
LEADING THE WAY
CampusEnergy2022
Feb. 15-18 | Westin Boston Seaport District Hotel | Boston, Mass.
INTERNATIONAL DISTRICT ENERGY ASSOCIATION

Maximizing Energy Efficiency Through Condensing Economizers

Joseph Richter, Combustion & Energy Systems, LTD.

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CampusEnergy2022
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COMBUSTION & ENERGY SYSTEMS LIMITED

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

- Until a renewable energy source is available for reliable and continuous District Heating, a solution to emission reductions is Energy Efficiency through Waste Heat Recovery.

- Utilizing waste heat not only reduces fuel consumption improving overall efficiency, but reduces greenhouse gas and carbon emissions.

The added benefit – **Lower operating costs for the same output**.

Condensing Heat Recovery Systems

- Standard heat recovery systems like economizers, can reduce boiler stack temperatures to about 250F and are designed to avoid condensation of the flue gas.
- A condensing economizer improves heat recovery by capturing energy well below the dew point of the flue gas.

The Goal: Recover the maximum amount of usable heat possible from your exhaust gas

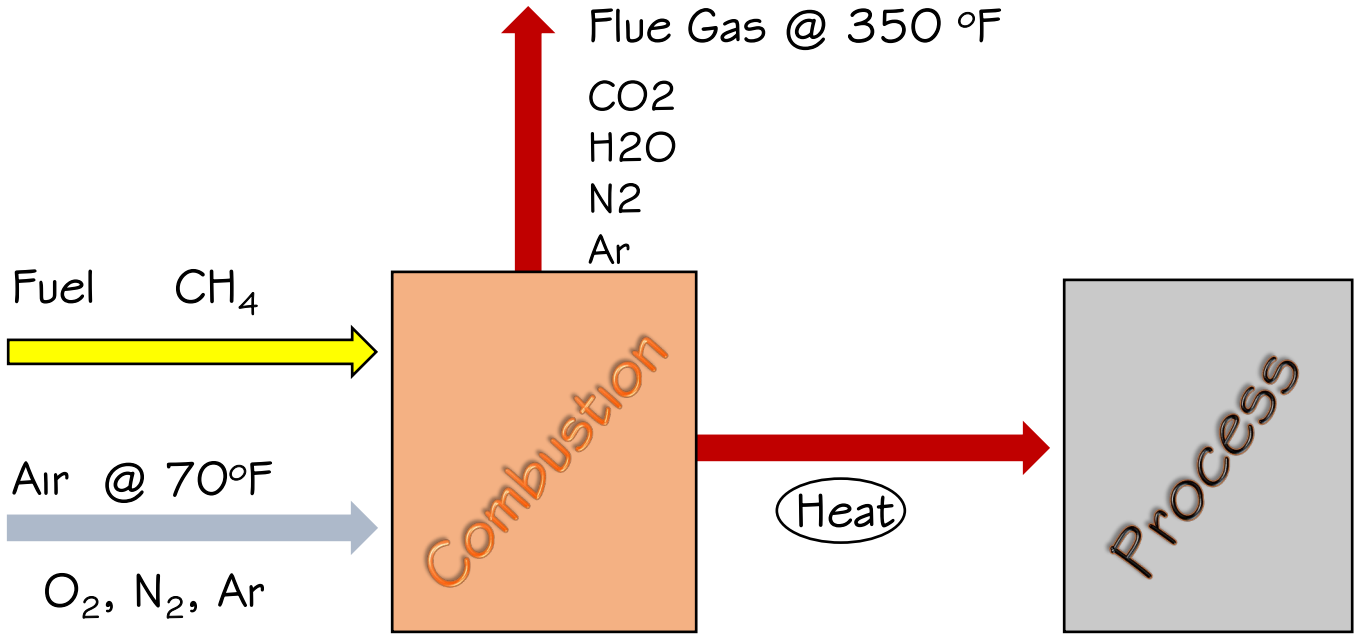
You paid for it, you might as well use it!

Sources of Hot Gas

Combustion Sources
- Boilers
- Turbines
- Engines
- Thermal Oxidizers
- Etc.

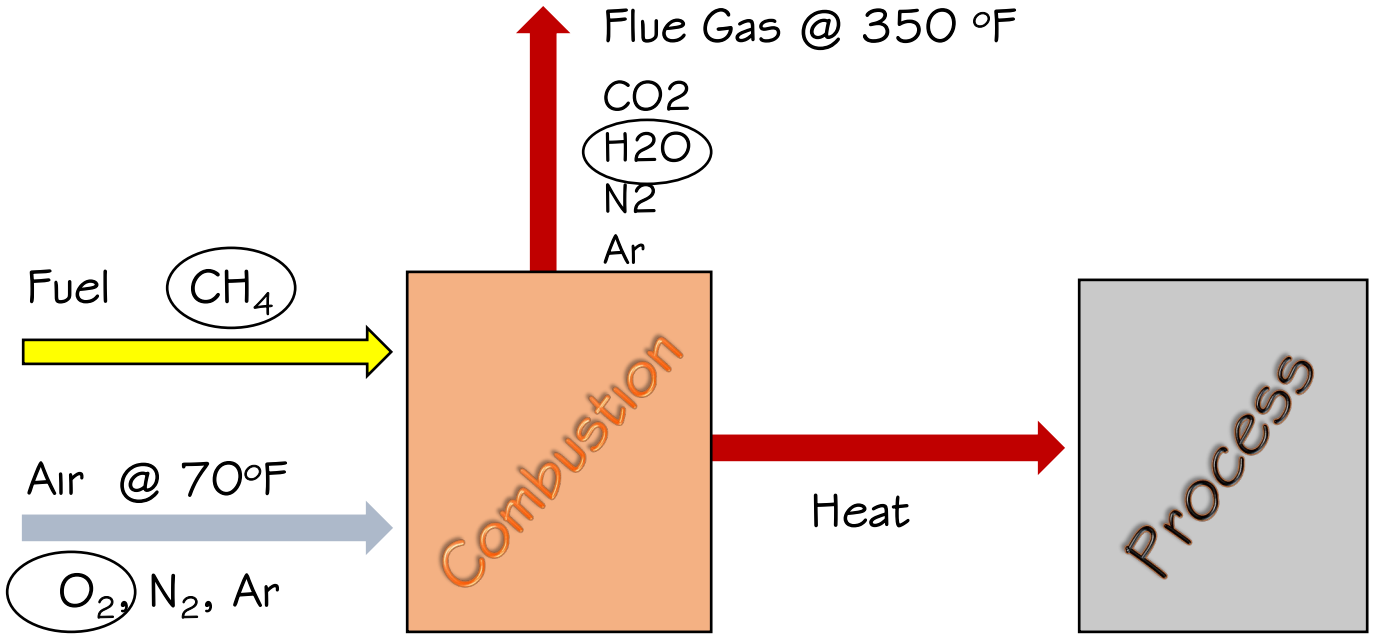
Hot Wet Air
- Dryers
- Ovens
- Etc.

