CALCULATION COVER SHEET

Calculation Preparation, Review and Approval Form PED-QP-3.1 Form Page No. 1 of 2 Calculation Cover Sheet * Short Term Calc: ☒ YES ☐ NO	CALCULATION NUMBER ○ FCØ 5916	Calc. Page No. 1 *TOTAL PAGES 33
	QA Category: ☒ CQE ☐ LIMITED CQE ☐ FIRE PROT. ☐ NON CQE ○ FILE NO. PED DEPARTMENT 357	

CALCULATION TITLE	VENDOR CALC. NO.
OPERATING TEMPERATURE LIMITS FOR DG-1 AND DG-2	☐ MR NO. ☒ ENGR. ANALYSIS 90-062 ☐ DBD NO. ☐ ECN NO. ☐ OTHER

* APPROVALS - SIGNATURE & DATE					CONFIRMATION *REQUIRED (✓)	
PREPARER(S)/DATE(S)	REVIEWER(S)/DATE(S)	INDEPENDENT REVIEWER(S)/DATE(S)	*REV. NO.	SUPERSEDES *CALC. NO.	YES	NO
Karl a Miller 4-20-92	Kirk Hyde 4-20-92	Kirk Hyde 4-20-92	A			✓
Karl a Miller 8-7-92	David G Baugh 8-7-92	E.D. Rohlig 8/10/92	B	A		✓
Karl a Miller 11-2-92	David G Baugh 11-2-92	E.D. Rohlig 11/9/92	C	B	✓	

* EXTERNAL ORGANIZATION DISTRIBUTION

NAME & LOCATION	COPY SENT (✓)	NAME & LOCATION	COPY SENT (✓)

9211230197 921116
PDR ADOCK 05000285
P PDR

* SEE INSTRUCTIONS ON REVERSE SIDE

PED-QP-3.24

CALC. PAGE NO. 1A (2 KA)

CALCULATION PREPARATION REVIEW AND APPROVAL FORM PED-QP-3.2 Form Page No. 1 of 1 PRODUCTION ENGINEERING DIVISION CALCULATION REVISION SHEET	CALCULATION NO. FC05916

REV. NO.	DESCRIPTION /REASON FOR CHANGE
B	P3 OPPD MAY SUPERCEDE EA-FC-90-062 r 2 INSTEAD OF REVISING, FOR THE PURPOSE OF CLARITY AND DOCUMENT CONTROL
B	p 5a PROVIDED ADDED JUSTIFICATION OF THE 1 DEGREE ΔT FAN INLET / AMBIENT
B	p 6 MWO 92 2346 WAS DONE TO REMEASURE DG-2 AIR FLOW
B	p 7 REMOVED NONESSENTIAL INFORMATION AND ADDED STATEMENT CONCERNING GENERATOR CAPACITY
B	p 10, 11 UTILIZED DATA FROM MWO ADDED ON p 6
B	p 12 REDREW GRAPH IN A MORE PROFESSIONAL FORMAT AND USED DATA FROM p 6
B	p 13 WORDING CHANGE FOR CLARITY
B	p 14-17 ADDED CLARITY TO TABLE ~~TITLES~~ 8-1-92 TITLES WITH RESPECT TO AMBIENT AIR AND FAN INLET TEMPERATURES. A MISTAKE WAS NOTED WHERE TURBOCHARGER INLET TEMPERATURES FOR 110 °F WERE USED FOR ALL CASES. THIS WAS CORRECTED TO THE PROPER TURBOCHARGER INLET TEMPERATURE AND THE NEW DERATION NUMBERS WERE THEN USED. THIS RESULTED IN OVERCONSERVATISM IN THE CALCULATION
B	p 18 REMOVED UNNECESSARY WORDING
B	p 19, 20 REDREW GRAPHS WITH NEW DERATION CURVES
B	p 25, 26 INSERTED TEST DATA FROM MWO 922346
B	p 34 ADDED LETTER TO EXPLAIN GENERATOR LIMIT
B	p 35 ADDED FAX FOR 208 °F WATER COOLANT AIR FLOW REQUIREMENTS

CALCULATION PREPARATION, REVIEW AND APPROVAL
FORM PED–QP–3.2 Form Page No. 1 of 1

PRODUCTION ENGINEERING DIVISION
CALCULATION REVISION SHEET

CALCULATION NO.

FL-05916

REV. NO.	DESCRIPTION /REASON FOR CHANGE
C	DEN MECHANICAL WAS NOTIFIED THAT MT-00077 "VELOCICALC PORTABLE AIR VELOCITY METER" WAS OUT OF CALIBRATION – LOW READING BY 12%. A NEW SET OF FAN FLOW READINGS WAS THEN TAKEN AND DRAMATICALLY NEW RESULTS MEASURED. THIS CALCULATION THEN REQUIRED REVISION
	ALSO UPDATED CALCULATION TO REDUCE FLOW MEASURED BY 2% TO ACCOUNT FOR INSTRUMENT INACCURACY
	ALSO UPDATED TO PREDICT EFFECTS OF USING PORTABLE FANS TO BLOW AWAY THE EXHAUST AIR FROM THE GENERATOR

REV.1

CALCULATION COVER SHEET

Calculation Preparation, Review and Approval Form PED-QP-3.1 Form Page No. 2 of 2 Calculation Cover Sheet	CALCULATION NUMBER FC-05916	Calc. Page No. 24
	FACILITY/SYSTEM DG KEYWORD ○ DIESEL GENERATOR	

CALCULATIONS USED AS INPUT IN THE ANALYSIS		EQUIPMENT TAGS		
CALC./REV. NO.	DEPT. NO. ○	SYSTEM	ADDED	DEPT. NO.
		DG-JW	JW-3-1	
		DG-JW	JW-3-2	
		DG	DG-1	
		DG	DG-2	

CALCULATION PREPARATION, REVIEW AND APPROVAL FORM PED–QP–3.3 FORM Page No. 1 of 5	CALCULATION NO.
PRODUCTION ENGINEERING CALCULATION SUMMARY SHEET	FC-05916 Rev. No. C

OBJECTIVE

THE OBJECTIVE OF THIS CALCULATION IS TO DETERMINE THE MAXIMUM AMBIENT AIR TEMPERATURE LIMITS FOR OPERATION OF THE FORT CALHOUN STATION EMERGENCY DIESEL GENERATORS WITHIN THE BOUNDS OF THE 2000 hr DERATION CURVES.

CALCULATION PREPARATION, REVIEW AND APPROVAL FORM PED-QP-3.3 FORM Page No. 2 of 5	CALCULATION NO.
PRODUCTION ENGINEERING CALCULATION SUMMARY SHEET	FC-05916 Rev. No. C

METHODS

To determine the Diesel Generator Upper Ambient Air Temperature Limit, the following steps are necessary.

1. Determine the KW Capacity of the diesel generator without considering the effects of elevated air temperature on jacket water temperature or turbo charger intake.

