Washington University ChE433 heat exchanger experiment E0002 P 2 Young model F302DY4P 9/23/ 3

CASE 1

SIZE	4 –	18	TYPE	BEM,	MULTI-PASS	FLOW,	SEGMENTAL	BAFFLES,	RATING
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SIZE 4- 18 TYPE BE	M, MULTI-PASS F	FLOW, SEGME	NTAL BAFFL	ES, RATING	
		HOT TU	BE SIDE	COLD SH	ELL SIDE
		Tube		Shell	
		SENSI	BLE LIQ	SENSI	BLE LIQ
TOTAL FLOW RATE	KLB/HR		.100		.200
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	86.7*	70.0	96.6*
DENSITY	LB/FT3	61.2913	62.0604	62.2515	61.9363
VISCOSITY	CP	.4726	.8006	.9783	.7175
SPECIFIC HEAT THERMAL COND.	BTU/LB-F	.9973	.9997	1.0015	.9989
THERMAL COND.	BTU/HR-FT-F	.3723	.3599	.3554	. 3624
MOLAR MASS	T.B / T.BMOT.		18.02		18.02
	בטין בטווטב	.3723			
TEMP, AVG & SKIN	DEGE	113.4	99.8	83.3	99.3
VISCOSITY AVG & ST	KIN CP	6035	6933	83.3 .8329	6969
VISCOSITY, AVG & SI PRESSURE, IN & DES	TON DOTA	50 00	165 00	50 00	165 00
INESSONE, IN & DES	IGN ISIA	30.00	103.00	30.00	103.00
DDFSSIIDF DOOD TOT	s allowed bei	г 01	10 00	0.0	10 00
PRESSURE DROP, TOT VELOCITY, CALC & M.	A ALLOWED ED.	/0 10	10.00	.00	10.00
VELOCITI, CALC & M.	AN ALLOWED FI/	.10	10.00	.03	10.00
EQUITING DESIGNANCE	UD_ETO_E /I	O TITO	0010	0	0010
FOULING RESISTANCE FILM COEFFICIENT		DIU .U	0 10	.0	3.27
	DIU/ NR-F12				3.21
TOTAL HEAT DUTY RE					.005317
EFF TEMP DIF, DEGF	ZOIKED MEGDIO/F	- 40 DVD1	CC- 02 DA	EE-1 00)	10.3
OVERALL COEFF REQU	TDED DMII/ID I	40,61FA	.32, DA	FF-1.00)	71.96
CLEAN & FOULED COE	IKED BIU/HK-H	7 I Z - F	72.0	0	
CLEAN & FOULED COE.	FF BTU/HK-F	72-F	72.9	U	71.77
CURLIC IN CERTEC	1 האהאנד 1		1 7 0 0 7	TITE O	7 1
SHELLS IN SERIES PASSES, SHELL	1 PARALLEL 1	TOTAL EFF	AKLA	FTZ	7.1
PASSES, SHELL	I TUBE 4	EFFECTIVE	AKEA	FTZ/SHELL	1.\
SHELL DIAMETER IN.	3.820	TEMA SHEL	L TYPE E	; REAR HE	AD FXTS
	000				4
BAFFLE TYPE HOSPACING, CENTRAL	JRZ SEGMENTL	CROSS PAS	SES PER SH	ELL PASS	4
SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING D	IN. 4.309	BAFFLE CU	T, PCT SHE.	LL I.D.	30.00
SPACING, INLET	IN. 4.309	CUT DISTA	NCE FROM C.	ENTER, IN.	. / 64
SPACING, OUTLET	IN. 4.309				
BAFFLE THICKNESS	IN125	IMPINGEME	INT BAFFLE	INCLUDED	NO
PAIRS OF SEALING D	EVICES 1	TUBESHEET	' BLANK ARE	A, %	.0
TUBE TYPE				LECTROLYTIC	
NO. OF TUBES/SHELL TUBE LGTH, OVERALL	76	EST MAX T	UBE COUNT		36
TUBE LGTH, OVERALL	FT 1.500	TUBE PITC	H	IN.	.3125
TUBE LGTH, EFF	FT 1.436	TUBE OUTS	SIDE DIAM	IN.	.250
TUBE LAYOUT	DEG 60	TUBE INSI	DE DIAM	IN.	.214
TUBE LAYOUT PITCH RATIO	1.250	TUBE SURF	'ACE RATIO,	OUT/IN	1.184
SHL NOZZ ID, IN&OU	T 1.0 1.0	TUBE NOZZ	ID, IN&OU'	T IN.	.8 .8

<sup>\*</sup> CALCULATED ITEM--HEAT BALANCE CODE = 8

Washington University ChE433 heat exchanger experiment  $\,$  E0002 P  $\,$  3 Young model F302DY4P 9/23/ 3

HT PARAMETERS	S U P P L E	M E N T A	R Y	R E S U	L T S	
WALL CORRECTION   1.025   0.00   NOMINAL VEL, X-FLOW   FT/S   0.05	HT PARAMETERS	SHELL TUBE	SHET	LSIDE PERFO	RMANCE	
READDIL NUMBER   5.6   4.0   NOMINAL VEL, WINDOW FM/S   134.2   RYNLD NO, AVG   89. 261.   CROSSFLOW COEF   BTU/HR-FT2-F   134.2   RYNLD NO, ON BUN   76. 333.   WINDOW COEF   BTU/HR-FT2-F   132.8   RYNLD NO, OUT BUN   103. 197.						03
RYNLD NO, AVG						
RYNLD NO, IN BUN						
RYNLD NO, OUT BUN   101						
FOULING LAYER IN.   .0014				COLL	DIO/IIIC IIZ	1 132.0
HEAT TRANSFER X-FLOW				LSIDE FLOW	% OF TOTAL	
THERMAL RESISTANCE, % OF TOTAL   TUBE TO BAFFLE LEAKAGE   A = 2.57	TOOLING LITTLIK IN.			•		
SHELL   TUBE   FOULING   METAL   MAIN CROSSFLOW   B = 68.27   53.25   45.15   1.56   .05   BUNDLE TO SHELL LEARAGE   E = 17.87   TOT FOUL RESIST   .000217   TUBE PASSLANE BYPASS   F = .00   DIFF RESIST  000037   TUBE PASSLANE BYPASS   F = .00   DIFF RESIST  000037   TUBE PASSLANE BYPASS   F = .00   DIFF RESIST  000037   TUBE PASSLANE BYPASS   F = .00   DIAMETRAL CLEARANCES   TOTAL = (BETA) (GAMMA) (FIN)   = .598   BUNDLE TO SHELL   IN0284   GAMMA (TUBE ROW ENTRY EFFT)   = .650   BAFFLE HOLE   IN0284   GAMMA (TUBE ROW ENTRY EFFT)   = .650   BAFFLE TO SHELL   IN1000   END (HT LOSS IN END ZONE)   = .997   DIAMETRAL CLEARANCES   TOTAL = (BETA) (GAMMA) (FIN)   = .598   BUNDLE TO SHELL   IN0284   GAMMA (TUBE ROW ENTRY EFFT)   = .650   BAFFLE TO SHELL   IN1000   END (HT LOSS IN END ZONE)   = .997   DIAMETRAL CLEARANCES   IN1000   END (HT LOSS IN END ZONE)   = .997   DIAMETRAL CLEARANCES   IN1000   END (HT LOSS IN END ZONE)   = .997   DIAMETRAL CLEARANCES   IN1000   END (HT LOSS IN END ZONE)   = .997   DIAMETRAL CLEARANCES   IN25   END ZONE   = .7.3   DIAMETRAL CLEARANCES   IN25   END ZONE   = .934   DIAMETRAL CLEARANCES   END ZONE   END ZONE   = .934   DIAMETRAL CLEARANCES   END ZONE   END Z	THERMAL RESISTANCE			-		
S3.25   45.15   1.56						
PCT OVER DESIGN						
TOT FOUL RESIST						
DIFF RESIST						
SHELLSIDE HEAT TRANSFER FACTORS   TOTAL   (BETA) (GAMMA) (FIN)   = .598			TODE I	ASSLAND DIT	100 1	00
DIAMETRAL CLEARANCES			SHET	тетре неде ј	TRANSFER FA	CTORS
BUNDLE TO SHELL IN5000 BETA (BAFF CUT FACTOR) = .920 TUBE TO BAFFLE HOLE IN0284 GAMMA (TUBE ROW ENTRY EFCT) = .650 BAFFLE TO SHELL IN1000 END (HT LOSS IN END ZONE) = .997  SHELL NOZZLE DATA IN OUT SHELL PRESSURE DROP, % OF TOTAL HT UNDR NOZ IN25 WINDOW = 9.8 HT OPP NOZ IN25 END ZONE = 7.3 VELOCITY FT/S .16 .16 CROSS FLOW = 5.6 DENSITY LB/FT3 62.252 61.936 INLET NOZZLE = 39.4 NOZZ RHO*VSQ LB/FT-S2 1 1 OUTLET NOZZLE = 37.9 BUND RHO*VSQ LB/FT-S2 1 1  TUBE NOZZLE DATA IN OUT WEIGHT PER SHELL, LB VELOCITY FT/S .15 .15 DRY = 165. DENSITY LB/FT3 61.291 62.060 WET = 165. PRESS. DROP % 2.3 1.5 Washington University Che433 heat exchanger experiment	DIAMETRAI, CLEARA	NCES	TOTAL.			
TUBE TO BAFFLE HOLE   IN.   .00284   GAMMA (TUBE ROW ENTRY EFCT)   = .650						
### SHELL NOZZLE DATA						
SHELL NOZZLE DATA IN OUT SHELL PRESSURE DROP, % OF TOTAL HT UNDR NOZ IN25 WINDOW = 9.8 HT OPP NOZ IN25 END ZONE = 7.3 VELOCITY FT/S .16 .16 CROSS FLOW = 5.6 DENSITY LB/FT3 62.252 61.936 INLET NOZZLE = 39.4 NOZZ RHO*VSQ LB/FT-S2 1 1 OUTLET NOZZLE = 37.9 BUND RHO*VSQ LB/FT-S2 1 1  TUBE NOZZLE DATA IN OUT WEIGHT PER SHELL, LB VELOCITY FT/S .15 .15 DRY = 165.  PRESS. DROP % 2.3 1.5 Washington University ChE433 heat exchanger experiment						
HT UNDR NOZ IN25						
HT OPP NOZ IN.   .25	SHELL NOZZLE DAT	A IN OUT	SHEL	L PRESSURE	DROP, % OF	TOTAL
VELOCITY	HT UNDR NOZ IN.	.25	WINDOW			= 9.8
DENSITY LB/FT3 62.252 61.936 INLET NOZZLE = 39.4  NOZZ RHO*VSQ LB/FT-S2 1 1 0UTLET NOZZLE = 37.9  BUND RHO*VSQ LB/FT-S2 1 1  TUBE NOZZLE DATA IN OUT WEIGHT PER SHELL, LB  VELOCITY FT/S .15 .15 DRY = 150.  DENSITY LB/FT3 61.291 62.060 WET = 165.  PRESS. DROP % 2.3 1.5  Washington University Che433 heat exchanger experiment	HT OPP NOZ IN.	.25	END ZO	NE		= 7.3
NOZZ RHO*VSQ LB/FT-S2 1 1 0 OUTLET NOZZLE	VELOCITY FT/S	.16 .16	CROSS	FLOW		
### BUND RHO*VSQ LB/FT-S2 1 1  TUBE NOZZLE DATA IN OUT WEIGHT PER SHELL, LB  VELOCITY FT/S .15 .15 DRY = 150.  DENSITY LB/FT3 61.291 62.060 WET = 165.  PRESS. DROP % 2.3 1.5  Washington University Che433 heat exchanger experiment	DENSITY LB/FT3	62.252 61.936	INLET	NOZZLE		= 39.4
TUBE NOZZLE DATA IN OUT WEIGHT PER SHELL, LB  VELOCITY FT/S	NOZZ RHO*VSQ LB/FT	3-S2 1 1	OUTLET	NOZZLE		= 37.9
VELOCITY         FT/S         .15         .15         DRY         =         150.           DENSITY         LB/FT3         61.291 62.060         WET         =         165.           PRESS. DROP %         2.3         1.5           Washington University ChE433 heat exchanger experiment         E0002 P 4           Young model F302DY4P         9/23/3         CASE 2           SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING         HOT TUBE SIDE         COLD SHELL SIDE           TUBE         SENSIBLE LIQ         SENSIBLE LIQ         SENSIBLE LIQ           TOTAL FLOW RATE         KLB/HR         .100         .300           TEMPERATURE         DEGF         140.0         81.5*         70.0         89.4*           DENSITY         LB/FT3         61.2913         62.1221         62.2515         62.0270           VISCOSITY         CP         .4726         .8501         .9783         .7763           SPECIFIC HEAT         BTU/LB-F         .9973         1.0002         1.0015         .9995           THERMAL COND.         BTU/HR-FT-F         .3723         .3585         .3554         .3606 <td>BUND RHO*VSQ LB/FT</td> <td>-S2 1 1</td> <td></td> <td></td> <td></td> <td></td>	BUND RHO*VSQ LB/FT	-S2 1 1				
VELOCITY         FT/S         .15         .15         DRY         =         150.           DENSITY         LB/FT3         61.291 62.060         WET         =         165.           PRESS. DROP %         2.3         1.5           Washington University ChE433 heat exchanger experiment         E0002 P 4           Young model F302DY4P         9/23/3         CASE 2           SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING         HOT TUBE SIDE         COLD SHELL SIDE           TUBE         SENSIBLE LIQ         SENSIBLE LIQ         SENSIBLE LIQ           TOTAL FLOW RATE         KLB/HR         .100         .300           TEMPERATURE         DEGF         140.0         81.5*         70.0         89.4*           DENSITY         LB/FT3         61.2913         62.1221         62.2515         62.0270           VISCOSITY         CP         .4726         .8501         .9783         .7763           SPECIFIC HEAT         BTU/LB-F         .9973         1.0002         1.0015         .9995           THERMAL COND.         BTU/HR-FT-F         .3723         .3585         .3554         .3606 <td>TUBE NOZZLE DATA</td> <td>IN OUT</td> <td>' WEIG</td> <td>HT PER SHEL</td> <td>L, LB</td> <td></td>	TUBE NOZZLE DATA	IN OUT	' WEIG	HT PER SHEL	L, LB	
PRESS. DROP %       2.3 1.5         Washington University ChE433 heat exchanger experiment       E0002 P 4         Young model F302DY4P       9/23/3         CASE 2         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       .100       .300         TEMPERATURE       DEGF       140.0       81.5*       70.0       89.4*         DENSITY       LB/FT3       61.2913       62.1221       62.2515       62.0270         VISCOSITY       CP       .4726       .8501       .9783       .7763         SPECIFIC HEAT       BTU/LB-F       .9973       1.0002       1.0015       .9995         THERMAL COND.       BTU/HR-FT-F       .3723       .3585       .354       <	VELOCITY FT/S	.15 .15	DRY		=	150.
Washington University ChE433 heat exchanger experiment       E0002 P 4         Young model F302DY4P       9/23/ 3 CASE 2         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       100       SENSIBLE LIQ         TOTAL FLOW RATE       KLB/HR       100       300         TEMPERATURE       DEGF       140.0       81.5*       70.0       89.4*         DENSITY       LB/FT3       61.2913       62.1221       62.2515       62.0270         VISCOSITY       CP       4726       .8501       .9783       .7763         SPECIFIC HEAT       BTU/LB-F       .9973       1.0002       1.0015       .9995         THEMMAL COND       BTU/HR-FT-F       .3723       .3554       .3606         <	DENSITY LB/FT3	61.291 62.060	WET		=	165.
Young model F302DY4P  SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING  HOT TUBE SIDE  TUBE  TUBE  Shell  SENSIBLE LIQ  SENSIBLE LIQ  TOTAL FLOW RATE  KLB/HR  IN  OUT  TEMPERATURE  DEGF  140.0  81.5*  70.0  89.4*  DENSITY  LB/FT3  61.2913  62.1221  62.2515  62.0270  VISCOSITY  CP  4726  8501  9783  7763  SPECIFIC HEAT  BTU/LB-F  9973  1.0002  1.0015  9995  THERMAL COND.  BTU/HR-FT-F  3723  3585  3554  3606  MOLAR MASS  LB/LBMOL  18.02  TEMP, AVG & SKIN  DEGF  110.8  95.4  79.7  94.8	PRESS. DROP %	2.3 1.5	1			
CASE 2  SIZE 4-18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING  HOT TUBE SIDE  Tube  Shell  SENSIBLE LIQ  SENSIBLE LIQ  TOTAL FLOW RATE  KLB/HR  IN  OUT  TEMPERATURE  DEGF  140.0  81.5*  70.0  89.4*  DENSITY  LB/FT3  61.2913  62.1221  62.2515  62.0270  VISCOSITY  CP  .4726  .8501  .9783  .7763  SPECIFIC HEAT  BTU/LB-F  .9973  1.0002  1.0015  .9995  THERMAL COND.  BTU/HR-FT-F  .3723  .3585  .3554  .3606  MOLAR MASS  LB/LBMOL  18.02  TEMP, AVG & SKIN  DEGF  110.8  95.4  79.7  94.8	Washington Unive	ersity ChE433 he	at exchan	ger experime	ent	E0002 P 4
SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING	Young model F302DY	74P				9/23/ 3
HOT TUBE SIDE   COLD SHELL SIDE						CASE 2
Tube     Shell       SENSIBLE LIQ       SENSIBLE LIQ       TOTAL FLOW RATE     KLB/HR     .100     .300       IN     OUT     IN     OUT       TEMP, AVG & SKIN     DEGF     140.0     81.5*     70.0     89.4*       DEGF     140.0     81.0015     .9995       THERMAL COND.     BTU/HR-FT-F     .3723     .3585     .3554     .3606       MOLAR MASS     LB/LBMOL     18.02     18.02       TEMP, AVG & SKIN     DEGF     110.8     95.4     79.7     .94.8	SIZE 4- 18 TYPE BE	CM, MULTI-PASS F	LOW, SEGM	ENTAL BAFFL	ES, RATING	
SENSIBLE LIQ   SENSIBLE LIQ			HOT T	UBE SIDE	COLD SH	ELL SIDE
TOTAL FLOW RATE   KLB/HR			Tube		Shell	
IN         OUT         IN         OUT           TEMPERATURE         DEGF         140.0         81.5*         70.0         89.4*           DENSITY         LB/FT3         61.2913         62.1221         62.2515         62.0270           VISCOSITY         CP         .4726         .8501         .9783         .7763           SPECIFIC HEAT         BTU/LB-F         .9973         1.0002         1.0015         .9995           THERMAL COND.         BTU/HR-FT-F         .3723         .3585         .3554         .3606           MOLAR MASS         LB/LBMOL         18.02         18.02           TEMP, AVG & SKIN         DEGF         110.8         95.4         79.7         94.8			SENS	IBLE LIQ	SENSI	BLE LIQ
TEMPERATURE         DEGF         140.0         81.5*         70.0         89.4*           DENSITY         LB/FT3         61.2913         62.1221         62.2515         62.0270           VISCOSITY         CP         .4726         .8501         .9783         .7763           SPECIFIC HEAT         BTU/LB-F         .9973         1.0002         1.0015         .9995           THERMAL COND.         BTU/HR-FT-F         .3723         .3585         .3554         .3606           MOLAR MASS         LB/LBMOL         18.02         18.02           TEMP, AVG & SKIN         DEGF         110.8         95.4         79.7         94.8	TOTAL FLOW RATE	KLB/HR		.100		.300
DENSITY LB/FT3 61.2913 62.1221 62.2515 62.0270 VISCOSITY CP .4726 .8501 .9783 .7763 SPECIFIC HEAT BTU/LB-F .9973 1.0002 1.0015 .9995 THERMAL COND. BTU/HR-FT-F .3723 .3585 .3554 .3606 MOLAR MASS LB/LBMOL 18.02 18.02 TEMP, AVG & SKIN DEGF 110.8 95.4 79.7 94.8			IN	OUT	IN	OUT
VISCOSITY CP .4726 .8501 .9783 .7763 SPECIFIC HEAT BTU/LB-F .9973 1.0002 1.0015 .9995 THERMAL COND. BTU/HR-FT-F .3723 .3585 .3554 .3606 MOLAR MASS LB/LBMOL 18.02 18.02 TEMP, AVG & SKIN DEGF 110.8 95.4 79.7 94.8	TEMPERATURE	DEGF	140.0	81.5*	70.0	89.4*
SPECIFIC HEAT       BTU/LB-F       .9973       1.0002       1.0015       .9995         THERMAL COND.       BTU/HR-FT-F       .3723       .3585       .3554       .3606         MOLAR MASS       LB/LBMOL       18.02       18.02         TEMP, AVG & SKIN       DEGF       110.8       95.4       79.7       94.8	DENSITY	LB/FT3	61.2913	62.1221	62.2515	62.0270
THERMAL COND. BTU/HR-FT-F .3723 .3585 .3554 .3606 MOLAR MASS LB/LBMOL 18.02 .18.02 TEMP, AVG & SKIN DEGF 110.8 95.4 79.7 94.8	VISCOSITY	CP	.4726	.8501	.9783	.7763
MOLAR MASS LB/LBMOL 18.02 18.02 TEMP, AVG & SKIN DEGF 110.8 95.4 79.7 94.8	SPECIFIC HEAT	BTU/LB-F	.9973	1.0002	1.0015	.9995
TEMP, AVG & SKIN DEGF 110.8 95.4 79.7 94.8	THERMAL COND.	BTU/HR-FT-F	.3723	.3585	.3554	.3606
TEMP, AVG & SKIN DEGF 110.8 95.4 79.7 94.8	MOLAR MASS	LB/LBMOL				
·	TEMP, AVG & SKIN	DEGF				