BTU Content in the fuel ≠ Energy to the process or heating load



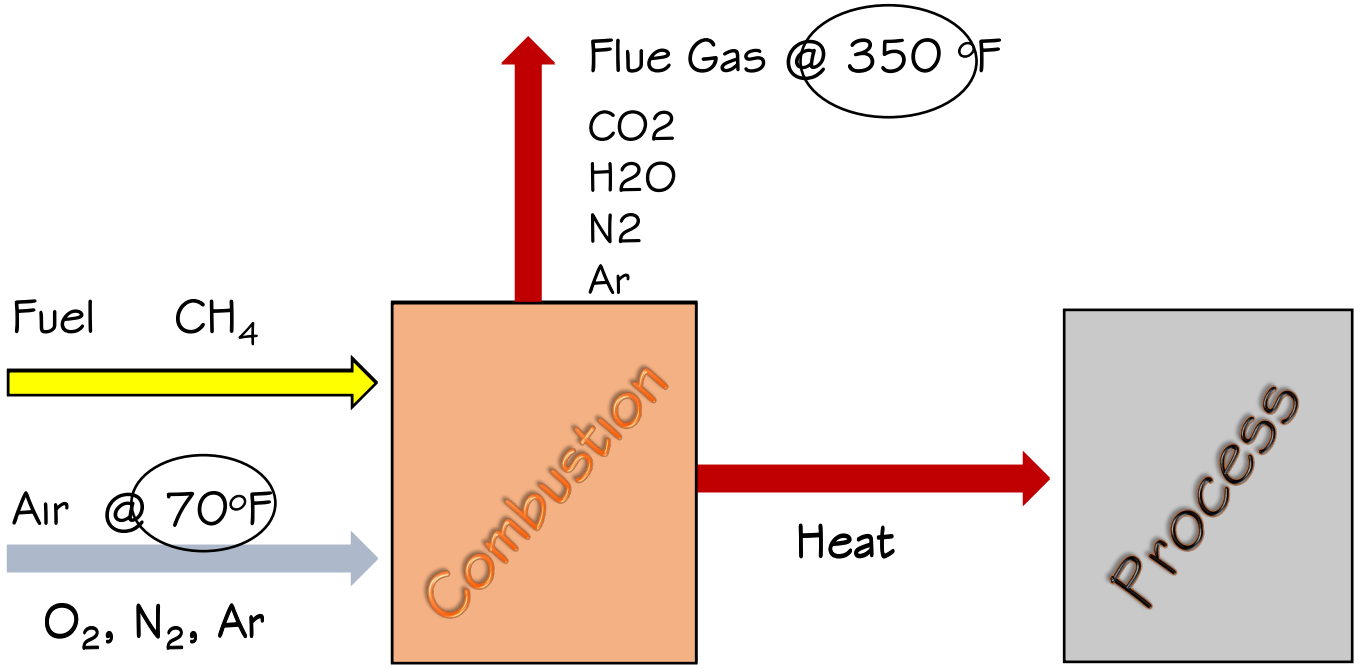
Energy From the Fuel

1. Process – 77%



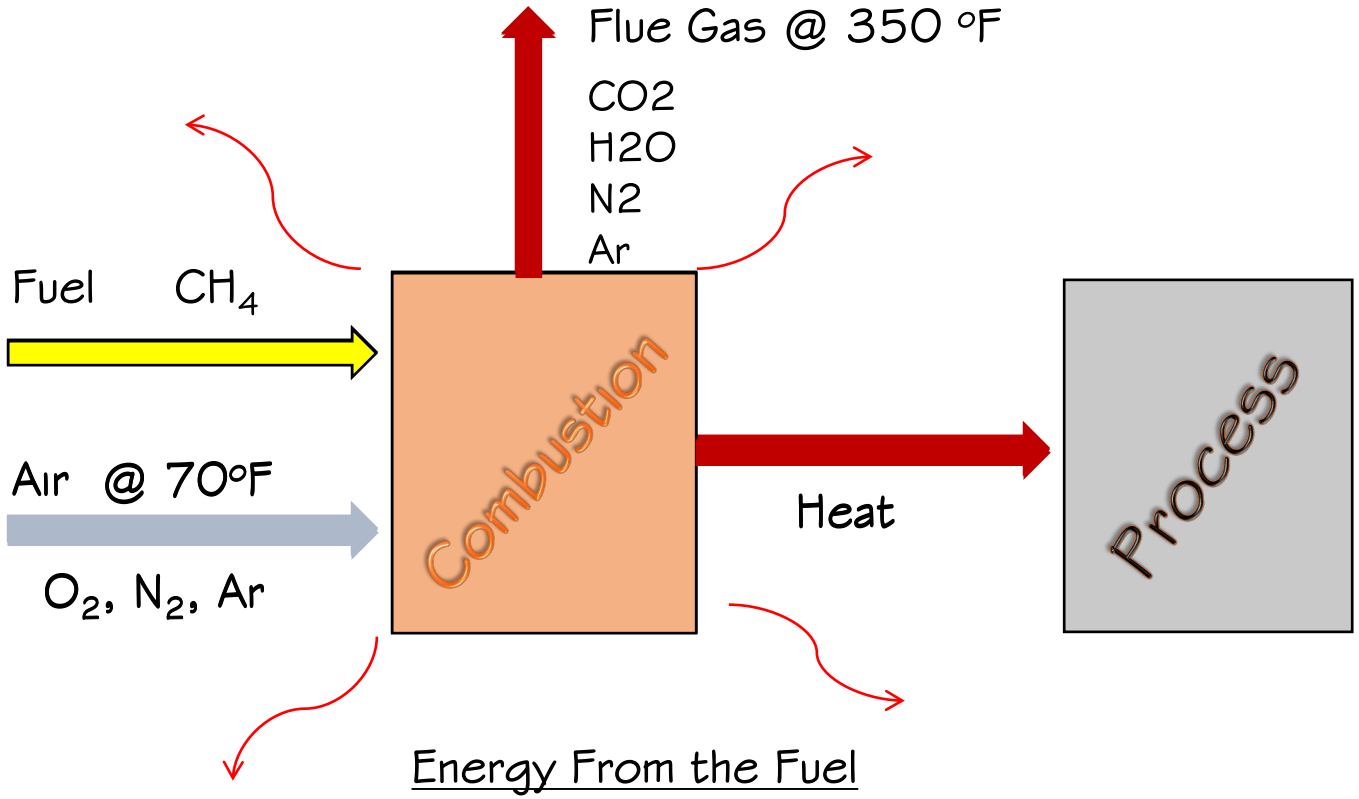
Energy From the Fuel

1. Process – 77%
2. Vaporize H_2O – 15%



Energy From the Fuel

1. Process – 77%
2. Vaporize H_2O – 15%
3. Heat The Air – 6%

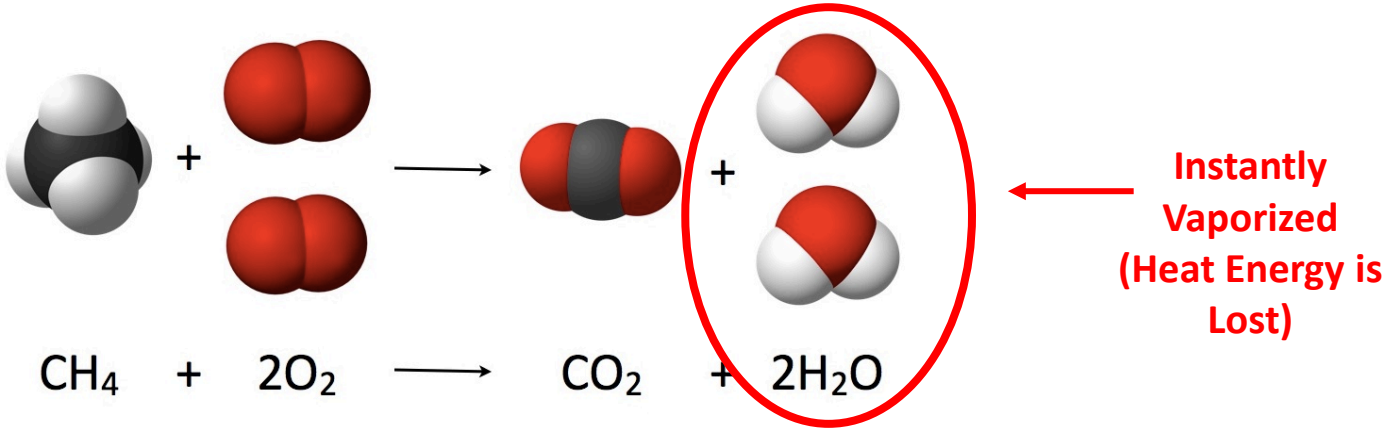


Energy From the Fuel

1. Process – 77%
2. Vaporize H_2O – 15%
3. Heat The Air – 6%
4. Setting Losses – 2%

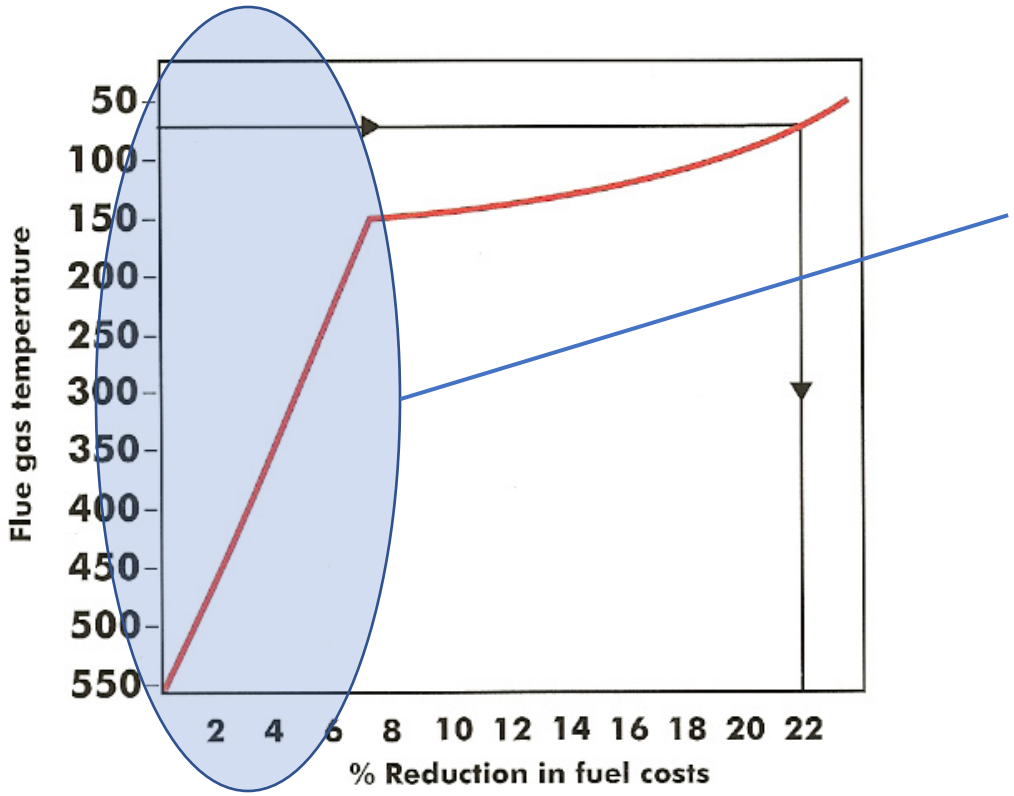
Condensing Heat Recovery
The Energy Bonus

- Waste heat is categorized as sensible and *latent heat*
- Evaporating water absorbs ~15-20% of the total heat created by the fuel and it is lost to the atmosphere in the exhaust gas



Condensing Heat Recovery Reduces This Loss!