2. Predict Turbocharger intake temperature at elevated conditions

3. Predict Jacket Water temperatures at elevated conditions:
   a. Determine fan flow rates at elevated temperarures
   b. Compare fan flows to required flows to maintain jacket water at 190 F and 208 deg F

4. Determine Deration factors from the predicted jacket water temperatures and turbocharger intake temperatures

~~5. Plot Derated Power vs Time and Required Load for each deisel~~

5. COMPARE DERATED POWER TO POST LOCA DEMANDS FROM CALCULATION FC-03382 R 4 (C)

CALCULATION PREPARATION, REVIEW AND APPROVAL FORM PED—QP—3.3 FORM Page No. 3 of 5

CALCULATION NO. FC-5916

PRODUCTION ENGINEERING CALCULATION SUMMARY SHEET

Rev. No. C

ASSUMPTIONS

1. Ambient air pressures are considered constant

2. The diesels are in a cold shutdown condition with the jacket water at a temperature of 125 F prior to the start of the accident.

3. Turbocharger inlet air temperature delta T with outside ambient air does not change dramatically with outside air temperature increases, ie the outside air temperature to turbocharger intake delta T from 90 deg F ambient can be used to predict turbocharger intake temperatures at 110 deg F ambient conditions.

4. The radiator fan intake is equivalent to outdoor temperature + 1 deg F. This is validated by test data gathered during the last test performed on DG-2.
For DG-1, the test data requires some interpretation. During the hot weather testing performed in 1991, the outdoor ambient temperature recorded was 95 deg F with fan inlet temperatures of 96 deg F on the north side of the radiator and 100 F on the south side. The majority of air flow in DG-1 entering the fan comes from the north side of the engine (ref EA-90-091 rev 0, attachment 8.8 fig 6A and & 7a). The configuration of the equipment in the room is such that a natural plenum is formed between the north wall and the engine skid through which the fresh air travels. The air on the south side is mostly eddies formed from fan blade tip recirculation containing heat rejected from the radiator.
The 1 deg F assumption is justifiable based on the following factors:
   a. The fan shroud/fan blade tip clearance was reduced substantially when the new fan blades were installed. This resulted in reduced tip recirculation.
   b. The majority of the makeup air comes from the north side of the engine down the natural plenum
   c. Any preheating of the air supplying the radiator is done by heat rejected by the radiator or the diesel engine itself. Heat removal from the engine by this air reduces the thermal loading on the jacket water cooling system. Air that backwashes from the blade tip /fan shroud gap removes heat from the radiator but is not measured as fan flow during testing, which indicates that more air cooling is supplied to the radiator than can be meausured in a test configuration. (B)

5. Only the minimum amount of emergency safeguards equipment

REV.1

CALCULATION PREPARATION, REVIEW AND APPROVAL FORM PED-QP-3.3 FORM Page No. 3 of 5

PRODUCTION ENGINEERING CALCULATION SUMMARY SHEET

CALCULATION NO. FC-05916

Rev. No. C

ASSUMPTIONS

required to respond to a large break LOCA is considered to be the required load for the diesels. Additional optional loads that may be desired to assist operations in accident response, such as station air compressors, are not included in the required electrical load calculations.

6. Although the new fans draw more air , the air flow in the room is such that the turbocharger inlet air temperature is assumed to be unaffected.

7. THE MAJOR SOURCE OF HEAT IN THE TURBOCHARGER INLET AREA IS THE DISCHARGE AIR FROM THE GENERATOR. IF THIS AIR IS DUCTED OR BLOWN AWAY FROM THE TURBO INLET, THE TURBO INLET AIR SHOULD BE MUCH CLOSER TO AMBIENT CONDITIONS.

ANOTHER RESOLUTION TO THIS PROBLEM WOULD BE DUCTING IN FRESH AIR OR RELOCATING THE TURBOCHARGER INTAKE FILTER SO THAT THE GENERATOR COOLING AIR DISCHARGE HAS LESS AFFECT.

THE CALCULATION SHOWN ON PAGE 24 ASSUMES A ΔT OF 5 °F BETWEEN AMBIENT AIR AND TURBOCHARGER INLET AIR. THIS ΔT IS A THEORETICAL ESTIMATE OF THE RESULTS THAT COULD BE ACHIEVED THROUGH ONE OF THE ABOVE OPTIONS.

CALCULATION PREPARATION, REVIEW AND APPROVAL FORM PED-QP-3.3 FORM Page No. 4 of 5

PRODUCTION ENGINEERING CALCULATION SUMMARY SHEET

CALCULATION NO. FC-05916

Rev. No. C

INPUTS / REFERENCES

REF. NO.

1. Letter From Ted Fryar to Randy Mueller , Dated 2/10/80 contained in EA-FC-90-062 r 2 Attachment 8.2-b

2. MWO 913677 Replace Fan with Substitute Replacement Item per ECN 91-306

3. MWO 913676 Replace Fan with Substitute Replacement Item per ECN 91-306

4. Diesel Generator Deration Curves from EA-FC-90-062 r 2 Attachment 8.2-a

5. Fax Transmission from Young Radiator Company to Dan Borcyk dated 4/8/91

6. Fax Transmission from Young Radiator Company to Dan Borcyk dated 4/15/91 found in EA-FC-90-062 r 2 Attachment 8.9a

7. FC03382 r 4 Diesel Generator LOCA Loads

8. Mechanical Engineering Review Manual Seventh Edition

9. EA-FC-90-062 r 2 Diesel Generator Upper Temperature Operating Limits

10. OP-ST-DG-0002 "DIESEL GENERATOR 2 CHECK" FOR OCTOBER 1992

11. OP-ST-DG-0001 "DIESEL GENERATOR 1 CHECK" FOR OCTOBER 1992

CALCULATION PREPARATION, REVIEW AND APPROVAL
FORM PED-QP-3.3 FORM Page No. 5 of 5

PRODUCTION ENGINEERING CALCULATION
SUMMARY SHEET

CALCULATION NO. FC-05916

Rev. No. 6

CONCLUSIONS

DG-1 will operate within its 2000 hr Deration Curve Limits under the following conditions:

1. 50 % Ethylene Glycol/ Water coolant mixture
   ambient air temperature ≤ 107 F (JW temp < 190 F)

2. Treated Water Coolant Mixture
   ambient air temperature ≤ 110 F (JW temp < 208)

3. 50 % Ethylene Glycol / Water Coolant mixture
   ambient air temperature ≤ 110 F
   Turbocharger air temperature < 115 F
   Jacket Water temperature ≤ 208

DG-2 will operate within its 2000 hr Deration Curve Limits under the following conditions:

1. 50 % Ethylene Glycol/ Water coolant mixture
   ambient air temperature ≤ 110 F (JW temp < 208 F)

2. Treated Water Coolant Mixture
   ambient air temperature ≤ 110 F (JW temp < 208)

Discussion:

DG-1

Above 107 F ambient air temperature, DG-1's Jacket Water temperature is expected to exceed 190 F. Per conversations with Morrison Knudsen, the 200-208 curve must then be used for determining the deration factor. This accounts for approximately 7 % reduction in diesel generator derated capacity. If the present turbocharger inlet temperatures predicted for this ambient air condition are used, 107 F becomes the upper ambient air temperature limit for DG-1. If the turbocharger air can be supplied at just 5 F above ambient, the limiting ambient air temperature can be raised to 110 F.

As stated in previous versions of this calculation, the alternative method of achieving a 110 F ambient air temperature limit is to replace the 50 % Ethylene Glycol / Water coolant mixture with treated water. This increases engine coolant efficiency and improves radiator performance, and accounts for a substantial base power increase.

