SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.100		.200	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	63.8*	40.0	77.9*
DENSITY	LB/FT3	61.2913	62.3159	62.5352	62.1641
VISCOSITY	CP	.4726	1.0585	1.4791	.8876
SPECIFIC HEAT	BTU/LB-F	.9973	1.0023	1.0058	1.0006
THERMAL COND.	BTU/HR-FT-F	.3723	.3536	.3466	.3575
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	101.9	82.6	59.0	81.9
VISCOSITY, AVG & SKIN	CP	.6779	.8397	1.1294	.8466
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.01	10.00	.00	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.10	10.00	.03	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	189.24		133.23	

TOTAL HEAT DUTY REQUIRED	MEGBTU/HR			.007604
EFF TEMP DIF, DEGF (LMTD= 40.0,F= .40,BYPASS= .92,BAFF=1.00)				14.8
OVERALL COEFF REQUIRED	BTU/HR-FT2-F			71.84
CLEAN & FOULED COEFF	BTU/HR-FT2-F	73.07		71.93

SHELLS IN SERIES 1 PARALLEL 1		TOTAL EFF AREA FT2	7.1
PASSES, SHELL 1 TUBE 4		EFFECTIVE AREA FT2/SHELL	7.1
SHELL DIAMETER IN.	3.820	TEMA SHELL TYPE E ; REAR HEAD	FXTS
BAFFLE TYPE HORZ SEGMENTL		CROSS PASSES PER SHELL PASS	4
SPACING, CENTRAL IN.	4.309	BAFFLE CUT, PCT SHELL I.D.	30.00
SPACING, INLET IN.	4.309	CUT DISTANCE FROM CENTER, IN.	.764
SPACING, OUTLET IN.	4.309		
BAFFLE THICKNESS IN.	.125	IMPINGEMENT BAFFLE INCLUDED	NO
PAIRS OF SEALING DEVICES	1	TUBESHEET BLANK AREA, %	.0
TUBE TYPE	PLAIN	MATERIAL	ELECTROLYTIC COPPER
NO. OF TUBES/SHELL	76	EST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT	1.500	TUBE PITCH IN.	.3125
TUBE LGTH, EFF FT	1.436	TUBE OUTSIDE DIAM IN.	.250
TUBE LAYOUT DEG	60	TUBE INSIDE DIAM IN.	.214
PITCH RATIO	1.250	TUBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT	1.0 1.0	TUBE NOZZ ID, IN&OUT IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

CASE 1

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.041	.000
PRANDTL NUMBER	7.8	4.5
RYNLD NO, AVG	65.	232.
RYNLD NO, IN BUN	49.	333.
RYNLD NO,OUT BUN	82.	149.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
53.39	45.00	1.56	.05

PCT OVER DESIGN	.13
TOT FOUL RESIST	.000217
DIFF RESIST	.000018

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.16	.16
DENSITY	LB/FT3	62.535	62.164
NOZZ RHO*VSQ	LB/FT-S2	1	1
BUND RHO*VSQ	LB/FT-S2	1	1

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	.15	.15
DENSITY	LB/FT3	61.291	62.316
PRESS. DROP	%	2.0	1.3

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW	FT/S	.03
NOMINAL VEL,WINDOW	FT/S	.05
CROSSFLOW COEF	BTU/HR-FT2-F	134.6
WINDOW COEF	BTU/HR-FT2-F	131.6

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		79.09
TUBE TO BAFFLE LEAKAGE	A =	2.50
MAIN CROSSFLOW	B =	67.71
BUNDLE TO SHELL BYPASS	C =	10.88
BAFFLE TO SHELL LEAKAGE	E =	18.92
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.598
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.650
END (HT LOSS IN END ZONE)	=	.998

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	10.2
END ZONE	=	8.9
CROSS FLOW	=	6.7
INLET NOZZLE	=	38.4
OUTLET NOZZLE	=	35.7

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

CASE 2

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.100		.300	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	56.5*	40.0	67.7*
DENSITY	LB/FT3	61.2913	62.3886	62.5352	62.2760
VISCOSITY	CP	.4726	1.1674	1.4791	1.0072
SPECIFIC HEAT	BTU/LB-F	.9973	1.0033	1.0058	1.0018
THERMAL COND.	BTU/HR-FT-F	.3723	.3515	.3466	.3547
MOLAR MASS	LB/LBMOL	18.02		18.02	
TEMP, AVG & SKIN	DEGF	98.3	76.8	53.8	76.0
VISCOSITY, AVG & SKIN	CP	.7048	.8998	1.2108	.9082

PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.01	10.00	.00	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.10	10.00	.05	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	189.20		153.05	

TOTAL HEAT DUTY REQUIRED MEGBTU/HR				.008340
EFF TEMP DIF, DEGF (LMTD= 37.8,F= .43,BYPASS= .92,BAFF=1.00)				15.2
OVERALL COEFF REQUIRED	BTU/HR-FT2-F			76.95
CLEAN & FOULED COEFF	BTU/HR-FT2-F	78.65		77.27

SHELLS IN SERIES 1 PARALLEL 1		TOTAL EFF AREA FT2	7.1
PASSES, SHELL 1 TUBE 4		EFFECTIVE AREA FT2/SHELL	7.1
SHELL DIAMETER IN.	3.820	TEMA SHELL TYPE E ; REAR HEAD	FXTS
BAFFLE TYPE HORZ SEGMENTL		CROSS PASSES PER SHELL PASS	4
SPACING, CENTRAL IN.	4.309	BAFFLE CUT, PCT SHELL I.D.	30.00
SPACING, INLET IN.	4.309	CUT DISTANCE FROM CENTER, IN.	.764
SPACING, OUTLET IN.	4.309		
BAFFLE THICKNESS IN.	.125	IMPINGEMENT BAFFLE INCLUDED	NO
PAIRS OF SEALING DEVICES	1	TUBESHEET BLANK AREA, %	.0
TUBE TYPE	PLAIN	MATERIAL	ELECTROLYTIC COPPER
NO. OF TUBES/SHELL	76	EST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT	1.500	TUBE PITCH IN.	.3125
TUBE LGTH, EFF FT	1.436	TUBE OUTSIDE DIAM IN.	.250
TUBE LAYOUT DEG	60	TUBE INSIDE DIAM IN.	.214
PITCH RATIO	1.250	TUBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT	1.0 1.0	TUBE NOZZ ID, IN&OUT IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.041	.000
PRANDTL NUMBER	8.4	4.7
RYNLD NO, AVG	92.	224.
RYNLD NO, IN BUN	75.	333.
RYNLD NO,OUT BUN	111.	135.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
49.92	48.35	1.68	.06

PCT OVER DESIGN	.41
TOT FOUL RESIST	.000217
DIFF RESIST	.000054

SHELLSIDE PERFORMANCE		
NOMINAL VEL,X-FLOW	FT/S	.04
NOMINAL VEL,WINDOW	FT/S	.08
CROSSFLOW COEF	BTU/HR-FT2-F	153.9
WINDOW COEF	BTU/HR-FT2-F	153.0

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		80.40
TUBE TO BAFFLE LEAKAGE	A =	2.60
MAIN CROSSFLOW	B =	68.85
BUNDLE TO SHELL BYPASS	C =	11.03
BAFFLE TO SHELL LEAKAGE	E =	17.52
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

DIAMETRAL CLEARANCES			TOTAL =(BETA)(GAMMA)(FIN)	=	.598
BUNDLE TO SHELL	IN.	.5000	BETA (BAFF CUT FACTOR)	=	.920
TUBE TO BAFFLE HOLE	IN.	.0284	GAMMA (TUBE ROW ENTRY EFCT)	=	.650
BAFFLE TO SHELL	IN.	.1000	END (HT LOSS IN END ZONE)	=	.997

SHELL NOZZLE DATA		IN	OUT	SHELL PRESSURE DROP, % OF TOTAL		
HT UNDR NOZ	IN.	.25		WINDOW	=	9.7
HT OPP NOZ	IN.	.25		END ZONE	=	7.1
VELOCITY	FT/S	.24	.25	CROSS FLOW	=	5.5
DENSITY	LB/FT3	62.535	62.276	INLET NOZZLE	=	39.8
NOZZ RHO*VSQ	LB/FT-S2	3	3	OUTLET NOZZLE	=	37.9
BUND RHO*VSQ	LB/FT-S2	2	2			

TUBE NOZZLE DATA		IN	OUT	WEIGHT PER SHELL, LB		
VELOCITY	FT/S	.15	.15	DRY	=	150.
DENSITY	LB/FT3	61.291	62.389	WET	=	165.
PRESS. DROP	%	1.9	1.2			

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.100		.400	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	52.5*	40.0	61.8*
DENSITY	LB/FT3	61.2913	62.4259	62.5352	62.3371
VISCOSITY	CP	.4726	1.2330	1.4791	1.0880
SPECIFIC HEAT	BTU/LB-F	.9973	1.0038	1.0058	1.0025
THERMAL COND.	BTU/HR-FT-F	.3723	.3504	.3466	.3530
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	96.3	72.9	50.9	72.1
VISCOSITY, AVG & SKIN	CP	.7199	.9430	1.2622	.9528
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.01	10.00	.00	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.10	10.00	.07	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	189.56		173.87	

TOTAL HEAT DUTY REQUIRED	MEGBTU/HR	.008737
EFF TEMP DIF, DEGF (LMTD= 35.9,F= .45,BYPASS= .93,BAFF=1.00)		14.9
OVERALL COEFF REQUIRED	BTU/HR-FT2-F	82.10
CLEAN & FOULED COEFF	BTU/HR-FT2-F	83.88 / 82.26

SHELLS IN SERIES	1	PARALLEL 1	TOTAL EFF AREA	FT2	7.1
PASSES, SHELL	1	TUBE 4	EFFECTIVE AREA	FT2/SHELL	7.1
SHELL DIAMETER IN.	3.820		TEMA SHELL TYPE E ; REAR HEAD FXTS		

BAFFLE TYPE	HORZ	SEGMENTL	CROSS PASSES PER SHELL PASS	4

SPACING, CENTRAL	IN.	4.309	BAFFLE CUT, PCT SHELL I.D.		30.00
SPACING, INLET	IN.	4.309	CUT DISTANCE FROM CENTER, IN.		.764
SPACING, OUTLET	IN.	4.309			
BAFFLE THICKNESS	IN.	.125	IMPINGEMENT BAFFLE INCLUDED		NO
PAIRS OF SEALING DEVICES		1	TUBESHEET BLANK AREA, %		.0
TUBE TYPE		PLAIN	MATERIAL		ELECTROLYTIC COPPER
NO. OF TUBES/SHELL		76	EST MAX TUBE COUNT		36
TUBE LGTH, OVERALL	FT	1.500	TUBE PITCH	IN.	.3125
TUBE LGTH, EFF	FT	1.436	TUBE OUTSIDE DIAM	IN.	.250
TUBE LAYOUT	DEG	60	TUBE INSIDE DIAM	IN.	.214
PITCH RATIO		1.250	TUBE SURFACE RATIO, OUT/IN		1.184
SHL NOZZ ID, IN&OUT	1.0	1.0	TUBE NOZZ ID, IN&OUT	IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.040	.000
PRANDTL NUMBER	8.8	4.8
RYNLD NO, AVG	119.	219.
RYNLD NO, IN BUN	102.	333.
RYNLD NO,OUT BUN	138.	128.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
46.78	51.38	1.78	.06

PCT OVER DESIGN	.19
TOT FOUL RESIST	.000217
DIFF RESIST	.000023

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.33	.33
DENSITY	LB/FT3	62.535	62.337
NOZZ RHO*VSQ	LB/FT-S2	6	6
BUND RHO*VSQ	LB/FT-S2	4	4

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	.15	.15
DENSITY	LB/FT3	61.291	62.426
PRESS. DROP	%	1.9	1.2

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW	FT/S	.05
NOMINAL VEL,WINDOW	FT/S	.10
CROSSFLOW COEF	BTU/HR-FT2-F	174.6
WINDOW COEF	BTU/HR-FT2-F	175.5

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.26
TUBE TO BAFFLE LEAKAGE	A =	2.69
MAIN CROSSFLOW	B =	69.47
BUNDLE TO SHELL BYPASS	C =	11.25
BAFFLE TO SHELL LEAKAGE	E =	16.60
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.599
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.651
END (HT LOSS IN END ZONE)	=	.994

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	9.3
END ZONE	=	6.0
CROSS FLOW	=	4.8
INLET NOZZLE	=	40.7
OUTLET NOZZLE	=	39.2

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.100		.500	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	50.1*	40.0	57.9*
DENSITY	LB/FT3	61.2913	62.4484	62.5352	62.3752
VISCOSITY	CP	.4726	1.2766	1.4791	1.1457
SPECIFIC HEAT	BTU/LB-F	.9973	1.0042	1.0058	1.0031
THERMAL COND.	BTU/HR-FT-F	.3723	.3496	.3466	.3519
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	95.0	70.0	48.9	69.1
VISCOSITY, AVG & SKIN	CP	.7297	.9783	1.2972	.9895
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.01	10.00	.01	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.10	10.00	.08	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	190.07		197.15	

TOTAL HEAT DUTY REQUIRED MEGBTU/HR			.008984
EFF TEMP DIF, DEGF (LMTD= 34.3,F= .45,BYPASS= .93,BAFF=1.00)			14.4
OVERALL COEFF REQUIRED	BTU/HR-FT2-F		87.40
CLEAN & FOULED COEFF	BTU/HR-FT2-F	89.08	87.20

SHELLS IN SERIES 1 PARALLEL 1		TOTAL EFF AREA FT2	7.1
PASSES, SHELL 1 TUBE 4		EFFECTIVE AREA FT2/SHELL	7.1
SHELL DIAMETER IN.	3.820	TEMA SHELL TYPE E ; REAR HEAD	FXTS
BAFFLE TYPE HORZ SEGMENTL		CROSS PASSES PER SHELL PASS	4
SPACING, CENTRAL IN.	4.309	BAFFLE CUT, PCT SHELL I.D.	30.00
SPACING, INLET IN.	4.309	CUT DISTANCE FROM CENTER, IN.	.764
SPACING, OUTLET IN.	4.309		
BAFFLE THICKNESS IN.	.125	IMPINGEMENT BAFFLE INCLUDED	NO
PAIRS OF SEALING DEVICES	1	TUBESHEET BLANK AREA, %	.0

TUBE TYPE	PLAIN	MATERIAL	ELECTROLYTIC COPPER
NO. OF TUBES/SHELL	76	EST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT	1.500	TUBE PITCH IN.	.3125
TUBE LGTH, EFF FT	1.436	TUBE OUTSIDE DIAM IN.	.250
TUBE LAYOUT DEG	60	TUBE INSIDE DIAM IN.	.214
PITCH RATIO	1.250	TUBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT	1.0 1.0	TUBE NOZZ ID, IN&OUT IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.039	.000
PRANDTL NUMBER	9.0	4.9
RYNLD NO, AVG	145.	216.
RYNLD NO, IN BUN	127.	333.
RYNLD NO,OUT BUN	164.	123.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
43.73	54.31	1.89	.06

PCT OVER DESIGN	-.24
TOT FOUL RESIST	.000217
DIFF RESIST	-.000027

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.41	.41
DENSITY	LB/FT3	62.535	62.375
NOZZ RHO*VSQ	LB/FT-S2	10	10
BUND RHO*VSQ	LB/FT-S2	7	7

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	.15	.14
DENSITY	LB/FT3	61.291	62.448
PRESS. DROP	%	1.8	1.1

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW	FT/S	.07
NOMINAL VEL,WINDOW	FT/S	.13
CROSSFLOW COEF	BTU/HR-FT2-F	198.0
WINDOW COEF	BTU/HR-FT2-F	199.1

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.37
TUBE TO BAFFLE LEAKAGE	A =	2.87
MAIN CROSSFLOW	B =	68.68
BUNDLE TO SHELL BYPASS	C =	12.11
BAFFLE TO SHELL LEAKAGE	E =	16.34
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.612
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.666
END (HT LOSS IN END ZONE)	=	.994

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	9.1
END ZONE	=	5.4
CROSS FLOW	=	4.4
INLET NOZZLE	=	41.1
OUTLET NOZZLE	=	39.9

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.100		.600	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	48.4*	40.0	55.2*
DENSITY	LB/FT3	61.2913	62.4633	62.5352	62.4012
VISCOSITY	CP	.4726	1.3071	1.4791	1.1888
SPECIFIC HEAT	BTU/LB-F	.9973	1.0044	1.0058	1.0034
THERMAL COND.	BTU/HR-FT-F	.3723	.3491	.3466	.3511
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	94.2	67.7	47.6	66.8
VISCOSITY, AVG & SKIN	CP	.7363	1.0068	1.3227	1.0191
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00

PRESSURE DROP, TOT & ALLOWED	PSI	.01	10.00	.01	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.10	10.00	.10	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	190.50		219.33	

TOTAL HEAT DUTY REQUIRED MEGBTU/HR	.009150
EFF TEMP DIF, DEGF (LMTD= 33.1,F= .46,BYPASS= .93,BAFF=1.00)	14.0
OVERALL COEFF REQUIRED BTU/HR-FT2-F	91.38
CLEAN & FOULED COEFF BTU/HR-FT2-F 93.47	91.35

SHELLS IN SERIES	1	PARALLEL	1
PASSES, SHELL	1	TUBE	4
SHELL DIAMETER IN.			3.820
TOTAL EFF AREA	FT2		7.1
EFFECTIVE AREA	FT2/SHELL		7.1
TEMA SHELL TYPE	E	; REAR HEAD	FXTS

BAFFLE TYPE	HORZ	SEGMENTL	
SPACING, CENTRAL IN.			4.309
SPACING, INLET IN.			4.309
SPACING, OUTLET IN.			4.309
BAFFLE THICKNESS IN.			.125
PAIRS OF SEALING DEVICES			1
CROSS PASSES PER SHELL PASS			4
BAFFLE CUT, PCT SHELL I.D.			30.00
CUT DISTANCE FROM CENTER, IN.			.764
IMPINGEMENT BAFFLE INCLUDED			NO
TUBESHEET BLANK AREA, %			.0

TUBE TYPE			PLAIN
NO. OF TUBES/SHELL			76
TUBE LGTH, OVERALL	FT		1.500
TUBE LGTH, EFF	FT		1.436
TUBE LAYOUT	DEG		60
PITCH RATIO			1.250
SHL NOZZ ID, IN&OUT	1.0	1.0	
MATERIAL			ELECTROLYTIC COPPER
EST MAX TUBE COUNT			36
TUBE PITCH	IN.		.3125
TUBE OUTSIDE DIAM	IN.		.250
TUBE INSIDE DIAM	IN.		.214
TUBE SURFACE RATIO, OUT/IN			1.184
TUBE NOZZ ID, IN&OUT	IN.	.8	.8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.037	.000
PRANDTL NUMBER	9.2	4.9
RYNLD NO, AVG	171.	214.
RYNLD NO, IN BUN	153.	333.
RYNLD NO,OUT BUN	190.	121.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
41.18	56.77	1.98	.07

PCT OVER DESIGN	-.03
TOT FOUL RESIST	.000217
DIFF RESIST	-.000004

DIAMETRAL CLEARANCES

SHELLSIDE PERFORMANCE		
NOMINAL VEL,X-FLOW	FT/S	.08
NOMINAL VEL,WINDOW	FT/S	.15
CROSSFLOW COEF	BTU/HR-FT2-F	220.2
WINDOW COEF	BTU/HR-FT2-F	221.6

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.44
TUBE TO BAFFLE LEAKAGE	A =	3.04
MAIN CROSSFLOW	B =	67.96
BUNDLE TO SHELL BYPASS	C =	12.87
BAFFLE TO SHELL LEAKAGE	E =	16.14
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN) =	.626

BUNDLE TO SHELL	IN.	.5000	BETA (BAFF CUT FACTOR)	=	.920
TUBE TO BAFFLE HOLE	IN.	.0284	GAMMA (TUBE ROW ENTRY EFCT)	=	.680
BAFFLE TO SHELL	IN.	.1000	END (HT LOSS IN END ZONE)	=	.994

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.49	.49
DENSITY	LB/FT3	62.535	62.401
NOZZ RHO*VSQ	LB/FT-S2	14	14
BUND RHO*VSQ	LB/FT-S2	10	10

SHELL PRESSURE DROP, % OF TOTAL		
WINDOW	=	9.0
END ZONE	=	5.0
CROSS FLOW	=	4.2
INLET NOZZLE	=	41.4
OUTLET NOZZLE	=	40.4

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	.15	.14
DENSITY	LB/FT3	61.291	62.463
PRESS. DROP	%	1.8	1.1

WEIGHT PER SHELL, LB		
DRY	=	150.
WET	=	165.

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE KLB/HR		.100		.700	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	47.2*	40.0	53.2*
DENSITY	LB/FT3	61.2913	62.4739	62.5352	62.4200
VISCOSITY	CP	.4726	1.3297	1.4791	1.2221
SPECIFIC HEAT	BTU/LB-F	.9973	1.0046	1.0058	1.0037
THERMAL COND.	BTU/HR-FT-F	.3723	.3488	.3466	.3506
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	93.6	65.9	46.6	64.9
VISCOSITY, AVG & SKIN	CP	.7411	1.0306	1.3419	1.0440
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.01	10.00	.01	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.10	10.00	.11	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	190.88		240.84	

TOTAL HEAT DUTY REQUIRED	MEGBTU/HR	.009270
EFF TEMP DIF, DEGF (LMTD= 32.0,F= .46,BYPASS= .93,BAFF=1.00)		13.7
OVERALL COEFF REQUIRED	BTU/HR-FT2-F	94.69
CLEAN & FOULED COEFF	BTU/HR-FT2-F	97.28 / 94.95

SHELLS IN SERIES 1 PARALLEL 1		TOTAL EFF AREA FT2	7.1
PASSES, SHELL 1 TUBE 4		EFFECTIVE AREA FT2/SHELL	7.1
SHELL DIAMETER IN.	3.820	TEMA SHELL TYPE E ; REAR HEAD	FXTS
BAFFLE TYPE	HORZ SEGMENTL	CROSS PASSES PER SHELL PASS	4
SPACING, CENTRAL IN.	4.309	BAFFLE CUT, PCT SHELL I.D.	30.00

SPACING, INLET	IN.	4.309	CUT DISTANCE FROM CENTER, IN.		.764
SPACING, OUTLET	IN.	4.309			
BAFFLE THICKNESS	IN.	.125	IMPINGEMENT BAFFLE INCLUDED		NO
PAIRS OF SEALING DEVICES		1	TUBESHEET BLANK AREA, %		.0
TUBE TYPE		PLAIN	MATERIAL		ELECTROLYTIC COPPER
NO. OF TUBES/SHELL		76	EST MAX TUBE COUNT		36
TUBE LGTH, OVERALL	FT	1.500	TUBE PITCH	IN.	.3125
TUBE LGTH, EFF	FT	1.436	TUBE OUTSIDE DIAM	IN.	.250
TUBE LAYOUT	DEG	60	TUBE INSIDE DIAM	IN.	.214
PITCH RATIO		1.250	TUBE SURFACE RATIO, OUT/IN		1.184
SHL NOZZ ID, IN&OUT	1.0	1.0	TUBE NOZZ ID, IN&OUT	IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.036	.000
PRANDTL NUMBER	9.4	5.0
RYNLD NO, AVG	196.	213.
RYNLD NO, IN BUN	178.	333.
RYNLD NO,OUT BUN	216.	119.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
38.98	58.89	2.06	.07

PCT OVER DESIGN	.28
TOT FOUL RESIST	.000217
DIFF RESIST	.000029

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.57	.57
DENSITY	LB/FT3	62.535	62.420
NOZZ RHO*VSQ	LB/FT-S2	20	20
BUND RHO*VSQ	LB/FT-S2	13	13

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	.15	.14
DENSITY	LB/FT3	61.291	62.474
PRESS. DROP	%	1.8	1.1

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW	FT/S	.09
NOMINAL VEL,WINDOW	FT/S	.18
CROSSFLOW COEF	BTU/HR-FT2-F	241.8
WINDOW COEF	BTU/HR-FT2-F	243.3

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.51
TUBE TO BAFFLE LEAKAGE	A =	3.18
MAIN CROSSFLOW	B =	67.31
BUNDLE TO SHELL BYPASS	C =	13.56
BAFFLE TO SHELL LEAKAGE	E =	15.95
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.639
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.695
END (HT LOSS IN END ZONE)	=	.994

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	8.9
END ZONE	=	4.6
CROSS FLOW	=	3.9
INLET NOZZLE	=	41.7
OUTLET NOZZLE	=	40.8

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

CASE 7

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.100		.800	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	46.3*	40.0	51.6*
DENSITY	LB/FT3	61.2913	62.4818	62.5352	62.4341
VISCOSITY	CP	.4726	1.3473	1.4791	1.2486
SPECIFIC HEAT	BTU/LB-F	.9973	1.0048	1.0058	1.0040
THERMAL COND.	BTU/HR-FT-F	.3723	.3485	.3466	.3501
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	93.2	64.4	45.8	63.4
VISCOSITY, AVG & SKIN	CP	.7448	1.0511	1.3569	1.0655
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.01	10.00	.02	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.10	10.00	.13	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	191.21		261.86	

TOTAL HEAT DUTY REQUIRED	MEGBTU/HR	.009361
EFF TEMP DIF, DEGF (LMTD= 31.1,F= .46,BYPASS= .93,BAFF=1.00)		13.3
OVERALL COEFF REQUIRED	BTU/HR-FT2-F	98.41
CLEAN & FOULED COEFF	BTU/HR-FT2-F	100.65 / 98.12

SHELLS IN SERIES	1	PARALLEL	1
PASSES, SHELL	1	TUBE	4
SHELL DIAMETER IN.			3.820
TOTAL EFF AREA	FT2		7.1
EFFECTIVE AREA	FT2/SHELL		7.1
TEMA SHELL TYPE	E	; REAR HEAD	FXTS

BAFFLE TYPE	HORZ	SEGMENTL	
SPACING, CENTRAL	IN.		4.309
SPACING, INLET	IN.		4.309
SPACING, OUTLET	IN.		4.309
BAFFLE THICKNESS	IN.		.125
PAIRS OF SEALING DEVICES			1
CROSS PASSES PER SHELL PASS			4
BAFFLE CUT, PCT SHELL I.D.			30.00
CUT DISTANCE FROM CENTER, IN.			.764
IMPINGEMENT BAFFLE INCLUDED			NO
TUBESHEET BLANK AREA, %			.0

TUBE TYPE			PLAIN
NO. OF TUBES/SHELL			76
TUBE LGTH, OVERALL	FT		1.500
TUBE LGTH, EFF	FT		1.436
TUBE LAYOUT	DEG		60
PITCH RATIO			1.250
SHL NOZZ ID, IN&OUT	1.0	1.0	
MATERIAL			ELECTROLYTIC COPPER
EST MAX TUBE COUNT			36
TUBE PITCH	IN.		.3125
TUBE OUTSIDE DIAM	IN.		.250
TUBE INSIDE DIAM	IN.		.214
TUBE SURFACE RATIO, OUT/IN			1.184
TUBE NOZZ ID, IN&OUT	IN.	.8	.8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.034	.000
PRANDTL NUMBER	9.5	5.0
RYNLD NO, AVG	222.	212.
RYNLD NO, IN BUN	204.	333.
RYNLD NO,OUT BUN	241.	117.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
37.05	60.75	2.13	.07

PCT OVER DESIGN	-.30
TOT FOUL RESIST	.000217
DIFF RESIST	-.000031

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.65	.65
DENSITY	LB/FT3	62.535	62.434
NOZZ RHO*VSQ	LB/FT-S2	26	26
BUND RHO*VSQ	LB/FT-S2	18	18

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	.15	.14
DENSITY	LB/FT3	61.291	62.482
PRESS. DROP	%	1.8	1.1

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW	FT/S	.10
NOMINAL VEL,WINDOW	FT/S	.20
CROSSFLOW COEF	BTU/HR-FT2-F	262.9
WINDOW COEF	BTU/HR-FT2-F	264.6

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.55
TUBE TO BAFFLE LEAKAGE	A =	3.31
MAIN CROSSFLOW	B =	66.70
BUNDLE TO SHELL BYPASS	C =	14.19
BAFFLE TO SHELL LEAKAGE	E =	15.80
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.653
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.710
END (HT LOSS IN END ZONE)	=	.994

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	8.9
END ZONE	=	4.4
CROSS FLOW	=	3.7
INLET NOZZLE	=	41.9
OUTLET NOZZLE	=	41.2

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.100		.900	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	45.6*	40.0	50.4*
DENSITY	LB/FT3	61.2913	62.4879	62.5352	62.4452
VISCOSITY	CP	.4726	1.3611	1.4791	1.2702
SPECIFIC HEAT	BTU/LB-F	.9973	1.0049	1.0058	1.0041
THERMAL COND.	BTU/HR-FT-F	.3723	.3483	.3466	.3497
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	92.8	63.1	45.2	62.0
VISCOSITY, AVG & SKIN	CP	.7477	1.0691	1.3690	1.0843
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00

PRESSURE DROP, TOT & ALLOWED	PSI	.01	10.00	.02	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.10	10.00	.14	10.00

FOULING RESISTANCE	HR-FT2-F/BTU	.00010	.00010
FILM COEFFICIENT	BTU/HR-FT2-F	191.49	282.43

TOTAL HEAT DUTY REQUIRED MEGBTU/HR	.009432
EFF TEMP DIF, DEGF (LMTD= 30.3,F= .46,BYPASS= .93,BAFF=1.00)	13.0
OVERALL COEFF REQUIRED BTU/HR-FT2-F	101.30
CLEAN & FOULED COEFF BTU/HR-FT2-F 103.64	100.93

SHELLS IN SERIES	1	PARALLEL	1
PASSES, SHELL	1	TUBE	4
SHELL DIAMETER IN.			3.820

TOTAL EFF AREA	FT2		7.1
EFFECTIVE AREA	FT2/SHELL		7.1
TEMA SHELL TYPE	E	; REAR HEAD	FXTS

BAFFLE TYPE	HORZ	SEGMENTL	
SPACING, CENTRAL	IN.		4.309
SPACING, INLET	IN.		4.309
SPACING, OUTLET	IN.		4.309
BAFFLE THICKNESS	IN.		.125
PAIRS OF SEALING DEVICES			1

CROSS PASSES PER SHELL PASS	4
BAFFLE CUT, PCT SHELL I.D.	30.00
CUT DISTANCE FROM CENTER, IN.	.764
IMPINGEMENT BAFFLE INCLUDED	NO
TUBESHEET BLANK AREA, %	.0

TUBE TYPE			PLAIN
NO. OF TUBES/SHELL			76
TUBE LGTH, OVERALL	FT		1.500
TUBE LGTH, EFF	FT		1.436
TUBE LAYOUT	DEG		60
PITCH RATIO			1.250
SHL NOZZ ID, IN&OUT	1.0	1.0	

MATERIAL			ELECTROLYTIC COPPER
EST MAX TUBE COUNT			36
TUBE PITCH	IN.		.3125
TUBE OUTSIDE DIAM	IN.		.250
TUBE INSIDE DIAM	IN.		.214
TUBE SURFACE RATIO, OUT/IN			1.184
TUBE NOZZ ID, IN&OUT	IN.	.8	.8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.033	.000
PRANDTL NUMBER	9.6	5.0
RYNLD NO, AVG	248.	211.
RYNLD NO, IN BUN	229.	333.
RYNLD NO,OUT BUN	267.	116.
FOULNG LAYER IN.	.0014	.0014

SHELLSIDE PERFORMANCE		
NOMINAL VEL,X-FLOW	FT/S	.12
NOMINAL VEL,WINDOW	FT/S	.23
CROSSFLOW COEF	BTU/HR-FT2-F	283.5
WINDOW COEF	BTU/HR-FT2-F	285.3

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
35.34	62.40	2.19	.07

PCT OVER DESIGN	-.36
TOT FOUL RESIST	.000217
DIFF RESIST	-.000036

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.54
TUBE TO BAFFLE LEAKAGE	A =	3.45
MAIN CROSSFLOW	B =	66.07
BUNDLE TO SHELL BYPASS	C =	14.78
BAFFLE TO SHELL LEAKAGE	E =	15.70
TUBE PASSLANE BYPASS	F =	.00

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.666
BETA (BAFF CUT FACTOR)	=	.920

TUBE TO BAFFLE HOLE	IN.	.0284		GAMMA (TUBE ROW ENTRY EFCT) =		.724
BAFFLE TO SHELL	IN.	.1000		END (HT LOSS IN END ZONE) =		.994

SHELL NOZZLE DATA		IN	OUT	SHELL PRESSURE DROP, % OF TOTAL		
HT UNDR NOZ	IN.	.25		WINDOW	=	8.9
HT OPP NOZ	IN.	.25		END ZONE	=	4.1
VELOCITY	FT/S	.73	.73	CROSS FLOW	=	3.6
DENSITY	LB/FT3	62.535	62.445	INLET NOZZLE	=	42.0
NOZZ RHO*VSQ	LB/FT-S2	33	33	OUTLET NOZZLE	=	41.4
BUND RHO*VSQ	LB/FT-S2	22	22			

TUBE NOZZLE DATA		IN	OUT	WEIGHT PER SHELL, LB		
VELOCITY	FT/S	.15	.14	DRY	=	150.
DENSITY	LB/FT3	61.291	62.488	WET	=	165.
PRESS. DROP	%	1.7	1.1			

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.200		.200	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	82.9*	40.0	96.9*
DENSITY	LB/FT3	61.2913	62.1061	62.5352	61.9324
VISCOSITY	CP	.4726	.8367	1.4791	.7152
SPECIFIC HEAT	BTU/LB-F	.9973	1.0001	1.0058	.9989
THERMAL COND.	BTU/HR-FT-F	.3723	.3589	.3466	.3625
MOLAR MASS	LB/LBMOL	18.02		18.02	
TEMP, AVG & SKIN	DEGF	111.5	92.5	68.4	91.8
VISCOSITY, AVG & SKIN	CP	.6150	.7502	.9977	.7561
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.02	10.00	.00	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.19	10.00	.03	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	197.38		133.70	

TOTAL HEAT DUTY REQUIRED	MEGBTU/HR	.011396
EFF TEMP DIF, DEGF (LMTD= 43.0,F= .55,BYPASS= .93,BAFF=1.00)		21.8
OVERALL COEFF REQUIRED	BTU/HR-FT2-F	73.26
CLEAN & FOULED COEFF	BTU/HR-FT2-F	74.60 73.43

SHELLS IN SERIES	1	PARALLEL 1	TOTAL EFF AREA	FT2	7.1
PASSES, SHELL	1	TUBE 4	EFFECTIVE AREA	FT2/SHELL	7.1
SHELL DIAMETER IN.	3.820		TEMA SHELL TYPE E	; REAR HEAD	FXTS
BAFFLE TYPE	HORZ	SEGMENTL	CROSS PASSES PER SHELL PASS		4
SPACING, CENTRAL	IN.	4.309	BAFFLE CUT, PCT SHELL I.D.		30.00
SPACING, INLET	IN.	4.309	CUT DISTANCE FROM CENTER, IN.		.764

SPACING, OUTLET	IN.	4.309			
BAFFLE THICKNESS	IN.	.125	IMPINGEMENT BAFFLE INCLUDED		NO
PAIRS OF SEALING DEVICES		1	TUBESHEET BLANK AREA, %		.0
TUBE TYPE		PLAIN	MATERIAL		ELECTROLYTIC COPPER
NO. OF TUBES/SHELL		76	EST MAX TUBE COUNT		36
TUBE LGTH, OVERALL	FT	1.500	TUBE PITCH	IN.	.3125
TUBE LGTH, EFF	FT	1.436	TUBE OUTSIDE DIAM	IN.	.250
TUBE LAYOUT	DEG	60	TUBE INSIDE DIAM	IN.	.214
PITCH RATIO		1.250	TUBE SURFACE RATIO, OUT/IN		1.184
SHL NOZZ ID, IN&OUT	1.0	1.0	TUBE NOZZ ID, IN&OUT	IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.040	.000
PRANDTL NUMBER	6.8	4.1
RYNLD NO, AVG	74.	512.
RYNLD NO, IN BUN	50.	667.
RYNLD NO,OUT BUN	103.	377.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL			
SHELL	TUBE	FOULING	METAL
54.31	44.05	1.59	.05

PCT OVER DESIGN	.23
TOT FOUL RESIST	.000217
DIFF RESIST	.000031

DIAMETRAL CLEARANCES		
BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.16	.16
DENSITY	LB/FT3	62.535	61.932
NOZZ RHO*VSQ	LB/FT-S2	1	1
BUND RHO*VSQ	LB/FT-S2	1	1

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	.30	.29
DENSITY	LB/FT3	61.291	62.106
PRESS. DROP	%	4.0	2.5

SHELLSIDE PERFORMANCE		
NOMINAL VEL,X-FLOW	FT/S	.03
NOMINAL VEL,WINDOW	FT/S	.05
CROSSFLOW COEF	BTU/HR-FT2-F	135.1
WINDOW COEF	BTU/HR-FT2-F	132.1

SHELLSIDE FLOW, % OF TOTAL		
HEAT TRANSFER X-FLOW		79.56
TUBE TO BAFFLE LEAKAGE	A =	2.53
MAIN CROSSFLOW	B =	68.09
BUNDLE TO SHELL BYPASS	C =	10.96
BAFFLE TO SHELL LEAKAGE	E =	18.42
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS		
TOTAL =(BETA)(GAMMA)(FIN)	=	.598
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.650
END (HT LOSS IN END ZONE)	=	.998

SHELL PRESSURE DROP, % OF TOTAL		
WINDOW	=	10.0
END ZONE	=	8.2
CROSS FLOW	=	6.2
INLET NOZZLE	=	39.7
OUTLET NOZZLE	=	35.9

WEIGHT PER SHELL, LB		
DRY	=	150.
WET	=	165.