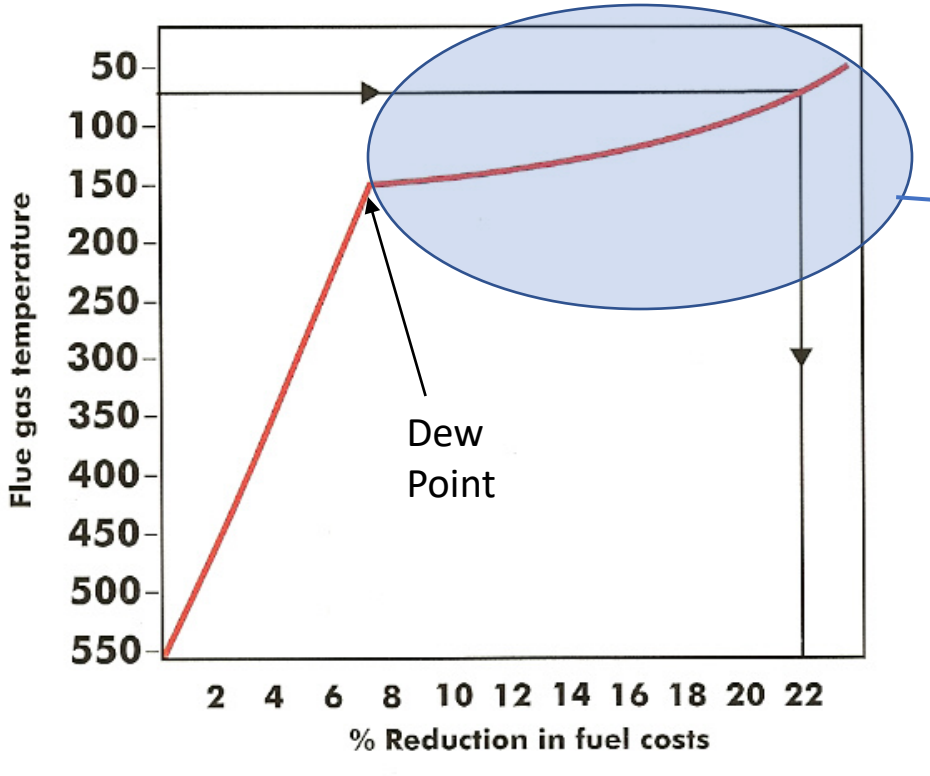
Sensible and Latent Heat



Air to Air Heat Exchangers, Energy Wheels & Standard Economizers utilize *Sensible* Heat Recovery

(heat available through temperature change only)

Sensible and Latent Heat



Condensing Economizers are designed to take advantage of latent heat recovery by condensing the water out of flue gases.

Condensing Heat Recovery
How it Works

- By heating cold process liquids with hot boiler exhaust gases the ConDex system recovers both *sensible* and *latent* heat energy.
- As the hot exhaust passes over the ConDex finned tubes, the gases are cooled beyond the point where water vapor condenses out, releasing the energy it took to vaporize it initially.
- The phase change from vapor to liquid recovers approx.:

1,000 BTU of Energy for every Pound of Water Condensed

How Much Energy Is Lost in Exhaust Gases?

Assume 80 Degree Ambient Temp.

Boiler Input – 100 MMBTU/Hr

Gas Outlet Temperature After Standard Economizer = 350 ^{o}F

86,000 #/Hr Exhaust at 350 ^{o}F

Application: Package Boiler

How Much Energy Is Lost in Exhaust Gases?

Application: Package Boiler

Assume 80 Degree Ambient Temp.

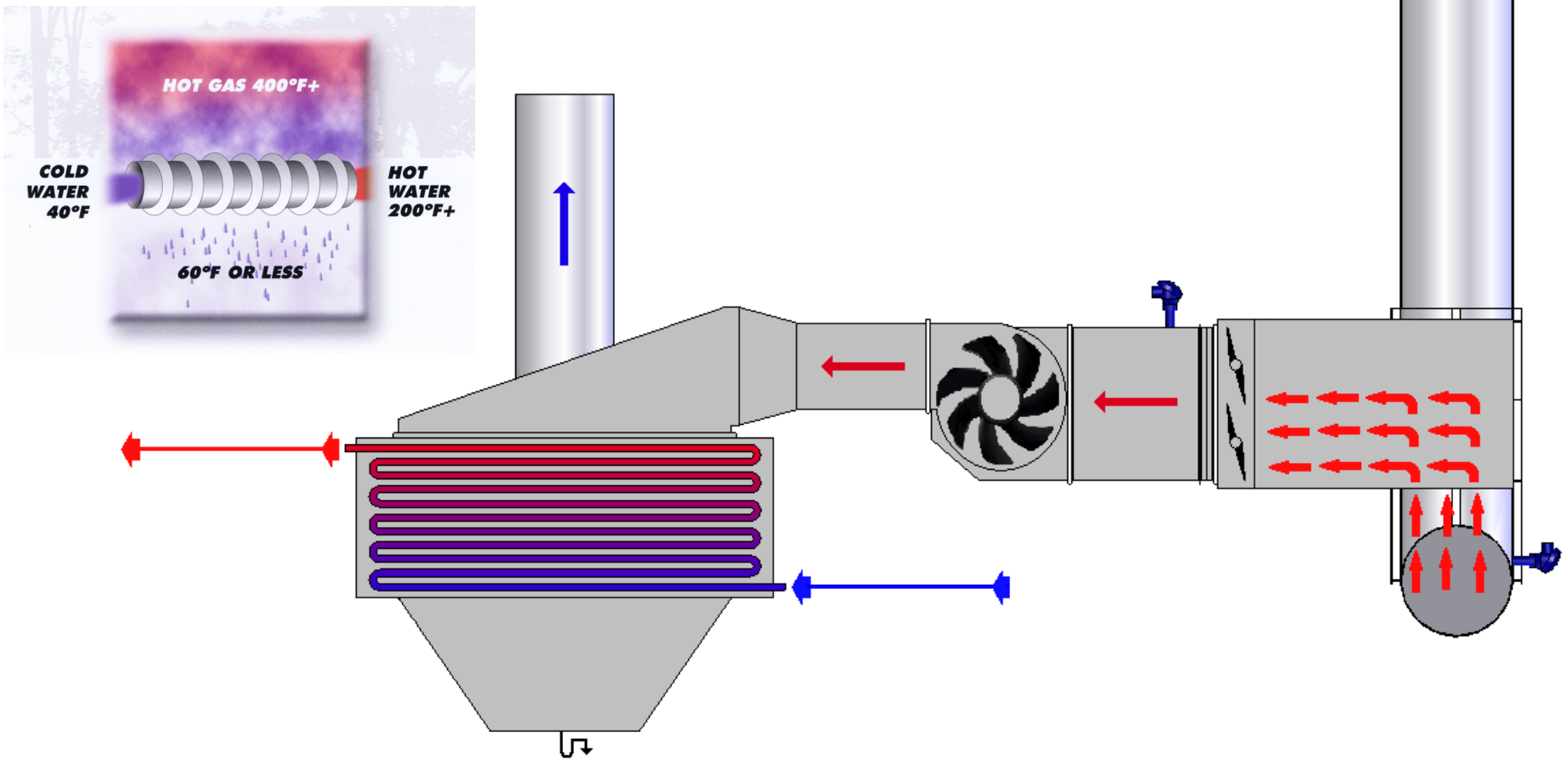
Boiler Input – 100 MMBTU/Hr

Gas Outlet Temperature After Standard Economizer = 350 °F

86,000 #/Hr Exhaust at 350 °F

12.3 MMBTU/Hr Lost to the Atmosphere!

Condensing Heat Recovery
The System



Because each installation is custom engineered, the required materials of construction are established based on the site specific requirements.

Standard material of construction is 304L stainless steel. Specialized metallurgy such as titanium, Incoloy or Hastelloy are used. Coatings such as Heresite are also used.