CALCULATION PREPARATION, REVIEW AND APPROVAL FORM PED-QP-3.3 FORM Page No. 5 of 5 PRODUCTION ENGINEERING CALCULATION SUMMARY SHEET	CALCULATION NO. FC-05916 Rev. No. 6

CONCLUSIONS

DG-2

Due to the load reduction performed during the 1992 Refueling Outage, DG-2 is in a satisfactory configuration up to 110 F with 50 % Ethylene Glycol/ Water as a coolant media. Although the Jacket Water temperature exceeds 190 F, it remains below 208 F in this temperature range. Because the demand was reduced on this Diesel Generator, the derated power, even with the 7 % reduction from the jacket water exceeding 190 F, exceeds the most severe accident demand load.

Jacket water temperature data collected during the warm weather testing performed in 1991 for both diesels were lower values than predicted by analysis. This testing was performed using treated water as a coolant media. Confirmation testing with 50 % Ethylene Glycol is expected to yeild data indicating that the same is true for that coolant mixture and may indicate that the 107 F ambient air temperature limit derived in this calculation can be increased. Due to the increased fan flow on the DG-1 radiator cooling system, the ambient air termperatures should be at least 95 F for this testing to be performed. This is required to ensure that all the flow passes through the radiators and that maximum ambient air temperature can be accurately established.

CALCULATION PREPARATION, REVIEW AND APPROVAL FORM PED–QP–3.4 Form Page No. 1 of 1	CALCULATION NO.
PRODUCTION ENGINEERING DIVISION CALCULATION SHEET	EC-05916 Rev. No. C

	REF. NO.
CALCULATE THE NET KW AVAILABLE FOR EACH DIESEL GENERATOR	
CASE 1 FAN REPLACED, 50/50 ETHYLENE GLYCOL COOLANT 2000 hr RATING BASE HP	
3950 HP 2000 hr ENGINE RATING	①
- 120 HP RADIATOR FAN DRIVE	②
- 20 HP GENERATOR COOLING FAN	
- 180 HP 50/50 GLYCOL SOLUTION COOLING WATER	
3630 AVAILABLE ENGINE HORSEPOWER	
CONVERT TO KW GENERATOR OUTPUT	
3630 MECH HORSEPOWER	
X .746 BHP/KW	① p8.26-3
2708 KW	
X .97 GEN EFF	① p8.26-3
2627 KW ⟸	

CALCULATION PREPARATION, REVIEW AND APPROVAL
FORM PED-QP-3.4 Form Page No. 1 of 1

PRODUCTION ENGINEERING DIVISION
CALCULATION SHEET

CALCULATION NO. FC-05916
Rev. No. C

	REF. NO.
CASE 2 FAN REPLACED, TREATED WATER COOLANT	
2000 hr RATING	
3950 HP 2000 HR RATING	① 8.26-3
− 120 HP RADIATOR FAN DRIVE	②
− 20 HP GENERATOR COOLING FAN	
3810 HP AVAILABLE ENGINE HORSEPOWER	
CONVERT TO KW GENERATOR OUTPUT	
3810	
x .746 BHP/KW	
2842	
x .97 GEN EFF	1 p 8.26-3
2757 KW ⇐	

CALCULATION PREPARATION, REVIEW AND APPROVAL
FORM PED–QP–3.4 Form Page No. 1 of 1

PRODUCTION ENGINEERING DIVISION
CALCULATION SHEET

CALCULATION NO. FC-05916

Rev. No. 0

REF. NO.

FROM FAN FLOW DATA, PREDICT FAN FLOWS AT ELEVATED TEMPERATURES

JW-3-1 (DG-1) RADIATOR FAN

FLOW = 123 263.3 SCFM @ 65.5 °F (NORTH QUADRANT)

$K_d = \frac{460 + 65.5}{530} = .9915$

123 263.3 X .9915 = 122216 cfm

SUBTRACT 2% INSTRUMENT ERROR = 119770

JW-3-2 (DG-2) RADIATOR FAN

FLOW = 115,963 @ 53 °F

$K_d = \frac{460 + 53}{530} = .968$

115,963 X .968 = 112,243 cfm

SUBTRACT 2% INSTRUMENT ERROR 109,998

CALCULATION PREPARATION, REVIEW AND APPROVAL
FORM PED–QP–3.4 Form Page No. 1 of 1

PRODUCTION ENGINEERING DIVISION
CALCULATION SHEET

CALCULATION NO. FC-05916

Rev. No. C

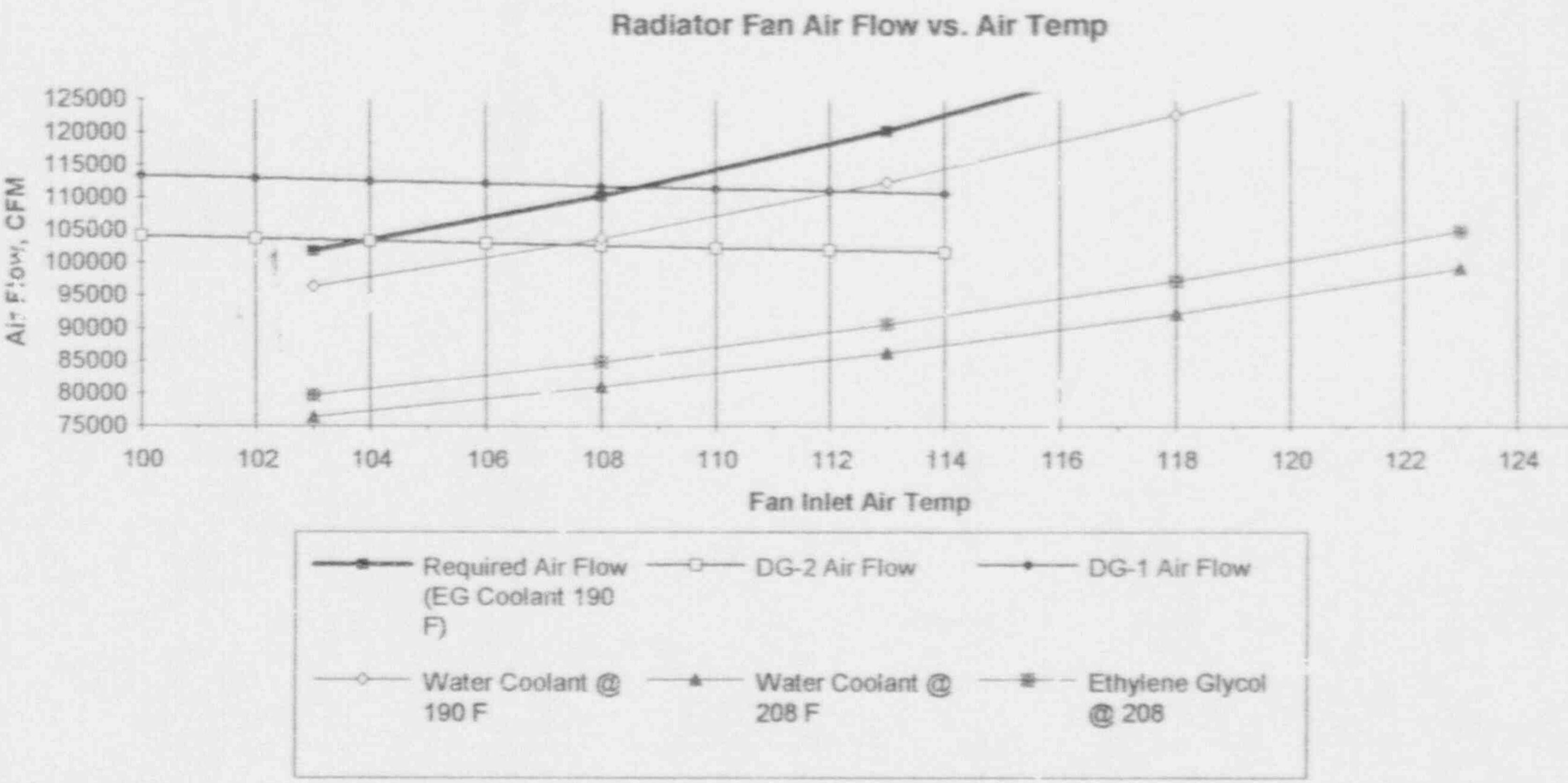
REF. NO.