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.200		.300	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	72.6*	40.0	84.7*
DENSITY	LB/FT3	61.2913	62.2231	62.5352	62.0844
VISCOSITY	CP	.4726	.9467	1.4791	.8191
SPECIFIC HEAT	BTU/LB-F	.9973	1.0012	1.0058	.9999
THERMAL COND.	BTU/HR-FT-F	.3723	.3561	.3466	.3593
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	106.3	85.4	62.4	84.6
VISCOSITY, AVG & SKIN	CP	.6477	.8131	1.0793	.8205
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.02	10.00	.00	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.19	10.00	.05	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	196.67		154.87	

TOTAL HEAT DUTY REQUIRED MEGBTU/HR			.013451
EFF TEMP DIF, DEGF (LMTD= 43.0,F= .59,BYPASS= .93,BAFF=1.00)			23.7
OVERALL COEFF REQUIRED	BTU/HR-FT2-F		79.55
CLEAN & FOULED COEFF	BTU/HR-FT2-F	80.62	79.19

SHELLS IN SERIES 1 PARALLEL 1		TOTAL EFF AREA FT2	7.1
PASSES, SHELL 1 TUBE 4		EFFECTIVE AREA FT2/SHELL	7.1
SHELL DIAMETER IN.	3.820	TEMA SHELL TYPE E ; REAR HEAD FXTS	
BAFFLE TYPE HORZ SEGMENTL		CROSS PASSES PER SHELL PASS	4
SPACING, CENTRAL IN.	4.309	BAFFLE CUT, PCT SHELL I.D.	30.00
SPACING, INLET IN.	4.309	CUT DISTANCE FROM CENTER, IN.	.764
SPACING, OUTLET IN.	4.309		
BAFFLE THICKNESS IN.	.125	IMPINGEMENT BAFFLE INCLUDED	NO
PAIRS OF SEALING DEVICES	1	TUBESHEET BLANK AREA, %	.0
TUBE TYPE	PLAIN	MATERIAL ELECTROLYTIC COPPER	
NO. OF TUBES/SHELL	76	EST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT	1.500	TUBE PITCH IN.	.3125
TUBE LGTH, EFF FT	1.436	TUBE OUTSIDE DIAM IN.	.250
TUBE LAYOUT DEG	60	TUBE INSIDE DIAM IN.	.214
PITCH RATIO	1.250	TUBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT	1.0 1.0	TUBE NOZZ ID, IN&OUT IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.039	.000
PRANDTL NUMBER	7.4	4.3
RYNLD NO, AVG	104.	487.
RYNLD NO, IN BUN	76.	667.
RYNLD NO,OUT BUN	137.	333.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
50.56	47.67	1.72	.06

PCT OVER DESIGN	-.46
TOT FOUL RESIST	.000217
DIFF RESIST	-.000058

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.24	.25
DENSITY	LB/FT3	62.535	62.084
NOZZ RHO*VSQ	LB/FT-S2	3	3
BUND RHO*VSQ	LB/FT-S2	2	2

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	.30	.29
DENSITY	LB/FT3	61.291	62.223
PRESS. DROP	%	3.8	2.4

□□Washington University ChE433 heat exchanger experiment E0002 P 22
Young model F302DY4P 9/23/ 3
CASE 11

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.200		.400	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	66.3*	40.0	76.7*
DENSITY	LB/FT3	61.2913	62.2904	62.5352	62.1781
VISCOSITY	CP	.4726	1.0251	1.4791	.9010
SPECIFIC HEAT	BTU/LB-F	.9973	1.0020	1.0058	1.0007
THERMAL COND.	BTU/HR-FT-F	.3723	.3543	.3466	.3572
MOLAR MASS	LB/LBMOL	18.02		18.02	
TEMP, AVG & SKIN	DEGF	103.2	80.2	58.3	79.4
VISCOSITY, AVG & SKIN	CP	.6692	.8635	1.1388	.8723
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.02	10.00	.00	10.00

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW	FT/S	.04
NOMINAL VEL,WINDOW	FT/S	.08
CROSSFLOW COEF	BTU/HR-FT2-F	155.5
WINDOW COEF	BTU/HR-FT2-F	156.4

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		80.81
TUBE TO BAFFLE LEAKAGE	A =	2.63
MAIN CROSSFLOW	B =	69.15
BUNDLE TO SHELL BYPASS	C =	11.12
BAFFLE TO SHELL LEAKAGE	E =	17.09
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.598
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.650
END (HT LOSS IN END ZONE)	=	.994

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	9.5
END ZONE	=	6.5
CROSS FLOW	=	5.1
INLET NOZZLE	=	40.9
OUTLET NOZZLE	=	37.9

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

VELOCITY, CALC & MAX ALLOWED	FT/S	.19	10.00	.07	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	196.61		179.08	

TOTAL HEAT DUTY REQUIRED MEGBTU/HR		.014712
EFF TEMP DIF, DEGF (LMTD= 42.2,F= .62,BYPASS= .93,BAFF=1.00)		24.3
OVERALL COEFF REQUIRED	BTU/HR-FT2-F	84.58
CLEAN & FOULED COEFF	BTU/HR-FT2-F 86.71	84.98

SHELLS IN SERIES	1	PARALLEL	1
PASSES, SHELL	1	TUBE	4
SHELL DIAMETER IN.			3.820
TOTAL EFF AREA	FT2		7.1
EFFECTIVE AREA	FT2/SHELL		7.1
TEMA SHELL TYPE	E	; REAR HEAD	FXTS

BAFFLE TYPE	HORZ	SEGMENTL	
SPACING, CENTRAL	IN.		4.309
SPACING, INLET	IN.		4.309
SPACING, OUTLET	IN.		4.309
BAFFLE THICKNESS	IN.		.125
PAIRS OF SEALING DEVICES			1
CROSS PASSES PER SHELL PASS			4
BAFFLE CUT, PCT SHELL I.D.			30.00
CUT DISTANCE FROM CENTER, IN.			.764
IMPINGEMENT BAFFLE INCLUDED			NO
TUBESHEET BLANK AREA, %			.0

TUBE TYPE			PLAIN
NO. OF TUBES/SHELL			76
TUBE LGTH, OVERALL	FT		1.500
TUBE LGTH, EFF	FT		1.436
TUBE LAYOUT	DEG		60
PITCH RATIO			1.250
SHL NOZZ ID, IN&OUT	1.0	1.0	
MATERIAL	ELECTROLYTIC COPPER		
EST MAX TUBE COUNT			36
TUBE PITCH	IN.		.3125
TUBE OUTSIDE DIAM	IN.		.250
TUBE INSIDE DIAM	IN.		.214
TUBE SURFACE RATIO, OUT/IN			1.184
TUBE NOZZ ID, IN&OUT	IN.	.8	.8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.038	.000
PRANDTL NUMBER	7.9	4.4
RYNLD NO, AVG	132.	471.
RYNLD NO, IN BUN	102.	667.
RYNLD NO,OUT BUN	167.	307.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
46.92	51.17	1.84	.06

PCT OVER DESIGN	.47
TOT FOUL RESIST	.000217
DIFF RESIST	.000056

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW	FT/S	.05
NOMINAL VEL,WINDOW	FT/S	.10
CROSSFLOW COEF	BTU/HR-FT2-F	179.8
WINDOW COEF	BTU/HR-FT2-F	180.8

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.32
TUBE TO BAFFLE LEAKAGE	A =	2.78
MAIN CROSSFLOW	B =	69.04
BUNDLE TO SHELL BYPASS	C =	11.72
BAFFLE TO SHELL LEAKAGE	E =	16.47
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.606
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.658

BAFFLE TO SHELL IN. .1000 END (HT LOSS IN END ZONE) = .994

SHELL NOZZLE DATA		IN	OUT	SHELL PRESSURE DROP, % OF TOTAL		
HT UNDR NOZ	IN.	.25		WINDOW	=	9.2
HT OPP NOZ	IN.	.25		END ZONE	=	5.6
VELOCITY	FT/S	.33	.33	CROSS FLOW	=	4.6
DENSITY	LB/FT3	62.535	62.178	INLET NOZZLE	=	41.5
NOZZ RHO*VSQ	LB/FT-S2	6	6	OUTLET NOZZLE	=	39.1
BUND RHO*VSQ	LB/FT-S2	4	4			

TUBE NOZZLE DATA		IN	OUT	WEIGHT PER SHELL, LB		
VELOCITY	FT/S	.30	.29	DRY	=	150.
DENSITY	LB/FT3	61.291	62.290	WET	=	165.
PRESS. DROP	%	3.7	2.3			

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ .200		COLD SHELL SIDE Shell SENSIBLE LIQ .500	
TOTAL FLOW RATE	KLB/HR				
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	62.0*	40.0	71.1*
DENSITY	LB/FT3	61.2913	62.3347	62.5352	62.2402
VISCOSITY	CP	.4726	1.0846	1.4791	.9654
SPECIFIC HEAT	BTU/LB-F	.9973	1.0025	1.0058	1.0014
THERMAL COND.	BTU/HR-FT-F	.3723	.3531	.3466	.3557
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	101.0	76.4	55.5	75.5
VISCOSITY, AVG & SKIN	CP	.6845	.9042	1.1831	.9144
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.02	10.00	.01	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.19	10.00	.08	10.00
FOULING RESISTANCE	HR-FT2-F/BTU		.00010		.00010
FILM COEFFICIENT	BTU/HR-FT2-F		196.65		202.78

TOTAL HEAT DUTY REQUIRED MEGBTU/HR .015580
EFF TEMP DIF, DEGF (LMTD= 41.1,F= .63,BYPASS= .93,BAFF=1.00) 24.3
OVERALL COEFF REQUIRED BTU/HR-FT2-F 89.72
CLEAN & FOULED COEFF BTU/HR-FT2-F 91.92 89.92

SHELLS IN SERIES	1	PARALLEL 1	TOTAL EFF AREA	FT2	7.1
PASSES, SHELL	1	TUBE 4	EFFECTIVE AREA	FT2/SHELL	7.1
SHELL DIAMETER IN.	3.820		TEMA SHELL TYPE E	; REAR HEAD	FXTS

BAFFLE TYPE	HORZ	SEGMENTL	CROSS PASSES PER SHELL PASS		4
SPACING, CENTRAL	IN.	4.309	BAFFLE CUT, PCT SHELL I.D.		30.00
SPACING, INLET	IN.	4.309	CUT DISTANCE FROM CENTER, IN.		.764
SPACING, OUTLET	IN.	4.309			

BAFFLE THICKNESS IN.	.125	IMPINGEMENT BAFFLE INCLUDED	NO
PAIRS OF SEALING DEVICES	1	TUBESHEET BLANK AREA, %	.0

TUBE TYPE	PLAIN	MATERIAL	ELECTROLYTIC COPPER
NO. OF TUBES/SHELL	76	EST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT	1.500	TUBE PITCH IN.	.3125
TUBE LGTH, EFF FT	1.436	TUBE OUTSIDE DIAM IN.	.250
TUBE LAYOUT DEG	60	TUBE INSIDE DIAM IN.	.214
PITCH RATIO	1.250	TUBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT	1.0 1.0	TUBE NOZZ ID, IN&OUT IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.037	.000
PRANDTL NUMBER	8.2	4.6
RYNLD NO, AVG	159.	460.
RYNLD NO, IN BUN	127.	667.
RYNLD NO,OUT BUN	195.	291.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
43.85	54.14	1.95	.06

PCT OVER DESIGN	.23
TOT FOUL RESIST	.000217
DIFF RESIST	.000025

SHELLSIDE PERFORMANCE		
NOMINAL VEL,X-FLOW	FT/S	.07
NOMINAL VEL,WINDOW	FT/S	.13
CROSSFLOW COEF	BTU/HR-FT2-F	203.6
WINDOW COEF	BTU/HR-FT2-F	204.8

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.40
TUBE TO BAFFLE LEAKAGE	A =	2.96
MAIN CROSSFLOW	B =	68.25
BUNDLE TO SHELL BYPASS	C =	12.55
BAFFLE TO SHELL LEAKAGE	E =	16.24
TUBE PASSLANE BYPASS	F =	.00

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.620
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.673
END (HT LOSS IN END ZONE)	=	.994

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.41	.41
DENSITY	LB/FT3	62.535	62.240
NOZZ RHO*VSQ	LB/FT-S2	10	10
BUND RHO*VSQ	LB/FT-S2	7	7

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	9.0
END ZONE	=	5.1
CROSS FLOW	=	4.3
INLET NOZZLE	=	41.8
OUTLET NOZZLE	=	39.8

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	.30	.29
DENSITY	LB/FT3	61.291	62.335
PRESS. DROP	%	3.6	2.3

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.200		.600	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	58.9*	40.0	66.9*
DENSITY	LB/FT3	61.2913	62.3655	62.5352	62.2843
VISCOSITY	CP	.4726	1.1304	1.4791	1.0175
SPECIFIC HEAT	BTU/LB-F	.9973	1.0029	1.0058	1.0019
THERMAL COND.	BTU/HR-FT-F	.3723	.3522	.3466	.3545
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	99.4	73.4	53.5	72.4
VISCOSITY, AVG & SKIN	CP	.6959	.9378	1.2175	.9491
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.02	10.00	.01	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.19	10.00	.10	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	196.73		225.36	

TOTAL HEAT DUTY REQUIRED	MEGBTU/HR				.016202
EFF TEMP DIF, DEGF (LMTD= 40.1,F= .65,BYPASS= .93,BAFF=1.00)					24.1
OVERALL COEFF REQUIRED	BTU/HR-FT2-F				93.93
CLEAN & FOULED COEFF	BTU/HR-FT2-F		96.31		94.08
SHELLS IN SERIES	1	PARALLEL	1	TOTAL EFF AREA FT2	7.1
PASSES, SHELL	1	TUBE	4	EFFECTIVE AREA FT2/SHELL	7.1
SHELL DIAMETER IN.			3.820	TEMA SHELL TYPE E ; REAR HEAD	FXTS
BAFFLE TYPE	HORZ	SEGMENTL		CROSS PASSES PER SHELL PASS	4
SPACING, CENTRAL IN.			4.309	BAFFLE CUT, PCT SHELL I.D.	30.00
SPACING, INLET IN.			4.309	CUT DISTANCE FROM CENTER, IN.	.764
SPACING, OUTLET IN.			4.309		
BAFFLE THICKNESS IN.			.125	IMPINGEMENT BAFFLE INCLUDED	NO
PAIRS OF SEALING DEVICES			1	TUBESHEET BLANK AREA, %	.0
TUBE TYPE			PLAIN	MATERIAL	ELECTROLYTIC COPPER
NO. OF TUBES/SHELL			76	EST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT			1.500	TUBE PITCH IN.	.3125
TUBE LGTH, EFF FT			1.436	TUBE OUTSIDE DIAM IN.	.250
TUBE LAYOUT DEG			60	TUBE INSIDE DIAM IN.	.214
PITCH RATIO			1.250	TUBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT	1.0	1.0		TUBE NOZZ ID, IN&OUT IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS SHELL TUBE SHELLSIDE PERFORMANCE

WALL CORRECTION	1.035	.000
PRANDTL NUMBER	8.4	4.6
RYNLD NO, AVG	186.	453.
RYNLD NO, IN BUN	153.	667.
RYNLD NO,OUT BUN	222.	279.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
41.28	56.61	2.04	.07

PCT OVER DESIGN	.16
TOT FOUL RESIST	.000217
DIFF RESIST	.000017

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

NOMINAL VEL,X-FLOW	FT/S	.08
NOMINAL VEL,WINDOW	FT/S	.15
CROSSFLOW COEF	BTU/HR-FT2-F	226.2
WINDOW COEF	BTU/HR-FT2-F	227.7

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.47
TUBE TO BAFFLE LEAKAGE	A =	3.12
MAIN CROSSFLOW	B =	67.55
BUNDLE TO SHELL BYPASS	C =	13.29
BAFFLE TO SHELL LEAKAGE	E =	16.04
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.633
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.689
END (HT LOSS IN END ZONE)	=	.994

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.49	.49
DENSITY	LB/FT3	62.535	62.284
NOZZ RHO*VSQ	LB/FT-S2	14	14
BUND RHO*VSQ	LB/FT-S2	10	10

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	8.9
END ZONE	=	4.8
CROSS FLOW	=	4.0
INLET NOZZLE	=	42.0
OUTLET NOZZLE	=	40.3

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	.30	.29
DENSITY	LB/FT3	61.291	62.366
PRESS. DROP	%	3.5	2.2

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.200		.700	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	56.5*	40.0	63.7*
DENSITY	LB/FT3	61.2913	62.3885	62.5352	62.3171
VISCOSITY	CP	.4726	1.1672	1.4791	1.0601
SPECIFIC HEAT	BTU/LB-F	.9973	1.0033	1.0058	1.0023
THERMAL COND.	BTU/HR-FT-F	.3723	.3515	.3466	.3536
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	98.3	71.0	51.9	70.0
VISCOSITY, AVG & SKIN	CP	.7047	.9662	1.2448	.9786
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.02	10.00	.01	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.19	10.00	.11	10.00

FOULING RESISTANCE	HR-FT2-F/BTU	.00010	.00010
FILM COEFFICIENT	BTU/HR-FT2-F	196.81	247.22

TOTAL HEAT DUTY REQUIRED MEGBTU/HR	.016677
EFF TEMP DIF, DEGF (LMTD= 39.1,F= .65,BYPASS= .93,BAFF=1.00)	23.8
OVERALL COEFF REQUIRED BTU/HR-FT2-F	97.90
CLEAN & FOULED COEFF BTU/HR-FT2-F 100.12	97.67

SHELLS IN SERIES	1	PARALLEL	1
PASSES, SHELL	1	TUBE	4
SHELL DIAMETER IN.	3.820		

TOTAL EFF AREA FT2	7.1
EFFECTIVE AREA FT2/SHELL	7.1
TEMA SHELL TYPE E ; REAR HEAD	FXTS

BAFFLE TYPE	HORZ SEGMENTL
SPACING, CENTRAL IN.	4.309
SPACING, INLET IN.	4.309
SPACING, OUTLET IN.	4.309
BAFFLE THICKNESS IN.	.125
PAIRS OF SEALING DEVICES	1

CROSS PASSES PER SHELL PASS	4
BAFFLE CUT, PCT SHELL I.D.	30.00
CUT DISTANCE FROM CENTER, IN.	.764
IMPINGEMENT BAFFLE INCLUDED	NO
TUBESHEET BLANK AREA, %	.0

TUBE TYPE	PLAIN	MATERIAL	ELECTROLYTIC COPPER
NO. OF TUBES/SHELL	76	EST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT	1.500	TUBE PITCH IN.	.3125
TUBE LGTH, EFF FT	1.436	TUBE OUTSIDE DIAM IN.	.250
TUBE LAYOUT DEG	60	TUBE INSIDE DIAM IN.	.214
PITCH RATIO	1.250	TUBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT	1.0 1.0	TUBE NOZZ ID, IN&OUT IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.034	.000
PRANDTL NUMBER	8.6	4.7
RYNLD NO, AVG	212.	447.
RYNLD NO, IN BUN	178.	667.
RYNLD NO,OUT BUN	249.	270.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL			
SHELL	TUBE	FOULING	METAL
39.06	58.75	2.12	.07

PCT OVER DESIGN	-.24
TOT FOUL RESIST	.000217
DIFF RESIST	-.000025

DIAMETRAL CLEARANCES		
BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELLSIDE PERFORMANCE		
NOMINAL VEL,X-FLOW	FT/S	.09
NOMINAL VEL,WINDOW	FT/S	.18
CROSSFLOW COEF	BTU/HR-FT2-F	248.2
WINDOW COEF	BTU/HR-FT2-F	249.8

SHELLSIDE FLOW, % OF TOTAL		
HEAT TRANSFER X-FLOW		81.54
TUBE TO BAFFLE LEAKAGE	A =	3.26
MAIN CROSSFLOW	B =	66.93
BUNDLE TO SHELL BYPASS	C =	13.96
BAFFLE TO SHELL LEAKAGE	E =	15.86
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS		
TOTAL =(BETA)(GAMMA)(FIN)	=	.647
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.704
END (HT LOSS IN END ZONE)	=	.994

SHELL NOZZLE DATA		IN	OUT	SHELL PRESSURE DROP, % OF TOTAL		
HT UNDR NOZ	IN.	.25		WINDOW	=	8.9
HT OPP NOZ	IN.	.25		END ZONE	=	4.5
VELOCITY	FT/S	.57	.57	CROSS FLOW	=	3.8
DENSITY	LB/FT3	62.535	62.317	INLET NOZZLE	=	42.2
NOZZ RHO*VSQ	LB/FT-S2	20	20	OUTLET NOZZLE	=	40.7
BUND RHO*VSQ	LB/FT-S2	13	13			

TUBE NOZZLE DATA		IN	OUT	WEIGHT PER SHELL, LB		
VELOCITY	FT/S	.30	.29	DRY	=	150.
DENSITY	LB/FT3	61.291	62.388	WET	=	165.
PRESS. DROP	%	3.5	2.2			

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.200		.800	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	54.7*	40.0	61.2*
DENSITY	LB/FT3	61.2913	62.4058	62.5352	62.3425
VISCOSITY	CP	.4726	1.1968	1.4791	1.0958
SPECIFIC HEAT	BTU/LB-F	.9973	1.0035	1.0058	1.0026
THERMAL COND.	BTU/HR-FT-F	.3723	.3510	.3466	.3529
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	97.3	69.0	50.6	68.0
VISCOSITY, AVG & SKIN	CP	.7117	.9907	1.2670	1.0040
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.02	10.00	.01	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.19	10.00	.12	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	196.90		268.41	

TOTAL HEAT DUTY REQUIRED	MEGBTU/HR	.017043
EFF TEMP DIF, DEGF (LMTD= 38.2,F= .66,BYPASS= .93,BAFF=1.00)		23.6
OVERALL COEFF REQUIRED	BTU/HR-FT2-F	101.19
CLEAN & FOULED COEFF	BTU/HR-FT2-F	103.46 / 100.80

SHELLS IN SERIES	1	PARALLEL 1	TOTAL EFF AREA	FT2	7.1
PASSES, SHELL	1	TUBE 4	EFFECTIVE AREA	FT2/SHELL	7.1
SHELL DIAMETER IN.	3.820		TEMA SHELL TYPE E	; REAR HEAD	FXTS

BAFFLE TYPE	HORZ	SEGMENTL	CROSS PASSES PER SHELL PASS		4
SPACING, CENTRAL	IN.	4.309	BAFFLE CUT, PCT SHELL I.D.		30.00
SPACING, INLET	IN.	4.309	CUT DISTANCE FROM CENTER, IN.		.764
SPACING, OUTLET	IN.	4.309			
BAFFLE THICKNESS	IN.	.125	IMPINGEMENT BAFFLE INCLUDED		NO

PAIRS OF SEALING DEVICES		1	TUBESHEET BLANK AREA, %		.0
TUBE TYPE		PLAIN	MATERIAL		ELECTROLYTIC COPPER
NO. OF TUBES/SHELL		76	EST MAX TUBE COUNT		36
TUBE LGTH, OVERALL	FT	1.500	TUBE PITCH	IN.	.3125
TUBE LGTH, EFF	FT	1.436	TUBE OUTSIDE DIAM	IN.	.250
TUBE LAYOUT	DEG	60	TUBE INSIDE DIAM	IN.	.214
PITCH RATIO		1.250	TUBE SURFACE RATIO, OUT/IN		1.184
SHL NOZZ ID, IN&OUT	1.0	1.0	TUBE NOZZ ID, IN&OUT	IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.033	.000
PRANDTL NUMBER	8.8	4.7
RYNLD NO, AVG	238.	443.
RYNLD NO, IN BUN	204.	667.
RYNLD NO,OUT BUN	275.	263.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
37.13	60.61	2.19	.07

PCT OVER DESIGN	-.38
TOT FOUL RESIST	.000217
DIFF RESIST	-.000038

SHELLSIDE PERFORMANCE		
NOMINAL VEL,X-FLOW	FT/S	.10
NOMINAL VEL,WINDOW	FT/S	.20
CROSSFLOW COEF	BTU/HR-FT2-F	269.5
WINDOW COEF	BTU/HR-FT2-F	271.2

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.54
TUBE TO BAFFLE LEAKAGE	A =	3.40
MAIN CROSSFLOW	B =	66.27
BUNDLE TO SHELL BYPASS	C =	14.58
BAFFLE TO SHELL LEAKAGE	E =	15.75
TUBE PASSLANE BYPASS	F =	.00

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.661
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.719
END (HT LOSS IN END ZONE)	=	.994

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.65	.65
DENSITY	LB/FT3	62.535	62.342
NOZZ RHO*VSQ	LB/FT-S2	26	26
BUND RHO*VSQ	LB/FT-S2	18	18

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	8.9
END ZONE	=	4.2
CROSS FLOW	=	3.6
INLET NOZZLE	=	42.3
OUTLET NOZZLE	=	41.0

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	.30	.29
DENSITY	LB/FT3	61.291	62.406
PRESS. DROP	%	3.4	2.1

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

	HOT TUBE SIDE	COLD SHELL SIDE

		Tube SENSIBLE LIQ		Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.200		.900	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	53.3*	40.0	59.2*
DENSITY	LB/FT3	61.2913	62.4189	62.5352	62.3628
VISCOSITY	CP	.4726	1.2202	1.4791	1.1262
SPECIFIC HEAT	BTU/LB-F	.9973	1.0037	1.0058	1.0029
THERMAL COND.	BTU/HR-FT-F	.3723	.3506	.3466	.3523
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	96.6	67.3	49.6	66.2
VISCOSITY, AVG & SKIN	CP	.7170	1.0120	1.2855	1.0263
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.02	10.00	.02	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.19	10.00	.14	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	197.02		289.32	

TOTAL HEAT DUTY REQUIRED	MEGBTU/HR			.017322
EFF TEMP DIF, DEGF	(LMTD= 37.4,F= .67,BYPASS= .93,BAFF=1.00)			23.5
OVERALL COEFF REQUIRED	BTU/HR-FT2-F			103.28
CLEAN & FOULED COEFF	BTU/HR-FT2-F	106.46		103.62

SHELLS IN SERIES	1	PARALLEL 1	TOTAL EFF AREA	FT2	7.1
PASSES, SHELL	1	TUBE 4	EFFECTIVE AREA	FT2/SHELL	7.1
SHELL DIAMETER IN.		3.820	TEMA SHELL TYPE E	; REAR HEAD	FXTS
BAFFLE TYPE	HORZ	SEGMENTL	CROSS PASSES PER SHELL PASS		4
SPACING, CENTRAL	IN.	4.309	BAFFLE CUT, PCT SHELL I.D.		30.00
SPACING, INLET	IN.	4.309	CUT DISTANCE FROM CENTER, IN.		.764
SPACING, OUTLET	IN.	4.309			
BAFFLE THICKNESS	IN.	.125	IMPINGEMENT BAFFLE INCLUDED		NO
PAIRS OF SEALING DEVICES		1	TUBESHEET BLANK AREA, %		.0
TUBE TYPE		PLAIN	MATERIAL	ELECTROLYTIC COPPER	
NO. OF TUBES/SHELL		76	EST MAX TUBE COUNT		36
TUBE LGTH, OVERALL	FT	1.500	TUBE PITCH	IN.	.3125
TUBE LGTH, EFF	FT	1.436	TUBE OUTSIDE DIAM	IN.	.250
TUBE LAYOUT	DEG	60	TUBE INSIDE DIAM	IN.	.214
PITCH RATIO		1.250	TUBE SURFACE RATIO, OUT/IN		1.184
SHL NOZZ ID, IN&OUT	1.0	1.0	TUBE NOZZ ID, IN&OUT	IN. .8	.8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE	SHELLSIDE PERFORMANCE		
WALL CORRECTION	1.032	.000	NOMINAL VEL,X-FLOW	FT/S	.12

PRANDTL NUMBER	8.9	4.8
RYNLD NO, AVG	264.	440.
RYNLD NO, IN BUN	229.	667.
RYNLD NO,OUT BUN	301.	258.
FOULNG LAYER IN.	.0014	.0014

NOMINAL VEL,WINDOW	FT/S	.23
CROSSFLOW COEF	BTU/HR-FT2-F	290.5
WINDOW COEF	BTU/HR-FT2-F	292.3

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
35.41	62.27	2.25	.07

PCT OVER DESIGN	.33
TOT FOUL RESIST	.000217
DIFF RESIST	.000032

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.54
TUBE TO BAFFLE LEAKAGE	A =	3.52
MAIN CROSSFLOW	B =	65.71
BUNDLE TO SHELL BYPASS	C =	15.12
BAFFLE TO SHELL LEAKAGE	E =	15.64
TUBE PASSLANE BYPASS	F =	.00

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.675
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.734
END (HT LOSS IN END ZONE)	=	.994

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.73	.73
DENSITY	LB/FT3	62.535	62.363
NOZZ RHO*VSQ	LB/FT-S2	33	33
BUND RHO*VSQ	LB/FT-S2	22	22

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	8.9
END ZONE	=	4.0
CROSS FLOW	=	3.5
INLET NOZZLE	=	42.4
OUTLET NOZZLE	=	41.3

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	.30	.29
DENSITY	LB/FT3	61.291	62.419
PRESS. DROP	%	3.4	2.1

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.300		.200	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	95.5*	40.0	106.5*
DENSITY	LB/FT3	61.2913	61.9502	62.5352	61.8032
VISCOSITY	CP	.4726	.7259	1.4791	.6465
SPECIFIC HEAT	BTU/LB-F	.9973	.9990	1.0058	.9982
THERMAL COND.	BTU/HR-FT-F	.3723	.3621	.3466	.3648
MOLAR MASS	LB/LBMOL	18.02		18.02	
TEMP, AVG & SKIN	DEGF	117.8	98.5	73.3	97.7
VISCOSITY, AVG & SKIN	CP	.5782	.7030	.9394	.7086
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.02	10.00	.00	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.29	10.00	.03	10.00

FOULING RESISTANCE	HR-FT2-F/BTU	.00010	.00010
FILM COEFFICIENT	BTU/HR-FT2-F	204.16	134.13

TOTAL HEAT DUTY REQUIRED MEGBTU/HR	.013316
EFF TEMP DIF, DEGF (LMTD= 43.6,F= .63,BYPASS= .92,BAFF=1.00)	25.0
OVERALL COEFF REQUIRED BTU/HR-FT2-F	74.57
CLEAN & FOULED COEFF BTU/HR-FT2-F 75.85	74.66

SHELLS IN SERIES	1	PARALLEL	1
PASSES, SHELL	1	TUBE	4
SHELL DIAMETER IN.			3.820

TOTAL EFF AREA FT2	7.1
EFFECTIVE AREA FT2/SHELL	7.1
TEMA SHELL TYPE E ; REAR HEAD	FXTS

BAFFLE TYPE HORZ SEGMENTL	
SPACING, CENTRAL IN.	4.309
SPACING, INLET IN.	4.309
SPACING, OUTLET IN.	4.309
BAFFLE THICKNESS IN.	.125
PAIRS OF SEALING DEVICES	1

CROSS PASSES PER SHELL PASS	4
BAFFLE CUT, PCT SHELL I.D.	30.00
CUT DISTANCE FROM CENTER, IN.	.764
IMPINGEMENT BAFFLE INCLUDED	NO
TUBESHEET BLANK AREA, %	.0

TUBE TYPE			PLAIN
NO. OF TUBES/SHELL			76
TUBE LGTH, OVERALL	FT		1.500
TUBE LGTH, EFF	FT		1.436
TUBE LAYOUT	DEG		60
PITCH RATIO			1.250
SHL NOZZ ID, IN&OUT	1.0	1.0	

MATERIAL			ELECTROLYTIC COPPER
EST MAX TUBE COUNT			36
TUBE PITCH	IN.		.3125
TUBE OUTSIDE DIAM	IN.		.250
TUBE INSIDE DIAM	IN.		.214
TUBE SURFACE RATIO, OUT/IN			1.184
TUBE NOZZ ID, IN&OUT	IN.	.8	.8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

□□Washington University ChE433 heat exchanger experiment E0002 P 35
Young model F302DY4P 9/23/ 3
CASE 17

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.040	.000
PRANDTL NUMBER	6.4	3.8
RYNLD NO, AVG	79.	818.
RYNLD NO, IN BUN	50.	1000.
RYNLD NO,OUT BUN	114.	651.
FOULNG LAYER IN.	.0014	.0014

SHELLSIDE PERFORMANCE		
NOMINAL VEL,X-FLOW	FT/S	.03
NOMINAL VEL,WINDOW	FT/S	.05
CROSSFLOW COEF	BTU/HR-FT2-F	135.6
WINDOW COEF	BTU/HR-FT2-F	132.5

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
55.04	43.29	1.62	.05

PCT OVER DESIGN	.12
TOT FOUL RESIST	.000217
DIFF RESIST	.000016

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		79.81
TUBE TO BAFFLE LEAKAGE	A =	2.55
MAIN CROSSFLOW	B =	68.32
BUNDLE TO SHELL BYPASS	C =	10.98
BAFFLE TO SHELL LEAKAGE	E =	18.15
TUBE PASSLANE BYPASS	F =	.00

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.598
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.650
END (HT LOSS IN END ZONE)	=	.998

SHELL NOZZLE DATA		IN	OUT	SHELL PRESSURE DROP, % OF TOTAL		
HT UNDR NOZ	IN.	.25		WINDOW	=	9.9
HT OPP NOZ	IN.	.25		END ZONE	=	7.9
VELOCITY	FT/S	.16	.16	CROSS FLOW	=	6.0
DENSITY	LB/FT3	62.535	61.803	INLET NOZZLE	=	40.3
NOZZ RHO*VSQ	LB/FT-S2	1	1	OUTLET NOZZLE	=	36.0
BUND RHO*VSQ	LB/FT-S2	1	1			

TUBE NOZZLE DATA		IN	OUT	WEIGHT PER SHELL, LB		
VELOCITY	FT/S	.44	.44	DRY	=	150.
DENSITY	LB/FT3	61.291	61.950	WET	=	165.
PRESS. DROP	%	5.9	3.7			

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.300		.300	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	85.2*	40.0	94.6*
DENSITY	LB/FT3	61.2913	62.0787	62.5352	61.9621
VISCOSITY	CP	.4726	.8147	1.4791	.7332
SPECIFIC HEAT	BTU/LB-F	.9973	.9999	1.0058	.9991
THERMAL COND.	BTU/HR-FT-F	.3723	.3595	.3466	.3619
MOLAR MASS	LB/LBMOL	18.02		18.02	
TEMP, AVG & SKIN	DEGF	112.6	91.2	67.3	90.4
VISCOSITY, AVG & SKIN	CP	.6081	.7608	1.0124	.7678
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.03	10.00	.00	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.29	10.00	.05	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	203.53		157.05	

TOTAL HEAT DUTY REQUIRED	MEGBTU/HR	.016407
EFF TEMP DIF, DEGF (LMTD= 45.3,F= .67,BYPASS= .93,BAFF=1.00)		28.4
OVERALL COEFF REQUIRED	BTU/HR-FT2-F	80.74
CLEAN & FOULED COEFF	BTU/HR-FT2-F	82.55 / 81.06

SHELLS IN SERIES	1	PARALLEL 1	TOTAL EFF AREA	FT2	7.1
PASSES, SHELL	1	TUBE 4	EFFECTIVE AREA	FT2/SHELL	7.1
SHELL DIAMETER IN.	3.820		TEMA SHELL TYPE E	; REAR HEAD	FXTS
BAFFLE TYPE	HORZ	SEGMENTL	CROSS PASSES PER SHELL PASS		4
SPACING, CENTRAL	IN.	4.309	BAFFLE CUT, PCT SHELL I.D.		30.00
SPACING, INLET	IN.	4.309	CUT DISTANCE FROM CENTER, IN.		.764
SPACING, OUTLET	IN.	4.309			
BAFFLE THICKNESS	IN.	.125	IMPINGEMENT BAFFLE INCLUDED		NO
PAIRS OF SEALING DEVICES		1	TUBESHEET BLANK AREA, %		.0

TUBE TYPE		PLAIN	MATERIAL		ELECTROLYTIC COPPER
NO. OF TUBES/SHELL		76	EST MAX TUBE COUNT		36
TUBE LGTH, OVERALL	FT	1.500	TUBE PITCH	IN.	.3125
TUBE LGTH, EFF	FT	1.436	TUBE OUTSIDE DIAM	IN.	.250
TUBE LAYOUT	DEG	60	TUBE INSIDE DIAM	IN.	.214
PITCH RATIO		1.250	TUBE SURFACE RATIO, OUT/IN		1.184
SHL NOZZ ID, IN&OUT	1.0	1.0	TUBE NOZZ ID, IN&OUT	IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.039	.000
PRANDTL NUMBER	6.9	4.0
RYNLD NO, AVG	111.	777.
RYNLD NO, IN BUN	76.	1000.
RYNLD NO,OUT BUN	153.	580.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
51.03	47.15	1.76	.06

PCT OVER DESIGN	.39
TOT FOUL RESIST	.000217
DIFF RESIST	.000049

DIAMETRAL CLEARANCES		
BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.24	.25
DENSITY	LB/FT3	62.535	61.962
NOZZ RHO*VSQ	LB/FT-S2	3	3
BUND RHO*VSQ	LB/FT-S2	2	2

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	.44	.44
DENSITY	LB/FT3	61.291	62.079
PRESS. DROP	%	5.6	3.5

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW	FT/S	.04
NOMINAL VEL,WINDOW	FT/S	.08
CROSSFLOW COEF	BTU/HR-FT2-F	157.7
WINDOW COEF	BTU/HR-FT2-F	158.5

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.05
TUBE TO BAFFLE LEAKAGE	A =	2.66
MAIN CROSSFLOW	B =	69.36
BUNDLE TO SHELL BYPASS	C =	11.15
BAFFLE TO SHELL LEAKAGE	E =	16.83
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.598
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.650
END (HT LOSS IN END ZONE)	=	.994

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	9.4
END ZONE	=	6.2
CROSS FLOW	=	4.9
INLET NOZZLE	=	41.5
OUTLET NOZZLE	=	38.0

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

	HOT TUBE SIDE	COLD SHELL SIDE
	Tube	Shell

			SENSIBLE LIQ		SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR		.300		.400	
			IN	OUT	IN	OUT
TEMPERATURE	DEGF		140.0	78.1*	40.0	86.2*
DENSITY	LB/FT3		61.2913	62.1613	62.5352	62.0667
VISCOSITY	CP		.4726	.8851	1.4791	.8055
SPECIFIC HEAT	BTU/LB-F		.9973	1.0006	1.0058	.9998
THERMAL COND.	BTU/HR-FT-F		.3723	.3576	.3466	.3597
MOLAR MASS	LB/LBMOL			18.02		18.02
TEMP, AVG & SKIN	DEGF		109.1	85.7	63.1	84.8
VISCOSITY, AVG & SKIN	CP		.6298	.8099	1.0690	.8183
PRESSURE, IN & DESIGN	PSIA		50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI		.03	10.00	.00	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S		.29	10.00	.06	10.00
FOULING RESISTANCE	HR-FT2-F/BTU		.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F		203.30		182.70	
TOTAL HEAT DUTY REQUIRED	MEGBTU/HR					.018520
EFF TEMP DIF, DEGF (LMTD= 45.5,F= .70,BYPASS= .94,BAFF=1.00)						29.6
OVERALL COEFF REQUIRED	BTU/HR-FT2-F					87.55
CLEAN & FOULED COEFF	BTU/HR-FT2-F			89.07		87.26

SHELLS IN SERIES 1 PARALLEL 1		TOTAL EFF AREA FT2	7.1
PASSES, SHELL 1 TUBE 4		EFFECTIVE AREA FT2/SHELL	7.1
SHELL DIAMETER IN. 3.820		TEMA SHELL TYPE E ; REAR HEAD FXTS	
BAFFLE TYPE HORZ SEGMENTL		CROSS PASSES PER SHELL PASS	4
SPACING, CENTRAL IN. 4.309		BAFFLE CUT, PCT SHELL I.D.	30.00
SPACING, INLET IN. 4.309		CUT DISTANCE FROM CENTER, IN.	.764
SPACING, OUTLET IN. 4.309			
BAFFLE THICKNESS IN. .125		IMPINGEMENT BAFFLE INCLUDED	NO
PAIRS OF SEALING DEVICES 1		TUBESHEET BLANK AREA, %	.0
TUBE TYPE PLAIN		MATERIAL ELECTROLYTIC COPPER	
NO. OF TUBES/SHELL 76		EST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT 1.500		TUBE PITCH IN.	.3125
TUBE LGTH, EFF FT 1.436		TUBE OUTSIDE DIAM IN.	.250
TUBE LAYOUT DEG 60		TUBE INSIDE DIAM IN.	.214
PITCH RATIO 1.250		TUBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT 1.0 1.0		TUBE NOZZ ID, IN&OUT IN. .8	.8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE	SHELLSIDE PERFORMANCE		
WALL CORRECTION	1.038	.000	NOMINAL VEL,X-FLOW	FT/S	.05
PRANDTL NUMBER	7.3	4.2	NOMINAL VEL,WINDOW	FT/S	.10

RYNLD NO, AVG	141.	751.	CROSSFLOW COEF	BTU/HR-FT2-F	183.5
RYNLD NO, IN BUN	102.	1000.	WINDOW COEF	BTU/HR-FT2-F	184.5
RYNLD NO,OUT BUN	187.	534.			
FOULNG LAYER IN.	.0014	.0014			

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
47.23	50.82	1.89	.06

PCT OVER DESIGN	-.32
TOT FOUL RESIST	.000217
DIFF RESIST	-.000037

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.35
TUBE TO BAFFLE LEAKAGE	A =	2.84
MAIN CROSSFLOW	B =	68.79
BUNDLE TO SHELL BYPASS	C =	11.99
BAFFLE TO SHELL LEAKAGE	E =	16.38
TUBE PASSLANE BYPASS	F =	.00

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.610
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.663
END (HT LOSS IN END ZONE)	=	.994

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.33	.33
DENSITY	LB/FT3	62.535	62.067
NOZZ RHO*VSQ	LB/FT-S2	6	6
BUND RHO*VSQ	LB/FT-S2	4	4

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	9.1
END ZONE	=	5.4
CROSS FLOW	=	4.5
INLET NOZZLE	=	41.9
OUTLET NOZZLE	=	39.0

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	.44	.44
DENSITY	LB/FT3	61.291	62.161
PRESS. DROP	%	5.4	3.4

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

□□Washington University ChE433 heat exchanger experiment E0002 P 40
Young model F302DY4P 9/23/ 3
CASE 20

