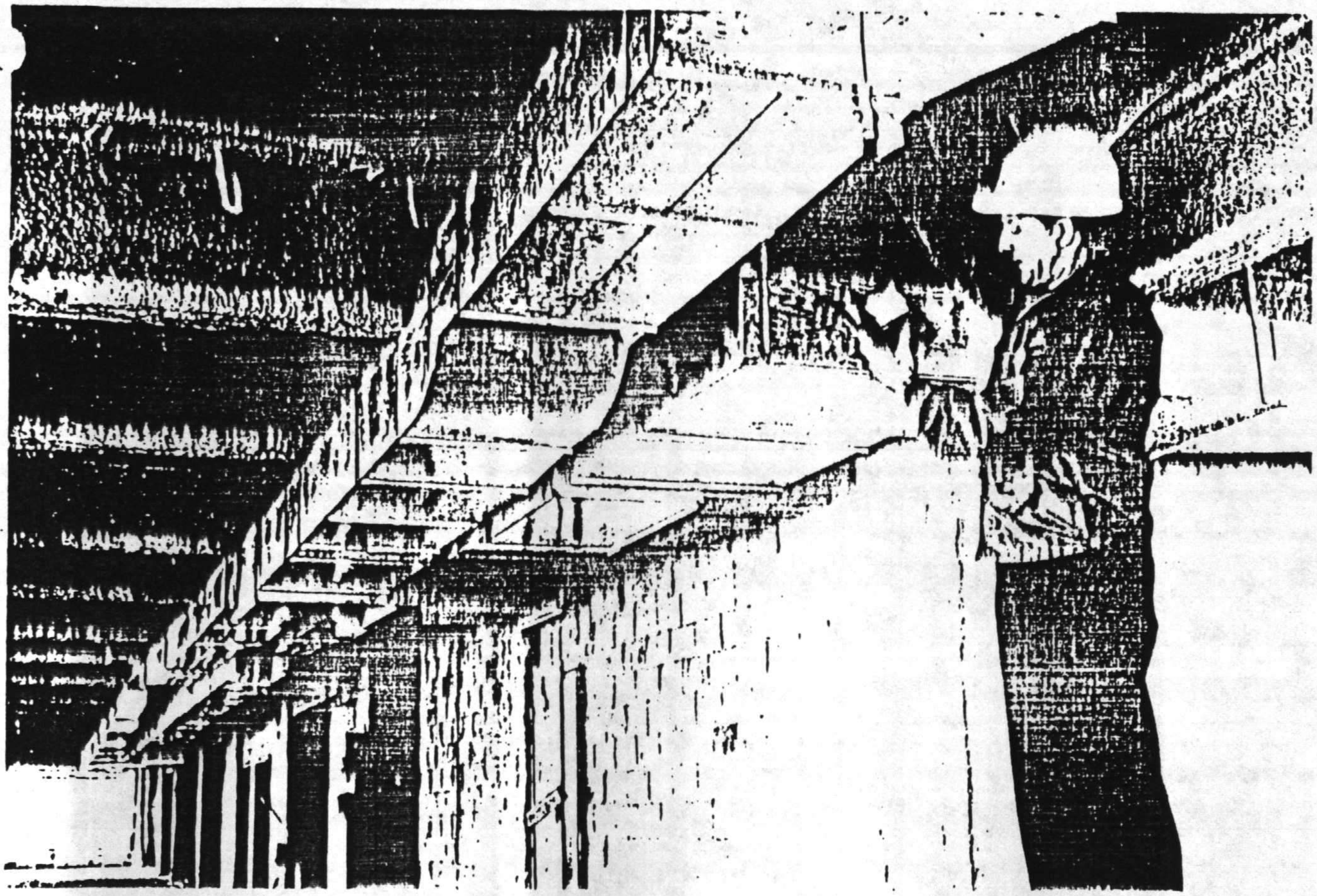


FIGURE 5-1 Making a Pitot Tube Traverse

9) Using the methods outlined in paragraph 8, determine the volume of air being handled by a return air fan if used; and/or if a central exhaust fan system is used, also determine the cfm being handled by the exhaust fan. If several exhaust fans, such as power roof ventilators, are related to a particular supply system, it is generally not necessary to measure the cfm of each such exhaust fan until after the supply system is balanced.

