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# Capture of Heat Energy From

# Diesel Engine After Cooler Circuit

Mark Teitzel

Alaska Village Energy Corporation

907-565-5337

[mteitzel@avec.org](mailto:mteitzel@avec.org)

Chuen-Sen Lin

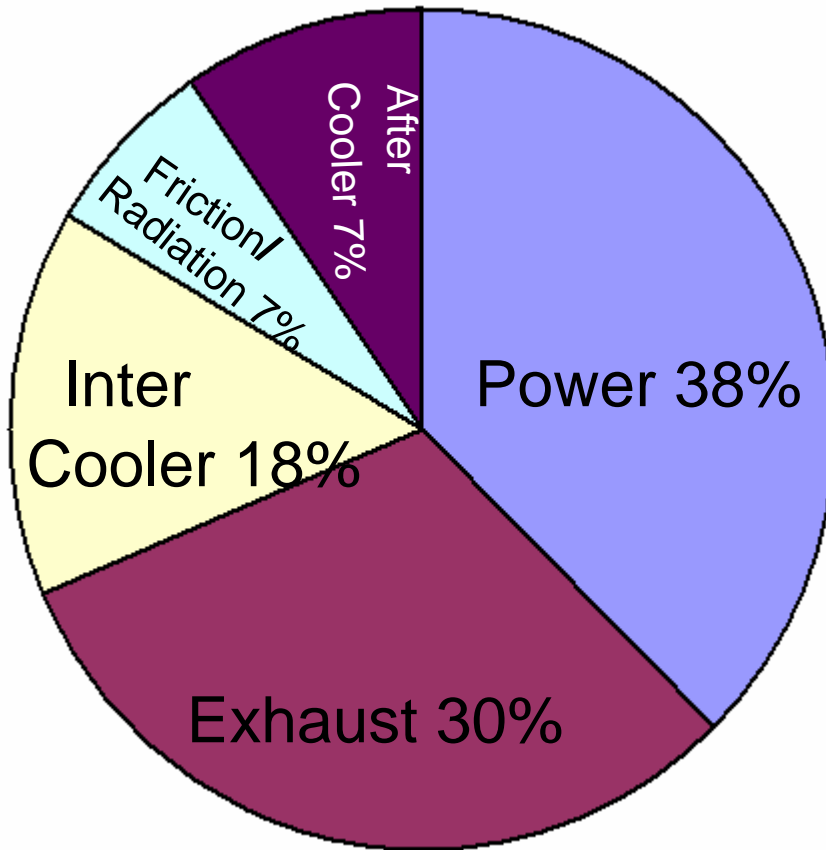
University of Alaska Fairbanks

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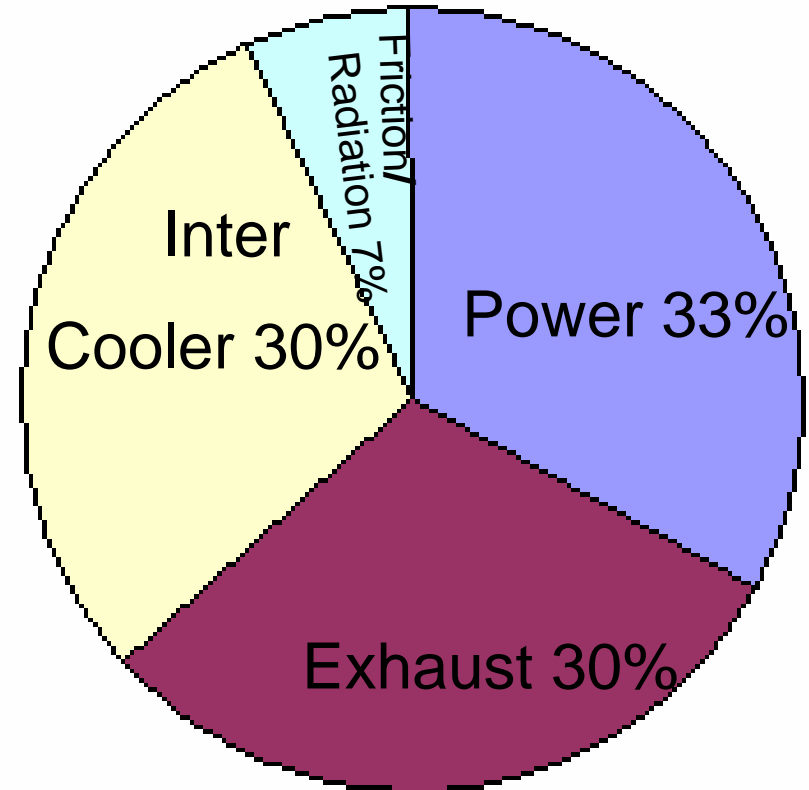
[ffcl@uaf.edu](mailto:ffcl@uaf.edu)

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# Energy Distribution of Diesel Generator



New Diesel Engine



Old Diesel Generator

(Detroit Diesel Series 50 Generator)

## Milestones...

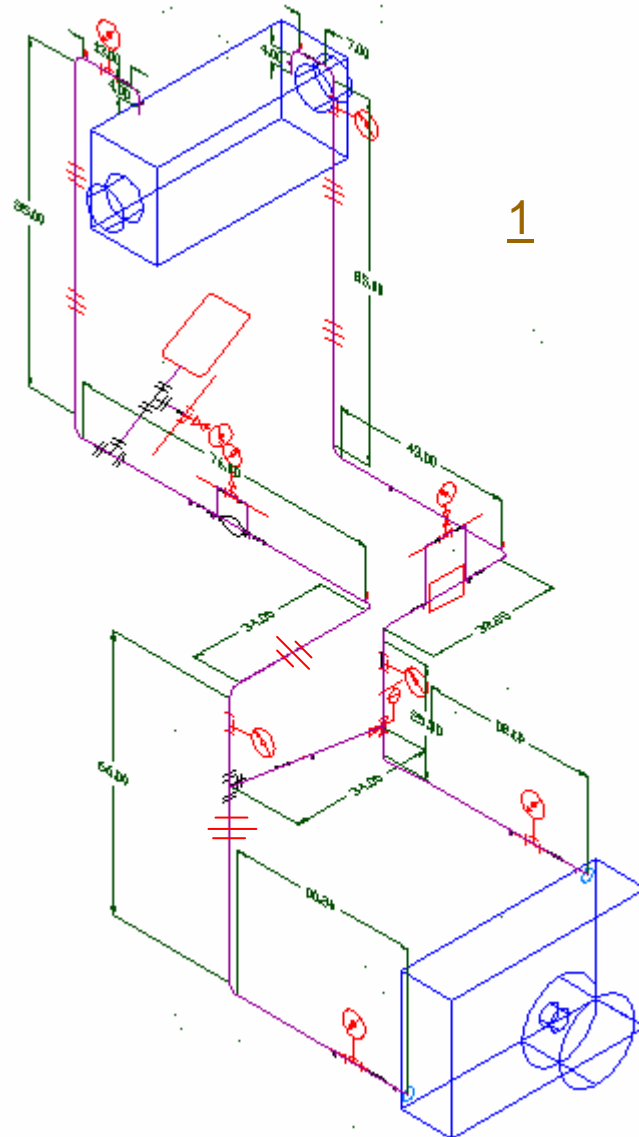
- Literature search (x)
  - Corrosion rate test (x)
  - Selection of heat recovery applications for exhaust and turbocharger compressed air (x)
    - For exhaust : Gas to liquid heat exchanger
    - For turbocharger air: 1. Air to liquid , 2. Air to air
  - Comparison of different types of heat exchanger: (x)
    - Parallel
    - Series
  - Design of exhaust heat exchanger system and procurement (x)
  - Exhaust heat exchanger system - Installation, measurement performance and cost analysis
  - Selection of compressed air heat exchanger design:
    - Air to liquid - verification of the information given in the quotation (x)
    - Air to air System
  - Field demonstration
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## Milestones This Quarter..