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ .300 IN	HOT TUBE SIDE Tube SENSIBLE LIQ .300 OUT	COLD SHELL SIDE Shell SENSIBLE LIQ .500 IN	COLD SHELL SIDE Shell SENSIBLE LIQ .500 OUT
TOTAL FLOW RATE	KLB/HR				
TEMPERATURE	DEGF	140.0	73.1*	40.0	79.9*
DENSITY	LB/FT3	61.2913	62.2176	62.5352	62.1407
VISCOSITY	CP	.4726	.9409	1.4791	.8664
SPECIFIC HEAT	BTU/LB-F	.9973	1.0011	1.0058	1.0004
THERMAL COND.	BTU/HR-FT-F	.3723	.3562	.3466	.3581
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	106.6	81.5	60.0	80.5
VISCOSITY, AVG & SKIN	CP	.6461	.8507	1.1141	.8604
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.03	10.00	.01	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.29	10.00	.08	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	

```
FILM COEFFICIENT       BTU/HR-FT2-F      203.18              206.97
                  -------------------------------------

TOTAL HEAT DUTY REQUIRED MEGBTU/HR                                  .020026
EFF TEMP DIF, DEGF  (LMTD= 45.3,F= .71,BYPASS= .94,BAFF=1.00)        30.2
OVERALL COEFF REQUIRED   BTU/HR-FT2-F                               92.79
CLEAN & FOULED COEFF     BTU/HR-FT2-F            94.44              92.35

SHELLS IN SERIES  1 PARALLEL  1   TOTAL EFF AREA      FT2            7.1
PASSES, SHELL     1 TUBE      4   EFFECTIVE AREA      FT2/SHELL      7.1
SHELL DIAMETER IN.        3.820   TEMA SHELL TYPE  E   ; REAR HEAD  FXTS

BAFFLE TYPE      HORZ  SEGMENTL   CROSS PASSES PER SHELL PASS          4
SPACING, CENTRAL  IN.     4.309   BAFFLE CUT, PCT SHELL I.D.       30.00
SPACING, INLET    IN.     4.309   CUT DISTANCE FROM CENTER, IN.     .764
SPACING, OUTLET   IN.     4.309
BAFFLE THICKNESS  IN.      .125   IMPINGEMENT BAFFLE INCLUDED         NO
PAIRS OF SEALING DEVICES      1   TUBESHEET BLANK AREA, %              .0

TUBE TYPE                 PLAIN   MATERIAL          ELECTROLYTIC COPPER
NO. OF TUBES/SHELL           76   EST MAX TUBE COUNT                  36
TUBE LGTH, OVERALL  FT    1.500   TUBE PITCH            IN.        .3125
TUBE LGTH, EFF      FT    1.436   TUBE OUTSIDE DIAM     IN.         .250
TUBE LAYOUT         DEG      60   TUBE INSIDE DIAM      IN.         .214
PITCH RATIO               1.250   TUBE SURFACE RATIO, OUT/IN       1.184
SHL NOZZ ID, IN&OUT   1.0   1.0   TUBE NOZZ ID, IN&OUT  IN.     .8    .8

  * CALCULATED ITEM--HEAT BALANCE CODE = 8
□□Washington University ChE433 heat exchanger experiment        E0002 P 41
Young model F302DY4P                                             9/23/ 3
                                                                 CASE 20
S  U  P  P  L  E  M  E  N  T  A  R  Y     R  E  S  U  L  T  S

  HT PARAMETERS    SHELL    TUBE      SHELLSIDE PERFORMANCE
WALL CORRECTION    1.037    .000    NOMINAL VEL,X-FLOW  FT/S         .07
PRANDTL NUMBER       7.7     4.3    NOMINAL VEL,WINDOW  FT/S         .13
RYNLD NO, AVG        169.    732.   CROSSFLOW COEF   BTU/HR-FT2-F  207.8
RYNLD NO, IN BUN     127.   1000.   WINDOW COEF      BTU/HR-FT2-F  209.1
RYNLD NO,OUT BUN     217.    502.
FOULNG LAYER IN.    .0014   .0014     SHELLSIDE FLOW, % OF TOTAL
                                      HEAT TRANSFER X-FLOW          81.43
THERMAL RESISTANCE, % OF TOTAL        TUBE TO BAFFLE LEAKAGE    A =   3.02
 SHELL   TUBE  FOULING  METAL         MAIN CROSSFLOW            B =  68.00
 44.12  53.81    2.00     .07        BUNDLE TO SHELL BYPASS    C =  12.83
PCT OVER DESIGN             -.47     BAFFLE TO SHELL LEAKAGE   E =  16.15
TOT FOUL RESIST          .000217     TUBE PASSLANE BYPASS      F =    .00
DIFF RESIST             -.000051
                                        SHELLSIDE HEAT TRANSFER FACTORS
  DIAMETRAL CLEARANCES                TOTAL =(BETA)(GAMMA)(FIN)   =   .625
BUNDLE TO SHELL      IN.    .5000     BETA  (BAFF CUT FACTOR)     =   .920
TUBE TO BAFFLE HOLE  IN.    .0284     GAMMA (TUBE ROW ENTRY EFCT) =   .679
BAFFLE TO SHELL      IN.    .1000     END   (HT LOSS IN END ZONE) =   .994

  SHELL NOZZLE DATA     IN    OUT     SHELL PRESSURE DROP, % OF TOTAL
```

HT UNDR NOZ	IN.	.25		WINDOW	=	9.0
HT OPP NOZ	IN.	.25		END ZONE	=	5.0
VELOCITY	FT/S	.41	.41	CROSS FLOW	=	4.2
DENSITY	LB/FT3	62.535	62.141	INLET NOZZLE	=	42.2
NOZZ RHO*VSQ	LB/FT-S2	10	10	OUTLET NOZZLE	=	39.7
BUND RHO*VSQ	LB/FT-S2	7	7			

TUBE NOZZLE DATA		IN	OUT	WEIGHT PER SHELL, LB		
VELOCITY	FT/S	.44	.44	DRY	=	150.
DENSITY	LB/FT3	61.291	62.218	WET	=	165.
PRESS. DROP	%	5.3	3.3			

□□Washington University ChE433 heat exchanger experiment E0002 P 42
Young model F302DY4P 9/23/ 3
CASE 21

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.300		.600	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	69.5*	40.0	75.1*
DENSITY	LB/FT3	61.2913	62.2574	62.5352	62.1957
VISCOSITY	CP	.4726	.9851	1.4791	.9183
SPECIFIC HEAT	BTU/LB-F	.9973	1.0016	1.0058	1.0009
THERMAL COND.	BTU/HR-FT-F	.3723	.3552	.3466	.3568
MOLAR MASS	LB/LBMOL	18.02		18.02	
TEMP, AVG & SKIN	DEGF	104.7	78.2	57.6	77.1
VISCOSITY, AVG & SKIN	CP	.6584	.8850	1.1509	.8959
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.03	10.00	.01	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.29	10.00	.10	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	203.14		230.02	

TOTAL HEAT DUTY REQUIRED	MEGBTU/HR	.021130
EFF TEMP DIF, DEGF	(LMTD= 44.9,F= .73,BYPASS= .94,BAFF=1.00)	30.6
OVERALL COEFF REQUIRED	BTU/HR-FT2-F	96.51
CLEAN & FOULED COEFF	BTU/HR-FT2-F 98.96	96.61

SHELLS IN SERIES	1	PARALLEL 1	TOTAL EFF AREA	FT2	7.1
PASSES, SHELL	1	TUBE 4	EFFECTIVE AREA	FT2/SHELL	7.1
SHELL DIAMETER IN.	3.820		TEMA SHELL TYPE E	; REAR HEAD	FXTS

BAFFLE TYPE	HORZ	SEGMENTL	CROSS PASSES PER SHELL PASS		4
SPACING, CENTRAL	IN.	4.309	BAFFLE CUT, PCT SHELL I.D.		30.00
SPACING, INLET	IN.	4.309	CUT DISTANCE FROM CENTER, IN.		.764
SPACING, OUTLET	IN.	4.309			
BAFFLE THICKNESS	IN.	.125	IMPINGEMENT BAFFLE INCLUDED		NO
PAIRS OF SEALING DEVICES		1	TUBESHEET BLANK AREA, %		.0

TUBE TYPE		PLAIN	MATERIAL		ELECTROLYTIC COPPER
NO. OF TUBES/SHELL		76	EST MAX TUBE COUNT		36
TUBE LGTH, OVERALL	FT	1.500	TUBE PITCH	IN.	.3125
TUBE LGTH, EFF	FT	1.436	TUBE OUTSIDE DIAM	IN.	.250
TUBE LAYOUT	DEG	60	TUBE INSIDE DIAM	IN.	.214
PITCH RATIO		1.250	TUBE SURFACE RATIO, OUT/IN		1.184
SHL NOZZ ID, IN&OUT	1.0	1.0	TUBE NOZZ ID, IN&OUT	IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.036	.000
PRANDTL NUMBER	7.9	4.4
RYNLD NO, AVG	196.	718.
RYNLD NO, IN BUN	153.	1000.
RYNLD NO,OUT BUN	246.	480.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
41.53	56.30	2.09	.07

PCT OVER DESIGN	.10
TOT FOUL RESIST	.000217
DIFF RESIST	.000011

DIAMETRAL CLEARANCES		
BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.49	.49
DENSITY	LB/FT3	62.535	62.196
NOZZ RHO*VSQ	LB/FT-S2	14	15
BUND RHO*VSQ	LB/FT-S2	10	10

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	.44	.44
DENSITY	LB/FT3	61.291	62.257
PRESS. DROP	%	5.1	3.2

SHELLSIDE PERFORMANCE		
NOMINAL VEL,X-FLOW	FT/S	.08
NOMINAL VEL,WINDOW	FT/S	.15
CROSSFLOW COEF	BTU/HR-FT2-F	230.9
WINDOW COEF	BTU/HR-FT2-F	232.4

SHELLSIDE FLOW, % OF TOTAL		
HEAT TRANSFER X-FLOW		81.51
TUBE TO BAFFLE LEAKAGE	A =	3.18
MAIN CROSSFLOW	B =	67.31
BUNDLE TO SHELL BYPASS	C =	13.56
BAFFLE TO SHELL LEAKAGE	E =	15.95
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS		
TOTAL =(BETA)(GAMMA)(FIN)	=	.639
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.695
END (HT LOSS IN END ZONE)	=	.994

SHELL PRESSURE DROP, % OF TOTAL		
WINDOW	=	8.9
END ZONE	=	4.6
CROSS FLOW	=	3.9
INLET NOZZLE	=	42.3
OUTLET NOZZLE	=	40.2

WEIGHT PER SHELL, LB		
DRY	=	150.
WET	=	165.

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

	HOT TUBE SIDE	COLD SHELL SIDE
	Tube	Shell
	SENSIBLE LIQ	SENSIBLE LIQ

TOTAL FLOW RATE	KLB/HR	.300		.700	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	66.5*	40.0	71.3*
DENSITY	LB/FT3	61.2913	62.2886	62.5352	62.2370
VISCOSITY	CP	.4726	1.0229	1.4791	.9619
SPECIFIC HEAT	BTU/LB-F	.9973	1.0019	1.0058	1.0013
THERMAL COND.	BTU/HR-FT-F	.3723	.3544	.3466	.3557
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	103.2	75.4	55.7	74.4
VISCOSITY, AVG & SKIN	CP	.6686	.9147	1.1808	.9267
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.03	10.00	.01	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.29	10.00	.11	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	203.07		252.24	

TOTAL HEAT DUTY REQUIRED	MEGBTU/HR		.022017
EFF TEMP DIF, DEGF (LMTD= 44.3,F= .74,BYPASS= .94,BAFF=1.00)			30.7
OVERALL COEFF REQUIRED	BTU/HR-FT2-F		100.36
CLEAN & FOULED COEFF	BTU/HR-FT2-F	102.83	100.26

SHELLS IN SERIES 1 PARALLEL 1		TOTAL EFF AREA FT2	7.1
PASSES, SHELL 1 TUBE 4		EFFECTIVE AREA FT2/SHELL	7.1
SHELL DIAMETER IN.	3.820	TEMA SHELL TYPE E ; REAR HEAD	FXTS
BAFFLE TYPE HORZ SEGMENTL		CROSS PASSES PER SHELL PASS	4
SPACING, CENTRAL IN.	4.309	BAFFLE CUT, PCT SHELL I.D.	30.00
SPACING, INLET IN.	4.309	CUT DISTANCE FROM CENTER, IN.	.764
SPACING, OUTLET IN.	4.309		
BAFFLE THICKNESS IN.	.125	IMPINGEMENT BAFFLE INCLUDED	NO
PAIRS OF SEALING DEVICES	1	TUBESHEET BLANK AREA, %	.0

TUBE TYPE	PLAIN	MATERIAL	ELECTROLYTIC COPPER
NO. OF TUBES/SHELL	76	EST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT	1.500	TUBE PITCH IN.	.3125
TUBE LGTH, EFF FT	1.436	TUBE OUTSIDE DIAM IN.	.250
TUBE LAYOUT DEG	60	TUBE INSIDE DIAM IN.	.214
PITCH RATIO	1.250	TUBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT	1.0 1.0	TUBE NOZZ ID, IN&OUT IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE	SHELLSIDE PERFORMANCE		
WALL CORRECTION	1.034	.000	NOMINAL VEL,X-FLOW	FT/S	.09
PRANDTL NUMBER	8.2	4.4	NOMINAL VEL,WINDOW	FT/S	.18
RYNLD NO, AVG	223.	707.	CROSSFLOW COEF	BTU/HR-FT2-F	253.2

RYNLD NO, IN BUN	178.	1000.	WINDOW COEF	BTU/HR-FT2-F	254.9
RYNLD NO,OUT BUN	274.	462.			
FOULNG LAYER IN.	.0014	.0014	SHELLSIDE FLOW, % OF TOTAL		
			HEAT TRANSFER X-FLOW		81.55
THERMAL RESISTANCE, % OF TOTAL			TUBE TO BAFFLE LEAKAGE	A =	3.32
SHELL TUBE FOULING METAL			MAIN CROSSFLOW	B =	66.67
39.30 58.45 2.17 .07			BUNDLE TO SHELL BYPASS	C =	14.21
PCT OVER DESIGN		-.10	BAFFLE TO SHELL LEAKAGE	E =	15.80
TOT FOUL RESIST		.000217	TUBE PASSLANE BYPASS	F =	.00
DIFF RESIST		-.000010			
			SHELLSIDE HEAT TRANSFER FACTORS		
DIAMETRAL CLEARANCES			TOTAL =(BETA)(GAMMA)(FIN)	=	.653
BUNDLE TO SHELL	IN.	.5000	BETA (BAFF CUT FACTOR)	=	.920
TUBE TO BAFFLE HOLE	IN.	.0284	GAMMA (TUBE ROW ENTRY EFCT)	=	.710
BAFFLE TO SHELL	IN.	.1000	END (HT LOSS IN END ZONE)	=	.994

SHELL NOZZLE DATA		IN	OUT	SHELL PRESSURE DROP, % OF TOTAL		
HT UNDR NOZ	IN.	.25		WINDOW	=	8.8
HT OPP NOZ	IN.	.25		END ZONE	=	4.3
VELOCITY	FT/S	.57	.57	CROSS FLOW	=	3.7
DENSITY	LB/FT3	62.535	62.237	INLET NOZZLE	=	42.5
NOZZ RHO*VSQ	LB/FT-S2	20	20	OUTLET NOZZLE	=	40.6
BUND RHO*VSQ	LB/FT-S2	13	13			

TUBE NOZZLE DATA		IN	OUT	WEIGHT PER SHELL, LB		
VELOCITY	FT/S	.44	.44	DRY	=	150.
DENSITY	LB/FT3	61.291	62.289	WET	=	165.
PRESS. DROP	%	5.1	3.2			

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.300		.800	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	64.1*	40.0	68.3*
DENSITY	LB/FT3	61.2913	62.3134	62.5352	62.2694
VISCOSITY	CP	.4726	1.0551	1.4791	.9993
SPECIFIC HEAT	BTU/LB-F	.9973	1.0022	1.0058	1.0017
THERMAL COND.	BTU/HR-FT-F	.3723	.3537	.3466	.3549
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	102.0	73.2	54.2	72.0
VISCOSITY, AVG & SKIN	CP	.6770	.9407	1.2056	.9537
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.03	10.00	.01	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.29	10.00	.12	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	203.01		273.80	

TOTAL HEAT DUTY REQUIRED MEGBTU/HR .022738
EFF TEMP DIF, DEGF (LMTD= 43.6,F= .75,BYPASS= .94,BAFF=1.00) 30.6
OVERALL COEFF REQUIRED BTU/HR-FT2-F 103.91
CLEAN & FOULED COEFF BTU/HR-FT2-F 106.22 103.44

SHELLS IN SERIES	1 PARALLEL 1	TOTAL EFF AREA FT2	7.1
PASSES, SHELL	1 TUBE 4	EFFECTIVE AREA FT2/SHELL	7.1
SHELL DIAMETER IN.	3.820	TEMA SHELL TYPE E ; REAR HEAD	FXTS
BAFFLE TYPE	HORZ SEGMENTL	CROSS PASSES PER SHELL PASS	4
SPACING, CENTRAL IN.	4.309	BAFFLE CUT, PCT SHELL I.D.	30.00
SPACING, INLET IN.	4.309	CUT DISTANCE FROM CENTER, IN.	.764
SPACING, OUTLET IN.	4.309		
BAFFLE THICKNESS IN.	.125	IMPINGEMENT BAFFLE INCLUDED	NO
PAIRS OF SEALING DEVICES	1	TUBESHEET BLANK AREA, %	.0
TUBE TYPE	PLAIN	MATERIAL	ELECTROLYTIC COPPER
NO. OF TUBES/SHELL	76	EST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT	1.500	TUBE PITCH IN.	.3125
TUBE LGTH, EFF FT	1.436	TUBE OUTSIDE DIAM IN.	.250
TUBE LAYOUT DEG	60	TUBE INSIDE DIAM IN.	.214
PITCH RATIO	1.250	TUBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT	1.0 1.0	TUBE NOZZ ID, IN&OUT IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

□□Washington University ChE433 heat exchanger experiment E0002 P 47
Young model F302DY4P 9/23/ 3
CASE 23

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.033	.000
PRANDTL NUMBER	8.3	4.5
RYNLD NO, AVG	250.	698.
RYNLD NO, IN BUN	204.	1000.
RYNLD NO,OUT BUN	302.	448.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
37.36	60.33	2.24	.07

PCT OVER DESIGN	-.45
TOT FOUL RESIST	.000217
DIFF RESIST	-.000044

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA	IN	OUT
HT UNDR NOZ IN.	.25	

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW FT/S		.10
NOMINAL VEL,WINDOW FT/S		.20
CROSSFLOW COEF	BTU/HR-FT2-F	274.9
WINDOW COEF	BTU/HR-FT2-F	276.6

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.55
TUBE TO BAFFLE LEAKAGE	A =	3.46
MAIN CROSSFLOW	B =	66.02
BUNDLE TO SHELL BYPASS	C =	14.82
BAFFLE TO SHELL LEAKAGE	E =	15.69
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.668
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.726
END (HT LOSS IN END ZONE)	=	.994

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	8.9

HT OPP NOZ IN.		.25		END ZONE	=	4.1
VELOCITY	FT/S	.65	.65	CROSS FLOW	=	3.6
DENSITY	LB/FT3	62.535	62.269	INLET NOZZLE	=	42.6
NOZZ RHO*VSQ	LB/FT-S2	26	26	OUTLET NOZZLE	=	40.9
BUND RHO*VSQ	LB/FT-S2	18	18			

TUBE NOZZLE DATA		IN	OUT	WEIGHT PER SHELL, LB		
VELOCITY	FT/S	.44	.44	DRY	=	150.
DENSITY	LB/FT3	61.291	62.313	WET	=	165.
PRESS. DROP	%	5.0	3.1			

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.300		.900	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	62.3*	40.0	65.8*
DENSITY	LB/FT3	61.2913	62.3321	62.5352	62.2961
VISCOSITY	CP	.4726	1.0809	1.4791	1.0323
SPECIFIC HEAT	BTU/LB-F	.9973	1.0025	1.0058	1.0020
THERMAL COND.	BTU/HR-FT-F	.3723	.3532	.3466	.3542
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	101.1	71.2	52.9	70.1
VISCOSITY, AVG & SKIN	CP	.6836	.9636	1.2270	.9776
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.03	10.00	.02	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.29	10.00	.14	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	203.02		295.08	

TOTAL HEAT DUTY REQUIRED	MEGBTU/HR					.023291
EFF TEMP DIF, DEGF	(LMTD= 43.1,F= .76,BYPASS= .94,BAFF=1.00)					30.7
OVERALL COEFF REQUIRED	BTU/HR-FT2-F					106.15
CLEAN & FOULED COEFF	BTU/HR-FT2-F		109.28			106.31

SHELLS IN SERIES	1	PARALLEL 1	TOTAL EFF AREA	FT2	7.1
PASSES, SHELL	1	TUBE 4	EFFECTIVE AREA	FT2/SHELL	7.1
SHELL DIAMETER IN.	3.820		TEMA SHELL TYPE E ; REAR HEAD FXTS		
BAFFLE TYPE	HORZ	SEGMENTL	CROSS PASSES PER SHELL PASS		4
SPACING, CENTRAL IN.	4.309		BAFFLE CUT, PCT SHELL I.D.		30.00
SPACING, INLET IN.	4.309		CUT DISTANCE FROM CENTER, IN.		.764
SPACING, OUTLET IN.	4.309				
BAFFLE THICKNESS IN.	.125		IMPINGEMENT BAFFLE INCLUDED		NO
PAIRS OF SEALING DEVICES	1		TUBESHEET BLANK AREA, %		.0

TUBE TYPE PLAIN MATERIAL ELECTROLYTIC COPPER

NO. OF TUBES/SHELL		76	EST MAX TUBE COUNT		36
TUBE LGTH, OVERALL	FT	1.500	TUBE PITCH	IN.	.3125
TUBE LGTH, EFF	FT	1.436	TUBE OUTSIDE DIAM	IN.	.250
TUBE LAYOUT	DEG	60	TUBE INSIDE DIAM	IN.	.214
PITCH RATIO		1.250	TUBE SURFACE RATIO, OUT/IN		1.184
SHL NOZZ ID, IN&OUT	1.0	1.0	TUBE NOZZ ID, IN&OUT	IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.032	.000
PRANDTL NUMBER	8.5	4.5
RYNLD NO, AVG	276.	692.
RYNLD NO, IN BUN	229.	1000.
RYNLD NO,OUT BUN	328.	437.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
35.62	62.00	2.31	.08

PCT OVER DESIGN	.15
TOT FOUL RESIST	.000217
DIFF RESIST	.000014

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.73	.74
DENSITY	LB/FT3	62.535	62.296
NOZZ RHO*VSQ	LB/FT-S2	33	33
BUND RHO*VSQ	LB/FT-S2	22	22

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	.44	.44
DENSITY	LB/FT3	61.291	62.332
PRESS. DROP	%	4.9	3.1

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW	FT/S	.12
NOMINAL VEL,WINDOW	FT/S	.23
CROSSFLOW COEF	BTU/HR-FT2-F	296.3
WINDOW COEF	BTU/HR-FT2-F	298.0

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.55
TUBE TO BAFFLE LEAKAGE	A =	3.59
MAIN CROSSFLOW	B =	65.51
BUNDLE TO SHELL BYPASS	C =	15.31
BAFFLE TO SHELL LEAKAGE	E =	15.59
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.682
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.741
END (HT LOSS IN END ZONE)	=	.994

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	8.9
END ZONE	=	3.9
CROSS FLOW	=	3.4
INLET NOZZLE	=	42.7
OUTLET NOZZLE	=	41.2

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ	COLD SHELL SIDE Shell SENSIBLE LIQ
TOTAL FLOW RATE	KLB/HR	.400	.200

		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	103.8*	40.0	112.1*
DENSITY	LB/FT3	61.2913	61.8397	62.5352	61.7249
VISCOSITY	CP	.4726	.6644	1.4791	.6112
SPECIFIC HEAT	BTU/LB-F	.9973	.9984	1.0058	.9979
THERMAL COND.	BTU/HR-FT-F	.3723	.3642	.3466	.3662
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	121.9	102.3	76.0	101.6
VISCOSITY, AVG & SKIN	CP	.5558	.6750	.9080	.6805
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.03	10.00	.00	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.39	10.00	.03	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	209.66		134.45	

TOTAL HEAT DUTY REQUIRED	MEGBTU/HR				.014426
EFF TEMP DIF, DEGF (LMTD= 43.4,F= .68,BYPASS= .91,BAFF=1.00)					26.8
OVERALL COEFF REQUIRED	BTU/HR-FT2-F				75.39
CLEAN & FOULED COEFF	BTU/HR-FT2-F		76.82		75.61
SHELLS IN SERIES	1	PARALLEL	1	TOTAL EFF AREA FT2	7.1
PASSES, SHELL	1	TUBE	4	EFFECTIVE AREA FT2/SHELL	7.1
SHELL DIAMETER IN.	3.820			TEMA SHELL TYPE E ; REAR HEAD	FXTS
BAFFLE TYPE	HORZ	SEGMENTL		CROSS PASSES PER SHELL PASS	4
SPACING, CENTRAL IN.	4.309			BAFFLE CUT, PCT SHELL I.D.	30.00
SPACING, INLET IN.	4.309			CUT DISTANCE FROM CENTER, IN.	.764
SPACING, OUTLET IN.	4.309				
BAFFLE THICKNESS IN.	.125			IMPINGEMENT BAFFLE INCLUDED	NO
PAIRS OF SEALING DEVICES	1			TUBESHEET BLANK AREA, %	.0
TUBE TYPE	PLAIN			MATERIAL	ELECTROLYTIC COPPER
NO. OF TUBES/SHELL	76			EST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT	1.500			TUBE PITCH IN.	.3125
TUBE LGTH, EFF FT	1.436			TUBE OUTSIDE DIAM IN.	.250
TUBE LAYOUT DEG	60			TUBE INSIDE DIAM IN.	.214
PITCH RATIO	1.250			TUBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT	1.0	1.0		TUBE NOZZ ID, IN&OUT IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE	SHELLSIDE PERFORMANCE		
WALL CORRECTION	1.041	.000	NOMINAL VEL,X-FLOW	FT/S	.03
PRANDTL NUMBER	6.2	3.6	NOMINAL VEL,WINDOW	FT/S	.05
RYNLD NO, AVG	81.	1134.	CROSSFLOW COEF	BTU/HR-FT2-F	135.9
RYNLD NO, IN BUN	50.	1334.	WINDOW COEF	BTU/HR-FT2-F	132.8

RYNLD NO,OUT BUN 121. 949.
FOULNG LAYER IN. .0014 .0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
55.61	42.70	1.64	.05

PCT OVER DESIGN .29
TOT FOUL RESIST .000217
DIFF RESIST .000039

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.16	.17
DENSITY	LB/FT3	62.535	61.725
NOZZ RHO*VSQ	LB/FT-S2	1	1
BUND RHO*VSQ	LB/FT-S2	1	1

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	.59	.59
DENSITY	LB/FT3	61.291	61.840
PRESS. DROP	%	7.4	4.7

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		79.96
TUBE TO BAFFLE LEAKAGE	A =	2.56
MAIN CROSSFLOW	B =	68.46
BUNDLE TO SHELL BYPASS	C =	10.98
BAFFLE TO SHELL LEAKAGE	E =	18.00
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.598
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.650
END (HT LOSS IN END ZONE)	=	.998

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	9.8
END ZONE	=	7.7
CROSS FLOW	=	5.9
INLET NOZZLE	=	40.6
OUTLET NOZZLE	=	36.1

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

□□Washington University ChE433 heat exchanger experiment E0002 P 52
Young model F302DY4P 9/23/ 3
CASE 26

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.400		.300	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	94.3*	40.0	100.7*
DENSITY	LB/FT3	61.2913	61.9661	62.5352	61.8816
VISCOSITY	CP	.4726	.7358	1.4791	.6864
SPECIFIC HEAT	BTU/LB-F	.9973	.9991	1.0058	.9986
THERMAL COND.	BTU/HR-FT-F	.3723	.3618	.3466	.3634
MOLAR MASS	LB/LBMOL	18.02		18.02	
TEMP, AVG & SKIN	DEGF	117.1	95.3	70.4	94.4
VISCOSITY, AVG & SKIN	CP	.5817	.7275	.9737	.7344
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.04	10.00	.00	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.39	10.00	.05	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	209.28		158.50	

TOTAL HEAT DUTY REQUIRED MEGBTU/HR			.018249
EFF TEMP DIF, DEGF (LMTD= 46.4,F= .72,BYPASS= .93,BAFF=1.00)			31.1
OVERALL COEFF REQUIRED BTU/HR-FT2-F			82.13
CLEAN & FOULED COEFF BTU/HR-FT2-F		84.04	82.51

SHELLS IN SERIES 1 PARALLEL 1		TOTAL EFF AREA FT2	7.1
PASSES, SHELL 1 TUBE 4		EFFECTIVE AREA FT2/SHELL	7.1
SHELL DIAMETER IN.	3.820	TEMA SHELL TYPE E ; REAR HEAD	FXTS

BAFFLE TYPE HORZ SEGMENTL		CROSS PASSES PER SHELL PASS	4
SPACING, CENTRAL IN.	4.309	BAFFLE CUT, PCT SHELL I.D.	30.00
SPACING, INLET IN.	4.309	CUT DISTANCE FROM CENTER, IN.	.764
SPACING, OUTLET IN.	4.309		
BAFFLE THICKNESS IN.	.125	IMPINGEMENT BAFFLE INCLUDED	NO
PAIRS OF SEALING DEVICES	1	TUBESHEET BLANK AREA, %	.0

TUBE TYPE	PLAIN	MATERIAL	ELECTROLYTIC COPPER
NO. OF TUBES/SHELL	76	EST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT	1.500	TUBE PITCH IN.	.3125
TUBE LGTH, EFF FT	1.436	TUBE OUTSIDE DIAM IN.	.250
TUBE LAYOUT DEG	60	TUBE INSIDE DIAM IN.	.214
PITCH RATIO	1.250	TUBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT 1.0	1.0	TUBE NOZZ ID, IN&OUT IN. .8	.8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.040	.000
PRANDTL NUMBER	6.6	3.8
RYNLD NO, AVG	116.	1084.
RYNLD NO, IN BUN	76.	1334.
RYNLD NO,OUT BUN	164.	857.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
51.48	46.68	1.79	.06

PCT OVER DESIGN	.47
TOT FOUL RESIST	.000217
DIFF RESIST	.000057

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA	IN	OUT
HT UNDR NOZ IN.	.25	
HT OPP NOZ IN.	.25	

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW FT/S		.04
NOMINAL VEL,WINDOW FT/S		.08
CROSSFLOW COEF BTU/HR-FT2-F		159.2
WINDOW COEF BTU/HR-FT2-F		160.0

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.20
TUBE TO BAFFLE LEAKAGE	A =	2.67
MAIN CROSSFLOW	B =	69.50
BUNDLE TO SHELL BYPASS	C =	11.16
BAFFLE TO SHELL LEAKAGE	E =	16.67
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.598
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.650
END (HT LOSS IN END ZONE)	=	.994

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	9.3
END ZONE	=	6.0

VELOCITY	FT/S	.24	.25	CROSS FLOW	= 4.8
DENSITY	LB/FT3	62.535	61.882	INLET NOZZLE	= 41.8
NOZZ RHO*VSQ	LB/FT-S2	3	3	OUTLET NOZZLE	= 38.0
BUND RHO*VSQ	LB/FT-S2	2	2		

TUBE NOZZLE DATA		IN	OUT	WEIGHT PER SHELL, LB	
VELOCITY	FT/S	.59	.58	DRY	= 150.
DENSITY	LB/FT3	61.291	61.966	WET	= 165.
PRESS. DROP	%	7.1	4.5		

□□Washington University ChE433 heat exchanger experiment E0002 P 54
Young model F302DY4P 9/23/ 3
CASE 27

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.400		.400	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	87.3*	40.0	92.4*
DENSITY	LB/FT3	61.2913	62.0527	62.5352	61.9894
VISCOSITY	CP	.4726	.7949	1.4791	.7507
SPECIFIC HEAT	BTU/LB-F	.9973	.9997	1.0058	.9992
THERMAL COND.	BTU/HR-FT-F	.3723	.3600	.3466	.3613
MOLAR MASS	LB/LBMOL	18.02		18.02	
TEMP, AVG & SKIN	DEGF	113.7	89.7	66.2	88.8
VISCOSITY, AVG & SKIN	CP	.6017	.7737	1.0265	.7820
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.04	10.00	.00	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.39	10.00	.06	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	209.12		185.24	

TOTAL HEAT DUTY REQUIRED	MEGBTU/HR				.021018
EFF TEMP DIF, DEGF	(LMTD= 47.5,F= .74,BYPASS= .94,BAFF=1.00)				33.1
OVERALL COEFF REQUIRED	BTU/HR-FT2-F				88.95
CLEAN & FOULED COEFF	BTU/HR-FT2-F		90.98		89.10

SHELLS IN SERIES	1	PARALLEL 1	TOTAL EFF AREA	FT2	7.1
PASSES, SHELL	1	TUBE 4	EFFECTIVE AREA	FT2/SHELL	7.1
SHELL DIAMETER IN.	3.820		TEMA SHELL TYPE E	; REAR HEAD	FXTS
BAFFLE TYPE	HORZ	SEGMENTL	CROSS PASSES PER SHELL PASS		4
SPACING, CENTRAL	IN.	4.309	BAFFLE CUT, PCT SHELL I.D.		30.00
SPACING, INLET	IN.	4.309	CUT DISTANCE FROM CENTER, IN.		.764
SPACING, OUTLET	IN.	4.309			
BAFFLE THICKNESS	IN.	.125	IMPINGEMENT BAFFLE INCLUDED		NO
PAIRS OF SEALING DEVICES		1	TUBESHEET BLANK AREA, %		.0
TUBE TYPE	PLAIN		MATERIAL	ELECTROLYTIC COPPER	
NO. OF TUBES/SHELL	76		EST MAX TUBE COUNT		36

TUBE LGTH, OVERALL	FT	1.500	TUBE PITCH	IN.	.3125
TUBE LGTH, EFF	FT	1.436	TUBE OUTSIDE DIAM	IN.	.250
TUBE LAYOUT	DEG	60	TUBE INSIDE DIAM	IN.	.214
PITCH RATIO		1.250	TUBE SURFACE RATIO, OUT/IN		1.184
SHL NOZZ ID, IN&OUT	1.0	1.0	TUBE NOZZ ID, IN&OUT	IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.039	.000
PRANDTL NUMBER	7.0	4.0
RYNLD NO, AVG	147.	1048.
RYNLD NO, IN BUN	102.	1334.
RYNLD NO,OUT BUN	200.	793.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
47.56	50.44	1.93	.06

PCT OVER DESIGN	.17
TOT FOUL RESIST	.000217
DIFF RESIST	.000019

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.33	.33
DENSITY	LB/FT3	62.535	61.989
NOZZ RHO*VSQ	LB/FT-S2	6	6
BUND RHO*VSQ	LB/FT-S2	4	4

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	.59	.58
DENSITY	LB/FT3	61.291	62.053
PRESS. DROP	%	6.9	4.3

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW	FT/S	.05
NOMINAL VEL,WINDOW	FT/S	.10
CROSSFLOW COEF	BTU/HR-FT2-F	186.0
WINDOW COEF	BTU/HR-FT2-F	187.1

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.38
TUBE TO BAFFLE LEAKAGE	A =	2.88
MAIN CROSSFLOW	B =	68.64
BUNDLE TO SHELL BYPASS	C =	12.15
BAFFLE TO SHELL LEAKAGE	E =	16.32
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.613
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.666
END (HT LOSS IN END ZONE)	=	.994

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	9.1
END ZONE	=	5.3
CROSS FLOW	=	4.4
INLET NOZZLE	=	42.2
OUTLET NOZZLE	=	39.0

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE		COLD SHELL SIDE	
		Tube		Shell	
		SENSIBLE LIQ		SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.400		.500	
		IN	OUT	IN	OUT

TEMPERATURE	DEGF	140.0	82.3*	40.0	86.0*
DENSITY	LB/FT3	61.2913	62.1138	62.5352	62.0691
VISCOSITY	CP	.4726	.8431	1.4791	.8073
SPECIFIC HEAT	BTU/LB-F	.9973	1.0002	1.0058	.9998
THERMAL COND.	BTU/HR-FT-F	.3723	.3587	.3466	.3597
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	111.1	85.4	63.0	84.4
VISCOSITY, AVG & SKIN	CP	.6170	.8128	1.0703	.8224
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.04	10.00	.01	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.39	10.00	.08	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	209.00		210.02	

TOTAL HEAT DUTY REQUIRED	MEGBTU/HR				.023053
EFF TEMP DIF, DEGF (LMTD= 47.9,F= .76,BYPASS= .94,BAFF=1.00)					34.2
OVERALL COEFF REQUIRED	BTU/HR-FT2-F				94.32
CLEAN & FOULED COEFF	BTU/HR-FT2-F		96.54		94.37

SHELLS IN SERIES	1	PARALLEL 1	TOTAL EFF AREA	FT2	7.1
PASSES, SHELL	1	TUBE 4	EFFECTIVE AREA	FT2/SHELL	7.1
SHELL DIAMETER IN.		3.820	TEMA SHELL TYPE E	; REAR HEAD	FXTS
BAFFLE TYPE	HORZ	SEGMENTL	CROSS PASSES PER SHELL PASS		4
SPACING, CENTRAL	IN.	4.309	BAFFLE CUT, PCT SHELL I.D.		30.00
SPACING, INLET	IN.	4.309	CUT DISTANCE FROM CENTER, IN.		.764
SPACING, OUTLET	IN.	4.309			
BAFFLE THICKNESS	IN.	.125	IMPINGEMENT BAFFLE INCLUDED		NO
PAIRS OF SEALING DEVICES		1	TUBESHEET BLANK AREA, %		.0
TUBE TYPE		PLAIN	MATERIAL	ELECTROLYTIC COPPER	
NO. OF TUBES/SHELL		76	EST MAX TUBE COUNT		36
TUBE LGTH, OVERALL	FT	1.500	TUBE PITCH	IN.	.3125
TUBE LGTH, EFF	FT	1.436	TUBE OUTSIDE DIAM	IN.	.250
TUBE LAYOUT	DEG	60	TUBE INSIDE DIAM	IN.	.214
PITCH RATIO		1.250	TUBE SURFACE RATIO, OUT/IN		1.184
SHL NOZZ ID, IN&OUT	1.0	1.0	TUBE NOZZ ID, IN&OUT	IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE	SHELLSIDE PERFORMANCE		
WALL CORRECTION	1.038	.000	NOMINAL VEL,X-FLOW	FT/S	.07
PRANDTL NUMBER	7.3	4.1	NOMINAL VEL,WINDOW	FT/S	.13
RYNLD NO, AVG	176.	1022.	CROSSFLOW COEF	BTU/HR-FT2-F	210.8
RYNLD NO, IN BUN	127.	1334.	WINDOW COEF	BTU/HR-FT2-F	212.1
RYNLD NO,OUT BUN	233.	748.			

FOULNG LAYER IN. .0014 .0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
44.43	53.46	2.05	.07

PCT OVER DESIGN .05
TOT FOUL RESIST .000217
DIFF RESIST .000005

DIAMETRAL CLEARANCES

BUNDLE TO SHELL IN. .5000
TUBE TO BAFFLE HOLE IN. .0284
BAFFLE TO SHELL IN. .1000

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.41	.41
DENSITY	LB/FT3	62.535	62.069
NOZZ RHO*VSQ	LB/FT-S2	10	10
BUND RHO*VSQ	LB/FT-S2	7	7

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	.59	.58
DENSITY	LB/FT3	61.291	62.114
PRESS. DROP	%	6.7	4.2

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW 81.46
TUBE TO BAFFLE LEAKAGE A = 3.07
MAIN CROSSFLOW B = 67.84
BUNDLE TO SHELL BYPASS C = 13.00
BAFFLE TO SHELL LEAKAGE E = 16.09
TUBE PASSLANE BYPASS F = .00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN) = .628
BETA (BAFF CUT FACTOR) = .920
GAMMA (TUBE ROW ENTRY EFCT) = .683
END (HT LOSS IN END ZONE) = .994

SHELL PRESSURE DROP, % OF TOTAL

WINDOW = 9.0
END ZONE = 4.9
CROSS FLOW = 4.1
INLET NOZZLE = 42.4
OUTLET NOZZLE = 39.7

WEIGHT PER SHELL, LB

DRY = 150.
WET = 165.

