Arizona Nuclear Power Project

DOCUMENT NUMBER
13-MC-HJ-255

TITLE/DESCRIPTION

CONTROL ROOM HEAT LOAD CALCULATION

QUALITY CLASS Q

REV	REVISION DESCRIPTION	ORIGINATOR DATE	CHECKER DATE	RS DATE	QA DATE	NEM/PEM DATE
0	ISSUED FOR USE	V.K. Clarke 9/21/88	RE Maynard 9/28/88	HLRiley 9/25/88	N/A —	N/A —

ENGINEERING SKETCH PAD

BY	DATE	SUBJECT	SHEET NO
V.K. Chawla	9/21/88	CONTROL ROOM HEAT LOAD CALC.	1 of 10
CHECKED BY	DATE		JOB NO.
P.E. Maynard	9/28/88		13-MC-HJ-255

TABLE OF CONTENTS

ENGINEERING SKETCH PAD

BY	DATE	SUBJECT	SHEET NO.
V.K. Chawla	9/21/88	CONTROL ROOM HEAT LOAD CALCULATION	2 of 10
CHECKED BY	DATE		JOB NO.
P.E. Maynard	9/28/88		13-MC-HJ-255

1.0 PURPOSE

THE PURPOSE OF THIS CALCULATION IS TO ESTIMATE THE HEAT LOAD FOR THE CONTROL ROOM. THE HEAT LOAD DATA FOR CONTROL ROOM IS REQUIRED FOR A SEPARATE EVALUATION COMPRISING OF NON-OPERATION OF ESSENTIAL CHILLERS.

ENGINEERING SKETCH PAD

BY:	DATE:	SUBJECT:	SHEET NO.:
V.K.Crowle	9/21/88	CONTROL ROOM HEAT LOAD CALC	3 of 10
CHECKED BY:	DATE:		JOB NO.:
P.E. Hayward	9/28/88		

2 SUMMARY OF RESULTS

(a) FAN HEAT LOAD, ONE FAN = 185700 BTU/HR

(b) CHILLER HEAT EXCHANGE = 866600 BTU/HR

(c) HEAT LOSS FROM CONTROL ROOM = 103800 BTU/HR

(d) HEAT LOAD (OSA-MAKE-UP) = 129750 BTU/HR

(e) CONTROL ROOM HEAT LOAD = 654950 BTU/HR

ENGINEERING SKETCH PAD

BY	DATE	SUBJECT	SHEET NO
V.K. Chawla	9/21/88	Control Room Heat Load Calculation	4 of 10
CHECKED BY	DATE		JOB NO
P.E. Maynard	9/28/88		13-MC-HJ-255

INPUT DATA & BASIS

DATA FROM THE TEST CONDUCTED BY ENGINEERING EVALUATION DEPARTMENT ON 7/21/88:

MAIN SUPPLY HEADER = 27500 SCFM

OUT-SIDE AIR MAKE-UP = 769 SCFM (OSA)

PROCESS TEMP: (SEE FLOW DIAGRAM ON PAGE No. 6)

@ Loc. #	LOCATION	D.B. TEMP	R. HUMIDITY
④	UPSTREAM FAN	77.1 °F	63 %
⑤	DOWNSTREAM FAN	84.1 °F	50 %
②	SUPPLY HEADER	68.6 °F	65 %
⑦	RETURN HEADER	77.0 °F	55 %
⑥	OSA HEADER	90.5 °F	46.9 %

ASSUMPTIONS:

(1) THE LOSS OF AIR FROM CONTROL ROOM IS NOT MEASURED. THE LOSS OCCURS BY WAY OF OPENING DOORS ETC. THE CONTROL ROOM IS MAINTAINED AT SLIGHT POSITIVE PRESSURE, AND IN THE STEADY STATE SCENARIO OF EQUILIBRIUM CONDITIONS UNDER WHICH TEST WAS CONDUCTED, THE RATE OF OUT-SIDE AIR MAKE-UP HAS TO BE EQUAL TO THE RATE OF LOSS OF AIR FROM CONTROL ROOM (FIRST LAW OF THERMODYNAMICS)

(2) NEGLECTING HEAT LOSS FROM DUCTING BETWEEN FAN AND ESSENTIAL CHILLER UNIT WILL RESULT IN MORE CONSERVATIVE HEAT LOAD. THIS IMPLIES THE ENTHALPY OF AIR AT EXIT OF FAN IS EQUAL TO THE ENTHALPY AT ENTRANCE TO THE CHILLER UNIT.