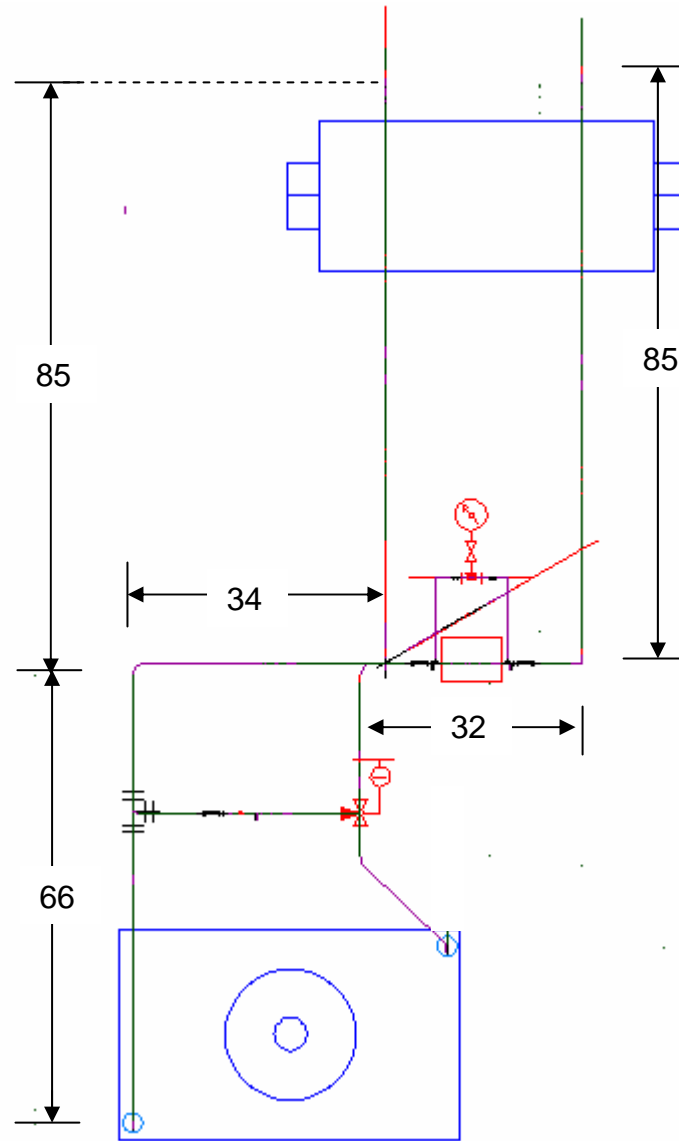
- Designing of the pipeline
  - Purchasing of the Heat Exchanger
  - Quotations for the pipeline components were obtained
  - Quotation for the unit heater
  - Purchasing of system components
  - Pressure drop analysis
  - Heat recovery analysis
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# Pipeline Design