10) If the measured cfm of the supply fan, central return fan or central exhaust fan varies more than 10% from design, adjust the drive of each fan to obtain approximate required cfm. Record fan suction static pressure, fan discharge static pressure, amperage and cfm measurements. Confirm that the fan motor is not overloaded.

11) Make a preliminary survey, spot checking air circulation in various rooms. With knowledge of the supply and return or exhaust fan volumes and data from the survey, determine if the re-

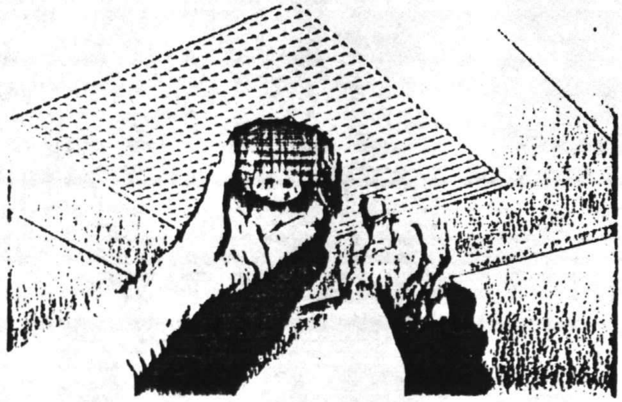


FIGURE 5-2 Return Air Measurement with a Rotating Vane Anemometer and Stop Watch

turn or exhaust air system should be balanced before the supply system is balanced. In continuation of this procedural outline, the assumption is made that the supply system balance is not restrained by the exhaust system or the return system. However, if such a restraint exists, the exhaust system or the return system should be balanced prior to continuing with the supply system.

12) The system is considered balanced in accordance with these procedural standards when the value of the air quantity of each inlet or outlet device is measured and found to be within 10% of the design air quantities (unless there are reasons beyond the control of the TAB firm—