PRESSURE DROP, TOT 6 ALLOWED PSI 0.01 10.00 .00 10.00  VELOCITY, CALC & MAX ALLOWED FT/S .10 10.00 .05 10.00  POULING RESISTANCE HR-FT2-F/BTU .00010 .00010  FILM COEFFICIENT BTU/HR-FT2-F 189.35 161.30  TOTAL HEAT DUTY REQUIRED MEGRTU/HR .000584  EFF TEMP DIF, DEGT (LMTD= 26.4, F= .42, BYPASS= .93, BAFF=1.00) 10.3  OVERALL COSFF REQUIRED BTU/HR-FT2-F 80.80 79.32  SHELLS IN SERIES 1 PARALLEL 1 TOTAL EFF AREA FT2/SHELL 7.1  SHELL SIN SERIES 1 PARALLEL 1 TOTAL EFF 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, INLET IN. 4.309 BAFFLE CUT, PCT SHELL ID. 30.00  SPACING, OUTLET IN. 4.309 CUT DISTANCE FROM CENTER, IN764  SPACING, OUTLET IN. 4.309 CUT DISTANCE FROM CENTER, IN764  SPACING, OUTLET IN. 4.309 CUT DISTANCE FROM CENTER, IN764  SPACING, OUTLET IN. 4.309 CUT DISTANCE FROM CENTER, IN764  SPACING, OUTLET IN. 4.309 CUT DISTANCE FROM CENTER, IN764  SPACING, OUTLET IN. 4.309 CUT DISTANCE FROM CENTER, IN764  SPACING, OUTLET IN. 4.309 CUT DISTANCE FROM CENTER, IN764  SPACING, OUTLET IN. 4.309 CUT DISTANCE FROM CENTER, IN764  SPACING, OUTLET IN. 4.309 CUT DISTANCE FROM CENTER, IN764  SPACING, OUTLET IN. 4.309 CUT DISTANCE FROM CENTER, IN764  SPACING, OUTLET IN. 4.309 CUT DISTANCE FROM CENTER, IN764  SPACING, OUTLET IN. 4.309 CUT DISTANCE FROM CENTER, IN764  SPACING, OUTLET IN. 4.309 CUT DISTANCE FROM CENTER, IN764  SPACING, OUTLET IN. 4.309 CUT DISTANCE FROM CENTER, IN764  SPACING, OUTLET IN. 4.309 CUT DISTANCE FROM CENTER, IN764  SPACING, OUTLET IN. 4.309 CUT DISTANCE FROM CENTER, IN764  SPACING, OUTLET IN. 4.309 CUT DISTANCE FROM CENTER, IN764  SPACING, OUTLET IN. 4.309 CUT DISTANCE FROM CENTER, IN764  TUBE TYPE SEALL TO COLOR T	PRESSURE, IN & DESIGN PSIA	50.00 165.00	50.00	165.00
TOTAL HEAT DUTY REQUIRED MEGBTU/HR	PRESSURE DROP, TOT & ALLOWED BY VELOCITY, CALC & MAX ALLOWED BY	PSI .01 10.00 FT/S .10 10.00	.00	10.00
### COTAL HEAT DUTY REQUIRED MEGBTU/HR  EFF TEMP DIF, DECF (IMITD= 26.4, F= .42, BYPASS= .93, BAFF=1.00)	FILM COEFFICIENT BTU/HR-F			
OVERALL COEFF REQUIRED   BTU/HR-FT2-F   80.80   78.99   CLEAN & FOULD COEFF   BTU/HR-FT2-F   80.80   79.32		J/HR		.005834
SHELLS IN SERIES 1 PARALLEL 1				
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, IN764 SPACING, OUTLET IN. 4.309 BAFFLE THICKNESS IN125 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 IN3125 TUBE LGTH, OVERALL FT 1.500 TUBE PITCH IN214 FITCH RATIO 1.250 TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN250 TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN214 SHL NOZZ ID, INGOUT 1.0 1.0 TUBE NOZZ ID, INGOUT IN8 .8  * CALCULATED ITEM—HEAT BALANCE CODE = 8 Washington University ChE433 heat exchanger experiment E0002 P 5 Young model F302DY4F 9/23/3 CASE 2  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 1.024 .000 NOMINAL VEL, X-FLOW FT/S .04 PRANDTA NUMBER 5.9 4.1 NOMINAL VEL, X-FLOW FT/S .08 RYNLD NO, AVG 130. 254. CROSSFLOW COEF BTU/HR-FT2-F 161.9 RYNLD NO, AVG 130. 254. CROSSFLOW COEF BTU/HR-FT2-F 162.9 RYNLD NO, OTT BUN 145. 185. FOULNG LAYER IN0014 .0014 SHELLSIDE FLOW, % OF TOTAL HEAT TRANSFER X-FLOW 81.17 THERMAL RESISTANCE, % OF TOTAL HEAT TRANSFER X-FLOW 81.17 THERMAL RESISTANCE, % OF TOTAL HEAT TRANSFER X-FLOW 81.17 THERMAL RESISTANCE, % OF TOTAL HEAT TRANSFER X-FLOW 81.17 THERMAL RESISTANCE, % OF TOTAL HEAT TRANSFER X-FLOW 81.17 THERMAL RESISTANCE, % OF TOTAL HEAT TRANSFER X-FLOW 81.17 THERMAL RESISTANCE, % OF TOTAL HEAT TRANSFER X-FLOW 81.17 THERMAL RESISTANCE, % OF TOTAL HEAT TRANSFER X-FLOW 81.17 THERMAL RESISTANCE, % OF TOTAL HEAT TRANSFER X-FLOW 81.17 THERMAL RESISTANCE, % OF TOTAL HEAT TRANSFER X-FLOW 81.17 THERMAL RESISTANCE, % OF TOTAL HEAT TRANSFER X-FLOW 81.17 THERMAL RESISTANCE, % OF TOTAL HEAT TRANSFER X-FLOW 81.17 THERMAL RE				
PASSES, SHELL	CLEAN & FOULED COEFF BTO/HE	<-F1Z-F 80	.80	19.32
### 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, OVERALL   FT   1.436   TUBE DIAM   IN.   .250   TUBE LGTH, OVERALL   FT   1.436   TUBE INSIDE DIAM   IN.   .214   PITCH RATIO   1.250   TUBE SURFACE RATIO, OUT/IN   1.184   SHL NOZZ ID, INGOUT   1.0   TUBE NOZZ ID, INGOUT   IN.   .8   .8    * CALCULATED ITEM—HEAT BALANCE CODE = 8   Washington University Che433 heat exchanger experiment   E0002 P   5   Young model   F302DY4P   9/23/3   CASE   2    ** CALCULATED ITEM—HEAT BALANCE CODE = 8   Washington University Che433 heat exchanger experiment   E0002 P   5   Young model   F302DY4P   9/23/3   CASE   2    ** THE PARAMETERS   SHELL   TUBE   SHELLSIDE PERFORMANCE   NOMINAL VEL, WINDOW   FT/S   .04   PRANDEL NUMBER   5.9   4.1   NOMINAL VEL, WINDOW   FT/S   .08   RYNLD NO, AVG   130.   254.   CROSSFLOW COEF   BTU/HR-FT2-F   161.9   RYNLD NO, OUT BUN   145.   185.   FOULMS LAYER IN.   .0014   .0014   SHELLSIDE FLOW, % OF TOTAL   HEAT TRANSFER X-FLOW   B   68.74   48.63   49.60   1.72   .06   BUNDLE TO SHELL BYPASS   C = 11.87   PCT OVER DESIGN   .42   BAFFLE TO SHELL LEAKAGE   E   16.64   TOT FOUL RESIST   .000015   TUBE PASSLANE BYPASS   F = .00   DIFF RESIST   .000053				
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, IN764 SPACING, OUTLET IN. 4.309 BAFFLE THICKNESS IN125 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 IN3125 TUBE LGTH, EFF FT 1.436 TUBE OUTSIDE DIAM IN250 TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN250 TUBE LAYOUT DEG 60 TUBE SURFACE RATIO, OUT/IN 1.184 SHL NOZZ ID, IN&OUT 1.0 1.0 TUBE NOZZ ID, IN&OUT IN8 .8  * CALCULATED ITEM-HEAT BALANCE CODE = 8 Washington University Che433 heat exchanger experiment E0002 P 5 Young model F302DY4P 9/23/3 CASE 2  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 1.024 .000 NOMINAL VEL, X-FLOW FT/S .04 PRANDTL NUMBER 5.9 4.1 NOMINAL VEL, WINDOW FT/S .08 RYNLD NO, AVG 130. 254. CROSSFLOW COEF BTU/HR-FT2-F 161.9 RYNLD NO, IN BUN 115. 333. WINDOW COEF BTU/HR-FT2-F 161.9 RYNLD NO, OUT BUN 145. 185. FOULNG LAYER IN0014 .0014 SHELLSIDE FLOW, % OF TOTAL HEAT TRANSFER X-FLOW B 168.74 48.63 49.60 1.72 .06 BUNDLE TO SHELL BYPASS C = 11.87 PCT OVER DESIGN .42 BAFFLE TO SHELL BYPASS C = 11.87 PCT OVER DESIGN .42 BAFFLE TO SHELL BYPASS C = 16.64 TOT FOUL RESIST .000017 TUBE FOULNESS TO TUBE PASSLANE BYPASS F = .00				
SPACING, CENTRAL IN. 4.309 BAFFLE CUT, PCT SHELL I.D. 30.00 SPACING, INLET IN. 4.309 CUT DISTANCE FROM CENTER, IN764 SPACING, OUTLET IN. 4.309 BAFFLE THICKNESS IN125 BAFFLE THICKNESS IN125 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 IN3125 TUBE LGTH, OVERALL FF 1.500 TUBE PITCH IN250 TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN250 TUBE LAYOUT DEG 60 TUBE SURFACE RATIO, OUT/IN 1.184 SHL NOZZ ID, INGOUT 1.0 1.0 TUBE NOZZ ID, INGOUT IN8 .8  * CALCULATED ITEMHEAT BALANCE CODE = 8 Washington University Che433 heat exchanger experiment E0002 P 5 Young model F302DY4P 223 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 1.024 .000 NOMINAL VEL, X-FLOW FT/S .04 PRANDTL NUMBER 5.9 4.1 NOMINAL VEL, X-FLOW FT/S .08 RYNLD NO, AVG 130. 254. CROSSFLOW COEF BTU/HR-FT2-F 161.9 RYNLD NO, OUT BUN 145. 185. FOULNG LAYER IN0014 .0014 SHELLSIDE FLOW, % OF TOTAL RYNLD NO, OUT BUN 145. 185. FOULNG LAYER IN0014 .0014 SHELLSIDE FLOW, % OF TOTAL BEAT TRANSFER X-FLOW 81.17 THERMAL RESISTANCE, % OF TOTAL TUBE TO BAFFLE LEAKAGE A = 2.75 SHELL TUBE FOULING METAL MAIN CROSSFLOW B = 68.74 48.63 49.60 1.72 .06 BUNDLE TO SHELL BEAKAGE A = 2.75 SHELL TUBE FOULING METAL MAIN CROSSFLOW B = 68.74 48.63 49.60 1.72 .06 BUNDLE TO SHELL BEAKAGE E = 16.64 TOT FOUL RESIST .000217 TUBE PASSLANE BYPASS F = .00 DIFF RESIST .000217 TUBE PASSLANE BYPASS F = .00	SHELL DIAMETER IN. 3.820	) TEMA SHELL TYPE	E ; REAR HEA	D FXTS
SPACING, INLET IN. 4.309 BAFFLE THICKNESS IN. 1.25 IMPINGEMENT BAFFLE INCLUDED  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 IN3125  TUBE LGTH, OVERALL FT 1.500 TUBE PITCH IN3125  TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN250  TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN214  PITCH RATIO 1.250 TUBE NOZZ ID, INGOUT IN8 8  * CALCULATED ITEM-HEAT BALANCE CODE = 8  Washington University ChE433 heat exchanger experiment 50002 P 5  Young model F302DY4P 9/23/3 CASE 2  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 1.024 .000 NOMINAL VEL, X-FLOW FT/S .08  RYNLD NO, AVG 130 .254. CROSSFLOW COEF BTU/HR-FT2-F 161.9  RYNLD NO, IN BUN 115 .333. WINDOW COEF BTU/HR-FT2-F 162.9  RYNLD NO, OUT BUN 145 .185.  FOULNG LAYER IN0014 .0014 SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW B 1.17  THERMAL RESISTANCE, % OF TOTAL TUBE TO BAFFLE LEARAGE A = 2.75  SHELL TUBE FOULING METAL MAIN CROSSFLOW B = 68.74  48.63 49.60 1.72 .06 BUNDLE TO SHELL LEARAGE E = 16.64  TOT FOUL RESIST .000013	BAFFLE TYPE HORZ SEGMENTI	CROSS PASSES PER	SHELL PASS	4
### SPACING, OUTLET IN. 4.309  BAFFLE THICKNESS IN125 IMPINGEMENT BAFFLE INCLUDED NO PAIRS OF SEALING DEVICES 1 TUBESHEET BLANK AREA, % .0  TUBE TYPE	SPACING, CENTRAL IN. 4.309	BAFFLE CUT, PCT S	HELL I.D.	30.00
BAFFLE THICKNESS IN. 1.25 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 IN3125 TUBE LGTH, OVERALL FT 1.500 TUBE PITCH IN3125 TUBE LGTH, EFF FT 1.436 TUBE OUTSIDE DIAM IN250 TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN214 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 IN8 .8  * CALCULATED ITEM-HEAT BALANCE CODE = 8 Washington University ChE433 heat exchanger experiment E0002 P 5 Young model F302DY4P 9/23/3 CASE 2  S U P 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 1.024 .000 NOMINAL VEL, X-FLOW FT/S .04 PRANDTL NUMBER 5.9 4.1 NOMINAL VEL, X-FLOW FT/S .08 RYNLD NO, AVG 130. 254. CROSSFLOW COFF BTU/HR-FT2-F 161.9 RYNLD NO, IN BUN 115. 333. WINDOW COFF BTU/HR-FT2-F 162.9 RYNLD NO, IN BUN 145. 185. FOULNG LAYER IN0014 .0014 SHELLSIDE FLOW, % OF TOTAL HEAT TRANSFER X-FLOW 81.17 THERMAL RESISTANCE, % OF TOTAL TUBE TO BAFFLE LEAKAGE A = 2.75 SHELL TUBE FOULING METAL MAIN CROSSFLOW B = 68.74 48.63 49.60 1.72 .06 BUNDLE TO SHELL BYPASS C = 11.87 PCT OVER DESIGN .42 BAFFLE TO SHELL LEAKAGE E = 16.64 TOT FOUL RESIST .0000217 TUBE PASSLANE BYPASS F = .00 DIFF RESIST .000053			CENTER, IN.	.764
TUBE TYPE				
TUBE TYPE				
NO. OF TUBES/SHELL	PAIRS OF SEALING DEVICES	TUBESHEET BLANK A	REA, %	.0
TUBE LGTH, OVERALL FT 1.500 TUBE PITCH IN3125  TUBE LGTH, EFF FT 1.436 TUBE OUTSIDE DIAM IN250  TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN214  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 IN8 .8  * CALCULATED ITEMHEAT BALANCE CODE = 8  Washington University ChE433 heat exchanger experiment E0002 P 5  Young model F302DY4P 9/23/3  CASE 2  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 1.024 .000 NOMINAL VEL, X-FLOW FT/S .08  RYNLD NO, AVG 130. 254. CROSSFLOW COEF BTU/HR-FT2-F 161.9  RYNLD NO, AVG 130. 254. CROSSFLOW COEF BTU/HR-FT2-F 162.9  RYNLD NO, OUT BUN 115. 333. WINDOW COEF BTU/HR-FT2-F 162.9  RYNLD NO, OUT BUN 145. 185.  FOULNG LAYER IN0014 .0014 SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81.17  THERMAL RESISTANCE, % OF TOTAL TUBE TO BAFFLE LEAKAGE A = 2.75  SHELL TUBE FOULING METAL MAIN CROSSFLOW B = 68.74  48.63 49.60 1.72 .06 BUNDLE TO SHELL BYPASS C = 11.87  PCT OVER DESIGN .42 BAFFLE TO SHELL LEAKAGE E = 16.64  TOT FOUL RESIST .000217 TUBE PASSLANE BYPASS F = .00  DIFF RESIST .000053	TUBE TYPE PLAIN	N MATERIAL	ELECTROLYTIC	COPPER
TUBE LGTH, OVERALL FT 1.500 TUBE PITCH IN3125  TUBE LGTH, EFF FT 1.436 TUBE OUTSIDE DIAM IN250  TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN214  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 IN8 .8  * CALCULATED ITEMHEAT BALANCE CODE = 8  Washington University ChE433 heat exchanger experiment E0002 P 5  Young model F302DY4P 9/23/3  CASE 2  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 1.024 .000 NOMINAL VEL, X-FLOW FT/S .08  RYNLD NO, AVG 130. 254. CROSSFLOW COEF BTU/HR-FT2-F 161.9  RYNLD NO, AVG 130. 254. CROSSFLOW COEF BTU/HR-FT2-F 162.9  RYNLD NO, OUT BUN 115. 333. WINDOW COEF BTU/HR-FT2-F 162.9  RYNLD NO, OUT BUN 145. 185.  FOULNG LAYER IN0014 .0014 SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81.17  THERMAL RESISTANCE, % OF TOTAL TUBE TO BAFFLE LEAKAGE A = 2.75  SHELL TUBE FOULING METAL MAIN CROSSFLOW B = 68.74  48.63 49.60 1.72 .06 BUNDLE TO SHELL BYPASS C = 11.87  PCT OVER DESIGN .42 BAFFLE TO SHELL LEAKAGE E = 16.64  TOT FOUL RESIST .000217 TUBE PASSLANE BYPASS F = .00  DIFF RESIST .000053				
TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN214 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 IN8 .8  * CALCULATED ITEMHEAT BALANCE CODE = 8 Washington University Che433 heat exchanger experiment E0002 P 5 Young model F302DY4P 9/23/3 CASE 2  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 1.024 .000 NOMINAL VEL, X-FLOW FT/S .04 PRANDTL NUMBER 5.9 4.1 NOMINAL VEL, WINDOW FT/S .08 RYNLD NO, AVG 130. 254. CROSSFLOW COEF BTU/HR-FT2-F 161.9 RYNLD NO, IN BUN 115. 333. WINDOW COEF BTU/HR-FT2-F 162.9 RYNLD NO, OUT BUN 145. 185. FOULNG LAYER IN0014 .0014 SHELLSIDE FLOW, % OF TOTAL HEAT TRANSFER X-FLOW 81.17 THERMAL RESISTANCE, % OF TOTAL TUBE TO BAFFLE LEAKAGE A = 2.75 SHELL TUBE FOULING METAL MAIN CROSSFLOW B = 68.74 48.63 49.60 1.72 .06 BUNDLE TO SHELL BYPASS C = 11.87 PCT OVER DESIGN .42 BAFFLE TO SHELL LEAKAGE E = 16.64 TOT FOUL RESIST .000013	TUBE LGTH, OVERALL FT 1.500	TUBE PITCH	IN.	
TUBE SURFACE RATIO, OUT/IN   1.184				
* CALCULATED ITEM—HEAT BALANCE CODE = 8 Washington University ChE433 heat exchanger experiment				
* CALCULATED ITEMHEAT BALANCE CODE = 8 Washington University Che433 heat exchanger experiment				
Washington University Che433 heat exchanger experiment   E0002 P   5   Young model F302DY4P	SHL NOZZ ID, IN&OUT 1.0 1.0	TUBE NOZZ ID, IN&	OUT IN	8 .8
Washington University Che433 heat exchanger experiment   E0002 P   5   Young model F302DY4P	* CALCULATED ITEMHEAT BALAN	NCE CODE = 8		
CASE 2  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 1.024 .000 NOMINAL VEL, X-FLOW FT/S .04 PRANDTL NUMBER 5.9 4.1 NOMINAL VEL, WINDOW FT/S .08 RYNLD NO, AVG 130. 254. CROSSFLOW COEF BTU/HR-FT2-F 161.9 RYNLD NO, IN BUN 115. 333. WINDOW COEF BTU/HR-FT2-F 162.9 RYNLD NO, OUT BUN 145. 185. FOULNG LAYER IN0014 .0014 SHELLSIDE FLOW, % OF TOTAL HEAT TRANSFER X-FLOW 81.17 THERMAL RESISTANCE, % OF TOTAL TUBE TO BAFFLE LEAKAGE A = 2.75 SHELL TUBE FOULING METAL MAIN CROSSFLOW B = 68.74 48.63 49.60 1.72 .06 BUNDLE TO SHELL BYPASS C = 11.87 PCT OVER DESIGN .42 BAFFLE TO SHELL LEAKAGE E = 16.64 TOT FOUL RESIST .0000217 TUBE PASSLANE BYPASS F = .00 DIFF RESIST .000053			iment E	0002 P 5
HT PARAMETERS SHELL TUBE SHELLSIDE PERFORMANCE WALL CORRECTION 1.024 .000 NOMINAL VEL, X-FLOW FT/S .04 PRANDTL NUMBER 5.9 4.1 NOMINAL VEL, WINDOW FT/S .08 RYNLD NO, AVG 130. 254. CROSSFLOW COEF BTU/HR-FT2-F 161.9 RYNLD NO, IN BUN 115. 333. WINDOW COEF BTU/HR-FT2-F 162.9 RYNLD NO, OUT BUN 145. 185. FOULNG LAYER IN0014 .0014 SHELLSIDE FLOW, % OF TOTAL HEAT TRANSFER X-FLOW 81.17 THERMAL RESISTANCE, % OF TOTAL TUBE TO BAFFLE LEAKAGE A = 2.75 SHELL TUBE FOULING METAL MAIN CROSSFLOW B = 68.74 48.63 49.60 1.72 .06 BUNDLE TO SHELL BYPASS C = 11.87 PCT OVER DESIGN .42 BAFFLE TO SHELL LEAKAGE E = 16.64 TOT FOUL RESIST .000053	Young model F302DY4P			9/23/ 3
HT PARAMETERS SHELL TUBE SHELLSIDE PERFORMANCE WALL CORRECTION 1.024 .000 NOMINAL VEL, X-FLOW FT/S .04 PRANDTL NUMBER 5.9 4.1 NOMINAL VEL, WINDOW FT/S .08 RYNLD NO, AVG 130. 254. CROSSFLOW COEF BTU/HR-FT2-F 161.9 RYNLD NO, IN BUN 115. 333. WINDOW COEF BTU/HR-FT2-F 162.9 RYNLD NO,OUT BUN 145. 185. FOULNG LAYER IN0014 .0014 SHELLSIDE FLOW, % OF TOTAL HEAT TRANSFER X-FLOW 81.17 THERMAL RESISTANCE, % OF TOTAL TUBE TO BAFFLE LEAKAGE A = 2.75 SHELL TUBE FOULING METAL MAIN CROSSFLOW B = 68.74 48.63 49.60 1.72 .06 BUNDLE TO SHELL BYPASS C = 11.87 PCT OVER DESIGN .42 BAFFLE TO SHELL LEAKAGE E = 16.64 TOT FOUL RESIST .0000217 TUBE PASSLANE BYPASS F = .00 DIFF RESIST .000053				CASE 2
WALL CORRECTION         1.024         .000         NOMINAL VEL, X-FLOW FT/S         .04           PRANDTL NUMBER         5.9         4.1         NOMINAL VEL, WINDOW FT/S         .08           RYNLD NO, AVG         130.         254.         CROSSFLOW COEF BTU/HR-FT2-F 161.9           RYNLD NO, IN BUN         115.         333.         WINDOW COEF BTU/HR-FT2-F 162.9           RYNLD NO, OUT BUN         145.         185.           FOULNG LAYER IN.         .0014         SHELLSIDE FLOW, % OF TOTAL HEAT TRANSFER X-FLOW         81.17           THERMAL RESISTANCE, % OF TOTAL SHELL TUBE TO BAFFLE LEAKAGE A = 2.75         2.75           SHELL TUBE FOULING METAL HAIN CROSSFLOW         B = 68.74           48.63         49.60         1.72         .06         BUNDLE TO SHELL BYPASS         C = 11.87           PCT OVER DESIGN         .42         BAFFLE TO SHELL LEAKAGE         E = 16.64           TOT FOUL RESIST         .000217         TUBE PASSLANE BYPASS         F = .00           DIFF RESIST         .000053	SUPPLEMENTA	ARY RES	U L T S	
PRANDTL NUMBER         5.9         4.1         NOMINAL VEL, WINDOW FT/S         .08           RYNLD NO, AVG         130.         254.         CROSSFLOW COEF BTU/HR-FT2-F 161.9           RYNLD NO, IN BUN         115.         333.         WINDOW COEF BTU/HR-FT2-F 162.9           RYNLD NO, OUT BUN         145.         185.           FOULNG LAYER IN.         .0014         .0014         SHELLSIDE FLOW, % OF TOTAL HEAT TRANSFER X-FLOW         81.17           THERMAL RESISTANCE, % OF TOTAL SHELL TUBE TO BAFFLE LEAKAGE         A = 2.75         2.75           SHELL TUBE FOULING METAL MAIN CROSSFLOW         B = 68.74           48.63         49.60         1.72         .06         BUNDLE TO SHELL BYPASS         C = 11.87           PCT OVER DESIGN         .42         BAFFLE TO SHELL LEAKAGE         E = 16.64           TOT FOUL RESIST         .000217         TUBE PASSLANE BYPASS         F = .00           DIFF RESIST         .000053	HT PARAMETERS SHELL TUE	BE SHELLSIDE PER	FORMANCE	
PRANDTL NUMBER         5.9         4.1         NOMINAL VEL, WINDOW FT/S         .08           RYNLD NO, AVG         130.         254.         CROSSFLOW COEF BTU/HR-FT2-F 161.9           RYNLD NO, IN BUN         115.         333.         WINDOW COEF BTU/HR-FT2-F 162.9           RYNLD NO, OUT BUN         145.         185.           FOULNG LAYER IN.         .0014         .0014         SHELLSIDE FLOW, % OF TOTAL HEAT TRANSFER X-FLOW         81.17           THERMAL RESISTANCE, % OF TOTAL SHELL TUBE TO BAFFLE LEAKAGE         A = 2.75         2.75           SHELL TUBE FOULING METAL MAIN CROSSFLOW         B = 68.74           48.63         49.60         1.72         .06         BUNDLE TO SHELL BYPASS         C = 11.87           PCT OVER DESIGN         .42         BAFFLE TO SHELL LEAKAGE         E = 16.64           TOT FOUL RESIST         .000217         TUBE PASSLANE BYPASS         F = .00           DIFF RESIST         .000053	WALL CORRECTION 1.024 .00	00 NOMINAL VEL,X-F	LOW FT/S	.04
RYNLD NO, IN BUN       115.       333.       WINDOW COEF       BTU/HR-FT2-F       162.9         RYNLD NO, OUT BUN       145.       185.         FOULNG LAYER IN.       .0014       .0014       SHELLSIDE FLOW, % OF TOTAL         HEAT TRANSFER X-FLOW       81.17         THERMAL RESISTANCE, % OF TOTAL       TUBE TO BAFFLE LEAKAGE       A = 2.75         SHELL TUBE FOULING METAL       MAIN CROSSFLOW       B = 68.74         48.63 49.60       1.72       .06       BUNDLE TO SHELL BYPASS       C = 11.87         PCT OVER DESIGN       .42       BAFFLE TO SHELL LEAKAGE       E = 16.64         TOT FOUL RESIST       .000217       TUBE PASSLANE BYPASS       F = .00         DIFF RESIST       .000053			DOW FT/S	.08
RYNLD NO, OUT BUN 145. 185.  FOULNG LAYER IN0014 .0014 SHELLSIDE FLOW, % OF TOTAL HEAT TRANSFER X-FLOW 81.17  THERMAL RESISTANCE, % OF TOTAL TUBE TO BAFFLE LEAKAGE A = 2.75 SHELL TUBE FOULING METAL MAIN CROSSFLOW B = 68.74 48.63 49.60 1.72 .06 BUNDLE TO SHELL BYPASS C = 11.87  PCT OVER DESIGN .42 BAFFLE TO SHELL LEAKAGE E = 16.64 TOT FOUL RESIST .0000217 TUBE PASSLANE BYPASS F = .00  DIFF RESIST .000053				
FOULNG LAYER IN0014 .0014 SHELLSIDE FLOW, % OF TOTAL HEAT TRANSFER X-FLOW 81.17 THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL MAIN CROSSFLOW B = 68.74 48.63 49.60 1.72 .06 BUNDLE TO SHELL BYPASS C = 11.87 PCT OVER DESIGN .42 BAFFLE TO SHELL LEAKAGE E = 16.64 TOT FOUL RESIST .0000217 TUBE PASSLANE BYPASS F = .00 DIFF RESIST .000053			BTU/HR-FT2-F	162.9
HEAT TRANSFER X-FLOW  THERMAL RESISTANCE, % OF TOTAL  SHELL TUBE FOULING METAL  48.63 49.60 1.72 .06  PCT OVER DESIGN  TOT FOUL RESIST  DIFF RESIST  HEAT TRANSFER X-FLOW  TUBE TO BAFFLE LEAKAGE  A = 2.75  MAIN CROSSFLOW  B = 68.74  BUNDLE TO SHELL BYPASS  C = 11.87  TUBE PASSLANE BYPASS  F = .00  TUBE PASSLANE BYPASS  TUBE PASSLANE BYPASS				
THERMAL RESISTANCE, % OF TOTAL  SHELL TUBE FOULING METAL  48.63 49.60 1.72 .06  PCT OVER DESIGN  TOT FOUL RESIST  DIFF RESIST  TUBE TO BAFFLE LEAKAGE  MAIN CROSSFLOW  B = 68.74  BUNDLE TO SHELL BYPASS  C = 11.87  BAFFLE TO SHELL LEAKAGE  TUBE PASSLANE BYPASS  F = .00	FOULNG LAYER IN0014 .001			
SHELL TUBE FOULING METAL MAIN CROSSFLOW B = 68.74 48.63 49.60 1.72 .06 BUNDLE TO SHELL BYPASS C = 11.87 PCT OVER DESIGN .42 BAFFLE TO SHELL LEAKAGE E = 16.64 TOT FOUL RESIST .0000217 TUBE PASSLANE BYPASS F = .00 DIFF RESIST .000053	MUDDMAL DEGLOCANOS O OS SOS			
48.63 49.60 1.72 .06 BUNDLE TO SHELL BYPASS C = 11.87  PCT OVER DESIGN .42 BAFFLE TO SHELL LEAKAGE E = 16.64  TOT FOUL RESIST .000217 TUBE PASSLANE BYPASS F = .00  DIFF RESIST .000053				
PCT OVER DESIGN .42 BAFFLE TO SHELL LEAKAGE E = 16.64 TOT FOUL RESIST .000217 TUBE PASSLANE BYPASS F = .00 DIFF RESIST .000053				
TOT FOUL RESIST .000217 TUBE PASSLANE BYPASS $F = .00$ DIFF RESIST .000053				
DIFF RESIST .000053				
			<del>-</del>	
		SHELLSIDE HEA	T TRANSFER FAC	TORS