□□Washington University ChE433 heat exchanger experiment E0002 P 58
Young model F302DY4P 9/23/ 3
CASE 29

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.400		.600	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	78.3*	40.0	80.9*
DENSITY	LB/FT3	61.2913	62.1591	62.5352	62.1294
VISCOSITY	CP	.4726	.8831	1.4791	.8564
SPECIFIC HEAT	BTU/LB-F	.9973	1.0006	1.0058	1.0003
THERMAL COND.	BTU/HR-FT-F	.3723	.3576	.3466	.3583
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	109.2	81.9	60.5	80.8
VISCOSITY, AVG & SKIN	CP	.6292	.8466	1.1069	.8574
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.04	10.00	.01	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.39	10.00	.10	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	208.91		233.52	

TOTAL HEAT DUTY REQUIRED MEGBTU/HR .024617

EFF TEMP DIF, DEGF (LMTD= 48.0,F= .78,BYPASS= .94,BAFF=1.00)		34.9
OVERALL COEFF REQUIRED BTU/HR-FT2-F		98.62
CLEAN & FOULED COEFF BTU/HR-FT2-F	101.20	98.76

SHELLS IN SERIES	1 PARALLEL 1	TOTAL EFF AREA FT2	7.1
PASSES, SHELL	1 TUBE 4	EFFECTIVE AREA FT2/SHELL	7.1
SHELL DIAMETER IN.	3.820	TEMA SHELL TYPE E ; REAR HEAD	FXTS
BAFFLE TYPE	HORZ SEGMENTL	CROSS PASSES PER SHELL PASS	4
SPACING, CENTRAL IN.	4.309	BAFFLE CUT, PCT SHELL I.D.	30.00
SPACING, INLET IN.	4.309	CUT DISTANCE FROM CENTER, IN.	.764
SPACING, OUTLET IN.	4.309		
BAFFLE THICKNESS IN.	.125	IMPINGEMENT BAFFLE INCLUDED	NO
PAIRS OF SEALING DEVICES	1	TUBESHEET BLANK AREA, %	.0
TUBE TYPE	PLAIN	MATERIAL	ELECTROLYTIC COPPER
NO. OF TUBES/SHELL	76	EST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT	1.500	TUBE PITCH IN.	.3125
TUBE LGTH, EFF FT	1.436	TUBE OUTSIDE DIAM IN.	.250
TUBE LAYOUT DEG	60	TUBE INSIDE DIAM IN.	.214
PITCH RATIO	1.250	TUBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT	1.0 1.0	TUBE NOZZ ID, IN&OUT IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

□□Washington University ChE433 heat exchanger experiment E0002 P 59
Young model F302DY4P 9/23/ 3
CASE 29

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.036	.000
PRANDTL NUMBER	7.6	4.2
RYNLD NO, AVG	204.	1002.
RYNLD NO, IN BUN	153.	1334.
RYNLD NO,OUT BUN	264.	714.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
41.82	55.97	2.14	.07

PCT OVER DESIGN	.14
TOT FOUL RESIST	.000217
DIFF RESIST	.000015

SHELLSIDE PERFORMANCE		
NOMINAL VEL,X-FLOW FT/S		.08
NOMINAL VEL,WINDOW FT/S		.15
CROSSFLOW COEF BTU/HR-FT2-F		234.4
WINDOW COEF BTU/HR-FT2-F		235.9

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.54
TUBE TO BAFFLE LEAKAGE	A =	3.22
MAIN CROSSFLOW	B =	67.15
BUNDLE TO SHELL BYPASS	C =	13.73
BAFFLE TO SHELL LEAKAGE	E =	15.89
TUBE PASSLANE BYPASS	F =	.00

DIAMETRAL CLEARANCES

BUNDLE TO SHELL IN.	.5000	
TUBE TO BAFFLE HOLE IN.	.0284	
BAFFLE TO SHELL IN.	.1000	

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.643
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.699
END (HT LOSS IN END ZONE)	=	.994

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.49	.49

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	8.9
END ZONE	=	4.5
CROSS FLOW	=	3.9

DENSITY	LB/FT3	62.535	62.129	INLET NOZZLE	= 42.6
NOZZ RHO*VSQ	LB/FT-S2	14	15	OUTLET NOZZLE	= 40.2
BUND RHO*VSQ	LB/FT-S2	10	10		

TUBE NOZZLE DATA		IN	OUT	WEIGHT PER SHELL, LB	
VELOCITY	FT/S	.59	.58	DRY	= 150.
DENSITY	LB/FT3	61.291	62.159	WET	= 165.
PRESS. DROP	%	6.6	4.1		

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.400		.700	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	75.1*	40.0	76.9*
DENSITY	LB/FT3	61.2913	62.1959	62.5352	62.1754
VISCOSITY	CP	.4726	.9185	1.4791	.8983
SPECIFIC HEAT	BTU/LB-F	.9973	1.0009	1.0058	1.0007
THERMAL COND.	BTU/HR-FT-F	.3723	.3568	.3466	.3573
MOLAR MASS	LB/LBMOL	18.02		18.02	
TEMP, AVG & SKIN	DEGF	107.5	79.0	58.5	77.9
VISCOSITY, AVG & SKIN	CP	.6397	.8761	1.1369	.8881
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.04	10.00	.01	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.39	10.00	.11	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	208.76		256.11	

TOTAL HEAT DUTY REQUIRED	MEGBTU/HR				.025917
EFF TEMP DIF, DEGF	(LMTD= 47.7,F= .78,BYPASS= .94,BAFF=1.00)				35.2
OVERALL COEFF REQUIRED	BTU/HR-FT2-F				103.05
CLEAN & FOULED COEFF	BTU/HR-FT2-F		105.18		102.50

SHELLS IN SERIES	1	PARALLEL 1	TOTAL EFF AREA	FT2	7.1
PASSES, SHELL	1	TUBE 4	EFFECTIVE AREA	FT2/SHELL	7.1
SHELL DIAMETER IN.	3.820		TEMA SHELL TYPE E	; REAR HEAD	FXTS
BAFFLE TYPE	HORZ	SEGMENTL	CROSS PASSES PER SHELL PASS		4
SPACING, CENTRAL	IN.	4.309	BAFFLE CUT, PCT SHELL I.D.		30.00
SPACING, INLET	IN.	4.309	CUT DISTANCE FROM CENTER, IN.		.764
SPACING, OUTLET	IN.	4.309			
BAFFLE THICKNESS	IN.	.125	IMPINGEMENT BAFFLE INCLUDED		NO
PAIRS OF SEALING DEVICES		1	TUBESHEET BLANK AREA, %		.0
TUBE TYPE	PLAIN		MATERIAL	ELECTROLYTIC COPPER	
NO. OF TUBES/SHELL	76		EST MAX TUBE COUNT		36
TUBE LGTH, OVERALL FT	1.500		TUBE PITCH IN.		.3125

TUBE LGTH, EFF	FT	1.436	TUBE OUTSIDE DIAM	IN.	.250
TUBE LAYOUT	DEG	60	TUBE INSIDE DIAM	IN.	.214
PITCH RATIO		1.250	TUBE SURFACE RATIO, OUT/IN		1.184
SHL NOZZ ID, IN&OUT	1.0	1.0	TUBE NOZZ ID, IN&OUT	IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.035	.000
PRANDTL NUMBER	7.8	4.2
RYNLD NO, AVG	232.	985.
RYNLD NO, IN BUN	178.	1334.
RYNLD NO,OUT BUN	294.	686.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL			
SHELL	TUBE	FOULING	METAL
39.57	58.13	2.22	.07

PCT OVER DESIGN	-.53
TOT FOUL RESIST	.000217
DIFF RESIST	-.000052

DIAMETRAL CLEARANCES		
BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.57	.57
DENSITY	LB/FT3	62.535	62.175
NOZZ RHO*VSQ	LB/FT-S2	20	20
BUND RHO*VSQ	LB/FT-S2	13	13

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	.59	.58
DENSITY	LB/FT3	61.291	62.196
PRESS. DROP	%	6.5	4.1

SHELLSIDE PERFORMANCE		
NOMINAL VEL,X-FLOW	FT/S	.09
NOMINAL VEL,WINDOW	FT/S	.18
CROSSFLOW COEF	BTU/HR-FT2-F	257.1
WINDOW COEF	BTU/HR-FT2-F	258.8

SHELLSIDE FLOW, % OF TOTAL		
HEAT TRANSFER X-FLOW		81.56
TUBE TO BAFFLE LEAKAGE	A =	3.37
MAIN CROSSFLOW	B =	66.49
BUNDLE TO SHELL BYPASS	C =	14.38
BAFFLE TO SHELL LEAKAGE	E =	15.75
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS		
TOTAL =(BETA)(GAMMA)(FIN)	=	.658
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.715
END (HT LOSS IN END ZONE)	=	.994

SHELL PRESSURE DROP, % OF TOTAL		
WINDOW	=	8.8
END ZONE	=	4.2
CROSS FLOW	=	3.7
INLET NOZZLE	=	42.7
OUTLET NOZZLE	=	40.6

WEIGHT PER SHELL, LB		
DRY	=	150.
WET	=	165.

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE		COLD SHELL SIDE	
		Tube		Shell	
		SENSIBLE LIQ		SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.400		.800	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	72.7*	40.0	73.5*

DENSITY	LB/FT3	61.2913	62.2226	62.5352	62.2135
VISCOSITY	CP	.4726	.9462	1.4791	.9366
SPECIFIC HEAT	BTU/LB-F	.9973	1.0012	1.0058	1.0011
THERMAL COND.	BTU/HR-FT-F	.3723	.3561	.3466	.3563
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	106.3	76.6	56.7	75.4
VISCOSITY, AVG & SKIN	CP	.6476	.9021	1.1636	.9151
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.04	10.00	.01	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.39	10.00	.12	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	208.73		278.00	

TOTAL HEAT DUTY REQUIRED MEGBTU/HR			.026883
EFF TEMP DIF, DEGF (LMTD= 47.6,F= .80,BYPASS= .94,BAFF=1.00)			35.7
OVERALL COEFF REQUIRED	BTU/HR-FT2-F		105.45
CLEAN & FOULED COEFF	BTU/HR-FT2-F	108.68	105.79

SHELLS IN SERIES	1	PARALLEL	1
PASSES, SHELL	1	TUBE	4
SHELL DIAMETER IN.			3.820
TOTAL EFF AREA	FT2		7.1
EFFECTIVE AREA	FT2/SHELL		7.1
TEMA SHELL TYPE	E	; REAR HEAD	FXTS

BAFFLE TYPE	HORZ	SEGMENTL	
SPACING, CENTRAL	IN.		4.309
SPACING, INLET	IN.		4.309
SPACING, OUTLET	IN.		4.309
BAFFLE THICKNESS	IN.		.125
PAIRS OF SEALING DEVICES			1
CROSS PASSES PER SHELL PASS			4
BAFFLE CUT, PCT SHELL I.D.			30.00
CUT DISTANCE FROM CENTER, IN.			.764
IMPINGEMENT BAFFLE INCLUDED			NO
TUBESHEET BLANK AREA, %			.0

TUBE TYPE			PLAIN
NO. OF TUBES/SHELL			76
TUBE LGTH, OVERALL	FT		1.500
TUBE LGTH, EFF	FT		1.436
TUBE LAYOUT	DEG		60
PITCH RATIO			1.250
SHL NOZZ ID, IN&OUT	1.0	1.0	
MATERIAL			ELECTROLYTIC COPPER
EST MAX TUBE COUNT			36
TUBE PITCH	IN.		.3125
TUBE OUTSIDE DIAM	IN.		.250
TUBE INSIDE DIAM	IN.		.214
TUBE SURFACE RATIO, OUT/IN			1.184
TUBE NOZZ ID, IN&OUT	IN.	.8	.8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.034	.000
PRANDTL NUMBER	8.0	4.3
RYNLD NO, AVG	259.	973.
RYNLD NO, IN BUN	204.	1334.
RYNLD NO,OUT BUN	322.	666.
FOULNG LAYER IN.	.0014	.0014

SHELLSIDE PERFORMANCE		
NOMINAL VEL,X-FLOW	FT/S	.10
NOMINAL VEL,WINDOW	FT/S	.20
CROSSFLOW COEF	BTU/HR-FT2-F	279.1
WINDOW COEF	BTU/HR-FT2-F	280.8

SHELLSIDE FLOW, % OF TOTAL

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
37.63	60.00	2.29	.08

PCT OVER DESIGN	.33
TOT FOUL RESIST	.000217
DIFF RESIST	.000031

HEAT TRANSFER X-FLOW		81.56
TUBE TO BAFFLE LEAKAGE	A =	3.50
MAIN CROSSFLOW	B =	65.86
BUNDLE TO SHELL BYPASS	C =	14.99
BAFFLE TO SHELL LEAKAGE	E =	15.65
TUBE PASSLANE BYPASS	F =	.00

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.672
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.731
END (HT LOSS IN END ZONE)	=	.994

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.65	.65
DENSITY	LB/FT3	62.535	62.214
NOZZ RHO*VSQ	LB/FT-S2	26	26
BUND RHO*VSQ	LB/FT-S2	18	18

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	8.8
END ZONE	=	4.0
CROSS FLOW	=	3.5
INLET NOZZLE	=	42.8
OUTLET NOZZLE	=	40.9

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	.59	.58
DENSITY	LB/FT3	61.291	62.223
PRESS. DROP	%	6.4	4.0

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

□□Washington University ChE433 heat exchanger experiment E0002 P 64
Young model F302DY4P 9/23/ 3
CASE 32

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ .400 IN	HOT TUBE SIDE Tube SENSIBLE LIQ .400 OUT	COLD SHELL SIDE Shell SENSIBLE LIQ .900 IN	COLD SHELL SIDE Shell SENSIBLE LIQ .900 OUT
TOTAL FLOW RATE	KLB/HR				
TEMPERATURE	DEGF	140.0	70.4*	40.0	70.8*
DENSITY	LB/FT3	61.2913	62.2469	62.5352	62.2434
VISCOSITY	CP	.4726	.9730	1.4791	.9690
SPECIFIC HEAT	BTU/LB-F	.9973	1.0015	1.0058	1.0014
THERMAL COND.	BTU/HR-FT-F	.3723	.3555	.3466	.3556
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	105.2	74.5	55.4	73.3
VISCOSITY, AVG & SKIN	CP	.6551	.9257	1.1855	.9396
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.04	10.00	.02	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.39	10.00	.14	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	208.61		299.76	

TOTAL HEAT DUTY REQUIRED MEGBTU/HR	.027780
EFF TEMP DIF, DEGF (LMTD= 47.2,F= .80,BYPASS= .94,BAFF=1.00)	35.7

OVERALL COEFF REQUIRED	BTU/HR-FT2-F		108.93
CLEAN & FOULED COEFF	BTU/HR-FT2-F	111.82	108.72

SHELLS IN SERIES 1 PARALLEL 1		TOTAL EFF AREA	FT2 7.1
PASSES, SHELL 1 TUBE 4		EFFECTIVE AREA	FT2/SHELL 7.1
SHELL DIAMETER IN.	3.820	TEMA SHELL TYPE E ; REAR HEAD	FXTS
BAFFLE TYPE HORZ SEGMENTL		CROSS PASSES PER SHELL PASS	4
SPACING, CENTRAL IN.	4.309	BAFFLE CUT, PCT SHELL I.D.	30.00
SPACING, INLET IN.	4.309	CUT DISTANCE FROM CENTER, IN.	.764
SPACING, OUTLET IN.	4.309		
BAFFLE THICKNESS IN.	.125	IMPINGEMENT BAFFLE INCLUDED	NO
PAIRS OF SEALING DEVICES	1	TUBESHEET BLANK AREA, %	.0
TUBE TYPE	PLAIN	MATERIAL	ELECTROLYTIC COPPER
NO. OF TUBES/SHELL	76	EST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT	1.500	TUBE PITCH IN.	.3125
TUBE LGTH, EFF FT	1.436	TUBE OUTSIDE DIAM IN.	.250
TUBE LAYOUT DEG	60	TUBE INSIDE DIAM IN.	.214
PITCH RATIO	1.250	TUBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT 1.0	1.0	TUBE NOZZ ID, IN&OUT IN. .8	.8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

□□Washington University ChE433 heat exchanger experiment E0002 P 65
Young model F302DY4P 9/23/ 3
CASE 32

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.033	.000
PRANDTL NUMBER	8.2	4.3
RYNLD NO, AVG	286.	962.
RYNLD NO, IN BUN	229.	1334.
RYNLD NO,OUT BUN	350.	648.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
35.86	61.70	2.36	.08

PCT OVER DESIGN	-.19
TOT FOUL RESIST	.000217
DIFF RESIST	-.000017

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.73	.74
DENSITY	LB/FT3	62.535	62.243

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW	FT/S	.12
NOMINAL VEL,WINDOW	FT/S	.23
CROSSFLOW COEF	BTU/HR-FT2-F	301.0
WINDOW COEF	BTU/HR-FT2-F	302.8

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.55
TUBE TO BAFFLE LEAKAGE	A =	3.63
MAIN CROSSFLOW	B =	65.45
BUNDLE TO SHELL BYPASS	C =	15.37
BAFFLE TO SHELL LEAKAGE	E =	15.55
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.687
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.747
END (HT LOSS IN END ZONE)	=	.994

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	8.8
END ZONE	=	3.8
CROSS FLOW	=	3.4
INLET NOZZLE	=	42.8

NOZZ RHO*VSQ LB/FT-S2 33 33 OUTLET NOZZLE = 41.2
BUND RHO*VSQ LB/FT-S2 22 22

TUBE NOZZLE DATA		IN	OUT	WEIGHT PER SHELL, LB		
VELOCITY	FT/S	.59	.58	DRY	=	150.
DENSITY	LB/FT3	61.291	62.247	WET	=	165.
PRESS. DROP	%	6.3	4.0			

□□Washington University ChE433 heat exchanger experiment E0002 P 66
Young model F302DY4P 9/23/ 3
CASE 33

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ .500 IN	HOT TUBE SIDE Tube SENSIBLE LIQ .500 OUT	COLD SHELL SIDE Shell SENSIBLE LIQ .200 IN	COLD SHELL SIDE Shell SENSIBLE LIQ .200 OUT
TOTAL FLOW RATE	KLB/HR				
TEMPERATURE	DEGF	140.0	109.6*	40.0	115.7*
DENSITY	LB/FT3	61.2913	61.7595	62.5352	61.6725
VISCOSITY	CP	.4726	.6263	1.4791	.5899
SPECIFIC HEAT	BTU/LB-F	.9973	.9981	1.0058	.9978
THERMAL COND.	BTU/HR-FT-F	.3723	.3656	.3466	.3670
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	124.8	105.0	77.8	104.2
VISCOSITY, AVG & SKIN	CP	.5410	.6566	.8884	.6621
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.05	10.00	.00	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.49	10.00	.03	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	214.29		134.73	

TOTAL HEAT DUTY REQUIRED MEGBTU/HR .015146
EFF TEMP DIF, DEGF (LMTD= 43.1,F= .71,BYPASS= .90,BAFF=1.00) 27.8
OVERALL COEFF REQUIRED BTU/HR-FT2-F 76.27
CLEAN & FOULED COEFF BTU/HR-FT2-F 77.63 76.41

SHELLS IN SERIES	1	PARALLEL	1
PASSES, SHELL	1	TUBE	4
SHELL DIAMETER IN.	3.820		
TOTAL EFF AREA	FT2	7.1	
EFFECTIVE AREA	FT2/SHELL	7.1	
TEMA SHELL TYPE	E	; REAR HEAD	FXTS
BAFFLE TYPE	HORZ	SEGMENTL	
SPACING, CENTRAL	IN.	4.309	
SPACING, INLET	IN.	4.309	
SPACING, OUTLET	IN.	4.309	
BAFFLE THICKNESS	IN.	.125	
PAIRS OF SEALING DEVICES		1	
CROSS PASSES PER SHELL PASS		4	
BAFFLE CUT, PCT SHELL I.D.		30.00	
CUT DISTANCE FROM CENTER, IN.		.764	
IMPINGEMENT BAFFLE INCLUDED		NO	
TUBESHEET BLANK AREA, %		.0	
TUBE TYPE	PLAIN		
NO. OF TUBES/SHELL	76		
TUBE LGTH, OVERALL	FT	1.500	
TUBE LGTH, EFF	FT	1.436	
MATERIAL	ELECTROLYTIC COPPER		
EST MAX TUBE COUNT		36	
TUBE PITCH	IN.	.3125	
TUBE OUTSIDE DIAM	IN.	.250	

TUBE LAYOUT	DEG 60	TUBE INSIDE DIAM	IN. .214
PITCH RATIO	1.250	TUBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT	1.0 1.0	TUBE NOZZ ID, IN&OUT	IN. .8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.042	.000
PRANDTL NUMBER	6.0	3.5
RYNLD NO, AVG	83.	1456.
RYNLD NO, IN BUN	50.	1667.
RYNLD NO,OUT BUN	125.	1258.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
56.07	42.21	1.66	.05

PCT OVER DESIGN	.18
TOT FOUL RESIST	.000217
DIFF RESIST	.000024

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.16	.17
DENSITY	LB/FT3	62.535	61.673
NOZZ RHO*VSQ	LB/FT-S2	1	1
BUND RHO*VSQ	LB/FT-S2	1	1

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	.74	.73
DENSITY	LB/FT3	61.291	61.760
PRESS. DROP	%	8.4	5.3

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW	FT/S	.03
NOMINAL VEL,WINDOW	FT/S	.05
CROSSFLOW COEF	BTU/HR-FT2-F	136.1
WINDOW COEF	BTU/HR-FT2-F	133.2

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		80.05
TUBE TO BAFFLE LEAKAGE	A =	2.57
MAIN CROSSFLOW	B =	68.56
BUNDLE TO SHELL BYPASS	C =	10.97
BAFFLE TO SHELL LEAKAGE	E =	17.90
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.598
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.650
END (HT LOSS IN END ZONE)	=	.998

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	9.7
END ZONE	=	7.5
CROSS FLOW	=	5.8
INLET NOZZLE	=	40.9
OUTLET NOZZLE	=	36.1

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ .500 IN	HOT TUBE SIDE Tube SENSIBLE LIQ .500 OUT	COLD SHELL SIDE Shell SENSIBLE LIQ .300 IN	COLD SHELL SIDE Shell SENSIBLE LIQ .300 OUT
TOTAL FLOW RATE	KLB/HR				
TEMPERATURE	DEGF	140.0	100.8*	40.0	105.0*
DENSITY	LB/FT3	61.2913	61.8803	62.5352	61.8234

VISCOSITY	CP	.4726	.6857	1.4791	.6563
SPECIFIC HEAT	BTU/LB-F	.9973	.9986	1.0058	.9983
THERMAL COND.	BTU/HR-FT-F	.3723	.3635	.3466	.3645
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	120.4	98.2	72.5	97.3
VISCOSITY, AVG & SKIN	CP	.5637	.7048	.9480	.7117
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.05	10.00	.00	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.49	10.00	.05	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	214.13		159.77	

TOTAL HEAT DUTY REQUIRED	MEGBTU/HR	.019535
EFF TEMP DIF, DEGF (LMTD= 46.7,F= .75,BYPASS= .93,BAFF=1.00)		32.6
OVERALL COEFF REQUIRED	BTU/HR-FT2-F	83.95
CLEAN & FOULED COEFF	BTU/HR-FT2-F	83.74

SHELLS IN SERIES	1	PARALLEL	1
PASSES, SHELL	1	TUBE	4
SHELL DIAMETER IN.			3.820
TOTAL EFF AREA	FT2		7.1
EFFECTIVE AREA	FT2/SHELL		7.1
TEMA SHELL TYPE	E	; REAR HEAD	FXTS

BAFFLE TYPE	HORZ	SEGMENTL	
SPACING, CENTRAL	IN.		4.309
SPACING, INLET	IN.		4.309
SPACING, OUTLET	IN.		4.309
BAFFLE THICKNESS	IN.		.125
PAIRS OF SEALING DEVICES			1
CROSS PASSES PER SHELL PASS			4
BAFFLE CUT, PCT SHELL I.D.			30.00
CUT DISTANCE FROM CENTER, IN.			.764
IMPINGEMENT BAFFLE INCLUDED			NO
TUBESHEET BLANK AREA, %			.0

TUBE TYPE			PLAIN
NO. OF TUBES/SHELL			76
TUBE LGTH, OVERALL	FT		1.500
TUBE LGTH, EFF	FT		1.436
TUBE LAYOUT	DEG		60
PITCH RATIO			1.250
SHL NOZZ ID, IN&OUT	1.0	1.0	
MATERIAL			ELECTROLYTIC COPPER
EST MAX TUBE COUNT			36
TUBE PITCH	IN.		.3125
TUBE OUTSIDE DIAM	IN.		.250
TUBE INSIDE DIAM	IN.		.214
TUBE SURFACE RATIO, OUT/IN			1.184
TUBE NOZZ ID, IN&OUT	IN.	.8	.8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.041	.000
PRANDTL NUMBER	6.5	3.7
RYNLD NO, AVG	119.	1398.
RYNLD NO, IN BUN	76.	1667.
RYNLD NO,OUT BUN	172.	1149.
FOULNG LAYER IN.	.0014	.0014

SHELLSIDE PERFORMANCE		
NOMINAL VEL,X-FLOW	FT/S	.04
NOMINAL VEL,WINDOW	FT/S	.08
CROSSFLOW COEF	BTU/HR-FT2-F	160.5
WINDOW COEF	BTU/HR-FT2-F	161.2
SHELLSIDE FLOW, % OF TOTAL		
HEAT TRANSFER X-FLOW		81.27

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
51.83	46.30	1.82	.06

PCT OVER DESIGN	-.25
TOT FOUL RESIST	.000217
DIFF RESIST	-.000030

TUBE TO BAFFLE LEAKAGE	A =	2.69
MAIN CROSSFLOW	B =	69.49
BUNDLE TO SHELL BYPASS	C =	11.23
BAFFLE TO SHELL LEAKAGE	E =	16.59
TUBE PASSLANE BYPASS	F =	.00

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.599
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.651
END (HT LOSS IN END ZONE)	=	.994

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.24	.25
DENSITY	LB/FT3	62.535	61.823
NOZZ RHO*VSQ	LB/FT-S2	3	3
BUND RHO*VSQ	LB/FT-S2	2	2

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	9.3
END ZONE	=	5.9
CROSS FLOW	=	4.7
INLET NOZZLE	=	42.0
OUTLET NOZZLE	=	38.0

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	.74	.73
DENSITY	LB/FT3	61.291	61.880
PRESS. DROP	%	8.3	5.2

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

□□Washington University ChE433 heat exchanger experiment E0002 P 70
Young model F302DY4P 9/23/ 3
CASE 35

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.500		.400	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	94.3*	40.0	96.8*
DENSITY	LB/FT3	61.2913	61.9651	62.5352	61.9330
VISCOSITY	CP	.4726	.7351	1.4791	.7156
SPECIFIC HEAT	BTU/LB-F	.9973	.9991	1.0058	.9989
THERMAL COND.	BTU/HR-FT-F	.3723	.3618	.3466	.3625
MOLAR MASS	LB/LBMOL	18.02		18.02	
TEMP, AVG & SKIN	DEGF	117.2	92.8	68.4	91.8
VISCOSITY, AVG & SKIN	CP	.5815	.7482	.9980	.7564
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.05	10.00	.00	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.49	10.00	.06	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	214.12		187.10	

TOTAL HEAT DUTY REQUIRED	MEGBTU/HR	.022773
EFF TEMP DIF, DEGF (LMTD= 48.5,F= .78,BYPASS= .93,BAFF=1.00)		35.2
OVERALL COEFF REQUIRED	BTU/HR-FT2-F	90.57

CLEAN & FOULED COEFF	BTU/HR-FT2-F		92.53		90.60

SHELLS IN SERIES 1 PARALLEL 1		TOTAL EFF AREA FT2	7.1
PASSES, SHELL 1 TUBE 4		EFFECTIVE AREA FT2/SHELL	7.1
SHELL DIAMETER IN.	3.820	TEMA SHELL TYPE E ; REAR HEAD	FXTS
BAFFLE TYPE HORZ SEGMENTL		CROSS PASSES PER SHELL PASS	4
SPACING, CENTRAL IN.	4.309	BAFFLE CUT, PCT SHELL I.D.	30.00
SPACING, INLET IN.	4.309	CUT DISTANCE FROM CENTER, IN.	.764
SPACING, OUTLET IN.	4.309		
BAFFLE THICKNESS IN.	.125	IMPINGEMENT BAFFLE INCLUDED	NO
PAIRS OF SEALING DEVICES	1	TUBESHEET BLANK AREA, %	.0
TUBE TYPE	PLAIN	MATERIAL	ELECTROLYTIC COPPER
NO. OF TUBES/SHELL	76	EST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT	1.500	TUBE PITCH IN.	.3125
TUBE LGTH, EFF FT	1.436	TUBE OUTSIDE DIAM IN.	.250
TUBE LAYOUT DEG	60	TUBE INSIDE DIAM IN.	.214
PITCH RATIO	1.250	TUBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT 1.0	1.0	TUBE NOZZ ID, IN&OUT IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.040	.000
PRANDTL NUMBER	6.8	3.8
RYNLD NO, AVG	151.	1355.
RYNLD NO, IN BUN	102.	1667.
RYNLD NO,OUT BUN	210.	1072.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
47.88	50.09	1.96	.07

PCT OVER DESIGN	.03
TOT FOUL RESIST	.000217
DIFF RESIST	.000004

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.33	.33
DENSITY	LB/FT3	62.535	61.933
NOZZ RHO*VSQ	LB/FT-S2	6	6

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW	FT/S	.05
NOMINAL VEL,WINDOW	FT/S	.10
CROSSFLOW COEF	BTU/HR-FT2-F	187.9
WINDOW COEF	BTU/HR-FT2-F	188.9

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.40
TUBE TO BAFFLE LEAKAGE	A =	2.91
MAIN CROSSFLOW	B =	68.54
BUNDLE TO SHELL BYPASS	C =	12.27
BAFFLE TO SHELL LEAKAGE	E =	16.28
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.615
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.669
END (HT LOSS IN END ZONE)	=	.994

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	9.1
END ZONE	=	5.2
CROSS FLOW	=	4.3
INLET NOZZLE	=	42.4
OUTLET NOZZLE	=	39.0

BUND RHO*VSQ LB/FT-S2 4 4

TUBE NOZZLE DATA		IN	OUT	WEIGHT PER SHELL, LB		
VELOCITY	FT/S	.74	.73	DRY	=	150.
DENSITY	LB/FT3	61.291	61.965	WET	=	165.
PRESS. DROP	%	8.2	5.2			

□□Washington University ChE433 heat exchanger experiment E0002 P 72
Young model F302DY4P 9/23/ 3
CASE 36

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.500		.500	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	89.4*	40.0	90.4*
DENSITY	LB/FT3	61.2913	62.0275	62.5352	62.0151
VISCOSITY	CP	.4726	.7767	1.4791	.7681
SPECIFIC HEAT	BTU/LB-F	.9973	.9995	1.0058	.9994
THERMAL COND.	BTU/HR-FT-F	.3723	.3606	.3466	.3608
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	114.7	88.4	65.2	87.3
VISCOSITY, AVG & SKIN	CP	.5956	.7854	1.0401	.7950
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.05	10.00	.01	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.49	10.00	.08	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	214.05		212.31	

TOTAL HEAT DUTY REQUIRED MEGBTU/HR .025248
EFF TEMP DIF, DEGF (LMTD= 49.5,F= .79,BYPASS= .94,BAFF=1.00) 36.9
OVERALL COEFF REQUIRED BTU/HR-FT2-F 95.84
CLEAN & FOULED COEFF BTU/HR-FT2-F 98.28 96.04

SHELLS IN SERIES	1	PARALLEL 1	TOTAL EFF AREA	FT2	7.1
PASSES, SHELL	1	TUBE 4	EFFECTIVE AREA	FT2/SHELL	7.1
SHELL DIAMETER IN.		3.820	TEMA SHELL TYPE E	; REAR HEAD	FXTS
BAFFLE TYPE	HORZ	SEGMENTL	CROSS PASSES PER SHELL PASS		4
SPACING, CENTRAL	IN.	4.309	BAFFLE CUT, PCT SHELL I.D.		30.00
SPACING, INLET	IN.	4.309	CUT DISTANCE FROM CENTER, IN.		.764
SPACING, OUTLET	IN.	4.309			
BAFFLE THICKNESS	IN.	.125	IMPINGEMENT BAFFLE INCLUDED		NO
PAIRS OF SEALING DEVICES		1	TUBESHEET BLANK AREA, %		.0
TUBE TYPE		PLAIN	MATERIAL	ELECTROLYTIC COPPER	
NO. OF TUBES/SHELL		76	EST MAX TUBE COUNT		36
TUBE LGTH, OVERALL	FT	1.500	TUBE PITCH	IN.	.3125
TUBE LGTH, EFF	FT	1.436	TUBE OUTSIDE DIAM	IN.	.250
TUBE LAYOUT	DEG	60	TUBE INSIDE DIAM	IN.	.214

PITCH RATIO		1.250	TUBE SURFACE RATIO, OUT/IN		1.184
SHL NOZZ ID, IN&OUT	1.0	1.0	TUBE NOZZ ID, IN&OUT IN.	.8	.8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.038	.000
PRANDTL NUMBER	7.1	3.9
RYNLD NO, AVG	181.	1323.
RYNLD NO, IN BUN	127.	1667.
RYNLD NO,OUT BUN	245.	1014.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
44.73	53.12	2.08	.07

PCT OVER DESIGN	.21
TOT FOUL RESIST	.000217
DIFF RESIST	.000021

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.41	.41
DENSITY	LB/FT3	62.535	62.015
NOZZ RHO*VSQ	LB/FT-S2	10	10
BUND RHO*VSQ	LB/FT-S2	7	7

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	.74	.73
DENSITY	LB/FT3	61.291	62.028
PRESS. DROP	%	8.1	5.1

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW	FT/S	.07
NOMINAL VEL,WINDOW	FT/S	.13
CROSSFLOW COEF	BTU/HR-FT2-F	213.2
WINDOW COEF	BTU/HR-FT2-F	214.5

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.48
TUBE TO BAFFLE LEAKAGE	A =	3.10
MAIN CROSSFLOW	B =	67.74
BUNDLE TO SHELL BYPASS	C =	13.12
BAFFLE TO SHELL LEAKAGE	E =	16.04
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.631
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.686
END (HT LOSS IN END ZONE)	=	.994

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	8.9
END ZONE	=	4.8
CROSS FLOW	=	4.0
INLET NOZZLE	=	42.6
OUTLET NOZZLE	=	39.7

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.500		.600	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	85.5*	40.0	85.2*
DENSITY	LB/FT3	61.2913	62.0751	62.5352	62.0785
VISCOSITY	CP	.4726	.8119	1.4791	.8145

SPECIFIC HEAT	BTU/LB-F	.9973	.9999	1.0058	.9999
THERMAL COND.	BTU/HR-FT-F	.3723	.3595	.3466	.3595
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	112.7	84.8	62.6	83.7
VISCOSITY, AVG & SKIN	CP	.6072	.8181	1.0759	.8289
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.05	10.00	.01	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.49	10.00	.10	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	213.96		236.21	

TOTAL HEAT DUTY REQUIRED	MEGBTU/HR	.027195
EFF TEMP DIF, DEGF	(LMTD= 50.0,F= .81,BYPASS= .94,BAFF=1.00)	37.9
OVERALL COEFF REQUIRED	BTU/HR-FT2-F	100.44
CLEAN & FOULED COEFF	BTU/HR-FT2-F 103.09	100.57

SHELLS IN SERIES	1	PARALLEL	1
PASSES, SHELL	1	TUBE	4
SHELL DIAMETER IN.			3.820
TOTAL EFF AREA	FT2		7.1
EFFECTIVE AREA	FT2/SHELL		7.1
TEMA SHELL TYPE	E	; REAR HEAD	FXTS
BAFFLE TYPE	HORZ	SEGMENTL	
SPACING, CENTRAL	IN.		4.309
SPACING, INLET	IN.		4.309
SPACING, OUTLET	IN.		4.309
BAFFLE THICKNESS	IN.		.125
PAIRS OF SEALING DEVICES			1
CROSS PASSES PER SHELL PASS			4
BAFFLE CUT, PCT SHELL I.D.			30.00
CUT DISTANCE FROM CENTER, IN.			.764
IMPINGEMENT BAFFLE INCLUDED			NO
TUBESHEET BLANK AREA, %			.0
TUBE TYPE			PLAIN
NO. OF TUBES/SHELL			76
TUBE LGTH, OVERALL	FT		1.500
TUBE LGTH, EFF	FT		1.436
TUBE LAYOUT	DEG		60
PITCH RATIO			1.250
SHL NOZZ ID, IN&OUT	1.0	1.0	
MATERIAL	ELECTROLYTIC COPPER		
EST MAX TUBE COUNT			36
TUBE PITCH	IN.		.3125
TUBE OUTSIDE DIAM	IN.		.250
TUBE INSIDE DIAM	IN.		.214
TUBE SURFACE RATIO, OUT/IN			1.184
TUBE NOZZ ID, IN&OUT	IN.	.8	.8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.037	.000
PRANDTL NUMBER	7.4	4.0
RYNLD NO, AVG	210.	1298.
RYNLD NO, IN BUN	153.	1667.
RYNLD NO,OUT BUN	278.	970.
FOULNG LAYER IN.	.0014	.0014

SHELLSIDE PERFORMANCE		
NOMINAL VEL,X-FLOW	FT/S	.08
NOMINAL VEL,WINDOW	FT/S	.15
CROSSFLOW COEF	BTU/HR-FT2-F	237.1
WINDOW COEF	BTU/HR-FT2-F	238.7

SHELLSIDE FLOW, % OF TOTAL		
HEAT TRANSFER X-FLOW		81.56
THERMAL RESISTANCE, % OF TOTAL	TUBE TO BAFFLE LEAKAGE	A = 3.25

SHELL	TUBE	FOULING	METAL
42.10	55.65	2.18	.07

PCT OVER DESIGN .13
TOT FOUL RESIST .000217
DIFF RESIST .000013

DIAMETRAL CLEARANCES

BUNDLE TO SHELL IN. .5000
TUBE TO BAFFLE HOLE IN. .0284
BAFFLE TO SHELL IN. .1000

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.49	.49
DENSITY	LB/FT3	62.535	62.079
NOZZ RHO*VSQ	LB/FT-S2	14	15
BUND RHO*VSQ	LB/FT-S2	10	10

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	.74	.73
DENSITY	LB/FT3	61.291	62.075
PRESS. DROP	%	8.0	5.0

MAIN CROSSFLOW B = 67.05
BUNDLE TO SHELL BYPASS C = 13.86
BAFFLE TO SHELL LEAKAGE E = 15.84
TUBE PASSLANE BYPASS F = .00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN) = .647
BETA (BAFF CUT FACTOR) = .920
GAMMA (TUBE ROW ENTRY EFCT) = .703
END (HT LOSS IN END ZONE) = .994

SHELL PRESSURE DROP, % OF TOTAL

WINDOW = 8.8
END ZONE = 4.5
CROSS FLOW = 3.8
INLET NOZZLE = 42.7
OUTLET NOZZLE = 40.2

WEIGHT PER SHELL, LB

DRY = 150.
WET = 165.