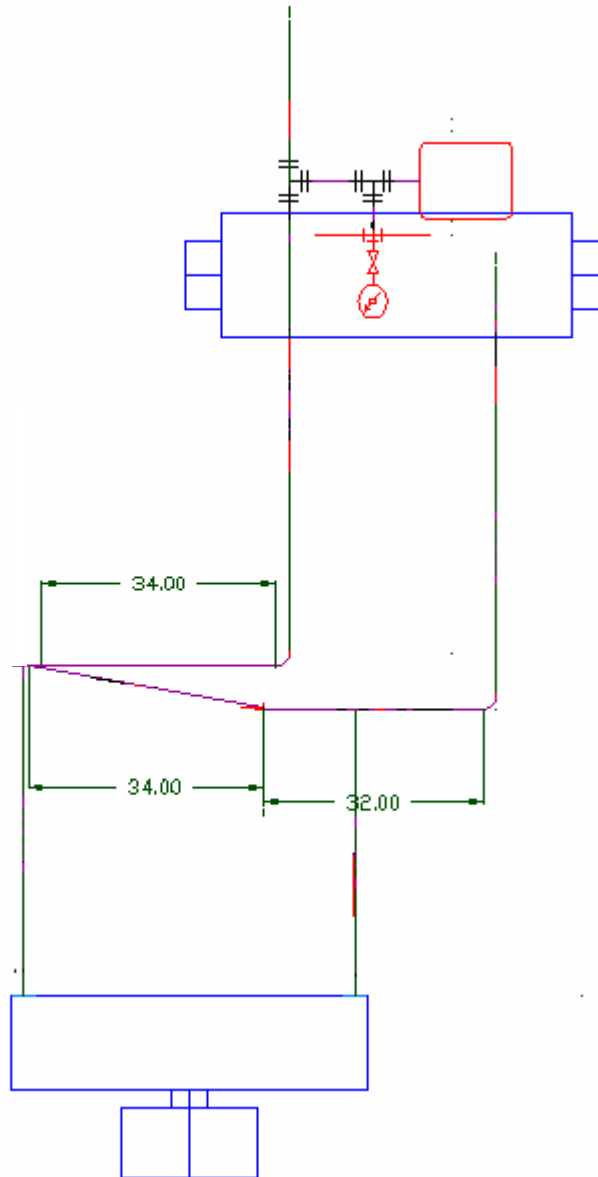




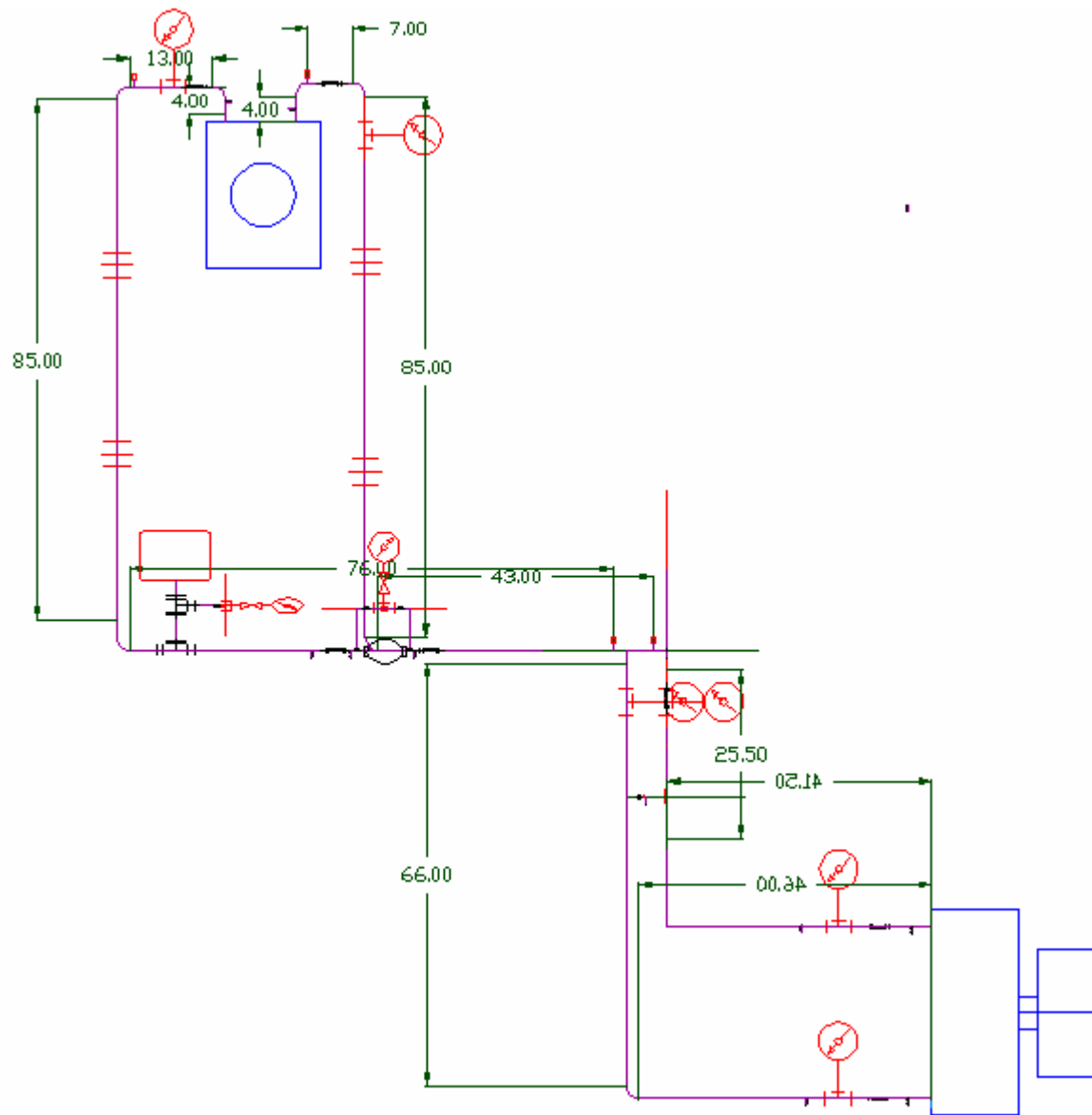
# Front View



# Top View

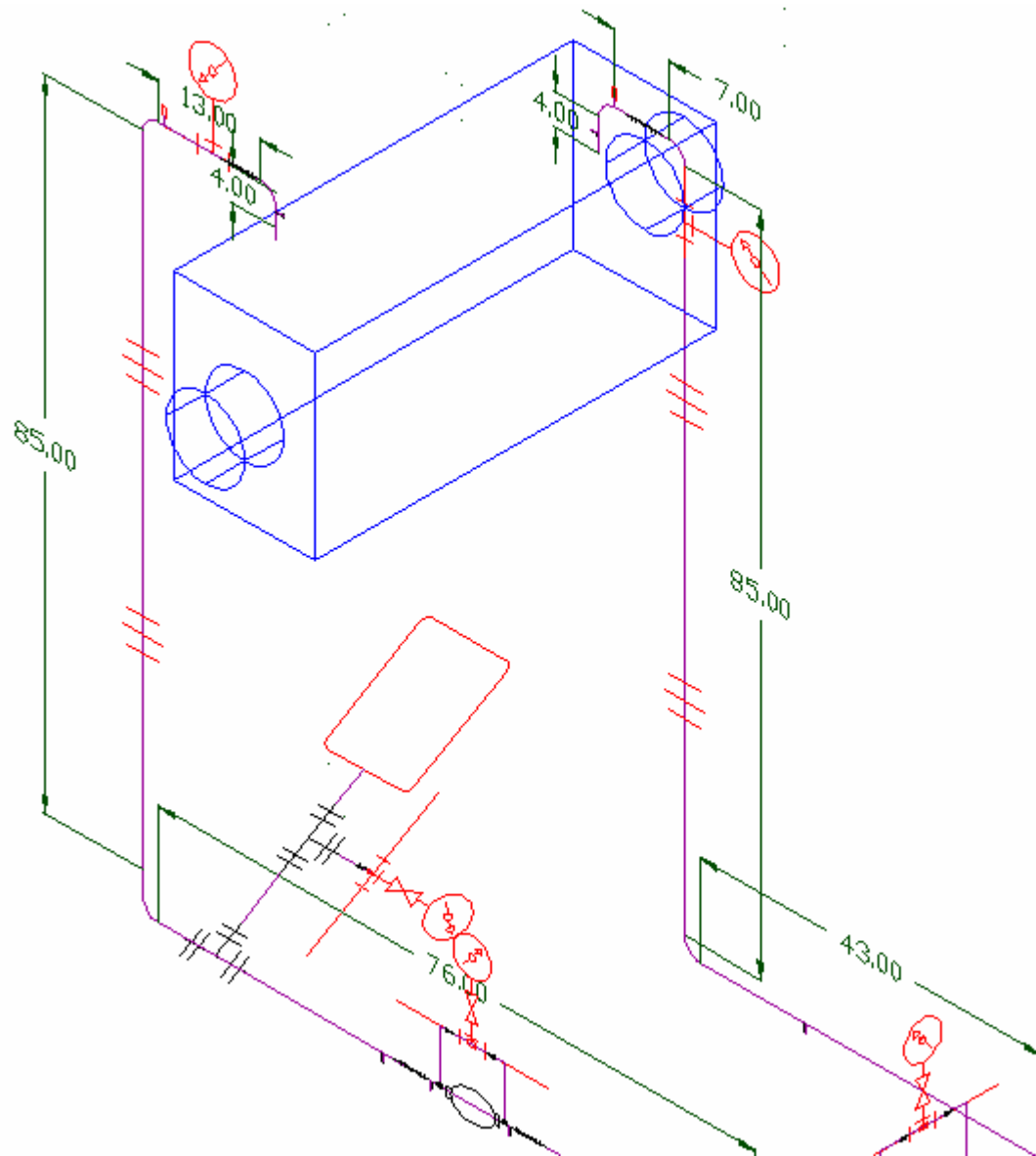


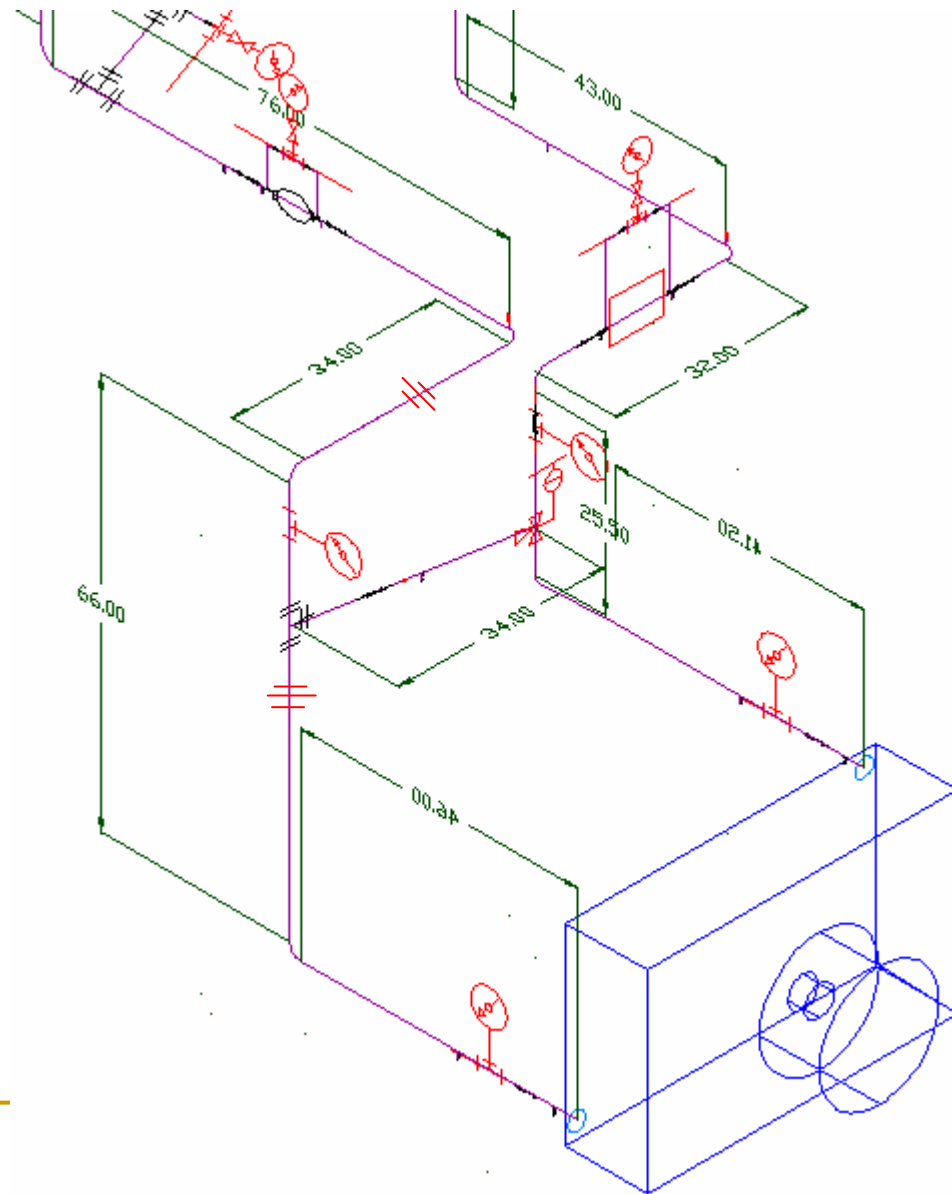
# Left View



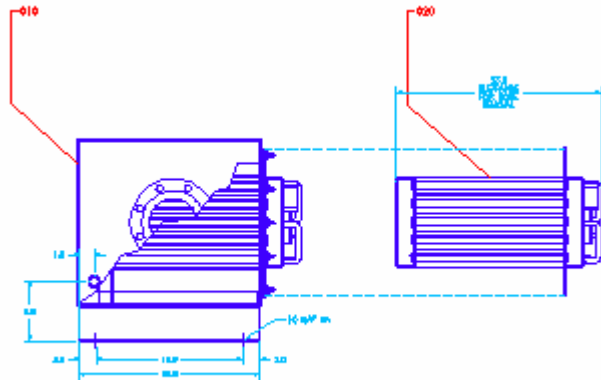
# Part List

Part	Description	Amount	Each cost	Total cost
Temperature Thermocouple	K or T type	6		0
Pressure Gauge	DPG1000DAR 4-20mA analog output, 0-60PSI, 9-32 VDC	3	259	777
Expansion Tank	HFT30, 4.4Gal total capacity, 2Gal expansion	1	34.18	34.18
Bronze Ball Valve	Reinforced TFE-seat material, 1-1/2in full port, 2-piece body	10	V	#VALUE!
Circuit setter,sweat	30 Gpm, 1-1/2 in.. Pipe	1	74	74
Pump	Centrifugal, 1/3Hp, 30Gpm, single phaze	1	672	672
Unit Heater	290,000 Btu/hr, S-type	1	1655	1655
Heat exchanger	Cains	1	10000	10000
Stop cock ball valves		5	V	#VALUE!
Snubbers	PS4E 1/4 x 1/4"	3	10	30
Thermocouple wells	For 1/8 in.. Thermocouples	6	V	#VALUE!
Mass flow meter	FLSC28-Signal conditioner,0-5V	1	524	524
	FTB106-Turbine flow mwter, 4-60 linear range (Gpm)	1	1289	1289
Drainer	To drain out the fluid from the isolated area with 1/2 in fitting	12	V	#VALUE!
Charger	To charge the fluid in the system	1		0
Air vent	400 automatic air vent	4	6.45	25.8
Joints	<b>T-Joints</b> 1-1/2 to 1-1/2	1	V	#VALUE!
	1-1/2 to 3/4	1	V	#VALUE!
	3/4 to 1/2	1	V	#VALUE!