				(70).OUT		
DIAMETRAL CLEARA	NCES		TOTAL	= (BETA) (GAI	MMA) (FIN)	= .604
BUNDLE TO SHELL				(BAFF CUT	FACTOR)	= .920
TUBE TO BAFFLE HOL						
BAFFLE TO SHELL	IN	1000	END	(HT LOSS II	N END ZONE)	= .994
SHELL NOZZLE DAT	דא אי	OTTE	CUET	T DDFCCIIDF	DDOD & OF	T ∩ T λ T
HT UNDR NOZ IN.					DROI, & OF	
						= 9.3
HT OPP NOZ IN.				ONE		= 5.7
VELOCITY FT/S						= 4.6
DENSITY LB/FT3	62.252 62	.027	INLET	NOZZLE		= 40.7
NOZZ RHO*VSQ LB/FT	'-s2 3	3	OUTLET	NOZZLE		= 39.7
BUND RHO*VSQ LB/FI						
Don't into the LD, II		_				
TUBE NOZZLE DATA	IN	OUT	WEIG	HT PER SHE	LL, LB	
VELOCITY FT/S	.15	.15	DRY		=	150.
DENSITY LB/FT3					=	
PRESS. DROP %			***			100.
						E0000 D C
Washington Unive	_	3 heat	t exchar	nger experi	ment	
Young model F302DY	74 P					9/23/ 3
						CASE 3
SIZE 4- 18 TYPE BE	M, MULTI-PA	SS FLO	OW, SEGN	MENTAL BAFF	LES, RATING	
			HOT T	UBE SIDE	COLD S	HELL SIDE
					Shel	
					SENS	
TOTAL FLOW RATE	מוז / מוא		DHIL	100	SLINS	100
TOTAL FLOW RATE	KLB/HK					
					IN	
TEMPERATURE						
DENSITY	LB/FT3	(	51.2913	62.1545	62.2515	62.0778
VISCOSITY	CP		.4726	.8788	.9783	.8140
SPECIFIC HEAT	BTU/LB-F		.9973	1.0005	1.0015	.9999
THERMAL COND.						
MOLAR MASS		_		18.02		18.02
MOLAK MASS	TD/ TDMOT					
TEMP, AVG & SKIN	DEGF				77.6	
VISCOSITY, AVG & S						
PRESSURE, IN & DES					50.00	
PRESSURE, IN & DES	IGN PSIA		30.00	163.00	30.00	165.00
PRESSURE DROP, TOT	' & ALLOWED	PSI	.01	10.00	.00	10.00
VELOCITY, CALC & M						
villociti, chile u i	ZIZI ZILLOWLD	11/0	• 10	10.00	• 0 0	10.00
FOULING RESISTANCE	HR-FT2	_F/BTI	ī	00010		00010
FILM COEFFICIENT	ם שול וות ב	エノユエ、	· ·	90 50	1	
FILM COEFFICIENT	B10/ NK					91.02
						006114
TOTAL HEAT DUTY RE						.006114
EFF TEMP DIF, DEGF				PASS= .93,B	AFF=1.00)	
OVERALL COEFF REQU						86.27
CLEAN & FOULED COE	FF BTU/	HR-FT2	2-F	87.	91	86.09
SHELLS IN SERIES						
PASSES, SHELL						
SHELL DIAMETER IN.	3.8	20 5	TEMA SHE	ELL TYPE E	; REAR H	EAD FXTS
BAFFLE TYPE H	ORZ SEGMEN	TL (	CROSS PA	ASSES PER S	HELL PASS	4