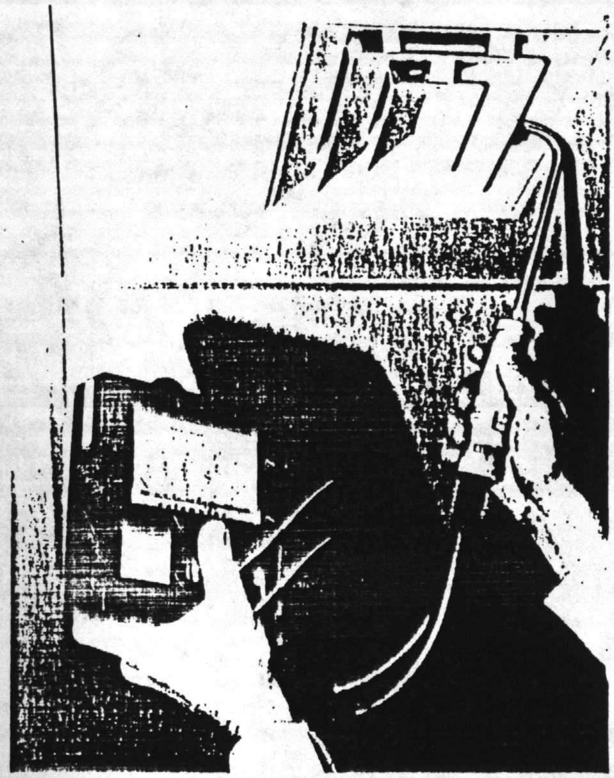


FIGURE 5-3 A Typical Air Diffuser Velocity Measurement

B SUPPLY AIR SYSTEM PROCEDURES

1) Make Pitot tube traverses on all main supply and major branch ducts to determine the air distribution. Investigate any branch that is very low in capacity to make sure that no blockage exists.
2) Adjust the volume dampers in the main and branch ducts to the approximate airflow (cfm) requirement.
3) Without adjusting any terminal device, measure and record the airflow at each terminal in the system. Study any radical conditions and correct them. Plan the sequence of branch balancing. In making adjustments, it is preferable to adjust volume dampers instead of extractors (if installed) or the dampers at the air terminals. If the throttling process at the terminal involves closing the damper to a degree that generates noise, evaluate the design cfm capacity of branch duct.
4) Working from the branch with the highest measured capacity to the branch with the lowest measured capacity, make adjustments in each branch. Beginning with the outlet most distant from the branch connection and proceeding toward the branch connection, make volume adjustments at each terminal as necessary. It is important that the balancer uses the proper "k" factor prescribed by the air terminal manufacturer for use in conjunction with a particular instrument. In addition, it is necessary that the readings at grilles, registers and diffusers be taken in a position or number of positions prescribed by the manufacturer of the air terminal device.
5) Repeat the branch balancing until the system is in balance.
6) Verify the fan capacity and operating conditions again and make a final adjustment in the fan drive if necessary.
7) If the supply system was tested with dry coil surfaces and is designed for dehumidification, the air quantity should be checked under wet coil conditions. (Often, 10% to 15% is added to the system setting instead.)
8) After the supply and return exhaust systems are balanced, the supply fan capacity should be checked with 100% outside air operation if this alternative is included in system design. Appropriate damper adjustments should be made if necessary.
9) Record the "as balanced" state of the system on report forms for all terminals and duct apparatus.

achieve balanced circuits as outlined above. Vent air from low flow circuits. Then proceed with the balancing of terminal units on each branch.

l) Before adjusting any balancing cocks at equipment (i.e. chillers, boilers, hot water exchangers, hot water coils, chilled water coils, etc.) take a complete set of pressure drop readings through all equipment and compare this with submittal data readings. Determine which are high and which are low in water flow. Vent air from low flow circuits or units and retake readings.

m) Make a preliminary adjustment to the balancing cocks on all units with high water flow, setting each about 10% higher than the design flow rate.

n) Take another complete set of pressure, voltage and ampere readings on all pumps in the system. If system total flow has fallen below design flow, open the balancing cock at each pump discharge to bring the flow at each pump within 105—110% of the design reading (if pump capacity permits).

o) Make another adjustment to the balancing cocks on all units which have readings more than 10% above design flow in order to increase the flow through those units with less than design flow.

p) Repeat this process until the actual fluid flow through each piece of equipment is within plus or minus 10% of the design flow.

q) Make a final check of the pressures and the flow of all pump and equipment; of the voltage and amperage of pump motors; and record the data.

r) Where three-way automatic valves are used, set all bypass line balancing cocks to restrict the bypassed water to 90% of the maximum demand through coils, heat exchangers and other terminal units.

s) After all TAB work has been completed and the systems are operating within plus or minus 10% of design flow, mark or score all balancing cocks, gauges, and thermometers at final set points and/or range of operation.

t) Verify the action of all water flow safety shutdown controls.

u) Prepare all TAB report forms and submit as required using the NEBB TAB Report Forms found in Section VIII.