ENGINEERING SKETCH PAD

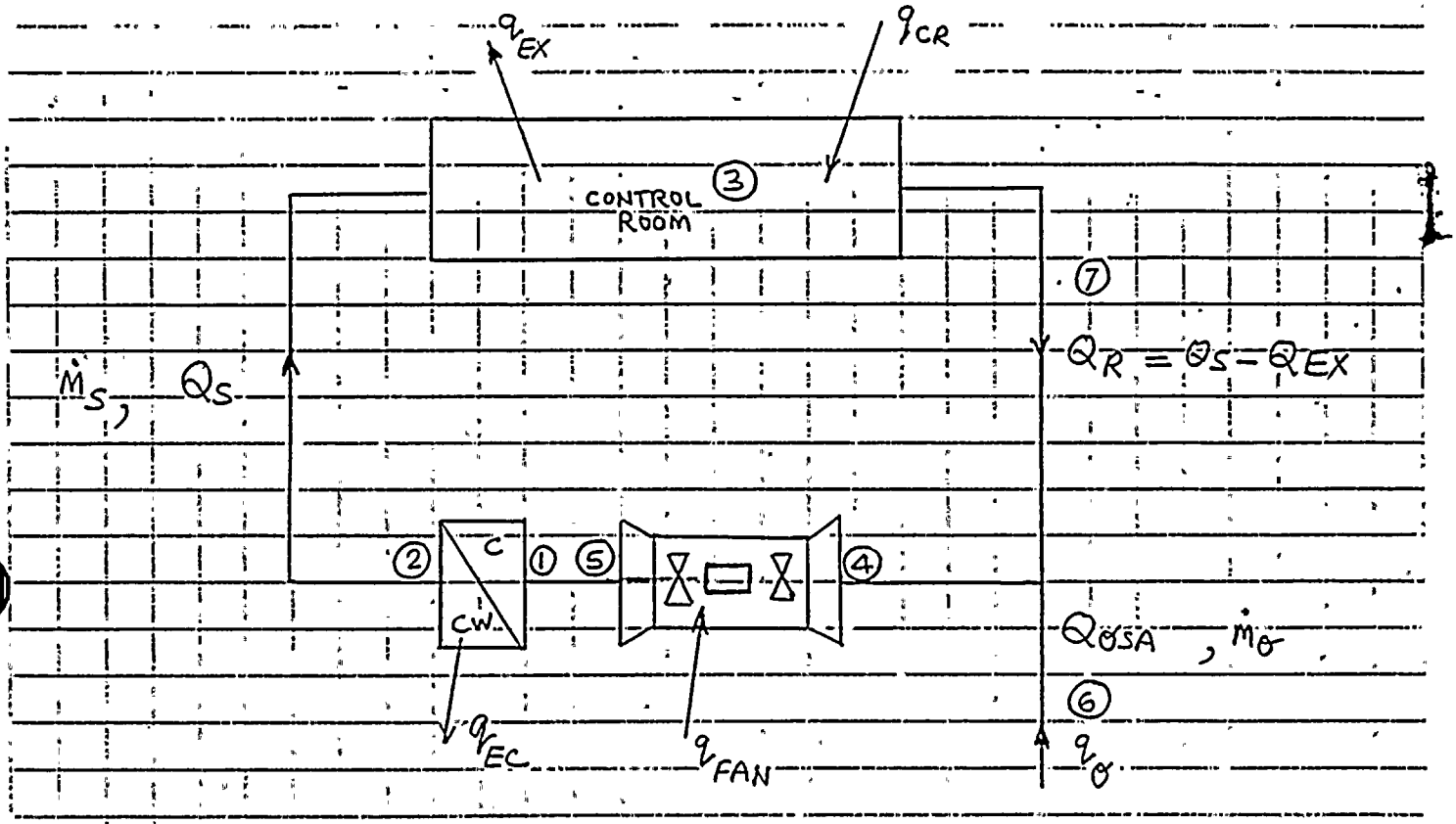
BY: V.K. Chawla	DATE: 9/21/88	SUBJECT: CONTROL ROOM HEAT LOAD CALCULATION	SHEET NO. 5 of 10
CHECKED BY: P.E. Maynard	DATE: 9/28/88		JOB NO.