		che433b(70).OUT			
SPACING, CENTRAL IN.	4.309 E	BAFFLE CUT, PCT SHELL I.D.		30.00	
SPACING, INLET IN.		CUT DISTANCE FROM CENTER, I			
SPACING, OUTLET IN.					
		WEINGEWENE DAREE INGLIE		210	
BAFFLE THICKNESS IN.		MPINGEMENT BAFFLE INCLUDED			
PAIRS OF SEALING DEVICES	1 Т	UBESHEET BLANK AREA, %		.0	
TUBE TYPE		MATERIAL ELECTROLY			
NO. OF TUBES/SHELL	76 E	ST MAX TUBE COUNT		36	
TUBE LGTH, OVERALL FT	1.500 т	UBE PITCH IN.		.3125	
TUBE LGTH, EFF FT					
TUBE LAYOUT DEG				.214	
PITCH RATIO		UBE SURFACE RATIO, OUT/IN			
SHL NOZZ ID, IN&OUT 1.0	1.0 1	UBE NOZZ ID, IN&OUT IN.	. 8	. 8	
* CALCULATED ITEMHEAT H	BALANCE C	CODE = 8			
Washington University Chl	E433 heat	exchanger experiment	E00	02 P 7	
Young model F302DY4P		J. I. I.		23/ 3	
roung moder roughtr				SE 3	
		V D D C II I B C		SE S	
SUPPLEMEN	T A R	Y RESULTS	i		
	TUBE				
WALL CORRECTION 1.023	.000	NOMINAL VEL, X-FLOW FT/S		.05	
PRANDTL NUMBER 6.0	4.1	NOMINAL VEL, WINDOW FT/S		.10	
RYNLD NO, AVG 169.					
RYNLD NO, IN BUN 154.					
		WINDOW COEF BIO/IIK F	12 1	193.0	
RYNLD NO, OUT BUN 185.					
FOULNG LAYER IN0014	.0014				
		HEAT TRANSFER X-FLOW			
THERMAL RESISTANCE, % OF TO	JATC	TUBE TO BAFFLE LEAKAGE	A =	3.01	
SHELL TUBE FOULING ME	TAL	MAIN CROSSFLOW	B =	67.62	
44.57 53.50 1.87			C =	13.08	
PCT OVER DESIGN					
TOT FOUL RESIST .(					
		TOBE PASSLANE DIPASS	г —	.00	
DIFF RESIST(	000024				
		SHELLSIDE HEAT TRANSFER			
DIAMETRAL CLEARANCES		TOTAL = (BETA) (GAMMA) (FIN)	=	.624	
BUNDLE TO SHELL IN.	.5000	BETA (BAFF CUT FACTOR)	=	.920	
TUBE TO BAFFLE HOLE IN.	.0284	GAMMA (TUBE ROW ENTRY EFC	T) =	.679	
BAFFLE TO SHELL IN.	.1000	END (HT LOSS IN END ZON	E) =	.994	
SHELL NOZZLE DATA IN	OIIT	SHELL PRESSURE DROP, %		ΔT.	
HT UNDR NOZ IN25			=	9.0	
HT OPP NOZ IN25				5.0	
VELOCITY FT/S .33				4.2	
DENSITY LB/FT3 62.252	62.078	INLET NOZZLE	=	41.3	
NOZZ RHO*VSQ LB/FT-S2 6	6	OUTLET NOZZLE	=	40.5	
BUND RHO*VSQ LB/FT-S2 4					
~ , -					
TUBE NOZZLE DATA IN	OTT	WEICHT DED CUEIT ID			
			_	1 5 0	
VELOCITY FT/S .15			=		
DENSITY LB/FT3 61.291		WET	=	165.	
PRESS. DROP % 2.2					
Washington University Chl	E433 heat	exchanger experiment	E00	02 P 8	
_					

					CASE 4	1
SIZE 4- 18 TYPE BEM,	, MULTI-PASS F	LOW, SEGM	ENTAL BAFFLI	ES, RATING		
		HOT TU	UBE SIDE	COLD S	HELL SIDE	S
				Shel		
		SENS	IBLE LIQ	SENS	IBLE LIQ	
TOTAL FLOW RATE	KLB/HR		IBLE LIQ .100 OUT		.500	
		IN	OUT	IN	OUT	
TEMPERATURE I	DEGF	140.0	77.0*	70.0	82.6	5 *
	LB/FT3	61 2913	62 1741	62 2515	62 1101	
	CP	.4726	.8971	.9783	.8400	)
SPECIFIC HEAT H		.9973	1.0007	1.0015	1.0001	L
	BTU/HR-FT-F	.3723	.3573	.3554	.3588	3
MOLAR MASS	LB/LBMOL		18.02		18.02	
	,					
TEMP, AVG & SKIN	DEGF	108.5	90.3	76.3	89.6	5
VISCOSITY, AVG & SKI		- 6334	.7693	.9053	. 7750	)
PRESSURE, IN & DESIG		50 00	165.00	50 00	165 00	)
TREBUGRE, TR & BEST		00.00	100.00	00.00	100.00	
PRESSURE DROP, TOT 8	C ATTOMED PST	0.1	10 00	0.1	10 00	)
VELOCITY, CALC & MAX	X ALLOWED FT/	s 10	10.00	0.8	10.00	) )
VELOCITI, CHEC & THE	1 TILLOWED II,		10.00	• 00	10.00	,
FOULING RESISTANCE	HR-FT2-F/F	ر ا ت ا	00010		00010	
FILM COEFFICIENT			91.41		19.39	
TOTAL HEAT DUTY REQU	JIRED MEGBTU/H	IR			.006285	5
EFF TEMP DIF, DEGF			ASS= .93.BAI	FF=1.00)	9.6	
OVERALL COEFF REQUIR			,	,	91.90	
CLEAN & FOULED COEFF			93.73	3	91.61	
	210, 1111 1		30.7		31.01	-
SHELLS IN SERIES 1	PARALLEL 1	TOTAL EF	F AREA	FT2	7.1	L
PASSES, SHELL 1						
SHELL DIAMETER IN.						
	0.020	12111 0112		, 1121111 11		
BAFFLE TYPE HOP	RZ SEGMENTI	CROSS PAS	SSES PER SHI	ZIJ PASS	۷	1
SPACING, CENTRAL IN						
SPACING INLET IN	v 4 309	CUT DIST	ANCE FROM C	ENTER IN	764	1
SPACING, INLET IN SPACING, OUTLET IN	v 4 309	COI DIDII	INCL TROIT OF	inibit, in.	• 7 0 .	1
BAFFLE THICKNESS IN			ENT BAFFLE			
PAIRS OF SEALING DEV			INI ВАПТЫ Г BLANK AREA		. (	
TAIRS OF SHAHING DEV	VICED I	TODESHEE	I DDAM AMD	2, 0	• (	,
TUBE TYPE	PLAIN	ΜΔΨΕΡΤΔΙ.	El	.FCTROLVTI	COPPER	
NO. OF TUBES/SHELL			TUBE COUNT	JECTIOETTT	36	
				IN.	.3125	
TUBE LGTH, OVERALL	FT 1.300	TODE III	SIDE DIVM		.250	
TUBE LGTH, EFF TUBE LAYOUT	DEC 60	TUDE TNC	TUE DIAM	IN.	.214	
PITCH RATIO	DEG 60					
SHL NOZZ ID, IN&OUT		TODE SOK	FACE RATIO,	L LM	D C	Ξ Ο
SUT NOVY IN' INGOLL	1.0 1.0	TORE NOZ	TN&OU.	T TIN •	.0 .8	)
* CATCIIIAMED TMEM		CODE - 0				
* CALCULATED ITEM-				~ ~ <del>+</del>	E0000 5	^
Washington Univers	_	eat exchan	ger experime	311€	E0002 P	
Young model F302DY41	F				9/23/ 3	)
					CASE 4	

HT PARAMETERS						
WALL CORRECTION						
PRANDTL NUMBER	6.1	4.2	NOMINA:	L VEL,WIND	OW FT/S	.13
RYNLD NO, AVG						
RYNLD NO, IN BUN			WINDOW	COEF	BTU/HR-FT2	-F 221.8
RYNLD NO, OUT BUN						
FOULNG LAYER IN.	.0014	.0014				
					FLOW	
THERMAL RESISTANCE						
SHELL TUBE FOU						
41.29 56.66 1	.99	.07	BUNDLE	TO SHELL	BYPASS C	= 14.10
PCT OVER DESIGN		32	BAFFLE	TO SHELL	LEAKAGE E	= 16.00
TOT FOUL RESIST	. (	000217	TUBE P	ASSLANE BY	PASS F	= .00
PCT OVER DESIGN TOT FOUL RESIST DIFF RESIST	(	000034				
			SHEL	LSIDE HEAT	TRANSFER F	ACTORS
DIAMETRAL CLEARA						
BUNDLE TO SHELL						
TUBE TO BAFFLE HOL						
BAFFLE TO SHELL	IN.	.1000	END	(HT LOSS I	N END ZONE)	= .994
SHELL NOZZLE DAT	0 =					
HT UNDR NOZ IN. HT OPP NOZ IN. VELOCITY FT/S	.25		MINDOM			= 8.9 = 4.5
HT OPP NOZ IN.	.25	4.4	END ZO	NE		= 4.5
VELOCITY FT/S	.41	.41	CROSS	F.TOM		= 3.9
VELOCITY FT/S DENSITY LB/FT3 NOZZ RHO*VSQ LB/FT	62.252	62.110	INLET	NOZZLE		= 41./
NOZZ RHO*VSQ LB/FT	-S2 10	10	OUTLET	NOZZLE		= 41.1
BUND RHO*VSQ LB/FT	-S2 /	/				
TUBE NOZZLE DATA	TNI	OTIM	WETC	um DED CHE	TT TD	
VELOCITY FT/S				ni pek sne	= TT, TB	150.
DENSITY LB/FT3					=	
PRESS. DROP %			WEI		_	100.
Washington Unive			. orrahan	~~~ ~~~~~	man+	E0002 D 10
Young model F302DY		E433 Heat	. excilail	ger experi	merrc	9/23/ 3
Tourig moder rought	41					9/23/ 3 CASE 5
SIZE 4- 18 TYPE BE	M MIIT TT.	-DACC ELC	M CECM	האושאד האהה	TEC DAMINO	
312E 4- 10 11FE BE	•		•		COLD S	
					Shel	
			Tube	IBLE LIQ		IBLE LIQ
TOTAL FLOW RATE	ענס/עס		SENS	.100	SENS	.600
IOIAL FLOW RAIL	VTD/UK		TNI		IN	
	DEGF			OUT 75 0*	70.0	OUT
TEMPERATURE DENSITY	LB/FT3	c			62.2515	
	LB/F13 CP	C		.9098		.8590
SPECIFIC HEAT		r			1.0015	
THERMAL COND.				.3570		.3583
			.3/23			
MOLAR MASS	LB/LBMO	Ь		18.02		18.02
TEMP, AVG & SKIN	DEGI	F		88.6		87.9
VISCOSITY, AVG & SKIN				.7837		.7900
PRESSURE, IN & DES				165.00		165.00
THEOLOGIE, IN & DEO	TOW ENT	. 4	50.00	100.00	50.00	100.00

PRESSURE DROP, TOT & AI VELOCITY, CALC & MAX AI				
FOULING RESISTANCE FILM COEFFICIENT	BTU/HR-FT2-	J .00010 F 192.16		.00010
TOTAL HEAT DUTY REQUIRE EFF TEMP DIF, DEGF (LM OVERALL COEFF REQUIRED CLEAN & FOULED COEFF	ED MEGBTU/HR MTD= 23.1,F= BTU/HR-FT	.43,BYPASS= .9	93,BAFF=1.00)	.006402 9.3 96.62 96.24
SHELLS IN SERIES 1 PAR PASSES, SHELL 1 TUR SHELL DIAMETER IN.	BE 4 1	EFFECTIVE AREA	FT2/SHEL	L 7.1
BAFFLE TYPE HORZ SPACING, CENTRAL IN. SPACING, INLET IN. SPACING, OUTLET IN. BAFFLE THICKNESS IN. PAIRS OF SEALING DEVICE	4.309 4.309 4.309 .125		T SHELL I.D. ROM CENTER, IN FFLE INCLUDED	30.00 .764 NO
TUBE TYPE  NO. OF TUBES/SHELL  TUBE LGTH, OVERALL FT  TUBE LGTH, EFF FT  TUBE LAYOUT DEC  PITCH RATIO  SHL NOZZ ID, IN&OUT	76 1 1.500 5 1.436 5 60 5 1.250 5		OUNT IN. IAM IN. AM IN. ATIO, OUT/IN	36 .3125 .250 .214 1.184
* CALCULATED ITEMHE Washington University Young model F302DY4P			periment	E0002 P 11 9/23/ 3 CASE 5
HT PARAMETERS SHEIM WALL CORRECTION 1.02 PRANDTL NUMBER 6. RYNLD NO, AVG 24 RYNLD NO, IN BUN 233 RYNLD NO,OUT BUN 263 FOULNG LAYER IN003  THERMAL RESISTANCE, % 0 SHELL TUBE FOULING 38.55 59.29 2.09 PCT OVER DESIGN TOT FOUL RESIST DIFF RESIST	L TUBE 21 .000 2 4.2 7. 247. 3333. 3. 173. 4 .0014  DF TOTAL METAL .0740 .000217	SHELLSIDE INOMINAL VEL, INOMINAL VEL, INOMINAL VEL, INCRESSFLOW CONTROL OF WINDOW COEF  SHELLSIDE INTERPORT OF THE TRANSFER TUBE TO BAFFI MAIN CROSSFLOW BUNDLE TO SHE BAFFLE TO SHE TUBE PASSLANE	PERFORMANCE X-FLOW FT/S WINDOW FT/S EF BTU/HR-FT BTU/HR-FT FLOW, % OF TOT R X-FLOW LE LEAKAGE OW ELL BYPASS ELL LEAKAGE E BYPASS	.15 2-F 247.8 2-F 249.5 AL 81.45 A = 3.43 B = 65.74 C = 15.01 E = 15.82 F = .00
DIAMETRAL CLEARANCES			HEAT TRANSFER )(GAMMA)(FIN)	

BUNDLE TO SHELL TUBE TO BAFFLE HOL	E IN.	.0284	GAMMA	(TUBE ROW E	NTRY EFCT)	= .723
BAFFLE TO SHELL						
SHELL NOZZLE DAT					DROP, % OF	
HT UNDR NOZ IN.				Ī		= 8.9
HT OPP NOZ IN.				ONE		= 4.1
VELOCITY FT/S						= 3.6
DENSITY LB/FT3	62.252	62.132	INLET	NOZZLE		= 42.0
NOZZ RHO*VSQ LB/FT BUND RHO*VSQ LB/FT			OUTLET	T NOZZLE		= 41.4
TUBE NOZZLE DATA	IN	OUT	WEIG	GHT PER SHEL	L, LB	
VELOCITY FT/S	.15	.15	DRY		=	150.
DENSITY LB/FT3	61.291	62.187	WET		=	165.
PRESS. DROP %	2.1	1.3				
Washington Unive		1433 heat	t exchar	nger experim		
Young model F302DY	4P					9/23/ 3
						CASE 6
SIZE 4- 18 TYPE BE	M, MULTI-	PASS FLO				
				TUBE SIDE		
			Tube		Shell	
				SIBLE LIQ	SENS	
TOTAL FLOW RATE	KLB/HR					
				OUT		
TEMPERATURE						
DENSITY						
VISCOSITY						
SPECIFIC HEAT						
THERMAL COND.						
MOLAR MASS	LB/LBMOL	1		18.02		18.02
TEMP, AVG & SKIN	DEGE	1		87.3		
VISCOSITY, AVG & S						
PRESSURE, IN & DES						
,						
PRESSURE DROP, TOT	& ALLOWE	D PSI	.01	10.00	.01	10.00
VELOCITY, CALC & M	AX ALLOWE	D FT/S	.10	10.00	.11	10.00
FOULING RESISTANCE						
FILM COEFFICIENT						74.10
TOTAL HEAT DUTY RE						.006485
EFF TEMP DIF, DEGF						
OVERALL COEFF REQU CLEAN & FOULED COE	IKED BI	'U/HR-FT2	7 – F.	100.0	2	100.44
CLEAN & FOULED COE	F.F. B.I	'U/HR-FTZ	Z — F.	102.9	3	100.28
SHELLS IN SERIES	1 PARAT.T.F	:T. 1 7	ГОТАТ, Е.Е	F AREA	FT2	7 1
PASSES, SHELL						
SHELL DIAMETER IN.						
	~				, 1	
BAFFLE TYPE H	ORZ SEGM	IENTL (	CROSS PA	ASSES PER SH	ELL PASS	4
SPACING, CENTRAL						
•				•		

	che433b(70).OUT	
SPACING, INLET IN. 4.309 C	UT DISTANCE FROM CENTER, IN.	.764
SPACING, OUTLET IN. 4.309		
	MPINGEMENT BAFFLE INCLUDED	NO
	UBESHEET BLANK AREA, %	
FAIRS OF SEALING DEVICES I I	ODESHEET BLANK AREA, 6	. 0
MIDE MADE		
	ATERIAL ELECTROLYTIC	
•	ST MAX TUBE COUNT	36
•		.3125
TUBE LGTH, EFF FT 1.436 T	UBE OUTSIDE DIAM IN.	.250
TUBE LAYOUT DEG 60 T	UBE INSIDE DIAM IN.	.214
PITCH RATIO 1.250 T	UBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT 1.0 1.0 T	UBE NOZZ ID, IN&OUT IN.	.8 .8
* CALCULATED ITEMHEAT BALANCE C	ODE = 8	
Washington University ChE433 heat		E0002 P 13
Young model F302DY4P	exemanger experiment	9/23/ 3
Toding moder F302D14F		
		CASE 6
SUPPLEMENTAR	Y RESULTS	
HT PARAMETERS SHELL TUBE		
WALL CORRECTION 1.020 .000	NOMINAL VEL, X-FLOW FT/S	
PRANDTL NUMBER 6.3 4.2	NOMINAL VEL, WINDOW FT/S	.18
RYNLD NO, AVG 285. 246.	CROSSFLOW COEF BTU/HR-FT2-	F 275.2
RYNLD NO, IN BUN 269. 333.	WINDOW COEF BTU/HR-FT2-	F 276.9
RYNLD NO, OUT BUN 302. 171.		
FOULNG LAYER IN0014 .0014	SHELLSIDE FLOW, % OF TOTAL	
TOOLING LITTLIC IN	HEAT TRANSFER X-FLOW	
THERMAL RESISTANCE, % OF TOTAL	TUBE TO BAFFLE LEAKAGE A	
SHELL TUBE FOULING METAL	MAIN CROSSFLOW B	
36.17 61.58 2.17 .07	BUNDLE TO SHELL BYPASS C	
PCT OVER DESIGN16	BAFFLE TO SHELL LEAKAGE E	
TOT FOUL RESIST .000217	TUBE PASSLANE BYPASS F	= .00
DIFF RESIST000016		
	SHELLSIDE HEAT TRANSFER FA	CTORS
DIAMETRAL CLEARANCES	TOTAL = (BETA) (GAMMA) (FIN)	= .686
BUNDLE TO SHELL IN5000	BETA (BAFF CUT FACTOR)	= .920
TUBE TO BAFFLE HOLE IN0284	GAMMA (TUBE ROW ENTRY EFCT)	= .746
BAFFLE TO SHELL IN1000		
	,	
SHELL NOZZLE DATA IN OUT	SHELL PRESSURE DROP, % OF	TOTAL
HT UNDR NOZ IN25	WINDOW	= 8.9
HT OPP NOZ IN25		= 3.8
		= 3.4
VELOCITY FT/S .57 .57		
DENSITY LB/FT3 62.252 62.149		= 42.2
NOZZ RHO*VSQ LB/FT-S2 20 20	OUTLET NOZZLE	= 41.7
BUND RHO*VSQ LB/FT-S2 13 13		
TUBE NOZZLE DATA IN OUT		
VELOCITY FT/S .15 .15	DRY =	150.
DENSITY LB/FT3 61.291 62.196	WET =	165.
PRESS. DROP % 2.1 1.3		
Washington University ChE433 heat	exchanger experiment	E0002 P 14
Young model F302DY4P	- 5 1	9/23/ 3
10011g 110001 1002D111		J, 231 J