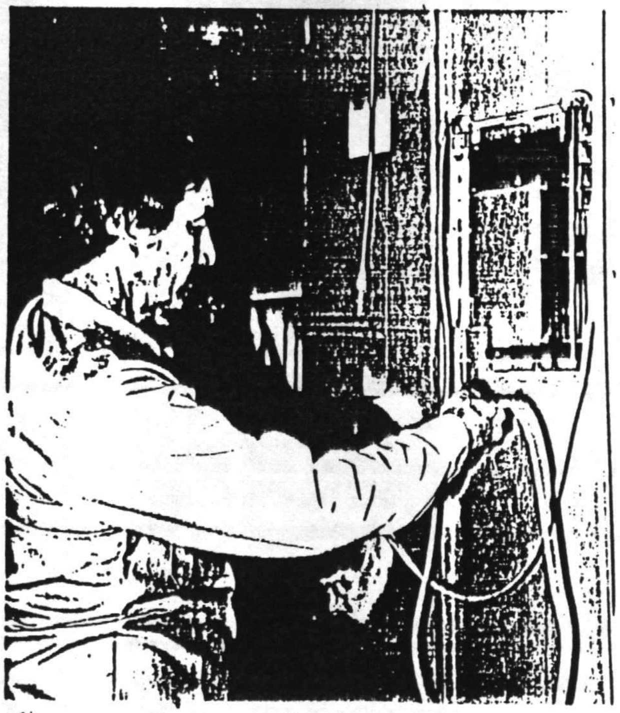


FIGURE 7-1 Balancing a Hydronic Coil

B SPECIFIC SYSTEM PROCEDURES

The basic steps previously outlined in Section A form the foundation for balancing any hydronic distribution system. In this section, additional or special balancing procedures are outlined for use in balancing specific types of hydronic distribution systems. **All equipment such as boilers, chillers, compressors, etc., shall be started by, and operated under, the supervision of the responsible contractor or the designated authority.**

1. Chilled and/or Hot Water Systems

a) Water flow through chillers, coils and heat exchangers should be determined by using man-

A BASIC HYDRONIC SYSTEM PROCEDURES

"Preliminary TAB Procedures" outlined the preparation work that must be done prior to the actual on the job testing, adjusting, and balancing of HVAC systems. Confirm that these preliminary procedures have been completed and that check lists have been prepared. The following balancing procedures are basic to all types of hydronic distribution systems:

a) Check to see that all necessary electrical wiring, temperature control systems, all related hydronic piping circuits and all related duct systems are functional and that any necessary compensation for seasonal effects have been made.

b) Determine that all hydronic systems have been cleaned, flushed, refilled and vented as required.

c) Determine that all manual valves are open, or preset as required and all temperature control (automatic) valves are in the normal position.

d) Determine that all automatically controlled devices in the piping or duct systems will not adversely affect the balancing procedures.

e) With the pump(s) off, observe and record system static pressure at the pump(s).

f) Place the systems into operation, check that all air has been vented from the piping systems and allow flow conditions to stabilize.

g) Record the operating voltage and amperage; and compare these with nameplate ratings and thermal overload heater ratings.

h) Record the speed of each pump.

i) With the pump(s) running, slowly close the balancing cock in pump discharge piping and record discharge and suction pressures at the pump gauge connections. Using shut-off head, determine and verify each actual pump operating curve and the size of each impeller. Compare this data with the submittal data curves. If the test point falls on the design curve, proceed to the next step; if not, plot a new curve parallel with other curves on the chart, from zero flow to maximum flow. Make sure the test readings were taken correctly before plotting a new curve. Preferably one gauge should be used to read differential pressure. It is important that gauge readings should be corrected to center line elevation of the pump.

j) Open the discharge balancing cock slowly to a fully open position; record the discharge pressure, suction pressure and total head. Using the total head, read the system water flow from the corrected pump curve established in paragraph i.