	1-1/2 to 1/2	4	V	#VALUE!
	1/2 to 1/4	1	V	#VALUE!
	<b>Elbow joints</b> 1-1/2 to 1-1/2	12	V	#VALUE!
	1/2 to 1/2	4	V	#VALUE!
	<b>Unions</b> 1-1/2 to 1-1/2	6	V	
3-way valve	Rwd62U-single loop controller with two 0-10VDC analog outputs	1	100.45	100.45
	3213-1-1/4in 3W BR control valve UFXUF with 0-10VDC	1	292.77	292.77
	556-541- Nickel immersion temperature sensor	1	35.02	35.02
	30VA transformer for RWD controller	1	21.64	21.64
	RWD paramerer adjustment software tool CD (Windows based)	1	6	6
Insulation material	Fiber glass, Neoprene (AS&T)			

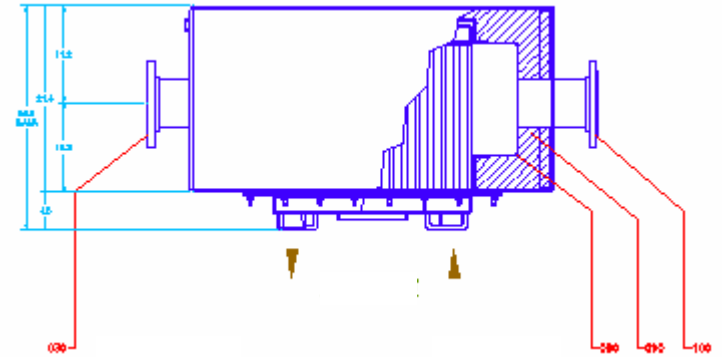




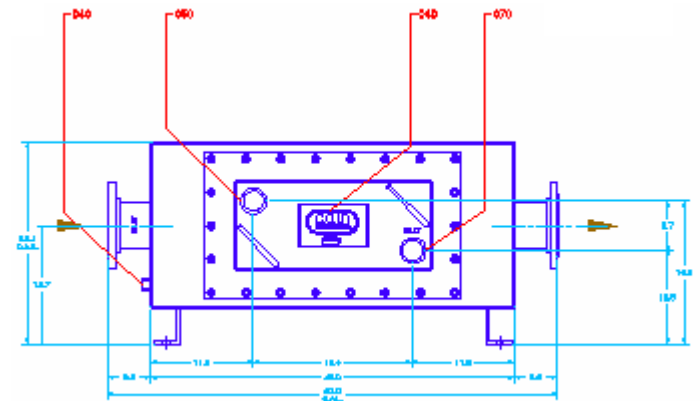
# Heat Exchanger



Inlet View



Top View



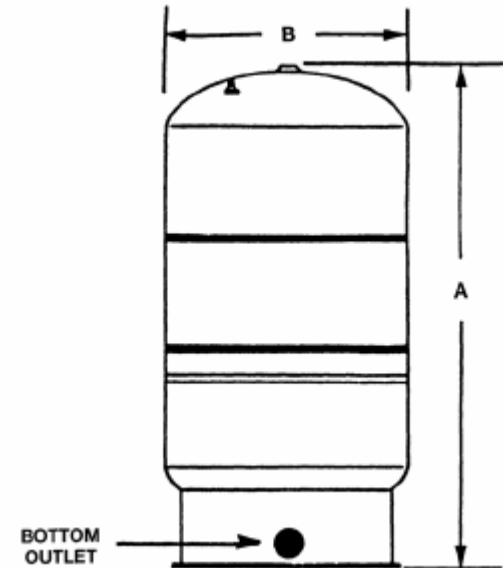
Header View

# Heat Exchanger

- Exhaust gas entering temperature = 1004 °F
- Exhaust gas leaving temperature = 356 °F
- Maximum inlet exhaust temperature = 1250 °F
- Exhaust gas flow rate = 356 CFM
- Liquid entering temperature = 170 °F
- Liquid leaving temperature = 190 °F
- Liquid flow rate = 30 GPM
- Pressure drop = 0.31 PSIG
- Heat Recovered = 290,000 Btu/hr
- Dry weight = 725 lbs
- Surface area = 87 ft<sup>2</sup>
- Design pressure = 75 PSIG
- Material of construction:
  - ✓ Tube – TP316 stainless steel
  - ✓ Fins – TP304 stainless steel
  - ✓ Shell – stainless steel