TEMPERATURE CORRECTED AIR FLOWS

FCS EMERGENCY DIESEL GENERATOR RADIATOR FANS

TEMP	Kd	DG-1 SCFM	DG-2 SCFM
95	1.047	114,343	105,060
100	1.057	113,311	104,066
102	1.060	112,990	103,771
104	1.064	112,565	103,381
106	1.068	112 144	102,994
108	1.072	111 725	102,610
110	1.076	111310	102,228
112	1.079	111,000	101,944
114	1 083	110,590	101,568

REV.1



FC-05916 r C
p 15

CALCULATION PREPARATION, REVIEW AND APPROVAL
FORM PED-QP-3.4 Form Page No. 1 of 1

PRODUCTION ENGINEERING DIVISION
CALCULATION SHEET

CALCULATION NO. FC-05916

Rev. No. 0

REF. NO.

From the Deration Curve (Ref 4) select the deration % for the corresponding Jacket Water and Turbocharger Inlet Temperatures.
Note: From discussion in EA-FC-90-062 r 2 the Jacket Water system does not immediately warm up. Usually it takes more than 15 minutes of engine operating time before the TCV valve is fully open and the Jacket Water has reached its normal operating ~~setpoint.~~ temperature

The Turbocharger intake temperature is taken from information contained in attachment 8.8a-1 of EA-FC-90-062 r 2.

3

CALCULATION PREPARATION, REVIEW AND APPROVAL
FORM PED–QP–3.4 Form Page No. 1 of 1

PRODUCTION ENGINEERING DIVISION
CALCULATION SHEET

CALCULATION NO. FC-05916

Rev. No. C

REF. NO.

DG-1 DERATED POWER

107 DEGREE AMBIENT AIR TEMPERATURE

108 DEGREE FAN INLET, ETHYLENE GLYCOL COOLANT

TIME	TURBO INLET TEMP	JACKET WATER TEMP	KW	DERATE FACTOR	DERATE KW	POST LOCA LOAD
0	115	125	2627	1.0	2627	2490
10	115	174	2627	1.0	2627	2472 *
20	117	190	2627	.99	2600	2454 *
30	119	190	2627	.985	2587	2431
40	120	190	2627	.983	2582	2431
50	119	190	2627	.985	2587	2431
60	120	190	2627	.983	2582	2431
70	121	190	2627	.98	2574	2176
90	121	190	2627	.98	2574	2176
120	122	190	2627	.98	2574	2176

* DEMAND IS REDUCED AT A LINEAR RATE BETWEEN T=0 AND T=30 AS CONTAINMENT DEPRESSURIZES AND DISCHARGE HEAD OF THE CONTAINMENT SPRAY PUMPS DECREASES.

CALCULATION PREPARATION, REVIEW AND APPROVAL
FORM PED-QP-3.4 Form Page No. 1 of 1

PRODUCTION ENGINEERING DIVISION
CALCULATION SHEET

CALCULATION NO. EC-05916

Rev. No. C

REF. NO.

DG-1 DERATED POWER

110 DEGREE AMBIENT AIR TEMPERATURE

111 DEGREE F FAN INLET, 50% EG/WATER COOLANT

TIME	TURBO INLET TEMP	JW TEMP	KW INIT	DERATE FACTOR	DERATE KW	DEMAND KW
0	118	125	2627	1.	2627	2490
.5	118	174	2627	.99	2601	2472 *
20	120	190-208	2627	.915	2404	2454 *
30	122	190-208	2627	.91	2391	2431
40	123	190-208	2627	.907	2383	2431
50	122	190-208	2627	.91	2391	2431
60	123	190-208	2627	.907	2383	2431
70	124	190-208	2627	.905	2377	2176
90	124	190-208	2627	.905	2377	2176
120	125	190-208	2627	.903	2372	2176

* DEMAND IS REDUCED AT A LINEAR RATE BETWEEN t=0 AND t=30 AS CONTAINMENT DEPRESSURIZES

CALCULATION PREPARATION, REVIEW AND APPROVAL
FORM PED–QP–3.4 Form Page No. 1 of 1

PRODUCTION ENGINEERING DIVISION
CALCULATION SHEET

CALCULATION NO. FC-05916

Rev. No. 0

REF. NO.

DG-1 DERATED POWER

110 DEGREE AMBIENT AIR

111 DEGREE F FAN INLET, TREATED WATER COOLANT

TIME MIN	TURBO INLET TEMP OF	JW TEMP OF	KW INIT	DERATE %	DERATE KW	DEMAND KW	
0	118	125	2757	.99	2729	2490	
10	118	174	2757	.99	2729	2472	*
20	120	190	2757	.985	2715	2454	*
30	122	190	2757	.98	2701	2431	
40	123	190	2757	.975	2688	2431	
50	122	190	2757	.98	2701	2431	
60	123	190	2757	.975	2688	2431	
70	124	190	2757	.972	2680	2176	
90	124	190	2757	.972	2680	2176	
120	125	190	2757	.97	2674	2176	

* DEMAND IS REDUCED AT A LINEAR RATE BETWEEN t=0 AND t=30 AS CONTAINMENT DEPRESSURIZES.

CALCULATION PREPARATION, REVIEW AND APPROVAL FORM PED-QP-3.4 Form Page No. 1 of 1

PRODUCTION ENGINEERING DIVISION CALCULATION SHEET

CALCULATION NO. FC05916

Rev. No. C

REF. NO.

DG-2 DERATED POWER

103 DEGREE AMBIENT AIR TEMPERATURE

104 DEGREE FAN INLET, ETHYLENE GLYCOL COOLANT

TIME	TURBO INLET TEMP °F	JACKET WATER TEMP °F	KW	DERATE FACTOR	DERATE KW	POST LOCA LOAD
0	116	125	2627	.995	2613	2236
10	119	174	2627	.985	2587	2226
20	122	190	2627	.975	2561	2216
30	124	190	2627	.973	2556	2206
40	124	190	2627	.973	2556	2203
50	127	190	2627	.965	2535	2203
60	128	190	2627	.963	2529	2203
70	127	190	2627	.965	2535	1947
90	128	190	2627	.963	2529	1947
120	131	190	2627	.955	2509	1947

CALCULATION PREPARATION, REVIEW AND APPROVAL
FORM PED—QP—3.4 Form Page No. 1 of 1

PRODUCTION ENGINEERING DIVISION
CALCULATION SHEET

CALCULATION NO. FC-05916

Rev. No. C

REF. NO.