					CASE 7
SIZE 4- 18 TYPE BE	M, MULTI-PASS E	TLOW, SEGME	NTAL BAFFLE	ES, RATING	
		HOT TU	BE SIDE	COLD SI	HELL SIDE
		Tube		Shell	1
		SENSI	BLE LIQ	SENS	IBLE LIQ
TOTAL FLOW RATE	KI.B/HR		.100		. 800
TOTTLE TEOM TUTLE	TCDD/ IIIC	TN	.100 OUT	TN	OIIT
TEMPERATURE	DECE	1/0 0	7/ /*	70 0	78 2*
	LB/FT3				
	CP		.9262		.8848
VISCOSITY		.4/26	1.0010	.9/83	.8848
SPECIFIC HEAT	BTU/LB-F	.99/3	1.0010		
THERMAL COND. MOLAR MASS	BTU/HR-FT-F	.3723	.3566	.3554	.3576
MOLAR MASS	LB/LBMOL		18.02		18.02
			18.02  86.1		
TEMP, AVG & SKIN					
VISCOSITY, AVG & S	KIN CP	.6419	.8061	.9298	.8132
PRESSURE, IN & DES	IGN PSIA	50.00	165.00	50.00	165.00
		- 01	10.00	0.1	10.00
PRESSURE DROP, TOT	'& ALLOWED PSI	.01	10.00	.01	10.00
VELOCITY, CALC & M	IAX ALLOWED FT/	'S .10	10.00	.12	10.00
FOULING RESISTANCE	UD_ETO_E/E	ס דוד ר	10010	,	0.001.0
FILM COEFFICIENT					01.66
FILM COEFFICIENT	BTU/HR-FT2				01.00
TOTAL HEAT DUTY RE					.006548
EFF TEMP DIF, DEGF			CC- 02 DAI	zr_1 00)	
			15595, BAI	F-1.00)	
OVERALL COEFF REQU	IRED BTU/HK-E	I. Z – E.	106 8		104.05
CLEAN & FOULED COE	FF BTU/HR-E	iI.S – F.	106.78	3	103.89
SHELLS IN SERIES	1 PARALLET. 1	TOTAL EFF	' AREA	FT2	7 1
PASSES, SHELL					
SHELL DIAMETER IN.					
SHELL DIAMETER IN.	3.020	TEMA SHEL	11 11FE E	, KEAK III	EAD FAIS
BAFFLE TYPE H	ORZ SEGMENTL	CROSS PAS	SES PER SHE	ELL PASS	4
SPACING, CENTRAL					
SPACING, INLET					
SPACING, OUTLET	TN 1.309	COI DIGII.	IIVOLI TIKOTI CI	111111, 111.	. / 0 1
BAFFLE THICKNESS		TMDTNCEME	יאים או האי	INCILIDED	NO
PAIRS OF SEALING D	EAICE2 I	IORESHEET	BLANK AREA	1, ⊙	. 0
TUBE TYPE	PLAIN	MATERTAL	ΕI	FCTROLYTI	COPPER
NO. OF TUBES/SHELL			UBE COUNT		36
TUBE LGTH, OVERALL	,	שוושה בותני	'U	IN.	.3125
TUBE LGTH, EFF	FT 1.500	TUDE TITC	TOP DIAM		.250
TUDE LAYOUR	DEG 60	TUBE OUIS	DE DIAM	_ IN •	
		TORE INSI	DE DIAM	IN.	.214
PITCH RATIO	1.250	TUBE SURE	ACE RATIO,	OUT/IN	1.184
SHL NOZZ ID, IN&OU	T 1.0 1.0	TUBE NOZZ	ID, IN&OUT	r IN.	.8 .8
* CALCULATED ITE	MUEAT האואים	CODE - 0			
Washington Unive			er experim	ant	E0002 P 15
Young model F302DY	=	Lac Excitation	or cybering	J11 C	9/23/ 3
Tourig moder F302D1					9/23/ 3 CASE 7
SUPPLE	M E N T A	R Y F	e e c ii	L T S	CASE /
	11 TI IN T A	1, 1 P	. 1 2 0	1 1 0	

HT PARAMETERS	SHELL TUB	· C	CUFI	LLSIDE PERF	ODMANCE		
WALL CORRECTION					ORMANCE OW FT/S	1.0	
PRANDTL NUMBER					OW FT/S		
RYNLD NO, AVG				•	OW F1/5 BTU/HR-FT2-		
RYNLD NO, IN BUN			MINDOM	A COEF.	BTU/HR-FT2-	-F 304.8	
RYNLD NO, OUT BUN							
FOULNG LAYER IN.	.0014 .001	. 4			, % OF TOTAL FLOW		
THERMAL RESISTANCE,	° OF TOTAL				EAKAGE A		
					EARAGE A		
SHELL TUBE FOUL							
34.05 63.62 2.							
PCT OVER DESIGN	1	. 6	BAFFL	S TO SHELL .	LEAKAGE E	= 15.56	
TOT FOUL RESIST			TUBE I	PASSLANE BY	PASS F	= .00	
DIFF RESIST	00001	.5					
					TRANSFER FA		
DIAMETRAL CLEARAN	CES		TOTAL		MMA) (FIN)		
BUNDLE TO SHELL	IN50	00	BETA		FACTOR)		
TUBE TO BAFFLE HOLE				•	•		
BAFFLE TO SHELL	IN10	00	END	(HT LOSS I	N END ZONE)	= .994	
SHELL NOZZLE DATA	TN O	ידותי	CHEI	T DDFQQIIDF	DDOD 9 OF	TOTAT	
HT UNDR NOZ IN.			WINDOV		DROI, & OF	= 8.9	
HT OPP NOZ IN.				) NE		= 3.6	
VELOCITY FT/S						= 3.0	
DENSITY LB/FT3						= 42.3	
NOZZ RHO*VSQ LB/FT-				NOZZLE NOZZLE		= 42.3 $=$ 42.0	
BUND RHO*VSQ LB/FT-			OOILE	I NOZZLE		- 42.0	
BOND KHO VSQ LB/F1-	52 10	10					
TUBE NOZZLE DATA	IN C	UT	WEIC	GHT PER SHE	LL, LB		
VELOCITY FT/S			DRY		=	150.	
DENSITY LB/FT3	61.291 62.2	03	WET		=	165.	
PRESS. DROP %							
Washington Univer			exchar	nger experi	ment	E0002 P 1	6
Young model F302DY4				3 1		9/23/ 3	
5						CASE 8	
SIZE 4- 18 TYPE BEM	, MULTI-PASS	FLO'	W, SEGN	MENTAL BAFF	LES, RATING		
			HOT 7	TUBE SIDE	COLD SI	HELL SIDE	
			Tube	9	Shell	L	
			SENS	SIBLE LIQ	SENS	BLE LIQ	
TOTAL FLOW RATE	KLB/HR			.100		.900	
			IN	OUT	IN	OUT	
TEMPERATURE	DEGF		140.0	73.9*	70.0	77.3*	
DENSITY	LB/FT3	6	1.2913	62.2089	62.2515	62.1707	
VISCOSITY	CP		.4726	.9318	.9783	.8939	
SPECIFIC HEAT	BTU/LB-F		.9973	1.0010	1.0015	1.0007	
THERMAL COND.				.3564		.3574	
	LB/LBMOL			18.02		18.02	
TEMP, AVG & SKIN				85.2		84.4	
VISCOSITY, AVG & SK					.9347		
PRESSURE, IN & DESI	GN PSIA		50.00	165.00	50.00	165.00	

	che433b(70).OUT	
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/BT	U .00010 .0	00010
FILM COEFFICIENT BTU/HR-FT2-		29.52
TOTAL HEAT DUTY REQUIRED MEGBTU/HR		.006597
EFF TEMP DIF, DEGF (LMTD= 21.2,F=		
OVERALL COEFF REQUIRED BTU/HR-FT		107.11
CLEAN & FOULED COEFF BTU/HR-FT	2-F 110 26	107.14
CLEAN & FOOLED COEFF BIOTIN FI	2 F 110.20	107.14
SHELLS IN SERIES 1 PARALLEL 1		7 1
PASSES, SHELL 1 TUBE 4	EFFECUTIVE ADEA FIZ	7 · 1
SHELL DIAMETER IN. 3.820	EFFECTIVE AREA F12/SHELL	/ • I
SHELL DIAMETER IN. 3.820	TEMA SHELL TYPE E ; REAR HE	LAD FXTS
		4
BAFFLE TYPE HORZ SEGMENTL		
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 IN125	IMPINGEMENT BAFFLE INCLUDED	NO
SPACING, CENTRAL IN. 4.309 SPACING, INLET IN. 4.309 SPACING, OUTLET IN. 4.309 BAFFLE THICKNESS IN125 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
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	TUBE NOZZ ID, IN&OUT IN.	.8 .8
* CALCULATED ITEMHEAT BALANCE	CODE = 8	
Washington University ChE433 hea	t exchanger experiment	E0002 P 17
Young model F3UZDY4P		9/23/ 3
Young model F302DY4P		9/23/ 3 CASE 8
-	Y RESILLTS	9/23/ 3 CASE 8
S U P P L E M E N T A R		CASE 8
S U P P L E M E N T A R		CASE 8
S U P P L E M E N T A R		CASE 8
S U P P L E M E N T A R		CASE 8
S U P P L E M E N T A R		CASE 8
S U P P L E M E N T A R		CASE 8
S U P P L E M E N T A R		CASE 8
S U P P L E M E N T A R		CASE 8
S U P P L E M E N T A R  HT PARAMETERS SHELL TUBE WALL CORRECTION 1.018 .000 PRANDTL NUMBER 6.4 4.3 RYNLD NO, AVG 362. 245. RYNLD NO, IN BUN 346. 333. RYNLD NO, OUT BUN 379. 169. FOULNG LAYER IN0014 .0014	SHELLSIDE PERFORMANCE  NOMINAL VEL,X-FLOW FT/S  NOMINAL VEL,WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-  WINDOW COEF BTU/HR-FT2-  SHELLSIDE FLOW, % OF TOTAL	.12 .23 -F 330.9 -F 332.9
S U P P L E M E N T A R  HT PARAMETERS SHELL TUBE WALL CORRECTION 1.018 .000 PRANDTL NUMBER 6.4 4.3 RYNLD NO, AVG 362. 245. RYNLD NO, IN BUN 346. 333. RYNLD NO, OUT BUN 379. 169. FOULNG LAYER IN0014 .0014	SHELLSIDE PERFORMANCE  NOMINAL VEL,X-FLOW FT/S  NOMINAL VEL,WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-  WINDOW COEF BTU/HR-FT2-  SHELLSIDE FLOW, % OF TOTAL	.12 .23 -F 330.9 -F 332.9
S U P P L E M E N T A R  HT PARAMETERS SHELL TUBE WALL CORRECTION 1.018 .000 PRANDTL NUMBER 6.4 4.3 RYNLD NO, AVG 362. 245. RYNLD NO, IN BUN 346. 333. RYNLD NO, OUT BUN 379. 169. FOULNG LAYER IN0014 .0014	SHELLSIDE PERFORMANCE  NOMINAL VEL,X-FLOW FT/S  NOMINAL VEL,WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-  WINDOW COEF BTU/HR-FT2-  SHELLSIDE FLOW, % OF TOTAL	.12 .23 -F 330.9 -F 332.9
S U P P L E M E N T A R  HT PARAMETERS SHELL TUBE WALL CORRECTION 1.018 .000 PRANDTL NUMBER 6.4 4.3 RYNLD NO, AVG 362. 245. RYNLD NO, IN BUN 346. 333. RYNLD NO, OUT BUN 379. 169. FOULNG LAYER IN0014 .0014	SHELLSIDE PERFORMANCE  NOMINAL VEL,X-FLOW FT/S  NOMINAL VEL,WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-  WINDOW COEF BTU/HR-FT2-  SHELLSIDE FLOW, % OF TOTAL	.12 .23 -F 330.9 -F 332.9
S U P P L E M E N T A R  HT PARAMETERS SHELL TUBE WALL CORRECTION 1.018 .000 PRANDTL NUMBER 6.4 4.3 RYNLD NO, AVG 362. 245. RYNLD NO, IN BUN 346. 333. RYNLD NO, OUT BUN 379. 169. FOULNG LAYER IN0014 .0014	SHELLSIDE PERFORMANCE  NOMINAL VEL,X-FLOW FT/S  NOMINAL VEL,WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-  WINDOW COEF BTU/HR-FT2-  SHELLSIDE FLOW, % OF TOTAL	.12 .23 -F 330.9 -F 332.9
S U P P L E M E N T A R  HT PARAMETERS SHELL TUBE WALL CORRECTION 1.018 .000 PRANDTL NUMBER 6.4 4.3 RYNLD NO, AVG 362. 245. RYNLD NO, IN BUN 346. 333. RYNLD NO, OUT BUN 379. 169. FOULNG LAYER IN0014 .0014	SHELLSIDE PERFORMANCE  NOMINAL VEL,X-FLOW FT/S  NOMINAL VEL,WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-  WINDOW COEF BTU/HR-FT2-  SHELLSIDE FLOW, % OF TOTAL	.12 .23 -F 330.9 -F 332.9
S U P P L E M E N T A R  HT PARAMETERS SHELL TUBE WALL CORRECTION 1.018 .000 PRANDTL NUMBER 6.4 4.3 RYNLD NO, AVG 362. 245. RYNLD NO, IN BUN 346. 333. RYNLD NO, OUT BUN 379. 169. FOULNG LAYER IN0014 .0014	SHELLSIDE PERFORMANCE  NOMINAL VEL,X-FLOW FT/S  NOMINAL VEL,WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-  WINDOW COEF BTU/HR-FT2-  SHELLSIDE FLOW, % OF TOTAL	.12 .23 -F 330.9 -F 332.9
S U P P L E M E N T A R  HT PARAMETERS SHELL TUBE WALL CORRECTION 1.018 .000 PRANDTL NUMBER 6.4 4.3 RYNLD NO, AVG 362. 245. RYNLD NO, IN BUN 346. 333. RYNLD NO, OUT BUN 379. 169. FOULNG LAYER IN0014 .0014	SHELLSIDE PERFORMANCE NOMINAL VEL, X-FLOW FT/S NOMINAL VEL, WINDOW FT/S CROSSFLOW COEF BTU/HR-FT2- WINDOW COEF BTU/HR-FT2- SHELLSIDE FLOW, % OF TOTAL HEAT TRANSFER X-FLOW TUBE TO BAFFLE LEAKAGE A MAIN CROSSFLOW B BUNDLE TO SHELL BYPASS C BAFFLE TO SHELL LEAKAGE E TUBE PASSLANE BYPASS F	.12 .23 -F 330.9 -F 332.9 
S U P P L E M E N T A R  HT PARAMETERS SHELL TUBE WALL CORRECTION 1.018 .000 PRANDTL NUMBER 6.4 4.3 RYNLD NO, AVG 362. 245. RYNLD NO, IN BUN 346. 333. RYNLD NO,OUT BUN 379. 169. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 32.15 65.45 2.32 .08 PCT OVER DESIGN .03 TOT FOUL RESIST .000217 DIFF RESIST .000003	SHELLSIDE PERFORMANCE  NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-  WINDOW COEF BTU/HR-FT2-  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW  TUBE TO BAFFLE LEAKAGE A  MAIN CROSSFLOW B  BUNDLE TO SHELL BYPASS C  BAFFLE TO SHELL LEAKAGE E  TUBE PASSLANE BYPASS F	.12 .23 -F 330.9 -F 332.9 
S U P P L E M E N T A R  HT PARAMETERS SHELL TUBE WALL CORRECTION 1.018 .000 PRANDTL NUMBER 6.4 4.3 RYNLD NO, AVG 362. 245. RYNLD NO, IN BUN 346. 333. RYNLD NO,OUT BUN 379. 169. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 32.15 65.45 2.32 .08 PCT OVER DESIGN .03 TOT FOUL RESIST .000217 DIFF RESIST .000003	SHELLSIDE PERFORMANCE  NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-  WINDOW COEF BTU/HR-FT2-  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW  TUBE TO BAFFLE LEAKAGE A  MAIN CROSSFLOW B  BUNDLE TO SHELL BYPASS C  BAFFLE TO SHELL LEAKAGE E  TUBE PASSLANE BYPASS F	.12 .23 -F 330.9 -F 332.9 
S U P P L E M E N T A R  HT PARAMETERS SHELL TUBE WALL CORRECTION 1.018 .000 PRANDTL NUMBER 6.4 4.3 RYNLD NO, AVG 362. 245. RYNLD NO, IN BUN 346. 333. RYNLD NO, OUT BUN 379. 169. FOULNG LAYER IN0014 .0014	SHELLSIDE PERFORMANCE  NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-  WINDOW COEF BTU/HR-FT2-  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW  TUBE TO BAFFLE LEAKAGE A  MAIN CROSSFLOW B  BUNDLE TO SHELL BYPASS C  BAFFLE TO SHELL LEAKAGE E  TUBE PASSLANE BYPASS F	.12 .23 -F 330.9 -F 332.9 