If the total head is higher than the design total head, the water flow will be lower than designed. If the total head is less than design, water flow will be greater; in which case the pump discharge pressure should be increased by partially closing the balancing cock until the system water flow is approximately 110% of design. Record the pressures and the water flow. Check pump motor voltage and amperage and record. This data should still be within the motor nameplate ratings. Start any secondary system pumps and readjust the balancing cock in the primary circuit pump discharge piping if necessary. Again record all readings.

k) If orifice plates, venturi meters or other flow measuring or control devices have been provided in the water piping system, an initial recording of the flow distribution throughout the system should be made without making any adjustments. After studying the system, adjust the distribution branches or risers to

Heat Exchangers/Converters

a) Determine the water flow pressure drop through the heat exchanger for all circuits. With the measured differential pressure, the water flow can be obtained from the manufacturer's submittal data curves or tables. Adjust the water flow to design conditions and record flow data.

b) After all fan-coil type units have been put into operation with automatic valves fully open with flow through the coil and after the specified air flow over the coil has been established, take the entering and leaving water temperatures of all chillers, boilers, heat exchangers and coils. Record and compare with design conditions.

c) Hydronic systems installed with reverse return piping are less difficult to balance than the direct return systems. When fan-coil units or induction units are used with a direct return piping system, a flow check through each unit should be made, either from pressure readings across each coil, from pressure readings across each automatic water valve, or (as a last resort) from water or air temperature readings to determine the water flow rate.

When a reverse return riser piping system is installed, a distribution flow check can be made at each set of risers to make sure that all units are getting a sufficient flow of water to provide a fairly uniform water temperature drop. All automatic water valves must be open and coils must have the rated air flow when water temperatures are being checked.

d) When systems have multiple coil sections, where possible, balance the water flow by establishing the design water pressure drop across each coil. An alternate method of balancing multiple sections involves reading the water temperatures at each coil section with insertion thermometers or contact pyrometer probes, and adjusting the balancing cocks until uniform temperatures are obtained.

e) Complete the procedures by recording the data, preparing the TAB report forms for submittal as required.

b) Take inlet and outlet water temperature readings; check against design data and record.

c) Check and record the steam pressure; check the setting and/or operation of automatic temperature control valves, self-contained control valves, or pressure reducing valves where used. Record data.

d) Record safety valve settings.

e) Confirm that all pipe strainers are clean.

f) Check the operation of steam traps.

g) Check all automatic air vents; manually vent air as required.

h) Follow the basic procedures for hot water or steam system TAB work for items not mentioned above.

i) Prepare all report forms and submit as required.

3. Simulated Loads:

All simulated loads shall be accomplished through the control system by introducing a false signal to the control device. The controls on this job are existing pneumatic, and the various control valves can be positioned either fully open or closed by varying the control air pressure to the device with a pneumatic "squeeze bulb". The performance of the equipment can then be measured to establish its full heating and cooling capabilities.

4. Seasonal Restrictions:

The TAB work will be performed during August which will fully demonstrate the equipment performance during the cooling season. At some time during the month of February, the TAB Contractor shall re-visit the facility and check the operation of the new HVAC equipment (AHU-1, AHU-2, FC-1 thru FC-5, steam-HW converter). All necessary adjustments and TAB should be accomplished within a three day period. It should be noted that the TAB contractor is not responsible for the TAB of the existing equipment but will so notify the owner of any problems found so discovered.

5. Support Required:

During the TAB operations the TAB Contractor will need assistance from the government personnel the chiller and boiler plants and some one to make necessary adjustments to the existing AHU that may be required.

II. PREREQUISITE WORK CHECK LIST

TABLE OF CONTENTS

1. General: The Prime Contractor shall be responsible for the completion of all HVAC equipment start-up and debugging prior to the TAB engineer arriving at the project site to begin the TAB work. Prior to TAB engineer's arrival, the Prime Contractor shall, at a minimum ensure completion of the applicable inspections and work items listed in the "Preliminary TAB Procedures" under paragraphs "Air Distribution System Inspection" and "Hydronic Distribution System Inspection".