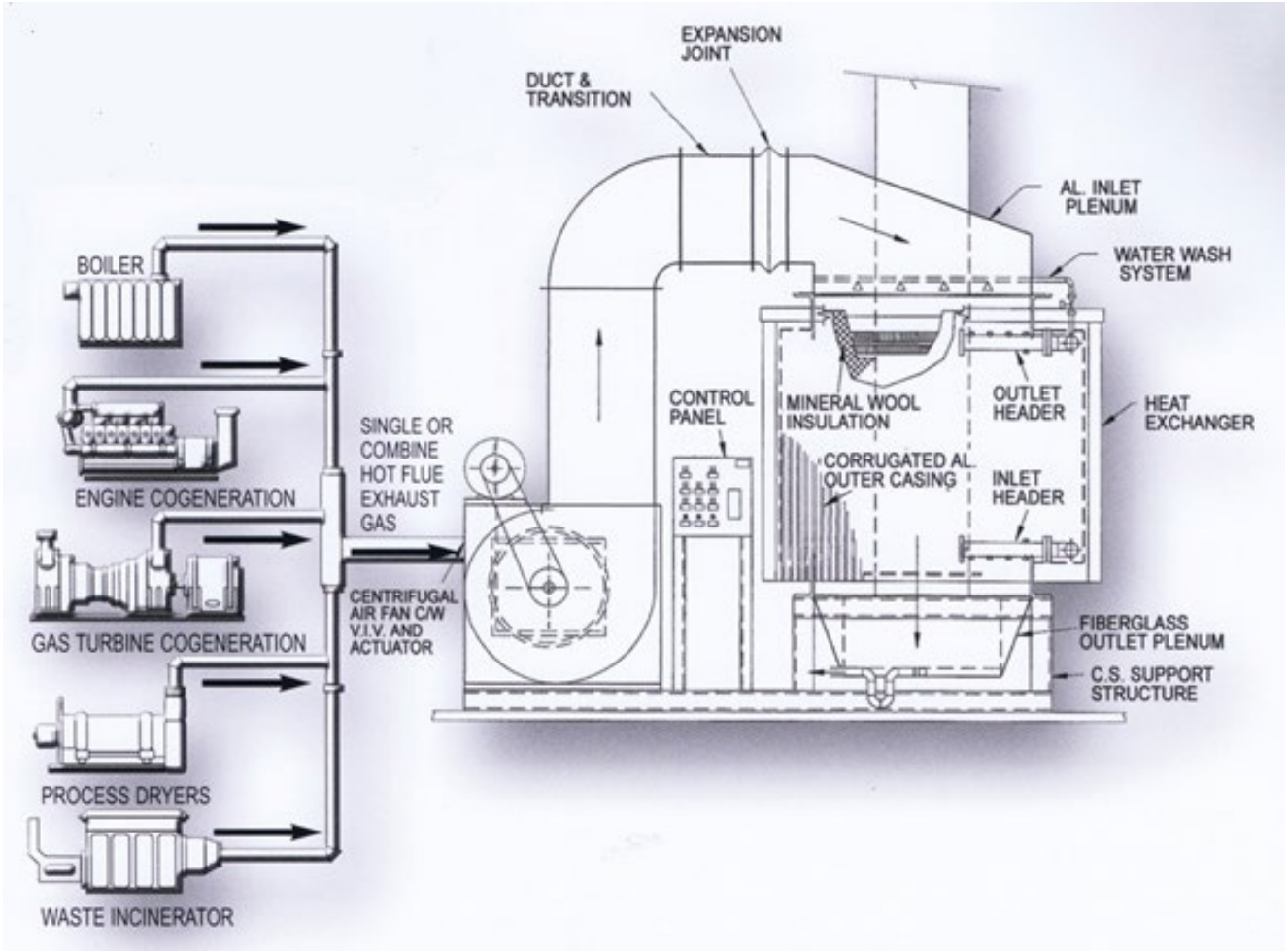
WATER RECOVERY FROM EXHAUST GAS

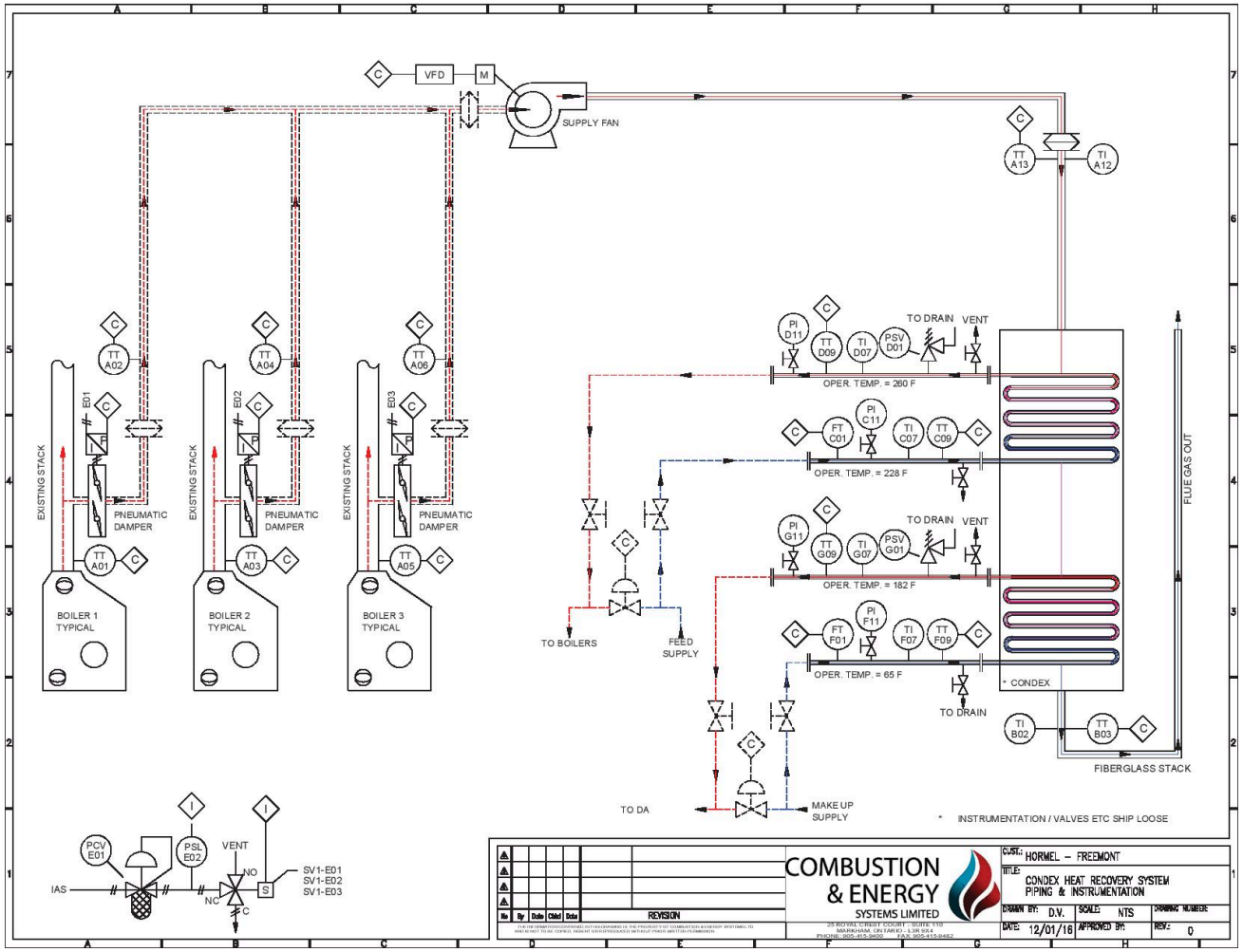
- Condensed water recovery rates vary from 4 – 60 Gallons Per Minute, depending on the application.

- Water is reusable in many applications such as boiler make up water, cooling tower water or process water.

Standard Condex Condensing Economizer

- Can take hot gas from multiple generators
- Does not interfere with existing exhaust flow
- Includes ID Fan, stack and controls
- Can heat multiple, independent liquid streams





Capture heat from multiple heat sources using a single ConDex Economizer.

Heat multiple independent Liquid streams such as process water and make up water.

vicinity

Grand Rapids, MI

Provides Steam to buildings in the downtown area for space heating and cooling, domestic hot water, chilled water, humidification and sterilization.

2 Natural Gas- Powered Boilers

Make-Up water going to the DA

Fuel Savings $1.1 MM/Year

CO2 Reduction: 6,350 Tons/Year

NOx Reduction: 4.14 Tons/Year

ConDex PERFORMANCE DATA SHEET

Date:	January 27, 2009	Designed by:	Dan Veitch
Customer:	Trigen		
Reference:	Grand Rapids		
Quotation No.:	209055	**MONTHLY AVERAGE DESIGN**	

Heat recovery system in the ***Condensing*** mode.