# Expansion Tank

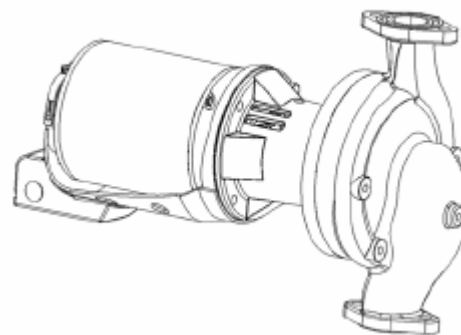
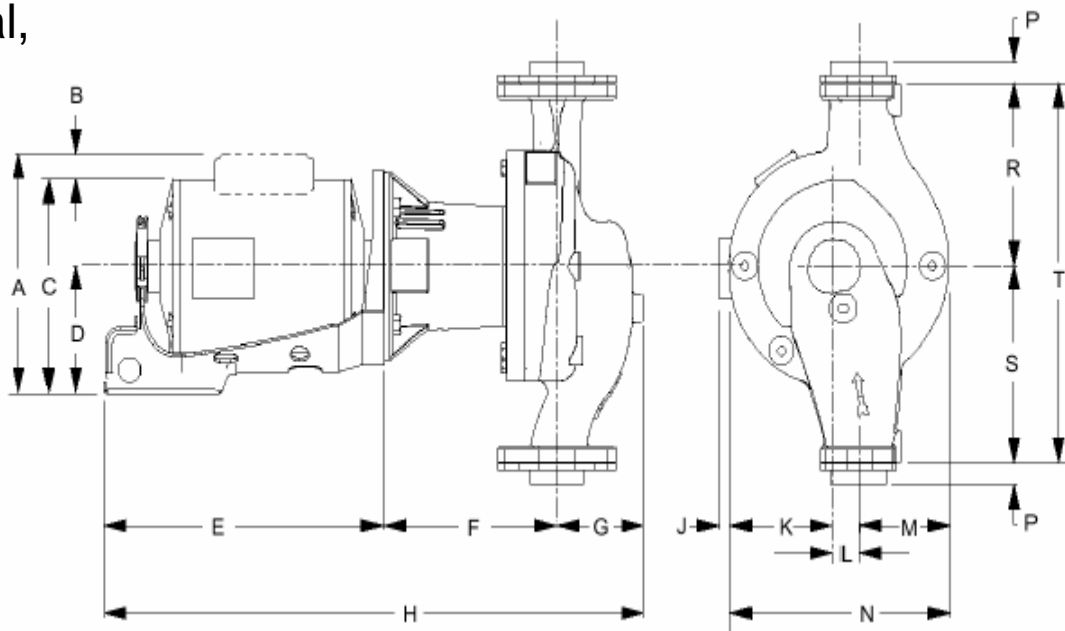
- Model: HFT30
- System connection: ¼" NPT
- A = 15 ½"
- B = 11"
- Weight = 9 lbs
- Total capacity – 4.4 gal
- Expansion – 2 gal
- Max. design pressure – 100 psi
- Max. design temperature – 240 °F



# Pump

- Model – Series60, Centrifugal,  
1/3 HP, Single phaze,  
1750 RPM

A = 10"	K = 3"
B = 2 ¼"	L = 1"
C = 7"	M = 2 ½"
D = 4"	N = 7 ½"
E = 10"	P = ¾"
F = 6"	R = 5"
G = 3"	S = 6"
H = 19"	T = 11"



- Maximum working pressure = 175 PSI
- Attainable head loss (30GPM) = 27ft of water (11PSI)
- Head loss in the pipeline = 23ft of water(10 PSI)

# Circuit Setter

➤ Model – CB-1 ½ S

A = 5"

B = 3"

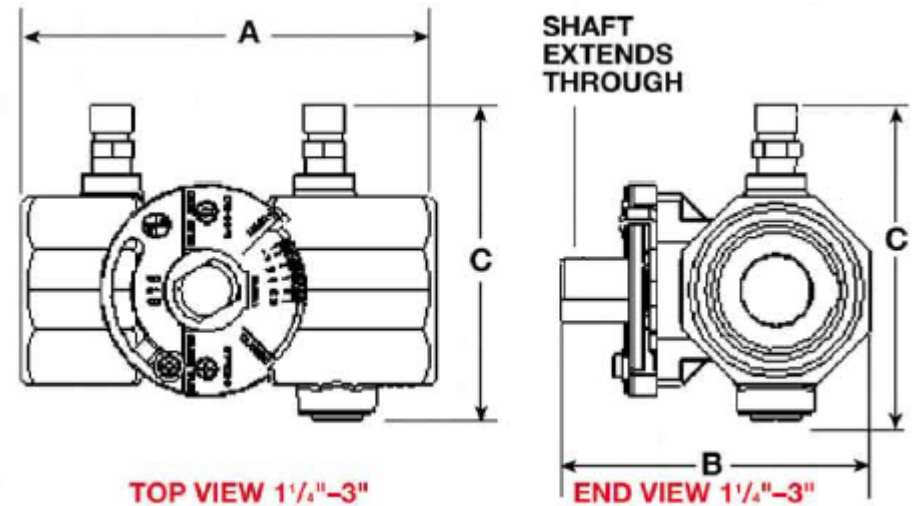
C = 4"

➤ Weight = 3 ½ lbs

➤ Flow rate – 30 gpm

➤ Design pressure – 175 psi

➤ Design temperature – 250 °F



# Unit Heater

## ➤ Model – S type (horizontal)

A = 52"

B = 32 1/4"

C = 13 3/4"

DD = 26 1/2"

EE = 12 3/4"

F = 5"

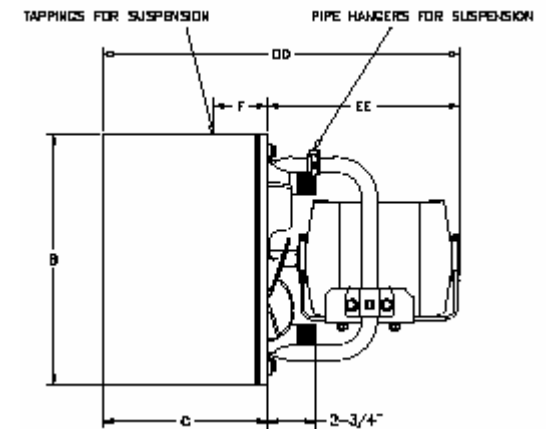
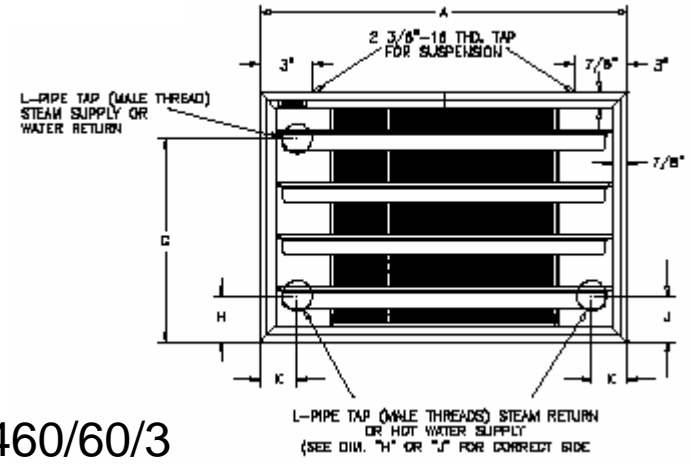
G = 22"