DG-2 DERATED POWER

110 DEG F AMBIENT AIR

111 °F FAN INLET, EG COOLANT

TIME MIN	TURBO INLET TEMP	JW TEMP	KW INIT	DERATE FACTOR	DERATE KW	POST LOCA DEMAND
0	121	125	2627	.985	2587	2236
10	124	174	2627	.973	2556	2226
20	127	200-208	2627	.895	2351	2216
30	129	200-208	2627	.89	2338	2206
40	129	200-208	2627	.89	2338	2203
50	132	200-208	2627	.88	2312	2203
60	133	200-208	2627	.88	2312	2203
70	132	200-208	2627	.88	2312	1947
90	133	200-208	2627	.88	2312	1947
120	136	200-208	2627	.875	2299	1947

REV.J

CALCULATION PREPARATION, REVIEW AND APPROVAL
FORM PED-QP-3.4 Form Page No. 1 of 1

PRODUCTION ENGINEERING DIVISION
CALCULATION SHEET

CALCULATION NO. FC-05916

Rev. No. C

REF. NO.

DG-2 DERATED POWER

110 DEGREE F AMBIENT AIR

111 DEGREE F FAN INLET, WATER COOLANT

TIME	TURBO INLET TEMP	JACKET WATER TEMP	KW UNIT	DERATE FACTOR	DERATE KW	DEMAND KW
0	121	125	2757	.985	2716	2236
10	124	174	2757	.973	2682	2226
20	127	190-208	2757	.895	2467	2216
30	129	190-208	2757	.89	2454	2206
40	129	190-208	2757	.89	2454	2203
50	132	190-208	2757	.88	2426	2203
60	133	190-208	2757	.88	2426	2203
70	132	190-208	2757	.88	2426	1947
90	133	190-208	2757	.88	2426	1947
120	136	190-208	2757	.875	2412	1947

CALCULATION PREPARATION, REVIEW AND APPROVAL
FORM PED–QP–3.4 Form Page No. 1 of 1

PRODUCTION ENGINEERING DIVISION
CALCULATION SHEET

CALCULATION NO. FC-05916

Rev. No. C

REF. NO.

ASSUME THAT THE GENERATOR COOLING AIR DISCHARGE IS DUCTED OR BLOWN AWAY FROM THE TURBO INLET. THE AMBIENT AIR TO TURBO INLET TEMPERATURE RISE SHOULD ONLY BE 5 °F, CALCULATE DERATED POWER BASED ON THIS ΔT AND JACKET WATER TEMP = 200 - 208.

BECAUSE DG-2 HAS ALREADY BEEN DEMONSTRATED TO BE CAPABLE OF MAINTAINING ITS POST LOCA LOADS WITHIN THE 2000 hr DERATION CURVES UP TO AN AMBIENT AIR TEMPERATURE OF 110 °F, ONLY DG-1 WILL BE EVALUATED.

CALCULATION PREPARATION, REVIEW AND APPROVAL FORM PED–QP–3.4 Form Page No. 1 of 1	CALCULATION NO.
PRODUCTION ENGINEERING DIVISION CALCULATION SHEET	FC-05916 Rev. No. C

REF. NO.

DG-1 DERATED POWER

T= 110 AMBIENT, 111 FAN INLET, EG COOLANT

TIME	TURBO INLET TEMP	JACKET WATER TEMP	KW	DERATE FACTOR	DERATE KW	POST LOCA LOAD
0	113	125	2627	1.0	2627	2490
10	113	174	2627	1.0	2627	2472
20	115	200	2627	.93	2443	2455
30	115	200	2627	.9	2440	2431
40	115	200	2627	.93	2440	2431
50	115	200	2627	.93	2440	2431
60	115	200	2627	.93	2440	2431
70	115	200	2627	.93	2440	2176
90	115	200	2627	.93	2440	2176
120	115	200	2627	.93	2440	2176

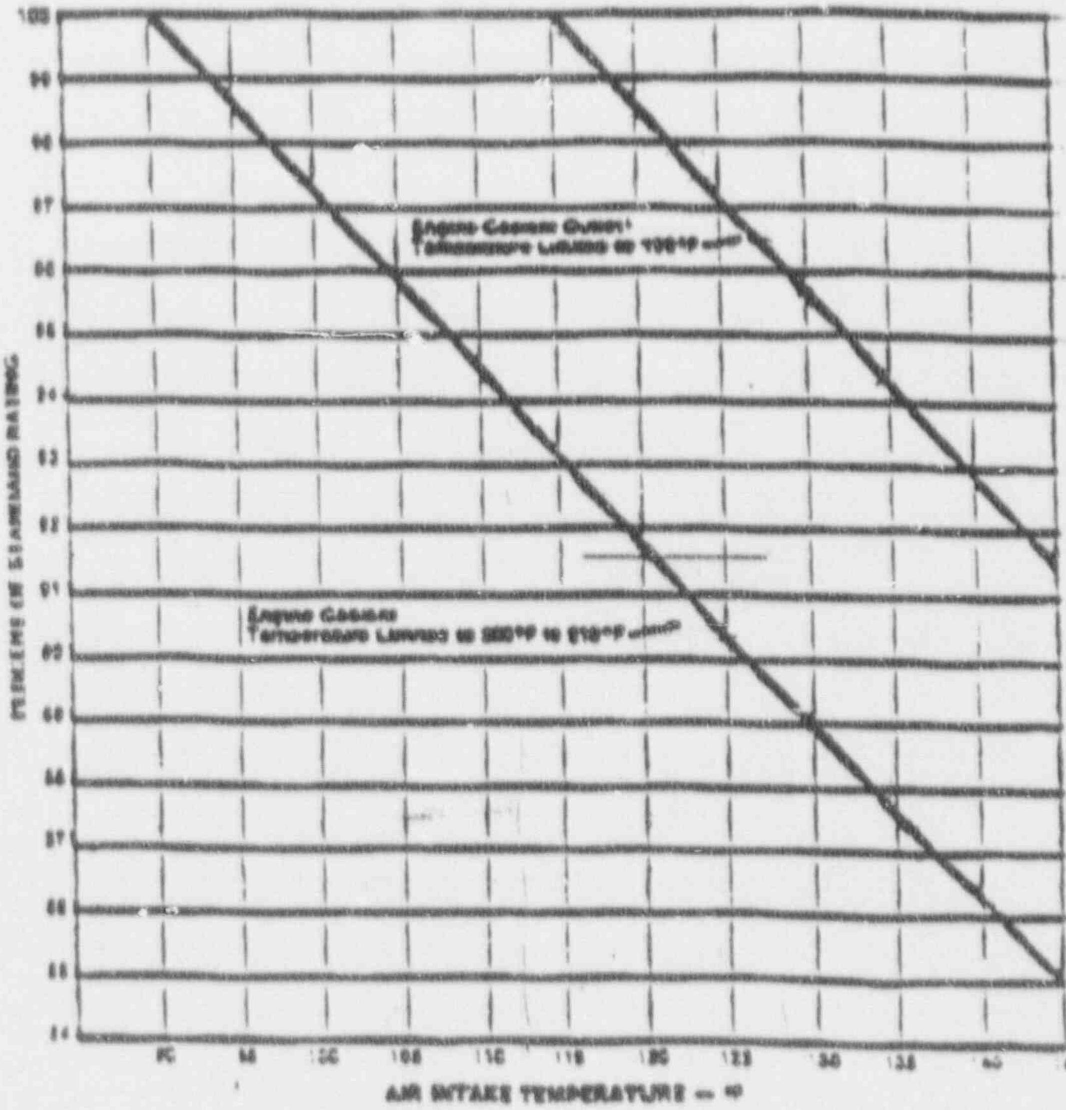
DIESEL GENERATOR DERATION CURVES

ENGINE TEMPERATURE SWITCH NOMINAL SETTINGS

Switch	Pickup	Dropout
ETS 1	208° F.	198° F.
ETS or ETS 2	215° F.	205° F.