□□Washington University ChE433 heat exchanger experiment E0002 P 76
Young model F302DY4P 9/23/ 3
CASE 38

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.500		.700	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	82.3*	40.0	81.0*
DENSITY	LB/FT3	61.2913	62.1131	62.5352	62.1282
VISCOSITY	CP	.4726	.8425	1.4791	.8554
SPECIFIC HEAT	BTU/LB-F	.9973	1.0002	1.0058	1.0003
THERMAL COND.	BTU/HR-FT-F	.3723	.3587	.3466	.3584
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	111.2	81.9	60.5	80.7
VISCOSITY, AVG & SKIN	CP	.6168	.8469	1.1061	.8588
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.05	10.00	.01	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.49	10.00	.11	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	213.85		259.06	

TOTAL HEAT DUTY REQUIRED MEGBTU/HR .028789
EFF TEMP DIF, DEGF (LMTD= 50.2,F= .82,BYPASS= .94,BAFF=1.00) 38.6
OVERALL COEFF REQUIRED BTU/HR-FT2-F 104.52
CLEAN & FOULED COEFF BTU/HR-FT2-F 107.18 104.42

SHELLS IN SERIES 1 PARALLEL 1		TOTAL EFF AREA FT2	7.1
PASSES, SHELL 1 TUBE 4		EFFECTIVE AREA FT2/SHELL	7.1
SHELL DIAMETER IN.	3.820	TEMA SHELL TYPE E ; REAR HEAD	FXTS
BAFFLE TYPE HORZ SEGMENTL		CROSS PASSES PER SHELL PASS	4
SPACING, CENTRAL IN.	4.309	BAFFLE CUT, PCT SHELL I.D.	30.00
SPACING, INLET IN.	4.309	CUT DISTANCE FROM CENTER, IN.	.764
SPACING, OUTLET IN.	4.309		
BAFFLE THICKNESS IN.	.125	IMPINGEMENT BAFFLE INCLUDED	NO
PAIRS OF SEALING DEVICES	1	TUBESHEET BLANK AREA, %	.0
TUBE TYPE	PLAIN	MATERIAL	ELECTROLYTIC COPPER
NO. OF TUBES/SHELL	76	EST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT	1.500	TUBE PITCH IN.	.3125
TUBE LGTH, EFF FT	1.436	TUBE OUTSIDE DIAM IN.	.250
TUBE LAYOUT DEG	60	TUBE INSIDE DIAM IN.	.214
PITCH RATIO	1.250	TUBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT 1.0	1.0	TUBE NOZZ ID, IN&OUT IN. .8	.8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.036	.000
PRANDTL NUMBER	7.6	4.1
RYNLD NO, AVG	238.	1277.
RYNLD NO, IN BUN	178.	1667.
RYNLD NO,OUT BUN	308.	935.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
39.86	57.81	2.26	.07

PCT OVER DESIGN	-.10
TOT FOUL RESIST	.000217
DIFF RESIST	-.000009

DIAMETRAL CLEARANCES		
BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA	IN	OUT
HT UNDR NOZ IN.	.25	
HT OPP NOZ IN.	.25	
VELOCITY FT/S	.57	.57
DENSITY LB/FT3	62.535	62.128
NOZZ RHO*VSQ LB/FT-S2	20	20
BUND RHO*VSQ LB/FT-S2	13	13

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW FT/S		.09
NOMINAL VEL,WINDOW FT/S		.18
CROSSFLOW COEF	BTU/HR-FT2-F	260.1
WINDOW COEF	BTU/HR-FT2-F	261.7

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.56
TUBE TO BAFFLE LEAKAGE	A =	3.41
MAIN CROSSFLOW	B =	66.34
BUNDLE TO SHELL BYPASS	C =	14.54
BAFFLE TO SHELL LEAKAGE	E =	15.72
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.661
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.719
END (HT LOSS IN END ZONE)	=	.994

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	8.8
END ZONE	=	4.2
CROSS FLOW	=	3.6
INLET NOZZLE	=	42.8
OUTLET NOZZLE	=	40.5

TUBE NOZZLE DATA		IN	OUT	WEIGHT PER SHELL, LB		
VELOCITY	FT/S	.74	.73	DRY	=	150.
DENSITY	LB/FT3	61.291	62.113	WET	=	165.
PRESS. DROP	%	7.8	4.9			

□□Washington University ChE433 heat exchanger experiment E0002 P 78
Young model F302DY4P 9/23/ 3
CASE 39

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.500		.800	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	79.7*	40.0	77.5*
DENSITY	LB/FT3	61.2913	62.1434	62.5352	62.1687
VISCOSITY	CP	.4726	.8688	1.4791	.8920
SPECIFIC HEAT	BTU/LB-F	.9973	1.0004	1.0058	1.0007
THERMAL COND.	BTU/HR-FT-F	.3723	.3580	.3466	.3574
MOLAR MASS	LB/LBMOL	18.02		18.02	
TEMP, AVG & SKIN	DEGF	109.9	79.3	58.8	78.1
VISCOSITY, AVG & SKIN	CP	.6249	.8727	1.1325	.8857
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.05	10.00	.01	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.49	10.00	.12	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	213.77		281.36	

TOTAL HEAT DUTY REQUIRED	MEGBTU/HR				.030088
EFF TEMP DIF, DEGF (LMTD= 50.2,F= .82,BYPASS= .94,BAFF=1.00)					39.1
OVERALL COEFF REQUIRED	BTU/HR-FT2-F				107.79
CLEAN & FOULED COEFF	BTU/HR-FT2-F		110.79		107.80

SHELLS IN SERIES	1	PARALLEL 1	TOTAL EFF AREA	FT2	7.1
PASSES, SHELL	1	TUBE 4	EFFECTIVE AREA	FT2/SHELL	7.1
SHELL DIAMETER IN.		3.820	TEMA SHELL TYPE E	; REAR HEAD	FXTS
BAFFLE TYPE	HORZ	SEGMENTL	CROSS PASSES PER SHELL PASS		4
SPACING, CENTRAL	IN.	4.309	BAFFLE CUT, PCT SHELL I.D.		30.00
SPACING, INLET	IN.	4.309	CUT DISTANCE FROM CENTER, IN.		.764
SPACING, OUTLET	IN.	4.309			
BAFFLE THICKNESS	IN.	.125	IMPINGEMENT BAFFLE INCLUDED		NO
PAIRS OF SEALING DEVICES		1	TUBESHEET BLANK AREA, %		.0
TUBE TYPE		PLAIN	MATERIAL	ELECTROLYTIC COPPER	
NO. OF TUBES/SHELL		76	EST MAX TUBE COUNT		36
TUBE LGTH, OVERALL	FT	1.500	TUBE PITCH	IN.	.3125
TUBE LGTH, EFF	FT	1.436	TUBE OUTSIDE DIAM	IN.	.250
TUBE LAYOUT	DEG	60	TUBE INSIDE DIAM	IN.	.214
PITCH RATIO		1.250	TUBE SURFACE RATIO, OUT/IN		1.184

SHL NOZZ ID, IN&OUT 1.0 1.0 TUBE NOZZ ID, IN&OUT IN. .8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.035	.000
PRANDTL NUMBER	7.8	4.1
RYNLD NO, AVG	266.	1261.
RYNLD NO, IN BUN	204.	1667.
RYNLD NO,OUT BUN	338.	907.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
37.88	59.70	2.34	.08

PCT OVER DESIGN	.00
TOT FOUL RESIST	.000217
DIFF RESIST	.000000

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.65	.66
DENSITY	LB/FT3	62.535	62.169
NOZZ RHO*VSQ	LB/FT-S2	26	26
BUND RHO*VSQ	LB/FT-S2	18	18

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	.74	.73
DENSITY	LB/FT3	61.291	62.143
PRESS. DROP	%	7.7	4.9

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW	FT/S	.10
NOMINAL VEL,WINDOW	FT/S	.20
CROSSFLOW COEF	BTU/HR-FT2-F	282.5
WINDOW COEF	BTU/HR-FT2-F	284.2

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.57
TUBE TO BAFFLE LEAKAGE	A =	3.54
MAIN CROSSFLOW	B =	65.75
BUNDLE TO SHELL BYPASS	C =	15.10
BAFFLE TO SHELL LEAKAGE	E =	15.61
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.676
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.735
END (HT LOSS IN END ZONE)	=	.994

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	8.8
END ZONE	=	3.9
CROSS FLOW	=	3.5
INLET NOZZLE	=	42.9
OUTLET NOZZLE	=	40.9

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.500		.900	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	77.5*	40.0	74.6*
DENSITY	LB/FT3	61.2913	62.1692	62.5352	62.2016
VISCOSITY	CP	.4726	.8925	1.4791	.9243
SPECIFIC HEAT	BTU/LB-F	.9973	1.0007	1.0058	1.0010

THERMAL COND.	BTU/HR-FT-F	.3723	.3574	.3466	.3566
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	108.7	77.1	57.3	75.9
VISCOSITY, AVG & SKIN	CP	.6320	.8961	1.1551	.9101
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.05	10.00	.02	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.49	10.00	.14	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	213.66		303.50	

TOTAL HEAT DUTY REQUIRED	MEGBTU/HR	.031211
EFF TEMP DIF, DEGF (LMTD= 50.2,F= .83,BYPASS= .94,BAFF=1.00)		39.4
OVERALL COEFF REQUIRED	BTU/HR-FT2-F	110.97
CLEAN & FOULED COEFF	BTU/HR-FT2-F	114.03 / 110.83

SHELLS IN SERIES 1 PARALLEL 1		TOTAL EFF AREA FT2	7.1
PASSES, SHELL 1 TUBE	4	EFFECTIVE AREA FT2/SHELL	7.1
SHELL DIAMETER IN.	3.820	TEMA SHELL TYPE E ; REAR HEAD	FXTS
BAFFLE TYPE	HORZ SEGMENTL	CROSS PASSES PER SHELL PASS	4
SPACING, CENTRAL IN.	4.309	BAFFLE CUT, PCT SHELL I.D.	30.00
SPACING, INLET IN.	4.309	CUT DISTANCE FROM CENTER, IN.	.764
SPACING, OUTLET IN.	4.309		
BAFFLE THICKNESS IN.	.125	IMPINGEMENT BAFFLE INCLUDED	NO
PAIRS OF SEALING DEVICES	1	TUBESHEET BLANK AREA, %	.0

TUBE TYPE	PLAIN	MATERIAL	ELECTROLYTIC COPPER
NO. OF TUBES/SHELL	76	EST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT	1.500	TUBE PITCH IN.	.3125
TUBE LGTH, EFF FT	1.436	TUBE OUTSIDE DIAM IN.	.250
TUBE LAYOUT DEG	60	TUBE INSIDE DIAM IN.	.214
PITCH RATIO	1.250	TUBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT	1.0 1.0	TUBE NOZZ ID, IN&OUT IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

□□Washington University ChE433 heat exchanger experiment E0002 P 81
Young model F302DY4P 9/23/ 3
CASE 40

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.034	.000
PRANDTL NUMBER	8.0	4.2
RYNLD NO, AVG	294.	1247.
RYNLD NO, IN BUN	229.	1667.
RYNLD NO,OUT BUN	367.	883.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL

SHELLSIDE PERFORMANCE		
NOMINAL VEL,X-FLOW	FT/S	.12
NOMINAL VEL,WINDOW	FT/S	.23
CROSSFLOW COEF	BTU/HR-FT2-F	304.8
WINDOW COEF	BTU/HR-FT2-F	306.5

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.55
TUBE TO BAFFLE LEAKAGE	A =	3.67
MAIN CROSSFLOW	B =	65.41

```
 36.11  61.41    2.40     .08       BUNDLE TO SHELL BYPASS    C =  15.40
PCT OVER DESIGN             -.13    BAFFLE TO SHELL LEAKAGE   E =  15.52
TOT FOUL RESIST           .000217   TUBE PASSLANE BYPASS      F =    .00
DIFF RESIST              -.000012
                                     SHELLSIDE HEAT TRANSFER FACTORS
  DIAMETRAL CLEARANCES               TOTAL =(BETA)(GAMMA)(FIN)   =   .692
BUNDLE TO SHELL      IN.    .5000   BETA  (BAFF CUT FACTOR)     =   .920
TUBE TO BAFFLE HOLE  IN.    .0284   GAMMA (TUBE ROW ENTRY EFCT) =   .752
BAFFLE TO SHELL      IN.    .1000   END   (HT LOSS IN END ZONE) =   .994

  SHELL NOZZLE DATA     IN    OUT     SHELL PRESSURE DROP, % OF TOTAL
HT UNDR NOZ  IN.       .25           WINDOW                      =    8.8
HT OPP  NOZ  IN.       .25           END ZONE                    =    3.8
VELOCITY     FT/S      .73    .74    CROSS FLOW                  =    3.3
DENSITY    LB/FT3   62.535 62.202   INLET NOZZLE                =   43.0
NOZZ RHO*VSQ LB/FT-S2   33     33    OUTLET NOZZLE               =   41.1
BUND RHO*VSQ LB/FT-S2   22     22

  TUBE NOZZLE DATA      IN    OUT     WEIGHT PER SHELL, LB
VELOCITY     FT/S      .74    .73    DRY                     =      150.
DENSITY    LB/FT3   61.291 62.169    WET                     =      165.
PRESS. DROP  %         7.6    4.8
□□Washington University ChE433 heat exchanger experiment        E0002 P 82
Young model F302DY4P                                             9/23/ 3
                                                                 CASE 41
SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING
                                    HOT TUBE SIDE       COLD SHELL SIDE
                                     Tube                 Shell
                                     SENSIBLE LIQ         SENSIBLE LIQ
TOTAL FLOW RATE    KLB/HR                 .600                 .200
                                     IN       OUT         IN       OUT
TEMPERATURE        DEGF             140.0     113.9*      40.0     118.1*
DENSITY            LB/FT3         61.2913   61.6988    62.5352   61.6366
VISCOSITY          CP               .4726     .6004     1.4791     .5762
SPECIFIC HEAT      BTU/LB-F         .9973     .9979     1.0058     .9977
THERMAL COND.      BTU/HR-FT-F      .3723     .3666      .3466     .3676
MOLAR MASS         LB/LBMOL                   18.02                18.02
                                   ---------------      ---------------
TEMP, AVG & SKIN       DEGF         126.9     106.9       79.1     106.1
VISCOSITY, AVG & SKIN  CP           .5305     .6437      .8755     .6492
PRESSURE, IN & DESIGN  PSIA         50.00    165.00      50.00    165.00

PRESSURE DROP, TOT & ALLOWED  PSI     .07     10.00        .00     10.00
VELOCITY, CALC & MAX ALLOWED  FT/S    .59     10.00        .03     10.00

FOULING RESISTANCE     HR-FT2-F/BTU      .00010              .00010
FILM COEFFICIENT       BTU/HR-FT2-F      218.37              135.02
                  ------------------------------------
TOTAL HEAT DUTY REQUIRED MEGBTU/HR                                .015633
EFF TEMP DIF, DEGF  (LMTD= 42.7,F= .74,BYPASS= .90,BAFF=1.00)       28.5
OVERALL COEFF REQUIRED   BTU/HR-FT2-F                               76.78
CLEAN & FOULED COEFF     BTU/HR-FT2-F           78.35               77.11
```

SHELLS IN SERIES	1	PARALLEL 1	TOTAL EFF AREA FT2	7.1
PASSES, SHELL	1	TUBE 4	EFFECTIVE AREA FT2/SHELL	7.1
SHELL DIAMETER IN.	3.820		TEMA SHELL TYPE E ; REAR HEAD FXTS	
BAFFLE TYPE	HORZ	SEGMENTL	CROSS PASSES PER SHELL PASS	4
SPACING, CENTRAL IN.	4.309		BAFFLE CUT, PCT SHELL I.D.	30.00
SPACING, INLET IN.	4.309		CUT DISTANCE FROM CENTER, IN.	.764
SPACING, OUTLET IN.	4.309			
BAFFLE THICKNESS IN.	.125		IMPINGEMENT BAFFLE INCLUDED	NO
PAIRS OF SEALING DEVICES	1		TUBESHEET BLANK AREA, %	.0
TUBE TYPE	PLAIN		MATERIAL	ELECTROLYTIC COPPER
NO. OF TUBES/SHELL	76		EST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT	1.500		TUBE PITCH IN.	.3125
TUBE LGTH, EFF FT	1.436		TUBE OUTSIDE DIAM IN.	.250
TUBE LAYOUT DEG	60		TUBE INSIDE DIAM IN.	.214
PITCH RATIO	1.250		TUBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT	1.0 1.0		TUBE NOZZ ID, IN&OUT IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

□□Washington University ChE433 heat exchanger experiment E0002 P 83
Young model F302DY4P 9/23/ 3
CASE 41

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.043	.000
PRANDTL NUMBER	5.9	3.5
RYNLD NO, AVG	85.	1782.
RYNLD NO, IN BUN	50.	2000.
RYNLD NO,OUT BUN	128.	1575.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL			
SHELL	TUBE	FOULING	METAL
56.47	41.80	1.67	.06

PCT OVER DESIGN	.42
TOT FOUL RESIST	.000217
DIFF RESIST	.000055

DIAMETRAL CLEARANCES		
BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.16	.17
DENSITY	LB/FT3	62.535	61.637
NOZZ RHO*VSQ	LB/FT-S2	1	1
BUND RHO*VSQ	LB/FT-S2	1	1

SHELLSIDE PERFORMANCE		
NOMINAL VEL,X-FLOW	FT/S	.03
NOMINAL VEL,WINDOW	FT/S	.05
CROSSFLOW COEF	BTU/HR-FT2-F	136.3
WINDOW COEF	BTU/HR-FT2-F	133.7

SHELLSIDE FLOW, % OF TOTAL		
HEAT TRANSFER X-FLOW		80.12
TUBE TO BAFFLE LEAKAGE	A =	2.58
MAIN CROSSFLOW	B =	68.63
BUNDLE TO SHELL BYPASS	C =	10.97
BAFFLE TO SHELL LEAKAGE	E =	17.83
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS		
TOTAL =(BETA)(GAMMA)(FIN)	=	.598
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.650
END (HT LOSS IN END ZONE)	=	.998

SHELL PRESSURE DROP, % OF TOTAL		
WINDOW	=	9.7
END ZONE	=	7.4
CROSS FLOW	=	5.7
INLET NOZZLE	=	41.0
OUTLET NOZZLE	=	36.1

TUBE NOZZLE DATA		IN	OUT	WEIGHT PER SHELL, LB		
VELOCITY	FT/S	.89	.88	DRY	=	150.
DENSITY	LB/FT3	61.291	61.699	WET	=	165.
PRESS. DROP	%	8.5	5.4			

*** SPECIAL MESSAGES AND WARNINGS ***

WARNING--TUBESIDE FLUID HAS PASSED THROUGH TRANSITION ZONE. CONSIDER RERUNNING WITH ITEM 132 IN EFFECT.

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.600		.300	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	105.9*	40.0	108.0*
DENSITY	LB/FT3	61.2913	61.8116	62.5352	61.7829
VISCOSITY	CP	.4726	.6505	1.4791	.6369
SPECIFIC HEAT	BTU/LB-F	.9973	.9983	1.0058	.9982
THERMAL COND.	BTU/HR-FT-F	.3723	.3647	.3466	.3652
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	122.9	100.4	74.0	99.5
VISCOSITY, AVG & SKIN	CP	.5505	.6885	.9310	.6953
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.07	10.00	.00	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.59	10.00	.05	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	218.44		160.80	

TOTAL HEAT DUTY REQUIRED	MEGBTU/HR	.020412
EFF TEMP DIF, DEGF	(LMTD= 46.9,F= .78,BYPASS= .92,BAFF=1.00)	33.8
OVERALL COEFF REQUIRED	BTU/HR-FT2-F	84.47
CLEAN & FOULED COEFF	BTU/HR-FT2-F 86.40	84.79

SHELLS IN SERIES	1	PARALLEL	1
PASSES, SHELL	1	TUBE	4
SHELL DIAMETER IN.			3.820
TOTAL EFF AREA	FT2		7.1
EFFECTIVE AREA	FT2/SHELL		7.1
TEMA SHELL TYPE	E	; REAR HEAD	FXTS

BAFFLE TYPE	HORZ	SEGMENTL	
SPACING, CENTRAL	IN.		4.309
SPACING, INLET	IN.		4.309
SPACING, OUTLET	IN.		4.309
BAFFLE THICKNESS	IN.		.125
PAIRS OF SEALING DEVICES			1
CROSS PASSES PER SHELL PASS			4
BAFFLE CUT, PCT SHELL I.D.			30.00
CUT DISTANCE FROM CENTER, IN.			.764
IMPINGEMENT BAFFLE INCLUDED			NO
TUBESHEET BLANK AREA, %			.0

TUBE TYPE		PLAIN	MATERIAL		ELECTROLYTIC COPPER
NO. OF TUBES/SHELL		76	EST MAX TUBE COUNT		36
TUBE LGTH, OVERALL	FT	1.500	TUBE PITCH	IN.	.3125
TUBE LGTH, EFF	FT	1.436	TUBE OUTSIDE DIAM	IN.	.250
TUBE LAYOUT	DEG	60	TUBE INSIDE DIAM	IN.	.214
PITCH RATIO		1.250	TUBE SURFACE RATIO, OUT/IN		1.184
SHL NOZZ ID, IN&OUT	1.0	1.0	TUBE NOZZ ID, IN&OUT	IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

Washington University ChE433 heat exchanger experiment E0002 P 85

Young model F302DY4P 9/23/ 3

CASE 42

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.042	.000
PRANDTL NUMBER	6.3	3.6
RYNLD NO, AVG	121.	1718.
RYNLD NO, IN BUN	76.	2000.
RYNLD NO,OUT BUN	177.	1453.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
52.14	45.96	1.84	.06

PCT OVER DESIGN	.38
TOT FOUL RESIST	.000217
DIFF RESIST	.000045

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.24	.25
DENSITY	LB/FT3	62.535	61.783
NOZZ RHO*VSQ	LB/FT-S2	3	3
BUND RHO*VSQ	LB/FT-S2	2	2

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	.89	.88
DENSITY	LB/FT3	61.291	61.812
PRESS. DROP	%	8.4	5.3

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW	FT/S	.04
NOMINAL VEL,WINDOW	FT/S	.08
CROSSFLOW COEF	BTU/HR-FT2-F	161.5
WINDOW COEF	BTU/HR-FT2-F	162.3

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.30
TUBE TO BAFFLE LEAKAGE	A =	2.70
MAIN CROSSFLOW	B =	69.46
BUNDLE TO SHELL BYPASS	C =	11.29
BAFFLE TO SHELL LEAKAGE	E =	16.55
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.600
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.652
END (HT LOSS IN END ZONE)	=	.994

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	9.2
END ZONE	=	5.8
CROSS FLOW	=	4.7
INLET NOZZLE	=	42.2
OUTLET NOZZLE	=	38.1

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

*** SPECIAL MESSAGES AND WARNINGS ***

WARNING--TUBESIDE FLUID HAS PASSED THROUGH TRANSITION ZONE. CONSIDER RERUNNING WITH ITEM 132 IN EFFECT.

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.600		.400	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	99.7*	40.0	100.2*
DENSITY	LB/FT3	61.2913	61.8949	62.5352	61.8894
VISCOSITY	CP	.4726	.6937	1.4791	.6906
SPECIFIC HEAT	BTU/LB-F	.9973	.9987	1.0058	.9987
THERMAL COND.	BTU/HR-FT-F	.3723	.3632	.3466	.3633
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	119.9	95.1	70.1	94.1
VISCOSITY, AVG & SKIN	CP	.5667	.7293	.9773	.7375
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.07	10.00	.00	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.59	10.00	.06	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	218.48		188.53	

TOTAL HEAT DUTY REQUIRED	MEGBTU/HR		.024098
EFF TEMP DIF, DEGF (LMTD= 49.1,F= .80,BYPASS= .93,BAFF=1.00)			36.6
OVERALL COEFF REQUIRED	BTU/HR-FT2-F		92.27
CLEAN & FOULED COEFF	BTU/HR-FT2-F	93.82	91.85

SHELLS IN SERIES	1	PARALLEL	1
PASSES, SHELL	1	TUBE	4
SHELL DIAMETER IN.			3.820
TOTAL EFF AREA	FT2		7.1
EFFECTIVE AREA	FT2/SHELL		7.1
TEMA SHELL TYPE	E	; REAR HEAD	FXTS

BAFFLE TYPE	HORZ	SEGMENTL	
SPACING, CENTRAL	IN.		4.309
SPACING, INLET	IN.		4.309
SPACING, OUTLET	IN.		4.309
BAFFLE THICKNESS	IN.		.125
PAIRS OF SEALING DEVICES			1
CROSS PASSES PER SHELL PASS			4
BAFFLE CUT, PCT SHELL I.D.			30.00
CUT DISTANCE FROM CENTER, IN.			.764
IMPINGEMENT BAFFLE INCLUDED			NO
TUBESHEET BLANK AREA, %			.0

TUBE TYPE		PLAIN	
NO. OF TUBES/SHELL			76
TUBE LGTH, OVERALL	FT		1.500
TUBE LGTH, EFF	FT		1.436
TUBE LAYOUT	DEG		60
PITCH RATIO			1.250
SHL NOZZ ID, IN&OUT		1.0	1.0
MATERIAL		ELECTROLYTIC COPPER	
EST MAX TUBE COUNT			36
TUBE PITCH	IN.		.3125
TUBE OUTSIDE DIAM	IN.		.250
TUBE INSIDE DIAM	IN.		.214
TUBE SURFACE RATIO, OUT/IN			1.184
TUBE NOZZ ID, IN&OUT	IN.	.8	.8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

CASE 43

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.040	.000
PRANDTL NUMBER	6.7	3.7
RYNLD NO, AVG	154.	1668.
RYNLD NO, IN BUN	102.	2000.
RYNLD NO,OUT BUN	218.	1363.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
48.17	49.77	1.99	.07

PCT OVER DESIGN	-.46
TOT FOUL RESIST	.000217
DIFF RESIST	-.000050

DIAMETRAL CLEARANCES		
BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.33	.33
DENSITY	LB/FT3	62.535	61.889
NOZZ RHO*VSQ	LB/FT-S2	6	6
BUND RHO*VSQ	LB/FT-S2	4	4

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	.89	.88
DENSITY	LB/FT3	61.291	61.895
PRESS. DROP	%	8.3	5.3

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW	FT/S	.05
NOMINAL VEL,WINDOW	FT/S	.10
CROSSFLOW COEF	BTU/HR-FT2-F	189.3
WINDOW COEF	BTU/HR-FT2-F	190.4

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.42
TUBE TO BAFFLE LEAKAGE	A =	2.93
MAIN CROSSFLOW	B =	68.47
BUNDLE TO SHELL BYPASS	C =	12.35
BAFFLE TO SHELL LEAKAGE	E =	16.24
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.617
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.671
END (HT LOSS IN END ZONE)	=	.994

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	9.0
END ZONE	=	5.2
CROSS FLOW	=	4.3
INLET NOZZLE	=	42.5
OUTLET NOZZLE	=	39.0

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

*** SPECIAL MESSAGES AND WARNINGS ***

WARNING--TUBESIDE FLUID HAS PASSED THROUGH TRANSITION ZONE. CONSIDER
RERUNNING WITH ITEM 132 IN EFFECT.

CASE 44

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.600		.500	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	95.1*	40.0	93.7*
DENSITY	LB/FT3	61.2913	61.9561	62.5352	61.9733

VISCOSITY	CP	.4726	.7295	1.4791	.7403
SPECIFIC HEAT	BTU/LB-F	.9973	.9990	1.0058	.9991
THERMAL COND.	BTU/HR-FT-F	.3723	.3620	.3466	.3617
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	117.5	90.8	66.9	89.7
VISCOSITY, AVG & SKIN	CP	.5795	.7648	1.0181	.7744
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.07	10.00	.01	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.59	10.00	.08	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	218.49		214.09	

TOTAL HEAT DUTY REQUIRED MEGBTU/HR			.026906
EFF TEMP DIF, DEGF (LMTD= 50.5,F= .82,BYPASS= .94,BAFF=1.00)			38.6
OVERALL COEFF REQUIRED	BTU/HR-FT2-F		97.48
CLEAN & FOULED COEFF	BTU/HR-FT2-F	99.75	97.45

SHELLS IN SERIES	1	PARALLEL 1	
PASSES, SHELL	1	TUBE 4	
SHELL DIAMETER IN.		3.820	
TOTAL EFF AREA	FT2		7.1
EFFECTIVE AREA	FT2/SHELL		7.1
TEMA SHELL TYPE	E	; REAR HEAD	FXTS
BAFFLE TYPE	HORZ	SEGMENTL	
SPACING, CENTRAL	IN.	4.309	
SPACING, INLET	IN.	4.309	
SPACING, OUTLET	IN.	4.309	
BAFFLE THICKNESS	IN.	.125	
PAIRS OF SEALING DEVICES		1	
CROSS PASSES PER SHELL PASS			4
BAFFLE CUT, PCT SHELL I.D.			30.00
CUT DISTANCE FROM CENTER, IN.			.764
IMPINGEMENT BAFFLE INCLUDED			NO
TUBESHEET BLANK AREA, %			.0

TUBE TYPE		PLAIN	MATERIAL		ELECTROLYTIC COPPER
NO. OF TUBES/SHELL		76	EST MAX TUBE COUNT		36
TUBE LGTH, OVERALL	FT	1.500	TUBE PITCH	IN.	.3125
TUBE LGTH, EFF	FT	1.436	TUBE OUTSIDE DIAM	IN.	.250
TUBE LAYOUT	DEG	60	TUBE INSIDE DIAM	IN.	.214
PITCH RATIO		1.250	TUBE SURFACE RATIO, OUT/IN		1.184
SHL NOZZ ID, IN&OUT	1.0	1.0	TUBE NOZZ ID, IN&OUT	IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.039	.000
PRANDTL NUMBER	7.0	3.8
RYNLD NO, AVG	185.	1631.
RYNLD NO, IN BUN	127.	2000.
RYNLD NO,OUT BUN	254.	1296.
FOULNG LAYER IN.	.0014	.0014

SHELLSIDE PERFORMANCE		
NOMINAL VEL,X-FLOW	FT/S	.07
NOMINAL VEL,WINDOW	FT/S	.13
CROSSFLOW COEF	BTU/HR-FT2-F	214.9
WINDOW COEF	BTU/HR-FT2-F	216.3
SHELLSIDE FLOW, % OF TOTAL		
HEAT TRANSFER X-FLOW		81.50

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
45.01	52.81	2.11	.07

PCT OVER DESIGN	-.03
TOT FOUL RESIST	.000217
DIFF RESIST	-.000003

DIAMETRAL CLEARANCES		
BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.41	.41
DENSITY	LB/FT3	62.535	61.973
NOZZ RHO*VSQ	LB/FT-S2	10	10
BUND RHO*VSQ	LB/FT-S2	7	7

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	.89	.88
DENSITY	LB/FT3	61.291	61.956
PRESS. DROP	%	8.3	5.2

TUBE TO BAFFLE LEAKAGE	A =	3.12
MAIN CROSSFLOW	B =	67.66
BUNDLE TO SHELL BYPASS	C =	13.21
BAFFLE TO SHELL LEAKAGE	E =	16.01
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.633
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.688
END (HT LOSS IN END ZONE)	=	.994

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	8.9
END ZONE	=	4.7
CROSS FLOW	=	4.0
INLET NOZZLE	=	42.7
OUTLET NOZZLE	=	39.6

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

*** SPECIAL MESSAGES AND WARNINGS ***

WARNING--TUBESIDE FLUID HAS PASSED THROUGH TRANSITION ZONE. CONSIDER RERUNNING WITH ITEM 132 IN EFFECT.

□□Washington University ChE433 heat exchanger experiment E0002 P 90
Young model F302DY4P 9/23/ 3
CASE 45

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.600		.600	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	91.2*	40.0	88.5*
DENSITY	LB/FT3	61.2913	62.0044	62.5352	62.0381
VISCOSITY	CP	.4726	.7607	1.4791	.7843
SPECIFIC HEAT	BTU/LB-F	.9973	.9993	1.0058	.9996
THERMAL COND.	BTU/HR-FT-F	.3723	.3610	.3466	.3603
MOLAR MASS	LB/LBMOL	18.02		18.02	
TEMP, AVG & SKIN	DEGF	115.6	87.2	64.3	86.0
VISCOSITY, AVG & SKIN	CP	.5903	.7962	1.0527	.8070
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.07	10.00	.01	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.58	10.00	.09	10.00

FOULING RESISTANCE	HR-FT2-F/BTU	.00010	.00010
FILM COEFFICIENT	BTU/HR-FT2-F	218.43	238.33

TOTAL HEAT DUTY REQUIRED MEGBTU/HR	.029186
EFF TEMP DIF, DEGF (LMTD= 51.4,F= .83,BYPASS= .94,BAFF=1.00)	40.0
OVERALL COEFF REQUIRED BTU/HR-FT2-F	102.11
CLEAN & FOULED COEFF BTU/HR-FT2-F 104.70	102.12

SHELLS IN SERIES	1	PARALLEL	1
PASSES, SHELL	1	TUBE	4
SHELL DIAMETER IN.			3.820

TOTAL EFF AREA FT2	7.1
EFFECTIVE AREA FT2/SHELL	7.1
TEMA SHELL TYPE E ; REAR HEAD	FXTS

BAFFLE TYPE HORZ SEGMENTL	
SPACING, CENTRAL IN.	4.309
SPACING, INLET IN.	4.309
SPACING, OUTLET IN.	4.309
BAFFLE THICKNESS IN.	.125
PAIRS OF SEALING DEVICES	1

CROSS PASSES PER SHELL PASS	4
BAFFLE CUT, PCT SHELL I.D.	30.00
CUT DISTANCE FROM CENTER, IN.	.764
IMPINGEMENT BAFFLE INCLUDED	NO
TUBESHEET BLANK AREA, %	.0

TUBE TYPE			PLAIN
NO. OF TUBES/SHELL			76
TUBE LGTH, OVERALL	FT		1.500
TUBE LGTH, EFF	FT		1.436
TUBE LAYOUT	DEG		60
PITCH RATIO			1.250
SHL NOZZ ID, IN&OUT	1.0	1.0	

MATERIAL			ELECTROLYTIC COPPER
EST MAX TUBE COUNT			36
TUBE PITCH	IN.		.3125
TUBE OUTSIDE DIAM	IN.		.250
TUBE INSIDE DIAM	IN.		.214
TUBE SURFACE RATIO, OUT/IN			1.184
TUBE NOZZ ID, IN&OUT	IN.	.8	.8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

□□Washington University ChE433 heat exchanger experiment E0002 P 91
Young model F302DY4P 9/23/ 3
CASE 45

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.038	.000
PRANDTL NUMBER	7.2	3.9
RYNLD NO, AVG	215.	1602.
RYNLD NO, IN BUN	153.	2000.
RYNLD NO,OUT BUN	288.	1243.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
42.37	55.35	2.21	.07

PCT OVER DESIGN	.00
TOT FOUL RESIST	.000217
DIFF RESIST	.000000

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW FT/S	.08
NOMINAL VEL,WINDOW FT/S	.15
CROSSFLOW COEF BTU/HR-FT2-F	239.3
WINDOW COEF BTU/HR-FT2-F	240.8

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.58
TUBE TO BAFFLE LEAKAGE	A =	3.28
MAIN CROSSFLOW	B =	66.96
BUNDLE TO SHELL BYPASS	C =	13.95
BAFFLE TO SHELL LEAKAGE	E =	15.81
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.649
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.705
END (HT LOSS IN END ZONE)	=	.994

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.49	.49
DENSITY	LB/FT3	62.535	62.038
NOZZ RHO*VSQ	LB/FT-S2	14	15
BUND RHO*VSQ	LB/FT-S2	10	10

SHELL PRESSURE DROP, % OF TOTAL		
WINDOW	=	8.8
END ZONE	=	4.4
CROSS FLOW	=	3.8
INLET NOZZLE	=	42.8
OUTLET NOZZLE	=	40.1

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	.89	.88
DENSITY	LB/FT3	61.291	62.004
PRESS. DROP	%	8.2	5.2

WEIGHT PER SHELL, LB		
DRY	=	150.
WET	=	165.

*** SPECIAL MESSAGES AND WARNINGS ***

WARNING--TUBESIDE FLUID HAS PASSED THROUGH TRANSITION ZONE. CONSIDER RERUNNING WITH ITEM 132 IN EFFECT.

□□Washington University ChE433 heat exchanger experiment E0002 P 92
Young model F302DY4P 9/23/ 3
CASE 46

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.600		.700	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	88.1*	40.0	84.2*
DENSITY	LB/FT3	61.2913	62.0429	62.5352	62.0902
VISCOSITY	CP	.4726	.7877	1.4791	.8238
SPECIFIC HEAT	BTU/LB-F	.9973	.9996	1.0058	1.0000
THERMAL COND.	BTU/HR-FT-F	.3723	.3602	.3466	.3592
MOLAR MASS	LB/LBMOL	18.02		18.02	
TEMP, AVG & SKIN	DEGF	114.1	84.2	62.1	83.0
VISCOSITY, AVG & SKIN	CP	.5993	.8243	1.0828	.8362
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.07	10.00	.01	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.58	10.00	.11	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	218.35		261.47	

TOTAL HEAT DUTY REQUIRED	MEGBTU/HR			.031044
EFF TEMP DIF, DEGF (LMTD= 51.9,F= .84,BYPASS= .94,BAFF=1.00)				40.9
OVERALL COEFF REQUIRED	BTU/HR-FT2-F			106.19
CLEAN & FOULED COEFF	BTU/HR-FT2-F	108.91		106.07

SHELLS IN SERIES	1	PARALLEL 1	TOTAL EFF AREA	FT2	7.1
PASSES, SHELL	1	TUBE 4	EFFECTIVE AREA	FT2/SHELL	7.1

SHELL DIAMETER IN.	3.820	TEMA SHELL TYPE E ; REAR HEAD FXTS	
BAFFLE TYPE	HORZ SEGMENTL	CROSS PASSES PER SHELL PASS	4
SPACING, CENTRAL IN.	4.309	BAFFLE CUT, PCT SHELL I.D.	30.00
SPACING, INLET IN.	4.309	CUT DISTANCE FROM CENTER, IN.	.764
SPACING, OUTLET IN.	4.309		
BAFFLE THICKNESS IN.	.125	IMPINGEMENT BAFFLE INCLUDED	NO
PAIRS OF SEALING DEVICES	1	TUBESHEET BLANK AREA, %	.0
TUBE TYPE	PLAIN	MATERIAL	ELECTROLYTIC COPPER
NO. OF TUBES/SHELL	76	EST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT	1.500	TUBE PITCH IN.	.3125
TUBE LGTH, EFF FT	1.436	TUBE OUTSIDE DIAM IN.	.250
TUBE LAYOUT DEG	60	TUBE INSIDE DIAM IN.	.214
PITCH RATIO	1.250	TUBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT	1.0 1.0	TUBE NOZZ ID, IN&OUT IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

□□Washington University ChE433 heat exchanger experiment E0002 P 93
Young model F302DY4P 9/23/ 3
CASE 46

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.037	.000
PRANDTL NUMBER	7.4	3.9
RYNLD NO, AVG	244.	1578.
RYNLD NO, IN BUN	178.	2000.
RYNLD NO,OUT BUN	320.	1200.
FOULNG LAYER IN.	.0014	.0014

SHELLSIDE PERFORMANCE		
NOMINAL VEL,X-FLOW FT/S		.09
NOMINAL VEL,WINDOW FT/S		.18
CROSSFLOW COEF BTU/HR-FT2-F		262.5
WINDOW COEF BTU/HR-FT2-F		264.1

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
40.11	57.51	2.30	.08

PCT OVER DESIGN	-.11
TOT FOUL RESIST	.000217
DIFF RESIST	-.000010

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.57
TUBE TO BAFFLE LEAKAGE	A =	3.43
MAIN CROSSFLOW	B =	66.25
BUNDLE TO SHELL BYPASS	C =	14.63
BAFFLE TO SHELL LEAKAGE	E =	15.69
TUBE PASSLANE BYPASS	F =	.00

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.664
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.722
END (HT LOSS IN END ZONE)	=	.994

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.57	.57
DENSITY	LB/FT3	62.535	62.090
NOZZ RHO*VSQ	LB/FT-S2	20	20
BUND RHO*VSQ	LB/FT-S2	13	13

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	8.8
END ZONE	=	4.1
CROSS FLOW	=	3.6
INLET NOZZLE	=	42.9
OUTLET NOZZLE	=	40.5

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	.89	.88

WEIGHT PER SHELL, LB

DRY	=	150.

DENSITY LB/FT3 61.291 62.043 WET = 165.
PRESS. DROP % 8.2 5.1

*** SPECIAL MESSAGES AND WARNINGS ***

WARNING--TUBESIDE FLUID HAS PASSED THROUGH TRANSITION ZONE. CONSIDER
RERUNNING WITH ITEM 132 IN EFFECT.