		che433b	(70).OUT		
TUBE TO BAFFLE HOLD BAFFLE TO SHELL		GAMMA			
SHELL NOZZLE DATZ	A IN OUT	' SHEI	L PRESSURE I	DROP, % OF	TOTAL
HT UNDR NOZ IN.				•	= 8.9
HT OPP NOZ IN.					= 3.4
VELOCITY FT/S			FLOW		= 3.1
DENSITY LB/FT3					
			NOZZLE		= 42.5
NOZZ RHO*VSQ LB/FT			' NOZZLE		= 42.1
TUBE NOZZLE DATA	IN OUT	' WEIG	GHT PER SHELI	L, LB	
VELOCITY FT/S					150.
DENSITY LB/FT3				=	165.
PRESS. DROP %					
Washington Unive			nger evnerim	ant	F0002 P 18
Young model F302DY	_	ac cheman	iger experim		9/23/ 3
0.170 4 10 mypn pn	A MILLER DAGGE	17 057 050	,		CASE 9
SIZE 4- 18 TYPE BEI	M, MULTI-PASS F				
			UBE SIDE		
		Tube		Shell	
		SENS	SIBLE LIQ	SENSI	
TOTAL FLOW RATE	KLB/HR		.200		.200
			OUT		
TEMPERATURE			100.0*		
DENSITY	LB/FT3				
VISCOSITY	CP	.4726	.6915	.9783	.6247
SPECIFIC HEAT	BTU/LB-F	.9973	.9987	1.0015	.9981
THERMAL COND.	BTU/HR-FT-F	.3723	.3633	.3554	.3657
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF		106.7		
VISCOSITY, AVG & SI			.6455	.7719	.6487
PRESSURE, IN & DES			165.00		
PRESSURE DROP, TOT	& ALLOWED PSI	.01	10.00	.00	10.00
VELOCITY, CALC & MA	AX ALLOWED FT/	s .20	10.00	.03	10.00
FOULING RESISTANCE	HR-FT2-F/B	STU .	00010	. (	
FILM COEFFICIENT					34.15
					0.07.07.0
TOTAL HEAT DUTY RE	-				.007973
EFF TEMP DIF, DEGF			PASS= .93, BA	F.F.=T.00)	
OVERALL COEFF REQU					73.45
CLEAN & FOULED COE	FF BTU/HR-F	T2-F	74.34	1	73.18
SHELLS IN SERIES	1 PARALLET, 1	TOTAL EF	F AREA	FT2	7 . 1
PASSES, SHELL					
SHELL DIAMETER IN.					
BAFFLE TYPE HO	ORZ SEGMENTI	CROSS PI	SSES PER SHI	ZI.I. PASS	Д
SPACING, CENTRAL					
SPACING, CENTRAL SPACING, INLET					
DIACING, INDEI	111.	רפות ווסו	.ANCE ENUM CI	714 TH.	. / 04

	che433b(70).OUT
SPACING, OUTLET IN. 4.30	9
BAFFLE THICKNESS IN12	5 IMPINGEMENT BAFFLE INCLUDED NO
PAIRS OF SEALING DEVICES	1 TUBESHEET BLANK AREA, % .0
TUBE TYPE PLAI	N MATERIAL ELECTROLYTIC COPPER
NO. OF TUBES/SHELL 7	
TUBE LGTH, OVERALL FT 1.50	
TUBE LGTH, EFF FT 1.43	
TUBE LAYOUT DEG 6	
	0 TUBE SURFACE RATIO, OUT/IN 1.184
SHL NOZZ ID, IN&OUT 1.0 1.	O TUBE NOZZ ID, IN&OUT IN8 .8
* CALCULATED ITEMHEAT BALA	NCE CODE = 8
Washington University ChE433	
Young model F302DY4P	9/23/3
Tourig model F302D141	CASE 9
SUPPLEMENT	ARY RESULTS
HT PARAMETERS SHELL TU	BE SHELLSIDE PERFORMANCE
WALL CORRECTION 1.025 .0	00 NOMINAL VEL, X-FLOW FT/S .03
PRANDTL NUMBER 5.2 3	.7 NOMINAL VEL, WINDOW FT/S .05
RYNLD NO, AVG 96. 55	7. CROSSFLOW COEF BTU/HR-FT2-F 134.6
RYNLD NO, IN BUN 76. 66	
RYNLD NO, OUT BUN 119. 45	
FOULNG LAYER IN0014 .00	
FOOLING LATER IN	
THERMAL RESISTANCE, % OF TOTAL	
SHELL TUBE FOULING METAL	
53.94 44.42 1.59 .05	
PCT OVER DESIGN	37 BAFFLE TO SHELL LEAKAGE E = 17.56
TOT FOUL RESIST .0002	17 TUBE PASSLANE BYPASS $F = .00$
DIFF RESIST0000	51
	SHELLSIDE HEAT TRANSFER FACTORS
DIAMETRAL CLEARANCES	TOTAL = (BETA) (GAMMA) (FIN) = .598
BUNDLE TO SHELL IN5	
	284 GAMMA (TUBE ROW ENTRY EFCT) = .650
BAFFLE TO SHELL IN1	000 END (HT LOSS IN END ZONE) = .996
	OUT SHELL PRESSURE DROP, % OF TOTAL
HT UNDR NOZ IN25	
HT OPP NOZ IN25	
VELOCITY FT/S .16	.16 CROSS FLOW $= 5.4$
DENSITY LB/FT3 62.252 61.	756 INLET NOZZLE = 40.1
NOZZ RHO*VSQ LB/FT-S2 1	1 OUTLET NOZZLE = 37.9
BUND RHO*VSQ LB/FT-S2 1	
20112 1410 152 22,11 52 1	-
TIIRE NO77IE DATA TA	OUT WEIGHT PER SHELL, LB
VELOCITY FT/S .30	
DENSITY LB/FT3 61.291 61.	
PRESS. DROP % 4.5	
Washington University ChE433	heat exchanger experiment E0002 P 20
Young model F302DY4P	9/23/ 3
	CASE 10

SIZE 4- 18 TYPE B	EM, MULTI-PASS E	FLOW, SEGME	ENTAL BAFFL	ES, RATING	
		HOT TU	JBE SIDE	COLD SE	HELL SIDE
				Shell	
		SENSI	BLE LIQ	SENS	BLE LIQ
OTAL FLOW RATE	KLB/HR				
		IN	.200 OUT	IN	OUT
'EMPERATURE	DEGF	140.0	92.7*	70.0	101.4*
			61.9857		
ISCOSITY	CP			.9783	
PECIFIC HEAT	BTII/I.B-F	9973	9992	1 0015	.9986
HEDMAI COND	BTU/ HD - FT - F	3723	361/	.3554	
HERMAL COND. OLAR MASS	TR/TRMOT	.5725	18 02	. 5554	
OLAN MASS	пр/ приоп		18.02		10.02
EMP, AVG & SKIN	DECE				
ISCOSITY, AVG & SKIN			.6826		
RESSURE, IN & DE	SKIN CI STCN DSTA	50 00	165 00	50 00	165 00
NESSURE, IN & DE	SIGN FSIA	30.00	103.00	30.00	103.00
RESSURE DROP, TO	T & ALLOWED PSI	г .01	10.00	- 00	10.00
ELOCITY, CALC & 1	MAX ALLOWED FT	/s 19	10.00	05	10.00
diociti, chic a	IMM TIBLOWED II,	.19	10.00	•00	10.00
OULING RESISTANC	E HR-FT2-F/F	3TU . (	0010	. (	0010
ILM COEFFICIENT	BTII/HR-FT2	)_F 19	95 63		54.73
OTAL HEAT DUTY R	EOUIRED MEGBTU/F	НR			.009432
	F (LMTD= 30.0, F		VCC- 03 D7:	FF-1 00)	
			ASS93, BA	FF-1.00)	
VERALL COEFF REQ	UIRED BTU/HR-E	FT2-F			81.43
VERALL COEFF REQ	UIRED BTU/HR-E	FT2-F			
VERALL COEFF REQ LEAN & FOULED CO	UIRED BTU/HR-F EFF BTU/HR-F	FT2-F FT2-F	82.9	9	81.43 81.45
VERALL COEFF REQ LEAN & FOULED CO: HELLS IN SERIES	UIRED BTU/HR-F EFF BTU/HR-F 1 PARALLEL 1	FT2-F FT2-F TOTAL EFF	82.9 F AREA	9 FT2	81.43 81.45 7.1
VERALL COEFF REQ LEAN & FOULED CO HELLS IN SERIES ASSES, SHELL	UIRED BTU/HR-F EFF BTU/HR-F 1 PARALLEL 1 1 TUBE 4	FT2-F FT2-F TOTAL EFF EFFECTIVE	82.9 F AREA E AREA	9 FT2 FT2/SHELL	81.43 81.45 7.1 7.1
VERALL COEFF REQ LEAN & FOULED CO HELLS IN SERIES ASSES, SHELL	UIRED BTU/HR-F EFF BTU/HR-F 1 PARALLEL 1 1 TUBE 4	FT2-F FT2-F TOTAL EFF EFFECTIVE	82.9 F AREA E AREA	9 FT2 FT2/SHELL	81.43 81.45 7.1 7.1
VERALL COEFF REQ LEAN & FOULED CO HELLS IN SERIES ASSES, SHELL HELL DIAMETER IN	UIRED BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF 1 PARALLEL 1 1 TUBE 4 3.820	FT2-F FT2-F TOTAL EFF EFFECTIVE TEMA SHEI	82.9 F AREA E AREA LL TYPE E	FT2 FT2/SHELL ; REAR HI	81.43 81.45 7.1 7.1 EAD FXTS
VERALL COEFF REQ LEAN & FOULED CO HELLS IN SERIES ASSES, SHELL HELL DIAMETER IN	UIRED BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF	FT2-F FT2-F  TOTAL EFF EFFECTIVE TEMA SHEI  CROSS PAS	82.9 F AREA E AREA LL TYPE E SSES PER SH	9 FT2 FT2/SHELL ; REAR HE	81.43 81.45 7.1 7.1 EAD FXTS
VERALL COEFF REQ LEAN & FOULED CO HELLS IN SERIES ASSES, SHELL HELL DIAMETER IN AFFLE TYPE PACING, CENTRAL	UIRED BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF	FT2-F FT2-F  TOTAL EFF EFFECTIVE TEMA SHEI  CROSS PAS BAFFLE CU	82.9 F AREA E AREA LL TYPE E SSES PER SHI	FT2 FT2/SHELL ; REAR HH	81.43 81.45 7.1 7.1 EAD FXTS 4 30.00
VERALL COEFF REQ LEAN & FOULED CO HELLS IN SERIES ASSES, SHELL HELL DIAMETER IN AFFLE TYPE PACING, CENTRAL PACING, INLET	UIRED BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF	FT2-F FT2-F  TOTAL EFF EFFECTIVE TEMA SHEI  CROSS PAS BAFFLE CU	82.9 F AREA E AREA LL TYPE E SSES PER SHI	FT2 FT2/SHELL ; REAR HH	81.43 81.45 7.1 7.1 EAD FXTS 4 30.00
VERALL COEFF REQ LEAN & FOULED CO HELLS IN SERIES ASSES, SHELL HELL DIAMETER IN AFFLE TYPE PACING, CENTRAL PACING, INLET PACING, OUTLET	UIRED BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFFF BTU/HR-FEFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF	FT2-F FT2-F  TOTAL EFF EFFECTIVE TEMA SHEI  CROSS PAS BAFFLE CU CUT DISTA	82.9 F AREA E AREA LL TYPE E SSES PER SHI JT, PCT SHE	FT2 FT2/SHELL ; REAR HI ELL PASS LL I.D. ENTER, IN.	81.43 81.45 7.1 7.1 EAD FXTS 4 30.00 .764
VERALL COEFF REQ LEAN & FOULED CO HELLS IN SERIES ASSES, SHELL HELL DIAMETER IN AFFLE TYPE PACING, CENTRAL PACING, INLET PACING, OUTLET AFFLE THICKNESS	UIRED BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF	FT2-F FT2-F  TOTAL EFF EFFECTIVE TEMA SHEI  CROSS PAS BAFFLE CU CUT DISTA	82.9 F AREA E AREA LL TYPE E SSES PER SHI JT, PCT SHE ANCE FROM C	FT2 FT2/SHELL ; REAR HE ELL PASS LL I.D. ENTER, IN.	81.43 81.45 7.1 7.1 EAD FXTS 4 30.00 .764 NO
VERALL COEFF REQ LEAN & FOULED CO HELLS IN SERIES ASSES, SHELL HELL DIAMETER IN AFFLE TYPE PACING, CENTRAL PACING, INLET PACING, OUTLET AFFLE THICKNESS	UIRED BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF	FT2-F FT2-F  TOTAL EFF EFFECTIVE TEMA SHEI  CROSS PAS BAFFLE CU CUT DISTA	82.9 F AREA E AREA LL TYPE E SSES PER SHI JT, PCT SHE	FT2 FT2/SHELL ; REAR HE ELL PASS LL I.D. ENTER, IN.	81.43 81.45 7.1 7.1 EAD FXTS 4 30.00 .764
VERALL COEFF REQ LEAN & FOULED CO HELLS IN SERIES ASSES, SHELL HELL DIAMETER IN AFFLE TYPE PACING, CENTRAL PACING, INLET PACING, OUTLET AFFLE THICKNESS AIRS OF SEALING	UIRED BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFFF BTU/HR-FEFFF BTU/HR-FEFFFF BTU/HR-FEFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF	FT2-F FT2-F  TOTAL EFF EFFECTIVE TEMA SHEI  CROSS PAS BAFFLE CU CUT DISTA  IMPINGEME TUBESHEET	82.9 F AREA E AREA LL TYPE E SSES PER SHI JT, PCT SHE ANCE FROM CI	FT2 FT2/SHELL ; REAR HE ELL PASS LL I.D. ENTER, IN. INCLUDED A, %	81.43 81.45 7.1 7.1 FXTS 4 30.00 .764 NO .0
VERALL COEFF REQ LEAN & FOULED CO HELLS IN SERIES ASSES, SHELL HELL DIAMETER IN AFFLE TYPE PACING, CENTRAL PACING, INLET PACING, OUTLET AFFLE THICKNESS AIRS OF SEALING UBE TYPE	UIRED BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFFF BTU/HR-FEFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF	FT2-F FT2-F  TOTAL EFF EFFECTIVE TEMA SHEI  CROSS PAS BAFFLE CU CUT DISTA  IMPINGEME TUBESHEET	82.9  F AREA E AREA LL TYPE E  SSES PER SHI JT, PCT SHE ANCE FROM CI	FT2 FT2/SHELL ; REAR HE ELL PASS LL I.D. ENTER, IN.	81.43 81.45 7.1 7.1 FAD FXTS 4 30.00 .764 NO .0
VERALL COEFF REQ LEAN & FOULED CO HELLS IN SERIES ASSES, SHELL HELL DIAMETER IN AFFLE TYPE PACING, CENTRAL PACING, INLET PACING, OUTLET AFFLE THICKNESS AIRS OF SEALING UBE TYPE O. OF TUBES/SHEL	UIRED BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFFF BTU/HR-FEFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF	TT2-F TT2-F TOTAL EFF EFFECTIVE TEMA SHEI CROSS PAS BAFFLE CU CUT DISTA IMPINGEME TUBESHEET MATERIAL EST MAX T	82.9  F AREA E AREA LL TYPE E  SSES PER SHI JT, PCT SHE ANCE FROM CI ENT BAFFLE F BLANK ARE FUBE COUNT	FT2 FT2/SHELL ; REAR HI ELL PASS LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC	81.43 81.45 7.1 7.1 7.1 EAD FXTS 4 30.00 .764 NO .0
VERALL COEFF REQ LEAN & FOULED CO HELLS IN SERIES ASSES, SHELL HELL DIAMETER IN AFFLE TYPE PACING, CENTRAL PACING, INLET PACING, OUTLET AFFLE THICKNESS AIRS OF SEALING UBE TYPE O. OF TUBES/SHEL UBE LGTH, OVERAL	UIRED BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF	TT2-F TT2-F TOTAL EFF EFFECTIVE TEMA SHEI CROSS PAS BAFFLE CU CUT DISTA IMPINGEME TUBESHEET MATERIAL EST MAX T	82.9  F AREA E AREA LL TYPE E  SSES PER SHI JT, PCT SHE ANCE FROM CI ENT BAFFLE F BLANK ARE TUBE COUNT	FT2 FT2/SHELL ; REAR HE ELL PASS LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC	81.43 81.45 7.1 7.1 7.1 EAD FXTS 4 30.00 .764 NO .0
VERALL COEFF REQ LEAN & FOULED CO: HELLS IN SERIES ASSES, SHELL HELL DIAMETER IN AFFLE TYPE PACING, CENTRAL PACING, INLET PACING, OUTLET AFFLE THICKNESS AIRS OF SEALING UBE TYPE O. OF TUBES/SHEL UBE LGTH, OVERAL UBE LGTH, EFF	UIRED BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFFF BTU/HR-FEFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF	TT2-F TT2-F TOTAL EFF EFFECTIVE TEMA SHEIF CROSS PASS BAFFLE CU CUT DISTA IMPINGEME TUBESHEET MATERIAL EST MAX TOBE PITCE TUBE OUTS	82.9  F AREA E AREA LL TYPE E  SSES PER SHI JT, PCT SHE ANCE FROM CI ENT BAFFLE F BLANK ARE TUBE COUNT CH SIDE DIAM	FT2 FT2/SHELL ; REAR HH ELL PASS LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC IN. IN.	81.43 81.45 7.1 7.1 7.1 EAD FXTS 4 30.00 .764 NO .0 C COPPER 36 .3125 .250
VERALL COEFF REQ LEAN & FOULED CO HELLS IN SERIES ASSES, SHELL HELL DIAMETER IN AFFLE TYPE PACING, CENTRAL PACING, INLET PACING, OUTLET AFFLE THICKNESS AIRS OF SEALING UBE TYPE O. OF TUBES/SHEL UBE LGTH, OVERAL UBE LGTH, EFF UBE LAYOUT	UIRED BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFFF BTU/HR-FEFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF	TT2-F TT2-F TOTAL EFF EFFECTIVE TEMA SHEIL CROSS PASS BAFFLE CU CUT DISTA IMPINGEME TUBESHEET MATERIAL EST MAX TOTAL TUBE PITCE TUBE OUTS TUBE INST	82.9  F AREA E AREA LL TYPE E  SSES PER SHI JT, PCT SHE ANCE FROM CI ENT BAFFLE F BLANK ARE TUBE COUNT CH SIDE DIAM IDE DIAM	FT2 FT2/SHELL ; REAR HE ELL PASS LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC IN. IN. IN.	81.43 81.45 7.1 7.1 7.1 EAD FXTS 4 30.00 .764 NO .0 C COPPER 36 .3125 .250 .214
VERALL COEFF REQ LEAN & FOULED CO HELLS IN SERIES ASSES, SHELL HELL DIAMETER IN AFFLE TYPE PACING, CENTRAL PACING, INLET PACING, OUTLET AFFLE THICKNESS AIRS OF SEALING UBE TYPE O. OF TUBES/SHEL UBE LGTH, OVERAL UBE LGTH, EFF UBE LAYOUT ITCH RATIO	UIRED BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFFF BTU/HR-FEFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF	TT2-F TT2-F TOTAL EFF EFFECTIVE TEMA SHEI  CROSS PAS BAFFLE CU CUT DISTA  IMPINGEME TUBESHEET  MATERIAL EST MAX T TUBE PITC TUBE OUTS TUBE INSI	82.9  F AREA E AREA LL TYPE E  SSES PER SHI ANCE FROM CI ENT BAFFLE F BLANK ARE CUBE COUNT CH SIDE DIAM FACE RATIO,	FT2 FT2/SHELL ; REAR HE ELL PASS LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC IN. IN. IN. OUT/IN	81.43 81.45 7.1 7.1 7.1 EAD FXTS 4 30.00 .764 NO .0 C COPPER 36 .3125 .250 .214 1.184
VERALL COEFF REQ LEAN & FOULED CO HELLS IN SERIES ASSES, SHELL HELL DIAMETER IN AFFLE TYPE PACING, CENTRAL PACING, INLET PACING, OUTLET AFFLE THICKNESS AIRS OF SEALING UBE TYPE O. OF TUBES/SHEL UBE LGTH, OVERAL UBE LGTH, EFF UBE LAYOUT ITCH RATIO	UIRED BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFFF BTU/HR-FEFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF	TT2-F TT2-F TOTAL EFF EFFECTIVE TEMA SHEI  CROSS PAS BAFFLE CU CUT DISTA  IMPINGEME TUBESHEET  MATERIAL EST MAX T TUBE PITC TUBE OUTS TUBE INSI	82.9  F AREA E AREA LL TYPE E  SSES PER SHI JT, PCT SHE ANCE FROM CI ENT BAFFLE F BLANK ARE TUBE COUNT CH SIDE DIAM IDE DIAM	FT2 FT2/SHELL ; REAR HE ELL PASS LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC IN. IN. IN. OUT/IN	81.43 81.45 7.1 7.1 7.1 EAD FXTS 4 30.00 .764 NO .0 C COPPER 36 .3125 .250 .214 1.184
VERALL COEFF REQ LEAN & FOULED CO HELLS IN SERIES ASSES, SHELL HELL DIAMETER IN AFFLE TYPE PACING, CENTRAL PACING, INLET PACING, OUTLET AFFLE THICKNESS AIRS OF SEALING UBE TYPE O. OF TUBES/SHEL UBE LGTH, OVERAL UBE LGTH, EFF UBE LAYOUT ITCH RATIO HL NOZZ ID, IN&O	UIRED BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFFF BTU/HR-FEFFF A 1.820 BTU/HR-FEFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF	TT2-F TT2-F TOTAL EFF EFFECTIVE TEMA SHEI CROSS PAS BAFFLE CU CUT DISTA IMPINGEME TUBESHEET MATERIAL EST MAX TUBE PITC TUBE OUTS TUBE INST	82.9  F AREA E AREA LL TYPE E  SSES PER SHI ANCE FROM CI ENT BAFFLE F BLANK ARE CUBE COUNT CH SIDE DIAM FACE RATIO,	FT2 FT2/SHELL ; REAR HE ELL PASS LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC IN. IN. IN. OUT/IN	81.43 81.45 7.1 7.1 7.1 EAD FXTS 4 30.00 .764 NO .0 C COPPER 36 .3125 .250 .214 1.184
VERALL COEFF REQUEAN & FOULED COMBELLS IN SERIES PASSES, SHELL HELL DIAMETER IN PACING, CENTRAL PACING, CENTRAL PACING, OUTLET PACING, OUTLET PAFILE THICKNESS PAIRS OF SEALING PACING OF TUBES/SHELD UBE LGTH, OVERALD UBE LGTH, EFF UBE LAYOUT PITCH RATIO HL NOZZ ID, IN&O' * CALCULATED IT.	UIRED BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFFF A 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	TT2-F TT2-F TOTAL EFF EFFECTIVE TEMA SHEIL CROSS PASS BAFFLE CU CUT DISTA IMPINGEME TUBESHEET MATERIAL EST MAX TOBE PITC TUBE OUTS TUBE INST TUBE SURE TUBE SURE TUBE NOZZ	82.9  F AREA E AREA LL TYPE E  SSES PER SHI JT, PCT SHE ANCE FROM CI ENT BAFFLE F BLANK ARE FUBE COUNT CH SIDE DIAM FACE RATIO, Z ID, IN&OU	FT2 FT2/SHELL ; REAR HI ELL PASS LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC IN. IN. IN. OUT/IN I IN.	81.43 81.45 7.1 7.1 7.1 EAD FXTS 4 30.00 .764 NO .0 C COPPER 36 .3125 .250 .214 1.184
VERALL COEFF REQ LEAN & FOULED CO HELLS IN SERIES ASSES, SHELL HELL DIAMETER IN AFFLE TYPE PACING, CENTRAL PACING, INLET PACING, OUTLET AFFLE THICKNESS AIRS OF SEALING UBE TYPE O. OF TUBES/SHEL UBE LGTH, OVERAL UBE LGTH, EFF UBE LAYOUT ITCH RATIO HL NOZZ ID, IN&O  * CALCULATED IT Washington Univ	UIRED BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFFF BTU/HR-FEFFF BTU/HR-FEFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF	TT2-F TT2-F TOTAL EFF EFFECTIVE TEMA SHEIL CROSS PASS BAFFLE CU CUT DISTA IMPINGEME TUBESHEET MATERIAL EST MAX TOBE PITC TUBE OUTS TUBE INST TUBE SURE TUBE SURE TUBE NOZZ	82.9  F AREA E AREA LL TYPE E  SSES PER SHI JT, PCT SHE ANCE FROM CI ENT BAFFLE F BLANK ARE FUBE COUNT CH SIDE DIAM FACE RATIO, Z ID, IN&OU	FT2 FT2/SHELL ; REAR HI ELL PASS LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC IN. IN. IN. OUT/IN I IN.	81.43 81.45 7.1 7.1 7.1 EAD FXTS 4 30.00 .764 NO .0 C COPPER 36 .3125 .250 .214 1.184 .8
VERALL COEFF REQ LEAN & FOULED CO HELLS IN SERIES ASSES, SHELL HELL DIAMETER IN AFFLE TYPE PACING, CENTRAL PACING, INLET PACING, OUTLET AFFLE THICKNESS AIRS OF SEALING UBE TYPE O. OF TUBES/SHEL UBE LGTH, OVERAL UBE LGTH, EFF UBE LAYOUT ITCH RATIO HL NOZZ ID, IN&O  * CALCULATED IT	UIRED BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFF BTU/HR-FEFFF BTU/HR-FEFFF BTU/HR-FEFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF	TT2-F TT2-F TOTAL EFF EFFECTIVE TEMA SHEIL CROSS PASS BAFFLE CU CUT DISTA IMPINGEME TUBESHEET MATERIAL EST MAX TOBE PITC TUBE OUTS TUBE INST TUBE SURE TUBE SURE TUBE NOZZ	82.9  F AREA E AREA LL TYPE E  SSES PER SHI JT, PCT SHE ANCE FROM CI ENT BAFFLE F BLANK ARE FUBE COUNT CH SIDE DIAM FACE RATIO, Z ID, IN&OU	FT2 FT2/SHELL ; REAR HI ELL PASS LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC IN. IN. IN. OUT/IN I IN.	81.43 81.45 7.1 7.1 7.1 EAD FXTS 4 30.00 .764 NO .0 C COPPER 36 .3125 .250 .214 1.184