(3) BY FIRST LAW OF THERMODYNAMICS,
AT THE EQUILIBRIUM CONDITIONS OF STEADY STATE,
THE HEAT INPUT = HEAT OUTPUT FOR THE
CONTROL ROOM

ENGINEERING SKETCH PAD

BY	DATE	SUBJECT	SHEET NO
V.K. Clark	9/21/88	Control Room Heat Load Calculation	6 of 10
CHECKED BY	DATE		JOB NO.
P.E. Maynard	9/28/88		13-MC-HJ-255

CALCULATIONS AND RESULTS:



RATES:

LET Q_S = AIR SUPPLY TO CONTROL ROOM, SCFM

Q_R = AIR RETURN FROM CONTROL ROOM, SCFM

Q_{OSA} = OUTSIDE AIR MAKE UP, SCFM

Q_{EX} = AIR LOST FROM CONTROL ROOM, SCFM = Q_{OSA}

$\dot{M}_S$ = MASS FLOW RATE, SUPPLY AIR TO CONTROL ROOM, LBS/HR

$\dot{M}_O$ = MASS FLOW RATE, OUTSIDE MAKE-UP AIR, LBS/HR

q_{CR} = CONTROL ROOM HEAT LOAD, BTU/HR

q_{EX} = HEAT LOAD OF AIR LOST FROM CONTROL ROOM, BTU/HR

q_{FAN} = HEAT LOAD FOR ONE FAN, BTU/HR

q_{EC} = HEAT EXCHANGED IN THE ESSENTIAL CHILLER, BTU/HR

q_O = HEAT INPUT FROM THE MAKE-UP OUTSIDE AIR, BTU/HR

ENGINEERING SKETCH PAD

BY	DATE	SUBJECT	SHEET NO.
V.K. Clark	9/21/88	CONTROL ROOM HEAT LOAD CALCULATION	7 of 10
CHECKED BY	DATE		JOB NO
P.E. Maynard	9/28/88		13-MC-HJ-255

THE DENSITY OF AIR (REF 2, PAGE 13) = 0.075 lbs/Ft^3

CONVERTING VOLUMETRIC FLOW TO MASS FLOW :

$\dot{M}_S = 27500\ (Ft^3/MIN) \times 60\left(\frac{MIN}{HR}\right) \times 0.075\ \frac{LB}{Ft^3}$

$\cong 123800$ LSB/HR

AND $\dot{M}_O = Q_O \times 0.075 = 769 \times 60 \times 0.075$

$= 3460$ LBS/HR

FROM PSYCHROMETRIC CHART (REF 13, PAGE 6.14) THE ENTHALPY VALUES OF AIR AT VARIOUS LOCATIONS ALONG THE FLOW PATH :

(REFER TO SKETCH ON PAGE 6 TO FIND LOCATIONS LOCATIONS ARE INDICATED BY CIRCLED NUMBERS)

USED DATA ON PAGE NO 4 :

$h_1 = 34$ BTU/LB $= h_5$ at LOCATION ①

$h_2 = 27$ BTU/LB " " ②

$h_3 = 30$ BTU/LB " " ③

$h_4 = 32.5$ BTU/LB " " ④

$h_5 = 34$ BTU/LB $= h_1$ " " ⑤

$h_6 = 37.5$ BTU/LB " " ⑥

BY FORMULA (REF 1, PAGE 303),

HEAT INPUT FROM FAN

$q_{FAN} = \dot{M}_S \times (h_5 - h_4) = 123800 \times (34 - 32.5)$

$= 185700$ BTU/HR

HEAT REMOVED BY EC

$q_{EC} = \dot{M}_S \times (h_1 - h_2) = 123800 \times (34 - 27)$

$= 866600$ BTU/HR

HEAT LOST FROM THE CONTROL ROOM

$q_{EX} = .3460 \times h_3 = 3460 \times 30$

$= 103800$ BTU/HR

ENGINEERING SKETCH PAD

BY	DATE	SUBJECT	SHEET NO.
V.K. Clarke	9/21/88	CONTROL ROOM HEAT LOAD CALCULATION	8 of 10
CHECKED BY	DATE		JOB NO
P.E. Maynard	9/28/88		13-MC-HJ-255

HEAT INPUT BY MAKE-UP AIR (OUT-SIDE AIR, OSA)

$q_o = 3460 \times 26 = 3460 \times 37.5$

$= 129750$ BTU/HR

AS THE TEST WAS CONDUCTED UNDER A STEADY STATE CONDITION, THE OVERALL ENERGY BALANCE, BY FIRST LAW OF THERMODYNAMICS, GIVES:

HEAT INPUT = HEAT OUTPUT

$q_{CR} + q_o + q_{FAN} = q_{EX} + q_{EC}$

OR $q_{CR} = (q_{EX} + q_{EC}) - (q_{FAN} + q_o)$

$= (103800 + 86660.0) - (18.5700 + 129750)$

$= 654,950$ BTU/HR

ENGINEERING SKETCH PAD

BY	DATE	SUBJECT	SHEET NO
V.K. Chawla	9/21/88	CONTROL ROOM HEAT LOAD CALCULATION	9 of 10
CHECKED BY	DATE		JOB NO
P.E. Maynard	9/28/88		