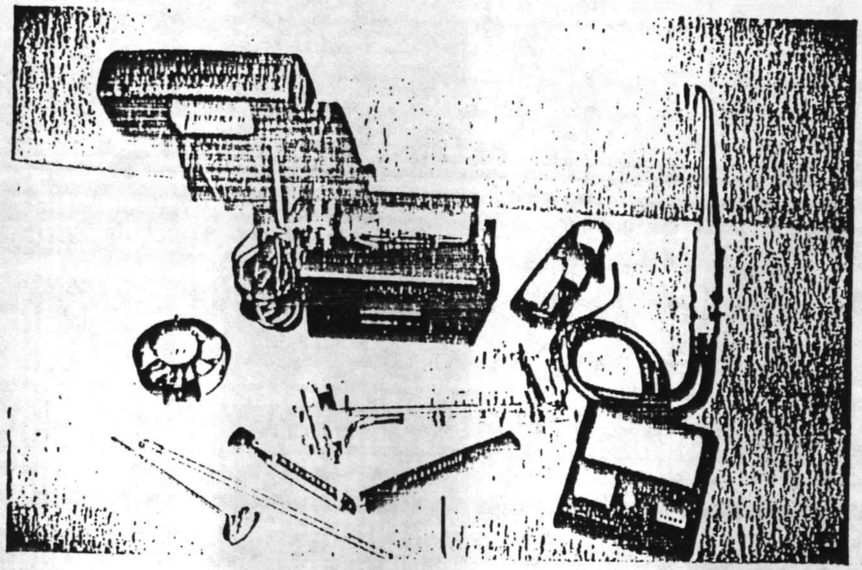


FIGURE 3-2 Instruments Selected for a TAB Job (Sample)

2. Inspection Procedures:

A AIR DISTRIBUTION SYSTEM INSPECTION

Before starting the TAB field procedures, the G.C. team must make the necessary inspections to confirm that the HVAC systems and equipment have been completely installed, that the proper electrical connections have been made to the equipment, that automatic controls are complete and operating, and that the building is completely closed in with windows, doors, etc. The following is a list of items to confirm that all of the systems have been installed in accordance with the contract documents and are ready to be tested, adjusted, and balanced. Check list(enclosed)can be used as a guide by the TAB team.

1. Fans

a) Confirm that all HVAC equipment containing fans has been checked and verify that:

1) the equipment matches the test report data such as model number, make, arrangement, class, etc.
2) the test report forms have had data entered that must be obtained from the field.
3) all bearings have been lubricated.
4) fan wheels clear the housings: improper clearance can greatly affect fan performance, especially backward inclined fans.
5) all foreign objects have been removed (such as shipping restraints, and protective covers).
6) motors have been fastened securely.
7) all drives have been correctly aligned.
8) all drive set screws and keyways are tight.
9) belt tensions are correct.

10) fan rotations are in the correct direction.

11) duct flexible connections are properly aligned.

12) vibration isolators or bases have the correct springs and in the right location, and that the springs are not collapsed. Be sure that the equipment is level and the isolators are not totally compressed. Check for the proper seismic restraints if they are required.

13) the static pressure controls are free and operable.

14) equipment drains are piped and trapped properly (no moisture present).

15) all equipment is clean and free of paper, rags, and other foreign objects.

16) belt guards are in place.

b) Locate all start-stop, disconnect switches, electrical interlocks and motor starters. Motor starters must be equipped with thermal overload protection of the proper size.

c) Check availability of electrical power to all equipment needed for TAB work and verify the compatibility of voltage and phase.

d) Inspect the fan inlet and discharge of fan plenums for obstructions such as pipes or conduits, and for closed or unconnected dampers such as return air, fire or smoke dampers. *CLOSED DAMPERS CAN CAUSE PLENUM AND DUCTWORK FAILURE OR COLLAPSE.*

e) Confirm air filter size, type, number and condition of filters to be used for the TAB work. Are filters temporary or to be used as permanent filters after start-up? Are the filter frames sealed to the plenum or duct to prevent leakage? (Important if high efficiency filters are used.)