K = 2"

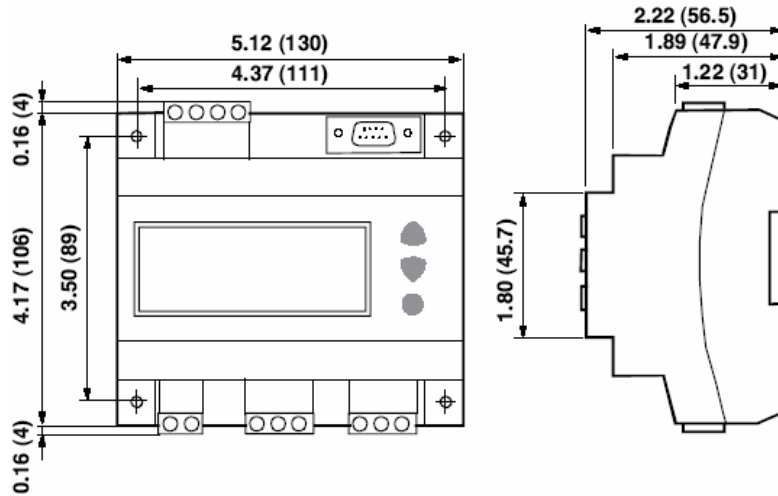
L = 1 1/2"

## ➤ Motor:

- ✓ Model – 400
- ✓ Type – Totally enclosed
- ✓ Operating Voltage – 208-230/460/60/3
- ✓ HP – 3/4
- ✓ RPM - 1140



# 3 Way Valve – Temperature Controller



- Model – RWD62U
  - ✓ Operation : Temperature – 23 to 122 °F  
Humidity - <95% RH
  - ✓ Inputs/Outputs: Input – 2 Analog, 1 Digital  
Output – 2 Analog, 0-10Vdc
  - ✓ Digital (LCD): Actual and nominal values – 3 digits  
Resolution of values <100 – 0.5 °F
  - ✓ Power consumption: 1.7 VA
  - ✓ Interrogation speed cycle time – 2sec

## 3 Way Valve – Mixing Valve

- Model – APC 271, 1/2 to 2” mixing
- Type – Electronic non-spring return actuator
- Material – Brass
- Connection – UF x UF   UF – Union Female
- Voltage – 0-10VDC



## 3 Way Valve – Temperature Sensor

- Model – 556-541
- Type – Immersion sensor
- Range of use: -13 to 203 °F
- Sensing element: SBT Ni 1000
- Connecting cable length: 6ft



## Flow Meter

Signal conditioner:

- Model – FLSC-28
- Output voltage – 0-5V
- Power – 10-40Vdc @ 10mA
- Accuracy – up to 0.5%

Ball bearing:

- Model – FTB-106
- End connections – 1" NPT
- Linear range – 4-60 GPM
- Accuracy – 1/2 %
- Temperature range - -450 to 450 °F
- Material of body – 304 stainless steel
- Material of bearings – 440C stainless steel



## Pressure Gauge

- Model : DPG1000DAR
- Type : DC powered with dual alarms and analog output
- Pressure Range : 0 – 60 psi
- Accuracy = 0.25%
- Operating temperature : - 4 – 185F
- Analog output : 4 – 20 mA dc
- Analog output response time : 50 msec
- Power : 9 – 32 Vdc
- Electrical connection : 3 ft long, 4-conductor 22 AWG shielded cable for power and retransmitted output. 3 ft long, 6-conductor 22 AWG shielded cable for alarm contacts.
- Thread type : ¼” NPT