REFRENCES:

(1) UNIT OPERATIONS OF CHEMICAL ENGINEERING BY McCABE AND SMITH, 2nd EDITION, Mc GRAW HILL

(2) FAN ENGINEERING, ROBERT JORGENSEN, BUFFALO FORGE, SEVENTH EDITION

(3) ASHRAE HANDBOOK 1985 FUNDAMENTALS INCH-POUND EDITION

(5) CONTROL ROOM HEAT LOAD TEST, CONDUCTED BY ENGINEERING EVALUATION DEPT. ON 7/21/88, (WILL BE ASSIGNED A DOCUMENT NUMBER ON A LATER DATE). ATTACHMENT 1.

ATTACHMENT 1

PAGE 1 OF 5

CONTROL ROOM HEAT LOAD TEST

ESTABLISH EQUILIBRIUM TEMPERATURE OF ~75°F IN CONSOLE AREA USING CONTROL ROOM ESSENTIAL AFU.

TRAVERSE MAIN SUPPLY HEADER TO DETERMINE FLOWRATE.

TRAVERSE OUTSIDE AIR DUCT TO DETERMINE FLOWRATE.

MEASURE DIFFERENTIAL PRESSURE ACROSS THE WATER SIDE OF AFU COOLING COIL. RECORD INLET AND OUTLET WATER TEMPERATURE

MEASURE/RECORD AIR TEMPERATURE AND HUMIDITY IN:

i. UPSTREAM OF CIRC FAN*
ii. DOWNSTREAM OF CIRC FAN*
iii. SUPPLY HEADER*
iv. RETURN HEADER*
v. OSA HEADER*

MEASURE/RECORD CONTROLROOM AIR TEMPERATURE IN

i. ZONE 1 145'
ii. ZONE 1 152'
iii. ZONE 2 145'
iv. ZONE 2 152'
v. ZONE 3 145'
vi. ZONE 3 155'
vii. ZONE 4 145'
viii. ZONE 4 155'
ix. ZONE 5 145'
x. ZONE 5 155'

*

RETURN TO NORMAL VENTILATION

REMOVE TEST GATE AND RESTORE SYSTEM.

* SPECIAL TEST INSTALLED GATE

CONTROL ROOM HEAT RATE TEST

SUBCOOL CONTROL ROOM T/S BY OPERATING CONTROL ROOM ESSENTIAL AFU (OR NORMAL AHU WITH T.I.C @ 62°F) FOR 48 HOURS

ENGAGE TEMPERATURE DATA RECORDERS IN THE FOLLOWING AREAS

ZONE 1 145'
ZONE 1 152'
ZONE 2 145'
ZONE 2 152'
ZONE 3 145'
ZONE 3 155'
ZONE 4 145'
ZONE 4 155'
ZONE 5 145'
ZONE 5 155'
RETURN AIR HEADER (REDUNDANT TRAIN)

→ ALIGN HJ IN CREFAS MODE

START REDUNDANT CONTROL ROOM ESSENTIAL AFU WITH EC CIRC PUMP

AND CHILLER IN STANDBY. IMMEDIATELY STOP THE ORIGINAL CONTROL ROOM ESSENTIAL AFU. RECORD TIME.

MAINTAIN TEMPERATURE RECORDERS AND ALLOW CONTROLROOM TO HEAT UP UNTIL THE FIRST ZONE TEMPERATURE LIMIT IS REACHED

ZONE LIMITS

ZONE 1	84°
ZONE 2	84°
ZONE 3	84°
ZONE 4	90°
ZONE 5	90°

RESTORE NORMAL COOLING

REMOVE TEST EQUIPMENT

MAIN SUPPLY HEADER

Q = ~~26750~~ 27500 SCFM

OSA TAG

Q = ~~713~~ SCFM

WATERSIDE

INLET TEMP 43 °F TI 26

OUTLET TEMP 75 °F TI 128

ACTUATOR FULL OPEN

UPPER COIL DP 6 "WC

LOWER COIL DP 6 "WC

PROCESS TEMP 110 - 75 = 35

① UPSTRM FAN 77.1 °F : 63 % RH FROM CHART

② DWNSTRM FAN 84.1 °F 50 % RH

③ SUPPLY HEADER 68.6°F 65 % RH

④ RETURN HEADER 77.0°F 55 % RH

⑤ OSA HEADER 90.5 °F 46.9 % RH

TI 117 64 °F