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.600		.800	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	85.6*	40.0	80.6*
DENSITY	LB/FT3	61.2913	62.0742	62.5352	62.1328
VISCOSITY	CP	.4726	.8112	1.4791	.8594
SPECIFIC HEAT	BTU/LB-F	.9973	.9998	1.0058	1.0003
THERMAL COND.	BTU/HR-FT-F	.3723	.3596	.3466	.3583
MOLAR MASS	LB/LBMOL	18.02		18.02	
TEMP, AVG & SKIN	DEGF	112.8	81.6	60.3	80.3
VISCOSITY, AVG & SKIN	CP	.6069	.8496	1.1090	.8626
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.07	10.00	.01	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.58	10.00	.12	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	218.28		284.03	

TOTAL HEAT DUTY REQUIRED MEGBTU/HR .032589
EFF TEMP DIF, DEGF (LMTD= 52.2,F= .84,BYPASS= .94,BAFF=1.00) 41.6
OVERALL COEFF REQUIRED BTU/HR-FT2-F 109.59
CLEAN & FOULED COEFF BTU/HR-FT2-F 112.61 109.54

SHELLS IN SERIES 1 PARALLEL 1		TOTAL EFF AREA FT2	7.1
PASSES, SHELL 1 TUBE	4	EFFECTIVE AREA FT2/SHELL	7.1
SHELL DIAMETER IN.	3.820	TEMA SHELL TYPE E ; REAR HEAD	FXTS
BAFFLE TYPE HORZ	SEGMENTL	CROSS PASSES PER SHELL PASS	4
SPACING, CENTRAL IN.	4.309	BAFFLE CUT, PCT SHELL I.D.	30.00
SPACING, INLET IN.	4.309	CUT DISTANCE FROM CENTER, IN.	.764
SPACING, OUTLET IN.	4.309		
BAFFLE THICKNESS IN.	.125	IMPINGEMENT BAFFLE INCLUDED	NO
PAIRS OF SEALING DEVICES	1	TUBESHEET BLANK AREA, %	.0
TUBE TYPE	PLAIN	MATERIAL	ELECTROLYTIC COPPER
NO. OF TUBES/SHELL	76	EST MAX TUBE COUNT	36

TUBE LGTH, OVERALL	FT	1.500	TUBE PITCH	IN.	.3125
TUBE LGTH, EFF	FT	1.436	TUBE OUTSIDE DIAM	IN.	.250
TUBE LAYOUT	DEG	60	TUBE INSIDE DIAM	IN.	.214
PITCH RATIO		1.250	TUBE SURFACE RATIO, OUT/IN		1.184
SHL NOZZ ID, IN&OUT	1.0	1.0	TUBE NOZZ ID, IN&OUT	IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.036	.000
PRANDTL NUMBER	7.6	4.0
RYNLD NO, AVG	272.	1558.
RYNLD NO, IN BUN	204.	2000.
RYNLD NO,OUT BUN	351.	1166.
FOULNG LAYER IN.	.0014	.0014

SHELLSIDE PERFORMANCE		
NOMINAL VEL,X-FLOW	FT/S	.10
NOMINAL VEL,WINDOW	FT/S	.20
CROSSFLOW COEF	BTU/HR-FT2-F	285.2
WINDOW COEF	BTU/HR-FT2-F	286.9

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
38.13	59.41	2.38	.08

PCT OVER DESIGN	-.04
TOT FOUL RESIST	.000217
DIFF RESIST	-.000004

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.58
TUBE TO BAFFLE LEAKAGE	A =	3.57
MAIN CROSSFLOW	B =	65.64
BUNDLE TO SHELL BYPASS	C =	15.22
BAFFLE TO SHELL LEAKAGE	E =	15.58
TUBE PASSLANE BYPASS	F =	.00

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.679
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.738
END (HT LOSS IN END ZONE)	=	.994

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.65	.66
DENSITY	LB/FT3	62.535	62.133
NOZZ RHO*VSQ	LB/FT-S2	26	26
BUND RHO*VSQ	LB/FT-S2	18	18

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	8.8
END ZONE	=	3.9
CROSS FLOW	=	3.4
INLET NOZZLE	=	43.0
OUTLET NOZZLE	=	40.8

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	.89	.88
DENSITY	LB/FT3	61.291	62.074
PRESS. DROP	%	8.1	5.1

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

*** SPECIAL MESSAGES AND WARNINGS ***

WARNING--TUBESIDE FLUID HAS PASSED THROUGH TRANSITION ZONE. CONSIDER
RERUNNING WITH ITEM 132 IN EFFECT.

CASE 48

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.600		.900	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	83.3*	40.0	77.6*
DENSITY	LB/FT3	61.2913	62.1011	62.5352	62.1676
VISCOSITY	CP	.4726	.8326	1.4791	.8910
SPECIFIC HEAT	BTU/LB-F	.9973	1.0001	1.0058	1.0006
THERMAL COND.	BTU/HR-FT-F	.3723	.3590	.3466	.3574
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	111.7	79.3	58.8	78.0
VISCOSITY, AVG & SKIN	CP	.6137	.8727	1.1317	.8868
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.07	10.00	.02	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.58	10.00	.14	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	218.17		306.55	

TOTAL HEAT DUTY REQUIRED	MEGBTU/HR	.033937
EFF TEMP DIF, DEGF (LMTD= 52.3,F= .85,BYPASS= .95,BAFF=1.00)		42.1
OVERALL COEFF REQUIRED	BTU/HR-FT2-F	112.89
CLEAN & FOULED COEFF	BTU/HR-FT2-F	115.96 / 112.66

SHELLS IN SERIES	1	PARALLEL	1
PASSES, SHELL	1	TUBE	4
SHELL DIAMETER IN.			3.820
TOTAL EFF AREA	FT2		7.1
EFFECTIVE AREA	FT2/SHELL		7.1
TEMA SHELL TYPE	E	; REAR HEAD	FXTS

BAFFLE TYPE	HORZ	SEGMENTL	
SPACING, CENTRAL	IN.		4.309
SPACING, INLET	IN.		4.309
SPACING, OUTLET	IN.		4.309
BAFFLE THICKNESS	IN.		.125
PAIRS OF SEALING DEVICES			1
CROSS PASSES PER SHELL PASS			4
BAFFLE CUT, PCT SHELL I.D.			30.00
CUT DISTANCE FROM CENTER, IN.			.764
IMPINGEMENT BAFFLE INCLUDED			NO
TUBESHEET BLANK AREA, %			.0

TUBE TYPE			PLAIN
NO. OF TUBES/SHELL			76
TUBE LGTH, OVERALL	FT		1.500
TUBE LGTH, EFF	FT		1.436
TUBE LAYOUT	DEG		60
PITCH RATIO			1.250
SHL NOZZ ID, IN&OUT	1.0	1.0	
MATERIAL			ELECTROLYTIC COPPER
EST MAX TUBE COUNT			36
TUBE PITCH	IN.		.3125
TUBE OUTSIDE DIAM	IN.		.250
TUBE INSIDE DIAM	IN.		.214
TUBE SURFACE RATIO, OUT/IN			1.184
TUBE NOZZ ID, IN&OUT	IN.	.8	.8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.035	.000
PRANDTL NUMBER	7.8	4.0
RYNLD NO, AVG	300.	1541.
RYNLD NO, IN BUN	229.	2000.
RYNLD NO,OUT BUN	381.	1136.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
36.34	61.14	2.44	.08

PCT OVER DESIGN	-.20
TOT FOUL RESIST	.000217
DIFF RESIST	-.000018

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.73	.74
DENSITY	LB/FT3	62.535	62.168
NOZZ RHO*VSQ	LB/FT-S2	33	33
BUND RHO*VSQ	LB/FT-S2	22	23

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	.89	.87
DENSITY	LB/FT3	61.291	62.101
PRESS. DROP	%	8.1	5.1

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW	FT/S	.12
NOMINAL VEL,WINDOW	FT/S	.23
CROSSFLOW COEF	BTU/HR-FT2-F	307.8
WINDOW COEF	BTU/HR-FT2-F	309.6

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.56
TUBE TO BAFFLE LEAKAGE	A =	3.69
MAIN CROSSFLOW	B =	65.38
BUNDLE TO SHELL BYPASS	C =	15.43
BAFFLE TO SHELL LEAKAGE	E =	15.50
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.695
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.756
END (HT LOSS IN END ZONE)	=	.994

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	8.8
END ZONE	=	3.7
CROSS FLOW	=	3.3
INLET NOZZLE	=	43.1
OUTLET NOZZLE	=	41.1

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

*** SPECIAL MESSAGES AND WARNINGS ***

WARNING--TUBESIDE FLUID HAS PASSED THROUGH TRANSITION ZONE. CONSIDER
RERUNNING WITH ITEM 132 IN EFFECT.

□□Washington University ChE433 heat exchanger experiment E0002 P 98
Young model F302DY4P 9/23/ 3
CASE 49

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE		COLD SHELL SIDE	
		Tube		Shell	
		SENSIBLE LIQ		SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.700		.200	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	117.0*	40.0	120.3*
DENSITY	LB/FT3	61.2913	61.6533	62.5352	61.6045
VISCOSITY	CP	.4726	.5825	1.4791	.5645
SPECIFIC HEAT	BTU/LB-F	.9973	.9977	1.0058	.9976

THERMAL COND.	BTU/HR-FT-F	.3723	.3673	.3466	.3681
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	128.5	109.1	80.1	108.2
VISCOSITY, AVG & SKIN	CP	.5230	.6298	.8643	.6353
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.09	10.00	.00	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.68	10.00	.03	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	234.24		135.35	

TOTAL HEAT DUTY REQUIRED	MEGBTU/HR	.016061
EFF TEMP DIF, DEGF (LMTD= 42.1,F= .76,BYPASS= .88,BAFF=1.00)		28.3
OVERALL COEFF REQUIRED	BTU/HR-FT2-F	79.54
CLEAN & FOULED COEFF	BTU/HR-FT2-F	80.76 / 79.47

SHELLS IN SERIES 1 PARALLEL 1		TOTAL EFF AREA FT2	7.1
PASSES, SHELL 1 TUBE 4		EFFECTIVE AREA FT2/SHELL	7.1
SHELL DIAMETER IN.	3.820	TEMA SHELL TYPE E ; REAR HEAD	FXTS
BAFFLE TYPE HORZ SEGMENTL		CROSS PASSES PER SHELL PASS	4
SPACING, CENTRAL IN.	4.309	BAFFLE CUT, PCT SHELL I.D.	30.00
SPACING, INLET IN.	4.309	CUT DISTANCE FROM CENTER, IN.	.764
SPACING, OUTLET IN.	4.309		
BAFFLE THICKNESS IN.	.125	IMPINGEMENT BAFFLE INCLUDED	NO
PAIRS OF SEALING DEVICES	1	TUBESHEET BLANK AREA, %	.0
TUBE TYPE	PLAIN	MATERIAL	ELECTROLYTIC COPPER
NO. OF TUBES/SHELL	76	EST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT	1.500	TUBE PITCH IN.	.3125
TUBE LGTH, EFF FT	1.436	TUBE OUTSIDE DIAM IN.	.250
TUBE LAYOUT DEG	60	TUBE INSIDE DIAM IN.	.214
PITCH RATIO	1.250	TUBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT	1.0 1.0	TUBE NOZZ ID, IN&OUT IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

□□Washington University ChE433 heat exchanger experiment E0002 P 99
Young model F302DY4P 9/23/ 3
CASE 49

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.044	.969
PRANDTL NUMBER	5.8	3.4
RYNLD NO, AVG	86.	2109.
RYNLD NO, IN BUN	50.	2334.
RYNLD NO,OUT BUN	131.	1894.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL
SHELL TUBE FOULING METAL

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW	FT/S	.03
NOMINAL VEL,WINDOW	FT/S	.05
CROSSFLOW COEF	BTU/HR-FT2-F	136.6
WINDOW COEF	BTU/HR-FT2-F	134.2

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		80.18
TUBE TO BAFFLE LEAKAGE	A =	2.58
MAIN CROSSFLOW	B =	68.71

58.06	40.16	1.72	.06
PCT OVER DESIGN			-.09
TOT FOUL RESIST			.000217
DIFF RESIST			-.000011

BUNDLE TO SHELL BYPASS	C = 10.95
BAFFLE TO SHELL LEAKAGE	E = 17.76
TUBE PASSLANE BYPASS	F = .00

DIAMETRAL CLEARANCES		
BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELLSIDE HEAT TRANSFER FACTORS	
TOTAL =(BETA)(GAMMA)(FIN)	= .598
BETA (BAFF CUT FACTOR)	= .920
GAMMA (TUBE ROW ENTRY EFCT)	= .650
END (HT LOSS IN END ZONE)	= .998

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.16	.17
DENSITY	LB/FT3	62.535	61.604
NOZZ RHO*VSQ	LB/FT-S2	1	1
BUND RHO*VSQ	LB/FT-S2	1	1

SHELL PRESSURE DROP, % OF TOTAL	
WINDOW	= 9.7
END ZONE	= 7.4
CROSS FLOW	= 5.7
INLET NOZZLE	= 41.1
OUTLET NOZZLE	= 36.2

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	1.03	1.03
DENSITY	LB/FT3	61.291	61.653
PRESS. DROP	%	8.7	5.5

WEIGHT PER SHELL, LB		
DRY	=	150.
WET	=	165.

*** SPECIAL MESSAGES AND WARNINGS ***

WARNING--TUBESIDE FLUID HAS PASSED THROUGH TRANSITION ZONE. CONSIDER
RERUNNING WITH ITEM 132 IN EFFECT.
HEAT TRANSFER COEFF. AT RE = 2000 IS 220.45 BTU/HR-FT2-F
HEAT TRANSFER COEFF. AT RE = 10000 IS 1233.15 BTU/HR-FT2-F

□□Washington University ChE433 heat exchanger experiment E0002 P100
Young model F302DY4P 9/23/ 3
CASE 50

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.700		.300	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	109.7*	40.0	110.5*
DENSITY	LB/FT3	61.2913	61.7589	62.5352	61.7471
VISCOSITY	CP	.4726	.6260	1.4791	.6208
SPECIFIC HEAT	BTU/LB-F	.9973	.9981	1.0058	.9980
THERMAL COND.	BTU/HR-FT-F	.3723	.3656	.3466	.3658
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	124.8	102.4	75.3	101.5
VISCOSITY, AVG & SKIN	CP	.5409	.6742	.9166	.6810
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.09	10.00	.00	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.68	10.00	.05	10.00

FOULING RESISTANCE	HR-FT2-F/BTU	.00010	.00010
FILM COEFFICIENT	BTU/HR-FT2-F	226.69	161.71

TOTAL HEAT DUTY REQUIRED MEGBTU/HR	.021171
EFF TEMP DIF, DEGF (LMTD= 46.7,F= .80,BYPASS= .92,BAFF=1.00)	34.2
OVERALL COEFF REQUIRED BTU/HR-FT2-F	86.52
CLEAN & FOULED COEFF BTU/HR-FT2-F 88.15	86.50

SHELLS IN SERIES	1	PARALLEL	1
PASSES, SHELL	1	TUBE	4
SHELL DIAMETER IN.			3.820

TOTAL EFF AREA FT2	7.1
EFFECTIVE AREA FT2/SHELL	7.1
TEMA SHELL TYPE E ; REAR HEAD	FXTS

BAFFLE TYPE HORZ SEGMENTL	
SPACING, CENTRAL IN.	4.309
SPACING, INLET IN.	4.309
SPACING, OUTLET IN.	4.309
BAFFLE THICKNESS IN.	.125
PAIRS OF SEALING DEVICES	1

CROSS PASSES PER SHELL PASS	4
BAFFLE CUT, PCT SHELL I.D.	30.00
CUT DISTANCE FROM CENTER, IN.	.764
IMPINGEMENT BAFFLE INCLUDED	NO
TUBESHEET BLANK AREA, %	.0

TUBE TYPE			PLAIN
NO. OF TUBES/SHELL			76
TUBE LGTH, OVERALL	FT		1.500
TUBE LGTH, EFF	FT		1.436
TUBE LAYOUT	DEG		60
PITCH RATIO			1.250
SHL NOZZ ID, IN&OUT	1.0	1.0	

MATERIAL			ELECTROLYTIC COPPER
EST MAX TUBE COUNT			36
TUBE PITCH	IN.		.3125
TUBE OUTSIDE DIAM	IN.		.250
TUBE INSIDE DIAM	IN.		.214
TUBE SURFACE RATIO, OUT/IN			1.184
TUBE NOZZ ID, IN&OUT	IN.	.8	.8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

□□Washington University ChE433 heat exchanger experiment E0002 P101

Young model F302DY4P 9/23/ 3

CASE 50

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.042	.964
PRANDTL NUMBER	6.2	3.5
RYNLD NO, AVG	123.	2039.
RYNLD NO, IN BUN	76.	2334.
RYNLD NO,OUT BUN	182.	1762.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
52.89	45.17	1.88	.06

PCT OVER DESIGN	-.03
TOT FOUL RESIST	.000217
DIFF RESIST	-.000004

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW	FT/S	.04
NOMINAL VEL,WINDOW	FT/S	.08
CROSSFLOW COEF	BTU/HR-FT2-F	162.4
WINDOW COEF	BTU/HR-FT2-F	163.2

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.33
TUBE TO BAFFLE LEAKAGE	A =	2.72
MAIN CROSSFLOW	B =	69.43
BUNDLE TO SHELL BYPASS	C =	11.35
BAFFLE TO SHELL LEAKAGE	E =	16.51
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.601
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.653
END (HT LOSS IN END ZONE)	=	.994

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.24	.25
DENSITY	LB/FT3	62.535	61.747
NOZZ RHO*VSQ	LB/FT-S2	3	3
BUND RHO*VSQ	LB/FT-S2	2	2

SHELL PRESSURE DROP, % OF TOTAL		
WINDOW	=	9.2
END ZONE	=	5.7
CROSS FLOW	=	4.7
INLET NOZZLE	=	42.3
OUTLET NOZZLE	=	38.1

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	1.03	1.03
DENSITY	LB/FT3	61.291	61.759
PRESS. DROP	%	8.6	5.4

WEIGHT PER SHELL, LB		
DRY	=	150.
WET	=	165.

*** SPECIAL MESSAGES AND WARNINGS ***

WARNING--TUBESIDE FLUID HAS PASSED THROUGH TRANSITION ZONE. CONSIDER
RERUNNING WITH ITEM 132 IN EFFECT.
HEAT TRANSFER COEFF. AT RE = 2000 IS 221.66 BTU/HR-FT2-F
HEAT TRANSFER COEFF. AT RE = 10000 IS 1241.91 BTU/HR-FT2-F

□□Washington University ChE433 heat exchanger experiment E0002 P102
Young model F302DY4P 9/23/ 3
CASE 51

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.700		.400	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	104.1*	40.0	102.5*
DENSITY	LB/FT3	61.2913	61.8356	62.5352	61.8580
VISCOSITY	CP	.4726	.6623	1.4791	.6738
SPECIFIC HEAT	BTU/LB-F	.9973	.9984	1.0058	.9985
THERMAL COND.	BTU/HR-FT-F	.3723	.3643	.3466	.3639
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	122.1	96.9	71.3	95.9
VISCOSITY, AVG & SKIN	CP	.5550	.7148	.9631	.7230
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.09	10.00	.00	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.68	10.00	.06	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	222.46		189.60	
TOTAL HEAT DUTY REQUIRED	MEGBTU/HR				.025034
EFF TEMP DIF, DEGF (LMTD= 49.6,F= .82,BYPASS= .93,BAFF=1.00)					37.8
OVERALL COEFF REQUIRED	BTU/HR-FT2-F				92.61
CLEAN & FOULED COEFF	BTU/HR-FT2-F		94.94		92.93

SHELLS IN SERIES	1	PARALLEL 1	TOTAL EFF AREA FT2	7.1
PASSES, SHELL	1	TUBE 4	EFFECTIVE AREA FT2/SHELL	7.1
SHELL DIAMETER IN.		3.820	TEMA SHELL TYPE E ; REAR HEAD	FXTS

BAFFLE TYPE	HORZ	SEGMENTL	CROSS PASSES PER SHELL PASS	4
SPACING, CENTRAL IN.		4.309	BAFFLE CUT, PCT SHELL I.D.	30.00
SPACING, INLET IN.		4.309	CUT DISTANCE FROM CENTER, IN.	.764
SPACING, OUTLET IN.		4.309		
BAFFLE THICKNESS IN.		.125	IMPINGEMENT BAFFLE INCLUDED	NO
PAIRS OF SEALING DEVICES		1	TUBESHEET BLANK AREA, %	.0

TUBE TYPE	PLAIN		MATERIAL	ELECTROLYTIC COPPER
NO. OF TUBES/SHELL	76		EST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT	1.500		TUBE PITCH IN.	.3125
TUBE LGTH, EFF FT	1.436		TUBE OUTSIDE DIAM IN.	.250
TUBE LAYOUT DEG	60		TUBE INSIDE DIAM IN.	.214
PITCH RATIO	1.250		TUBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT	1.0 1.0		TUBE NOZZ ID, IN&OUT IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

□□Washington University ChE433 heat exchanger experiment E0002 P103
Young model F302DY4P 9/23/ 3
CASE 51

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.041	.000
PRANDTL NUMBER	6.6	3.6
RYNLD NO, AVG	156.	1987.
RYNLD NO, IN BUN	102.	2334.
RYNLD NO,OUT BUN	223.	1665.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
48.46	49.45	2.01	.07

PCT OVER DESIGN	.34
TOT FOUL RESIST	.000217
DIFF RESIST	.000037

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.33	.33
DENSITY	LB/FT3	62.535	61.858
NOZZ RHO*VSQ	LB/FT-S2	6	6
BUND RHO*VSQ	LB/FT-S2	4	4

SHELLSIDE PERFORMANCE		
NOMINAL VEL,X-FLOW	FT/S	.05
NOMINAL VEL,WINDOW	FT/S	.10
CROSSFLOW COEF	BTU/HR-FT2-F	190.4
WINDOW COEF	BTU/HR-FT2-F	191.5

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.43
TUBE TO BAFFLE LEAKAGE	A =	2.95
MAIN CROSSFLOW	B =	68.43
BUNDLE TO SHELL BYPASS	C =	12.40
BAFFLE TO SHELL LEAKAGE	E =	16.22
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.618
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.672
END (HT LOSS IN END ZONE)	=	.994

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	9.0
END ZONE	=	5.1
CROSS FLOW	=	4.3
INLET NOZZLE	=	42.6
OUTLET NOZZLE	=	39.0

TUBE NOZZLE DATA		IN	OUT	WEIGHT PER SHELL, LB		
VELOCITY	FT/S	1.03	1.02	DRY	=	150.
DENSITY	LB/FT3	61.291	61.836	WET	=	165.
PRESS. DROP	%	8.5	5.4			

*** SPECIAL MESSAGES AND WARNINGS ***

WARNING--TUBESIDE FLUID HAS PASSED THROUGH TRANSITION ZONE. CONSIDER RERUNNING WITH ITEM 132 IN EFFECT.

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.700		.500	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	99.7*	40.0	96.3*
DENSITY	LB/FT3	61.2913	61.8960	62.5352	61.9407
VISCOSITY	CP	.4726	.6943	1.4791	.7201
SPECIFIC HEAT	BTU/LB-F	.9973	.9987	1.0058	.9989
THERMAL COND.	BTU/HR-FT-F	.3723	.3632	.3466	.3623
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	119.8	92.7	68.1	91.5
VISCOSITY, AVG & SKIN	CP	.5669	.7488	1.0018	.7583
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.09	10.00	.01	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.68	10.00	.08	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	222.50		215.49	

TOTAL HEAT DUTY REQUIRED	MEGBTU/HR	.028174
EFF TEMP DIF, DEGF	(LMTD= 51.3,F= .83,BYPASS= .94,BAFF=1.00)	40.0
OVERALL COEFF REQUIRED	BTU/HR-FT2-F	98.58
CLEAN & FOULED COEFF	BTU/HR-FT2-F 101.03	98.68

SHELLS IN SERIES	1	PARALLEL	1
PASSES, SHELL	1	TUBE	4
SHELL DIAMETER IN.			3.820
TOTAL EFF AREA	FT2		7.1
EFFECTIVE AREA	FT2/SHELL		7.1
TEMA SHELL TYPE	E	; REAR HEAD	FXTS

BAFFLE TYPE	HORZ	SEGMENTL	
SPACING, CENTRAL	IN.		4.309
SPACING, INLET	IN.		4.309
SPACING, OUTLET	IN.		4.309
BAFFLE THICKNESS	IN.		.125
PAIRS OF SEALING DEVICES			1
CROSS PASSES PER SHELL PASS			4
BAFFLE CUT, PCT SHELL I.D.			30.00
CUT DISTANCE FROM CENTER, IN.			.764
IMPINGEMENT BAFFLE INCLUDED			NO
TUBESHEET BLANK AREA, %			.0

TUBE TYPE		PLAIN	MATERIAL		ELECTROLYTIC COPPER
NO. OF TUBES/SHELL		76	EST MAX TUBE COUNT		36
TUBE LGTH, OVERALL	FT	1.500	TUBE PITCH	IN.	.3125
TUBE LGTH, EFF	FT	1.436	TUBE OUTSIDE DIAM	IN.	.250
TUBE LAYOUT	DEG	60	TUBE INSIDE DIAM	IN.	.214
PITCH RATIO		1.250	TUBE SURFACE RATIO, OUT/IN		1.184
SHL NOZZ ID, IN&OUT	1.0	1.0	TUBE NOZZ ID, IN&OUT	IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

Washington University ChE433 heat exchanger experiment E0002 P105
Young model F302DY4P 9/23/ 3
CASE 52

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.040	.000
PRANDTL NUMBER	6.8	3.7
RYNLD NO, AVG	188.	1946.
RYNLD NO, IN BUN	127.	2334.
RYNLD NO,OUT BUN	262.	1589.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
45.28	52.51	2.14	.07

PCT OVER DESIGN	.10
TOT FOUL RESIST	.000217
DIFF RESIST	.000011

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.41	.41
DENSITY	LB/FT3	62.535	61.941
NOZZ RHO*VSQ	LB/FT-S2	10	10
BUND RHO*VSQ	LB/FT-S2	7	7

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	1.03	1.02
DENSITY	LB/FT3	61.291	61.896
PRESS. DROP	%	8.4	5.3

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW	FT/S	.07
NOMINAL VEL,WINDOW	FT/S	.13
CROSSFLOW COEF	BTU/HR-FT2-F	216.3
WINDOW COEF	BTU/HR-FT2-F	217.7

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.52
TUBE TO BAFFLE LEAKAGE	A =	3.14
MAIN CROSSFLOW	B =	67.61
BUNDLE TO SHELL BYPASS	C =	13.27
BAFFLE TO SHELL LEAKAGE	E =	15.98
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.635
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.690
END (HT LOSS IN END ZONE)	=	.994

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	8.9
END ZONE	=	4.7
CROSS FLOW	=	4.0
INLET NOZZLE	=	42.8
OUTLET NOZZLE	=	39.6

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

*** SPECIAL MESSAGES AND WARNINGS ***

WARNING--TUBESIDE FLUID HAS PASSED THROUGH TRANSITION ZONE. CONSIDER
RERUNNING WITH ITEM 132 IN EFFECT.

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.700		.600	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	95.9*	40.0	91.2*
DENSITY	LB/FT3	61.2913	61.9446	62.5352	62.0054
VISCOSITY	CP	.4726	.7225	1.4791	.7614
SPECIFIC HEAT	BTU/LB-F	.9973	.9990	1.0058	.9993
THERMAL COND.	BTU/HR-FT-F	.3723	.3622	.3466	.3610
MOLAR MASS	LB/LBMOL	18.02		18.02	
TEMP, AVG & SKIN	DEGF	118.0	89.1	65.6	87.9
VISCOSITY, AVG & SKIN	CP	.5770	.7790	1.0349	.7898
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.09	10.00	.01	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.68	10.00	.09	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	222.44		240.03	

TOTAL HEAT DUTY REQUIRED	MEGBTU/HR		.030766
EFF TEMP DIF, DEGF (LMTD= 52.3,F= .84,BYPASS= .94,BAFF=1.00)			41.5
OVERALL COEFF REQUIRED	BTU/HR-FT2-F		103.84
CLEAN & FOULED COEFF	BTU/HR-FT2-F	106.10	103.46

SHELLS IN SERIES	1	PARALLEL	1
PASSES, SHELL	1	TUBE	4
SHELL DIAMETER IN.			3.820
TOTAL EFF AREA	FT2		7.1
EFFECTIVE AREA	FT2/SHELL		7.1
TEMA SHELL TYPE	E	; REAR HEAD	FXTS

BAFFLE TYPE	HORZ	SEGMENTL	
SPACING, CENTRAL	IN.		4.309
SPACING, INLET	IN.		4.309
SPACING, OUTLET	IN.		4.309
BAFFLE THICKNESS	IN.		.125
PAIRS OF SEALING DEVICES			1
CROSS PASSES PER SHELL PASS			4
BAFFLE CUT, PCT SHELL I.D.			30.00
CUT DISTANCE FROM CENTER, IN.			.764
IMPINGEMENT BAFFLE INCLUDED			NO
TUBESHEET BLANK AREA, %			.0

TUBE TYPE			PLAIN
NO. OF TUBES/SHELL			76
TUBE LGTH, OVERALL	FT		1.500
TUBE LGTH, EFF	FT		1.436
TUBE LAYOUT	DEG		60
PITCH RATIO			1.250
SHL NOZZ ID, IN&OUT	1.0	1.0	
MATERIAL			ELECTROLYTIC COPPER
EST MAX TUBE COUNT			36
TUBE PITCH	IN.		.3125
TUBE OUTSIDE DIAM	IN.		.250
TUBE INSIDE DIAM	IN.		.214
TUBE SURFACE RATIO, OUT/IN			1.184
TUBE NOZZ ID, IN&OUT	IN.	.8	.8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

CASE 53

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.039	.000
PRANDTL NUMBER	7.1	3.8
RYNLD NO, AVG	219.	1912.
RYNLD NO, IN BUN	153.	2334.
RYNLD NO,OUT BUN	297.	1527.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
42.62	55.06	2.24	.07

PCT OVER DESIGN	-.37
TOT FOUL RESIST	.000217
DIFF RESIST	-.000036

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.49	.49
DENSITY	LB/FT3	62.535	62.005
NOZZ RHO*VSQ	LB/FT-S2	14	15
BUND RHO*VSQ	LB/FT-S2	10	10

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	1.03	1.02
DENSITY	LB/FT3	61.291	61.945
PRESS. DROP	%	8.4	5.3

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW	FT/S	.08
NOMINAL VEL,WINDOW	FT/S	.15
CROSSFLOW COEF	BTU/HR-FT2-F	241.0
WINDOW COEF	BTU/HR-FT2-F	242.5

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.58
TUBE TO BAFFLE LEAKAGE	A =	3.30
MAIN CROSSFLOW	B =	66.89
BUNDLE TO SHELL BYPASS	C =	14.02
BAFFLE TO SHELL LEAKAGE	E =	15.78
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.651
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.708
END (HT LOSS IN END ZONE)	=	.994

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	8.8
END ZONE	=	4.4
CROSS FLOW	=	3.8
INLET NOZZLE	=	42.9
OUTLET NOZZLE	=	40.1

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

*** SPECIAL MESSAGES AND WARNINGS ***

WARNING--TUBESIDE FLUID HAS PASSED THROUGH TRANSITION ZONE. CONSIDER
RERUNNING WITH ITEM 132 IN EFFECT.

CASE 54

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.700		.700	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	92.9*	40.0	86.9*
DENSITY	LB/FT3	61.2913	61.9835	62.5352	62.0584

VISCOSITY	CP	.4726	.7469	1.4791	.7992
SPECIFIC HEAT	BTU/LB-F	.9973	.9992	1.0058	.9997
THERMAL COND.	BTU/HR-FT-F	.3723	.3615	.3466	.3599
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	116.5	86.1	63.4	84.8
VISCOSITY, AVG & SKIN	CP	.5855	.8063	1.0642	.8183
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.09	10.00	.01	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.68	10.00	.11	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	222.38		263.46	

TOTAL HEAT DUTY REQUIRED MEGBTU/HR			.032889
EFF TEMP DIF, DEGF (LMTD= 53.0,F= .85,BYPASS= .94,BAFF=1.00)			42.6
OVERALL COEFF REQUIRED	BTU/HR-FT2-F		108.00
CLEAN & FOULED COEFF	BTU/HR-FT2-F	110.42	107.52

SHELLS IN SERIES	1	PARALLEL 1	
PASSES, SHELL	1	TUBE 4	
SHELL DIAMETER IN.		3.820	
TOTAL EFF AREA	FT2		7.1
EFFECTIVE AREA	FT2/SHELL		7.1
TEMA SHELL TYPE	E	; REAR HEAD	FXTS
BAFFLE TYPE	HORZ	SEGMENTL	
SPACING, CENTRAL	IN.	4.309	
SPACING, INLET	IN.	4.309	
SPACING, OUTLET	IN.	4.309	
BAFFLE THICKNESS	IN.	.125	
PAIRS OF SEALING DEVICES		1	
CROSS PASSES PER SHELL PASS			4
BAFFLE CUT, PCT SHELL I.D.			30.00
CUT DISTANCE FROM CENTER, IN.			.764
IMPINGEMENT BAFFLE INCLUDED			NO
TUBESHEET BLANK AREA, %			.0

TUBE TYPE		PLAIN	MATERIAL		ELECTROLYTIC COPPER
NO. OF TUBES/SHELL		76	EST MAX TUBE COUNT		36
TUBE LGTH, OVERALL	FT	1.500	TUBE PITCH	IN.	.3125
TUBE LGTH, EFF	FT	1.436	TUBE OUTSIDE DIAM	IN.	.250
TUBE LAYOUT	DEG	60	TUBE INSIDE DIAM	IN.	.214
PITCH RATIO		1.250	TUBE SURFACE RATIO, OUT/IN		1.184
SHL NOZZ ID, IN&OUT	1.0	1.0	TUBE NOZZ ID, IN&OUT	IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.037	.000
PRANDTL NUMBER	7.3	3.9
RYNLD NO, AVG	248.	1884.
RYNLD NO, IN BUN	178.	2334.
RYNLD NO,OUT BUN	330.	1477.
FOULNG LAYER IN.	.0014	.0014

SHELLSIDE PERFORMANCE		
NOMINAL VEL,X-FLOW	FT/S	.09
NOMINAL VEL,WINDOW	FT/S	.18
CROSSFLOW COEF	BTU/HR-FT2-F	264.5
WINDOW COEF	BTU/HR-FT2-F	266.1
SHELLSIDE FLOW, % OF TOTAL		
HEAT TRANSFER X-FLOW		81.58

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
40.35	57.24	2.33	.08

PCT OVER DESIGN	-.45
TOT FOUL RESIST	.000217
DIFF RESIST	-.000041

TUBE TO BAFFLE LEAKAGE	A =	3.45
MAIN CROSSFLOW	B =	66.18
BUNDLE TO SHELL BYPASS	C =	14.70
BAFFLE TO SHELL LEAKAGE	E =	15.67
TUBE PASSLANE BYPASS	F =	.00

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.667
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.725
END (HT LOSS IN END ZONE)	=	.994

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.57	.57
DENSITY	LB/FT3	62.535	62.058
NOZZ RHO*VSQ	LB/FT-S2	20	20
BUND RHO*VSQ	LB/FT-S2	13	13

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	8.8
END ZONE	=	4.1
CROSS FLOW	=	3.6
INLET NOZZLE	=	43.0
OUTLET NOZZLE	=	40.5

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	1.03	1.02
DENSITY	LB/FT3	61.291	61.983
PRESS. DROP	%	8.3	5.2

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

*** SPECIAL MESSAGES AND WARNINGS ***

WARNING--TUBESIDE FLUID HAS PASSED THROUGH TRANSITION ZONE. CONSIDER RERUNNING WITH ITEM 132 IN EFFECT.

□□Washington University ChE433 heat exchanger experiment E0002 P110
Young model F302DY4P 9/23/ 3
CASE 55

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.700		.800	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	90.4*	40.0	83.2*
DENSITY	LB/FT3	61.2913	62.0146	62.5352	62.1030
VISCOSITY	CP	.4726	.7677	1.4791	.8341
SPECIFIC HEAT	BTU/LB-F	.9973	.9994	1.0058	1.0001
THERMAL COND.	BTU/HR-FT-F	.3723	.3608	.3466	.3589
MOLAR MASS	LB/LBMOL	18.02		18.02	
TEMP, AVG & SKIN	DEGF	115.2	83.5	61.6	82.2
VISCOSITY, AVG & SKIN	CP	.5926	.8311	1.0905	.8442
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.09	10.00	.01	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.68	10.00	.12	10.00

FOULING RESISTANCE	HR-FT2-F/BTU	.00010	.00010
FILM COEFFICIENT	BTU/HR-FT2-F	222.34	286.30

TOTAL HEAT DUTY REQUIRED MEGBTU/HR	.034620
EFF TEMP DIF, DEGF (LMTD= 53.6,F= .86,BYPASS= .95,BAFF=1.00)	43.5
OVERALL COEFF REQUIRED BTU/HR-FT2-F	111.28
CLEAN & FOULED COEFF BTU/HR-FT2-F 114.23	111.08

SHELLS IN SERIES	1	PARALLEL	1
PASSES, SHELL	1	TUBE	4
SHELL DIAMETER IN.	3.820		
TOTAL EFF AREA	FT2		7.1
EFFECTIVE AREA	FT2/SHELL		7.1
TEMA SHELL TYPE	E	; REAR HEAD	FXTS
BAFFLE TYPE	HORZ	SEGMENTL	
SPACING, CENTRAL	IN.	4.309	
SPACING, INLET	IN.	4.309	
SPACING, OUTLET	IN.	4.309	
BAFFLE THICKNESS	IN.	.125	
PAIRS OF SEALING DEVICES		1	
CROSS PASSES PER SHELL PASS			4
BAFFLE CUT, PCT SHELL I.D.			30.00
CUT DISTANCE FROM CENTER, IN.			.764
IMPINGEMENT BAFFLE INCLUDED			NO
TUBESHEET BLANK AREA, %			.0

TUBE TYPE	PLAIN	MATERIAL	ELECTROLYTIC COPPER
NO. OF TUBES/SHELL	76	EST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT	1.500	TUBE PITCH IN.	.3125
TUBE LGTH, EFF FT	1.436	TUBE OUTSIDE DIAM IN.	.250
TUBE LAYOUT DEG	60	TUBE INSIDE DIAM IN.	.214
PITCH RATIO	1.250	TUBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT	1.0 1.0	TUBE NOZZ ID, IN&OUT IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

□□Washington University ChE433 heat exchanger experiment E0002 P111

Young model F302DY4P 9/23/ 3

CASE 55

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.036	.000
PRANDTL NUMBER	7.5	3.9
RYNLD NO, AVG	277.	1861.
RYNLD NO, IN BUN	204.	2334.
RYNLD NO,OUT BUN	361.	1437.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
38.36	59.15	2.41	.08

PCT OVER DESIGN	-.18
TOT FOUL RESIST	.000217
DIFF RESIST	-.000016

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW	FT/S	.10
NOMINAL VEL,WINDOW	FT/S	.20
CROSSFLOW COEF	BTU/HR-FT2-F	287.5
WINDOW COEF	BTU/HR-FT2-F	289.1

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.58
TUBE TO BAFFLE LEAKAGE	A =	3.59
MAIN CROSSFLOW	B =	65.62
BUNDLE TO SHELL BYPASS	C =	15.24
BAFFLE TO SHELL LEAKAGE	E =	15.56
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.682
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.741
END (HT LOSS IN END ZONE)	=	.994

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.65	.66
DENSITY	LB/FT3	62.535	62.103
NOZZ RHO*VSQ	LB/FT-S2	26	26
BUND RHO*VSQ	LB/FT-S2	18	18

SHELL PRESSURE DROP, % OF TOTAL		
WINDOW	=	8.8
END ZONE	=	3.9
CROSS FLOW	=	3.4
INLET NOZZLE	=	43.1
OUTLET NOZZLE	=	40.8

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	1.03	1.02
DENSITY	LB/FT3	61.291	62.015
PRESS. DROP	%	8.3	5.2

WEIGHT PER SHELL, LB		
DRY	=	150.
WET	=	165.

*** SPECIAL MESSAGES AND WARNINGS ***

WARNING--TUBESIDE FLUID HAS PASSED THROUGH TRANSITION ZONE. CONSIDER RERUNNING WITH ITEM 132 IN EFFECT.