Fuel: Natural Gas

Gas side:	Gas type	Boiler Flue
	Total flow rate	114000 lb/hr
	Inlet temperature	396 °F
	Outlet temperature	127 °F
	Dew point	134 °F
	H_2O vapor by weight @ inlet	11.3 %
	H_2O vapor flow @ inlet	12882 lb/hr
	H_2O vapor flow @ outlet	10259 lb/hr
	H_2O condensed	2623 lb/hr
	Specific heat @ avg. temperature	.026 Btu/lb·°F
	Pressure drop	2.35 inch w.c.
	Fouling factor	.002 hr· ft^2· F/Btu
	Maximum velocity at inlet temperature through the new free area	26 fps

Liquid side:	Fluid type	Boiler Make Up
	Total flow rate	99567 lb/hr
	Inlet temperature	85 °F
	Outlet temperature	190 °F
	Pressure drop	10 psi
	Fouling factor	.001 hr· ft^2· F/Btu
	Velocity at average temperature	4 fps

Sensible Heat Load:	7,955,175 Btu/hr
Latent Heat Load:	2,619,834 Btu/hr
TOTAL HEAT RECOVERED (with 2% losses)	**10,575,009 Btu/hr**

Gas Flow: 114,000 Lb/Hr

Gas Temp In: 396 F

Gas Temp Out: 127 F

Water Flow: 99,567 Lb/Hr

Water Temp In: 85 F

Water Temp Out: 190 F

Energy Recovered: 10.57 MMBTU/Hr

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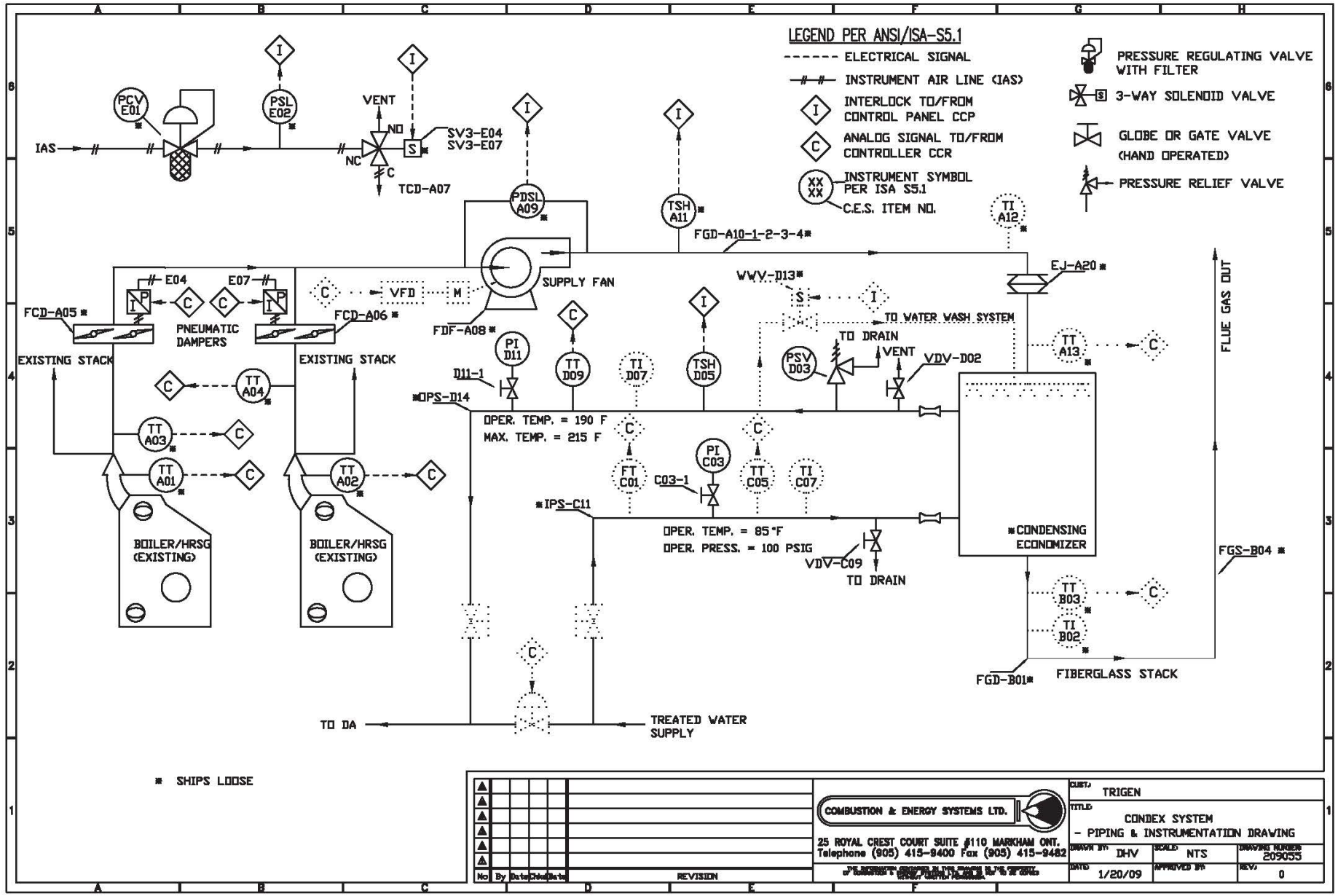

Indiana State University

Terra Haute, IN

Provides steam for heating, cooling and processes such as cooking or for research uses.

2 Natural Gas- Powered Boilers

Make-Up Water going to the DA

Fuel Savings $339 K/Year

CO2 Reduced: 1,939 Tons/Year

NOx Reduced: 1.27 Tons/Year

ConDex PERFORMANCE DATA SHEET

Date: October 26, 2009 Designed by: Dan Veitch
Customer: Indiana State University
Reference: Energy Recovery Project
Quotation No.: 209056

Heat recovery system in the ***Dry*** mode.

Fuel: Natural Gas

Gas side:	Gas type	Boiler Flue
	Total flow rate	92000 lb/hr
	Inlet temperature	290 °F
	Outlet temperature	158 °F
	Dew point	134 °F
	H_2O vapor by weight @ inlet	11.3 %
	H_2O vapor flow @ inlet	10396 lb/hr
	H_2O vapor flow @ outlet	10396 lb/hr
	H_2O condensed	0 lb/hr
	Specific heat @ avg. temperature	0.27 Btu/lb·°F
	Pressure drop	1.50 inch w.c.
	Fouling factor	.002 hr· ft^2· F/Btu
	Maximum velocity at inlet temperature through the new free area	30 fps
Liquid side:	Fluid type	Water
	Total flow rate	95000 lb/hr
	Inlet temperature	142 °F
	Outlet temperature	175 °F
	Pressure drop	20 psi
	Fouling factor	.001 hr· ft^2· F/Btu
	Velocity at average temperature	7 fps
Sensible Heat Load:		3,179,080 Btu/hr
Latent Heat Load:		0 Btu/hr
TOTAL HEAT RECOVERED (with 2% losses)		**3,179,080 Btu/hr**

Gas Flow:
Gas Temp In:
Gas Temp Out:
Water Flow:
Water Temp In:
Water Temp Out:
Total Energy Recovered:

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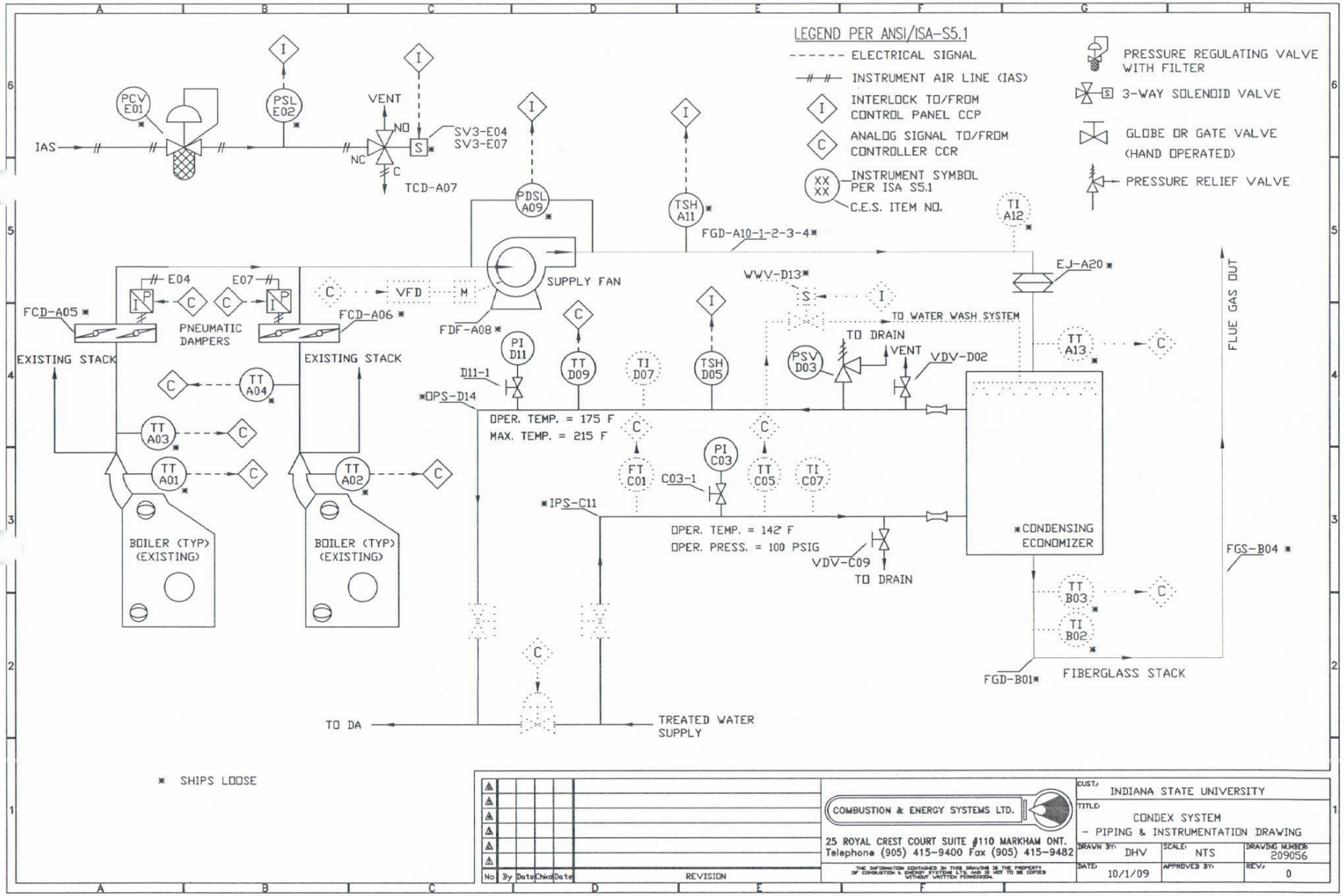