				(70).001		
HT PARAMETERS		'UBE		LSIDE PERF		
WALL CORRECTION	1.023 .	000	NOMINA	L VEL, X-FL	OW FT/S	.04
PRANDTL NUMBER	5.4	3.9	NOMINA		OW FT/S	
PRANDTL NUMBER RYNLD NO, AVG	139. 5	38.	CROSSF	LOW COEF	BTU/HR-FT2	-F 165.4
RYNLD NO, IN BUN	115. 6	67.	WINDOW	COEF	BTU/HR-FT2	-F 166.4
RYNLD NO, OUT BUN	165. 4	21.				
FOULNG LAYER IN.	.0014 .0	014	SHEL	LSIDE FLOW	, % OF TOTA	L
			HEAT T	RANSFER X-	FLOW	81.20
THERMAL RESISTANCE	. % OF TOTA	L	TUBE T	O BAFFLE L	FLOW EAKAGE A	= 2.81
SHELL TUBE FOU	TING METAI		MATN C	ROSSFLOW	В	= 68.43
48.89 49.29 1	77 06		BIINDLE	TO SHELL	BYPASS C	= 12 19
DCT OVER DESIGN	. , ,	0.2	BYELL			
PCT OVER DESIGN TOT FOUL RESIST	000	217	מ ממנוטה ט	ACCUANTE DV	DACC E	- 10.50
TOT FOOL RESIST	.000		IUDE P	ASSLANE DI	rass r	00
DIFF RESIST			0			
			SHEL		TRANSFER F	
DIAMETRAL CLEARA	NCES		TOTAL		MMA) (FIN)	
DIAMETRAL CLEARA BUNDLE TO SHELL TUBE TO BAFFLE HOL	IN	5000	BETA		FACTOR)	
BAFFLE TO SHELL	IN	1000	END	(HT LOSS I	N END ZONE)	= .994
SHELL NOZZLE DAT	A IN	OUT	SHEL	L PRESSURE	DROP, % OF	TOTAL
HT UNDR NOZ IN.	.25		WINDOW			= 9.2
HT OPP NOZ IN.	.25		END ZO	NE		= 5.5
VELOCITY FT/S	.25			FLOW		= 4.5
DENSITY LB/FT3				NOZZLE		= 41.2
NOZZ RHO*VSQ LB/FT				NOZZLE		= 39.6
BUND RHO*VSQ LB/FT			001111	1102222		33.0
DOND IMIO VOQ ID/II	52 2	2				
TIDE NOTTE DATA	TM	OIIT	METC			
TUBE NOZZLE DATA	. III	20	MEIG	HI FER SHE		150.
VELOCITY FT/S	.30	.29	DKI		=	150.
DENSITY LB/FT3			ME.T.		=	165.
PRESS. DROP %						
Washington Unive		3 heat	exchan	ger experi	ment	
Young model F302DY	4 P					9/23/ 3
						CASE 11
SIZE 4- 18 TYPE BE	M, MULTI-PA	SS FLO				
			HOT T	UBE SIDE	COLD S	HELL SIDE
			Tube		Shel	
				IBLE LIQ	SENS	IBLE LIQ
TOTAL FLOW RATE	KLB/HR			.200		.400
			IN	OUT	IN	OUT
TEMPERATURE	DEGF		140.0	88.2*	70.0	95.8*
DENSITY	LB/FT3			62.0422	62.2515	61.9460
VISCOSITY	CP		.4726		.9783	
	BTU/LB-F		.9973	.9996	1.0015	
THERMAL COND.				.3603		
MOLAR MASS		L	. 3723	18.02	.5554	18.02
MOLAK MASS	пр/ приоп			10.02		10.02
TEMP NIC CORTN	DECE			97.5		
TEMP, AVG & SKIN						
VISCOSITY, AVG & S				.7105		.7152
PRESSURE, IN & DES	IGN PSIA		50.00	165.00	50.00	165.00
PRESSURE DROP, TOT	& ALLOWED	PSI	.02	10.00	.00	10.00

	che433b(70).OUT	
VELOCITY, CALC & MAX ALLOWED FT/S	.19 10.00 .06	10.00
FOULING RESISTANCE HR-FT2-F/BTU FILM COEFFICIENT BTU/HR-FT2-F	J .00010	.00010
	F 196.31	195.02
TOTAL HEAT DUTY REQUIRED MEGBTU/HR		.010337
EFF TEMP DIF, DEGF (LMTD= 29.3,F=	.60.BYPASS= .93.BAFF=1.00)	16.4
,	_	
OVERALL COEFF REQUIRED BTU/HR-FT2 CLEAN & FOULED COEFF BTU/HR-FT2	2-F 90.20	88.30
SHELLS IN SERIES 1 PARALLEL 1	FOTAL EFF AREA FT2	7.1
PASSES, SHELL 1 TUBE 4	EFFECTIVE AREA FT2/SHEL	L 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		
SPACING, INLET IN. 4.309	CUT DISTANCE FROM CENTER, IN	. 764
SPACING, OUTLET IN. 4.309	,,,	
BAFFLE THICKNESS IN125	IMPINGEMENT BAFFLE INCLUDED	NO
PAIRS OF SEALING DEVICES 1	TUBESHEET BLANK AREA, %	. 0
TUBE TYPE PLAIN NO. OF TUBES/SHELL 76 FT TUBE LGTH, OVERALL FT 1.500 TUBE LGTH, EFF FT 1.436		
TUBE TYPE PLAIN N	MATERIAL ELECTROLYT	IC COPPER
NO. OF TUBES/SHELL 76	EST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT 1.500	TUBE PITCH IN.	.3125
•		
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 ITEMHEAT BALANCE (	CODE = 8	
Washington University ChE433 heat	t exchanger experiment	E0002 P 23
Young model F302DY4P	-	9/23/ 3
		CASE 11
S U P P L E M E N T A R	Y RESULTS	
HT PARAMETERS SHELL TUBE	SHELLSIDE PERFORMANCE	
WALL CORRECTION 1.022 .000		.05
PRANDTL NUMBER 5.6 3.9		
RYNLD NO, AVG 180. 526.	CROSSFLOW COEF BTU/HR-FT	
RYNLD NO, IN BUN 154. 667.	WINDOW COEF BTU/HR-FT	2-F 197.1
RYNLD NO, OUT BUN 208. 400.		
FOULNG LAYER IN0014 .0014	SHELLSIDE FLOW, % OF TOT	AL
	HEAT TRANSFER X-FLOW	
THERMAL RESISTANCE, % OF TOTAL	TUBE TO BAFFLE LEAKAGE	A = 3.07
SHELL TUBE FOULING METAL		
44.77 53.25 1.91 .06	BUNDLE TO SHELL BYPASS	C = 13.39
PCT OVER DESIGN .16	BAFFLE TO SHELL LEAKAGE	E = 16.21
PCT OVER DESIGN .16 TOT FOUL RESIST .000217	TUBE PASSLANE BYPASS	F = .00
DIFF RESIST .000018		
1 1	SHELLSIDE HEAT TRANSFER	FACTORS
DIAMETRAL CLEARANCES		
DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000	BETA (BAFF CUT FACTOR)	= .920
TUBE TO BAFFLE HOLE IN0284		

		che433b(			
BAFFLE TO SHELL	IN1000	END	(HT LOSS IN	END ZONE)	= .994
SHELL NOZZLE DAT	A IN OUT	SHELI	L PRESSURE	DROP, % OF	TOTAL
HT UNDR NOZ IN.				21.01, 0 01	= 9.0
HT OPP NOZ IN.			VE.		= 4.9
VELOCITY FT/S					= 4.1
DENSITY LB/FT3			NOZZLE		= 41.7
NOZZ RHO*VSQ LB/FT			NOZZLE		= 40.4
BUND RHO*VSQ LB/FT					
TUBE NOZZLE DATA			HT PER SHEL		
VELOCITY FT/S					150.
DENSITY LB/FT3		WET		=	165.
PRESS. DROP %					
Washington Unive		t exchang	ger experim	ent	
Young model F302DY	4 P				9/23/ 3
SIZE 4- 18 TYPE BE	M MIITTT-DAGG ET	OW SECMI	מאייאד אורבדי	FG DATING	CASE 12
0120 4 10 1110 00	M, MODII IASS ID		JBE SIDE		
		Tube		Shell	
			IBLE LIQ		
TOTAL FLOW RATE	KLB/HR		.200		
			OUT		
TEMPERATURE	DEGF	140.0	85.1*	70.0	91.9*
DENSITY	LB/FT3	61.2913	62.0794	62.2515	61.9963
VISCOSITY	CP	.4726	.8152	.9783	.7553
SPECIFIC HEAT		.9973		1.0015	.9993
THERMAL COND.		.3723	.3595	.3554	.3612
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF		94.7		
VISCOSITY, AVG & S			.7322	.8561	.7375
PRESSURE, IN & DES	IGN PSIA	50.00	165.00	50.00	165.00
	c allower bot	0.0	10.00	0.1	10.00
PRESSURE DROP, TOT VELOCITY, CALC & M				.01	
VELOCITI, CALC & M	AX ALLOWED F1/5	.19	10.00	.00	10.00
FOULING RESISTANCE	HR-FT2-F/BT	U .(	00010	. (	00010
FILM COEFFICIENT					23.83
TOTAL HEAT DUTY RE	-				.010949
EFF TEMP DIF, DEGF			ASS= .93,BA	FF=1.00)	
OVERALL COEFF REQU			0.6.0	-	93.84
CLEAN & FOULED COE	FF BTU/HR-FT	2-F	96.0	./	93.85
SHELLS IN SERIES	1 PARALLEL 1	TOTAL EF	F AREA	FT2	7.1
PASSES, SHELL					
SHELL DIAMETER IN.					
BAFFLE TYPE H					
SPACING, CENTRAL	IN. 4.309	BAFFLE C	JT, PCT SHE	LL I.D.	30.00
SPACING, INLET		CUT DISTA	ANCE FROM C	ENTER, IN.	.764
SPACING, OUTLET	IN. 4.309				