2. Air Conditioning Units

a) Generally follow the fan check list.

b) Check the airflow pattern from the outside air intake louver and return air/exhaust air damper to the fan discharge.

c) Inspect the ducts and plenums for obstructions and foreign objects.

d) Confirm filter sizes, types, number and installation.

e) Check cooling and heating coils for proper installation, and heat exchange position (counter flow, parallel flow, etc.)

f) Check and set all automatic control dampers as required.

g) Confirm that duct system connections have been made to the proper units and follow the correct flow patterns.

3. Duct System Checks

a) Check that all outside air intake, return air and exhaust air dampers are in the proper position and operable for the TAB work.

b) Confirm that all system volume dampers and fire dampers have been installed, are in the full open position, and are accessible.

c) Inspect access doors and hardware for tightness and leakage and verify that all necessary access doors have been installed.

d) Verify that all air terminals and terminal units have been installed and that terminal dampers are fully open.

e) Inspect coils, duct heaters and terminals for leakage at duct connections and piping penetrations.

f) Confirm locations for Pitot tube traverse measurements and accessibility for TAB measurements in general.

g) Confirm that openings have been provided in walls and plenums for proper air passage.

h) Confirm that all architectural features such as doors, ceilings, and windows are installed and are functional with regard to airflow of the duct systems being balanced.

i) Inspect duct systems for proper construction, that all turning vanes have been installed, and that all joints have been sealed where specified.

B HYDRONIC DISTRIBUTION SYSTEM INSPECTION

Before starting the TAB field procedures, the TAB team must make the necessary inspections to confirm that the HVAC systems have been completely installed, that there is the proper power to the equipment, that automatic controls are complete and

operating and that the building is completely closed in with windows, doors, etc. The following is a list of items to confirm that all of the systems have been installed in accordance with the contract documents and are ready to be tested, adjusted and balanced. Check list (Figure 3-3) can be used as a guide by the TAB team.

1. Pumps

a) Confirm that all pumps have been checked and verify that:
   1) the equipment matches the test report data such as model number, make, type, rpm, etc.
   2) the test report forms have had data entered that must be obtained from the field.
   3) all bearings have been lubricated.
   4) rotation is free and correct.
   5) motors have been aligned and fastened securely.
   6) pump bases have been correctly grouted.
   7) air has been bled from pump casing where required.
   8) all drive set screws and keyways are tight.
   9) vibration isolation and flexible pipe connectors are the correct size and type and in the proper position and alignment.
   10) all equipment is clean and free of foreign objects.
   11) drive guards are in place.
   12) access has been provided for pressure and/or temperature readings.

b) Locate all start-stop, disconnect switches, electrical interlocks and motor starters. Motor starters must be equipped with thermal overload protection of the proper size.

c) Check availability of electrical power to all equipment needed for TAB work and verify the compatibility of voltage and phase.

d) Verify that all strainers are clean.

e) Check system temperature and pressure combinations at pump inlets for possible flashing or cavatation problems.

2 Coils and Heat Exchangers

a) Confirm size and physical data.

b) Verify proper piping methods, connections for flow, pipe sizes, venting devices, etc.

c) Verify airflow direction.

d) Inspect face areas for fin damage, air leakage from tube sheets, fluid leakage from tubes or piping, foreign matter, etc.

e) Confirm provisions for pressure and temperature measurements.

f) Confirm operation type and size of automatic valve, expansions valves, and other control equipment. (Temperature control valves usually are set for full flow during TAB procedures.)

3 Piping Systems

a) Confirm that the system is free of leaks and that it has been hydrostatically tested, filled, flushed, refilled and vented as required.

b) Confirm that all strainers have been cleaned.

c) Inspect pressure reducing valve operation and settings for both system valves and make-up water valves.

d) Confirm settings and locations of all safety and relief valves.

e) Confirm that all manual and automatic valves are in the open position for TAB work.

f) Inspect and verify that the water level in the compression tanks is correct.

g) Confirm accessibility into ceilings and walls for adjustment of balancing valves, and for flow meters and measurement points.

h) Confirm that provisions have been made to obtain temperature, pressure, and flow measurements.