ConDex Condensing Economizer Systems
Less Exhaust Gas · Less Pollution · More Dollar Savings
www.condexenergy.com

K-STATE
Kansas State University

Manhattan, KS
Provides steam for campus heating and cooling

2 Natural Gas- Powered Boilers

Make-Up Water feeding to DA

Fuel Savings: $304 K/Year

CO2 Reduced: 2,683 Tons/Year

NOx Reduced: 1.75 Tons/Year

ConDex PERFORMANCE DATA SHEET

Date: August 19, 2010 Designed by: Dan Veitch
Customer: Kansas State University
Reference: Energy Recovery Project- Design Conditions
Quotation No.: 210237

Heat recovery system in the Condensing mode.

Fuel: Natural Gas

Gas side:	Gas type	Boiler Flue
	Total flow rate	70000 lb/hr
	Inlet temperature	310 °F
	Outlet temperature	129 °F
	Dew point	134 °F
	H_2O vapor by weight @ inlet	11.3 %
	H_2O vapor flow @ inlet	7910 lb/hr
	H_2O vapor flow @ outlet	6741 lb/hr
	H_2O condensed	1169 lb/hr
	Specific heat @ avg. temperature	0.26 Btu/lb·°F
	Pressure drop	1.75 inch w.c.
	Fouling factor	.002 hr· ft^2· F/Btu
	Maximum velocity at inlet temperature through the new free area	25 fps
Liquid side:	Fluid type	Water
	Total flow rate	31600 lb/hr
	Inlet temperature	55 °F
	Outlet temperature	195 °F
	Pressure drop	8.00 psi
	Fouling factor	.001 hr· ft^2· F/Btu
	Velocity at average temperature	3 fps
Sensible Heat Load:		3,302,170 Btu/hr
Latent Heat Load:		1,166,442 Btu/hr
TOTAL HEAT RECOVERED (with 2% losses)		4,468,612 **Btu/hr**

Gas Flow: 70,000 Lb/Hr

Gas Temp In: 310 F

Gas Temp Out: 129 F

Water Flow: 31,600 Lb/Hr

Water Temp In: 55 F

Water Temp Out: 195 F

Total Energy Recovered: 4.47 MMBTU/Hr

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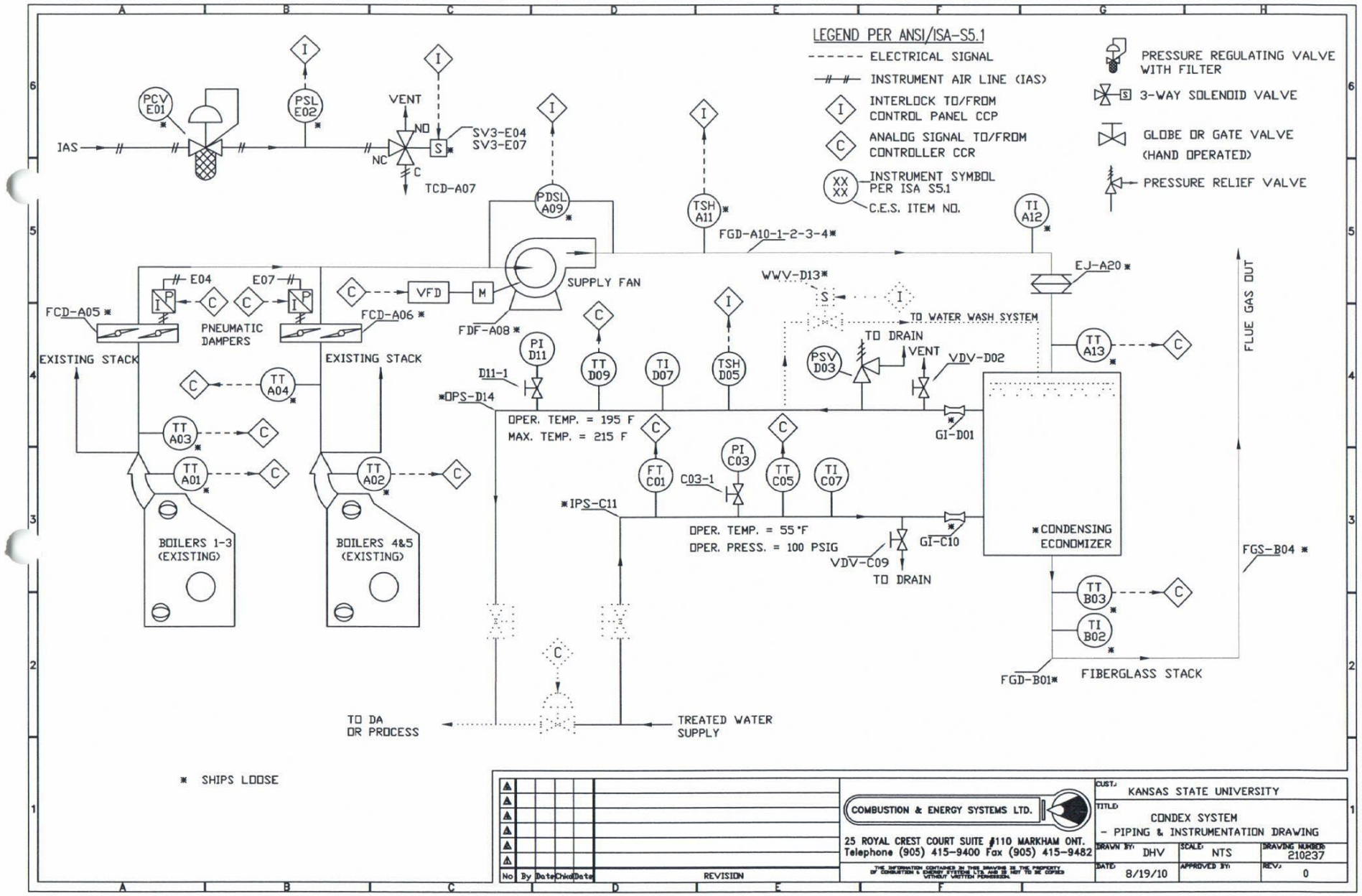

Central Washington University

Ellensburg, WA
Provides steam to campus for building heat and cooling

4 Natural Gas- Powered Boilers

Heating loop glycol for Samuelson Hall, Discovery Hall and the Health Sciences Building

Heat Recovered at Peak 6.28MM BTU/Hr

ConDex PERFORMANCE DATA SHEET

Date: March 8, 2013 Designed by: Sean Burrowes
Customer: Central Washington University
Reference: Operating Regime 3, OAT 0
Quotation No.: 212099-R2

Heat recovery system in the ***Condensing*** mode.