ETS 1 — Hot engine alarm SC. HC. S.
ETS — Hot engine alarm MD. LD.
ETS 2 — Hot engine shutdown SC. HC. S.

The D/G @ Omaha is equivalent to an "S" UNIT



Rating at Elevated Temperature (°F)
For EMD 645E4

FC-05916 r C

p 26

TOTAL P.06

Young Radiator Company

2825 Four Mile Road, Racine, Wisconsin 53404
Telephone: 414-639-1010 • EasyLink: 627-63631
TWX: 910-271-2397 • Telex: 26-4455
Telefax: 414-639-1013

FACSIMILE TRANSMISSION

TRANSMIT TO: FAX NO. 402-636-3946 C.C.

NAME DAN BORCYK TITLE

COMPANY OMAHA PUBLIC POWER CITY OMAHA STATE ZIP

NUMBER OF PAGES BEING TRANSMITTED, INCLUDING THIS COVER

HEAT LOAD: 120,970 Btu/m

COOLANT, FLOW, TEMP IN: 50% EG-WATER, 1100 GPM, 208°F

ALTITUDE: 1007 ft

RADIATOR FACE AREA: 105.1 ft²

RADIATOR TUBE LENGTH: 12.25 ft

°F TAIR IN	AIRFLOW REQ. SCFM	IWG SP	fpm FACE VEL.	EST. TOTAL SYST. RESISTANCE Iwg SP std. air
103	79,777	.42	759	1.30
108	84,873	.47	807	1.42
* 113	90,658	.52	862	1.57
118	97,279	.59	926	1.78
123	104,933	.67	998	2.00
128	113,934	.76	1084	2.29
133	124,539	.89	1185	2.60
138	137,294	1.05	1306	3.10

THE 9 ft dia, 8 blade fan @ 600 rpm is probably limited to 2.00 iwg ACTUAL ~~iwg~~ static pressure which leaves no room for de-rating. As you have suggested, purchase of a fan to overcome the system resistance appears to be a logical approach. THE system resistance shown on the attached sheet yield the following operating points on the un-derated fan curve: (Approx.) 8° pitch, 100,000 SCFM, 1.3 iwg; 10° pitch, 105,000 SCFM, 2.00 iwg; 12° pitch, 113,000 SCFM, 2.20 iwg; 14° pitch 120,000 SCFM, 2.40 iwg.

TRANSMISSION FROM:

NAME TOM TILLER TITLE

☑ RACINE, WI 414-639-1013 ☐ LEXINGTON, TN 901-968-3617 ☐ CENTERVILLE, IA 515-856-8834

FORM NO. 3613 REV. 6/89

DATE 4/8/91 TIME

FC 05916 FC

Young RADIATOR COMPANY

2825 Four Mile Road, Racine, Wisconsin 53404
Telephone: 414-639-1010 • EasyLink 627-83631
TWX: 910-271-2397 • Telex: 26-4435
Telefax: 414-639-1013

FACSIMILE TRANSMISSION

TRANSMIT TO: FAX NO. 402-636-3946 C.C.

NAME DAN BORCYK TITLE

COMPANY OMAHA PUBLIC POWER CITY OMAHA STATE NE ZIP

NUMBER OF PAGES BEING TRANSMITTED, INCLUDING THIS COVER 1

HEAT LOAD : 120,970 Btu/m
COOLANT, FLOW, TEMP IN : WATER, 1100 GPM, 208°F
ALTITUDE : 1007 ft
RADIATOR FACE AREA : 105.1 ft² RAD TUBE LENGTH 12.25 ft

°F TAIR IN	-WATER- AIRFLOW REQ SCFM	IWG SP	fpm FACE VEL	ESTIMATED SYSTEM TOTAL RESISTANCE IWG STP AIR
103°	76,457	.39	727	1.22
108°	81,097	.43	771	1.30
113°	86,336	.48	821	1.45
118°	92,294	.54	878	1.65
123°	99,200	.61	943	1.85

TRANSMISSION FROM:

NAME TOM TILLER TITLE

☒ RACINE, WI 414-639-1013 ☐ LEXINGTON, TN 901-968-3617 ☐ CENTERVILLE, IA 515-856-8634

FORM NO. 3613 REV. 6/89 DATE 4/15/91 TIME AM PM

FC-05916 rC

p 28

Young Radiator Company

2825 Four Mile Road, Racine, Wisconsin 53404
Telephone: 414-639-1010 • EasyLink: 627-63631
TWX: 910-271-2397 • Telex: 26-4436
Telefax: 414-639-1013

FACSIMILE TRANSMISSION

TRANSMIT TO: FAX NO. 402-636-3946 C.C.

NAME DAN BORCYK TITLE

COMPANY OMAHA PUBLIC POWER CITY OMAHA STATE NE ZIP

NUMBER OF PAGES BEING TRANSMITTED, INCLUDING THIS COVER 3

HEAT LOAD: 120,970 Btu/m

COOLANT FLOW, TEMP IN: 1100 GPM, 190°F

ALTITUDE: 1007 ft

RADIATOR FACE AREA: 105.1 ft² RAD TUBE LENGTH: 12.25 ft

50% EG-WATER

°F TAIR IN	AIRFLOW REQ SCFM	IWG	fpm FACE VEL	IWG STD. AIR EST. TOTAL SYST. RESISTANCE
103	101,792	.63	968	1.85
108	110,184	.72	1048	2.17
113	120,144	.84	1143	2.50
118	131,986	.98	1255	2.90
123	146,384	1.16	1392	3.45

WATER ONLY

°F TAIR IN	AIRFLOW REQ SCFM	IWG	fpm FACE VEL	IWG STD. AIR EST. TOTAL SYST. RESISTANCE
103	96,311	.58	916	1.75
108	103,766	.65	987	1.90
113	112,446	.75	1069	2.30
118	122,679	.87	1167	2.57
123	134,912	1.02	1283	3.05

TRANSMISSION FROM:

NAME TOM TILLER TITLE

☑ RACINE, WI 414-639-1013 ☐ LEXINGTON, TN 901-968-3617 ☐ CENTERVILLE, IA 515-856-8634

FORM NO. 3613 REV. 6/89 DATE 4.8.91 TIME AM PM

12 Blad·, 22 Degree Pitch, DS-1, 10-13-92
Standard Velocity /Temperature Measurement

11 Vel.= 2550 Temp.= 140	21 Vel.= 2775 Temp.= 139	31 Vel.= 2245 Temp.= 139	41 Vel.= 2320 Temp.= 138	51 Vel.= 2020 Temp.= 135	61 Vel.= 2665 Temp.= 136	71 Vel.= 2685 Temp.= 136	81 Vel.= 2655 Temp.= 136	91 Vel.= 2505 Temp.= 138
12 Vel.= 2920 Temp.= 137	22 Vel.= 3320 Temp.= 132	32 Vel.= 2450 Temp.= 138	42 Vel.= 2650 Temp.= 137	52 Vel.= 1900 Temp.= 137	62 Vel.= 2880 Temp.= 132	72 Vel.= 2880 Temp.= 133	82 Vel.= 3180 Temp.= 128	92 Vel.= 3060 Temp.= 130
13 Vel.= 2790 Temp.= 125	23 Vel.= 2965 Temp.= 127	33 Vel.= 2295 Temp.= 132	43 Vel.= 2450 Temp.= 133	53 Vel.= 1770 Temp.= 134	63 Vel.= 2415 Temp.= 127	73 Vel.= 2470 Temp.= 132	83 Vel.= 2965 Temp.= 120	93 Vel.= 2755 Temp.= 120
1[illegible] Vel.= 2550 Temp.= 121	24 Vel.= 2785 Temp.= 124	34 Vel.= 2300 Temp.= 128	44 Vel.= 2570 Temp.= 127	54 Vel.= 1390 Temp.= 125	64 Vel.= 2465 Temp.= 120	74 Vel.= 2640 Temp.= 125	84 Vel.= 2980 Temp.= 118	94 Vel.= 2487 Temp.= 114
15 Vel.= 1830 Temp.= 118	25 Vel.= 1780 Temp.= 117	35 Vel.= 2165 Temp.= 122	45 Vel.= 2600 Temp.= 118	55 Vel.= 1755 Temp.= 119	65 Vel.= 2050 Temp.= 115	75 Vel.= 1952 Temp.= 116	85 Vel.= 2411 Temp.= 110	95 Vel.= 1692 Temp.= 110

Equipment used= TSI Model 8359 Velocicalc, MT-00077;Digital Temp. MT-10101
Vel. = Velocity in Ft./Min. (standardized to 70 F and 14.7 Psia)
Temp. = Temperature in degrees F
Time constant = 15 seconds
Radiator Inlet Temperatures = (N. = 65.5F), (E. = 69.4 F), (W. = 66.8 F), (S. = 72F)
Wall Opening Temperature = 64.5 F

12 Blade, 22 Degree Pitch, DG-1, 10-13-92
Calculated Flow Rates

Cell	SCFM=	Temp.=
11	2833.33	140
21	3083.33	139
31	[illegible].44	[illegible]39
41	2577.78	138
51	2244.44	135
61	2961.11	136
71	2983.33	136
81	2950	136
91	2783.33	138
12	3244.44	137
22	3688.89	132
32	2722.22	138
42	2944.44	137
52	2111.11	137
62	3200	132
72	3200	133
82	3533.33	128
92	3400	130
13	3100	125
23	3294.44	127
33	2550	132
43	2722.22	133
53	1966.67	134
63	2683.33	127
73	2744.44	132
83	3294.44	120
93	3061.11	120
14	2833.33	121
24	3094.44	124
34	2555.56	128
44	2855.56	127
54	1544.44	125
64	2738.89	120
74	2933.33	125
84	3311.11	118
94	2763.33	114
15	2033.33	118
25	1977.78	117
35	2405.56	122
45	2888.89	118
55	1950	119
65	2277.78	115
75	2168.89	116
85	2678.89	110
95	1890	110

Total Calculated Flow Rate= 123263.3 SCFM

Average Temperature in Duct = 127.51 Degreees F

FC-05916 r C
p 31

12 Blade, 22 Degree Pitch, DG-2, 10-28-92
Standard Velocity /Temperature Measurement

11 Vel.= 2660 Temp.= 127	21 Vel.= 2480 Temp.= 126	31 Vel.= 2380 Temp.= 127	41 Vel.= 2720 Temp.= 129	51 Vel.= 1190 Temp.= 130	61 Vel.= 2660 Temp.= 128	71 Vel.= 2400 Temp.= 122	81 Vel = 2550 Temp.= 125	91 Vel.= 2640 Temp.= 130
12 Vel.= 2650 Temp.= 126	22 Vel.= 2645 Temp.= 119	32 Vel.= 2410 Temp.= 123	42 Vel.= 2470 Temp.= 126	52 Vel.= 1050 Temp.= 127	62 Vel.= 2370 Temp.= 124	72 Vel.= 2700 Temp.= 116	82 Vel.= 3000 Temp.= 118	92 Vel.= 2550 Temp.= 128
13 Vel.= 2860 Temp.= 110	23 Vel.= 2960 Temp.= 114	33 Vel.= 2590 Temp.= 120	43 Vel.= 2460 Temp.= 118	53 Vel.= 1050 Temp.= 120	63 Vel.= 2340 Temp.= 122	73 Vel.= 2380 Temp.= 113	83 Vel.= 2630 Temp.= 115	93 Vel.= 2480 Temp.= 112
14 Vel.= 2597 Temp.= 105	24 Vel.= 3000 Temp.= 106	34 Vel.= 2575 Temp.= 112	44 Vel.= 2350 Temp.= 109	54 Vel.= 1110 Temp.= 110	64 Vel.= 2130 Temp.= 110	74 Vel.= 2100 Temp.= 105	84 Vel.= 2130 Temp.= 105	94 Vel.= 2350 Temp.= 105
15 Vel.= 2350 Temp.= 9[illegible]	25 Vel.= 2440 Temp.= 98	35 Vel.= 2240 Temp.= 100	45 Vel.= 2060 Temp.= 102	55 Vel.= 1120 Temp.= 105	65 Vel.= 2000 Temp.= 103	75 Vel.= 1990 Temp.= 100	85 Vel.= 2300 Temp.= 100	95 Vel.= 2250 Temp.= 102

Equipment [illegible]= TSI Model [illegible]50 Velocicalc, MT-00077, Dig. Temp. = MT-10104
Vel. = Velocity in Ft./Min. (standardized to 70 F and 14.7 Psia)
Temp. = Temperature in Degrees F
Time constant = 15 seconds
Inlet Temperatures = (N. = 54F), (E. = 57 F), (W. = 54 F), (S. = 53F)