□□Washington University ChE433 heat exchanger experiment E0002 P112
Young model F302DY4P 9/23/ 3
CASE 56

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.700		.900	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	88.3*	40.0	80.0*
DENSITY	LB/FT3	61.2913	62.0414	62.5352	62.1396
VISCOSITY	CP	.4726	.7866	1.4791	.8654
SPECIFIC HEAT	BTU/LB-F	.9973	.9996	1.0058	1.0004
THERMAL COND.	BTU/HR-FT-F	.3723	.3603	.3466	.3581
MOLAR MASS	LB/LBMOL	18.02		18.02	
TEMP, AVG & SKIN	DEGF	114.1	81.2	60.0	79.8
VISCOSITY, AVG & SKIN	CP	.5989	.8538	1.1134	.8680
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.09	10.00	.02	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.68	10.00	.14	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	222.26		309.08	

TOTAL HEAT DUTY REQUIRED	MEGBTU/HR	.036135
EFF TEMP DIF, DEGF (LMTD= 53.9,F= .87,BYPASS= .95,BAFF=1.00)		44.2
OVERALL COEFF REQUIRED	BTU/HR-FT2-F	114.45
CLEAN & FOULED COEFF	BTU/HR-FT2-F	117.66 / 114.29

SHELLS IN SERIES	1	PARALLEL 1	TOTAL EFF AREA	FT2	7.1
PASSES, SHELL	1	TUBE 4	EFFECTIVE AREA	FT2/SHELL	7.1

SHELL DIAMETER IN.	3.820	TEMA SHELL TYPE E ; REAR HEAD	FXTS
BAFFLE TYPE	HORZ SEGMENTL	CROSS PASSES PER SHELL PASS	4
SPACING, CENTRAL IN.	4.309	BAFFLE CUT, PCT SHELL I.D.	30.00
SPACING, INLET IN.	4.309	CUT DISTANCE FROM CENTER, IN.	.764
SPACING, OUTLET IN.	4.309		
BAFFLE THICKNESS IN.	.125	IMPINGEMENT BAFFLE INCLUDED	NO
PAIRS OF SEALING DEVICES	1	TUBESHEET BLANK AREA, %	.0
TUBE TYPE	PLAIN	MATERIAL	ELECTROLYTIC COPPER
NO. OF TUBES/SHELL	76	EST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT	1.500	TUBE PITCH IN.	.3125
TUBE LGTH, EFF FT	1.436	TUBE OUTSIDE DIAM IN.	.250
TUBE LAYOUT DEG	60	TUBE INSIDE DIAM IN.	.214
PITCH RATIO	1.250	TUBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT	1.0 1.0	TUBE NOZZ ID, IN&OUT IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

□□Washington University ChE433 heat exchanger experiment E0002 P113

Young model F302DY4P 9/23/ 3

CASE 56

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.035	.000
PRANDTL NUMBER	7.7	3.9
RYNLD NO, AVG	305.	1842.
RYNLD NO, IN BUN	229.	2334.
RYNLD NO,OUT BUN	392.	1402.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
36.56	60.88	2.48	.08

PCT OVER DESIGN	-.14
TOT FOUL RESIST	.000217
DIFF RESIST	-.000012

SHELLSIDE PERFORMANCE		
NOMINAL VEL,X-FLOW FT/S		.12
NOMINAL VEL,WINDOW FT/S		.23
CROSSFLOW COEF BTU/HR-FT2-F		310.4
WINDOW COEF BTU/HR-FT2-F		312.1

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.56
TUBE TO BAFFLE LEAKAGE	A =	3.71
MAIN CROSSFLOW	B =	65.36
BUNDLE TO SHELL BYPASS	C =	15.45
BAFFLE TO SHELL LEAKAGE	E =	15.48
TUBE PASSLANE BYPASS	F =	.00

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.698
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.759
END (HT LOSS IN END ZONE)	=	.994

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.73	.74
DENSITY	LB/FT3	62.535	62.140
NOZZ RHO*VSQ	LB/FT-S2	33	33
BUND RHO*VSQ	LB/FT-S2	22	23

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	8.8
END ZONE	=	3.7
CROSS FLOW	=	3.3
INLET NOZZLE	=	43.1
OUTLET NOZZLE	=	41.1

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	1.03	1.02

WEIGHT PER SHELL, LB

DRY	=	150.

DENSITY LB/FT3 61.291 62.041 WET = 165.
PRESS. DROP % 8.3 5.2

*** SPECIAL MESSAGES AND WARNINGS ***

WARNING--TUBESIDE FLUID HAS PASSED THROUGH TRANSITION ZONE. CONSIDER
RERUNNING WITH ITEM 132 IN EFFECT.

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.800		.200	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	119.4*	40.0	122.3*
DENSITY	LB/FT3	61.2913	61.6182	62.5352	61.5735
VISCOSITY	CP	.4726	.5694	1.4791	.5537
SPECIFIC HEAT	BTU/LB-F	.9973	.9976	1.0058	.9975
THERMAL COND.	BTU/HR-FT-F	.3723	.3679	.3466	.3685
MOLAR MASS	LB/LBMOL	18.02		18.02	
TEMP, AVG & SKIN	DEGF	129.7	112.0	81.2	111.1
VISCOSITY, AVG & SKIN	CP	.5175	.6119	.8539	.6175
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.12	10.00	.00	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.78	10.00	.03	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	274.53		135.82	

TOTAL HEAT DUTY REQUIRED MEGBTU/HR .016469
EFF TEMP DIF, DEGF (LMTD= 41.1,F= .76,BYPASS= .87,BAFF=1.00) 27.2
OVERALL COEFF REQUIRED BTU/HR-FT2-F 84.71
CLEAN & FOULED COEFF BTU/HR-FT2-F 86.02 84.63

SHELLS IN SERIES 1 PARALLEL 1 TOTAL EFF AREA FT2 7.1
PASSES, SHELL 1 TUBE 4 EFFECTIVE AREA FT2/SHELL 7.1
SHELL DIAMETER IN. 3.820 TEMA SHELL TYPE E ; REAR HEAD FXTS

BAFFLE TYPE HORZ SEGMENTL CROSS PASSES PER SHELL PASS 4
SPACING, CENTRAL IN. 4.309 BAFFLE CUT, PCT SHELL I.D. 30.00
SPACING, INLET IN. 4.309 CUT DISTANCE FROM CENTER, IN. .764
SPACING, OUTLET IN. 4.309
BAFFLE THICKNESS IN. .125 IMPINGEMENT BAFFLE INCLUDED NO
PAIRS OF SEALING DEVICES 1 TUBESHEET BLANK AREA, % .0

TUBE TYPE PLAIN MATERIAL ELECTROLYTIC COPPER
NO. OF TUBES/SHELL 76 EST MAX TUBE COUNT 36

TUBE LGTH, OVERALL	FT	1.500	TUBE PITCH	IN.	.3125
TUBE LGTH, EFF	FT	1.436	TUBE OUTSIDE DIAM	IN.	.250
TUBE LAYOUT	DEG	60	TUBE INSIDE DIAM	IN.	.214
PITCH RATIO		1.250	TUBE SURFACE RATIO, OUT/IN		1.184
SHL NOZZ ID, IN&OUT	1.0	1.0	TUBE NOZZ ID, IN&OUT	IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.046	.972
PRANDTL NUMBER	5.8	3.4
RYNLD NO, AVG	87.	2436.
RYNLD NO, IN BUN	50.	2667.
RYNLD NO,OUT BUN	134.	2214.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
61.61	36.49	1.83	.06

PCT OVER DESIGN	-.09
TOT FOUL RESIST	.000217
DIFF RESIST	-.000011

DIAMETRAL CLEARANCES		
BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.16	.17
DENSITY	LB/FT3	62.535	61.573
NOZZ RHO*VSQ	LB/FT-S2	1	1
BUND RHO*VSQ	LB/FT-S2	1	1

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	1.18	1.18
DENSITY	LB/FT3	61.291	61.618
PRESS. DROP	%	8.8	5.6

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW	FT/S	.03
NOMINAL VEL,WINDOW	FT/S	.05
CROSSFLOW COEF	BTU/HR-FT2-F	137.0
WINDOW COEF	BTU/HR-FT2-F	134.8

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		80.26
TUBE TO BAFFLE LEAKAGE	A =	2.59
MAIN CROSSFLOW	B =	68.82
BUNDLE TO SHELL BYPASS	C =	10.92
BAFFLE TO SHELL LEAKAGE	E =	17.68
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.598
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.650
END (HT LOSS IN END ZONE)	=	.998

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	9.7
END ZONE	=	7.3
CROSS FLOW	=	5.6
INLET NOZZLE	=	41.2
OUTLET NOZZLE	=	36.2

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

*** SPECIAL MESSAGES AND WARNINGS ***

WARNING--TUBESIDE FLUID HAS PASSED THROUGH TRANSITION ZONE. CONSIDER
RERUNNING WITH ITEM 132 IN EFFECT.
HEAT TRANSFER COEFF. AT RE = 2000 IS 219.34 BTU/HR-FT2-F
HEAT TRANSFER COEFF. AT RE = 10000 IS 1231.85 BTU/HR-FT2-F

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.800		.300	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	112.4*	40.0	113.4*
DENSITY	LB/FT3	61.2913	61.7206	62.5352	61.7052
VISCOSITY	CP	.4726	.6094	1.4791	.6030
SPECIFIC HEAT	BTU/LB-F	.9973	.9979	1.0058	.9979
THERMAL COND.	BTU/HR-FT-F	.3723	.3662	.3466	.3665
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	126.2	105.7	76.7	104.7
VISCOSITY, AVG & SKIN	CP	.5342	.6517	.9005	.6587
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.12	10.00	.00	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.78	10.00	.05	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	266.57		162.98	

TOTAL HEAT DUTY REQUIRED	MEGBTU/HR				.022048
EFF TEMP DIF, DEGF (LMTD= 45.7,F= .80,BYPASS= .92,BAFF=1.00)					33.3
OVERALL COEFF REQUIRED	BTU/HR-FT2-F				92.76
CLEAN & FOULED COEFF	BTU/HR-FT2-F		95.01		93.18
SHELLS IN SERIES	1	PARALLEL	1	TOTAL EFF AREA FT2	7.1
PASSES, SHELL	1	TUBE	4	EFFECTIVE AREA FT2/SHELL	7.1
SHELL DIAMETER IN.			3.820	TEMA SHELL TYPE E ; REAR HEAD	FXTS
BAFFLE TYPE	HORZ	SEGMENTL		CROSS PASSES PER SHELL PASS	4
SPACING, CENTRAL IN.			4.309	BAFFLE CUT, PCT SHELL I.D.	30.00
SPACING, INLET IN.			4.309	CUT DISTANCE FROM CENTER, IN.	.764
SPACING, OUTLET IN.			4.309		
BAFFLE THICKNESS IN.			.125	IMPINGEMENT BAFFLE INCLUDED	NO
PAIRS OF SEALING DEVICES			1	TUBESHEET BLANK AREA, %	.0
TUBE TYPE			PLAIN	MATERIAL	ELECTROLYTIC COPPER
NO. OF TUBES/SHELL			76	EST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT			1.500	TUBE PITCH IN.	.3125
TUBE LGTH, EFF FT			1.436	TUBE OUTSIDE DIAM IN.	.250
TUBE LAYOUT DEG			60	TUBE INSIDE DIAM IN.	.214
PITCH RATIO			1.250	TUBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT	1.0	1.0		TUBE NOZZ ID, IN&OUT IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

CASE 58

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.045	.967
PRANDTL NUMBER	6.1	3.5
RYNLD NO, AVG	125.	2360.
RYNLD NO, IN BUN	76.	2667.
RYNLD NO,OUT BUN	187.	2068.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
56.53	41.38	2.02	.07

PCT OVER DESIGN	.46
TOT FOUL RESIST	.000217
DIFF RESIST	.000049

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.24	.25
DENSITY	LB/FT3	62.535	61.705
NOZZ RHO*VSQ	LB/FT-S2	3	3
BUND RHO*VSQ	LB/FT-S2	2	2

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	1.18	1.17
DENSITY	LB/FT3	61.291	61.721
PRESS. DROP	%	8.8	5.5

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW	FT/S	.04
NOMINAL VEL,WINDOW	FT/S	.08
CROSSFLOW COEF	BTU/HR-FT2-F	163.7
WINDOW COEF	BTU/HR-FT2-F	164.5

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.36
TUBE TO BAFFLE LEAKAGE	A =	2.73
MAIN CROSSFLOW	B =	69.42
BUNDLE TO SHELL BYPASS	C =	11.39
BAFFLE TO SHELL LEAKAGE	E =	16.46
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.602
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.655
END (HT LOSS IN END ZONE)	=	.994

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	9.2
END ZONE	=	5.7
CROSS FLOW	=	4.6
INLET NOZZLE	=	42.4
OUTLET NOZZLE	=	38.1

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

*** SPECIAL MESSAGES AND WARNINGS ***

WARNING--TUBESIDE FLUID HAS PASSED THROUGH TRANSITION ZONE. CONSIDER
RERUNNING WITH ITEM 132 IN EFFECT.
HEAT TRANSFER COEFF. AT RE = 2000 IS 220.70 BTU/HR-FT2-F
HEAT TRANSFER COEFF. AT RE = 10000 IS 1240.46 BTU/HR-FT2-F

CASE 59

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE		COLD SHELL SIDE	
		Tube		Shell	
		SENSIBLE LIQ		SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.800		.400	
		IN	OUT	IN	OUT

TEMPERATURE	DEGF	140.0	106.9*	40.0	106.0*
DENSITY	LB/FT3	61.2913	61.7981	62.5352	61.8100
VISCOSITY	CP	.4726	.6441	1.4791	.6497
SPECIFIC HEAT	BTU/LB-F	.9973	.9982	1.0058	.9983
THERMAL COND.	BTU/HR-FT-F	.3723	.3649	.3466	.3647
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	123.4	100.4	73.0	99.2
VISCOSITY, AVG & SKIN	CP	.5480	.6892	.9423	.6975
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.12	10.00	.00	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.78	10.00	.06	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	260.25		191.40	

TOTAL HEAT DUTY REQUIRED MEGBTU/HR			.026437
EFF TEMP DIF, DEGF (LMTD= 48.6,F= .81,BYPASS= .93,BAFF=1.00)			36.6
OVERALL COEFF REQUIRED	BTU/HR-FT2-F		101.04
CLEAN & FOULED COEFF	BTU/HR-FT2-F	102.87	100.61

SHELLS IN SERIES	1	PARALLEL	1
PASSES, SHELL	1	TUBE	4
SHELL DIAMETER IN.			3.820
TOTAL EFF AREA	FT2		7.1
EFFECTIVE AREA	FT2/SHELL		7.1
TEMA SHELL TYPE	E	; REAR HEAD	FXTS

BAFFLE TYPE	HORZ	SEGMENTL	
SPACING, CENTRAL	IN.		4.309
SPACING, INLET	IN.		4.309
SPACING, OUTLET	IN.		4.309
BAFFLE THICKNESS	IN.		.125
PAIRS OF SEALING DEVICES			1
CROSS PASSES PER SHELL PASS			4
BAFFLE CUT, PCT SHELL I.D.			30.00
CUT DISTANCE FROM CENTER, IN.			.764
IMPINGEMENT BAFFLE INCLUDED			NO
TUBESHEET BLANK AREA, %			.0

TUBE TYPE			PLAIN
NO. OF TUBES/SHELL			76
TUBE LGTH, OVERALL	FT		1.500
TUBE LGTH, EFF	FT		1.436
TUBE LAYOUT	DEG		60
PITCH RATIO			1.250
SHL NOZZ ID, IN&OUT	1.0	1.0	
MATERIAL	ELECTROLYTIC COPPER		
EST MAX TUBE COUNT			36
TUBE PITCH	IN.		.3125
TUBE OUTSIDE DIAM	IN.		.250
TUBE INSIDE DIAM	IN.		.214
TUBE SURFACE RATIO, OUT/IN			1.184
TUBE NOZZ ID, IN&OUT	IN.	.8	.8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE	SHELLSIDE PERFORMANCE		
WALL CORRECTION	1.043	.962	NOMINAL VEL,X-FLOW	FT/S	.05
PRANDTL NUMBER	6.4	3.6	NOMINAL VEL,WINDOW	FT/S	.10
RYNLD NO, AVG	160.	2301.	CROSSFLOW COEF	BTU/HR-FT2-F	192.2
RYNLD NO, IN BUN	102.	2667.	WINDOW COEF	BTU/HR-FT2-F	193.3
RYNLD NO,OUT BUN	232.	1957.			

FOULNG LAYER IN.	.0014	.0014			

THERMAL RESISTANCE, % OF TOTAL			
SHELL	TUBE	FOULING	METAL
51.98	45.77	2.18	.07

PCT OVER DESIGN	-.42
TOT FOUL RESIST	.000217
DIFF RESIST	-.000042

DIAMETRAL CLEARANCES		
BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.33	.33
DENSITY	LB/FT3	62.535	61.810
NOZZ RHO*VSQ	LB/FT-S2	6	6
BUND RHO*VSQ	LB/FT-S2	4	4

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	1.18	1.17
DENSITY	LB/FT3	61.291	61.798
PRESS. DROP	%	8.7	5.5

SHELLSIDE FLOW, % OF TOTAL		
HEAT TRANSFER X-FLOW		81.46
TUBE TO BAFFLE LEAKAGE	A =	2.97
MAIN CROSSFLOW	B =	68.40
BUNDLE TO SHELL BYPASS	C =	12.46
BAFFLE TO SHELL LEAKAGE	E =	16.17
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS		
TOTAL =(BETA)(GAMMA)(FIN)	=	.620
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.674
END (HT LOSS IN END ZONE)	=	.994

SHELL PRESSURE DROP, % OF TOTAL		
WINDOW	=	9.0
END ZONE	=	5.1
CROSS FLOW	=	4.2
INLET NOZZLE	=	42.7
OUTLET NOZZLE	=	39.0

WEIGHT PER SHELL, LB		
DRY	=	150.
WET	=	165.

*** SPECIAL MESSAGES AND WARNINGS ***

WARNING--TUBESIDE FLUID HAS PASSED THROUGH TRANSITION ZONE. CONSIDER
RERUNNING WITH ITEM 132 IN EFFECT.
HEAT TRANSFER COEFF. AT RE = 2000 IS 221.76 BTU/HR-FT2-F
HEAT TRANSFER COEFF. AT RE = 10000 IS 1246.28 BTU/HR-FT2-F

□□Washington University ChE433 heat exchanger experiment E0002 P120
Young model F302DY4P 9/23/ 3
CASE 60

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE		COLD SHELL SIDE	
		Tube		Shell	
		SENSIBLE LIQ		SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.800		.500	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	102.6*	40.0	99.6*
DENSITY	LB/FT3	61.2913	61.8563	62.5352	61.8971
VISCOSITY	CP	.4726	.6730	1.4791	.6949
SPECIFIC HEAT	BTU/LB-F	.9973	.9985	1.0058	.9987
THERMAL COND.	BTU/HR-FT-F	.3723	.3639	.3466	.3631
MOLAR MASS	LB/LBMOL	18.02		18.02	
TEMP, AVG & SKIN	DEGF	121.3	95.9	69.8	94.7
VISCOSITY, AVG & SKIN	CP	.5590	.7228	.9809	.7325

PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.12	10.00	.01	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.78	10.00	.08	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	255.31		217.59	

TOTAL HEAT DUTY REQUIRED MEGBTU/HR				.029831
EFF TEMP DIF, DEGF (LMTD= 50.7,F= .83,BYPASS= .93,BAFF=1.00)				39.4
OVERALL COEFF REQUIRED	BTU/HR-FT2-F			106.08
CLEAN & FOULED COEFF	BTU/HR-FT2-F	108.95		106.32

SHELLS IN SERIES 1 PARALLEL 1		TOTAL EFF AREA FT2	7.1
PASSES, SHELL 1 TUBE 4		EFFECTIVE AREA FT2/SHELL	7.1
SHELL DIAMETER IN.	3.820	TEMA SHELL TYPE E ; REAR HEAD	FXTS
BAFFLE TYPE HORZ SEGMENTL		CROSS PASSES PER SHELL PASS	4
SPACING, CENTRAL IN.	4.309	BAFFLE CUT, PCT SHELL I.D.	30.00
SPACING, INLET IN.	4.309	CUT DISTANCE FROM CENTER, IN.	.764
SPACING, OUTLET IN.	4.309		
BAFFLE THICKNESS IN.	.125	IMPINGEMENT BAFFLE INCLUDED	NO
PAIRS OF SEALING DEVICES	1	TUBESHEET BLANK AREA, %	.0
TUBE TYPE	PLAIN	MATERIAL	ELECTROLYTIC COPPER
NO. OF TUBES/SHELL	76	EST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT	1.500	TUBE PITCH IN.	.3125
TUBE LGTH, EFF FT	1.436	TUBE OUTSIDE DIAM IN.	.250
TUBE LAYOUT DEG	60	TUBE INSIDE DIAM IN.	.214
PITCH RATIO	1.250	TUBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT	1.0 1.0	TUBE NOZZ ID, IN&OUT IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

□□Washington University ChE433 heat exchanger experiment E0002 P121
Young model F302DY4P 9/23/ 3
CASE 60

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.042	.958
PRANDTL NUMBER	6.7	3.7
RYNLD NO, AVG	192.	2255.
RYNLD NO, IN BUN	127.	2667.
RYNLD NO,OUT BUN	271.	1873.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
48.32	49.30	2.31	.08

PCT OVER DESIGN	.23
TOT FOUL RESIST	.000217
DIFF RESIST	.000021

SHELLSIDE PERFORMANCE		
NOMINAL VEL,X-FLOW	FT/S	.07
NOMINAL VEL,WINDOW	FT/S	.13
CROSSFLOW COEF	BTU/HR-FT2-F	218.5
WINDOW COEF	BTU/HR-FT2-F	219.8

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.55
TUBE TO BAFFLE LEAKAGE	A =	3.16
MAIN CROSSFLOW	B =	67.57
BUNDLE TO SHELL BYPASS	C =	13.34
BAFFLE TO SHELL LEAKAGE	E =	15.93
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

DIAMETRAL CLEARANCES			TOTAL =(BETA)(GAMMA)(FIN)	=	.637
BUNDLE TO SHELL	IN.	.5000	BETA (BAFF CUT FACTOR)	=	.920
TUBE TO BAFFLE HOLE	IN.	.0284	GAMMA (TUBE ROW ENTRY EFCT)	=	.692
BAFFLE TO SHELL	IN.	.1000	END (HT LOSS IN END ZONE)	=	.994

SHELL NOZZLE DATA		IN	OUT	SHELL PRESSURE DROP, % OF TOTAL		
HT UNDR NOZ	IN.	.25		WINDOW	=	8.9
HT OPP NOZ	IN.	.25		END ZONE	=	4.6
VELOCITY	FT/S	.41	.41	CROSS FLOW	=	3.9
DENSITY	LB/FT3	62.535	61.897	INLET NOZZLE	=	42.9
NOZZ RHO*VSQ	LB/FT-S2	10	10	OUTLET NOZZLE	=	39.6
BUND RHO*VSQ	LB/FT-S2	7	7			

TUBE NOZZLE DATA		IN	OUT	WEIGHT PER SHELL, LB		
VELOCITY	FT/S	1.18	1.17	DRY	=	150.
DENSITY	LB/FT3	61.291	61.856	WET	=	165.
PRESS. DROP	%	8.6	5.4			

*** SPECIAL MESSAGES AND WARNINGS ***

WARNING--TUBESIDE FLUID HAS PASSED THROUGH TRANSITION ZONE. CONSIDER
RERUNNING WITH ITEM 132 IN EFFECT.
HEAT TRANSFER COEFF. AT RE = 2000 IS 222.54 BTU/HR-FT2-F
HEAT TRANSFER COEFF. AT RE = 10000 IS 1250.05 BTU/HR-FT2-F

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.800		.600	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	99.1*	40.0	94.3*
DENSITY	LB/FT3	61.2913	61.9033	62.5352	61.9658
VISCOSITY	CP	.4726	.6984	1.4791	.7356
SPECIFIC HEAT	BTU/LB-F	.9973	.9987	1.0058	.9991
THERMAL COND.	BTU/HR-FT-F	.3723	.3630	.3466	.3618
MOLAR MASS	LB/LBMOL	18.02		18.02	
TEMP, AVG & SKIN	DEGF	119.6	92.2	67.1	90.9
VISCOSITY, AVG & SKIN	CP	.5684	.7531	1.0143	.7641
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.12	10.00	.01	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.78	10.00	.09	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	251.13		242.36	

TOTAL HEAT DUTY REQUIRED MEGBTU/HR .032638

EFF TEMP DIF, DEGF (LMTD= 52.1,F= .84,BYPASS= .94,BAFF=1.00)		41.3
OVERALL COEFF REQUIRED BTU/HR-FT2-F		110.71
CLEAN & FOULED COEFF BTU/HR-FT2-F	113.83	110.89

SHELLS IN SERIES	1 PARALLEL 1	TOTAL EFF AREA FT2	7.1
PASSES, SHELL	1 TUBE 4	EFFECTIVE AREA FT2/SHELL	7.1
SHELL DIAMETER IN.	3.820	TEMA SHELL TYPE E ; REAR HEAD	FXTS
BAFFLE TYPE	HORZ SEGMENTL	CROSS PASSES PER SHELL PASS	4
SPACING, CENTRAL IN.	4.309	BAFFLE CUT, PCT SHELL I.D.	30.00
SPACING, INLET IN.	4.309	CUT DISTANCE FROM CENTER, IN.	.764
SPACING, OUTLET IN.	4.309		
BAFFLE THICKNESS IN.	.125	IMPINGEMENT BAFFLE INCLUDED	NO
PAIRS OF SEALING DEVICES	1	TUBESHEET BLANK AREA, %	.0
TUBE TYPE	PLAIN	MATERIAL	ELECTROLYTIC COPPER
NO. OF TUBES/SHELL	76	EST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT	1.500	TUBE PITCH IN.	.3125
TUBE LGTH, EFF FT	1.436	TUBE OUTSIDE DIAM IN.	.250
TUBE LAYOUT DEG	60	TUBE INSIDE DIAM IN.	.214
PITCH RATIO	1.250	TUBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT	1.0 1.0	TUBE NOZZ ID, IN&OUT IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

□□Washington University ChE433 heat exchanger experiment E0002 P123
Young model F302DY4P 9/23/ 3
CASE 61

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.040	.954
PRANDTL NUMBER	6.9	3.7
RYNLD NO, AVG	223.	2218.
RYNLD NO, IN BUN	153.	2667.
RYNLD NO,OUT BUN	308.	1805.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
45.24	52.28	2.40	.08

PCT OVER DESIGN	.16
TOT FOUL RESIST	.000217
DIFF RESIST	.000015

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA	IN	OUT
HT UNDR NOZ IN.	.25	
HT OPP NOZ IN.	.25	
VELOCITY FT/S	.49	.49

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW FT/S		.08
NOMINAL VEL,WINDOW FT/S		.15
CROSSFLOW COEF BTU/HR-FT2-F		243.3
WINDOW COEF BTU/HR-FT2-F		244.8

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.60
TUBE TO BAFFLE LEAKAGE	A =	3.33
MAIN CROSSFLOW	B =	66.84
BUNDLE TO SHELL BYPASS	C =	14.09
BAFFLE TO SHELL LEAKAGE	E =	15.75
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.653
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.710
END (HT LOSS IN END ZONE)	=	.994

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	8.8
END ZONE	=	4.3
CROSS FLOW	=	3.7

DENSITY	LB/FT3	62.535	61.966	INLET NOZZLE	= 43.0
NOZZ RHO*VSQ	LB/FT-S2	14	15	OUTLET NOZZLE	= 40.1
BUND RHO*VSQ	LB/FT-S2	10	10		

TUBE NOZZLE DATA		IN	OUT	WEIGHT PER SHELL, LB		
VELOCITY	FT/S	1.18	1.17	DRY	=	150.
DENSITY	LB/FT3	61.291	61.903	WET	=	165.
PRESS. DROP	%	8.6	5.4			

*** SPECIAL MESSAGES AND WARNINGS ***

WARNING--TUBESIDE FLUID HAS PASSED THROUGH TRANSITION ZONE. CONSIDER
RERUNNING WITH ITEM 132 IN EFFECT.
HEAT TRANSFER COEFF. AT RE = 2000 IS 223.08 BTU/HR-FT2-F
HEAT TRANSFER COEFF. AT RE = 10000 IS 1252.94 BTU/HR-FT2-F

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.800		.700	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	96.2*	40.0	89.8*
DENSITY	LB/FT3	61.2913	61.9410	62.5352	62.0224
VISCOSITY	CP	.4726	.7203	1.4791	.7731
SPECIFIC HEAT	BTU/LB-F	.9973	.9989	1.0058	.9995
THERMAL COND.	BTU/HR-FT-F	.3723	.3623	.3466	.3607
MOLAR MASS	LB/LBMOL	18.02		18.02	
TEMP, AVG & SKIN	DEGF	118.1	88.9	64.9	87.6
VISCOSITY, AVG & SKIN	CP	.5763	.7806	1.0441	.7928
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.12	10.00	.01	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.78	10.00	.11	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	247.68		266.01	

TOTAL HEAT DUTY REQUIRED	MEGBTU/HR	.034938
EFF TEMP DIF, DEGF (LMTD= 53.2,F= .85,BYPASS= .94,BAFF=1.00)		42.8
OVERALL COEFF REQUIRED	BTU/HR-FT2-F	114.28
CLEAN & FOULED COEFF	BTU/HR-FT2-F	117.88 / 114.66

SHELLS IN SERIES	1	PARALLEL 1	TOTAL EFF AREA	FT2	7.1
PASSES, SHELL	1	TUBE 4	EFFECTIVE AREA	FT2/SHELL	7.1
SHELL DIAMETER IN.	3.820		TEMA SHELL TYPE E	; REAR HEAD	FXTS
BAFFLE TYPE	HORZ	SEGMENTL	CROSS PASSES PER SHELL PASS		4

SPACING, CENTRAL IN.	4.309	BAFFLE CUT, PCT SHELL I.D.	30.00
SPACING, INLET IN.	4.309	CUT DISTANCE FROM CENTER, IN.	.764
SPACING, OUTLET IN.	4.309		
BAFFLE THICKNESS IN.	.125	IMPINGEMENT BAFFLE INCLUDED	NO
PAIRS OF SEALING DEVICES	1	TUBESHEET BLANK AREA, %	.0

TUBE TYPE	PLAIN	MATERIAL	ELECTROLYTIC COPPER
NO. OF TUBES/SHELL	76	EST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT	1.500	TUBE PITCH IN.	.3125
TUBE LGTH, EFF FT	1.436	TUBE OUTSIDE DIAM IN.	.250
TUBE LAYOUT DEG	60	TUBE INSIDE DIAM IN.	.214
PITCH RATIO	1.250	TUBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT 1.0	1.0	TUBE NOZZ ID, IN&OUT IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.039	.951
PRANDTL NUMBER	7.2	3.8
RYNLD NO, AVG	253.	2188.
RYNLD NO, IN BUN	178.	2667.
RYNLD NO,OUT BUN	341.	1750.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
42.62	54.81	2.49	.08

PCT OVER DESIGN	.33
TOT FOUL RESIST	.000217
DIFF RESIST	.000029

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.57	.57
DENSITY	LB/FT3	62.535	62.022
NOZZ RHO*VSQ	LB/FT-S2	20	20
BUND RHO*VSQ	LB/FT-S2	13	13

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	1.18	1.17
DENSITY	LB/FT3	61.291	61.941
PRESS. DROP	%	8.5	5.4

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW	FT/S	.09
NOMINAL VEL,WINDOW	FT/S	.18
CROSSFLOW COEF	BTU/HR-FT2-F	267.1
WINDOW COEF	BTU/HR-FT2-F	268.7

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.59
TUBE TO BAFFLE LEAKAGE	A =	3.48
MAIN CROSSFLOW	B =	66.13
BUNDLE TO SHELL BYPASS	C =	14.76
BAFFLE TO SHELL LEAKAGE	E =	15.63
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.669
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.727
END (HT LOSS IN END ZONE)	=	.994

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	8.8
END ZONE	=	4.0
CROSS FLOW	=	3.5
INLET NOZZLE	=	43.1
OUTLET NOZZLE	=	40.5

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

*** SPECIAL MESSAGES AND WARNINGS ***

WARNING--TUBESIDE FLUID HAS PASSED THROUGH TRANSITION ZONE. CONSIDER
RERUNNING WITH ITEM 132 IN EFFECT.
HEAT TRANSFER COEFF. AT RE = 2000 IS 223.49 BTU/HR-FT2-F
HEAT TRANSFER COEFF. AT RE = 10000 IS 1254.93 BTU/HR-FT2-F

Washington University ChE433 heat exchanger experiment E0002 P126
Young model F302DY4P 9/23/ 3
CASE 63

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.800		.800	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	93.7*	40.0	86.1*
DENSITY	LB/FT3	61.2913	61.9735	62.5352	62.0679
VISCOSITY	CP	.4726	.7405	1.4791	.8064
SPECIFIC HEAT	BTU/LB-F	.9973	.9991	1.0058	.9998
THERMAL COND.	BTU/HR-FT-F	.3723	.3617	.3466	.3597
MOLAR MASS	LB/LBMOL	18.02		18.02	
TEMP, AVG & SKIN	DEGF	116.8	86.1	63.0	84.7
VISCOSITY, AVG & SKIN	CP	.5833	.8059	1.0697	.8192
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.12	10.00	.01	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.78	10.00	.12	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	244.56		289.19	

TOTAL HEAT DUTY REQUIRED MEGBTU/HR					.036962
EFF TEMP DIF, DEGF (LMTD= 53.8,F= .86,BYPASS= .95,BAFF=1.00)					43.8
OVERALL COEFF REQUIRED	BTU/HR-FT2-F				118.05
CLEAN & FOULED COEFF	BTU/HR-FT2-F		121.33		117.87
SHELLS IN SERIES	1	PARALLEL 1		TOTAL EFF AREA FT2	7.1
PASSES, SHELL	1	TUBE 4		EFFECTIVE AREA FT2/SHELL	7.1
SHELL DIAMETER IN.	3.820			TEMA SHELL TYPE E ; REAR HEAD	FXTS
BAFFLE TYPE	HORZ	SEGMENTL		CROSS PASSES PER SHELL PASS	4
SPACING, CENTRAL IN.	4.309			BAFFLE CUT, PCT SHELL I.D.	30.00
SPACING, INLET IN.	4.309			CUT DISTANCE FROM CENTER, IN.	.764
SPACING, OUTLET IN.	4.309				
BAFFLE THICKNESS IN.	.125			IMPINGEMENT BAFFLE INCLUDED	NO
PAIRS OF SEALING DEVICES	1			TUBESHEET BLANK AREA, %	.0
TUBE TYPE	PLAIN			MATERIAL	ELECTROLYTIC COPPER
NO. OF TUBES/SHELL	76			EST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT	1.500			TUBE PITCH IN.	.3125

TUBE LGTH, EFF	FT	1.436	TUBE OUTSIDE DIAM	IN.	.250
TUBE LAYOUT	DEG	60	TUBE INSIDE DIAM	IN.	.214
PITCH RATIO		1.250	TUBE SURFACE RATIO, OUT/IN		1.184
SHL NOZZ ID, IN&OUT	1.0	1.0	TUBE NOZZ ID, IN&OUT	IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

Young model F302DY4P 9/23/ 3

CASE 63

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.038	.947
PRANDTL NUMBER	7.3	3.8
RYNLD NO, AVG	282.	2161.
RYNLD NO, IN BUN	204.	2667.
RYNLD NO,OUT BUN	374.	1702.
FOULNG LAYER IN.	.0014	.0014

SHELLSIDE PERFORMANCE		
NOMINAL VEL,X-FLOW	FT/S	.10
NOMINAL VEL,WINDOW	FT/S	.20
CROSSFLOW COEF	BTU/HR-FT2-F	290.4
WINDOW COEF	BTU/HR-FT2-F	292.0

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
40.30	57.06	2.56	.08

PCT OVER DESIGN	-.15
TOT FOUL RESIST	.000217
DIFF RESIST	-.000013

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.59
TUBE TO BAFFLE LEAKAGE	A =	3.62
MAIN CROSSFLOW	B =	65.61
BUNDLE TO SHELL BYPASS	C =	15.25
BAFFLE TO SHELL LEAKAGE	E =	15.52
TUBE PASSLANE BYPASS	F =	.00

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.685
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.745
END (HT LOSS IN END ZONE)	=	.994

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.65	.66
DENSITY	LB/FT3	62.535	62.068
NOZZ RHO*VSQ	LB/FT-S2	26	26
BUND RHO*VSQ	LB/FT-S2	18	18

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	8.8
END ZONE	=	3.8
CROSS FLOW	=	3.4
INLET NOZZLE	=	43.2
OUTLET NOZZLE	=	40.8

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	1.18	1.17
DENSITY	LB/FT3	61.291	61.974
PRESS. DROP	%	8.5	5.3

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

*** SPECIAL MESSAGES AND WARNINGS ***

WARNING--TUBESIDE FLUID HAS PASSED THROUGH TRANSITION ZONE. CONSIDER
RERUNNING WITH ITEM 132 IN EFFECT.
HEAT TRANSFER COEFF. AT RE = 2000 IS 223.77 BTU/HR-FT2-F
HEAT TRANSFER COEFF. AT RE = 10000 IS 1256.69 BTU/HR-FT2-F

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.800		.900	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	91.6*	40.0	82.8*
DENSITY	LB/FT3	61.2913	61.9994	62.5352	62.1076
VISCOSITY	CP	.4726	.7574	1.4791	.8379
SPECIFIC HEAT	BTU/LB-F	.9973	.9993	1.0058	1.0001
THERMAL COND.	BTU/HR-FT-F	.3723	.3611	.3466	.3588
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	115.8	83.7	61.4	82.2
VISCOSITY, AVG & SKIN	CP	.5891	.8292	1.0933	.8436
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.12	10.00	.02	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.78	10.00	.14	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	242.08		312.16	

TOTAL HEAT DUTY REQUIRED	MEGBTU/HR	.038596
EFF TEMP DIF, DEGF (LMTD= 54.4,F= .87,BYPASS= .95,BAFF=1.00)		44.8
OVERALL COEFF REQUIRED	BTU/HR-FT2-F	120.69
CLEAN & FOULED COEFF	BTU/HR-FT2-F	124.43 / 120.74

SHELLS IN SERIES	1	PARALLEL	1
PASSES, SHELL	1	TUBE	4
SHELL DIAMETER IN.			3.820
TOTAL EFF AREA	FT2		7.1
EFFECTIVE AREA	FT2/SHELL		7.1
TEMA SHELL TYPE	E	; REAR HEAD	FXTS

BAFFLE TYPE	HORZ	SEGMENTL	
SPACING, CENTRAL	IN.		4.309
SPACING, INLET	IN.		4.309
SPACING, OUTLET	IN.		4.309
BAFFLE THICKNESS	IN.		.125
PAIRS OF SEALING DEVICES			1
CROSS PASSES PER SHELL PASS			4
BAFFLE CUT, PCT SHELL I.D.			30.00
CUT DISTANCE FROM CENTER, IN.			.764
IMPINGEMENT BAFFLE INCLUDED			NO
TUBESHEET BLANK AREA, %			.0

TUBE TYPE			PLAIN
NO. OF TUBES/SHELL			76
TUBE LGTH, OVERALL	FT		1.500
TUBE LGTH, EFF	FT		1.436
TUBE LAYOUT	DEG		60
PITCH RATIO			1.250
SHL NOZZ ID, IN&OUT	1.0	1.0	
MATERIAL			ELECTROLYTIC COPPER
EST MAX TUBE COUNT			36
TUBE PITCH	IN.		.3125
TUBE OUTSIDE DIAM	IN.		.250
TUBE INSIDE DIAM	IN.		.214
TUBE SURFACE RATIO, OUT/IN			1.184
TUBE NOZZ ID, IN&OUT	IN.	.8	.8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.037	.945
PRANDTL NUMBER	7.5	3.9
RYNLD NO, AVG	310.	2140.
RYNLD NO, IN BUN	229.	2667.
RYNLD NO,OUT BUN	405.	1664.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
38.25	59.05	2.62	.09

PCT OVER DESIGN	.05
TOT FOUL RESIST	.000217
DIFF RESIST	.000004

DIAMETRAL CLEARANCES		
BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.73	.74
DENSITY	LB/FT3	62.535	62.108
NOZZ RHO*VSQ	LB/FT-S2	33	33
BUND RHO*VSQ	LB/FT-S2	22	23

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	1.18	1.17
DENSITY	LB/FT3	61.291	61.999
PRESS. DROP	%	8.4	5.3

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW	FT/S	.12
NOMINAL VEL,WINDOW	FT/S	.23
CROSSFLOW COEF	BTU/HR-FT2-F	313.5
WINDOW COEF	BTU/HR-FT2-F	315.2

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.57
TUBE TO BAFFLE LEAKAGE	A =	3.74
MAIN CROSSFLOW	B =	65.36
BUNDLE TO SHELL BYPASS	C =	15.46
BAFFLE TO SHELL LEAKAGE	E =	15.45
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.702
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.763
END (HT LOSS IN END ZONE)	=	.994

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	8.8
END ZONE	=	3.7
CROSS FLOW	=	3.3
INLET NOZZLE	=	43.2
OUTLET NOZZLE	=	41.0

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

*** SPECIAL MESSAGES AND WARNINGS ***

WARNING--TUBESIDE FLUID HAS PASSED THROUGH TRANSITION ZONE. CONSIDER
RERUNNING WITH ITEM 132 IN EFFECT.
HEAT TRANSFER COEFF. AT RE = 2000 IS 224.02 BTU/HR-FT2-F
HEAT TRANSFER COEFF. AT RE = 10000 IS 1257.56 BTU/HR-FT2-F