Fuel:	Natural Gas	
Gas side:	Gas type	Boiler flue
	Total flow rate	51,382 lb/hr
	Inlet temperature	269.2 °F
	Outlet temperature	93 °F
	Dew point	132°F
	H_2O vapor by weight @ inlet	11.13%
	H_2O vapor flow @ inlet	5,718 lb/hr
	H_2O vapor flow @ outlet	1,695 lb/hr
	H_2O condensed	4,023 lb/hr
	Specific heat @ avg. temperature	0.267 Btu/lb·°F
	Pressure drop	1.96 inch w.c.
	Fouling factor	0.002 hr· ft^2· F/Btu
	Maximum velocity at inlet temperature through the new free area	18.4 fps
Liquid side:	Fluid type	30% Propylene Glycol
	Total flow rate	170,000 lb/hr
	Inlet temperature	73 °F
	Outlet temperature	113 °F
	Density	64.08 lb/ft^3
	Specific heat @ avg. temperature	0.924 Btu/lb·°F
	Pressure drop	8.05 psi
	Fouling factor	0.001 hr· ft^2· F/Btu
	Velocity at average temperature	5.41 fps
Sensible Heat Load:		2,231,261 Btu/hr
Latent Heat Load:		4,051,939 Btu/hr
TOTAL HEAT RECOVERED (with 2% losses)		**6,283,200 Btu/hr**

Gas Flow: 51,382 Lb/Hr

Gas Temp In: 269 F

Gas Temp Out: 93 F

Glycol Flow: 170,000 Lb/Hr

Glycol Temp In: 73 F

Glycol Temp Out: 113 F

Total Energy Recovered: 6.28 MMBTU/Hr

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25 Royal Crest Court, Markham, Ontario L3R 9X4
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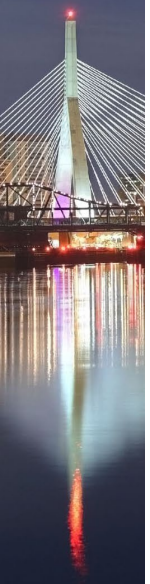

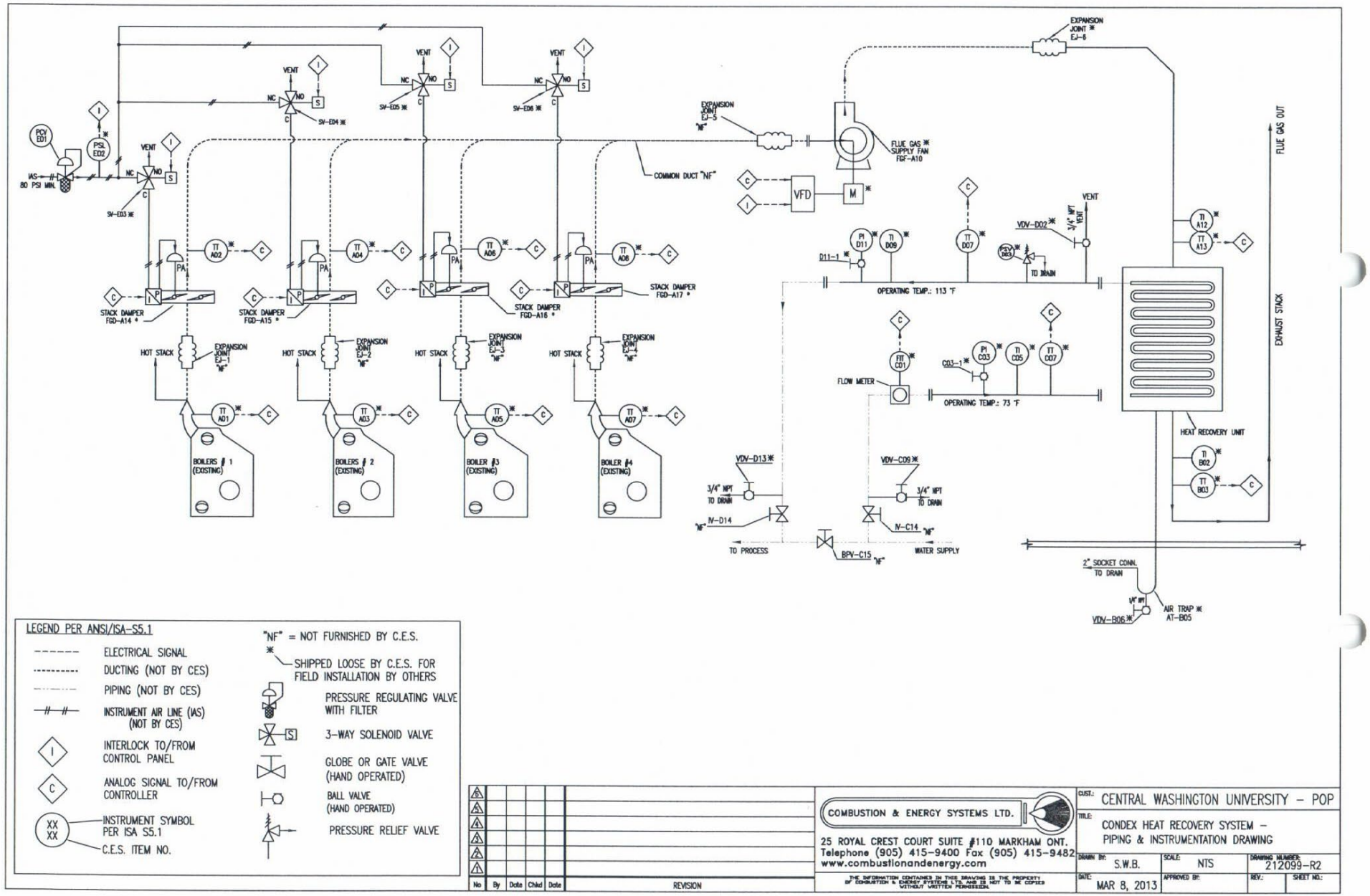

LEGEND PER ANSI/ISA-S5.1

- ELECTRICAL SIGNAL
- DUCTING (NOT BY CES)
- PIPING (NOT BY CES)
- INSTRUMENT AIR LINE (IAS) (NOT BY CES)
- INTERLOCK TO/FROM CONTROL PANEL
- ANALOG SIGNAL TO/FROM CONTROLLER
- XX / XX — INSTRUMENT SYMBOL PER ISA S5.1 / C.E.S. ITEM NO.

"NF" = NOT FURNISHED BY C.E.S.

* SHIPPED LOOSE BY C.E.S. FOR FIELD INSTALLATION BY OTHERS

- PRESSURE REGULATING VALVE WITH FILTER
- 3-WAY SOLENOID VALVE
- GLOBE OR GATE VALVE (HAND OPERATED)
- BALL VALVE (HAND OPERATED)
- PRESSURE RELIEF VALVE

No	By	Date	Chkd	Date	REVISION
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25 ROYAL CREST COURT SUITE #110 MARKHAM ONT.
Telephone (905) 415-9400 Fax (905) 415-9482
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CUST.: CENTRAL WASHINGTON UNIVERSITY – POP

TITLE: CONDEX HEAT RECOVERY SYSTEM – PIPING & INSTRUMENTATION DRAWING

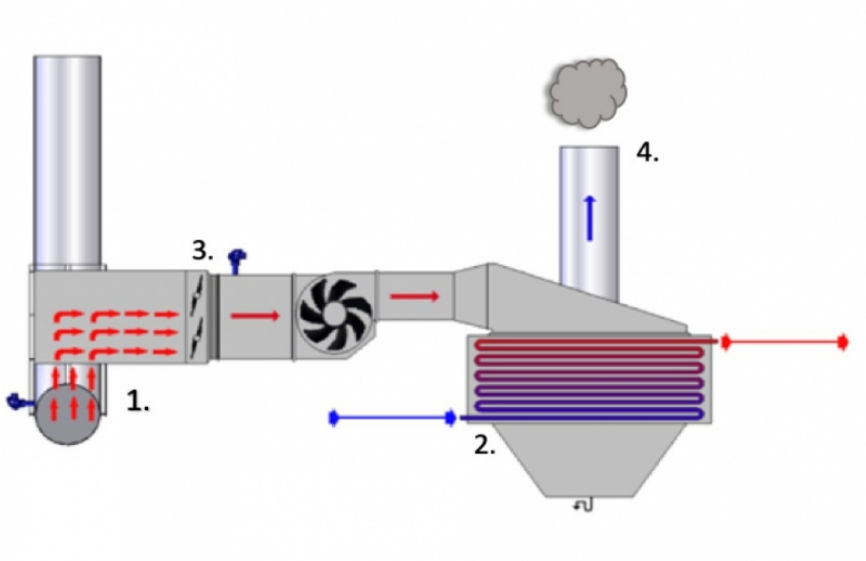
DRAWN BY:	SCALE:	DRAWING NUMBER:
S.W.B.	NTS	212099-R2

DATE:	APPROVED BY:	REV.:	SHEET NO.:
MAR 8, 2013			


NORTHERN BLOWER

How does the CONDEX system work?

1. Flue gases are drawn off of the boiler stacks by fans, which push them through the CONDEX heat exchanger
2. The gases are then cooled by glycol to the point where water vapor can condense, releasing the heat it took to vaporize initially
3. As the boilers load changes, the supply control dampers open and close to capture all available flue gases
4. The remaining 90° F gases leave the heat exchanger and are discharged to the atmosphere by a separate stack.



A model of the CONDEX heat exchanger

This new innovation allows CWU to:

- Prevent burning additional natural gas
- Reduce greenhouse gas emissions
- Save money
- Recover usable water from flue gas condensation
- Enhance sustainability on campus

UC DAVIS
UNIVERSITY OF CALIFORNIA

Davis, CA
Provides steam, electricity and chilled water to the campus.

2 Natural Gas Fired Boilers using Ultra Low NOx burners

3 heating coils
- Condensate Return
- Dormitory Heating Loop
- Make Up Water

Fuel Savings $1.4 MM/Year

CO2 Reduced: 9,194 Tons/Year

NOx Reduced: 0.68 Tons/Year

ConDex PERFORMANCE DATA SHEET

Date: October 11, 2011 Designed by: C Veitch
Customer: University of California, Davis
Reference: Condex Condensing Economizer System Performance Data
Quotation No.: 211088R4 CONDENSATE RETURN

Heat recovery system in the ***dry cooling*** mode.