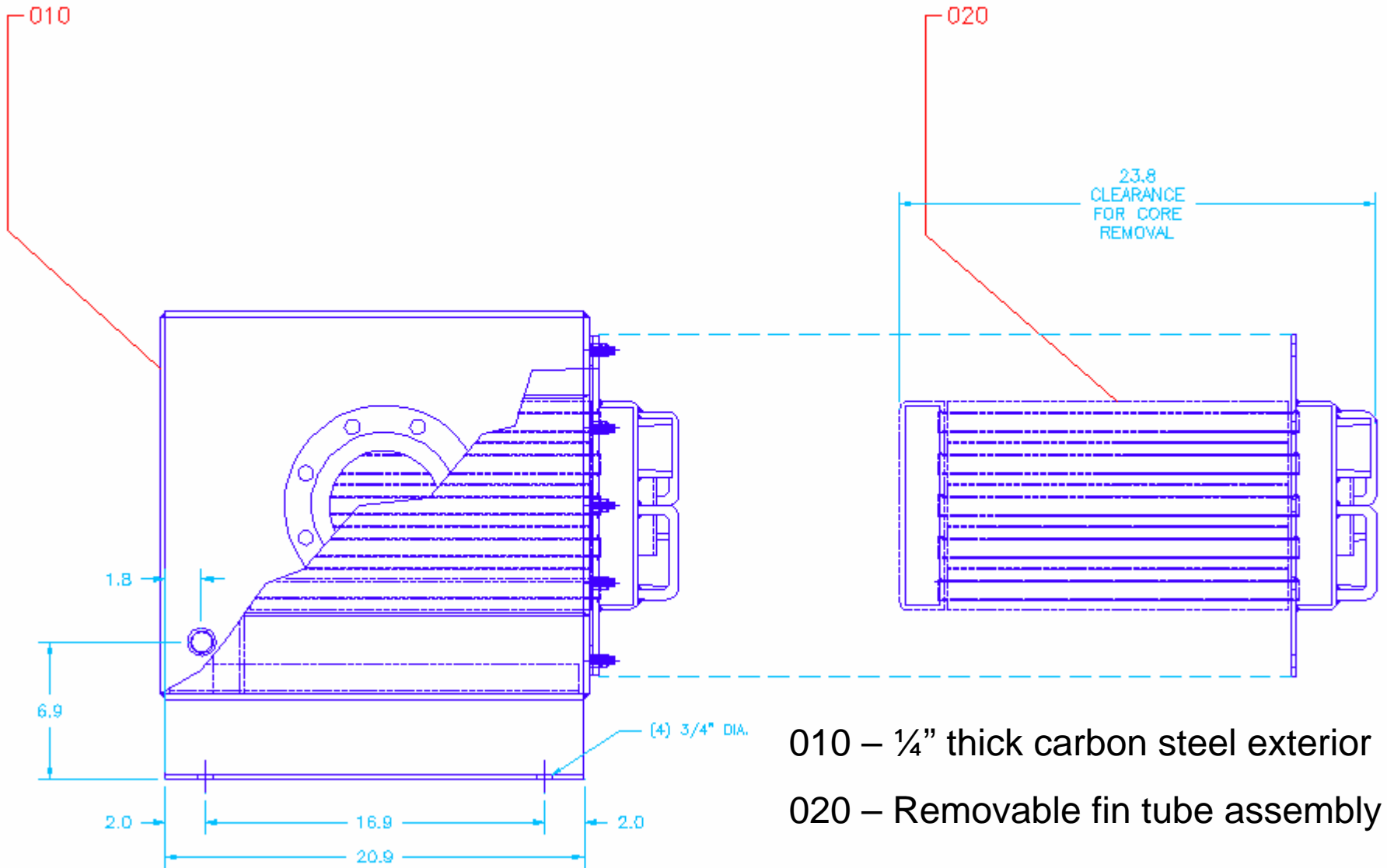


# Snubbers

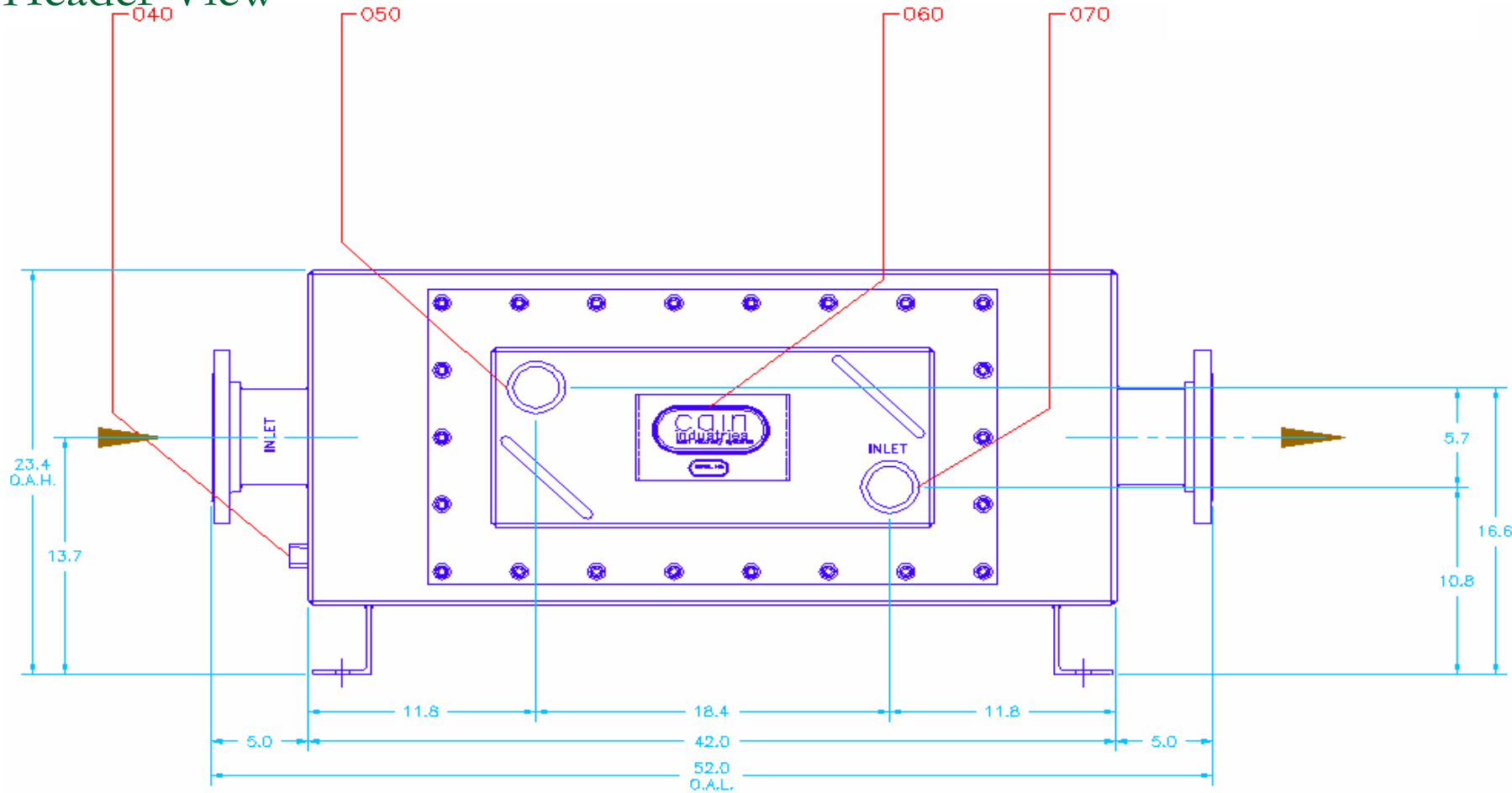


- Model – PS-4E
- Description – ¼ x ¼” NPT
- Pore Opening:
  - ✓ Mean -0.0013”
  - ✓ Max – 0.0025”

# Inlet View



# Header View



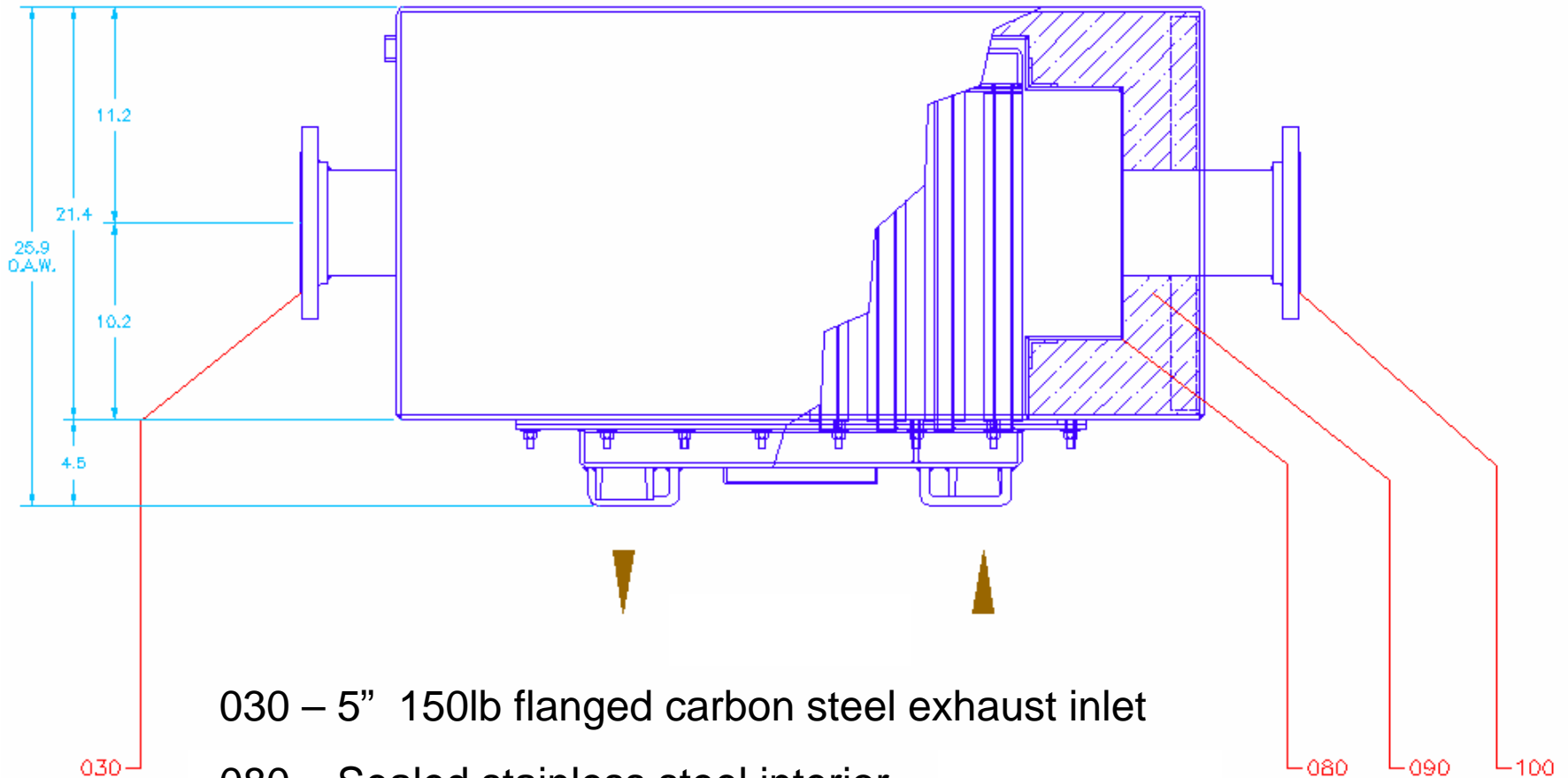
040 – ¾" NPT condensate drain connection