25916 r C
p 32

12 Blade, 22 Degree Pitch, DG-2, 10-28-92
Calculated Flow Rates

11 SCFM= 2955.56 Temp.= 127	21 SCFM= 2755.56 Temp.= 126	31 SCFM= 2644.44 Temp.= 127	41 SCFM= 3022.22 Temp.= 129	51 SCFM= 1322.22 Temp.= 130	61 SCFM= 2955.56 Temp.= 128	71 SCFM= 2666.67 Temp.= 122	81 SCFM= 2833.33 Temp.= 125	91 SCFM= 2933.33 Temp.= 130
12 SCFM= 2944.44 Temp.= 126	22 SCFM= 2938.89 Temp.= 119	32 SCFM= 2677.73 Temp.= 123	42 SCFM= 2744.44 Temp.= 126	52 SCFM= 1166.67 Temp.= 127	62 SCFM= 2633.33 Temp.= 124	72 SCFM= 3000 Temp.= 116	82 SCFM= 3333.33 Temp.= 118	92 SCFM= 2833.33 Temp.= 128
13 SCFM= 3177.78 Temp.= 110	23 SCFM= 3288.89 Temp.= 114	33 SCFM= 2877.78 Temp.= 120	43 SCFM= 2733.33 Temp.= 118	53 SCFM= 1166.67 Temp.= 120	63 SCFM= 2600 Temp.= 122	73 SCFM= 2644.44 Temp.= 113	83 SCFM= 2922.22 Temp.= 115	93 SCFM= 2755.56 Temp.= 112
14 SCFM= 2885.56 Temp.= 105	24 SCFM= 3333.33 Temp.= 106	34 SCFM= 2861.11 Temp.= 112	44 SCFM= 2611.11 Temp.= 109	54 SCFM= 1233.33 Temp.= 110	64 SCFM= 2366.67 Temp.= 110	74 SCFM= 2333.33 Temp.= 105	84 SCFM= 2366.67 Temp.= 105	94 SCFM= 2611.11 Temp.= 105
15 SCFM= 2611.11 Temp.= 99	25 SCFM= 2711.11 Temp.= 98	35 SCFM= 2488.89 Temp.= 100	45 SCFM= 2288.89 Temp.= 102	55 SCFM= 1244.44 Temp.= 105	65 SCFM= 2222.22 Temp.= 103	75 SCFM= 2211.11 Temp.= 100	85 SCFM= 2555.56 Temp.= 100	95 SCFM= 2500 Temp.= 102

Total Calculated Flow Rate= 115963.3 SCFM

Average Temperature in Duct = 114.91 Degreees F

MT-00077

FC-05916 rc p 33
as Found

TSI CERTIFICATE OF CALIBRATION AND TESTING

TSI Model 8350 TSI Serial No. 982

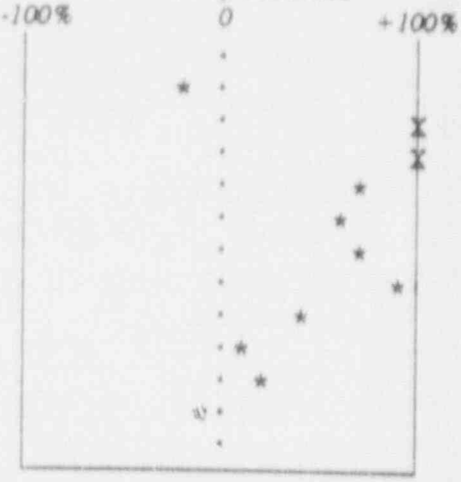
Description VELOCICALC PORTABLE AIR VELOCITY METER

Calibration Standard WIND TUNNEL CALIBRATION SYSTEM, SERIAL NO. 141

CALIBRATION VERIFICATION RESULTS

Calibration Standard Std Ft/Min	*Instrument Output* Std Ft/Min	*Percent Difference*
35.7	35.0	-1.9
65.2	69.0	5.9
150.4	159.5	6.1
325.0	332.2	2.2
648.9	664.8	2.5
997.6	1021.3	2.4
1477.2	1519.2	2.8
2514.0	2559.8	1.8
4483.6	4499.2	0.3
6993.2	7035.7	0.6
8205.9	8164.2	-0.5

Difference as a Percent of Tolerance



Indicated Temperature at 32°F 32.3 *140°F* 140.6

Standard Conditions
Ambient Temperature: 21.1°C
Barometric Pressure: 760.0 mmHg

Tolerance
±2.5% of reading ±2 f/m (30-500), 10 f/m (500-2000), 50 f/m (2000-6000), 100 f/m (6000-10000)

TSI Incorporated does hereby certify that all materials, components, and workmanship used in the manufacture of this equipment are in strict accordance with the applicable specifications agreed upon by TSI and the customer and with all published specifications. All performance and acceptance tests required under this contract were successfully conducted according to required specifications. Furthermore, all test and calibration data supplied by TSI has been obtained using standards whose accuracies are traceable to the National Institute of Standards and Technology (NIST) or has been verified with respect to instrumentation whose accuracy is traceable to NIST, or is derived from accepted values of physical constants.

Applicable NIST Test Report		Report Number	Date	Date Last Verified
DC voltage		100061	7-30-92	7-30-92
Barometric Pressure		P-8077	5-13-87	5-26-92
Temperature	19-35°C	213426	3-19-80	10-19-91
	0°C	246369	9-13-90	9-24-91
	60°C	216642	9-13-90	9-24-91
Pressure		040J/34FB2:001-2	10-23-85	1-16-92
Velocity:	(Gage Blocks)	738/231633-84	6-25-84	10-23-91
	(Frequency)	84071101	7-11-84	6-11-92
Dewpoint		248330	6-10-91	11-21-91

Karen Kerrick
Calibrated by

Oct 16, 1992
Calibration Date

TSI Incorporated
Industrial Test Instruments Group

Mailing Address: P.O. Box 64394 St. Paul, MN 55164 USA
Shipping Address: 500 Cardigan Road St. Paul, MN 55126 USA
Phone: (800) 876-9874 or (612) 490-2888 Fax: (612) 490-2874

CALCULATION NUMBER

FCØ5916 R C

		YES	NO	N/A
1.	Is Calculation Cover Sheet attached and completed, as required, to the calculation?	X		
2.	Is the calculation objective stated? Was this achieved?	X		
3.	Are inputs correctly selected and incorporated into the analysis?	X		
4.	Have inputs and/or assumptions which require confirmation at a later data, been identified on the Calculation Cover Sheet and in the calculation body?	X		
5.	Are the applicable codes, standards, regulatory requirements, and other references including issue and addenda identified such that they are traceable to source document?			X
6.	Was an appropriate calculation method used? Was the basic theory appropriate?	X		
7.	Have assumptions been noted and justified?	X		
8.	Are the calculations free of arithmetic errors?	X		
9.	Is the calculation consistent with the design basis requirements?	X		
10.	Is the conclusion stated?	X		
11.	Is the calculation legible and suitable for microfilming?	X		

CALCULATION NUMBER

FC Ø5916 R.C

		YES	NO	N/A
12.	Are all blocks on the Calculation Cover Sheet addressed correctly?	X		
13.	Have Forms PED-QP-3.2, 3, 4 and 5 been used and correctly completed?	X		
14.	If the calculation has been prepared to supersede another calculation, has all the valid information been transferred in the new calculation?			X

REVIEWER COMMENTS:

[signature] 11/2/92

Reviewer Date

CALCULATION NUMBER

FC-05916, Rev. C

		YES	NO	N/A
1.	Are the calculation methods accurate and appropriate?	X		
2.	Are input data sufficiently detailed?	X		
3.	Are the calculation assumptions reasonable?	X		
4.	Has the basis for engineering judgement been included in the calculation, when used?			X
5.	Is the calculation documented sufficiently such that the analysis is understandable to someone competent in the discipline without recourse to the Preparer?	X		
6.	Have the design interface requirements been satisfied?	X		
7.	Are the results reasonable and do they resolve the calculation objective?	X		
8.	If an alternate calculation was used to verify the adequacy of the analysis, is it attached to the calculation?			X
9.	If qualification testing was used to verify the adequacy of the analysis, has it been documented using a retrievable source, or attached to the calculation?			X
10.	Are calculations involving Technical Specification values and associated margins of safety identified?			X

INDEPENDENT REVIEWER COMMENTS:

B.D. Kohig 11/9/92
Independent Reviewer Date