Fuel: Natural Gas

Gas side:	Gas type	Boiler Flue
	Total flow rate	215,000 lb/hr
	Inlet temperature	301 °F
	Outlet temperature	215 °F
	Dew point	135 °F
	H_2O vapor by weight @ inlet	11.35 %
	H_2O vapor flow @ inlet	24,402 lb/hr
	H_2O vapor flow @ outlet	24,402 lb/hr
	H_2O condensed	0 lb/hr
	Specific heat @ avg. temperature	0.27 Btu/lb·°F
	Pressure drop	0.29 inch w.c.
	Fouling factor	0.001 hr· ft^2· F/Btu
	Maximum velocity at inlet temperature through the new free area	17.4 fps

Liquid side:	Fluid type	Water
	Total flow rate	159,000 lb/hr
	Inlet temperature	175 °F
	Outlet temperature	205 °F
	Pressure drop	14.92 psi
	Fouling factor	0.001 hr· ft^2· F/Btu
	Velocity at average temperature	7.44 fps

TOTAL HEAT RECOVERED (with 2% losses) 4,856,445 Btu/hr

Gas Flow: 215,000 Lb/Hr

Gas Temp In: 301 F

Gas Temp Out: 215 F

Water Flow: 159,000 Lb/Hr

Water Temp In: 175 F

Water Temp Out: 205 F

Total Energy Recovered: 4.85 MMBTU/Hr

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ConDex PERFORMANCE DATA SHEET

Date: October 11, 2011 Designed by: C Veitch
Customer: University of California, Davis
Reference: Condex Condensing Economizer System Performance Data
Quotation No.: 211088R4 DORMATORY HEATING LOOP

Heat recovery system in the ***dry cooling*** mode.

Fuel: Natural Gas

Gas side:	Gas type	Boiler Flue
	Total flow rate	215,000 lb/hr
	Inlet temperature	215 °F
	Outlet temperature	128 °F
	Dew point	135 °F
	H_2O vapor by weight @ inlet	11.35 %
	H_2O vapor flow @ inlet	24,402 lb/hr
	H_2O vapor flow @ outlet	19,688 lb/hr
	H_2O condensed	4,714 lb/hr
	Specific heat @ avg. temperature	0.266 Btu/lb·°F
	Pressure drop	0.94 inch w.c.
	Fouling factor	0.001 hr· ft^2· F/Btu
	Maximum velocity at inlet temperature through the new free area	15.4 fps
Liquid side:	Fluid type	Water
	Total flow rate	211,000 lb/hr
	Inlet temperature	105 °F
	Outlet temperature	150 °F
	Pressure drop	10.85 psi
	Fouling factor	0.001 hr· ft^2· F/Btu
	Velocity at average temperature	4.83 fps
Sensible Heat Load:		4,885,274 Btu/hr
Latent Heat Load:		4,708,167 Btu/hr
TOTAL HEAT RECOVERED (with 2% losses)		**9,593,441 Btu/hr**

Gas Flow: 215,000 Lb/hr

Gas Temp In: 215 F

Gas Temp Out: 128 F

Water Flow: 211,000 Lb/Hr

Water Temp In: 105 F

Water Temp Out: 150 F

Total Energy Recovered: 9.59 MMBTU/Hr

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Total Energy Recovered
15.82 MMBTU/Hr

ConDex PERFORMANCE DATA SHEET

Date: October 11, 2011 Designed by: C Veitch
Customer: University of California, Davis
Reference: Condex Condensing Economizer System Performance Data
Quotation No.: 211088R4 BOILER MAKE UP WATER

Heat recovery system in the ***dry cooling*** mode.

Fuel: Natural Gas

Gas side:	Gas type	Boiler Flue
	Total flow rate	210,286 lb/hr
	Inlet temperature	128 °F
	Outlet temperature	126 °F
	Dew point	128 °F
	H_2O vapor by weight @ inlet	9.3 %
	H_2O vapor flow @ inlet	19,688 lb/hr
	H_2O vapor flow @ outlet	18,447 lb/hr
	H_2O condensed	1,241 lb/hr
	Specific heat @ avg. temperature	0.261 Btu/lb·°F
	Pressure drop	0.12 inch w.c.
	Fouling factor	0.001 hr· ft^2· F/Btu
	Maximum velocity at inlet temperature through the new free area	13.1 fps
Liquid side:	Fluid type	Water
	Total flow rate	26,000 lb/hr
	Inlet temperature	70 °F
	Outlet temperature	123 °F
	Pressure drop	6.91 psi
	Fouling factor	0.001 hr· ft^2· F/Btu
	Velocity at average temperature	3.53 fps
Sensible Heat Load:		145,765 Btu/hr
Latent Heat Load:		1,241,907 Btu/hr
TOTAL HEAT RECOVERED (with 2% losses)		**1,387,672 Btu/hr**

Gas Flow: 210,286 Lb/Hr
Gas Temp In: 128 F
Gas Temp Out: 126 F
Water Flow: 26,000 Lb/Hr
Water Temp In: 70 F
Water Temp Out: 123 F
Total Energy Recovered:
1.38 MMBTU/Hr

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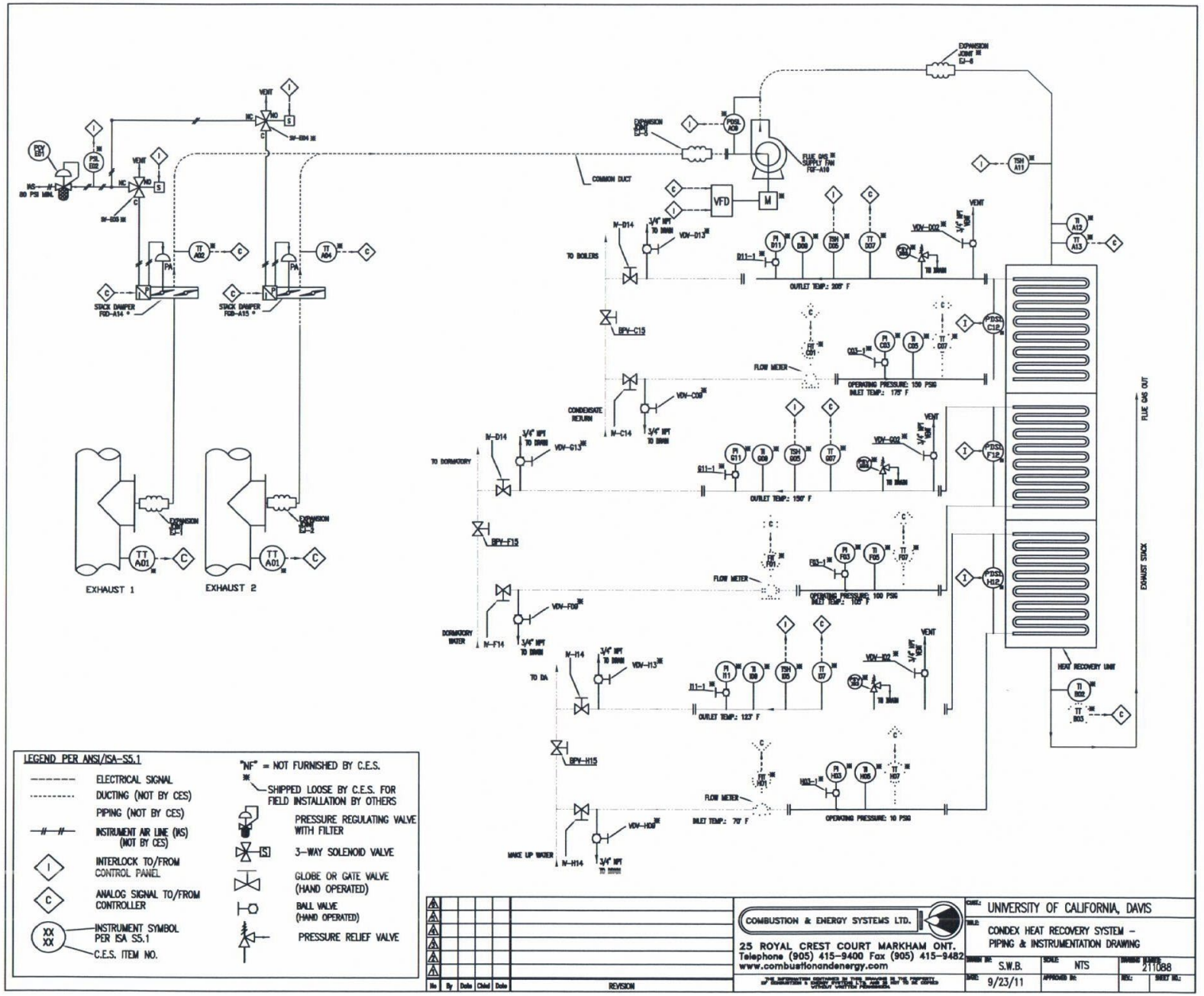


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