050 – 2" NPT liquid outlet connection

060 – CAIN logo and serial number ID

070 – 2" NPT liquid inlet connection

# Top View



030 – 5" 150lb flanged carbon steel exhaust inlet

080 – Sealed stainless steel interior

090 – 4" thickness factory insulation

100 - 5" 150lb flanged carbon steel exhaust outlet

## Air Vent



- Model - #400 automatic air vent
- Connection – 1/8" male NPT
- Max. operating temperature – 240 °F
- Max. operating pressure – 150 PSIG

## Ball Valve

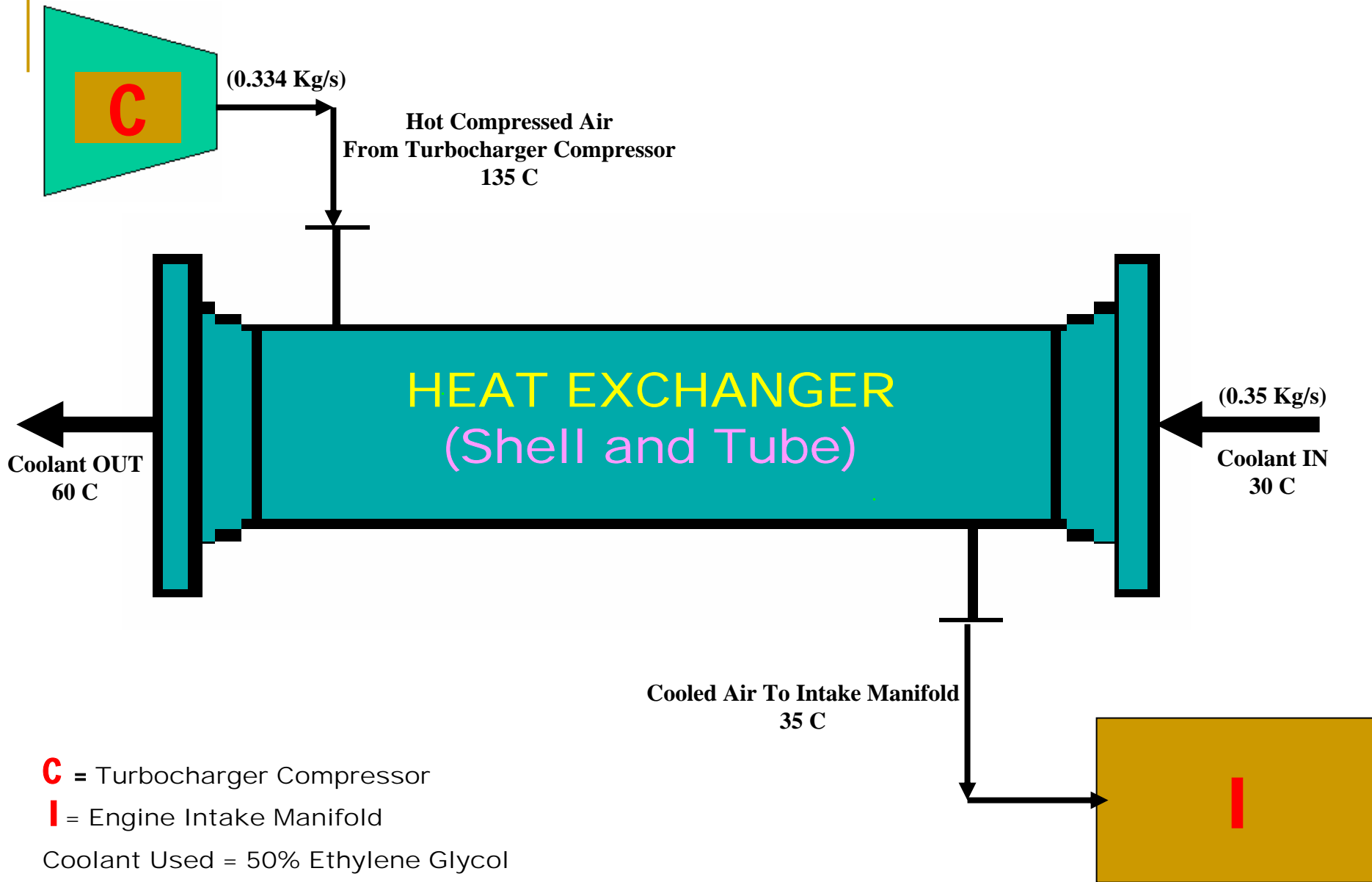
- Type – Full port, two piece body
- Orifice – 1 ½”
- Seat material – Reinforced TFE
- Ball material – Stainless steel
- Body material - Brass



## Stop Cock Ball Valve

- Orifice – ½”
- Body material - Brass





<b>Property</b> (at mean fluid temperature )	<b>Air</b> ( Compressed)	<b>Ethylene Glycol</b> ( 50% )
<b>Density</b> Kg/m <sup>3</sup>	<b>2.13</b>	<b>1040</b>
<b>Viscosity</b> Pa.s	<b>21x10<sup>-6</sup></b>	<b>0.0015</b>
<b>Thermal Conductivity</b> W/m-C	<b>0.033</b>	<b>0.42</b>
<b>Specific Heat</b> KJ/Kg-K	<b>1.01</b>	<b>3.3</b>

## Heat exchanger Specifications (Contd..)

### Fluid Allocation:

Shell Side:	Air
Tube Side:	Ethylene Glycol (50%)

### Flow Rate:

Air:	0.334 Kg/s
Ethylene Glycol:	0.355 Kg/s

**Heat Recovered:** 33.835 KW

### Temperatures:

Air:	135 C (in)	35 C (out)
Ethylene Glycol:	30 C (in)	60 C (out)
LMTD:	25 C	

# Heat exchanger Specifications

Item	Symbol	value	Description
1.	$D_s$	438 mm	Inside Shell diameter
2.	$D_t$	15.875 mm	Tube Outside diameter
3.	$L_{tw}$	2 mm	Tube wall thickness
4.	$D_{ti}$	11.875 mm	Inside tube diameter
6.	$L_{tp}$	20.000 mm	Tube layout pitch
7.	$L_{ta}$	2000 mm	Effective tube length
8.	$N_{tt}$	145	Total Number of Tubes
9.	$N_b$	9	Number of baffles
10.	$Re_s$	12,280	Shell Side Reynolds number
11.	$U_o$	120 W/m <sup>2</sup> K	Overall Heat Transfer Coefficient
12.	$A_o$	14.09 m <sup>2</sup>	Total heat transfer surface area of tubes
13.	$\Delta P_s$	0.8 psi	Shell Side pressure drop
14.	$\Delta P_t$	0.05 psi	Tube Side pressure drop

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## Intended Future Work

- Purchase of supplies and equipment for the exhaust heat exchanger system
  - Installation of the system
  - Measurement, system performance and cost analysis
  - Selection of turbocharger heat exchanger system
    - ✓ Air to liquid
    - ✓ Air to air
  - Procurement of turbocharger heat exchanger system
  - Installation of turbocharger heat exchanger system
  - Conformation of demonstration site
  - Outline the duty and expense list for the subcontract
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Thank you !!!

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