□□Washington University ChE433 heat exchanger experiment E0002 P130
Young model F302DY4P 9/23/ 3
CASE 65

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.900		.200	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	121.3*	40.0	123.8*

DENSITY	LB/FT3	61.2913	61.5886	62.5352	61.5511
VISCOSITY	CP	.4726	.5589	1.4791	.5462
SPECIFIC HEAT	BTU/LB-F	.9973	.9976	1.0058	.9975
THERMAL COND.	BTU/HR-FT-F	.3723	.3683	.3466	.3689
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	130.7	114.4	81.9	113.4
VISCOSITY, AVG & SKIN	CP	.5129	.5976	.8466	.6033
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.14	10.00	.00	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.88	10.00	.03	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	315.11		136.22	

TOTAL HEAT DUTY REQUIRED MEGBTU/HR			.016761
EFF TEMP DIF, DEGF (LMTD= 40.4,F= .77,BYPASS= .85,BAFF=1.00)			26.5
OVERALL COEFF REQUIRED	BTU/HR-FT2-F		88.44
CLEAN & FOULED COEFF	BTU/HR-FT2-F	90.45	88.97

SHELLS IN SERIES	1	PARALLEL 1	
PASSES, SHELL	1	TUBE 4	
SHELL DIAMETER IN.	3.820		
TOTAL EFF AREA	FT2	7.1	
EFFECTIVE AREA	FT2/SHELL	7.1	
TEMA SHELL TYPE E ; REAR HEAD		FXTS	
BAFFLE TYPE	HORZ	SEGMENTL	
SPACING, CENTRAL IN.	4.309		
SPACING, INLET IN.	4.309		
SPACING, OUTLET IN.	4.309		
BAFFLE THICKNESS IN.	.125		
PAIRS OF SEALING DEVICES	1		
CROSS PASSES PER SHELL PASS	4		
BAFFLE CUT, PCT SHELL I.D.	30.00		
CUT DISTANCE FROM CENTER, IN.	.764		
IMPINGEMENT BAFFLE INCLUDED	NO		
TUBESHEET BLANK AREA, %	.0		

TUBE TYPE	PLAIN	MATERIAL	ELECTROLYTIC COPPER
NO. OF TUBES/SHELL	76	EST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT	1.500	TUBE PITCH IN.	.3125
TUBE LGTH, EFF FT	1.436	TUBE OUTSIDE DIAM IN.	.250
TUBE LAYOUT DEG	60	TUBE INSIDE DIAM IN.	.214
PITCH RATIO	1.250	TUBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT	1.0 1.0	TUBE NOZZ ID, IN&OUT IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE	SHELLSIDE PERFORMANCE		
WALL CORRECTION	1.049	.975	NOMINAL VEL,X-FLOW FT/S		.03
PRANDTL NUMBER	5.7	3.3	NOMINAL VEL,WINDOW FT/S		.05
RYNLD NO, AVG	88.	2765.	CROSSFLOW COEF	BTU/HR-FT2-F	137.3
RYNLD NO, IN BUN	50.	3001.	WINDOW COEF	BTU/HR-FT2-F	135.4
RYNLD NO,OUT BUN	136.	2537.			
FOULNG LAYER IN.	.0014	.0014	SHELLSIDE FLOW, % OF TOTAL		

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
64.58	33.43	1.93	.06

PCT OVER DESIGN	.60
TOT FOUL RESIST	.000217
DIFF RESIST	.000068

HEAT TRANSFER X-FLOW		80.32
TUBE TO BAFFLE LEAKAGE	A =	2.59
MAIN CROSSFLOW	B =	68.91
BUNDLE TO SHELL BYPASS	C =	10.89
BAFFLE TO SHELL LEAKAGE	E =	17.61
TUBE PASSLANE BYPASS	F =	.00

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.598
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.650
END (HT LOSS IN END ZONE)	=	.998

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.16	.17
DENSITY	LB/FT3	62.535	61.551
NOZZ RHO*VSQ	LB/FT-S2	1	1
BUND RHO*VSQ	LB/FT-S2	1	1

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	9.6
END ZONE	=	7.2
CROSS FLOW	=	5.6
INLET NOZZLE	=	41.3
OUTLET NOZZLE	=	36.2

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	1.33	1.32
DENSITY	LB/FT3	61.291	61.589
PRESS. DROP	%	8.9	5.7

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

*** SPECIAL MESSAGES AND WARNINGS ***

WARNING--TUBESIDE FLUID HAS PASSED THROUGH TRANSITION ZONE. CONSIDER
RERUNNING WITH ITEM 132 IN EFFECT.
HEAT TRANSFER COEFF. AT RE = 2000 IS 218.29 BTU/HR-FT2-F
HEAT TRANSFER COEFF. AT RE = 10000 IS 1230.71 BTU/HR-FT2-F

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.900		.300	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	114.6*	40.0	116.0*
DENSITY	LB/FT3	61.2913	61.6884	62.5352	61.6683
VISCOSITY	CP	.4726	.5962	1.4791	.5883
SPECIFIC HEAT	BTU/LB-F	.9973	.9978	1.0058	.9978
THERMAL COND.	BTU/HR-FT-F	.3723	.3668	.3466	.3671
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	127.3	108.5	78.0	107.4
VISCOSITY, AVG & SKIN	CP	.5288	.6336	.8868	.6407
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00

PRESSURE DROP, TOT & ALLOWED	PSI	.14	10.00	.00	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.88	10.00	.05	10.00

FOULING RESISTANCE	HR-FT2-F/BTU	.00010	.00010
FILM COEFFICIENT	BTU/HR-FT2-F	306.65	164.07

TOTAL HEAT DUTY REQUIRED MEGBTU/HR	.022807
EFF TEMP DIF, DEGF (LMTD= 44.6,F= .79,BYPASS= .91,BAFF=1.00)	32.2
OVERALL COEFF REQUIRED BTU/HR-FT2-F	99.13
CLEAN & FOULED COEFF BTU/HR-FT2-F 100.89	98.90

SHELLS IN SERIES	1	PARALLEL	1
PASSES, SHELL	1	TUBE	4
SHELL DIAMETER IN.			3.820

TOTAL EFF AREA FT2	7.1
EFFECTIVE AREA FT2/SHELL	7.1
TEMA SHELL TYPE E ; REAR HEAD	FXTS

BAFFLE TYPE	HORZ	SEGMENTL
SPACING, CENTRAL IN.		4.309
SPACING, INLET IN.		4.309
SPACING, OUTLET IN.		4.309
BAFFLE THICKNESS IN.		.125
PAIRS OF SEALING DEVICES		1

CROSS PASSES PER SHELL PASS	4
BAFFLE CUT, PCT SHELL I.D.	30.00
CUT DISTANCE FROM CENTER, IN.	.764
IMPINGEMENT BAFFLE INCLUDED	NO
TUBESHEET BLANK AREA, %	.0

TUBE TYPE		PLAIN	
NO. OF TUBES/SHELL		76	
TUBE LGTH, OVERALL	FT	1.500	
TUBE LGTH, EFF	FT	1.436	
TUBE LAYOUT	DEG	60	
PITCH RATIO		1.250	
SHL NOZZ ID, IN&OUT		1.0	1.0

MATERIAL		ELECTROLYTIC COPPER	
EST MAX TUBE COUNT		36	
TUBE PITCH	IN.	.3125	
TUBE OUTSIDE DIAM	IN.	.250	
TUBE INSIDE DIAM	IN.	.214	
TUBE SURFACE RATIO, OUT/IN		1.184	
TUBE NOZZ ID, IN&OUT	IN.	.8	.8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

□□Washington University ChE433 heat exchanger experiment E0002 P133
Young model F302DY4P 9/23/ 3
CASE 66

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.047	.970
PRANDTL NUMBER	6.0	3.5
RYNLD NO, AVG	127.	2682.
RYNLD NO, IN BUN	76.	3001.
RYNLD NO,OUT BUN	192.	2379.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
59.60	38.18	2.14	.07

PCT OVER DESIGN	-.24
TOT FOUL RESIST	.000217
DIFF RESIST	-.000024

DIAMETRAL CLEARANCES

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW	FT/S	.04
NOMINAL VEL,WINDOW	FT/S	.08
CROSSFLOW COEF	BTU/HR-FT2-F	164.8
WINDOW COEF	BTU/HR-FT2-F	165.6

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.39
TUBE TO BAFFLE LEAKAGE	A =	2.75
MAIN CROSSFLOW	B =	69.41
BUNDLE TO SHELL BYPASS	C =	11.42
BAFFLE TO SHELL LEAKAGE	E =	16.42
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.603

BUNDLE TO SHELL	IN.	.5000	BETA (BAFF CUT FACTOR)	=	.920
TUBE TO BAFFLE HOLE	IN.	.0284	GAMMA (TUBE ROW ENTRY EFCT)	=	.656
BAFFLE TO SHELL	IN.	.1000	END (HT LOSS IN END ZONE)	=	.994

SHELL NOZZLE DATA		IN	OUT	SHELL PRESSURE DROP, % OF TOTAL		
HT UNDR NOZ	IN.	.25		WINDOW	=	9.2
HT OPP NOZ	IN.	.25		END ZONE	=	5.6
VELOCITY	FT/S	.24	.25	CROSS FLOW	=	4.6
DENSITY	LB/FT3	62.535	61.668	INLET NOZZLE	=	42.5
NOZZ RHO*VSQ	LB/FT-S2	3	3	OUTLET NOZZLE	=	38.1
BUND RHO*VSQ	LB/FT-S2	2	2			

TUBE NOZZLE DATA		IN	OUT	WEIGHT PER SHELL, LB		
VELOCITY	FT/S	1.33	1.32	DRY	=	150.
DENSITY	LB/FT3	61.291	61.688	WET	=	165.
PRESS. DROP	%	8.9	5.6			

*** SPECIAL MESSAGES AND WARNINGS ***

WARNING--TUBESIDE FLUID HAS PASSED THROUGH TRANSITION ZONE. CONSIDER
RERUNNING WITH ITEM 132 IN EFFECT.
HEAT TRANSFER COEFF. AT RE = 2000 IS 219.72 BTU/HR-FT2-F
HEAT TRANSFER COEFF. AT RE = 10000 IS 1239.34 BTU/HR-FT2-F

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ .900		COLD SHELL SIDE Shell SENSIBLE LIQ .400	
TOTAL FLOW RATE KLB/HR		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	109.3*	40.0	108.8*
DENSITY	LB/FT3	61.2913	61.7637	62.5352	61.7719
VISCOSITY	CP	.4726	.6282	1.4791	.6319
SPECIFIC HEAT	BTU/LB-F	.9973	.9981	1.0058	.9981
THERMAL COND.	BTU/HR-FT-F	.3723	.3655	.3466	.3654
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	124.7	103.3	74.4	102.1
VISCOSITY, AVG & SKIN	CP	.5417	.6681	.9265	.6766
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.15	10.00	.00	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.88	10.00	.06	10.00
FOULING RESISTANCE	HR-FT2-F/BTU		.00010		.00010
FILM COEFFICIENT	BTU/HR-FT2-F		300.04		192.90

TOTAL HEAT DUTY REQUIRED MEGBTU/HR	.027527
EFF TEMP DIF, DEGF (LMTD= 47.8,F= .81,BYPASS= .92,BAFF=1.00)	35.8

OVERALL COEFF REQUIRED	BTU/HR-FT2-F		107.48
CLEAN & FOULED COEFF	BTU/HR-FT2-F	110.08	107.58

SHELLS IN SERIES	1 PARALLEL 1	TOTAL EFF AREA FT2	7.1
PASSES, SHELL	1 TUBE 4	EFFECTIVE AREA FT2/SHELL	7.1
SHELL DIAMETER IN.	3.820	TEMA SHELL TYPE E ; REAR HEAD	FXTS
BAFFLE TYPE	HORZ SEGMENTL	CROSS PASSES PER SHELL PASS	4
SPACING, CENTRAL IN.	4.309	BAFFLE CUT, PCT SHELL I.D.	30.00
SPACING, INLET IN.	4.309	CUT DISTANCE FROM CENTER, IN.	.764
SPACING, OUTLET IN.	4.309		
BAFFLE THICKNESS IN.	.125	IMPINGEMENT BAFFLE INCLUDED	NO
PAIRS OF SEALING DEVICES	1	TUBESHEET BLANK AREA, %	.0
TUBE TYPE	PLAIN	MATERIAL	ELECTROLYTIC COPPER
NO. OF TUBES/SHELL	76	EST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT	1.500	TUBE PITCH IN.	.3125
TUBE LGTH, EFF FT	1.436	TUBE OUTSIDE DIAM IN.	.250
TUBE LAYOUT DEG	60	TUBE INSIDE DIAM IN.	.214
PITCH RATIO	1.250	TUBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT	1.0 1.0	TUBE NOZZ ID, IN&OUT IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

□□Washington University ChE433 heat exchanger experiment E0002 P135
Young model F302DY4P 9/23/ 3
CASE 67

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.045	.966
PRANDTL NUMBER	6.3	3.5
RYNLD NO, AVG	163.	2618.
RYNLD NO, IN BUN	102.	3001.
RYNLD NO,OUT BUN	238.	2258.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
55.14	42.45	2.33	.08

PCT OVER DESIGN	.09
TOT FOUL RESIST	.000217
DIFF RESIST	.000009

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA	IN	OUT
HT UNDR NOZ IN.	.25	
HT OPP NOZ IN.	.25	
VELOCITY FT/S	.33	.33
DENSITY LB/FT3	62.535	61.772

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW FT/S		.05
NOMINAL VEL,WINDOW FT/S		.10
CROSSFLOW COEF BTU/HR-FT2-F		193.7
WINDOW COEF BTU/HR-FT2-F		194.8

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.49
TUBE TO BAFFLE LEAKAGE	A =	2.99
MAIN CROSSFLOW	B =	68.38
BUNDLE TO SHELL BYPASS	C =	12.51
BAFFLE TO SHELL LEAKAGE	E =	16.12
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.622
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.676
END (HT LOSS IN END ZONE)	=	.994

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	9.0
END ZONE	=	5.0
CROSS FLOW	=	4.2
INLET NOZZLE	=	42.8

NOZZ RHO*VSQ LB/FT-S2	6	6	OUTLET NOZZLE	=	39.0
BUND RHO*VSQ LB/FT-S2	4	4			

TUBE NOZZLE DATA		IN	OUT	WEIGHT PER SHELL, LB		
VELOCITY	FT/S	1.33	1.32	DRY	=	150.
DENSITY	LB/FT3	61.291	61.764	WET	=	165.
PRESS. DROP	%	8.8	5.6			

*** SPECIAL MESSAGES AND WARNINGS ***

WARNING--TUBESIDE FLUID HAS PASSED THROUGH TRANSITION ZONE. CONSIDER
RERUNNING WITH ITEM 132 IN EFFECT.
HEAT TRANSFER COEFF. AT RE = 2000 IS 220.95 BTU/HR-FT2-F
HEAT TRANSFER COEFF. AT RE = 10000 IS 1244.90 BTU/HR-FT2-F

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.900		.500	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	105.0*	40.0	102.7*
DENSITY	LB/FT3	61.2913	61.8235	62.5352	61.8553
VISCOSITY	CP	.4726	.6563	1.4791	.6724
SPECIFIC HEAT	BTU/LB-F	.9973	.9983	1.0058	.9985
THERMAL COND.	BTU/HR-FT-F	.3723	.3645	.3466	.3639
MOLAR MASS	LB/LBMOL	18.02		18.02	
TEMP, AVG & SKIN	DEGF	122.5	99.0	71.3	97.7
VISCOSITY, AVG & SKIN	CP	.5527	.6992	.9619	.7090
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.15	10.00	.01	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.88	10.00	.08	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	294.49		219.59	

TOTAL HEAT DUTY REQUIRED MEGBTU/HR					.031390
EFF TEMP DIF, DEGF (LMTD= 49.9,F= .83,BYPASS= .93,BAFF=1.00)					38.4
OVERALL COEFF REQUIRED	BTU/HR-FT2-F				114.46
CLEAN & FOULED COEFF	BTU/HR-FT2-F		117.26		114.32

SHELLS IN SERIES	1	PARALLEL 1	TOTAL EFF AREA	FT2	7.1
PASSES, SHELL	1	TUBE 4	EFFECTIVE AREA	FT2/SHELL	7.1
SHELL DIAMETER IN.	3.820		TEMA SHELL TYPE E	; REAR HEAD	FXTS
BAFFLE TYPE	HORZ	SEGMENTL	CROSS PASSES PER SHELL PASS		4
SPACING, CENTRAL IN.	4.309		BAFFLE CUT, PCT SHELL I.D.		30.00

SPACING, INLET	IN.	4.309	CUT DISTANCE FROM CENTER, IN.		.764
SPACING, OUTLET	IN.	4.309			
BAFFLE THICKNESS	IN.	.125	IMPINGEMENT BAFFLE INCLUDED		NO
PAIRS OF SEALING DEVICES		1	TUBESHEET BLANK AREA, %		.0
TUBE TYPE		PLAIN	MATERIAL		ELECTROLYTIC COPPER
NO. OF TUBES/SHELL		76	EST MAX TUBE COUNT		36
TUBE LGTH, OVERALL	FT	1.500	TUBE PITCH	IN.	.3125
TUBE LGTH, EFF	FT	1.436	TUBE OUTSIDE DIAM	IN.	.250
TUBE LAYOUT	DEG	60	TUBE INSIDE DIAM	IN.	.214
PITCH RATIO		1.250	TUBE SURFACE RATIO, OUT/IN		1.184
SHL NOZZ ID, IN&OUT	1.0	1.0	TUBE NOZZ ID, IN&OUT	IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.044	.962
PRANDTL NUMBER	6.6	3.6
RYNLD NO, AVG	196.	2566.
RYNLD NO, IN BUN	127.	3001.
RYNLD NO,OUT BUN	280.	2161.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
51.48	45.96	2.48	.08

PCT OVER DESIGN	-.12
TOT FOUL RESIST	.000217
DIFF RESIST	-.000011

SHELLSIDE PERFORMANCE		
NOMINAL VEL,X-FLOW	FT/S	.07
NOMINAL VEL,WINDOW	FT/S	.13
CROSSFLOW COEF	BTU/HR-FT2-F	220.5
WINDOW COEF	BTU/HR-FT2-F	221.8

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.58
TUBE TO BAFFLE LEAKAGE	A =	3.19
MAIN CROSSFLOW	B =	67.54
BUNDLE TO SHELL BYPASS	C =	13.40
BAFFLE TO SHELL LEAKAGE	E =	15.88
TUBE PASSLANE BYPASS	F =	.00

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.639
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.695
END (HT LOSS IN END ZONE)	=	.994

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.41	.41
DENSITY	LB/FT3	62.535	61.855
NOZZ RHO*VSQ	LB/FT-S2	10	10
BUND RHO*VSQ	LB/FT-S2	7	7

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	8.8
END ZONE	=	4.6
CROSS FLOW	=	3.9
INLET NOZZLE	=	43.0
OUTLET NOZZLE	=	39.6

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	1.33	1.32
DENSITY	LB/FT3	61.291	61.823
PRESS. DROP	%	8.8	5.5

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

*** SPECIAL MESSAGES AND WARNINGS ***

WARNING--TUBESIDE FLUID HAS PASSED THROUGH TRANSITION ZONE. CONSIDER
RERUNNING WITH ITEM 132 IN EFFECT.
HEAT TRANSFER COEFF. AT RE = 2000 IS 221.80 BTU/HR-FT2-F
HEAT TRANSFER COEFF. AT RE = 10000 IS 1249.17 BTU/HR-FT2-F

□□Washington University ChE433 heat exchanger experiment E0002 P138
Young model F302DY4P 9/23/ 3
CASE 69

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.900		.600	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	101.6*	40.0	97.4*
DENSITY	LB/FT3	61.2913	61.8706	62.5352	61.9254
VISCOSITY	CP	.4726	.6805	1.4791	.7111
SPECIFIC HEAT	BTU/LB-F	.9973	.9986	1.0058	.9988
THERMAL COND.	BTU/HR-FT-F	.3723	.3636	.3466	.3626
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	120.8	95.3	68.7	93.9
VISCOSITY, AVG & SKIN	CP	.5618	.7275	.9943	.7387
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.15	10.00	.01	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.88	10.00	.09	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	289.94		244.74	

TOTAL HEAT DUTY REQUIRED MEGBTU/HR .034510
EFF TEMP DIF, DEGF (LMTD= 51.5,F= .84,BYPASS= .94,BAFF=1.00) 40.5
OVERALL COEFF REQUIRED BTU/HR-FT2-F 119.37
CLEAN & FOULED COEFF BTU/HR-FT2-F 123.12 119.80

SHELLS IN SERIES 1 PARALLEL 1		TOTAL EFF AREA FT2	7.1
PASSES, SHELL 1 TUBE 4		EFFECTIVE AREA FT2/SHELL	7.1
SHELL DIAMETER IN.	3.820	TEMA SHELL TYPE E ; REAR HEAD	FXTS
BAFFLE TYPE HORZ SEGMENTL		CROSS PASSES PER SHELL PASS	4
SPACING, CENTRAL IN.	4.309	BAFFLE CUT, PCT SHELL I.D.	30.00
SPACING, INLET IN.	4.309	CUT DISTANCE FROM CENTER, IN.	.764
SPACING, OUTLET IN.	4.309		
BAFFLE THICKNESS IN.	.125	IMPINGEMENT BAFFLE INCLUDED	NO
PAIRS OF SEALING DEVICES	1	TUBESHEET BLANK AREA, %	.0
TUBE TYPE	PLAIN	MATERIAL	ELECTROLYTIC COPPER
NO. OF TUBES/SHELL	76	EST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT	1.500	TUBE PITCH IN.	.3125
TUBE LGTH, EFF FT	1.436	TUBE OUTSIDE DIAM IN.	.250

TUBE LAYOUT	DEG 60	TUBE INSIDE DIAM	IN. .214
PITCH RATIO	1.250	TUBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT	1.0 1.0	TUBE NOZZ ID, IN&OUT	IN. .8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.042	.958
PRANDTL NUMBER	6.8	3.7
RYNLD NO, AVG	228.	2524.
RYNLD NO, IN BUN	153.	3001.
RYNLD NO,OUT BUN	318.	2084.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
48.40	48.92	2.60	.09

PCT OVER DESIGN	.36
TOT FOUL RESIST	.000217
DIFF RESIST	.000030

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.49	.49
DENSITY	LB/FT3	62.535	61.925
NOZZ RHO*VSQ	LB/FT-S2	14	15
BUND RHO*VSQ	LB/FT-S2	10	10

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	1.33	1.32
DENSITY	LB/FT3	61.291	61.871
PRESS. DROP	%	8.7	5.5

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW	FT/S	.08
NOMINAL VEL,WINDOW	FT/S	.15
CROSSFLOW COEF	BTU/HR-FT2-F	245.7
WINDOW COEF	BTU/HR-FT2-F	247.2

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.62
TUBE TO BAFFLE LEAKAGE	A =	3.35
MAIN CROSSFLOW	B =	66.80
BUNDLE TO SHELL BYPASS	C =	14.14
BAFFLE TO SHELL LEAKAGE	E =	15.71
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.656
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.713
END (HT LOSS IN END ZONE)	=	.994

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	8.8
END ZONE	=	4.3
CROSS FLOW	=	3.7
INLET NOZZLE	=	43.2
OUTLET NOZZLE	=	40.1

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

*** SPECIAL MESSAGES AND WARNINGS ***

WARNING--TUBESIDE FLUID HAS PASSED THROUGH TRANSITION ZONE. CONSIDER
RERUNNING WITH ITEM 132 IN EFFECT.
HEAT TRANSFER COEFF. AT RE = 2000 IS 222.45 BTU/HR-FT2-F
HEAT TRANSFER COEFF. AT RE = 10000 IS 1252.13 BTU/HR-FT2-F

CASE 70

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.900		.700	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	98.5*	40.0	93.1*
DENSITY	LB/FT3	61.2913	61.9112	62.5352	61.9808
VISCOSITY	CP	.4726	.7029	1.4791	.7451
SPECIFIC HEAT	BTU/LB-F	.9973	.9988	1.0058	.9992
THERMAL COND.	BTU/HR-FT-F	.3723	.3629	.3466	.3615
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	119.3	92.1	66.6	90.7
VISCOSITY, AVG & SKIN	CP	.5700	.7535	1.0220	.7659
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.15	10.00	.01	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.88	10.00	.11	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	285.83		268.89	

TOTAL HEAT DUTY REQUIRED	MEGBTU/HR	.037259
EFF TEMP DIF, DEGF (LMTD= 52.5,F= .85,BYPASS= .94,BAFF=1.00)		41.8
OVERALL COEFF REQUIRED	BTU/HR-FT2-F	124.74
CLEAN & FOULED COEFF	BTU/HR-FT2-F	127.99 / 124.33

SHELLS IN SERIES 1 PARALLEL 1		TOTAL EFF AREA FT2	7.1
PASSES, SHELL 1 TUBE 4		EFFECTIVE AREA FT2/SHELL	7.1
SHELL DIAMETER IN.	3.820	TEMA SHELL TYPE E ; REAR HEAD FXTS	
BAFFLE TYPE HORZ SEGMENTL		CROSS PASSES PER SHELL PASS	4
SPACING, CENTRAL IN.	4.309	BAFFLE CUT, PCT SHELL I.D.	30.00
SPACING, INLET IN.	4.309	CUT DISTANCE FROM CENTER, IN.	.764
SPACING, OUTLET IN.	4.309		
BAFFLE THICKNESS IN.	.125	IMPINGEMENT BAFFLE INCLUDED	NO
PAIRS OF SEALING DEVICES	1	TUBESHEET BLANK AREA, %	.0
TUBE TYPE	PLAIN	MATERIAL ELECTROLYTIC COPPER	
NO. OF TUBES/SHELL	76	EST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT	1.500	TUBE PITCH IN.	.3125
TUBE LGTH, EFF FT	1.436	TUBE OUTSIDE DIAM IN.	.250
TUBE LAYOUT DEG	60	TUBE INSIDE DIAM IN.	.214
PITCH RATIO	1.250	TUBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT	1.0 1.0	TUBE NOZZ ID, IN&OUT IN.	.8 .8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.041	.954
PRANDTL NUMBER	7.0	3.7
RYNLD NO, AVG	258.	2488.
RYNLD NO, IN BUN	178.	3001.
RYNLD NO,OUT BUN	354.	2018.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
45.72	51.50	2.70	.09

PCT OVER DESIGN	-.33
TOT FOUL RESIST	.000217
DIFF RESIST	-.000027

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.57	.58
DENSITY	LB/FT3	62.535	61.981
NOZZ RHO*VSQ	LB/FT-S2	20	20
BUND RHO*VSQ	LB/FT-S2	13	13

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	1.33	1.32
DENSITY	LB/FT3	61.291	61.911
PRESS. DROP	%	8.7	5.5

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW	FT/S	.09
NOMINAL VEL,WINDOW	FT/S	.18
CROSSFLOW COEF	BTU/HR-FT2-F	270.0
WINDOW COEF	BTU/HR-FT2-F	271.6

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.61
TUBE TO BAFFLE LEAKAGE	A =	3.51
MAIN CROSSFLOW	B =	66.07
BUNDLE TO SHELL BYPASS	C =	14.83
BAFFLE TO SHELL LEAKAGE	E =	15.59
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.672
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.731
END (HT LOSS IN END ZONE)	=	.994

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	8.8
END ZONE	=	4.0
CROSS FLOW	=	3.5
INLET NOZZLE	=	43.2
OUTLET NOZZLE	=	40.5

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

*** SPECIAL MESSAGES AND WARNINGS ***

WARNING--TUBESIDE FLUID HAS PASSED THROUGH TRANSITION ZONE. CONSIDER
RERUNNING WITH ITEM 132 IN EFFECT.
HEAT TRANSFER COEFF. AT RE = 2000 IS 222.89 BTU/HR-FT2-F
HEAT TRANSFER COEFF. AT RE = 10000 IS 1254.82 BTU/HR-FT2-F

□□Washington University ChE433 heat exchanger experiment E0002 P142
Young model F302DY4P 9/23/ 3
CASE 71

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ .900 IN	HOT TUBE SIDE Tube SENSIBLE LIQ .900 OUT	COLD SHELL SIDE Shell SENSIBLE LIQ .800 IN	COLD SHELL SIDE Shell SENSIBLE LIQ .800 OUT
TOTAL FLOW RATE	KLB/HR				
TEMPERATURE	DEGF	140.0	96.1*	40.0	89.2*
DENSITY	LB/FT3	61.2913	61.9432	62.5352	62.0297

VISCOSITY	CP	.4726	.7216	1.4791	.7782
SPECIFIC HEAT	BTU/LB-F	.9973	.9990	1.0058	.9995
THERMAL COND.	BTU/HR-FT-F	.3723	.3623	.3466	.3605
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	118.0	89.3	64.6	87.8
VISCOSITY, AVG & SKIN	CP	.5767	.7775	1.0481	.7911
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOWED	PSI	.15	10.00	.01	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.88	10.00	.12	10.00
FOULING RESISTANCE	HR-FT2-F/BTU	.00010		.00010	
FILM COEFFICIENT	BTU/HR-FT2-F	282.55		292.45	

TOTAL HEAT DUTY REQUIRED	MEGBTU/HR	.039460
EFF TEMP DIF, DEGF (LMTD= 53.4,F= .86,BYPASS= .94,BAFF=1.00)		43.1
OVERALL COEFF REQUIRED	BTU/HR-FT2-F	128.01
CLEAN & FOULED COEFF	BTU/HR-FT2-F	132.26 / 128.29

SHELLS IN SERIES	1	PARALLEL	1
PASSES, SHELL	1	TUBE	4
SHELL DIAMETER IN.			3.820
TOTAL EFF AREA	FT2		7.1
EFFECTIVE AREA	FT2/SHELL		7.1
TEMA SHELL TYPE	E	; REAR HEAD	FXTS

BAFFLE TYPE	HORZ	SEGMENTL	
SPACING, CENTRAL	IN.		4.309
SPACING, INLET	IN.		4.309
SPACING, OUTLET	IN.		4.309
BAFFLE THICKNESS	IN.		.125
PAIRS OF SEALING DEVICES			1
CROSS PASSES PER SHELL PASS			4
BAFFLE CUT, PCT SHELL I.D.			30.00
CUT DISTANCE FROM CENTER, IN.			.764
IMPINGEMENT BAFFLE INCLUDED			NO
TUBESHEET BLANK AREA, %			.0

TUBE TYPE		PLAIN	
NO. OF TUBES/SHELL			76
TUBE LGTH, OVERALL	FT		1.500
TUBE LGTH, EFF	FT		1.436
TUBE LAYOUT	DEG		60
PITCH RATIO			1.250
SHL NOZZ ID, IN&OUT	1.0	1.0	
MATERIAL		ELECTROLYTIC COPPER	
EST MAX TUBE COUNT			36
TUBE PITCH	IN.		.3125
TUBE OUTSIDE DIAM	IN.		.250
TUBE INSIDE DIAM	IN.		.214
TUBE SURFACE RATIO, OUT/IN			1.184
TUBE NOZZ ID, IN&OUT	IN.	.8	.8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.040	.951
PRANDTL NUMBER	7.2	3.8
RYNLD NO, AVG	288.	2459.
RYNLD NO, IN BUN	204.	3001.
RYNLD NO,OUT BUN	388.	1965.
FOULNG LAYER IN.	.0014	.0014

SHELLSIDE PERFORMANCE		
NOMINAL VEL,X-FLOW	FT/S	.10
NOMINAL VEL,WINDOW	FT/S	.20
CROSSFLOW COEF	BTU/HR-FT2-F	293.7
WINDOW COEF	BTU/HR-FT2-F	295.3
SHELLSIDE FLOW, % OF TOTAL		
HEAT TRANSFER X-FLOW		81.60

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
43.37	53.75	2.78	.09

PCT OVER DESIGN	.21
TOT FOUL RESIST	.000217
DIFF RESIST	.000017

TUBE TO BAFFLE LEAKAGE	A =	3.65
MAIN CROSSFLOW	B =	65.61
BUNDLE TO SHELL BYPASS	C =	15.26
BAFFLE TO SHELL LEAKAGE	E =	15.49
TUBE PASSLANE BYPASS	F =	.00

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000
TUBE TO BAFFLE HOLE	IN.	.0284
BAFFLE TO SHELL	IN.	.1000

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.689
BETA (BAFF CUT FACTOR)	=	.920
GAMMA (TUBE ROW ENTRY EFCT)	=	.749
END (HT LOSS IN END ZONE)	=	.994

SHELL NOZZLE DATA		IN	OUT
HT UNDR NOZ	IN.	.25	
HT OPP NOZ	IN.	.25	
VELOCITY	FT/S	.65	.66
DENSITY	LB/FT3	62.535	62.030
NOZZ RHO*VSQ	LB/FT-S2	26	26
BUND RHO*VSQ	LB/FT-S2	18	18

SHELL PRESSURE DROP, % OF TOTAL

WINDOW	=	8.8
END ZONE	=	3.8
CROSS FLOW	=	3.3
INLET NOZZLE	=	43.3
OUTLET NOZZLE	=	40.8

TUBE NOZZLE DATA		IN	OUT
VELOCITY	FT/S	1.33	1.32
DENSITY	LB/FT3	61.291	61.943
PRESS. DROP	%	8.6	5.4

WEIGHT PER SHELL, LB

DRY	=	150.
WET	=	165.

*** SPECIAL MESSAGES AND WARNINGS ***

WARNING--TUBESIDE FLUID HAS PASSED THROUGH TRANSITION ZONE. CONSIDER
RERUNNING WITH ITEM 132 IN EFFECT.
HEAT TRANSFER COEFF. AT RE = 2000 IS 223.28 BTU/HR-FT2-F
HEAT TRANSFER COEFF. AT RE = 10000 IS 1256.35 BTU/HR-FT2-F

□□Washington University ChE433 heat exchanger experiment E0002 P144
Young model F302DY4P 9/23/ 3
CASE 72

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING

		HOT TUBE SIDE Tube SENSIBLE LIQ		COLD SHELL SIDE Shell SENSIBLE LIQ	
TOTAL FLOW RATE	KLB/HR	.900		.900	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	93.9*	40.0	85.9*
DENSITY	LB/FT3	61.2913	61.9710	62.5352	62.0703
VISCOSITY	CP	.4726	.7389	1.4791	.8082
SPECIFIC HEAT	BTU/LB-F	.9973	.9991	1.0058	.9998
THERMAL COND.	BTU/HR-FT-F	.3723	.3617	.3466	.3597
MOLAR MASS	LB/LBMOL	18.02		18.02	
TEMP, AVG & SKIN	DEGF	116.9	86.8	62.9	85.2
VISCOSITY, AVG & SKIN	CP	.5828	.7998	1.0710	.8146
PRESSURE, IN & DESIGN	PSIA	50.00	165.00	50.00	165.00

PRESSURE DROP, TOT & ALLOWED	PSI	.15	10.00	.02	10.00
VELOCITY, CALC & MAX ALLOWED	FT/S	.88	10.00	.14	10.00

FOULING RESISTANCE	HR-FT2-F/BTU	.00010	.00010
FILM COEFFICIENT	BTU/HR-FT2-F	279.61	315.87

TOTAL HEAT DUTY REQUIRED	MEGBTU/HR	.041407
EFF TEMP DIF, DEGF (LMTD= 54.0,F= .86,BYPASS= .95,BAFF=1.00)		44.1
OVERALL COEFF REQUIRED	BTU/HR-FT2-F	131.32
CLEAN & FOULED COEFF	BTU/HR-FT2-F	136.03 131.78

SHELLS IN SERIES	1	PARALLEL	1
PASSES, SHELL	1	TUBE	4
SHELL DIAMETER IN.			3.820

TOTAL EFF AREA	FT2		7.1
EFFECTIVE AREA	FT2/SHELL		7.1
TEMA SHELL TYPE	E	; REAR HEAD	FXTS

BAFFLE TYPE	HORZ	SEGMENTL	
SPACING, CENTRAL	IN.		4.309
SPACING, INLET	IN.		4.309
SPACING, OUTLET	IN.		4.309
BAFFLE THICKNESS	IN.		.125
PAIRS OF SEALING DEVICES			1

CROSS PASSES PER SHELL PASS			4
BAFFLE CUT, PCT SHELL I.D.			30.00
CUT DISTANCE FROM CENTER, IN.			.764
IMPINGEMENT BAFFLE INCLUDED			NO
TUBESHEET BLANK AREA, %			.0

TUBE TYPE			PLAIN
NO. OF TUBES/SHELL			76
TUBE LGTH, OVERALL	FT		1.500
TUBE LGTH, EFF	FT		1.436
TUBE LAYOUT	DEG		60
PITCH RATIO			1.250
SHL NOZZ ID, IN&OUT		1.0	1.0

MATERIAL			ELECTROLYTIC COPPER
EST MAX TUBE COUNT			36
TUBE PITCH	IN.		.3125
TUBE OUTSIDE DIAM	IN.		.250
TUBE INSIDE DIAM	IN.		.214
TUBE SURFACE RATIO, OUT/IN			1.184
TUBE NOZZ ID, IN&OUT	IN.	.8	.8

* CALCULATED ITEM--HEAT BALANCE CODE = 8

□□Washington University ChE433 heat exchanger experiment E0002 P145
Young model F302DY4P 9/23/ 3
CASE 72

S U P P L E M E N T A R Y R E S U L T S

HT PARAMETERS	SHELL	TUBE
WALL CORRECTION	1.039	.949
PRANDTL NUMBER	7.4	3.8
RYNLD NO, AVG	317.	2433.
RYNLD NO, IN BUN	229.	3001.
RYNLD NO,OUT BUN	420.	1919.
FOULNG LAYER IN.	.0014	.0014

THERMAL RESISTANCE, % OF TOTAL

SHELL	TUBE	FOULING	METAL
41.25	55.80	2.86	.09

PCT OVER DESIGN		.35
TOT FOUL RESIST		.000217
DIFF RESIST		.000027

DIAMETRAL CLEARANCES

BUNDLE TO SHELL	IN.	.5000

SHELLSIDE PERFORMANCE

NOMINAL VEL,X-FLOW	FT/S	.12
NOMINAL VEL,WINDOW	FT/S	.23
CROSSFLOW COEF	BTU/HR-FT2-F	317.2
WINDOW COEF	BTU/HR-FT2-F	318.9

SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW		81.58
TUBE TO BAFFLE LEAKAGE	A =	3.77
MAIN CROSSFLOW	B =	65.36
BUNDLE TO SHELL BYPASS	C =	15.46
BAFFLE TO SHELL LEAKAGE	E =	15.41
TUBE PASSLANE BYPASS	F =	.00

SHELLSIDE HEAT TRANSFER FACTORS

TOTAL =(BETA)(GAMMA)(FIN)	=	.706
BETA (BAFF CUT FACTOR)	=	.920

TUBE TO BAFFLE HOLE	IN.	.0284		GAMMA (TUBE ROW ENTRY EFCT)	=	.767
BAFFLE TO SHELL	IN.	.1000		END (HT LOSS IN END ZONE)	=	.994

SHELL NOZZLE DATA		IN	OUT	SHELL PRESSURE DROP, % OF TOTAL		
HT UNDR NOZ	IN.	.25		WINDOW	=	8.8
HT OPP NOZ	IN.	.25		END ZONE	=	3.6
VELOCITY	FT/S	.73	.74	CROSS FLOW	=	3.2
DENSITY	LB/FT3	62.535	62.070	INLET NOZZLE	=	43.3
NOZZ RHO*VSQ	LB/FT-S2	33	33	OUTLET NOZZLE	=	41.0
BUND RHO*VSQ	LB/FT-S2	22	23			

TUBE NOZZLE DATA		IN	OUT	WEIGHT PER SHELL, LB		
VELOCITY	FT/S	1.33	1.31	DRY	=	150.
DENSITY	LB/FT3	61.291	61.971	WET	=	165.
PRESS. DROP	%	8.6	5.4			

*** SPECIAL MESSAGES AND WARNINGS ***

WARNING--TUBESIDE FLUID HAS PASSED THROUGH TRANSITION ZONE. CONSIDER
RERUNNING WITH ITEM 132 IN EFFECT.
HEAT TRANSFER COEFF. AT RE = 2000 IS 223.58 BTU/HR-FT2-F
HEAT TRANSFER COEFF. AT RE = 10000 IS 1257.62 BTU/HR-FT2-F