C	he433b(70).OUT	
BAFFLE THICKNESS IN125 IN	MPINGEMENT BAFFLE INCLUDED	NO
	JBESHEET BLANK AREA, %	. 0
		• •
	ATERIAL ELECTROLYTIC	C COPPER
NO. OF TUBES/SHELL 76 ES	ST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT 1.500 TO	JBE PITCH IN.	.3125
	JBE OUTSIDE DIAM IN.	.250
	JBE INSIDE DIAM IN.	.214
	JBE SURFACE RATIO, OUT/IN	
SHL NOZZ ID, IN&OUT 1.0 1.0 TO	JBE NOZZ ID, IN&OUT IN.	.8 .8
* CALCULATED ITEMHEAT BALANCE CO	DDE = 8	
Washington University ChE433 heat	exchanger experiment	E0002 P 25
Young model F302DY4P		9/23/ 3
Tourig model 1302D141		CASE 12
		CASE 12
SUPPLEMENTAR	Y RESULTS	
HT PARAMETERS SHELL TUBE	SHELLSIDE PERFORMANCE	
WALL CORRECTION 1.021 .000	NOMINAL VEL, X-FLOW FT/S	.07
PRANDTL NUMBER 5.8 4.0	NOMINAL VEL, WINDOW FT/S	
RYNLD NO, AVG 220. 518.	CROSSFLOW COEF BTU/HR-FT2	
RYNLD NO, IN BUN 192. 667.	WINDOW COEF BTU/HR-FT2-	-F 226.3
RYNLD NO, OUT BUN 249. 387.		
FOULNG LAYER IN0014 .0014	SHELLSIDE FLOW, % OF TOTAL	L
	HEAT TRANSFER X-FLOW	81.44
THERMAL RESISTANCE, % OF TOTAL	TUBE TO BAFFLE LEAKAGE A	= 3.29
SHELL TUBE FOULING METAL		= 66.38
41.46 56.44 2.03 .07		
	BUNDLE TO SHELL BYPASS C	
PCT OVER DESIGN .01		
TOT FOUL RESIST .000217	TUBE PASSLANE BYPASS F	= .00
DIFF RESIST .000001		
	SHELLSIDE HEAT TRANSFER FA	ACTORS
DIAMETRAL CLEARANCES	TOTAL = (BETA) (GAMMA) (FIN)	= .651
BUNDLE TO SHELL IN5000	BETA (BAFF CUT FACTOR)	
TUBE TO BAFFLE HOLE IN0284	GAMMA (TUBE ROW ENTRY EFCT)	
	·	
BAFFLE TO SHELL IN1000	END (HT LOSS IN END ZONE)	= .994
SHELL NOZZLE DATA IN OUT	SHELL PRESSURE DROP, % OF	TOTAL
HT UNDR NOZ IN25	WINDOW	= 8.9
HT OPP NOZ IN25	END ZONE	= 4.4
	CROSS FLOW	= 3.8
DENSITY LB/FT3 62.252 61.996		= 42.0
	OUTLET NOZZLE	= 41.0
BUND RHO*VSQ LB/FT-S2 7 7		
TUBE NOZZLE DATA IN OUT	WEIGHT PER SHELL, LB	
VELOCITY FT/S .30 .29	DRY =	150.
		165.
PRESS. DROP % 4.1 2.6		±00•
		E0000 D 00
Washington University ChE433 heat	exchanger experiment	E0002 P 26
Young model F302DY4P		9/23/ 3
		CASE 13

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

		Tube	JBE SIDE	Shell	L
TOTAL FLOW RATE	KLB/HR		.200		.600
IIIDIUIII OOND.	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES	KIN CP	111.5 .6149 50.00	92.6 .7497 165.00	79.5 .8711 50.00	91.9 .7556 165.00
PRESSURE DROP, TOT VELOCITY, CALC & M	& ALLOWED PSI AX ALLOWED FT/	.02 'S .19	10.00	.01	10.00
FOULING RESISTANCE FILM COEFFICIENT	HR-FT2-F/E BTU/HR-FT2	2-F 19	97.36	25	00010
TOTAL HEAT DUTY RE EFF TEMP DIF, DEGF OVERALL COEFF REQU CLEAN & FOULED COE	QUIRED MEGBTU/F (LMTD= 27.8,F IRED BTU/HR-F	HR F= .62,BYPA FT2-F	ASS= .93,BAI	FF=1.00)	.011387 16.2 98.52 98.50
SHELLS IN SERIES PASSES, SHELL SHELL DIAMETER IN.	1 PARALLEL 1 1 TUBE 4 3.820	TOTAL EFF EFFECTIVE TEMA SHEI	F AREA E AREA LL TYPE E	FT2 FT2/SHELL ; REAR HE	7.1 7.1 EAD FXTS
BAFFLE TYPE H SPACING, CENTRAL SPACING, INLET SPACING, OUTLET	IN. 4.309 IN. 4.309 IN. 4.309	BAFFLE CU CUT DISTA	JT, PCT SHE ANCE FROM CE	LL I.D. ENTER, IN.	30.00
BAFFLE THICKNESS PAIRS OF SEALING D			INT BAFFLE I		NO . 0
TUBE TYPE  NO. OF TUBES/SHELL  TUBE LGTH, OVERALL  TUBE LGTH, EFF  TUBE LAYOUT  PITCH RATIO  SHL NOZZ ID, IN&OU	FT 1.500 FT 1.436 DEG 60 1.250	EST MAX TOBE PITCE TUBE OUTS TUBE INSI TUBE SURE	SIDE DIAM DE DIAM FACE RATIO,	IN. IN. IN. OUT/IN	36 .3125 .250 .214 1.184
* CALCULATED ITE Washington Unive Young model F302DY S U P P L E	rsity ChE433 he	eat exchanç	_		E0002 P 27 9/23/ 3 CASE 13

HT PARAMETERS SHELL TUBE SHELLSIDE PERFORMANCE

	(	che433b	(70).OUT		
WALL CORRECTION 1.020			L VEL, X-FLO		
PRANDTL NUMBER 5.9					
RYNLD NO, AVG 259.					
RYNLD NO, IN BUN 231.		WINDOW	COEF 1	BTU/HR-FT2	-F 254.3
RYNLD NO, OUT BUN 289.					
FOULNG LAYER IN0014	.0014				
			'RANSFER X-F		
THERMAL RESISTANCE, % OF T			O BAFFLE LE		
SHELL TUBE FOULING ME			ROSSFLOW		
38.71 59.09 2.14			TO SHELL B		
PCT OVER DESIGN	02		TO SHELL L		
TOT FOUL RESIST .		TUBE P	ASSLANE BYPA	ASS F	= .00
DIFF RESIST	000002	21177			
			LSIDE HEAT		
DIAMETRAL CLEARANCES	F000		= (BETA) (GAMI		
DONDER TO DIEDER TIV.	.0000		(BAFF CUT F		
TUBE TO BAFFLE HOLE IN.					
BAFFLE TO SHELL IN.	.1000	END	(HT LOSS IN	END ZONE)	= .994
SHELL NOZZLE DATA IN	, OIIT	CHET	I DDECCIDE		ш∩шлт
HT UNDR NOZ IN25		WINDOW		DROP, 5 OF	= 8.9
HT OPP NOZ IN25			NE		= 4.0
VELOCITY FT/S .49			FLOW		= 3.5
DENSITY LB/FT3 62.252					= 42.2
NOZZ RHO*VSQ LB/FT-S2 14					= 41.4
BUND RHO*VSQ LB/FT-S2 10		OOIDDI	NOZZEE		11.1
2012 1010 100 22 12, 11 02 10					
TUBE NOZZLE DATA IN	TUO	WEIG	HT PER SHEL	L, LB	
VELOCITY FT/S .30			-		150.
DENSITY LB/FT3 61.291				=	
PRESS. DROP % 4.1					
Washington University Ch	E433 heat	exchan	ger experim	ent	E0002 P 28
Young model F302DY4P			-		9/23/ 3
-					CASE 14
SIZE 4- 18 TYPE BEM, MULTI	-PASS FLO	W, SEGM	ENTAL BAFFL	ES, RATING	
		HOT T	UBE SIDE	COLD SI	HELL SIDE
		Tube	:	Shel	1
		SENS	IBLE LIQ	SENS	IBLE LIQ
TOTAL FLOW RATE KLB/HR			.200		.700
		IN	OUT	IN	OUT
TEMPERATURE DEGF			81.3*		
	6		62.1250		
VISCOSITY CP			.8526		
SPECIFIC HEAT BTU/LB-			1.0003		
THERMAL COND. BTU/HR-		.3723	.3584	.3554	.3599
MOLAR MASS LB/LBMC	)L		18.02		18.02
MENUD ALIG 6 CTTT					00 1
TEMP, AVG & SKIN DEG			90.8		
VISCOSITY, AVG & SKIN CP			.7644		
PRESSURE, IN & DESIGN PSI	A	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT & ALLOW	ובט ספד	0.2	10.00	∩1	10.00
VELOCITY, CALC & MAX ALLOW					
VULLA VILLA VALUE & LIAA ALIUM		• + /	TO.00	• 4 4	± \/ • \/ //

FOULING RESISTANCE HR-FT2-F FILM COEFFICIENT BTU/HR-F		.00010 279.43
TOTAL HEAT DUTY REQUIRED MEGBTU EFF TEMP DIF, DEGF (LMTD= 27.1 OVERALL COEFF REQUIRED BTU/HR CLEAN & FOULED COEFF BTU/HR	F= .63,BYPASS= .93,BAFF=1.00)	
SHELLS IN SERIES 1 PARALLEL 1 PASSES, SHELL 1 TUBE 4 SHELL DIAMETER IN. 3.820	EFFECTIVE AREA FT2/SHE	TLL 7.1
BAFFLE TYPE HORZ SEGMENTL SPACING, CENTRAL IN. 4.309 SPACING, INLET IN. 4.309 SPACING, OUTLET IN. 4.309 BAFFLE THICKNESS IN125	BAFFLE CUT, PCT SHELL I.D. CUT DISTANCE FROM CENTER, I IMPINGEMENT BAFFLE INCLUDED	30.00 764 NO
PAIRS OF SEALING DEVICES 1	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	TUBE PITCH IN.  TUBE OUTSIDE DIAM IN.  TUBE INSIDE DIAM IN.  TUBE SURFACE RATIO, OUT/IN	36 .3125 .250 .214 1.184
* CALCULATED ITEMHEAT BALAN Washington University ChE433 Young model F302DY4P	CE CODE = 8 heat exchanger experiment	E0002 P 29 9/23/ 3
SUPPLEMENTA	RY RESULTS	CASE 14
S U P P L E M E N T A  HT PARAMETERS SHELL TUB  WALL CORRECTION 1.019 .00  PRANDTL NUMBER 6.0 4.  RYNLD NO, AVG 298. 508  RYNLD NO, IN BUN 269. 667  RYNLD NO, OUT BUN 329. 370	E SHELLSIDE PERFORMANCE  0 NOMINAL VEL,X-FLOW FT/S  1 NOMINAL VEL,WINDOW FT/S  . CROSSFLOW COEF BTU/HR-F  . WINDOW COEF BTU/HR-F	.09 .18 TT2-F 280.5 TT2-F 282.3
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.019 .00 PRANDTL NUMBER 6.0 4. RYNLD NO, AVG 298. 508 RYNLD NO, IN BUN 269. 667 RYNLD NO, OUT BUN 329. 370 FOULNG LAYER IN0014 .001	E SHELLSIDE PERFORMANCE  O NOMINAL VEL, X-FLOW FT/S  1 NOMINAL VEL, WINDOW FT/S  . CROSSFLOW COEF BTU/HR-F  . WINDOW COEF BTU/HR-F  .  4 SHELLSIDE FLOW, % OF TO HEAT TRANSFER X-FLOW TUBE TO BAFFLE LEAKAGE MAIN CROSSFLOW BUNDLE TO SHELL BYPASS  6 BAFFLE TO SHELL LEAKAGE  7 TUBE PASSLANE BYPASS	.09 .18 TT2-F 280.5 TT2-F 282.3 DTAL 81.44 A = 3.67 B = 65.00 C = 15.70

SHELL NOZZLE DAT HT UNDR NOZ IN. HT OPP NOZ IN. VELOCITY FT/S DENSITY LB/FT3 NOZZ RHO*VSQ LB/FT BUND RHO*VSQ LB/FT	.25 .57 .57 62.252 62.060 -s2 20 20	WINDOW END ZON CROSS F INLET N	E LOW		= 8.9 = 3.8 = 3.3 = 42.4
TUBE NOZZLE DATA VELOCITY FT/S DENSITY LB/FT3 PRESS. DROP % Washington Unive Young model F302DY	61.291 62.125 4.0 2.5 rsity ChE433 heat	DRY WET		=	
SIZE 4- 18 TYPE BE	M, MULTI-PASS FLO	HOT TU Tube	BE SIDE	COLD SH Shell	HELL SIDE
TOTAL FLOW RATE	KT.B/HR	SENSI	. 200	SENS1	. 800
	1122, 1111	IN	OUT	IN	OIIT
VISCOSITY	DEGF LB/FT3 CP	140.0 61.2913 .4726	80.0* 62.1397 .8655	70.0 62.2515 .9783	62.0816 .8170
SPECIFIC HEAT	BTU/LB-F	.9973	1.0004		
THERMAL COND. MOLAR MASS	BTU/HR-FT-F	.3723	.3581 18.02	.3554	.3594 18.02
HOLINIC HIMBO	пр/ приоп				
TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES	KIN CP	.6239	.7770	.8923	.7838
PRESSURE DROP, TOT VELOCITY, CALC & M	& ALLOWED PSI AX ALLOWED FT/S	.02	10.00	.01	10.00
FOULING RESISTANCE FILM COEFFICIENT	HR-FT2-F/BTU BTU/HR-FT2-I	_			00010
TOTAL HEAT DUTY RE EFF TEMP DIF, DEGF OVERALL COEFF REQU CLEAN & FOULED COE	QUIRED MEGBTU/HR (LMTD= 26.4,F= IRED BTU/HR-FT2	.64,BYPA 2-F	.SS= .93,BAE	FF=1.00)	.011971 15.8 106.14 106.22
SHELLS IN SERIES PASSES, SHELL SHELL DIAMETER IN.	1 TUBE 4 F	EFFECTIVE	AREA	FT2/SHELL	7.1
BAFFLE TYPE H SPACING, CENTRAL SPACING, INLET SPACING, OUTLET	IN. 4.309 IN. 4.309	BAFFLE CU	T, PCT SHEI	LL I.D.	30.00
BAFFLE THICKNESS	IN125	IMPINGEME	NT BAFFLE	INCLUDED	NO

SHELLSIDE HEAT TRANSFER FACTORS DIAMETRAL CLEARANCES TOTAL = (BETA) (GAMMA) (FIN) = .716DIAMETRAL CLEARANCES TOTAL = (BETA) (GAMMA) (FIN) = .716
BUNDLE TO SHELL IN. .5000 BETA (BAFF CUT FACTOR) = .920
TUBE TO BAFFLE HOLE IN. .0284 GAMMA (TUBE ROW ENTRY EFCT) = .779
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 HT OPP NOZ IN. .25 END ZONE = 3 VELOCITY FT/S .65 .66 CROSS FLOW = 3 3.2 DENSITY LB/FT3 62.252 62.082 INLET NOZZLE NOZZ RHO\*VSQ LB/FT-S2 26 26 OUTLET NOZZLE BUND RHO\*VSQ LB/FT-S2 18 18

TUBE NOZZLE DATA IN OUT WEIGHT PER SHELL, LB VELOCITY FT/S .30 .29 DRY 150. DENSITY LB/FT3 61.291 62.140 WET 165. PRESS. DROP % 4.0 2.5

Washington University ChE433 heat exchanger experiment E0002 P 32 Young model F302DY4P 9/23/ 3 CASE 16

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING HOT TUBE SIDE COLD SHELL SIDE

		Che433b (	70).OUT		
		Tube		Shell	1
		SENSI	BLE LIQ	SENS	IBLE LIQ
TOTAL FLOW RATE	KIB/HR				
101112 12011 14112	1122, 1111	TNI	.200 OUT	TM	OIIT
TEMPERATURE					
DENSITY					
VISCOSITY	CP	.4726	.8760	.9783	.8307
SPECIFIC HEAT	BTU/LB-F	.9973	1.0005	1.0015	1.0000
THERMAL COND.					
MOLAR MASS			18.02		18.02
MOLAK MASS	LB/ LBMOL		10.02		10.02
TEMP, AVG & SKIN	DEGE		88.1		
VISCOSITY, AVG & S					
PRESSURE, IN & DES	SIGN PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT	r allowed del	- 02	10 00	0.2	10 00
VELOCITY, CALC & N	MAX ALLOWED F"I'/	'S .19	10.00	. 14	10.00
DOLL THE DESIGNATION	IID DMO D/F	omri (	0.001.0	,	0.001.0
FOULING RESISTANCE					
FILM COEFFICIENT				33	35.71
					010175
TOTAL HEAT DUTY RE					.012175
EFF TEMP DIF, DEGE			ASS= .93,BA	FF=1.00)	
OVERALL COEFF REQU	JIRED BTU/HR-E	FT2-F			109.36
CLEAN & FOULED COE	EFF BTU/HR-F	TT2-F	112.7	3	109.49
SHELLS IN SERIES	1 PARALLEL 1	TOTAL EFF	F AREA	FT2	7.1
PASSES, SHELL					
SHELL DIAMETER IN.					
SHELL DIAMETER IN.	3.020	IEMA SHEI	TO TIPE E	, KEAK DI	FAD LVI2
			SSES PER SHI	ETT DACC	1
RAFFIE TYPE I	IORZ SEGMENTI.	CROSS PAS			
BAFFLE TYPE F					
SPACING, CENTRAL	IN. 4.309	BAFFLE CU	JT, PCT SHE	LL I.D.	30.00
SPACING, CENTRAL SPACING, INLET	IN. 4.309 IN. 4.309	BAFFLE CU		LL I.D.	30.00
SPACING, CENTRAL	IN. 4.309 IN. 4.309	BAFFLE CU	JT, PCT SHE	LL I.D.	30.00
SPACING, CENTRAL SPACING, INLET	IN. 4.309 IN. 4.309 IN. 4.309	BAFFLE CUCCUT DISTA	JT, PCT SHE	LL I.D. ENTER, IN.	30.00 .764
SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS	IN. 4.309 IN. 4.309 IN. 4.309 IN125	BAFFLE CUCUT DISTA	JT, PCT SHE: ANCE FROM CI ENT BAFFLE	LL I.D. ENTER, IN.	30.00 .764 NO
SPACING, CENTRAL SPACING, INLET SPACING, OUTLET	IN. 4.309 IN. 4.309 IN. 4.309 IN125	BAFFLE CUCUT DISTA	JT, PCT SHE: ANCE FROM C	LL I.D. ENTER, IN.	30.00 .764 NO
SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS	IN. 4.309 IN. 4.309 IN. 4.309 IN125	BAFFLE CUCUT DISTA	JT, PCT SHE ANCE FROM CI ENT BAFFLE :	LL I.D. ENTER, IN.	30.00 .764 NO .0
SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I	IN. 4.309 IN. 4.309 IN. 4.309 IN125 DEVICES 1 PLAIN	BAFFLE CUCUT DISTAINED IMPINGEMENTUBESHEED	JT, PCT SHE ANCE FROM C ENT BAFFLE : BLANK ARE	LL I.D. ENTER, IN. INCLUDED A, %	30.00 .764 NO .0
SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING ITUBE TYPE NO. OF TUBES/SHELI	IN. 4.309 IN. 4.309 IN. 4.309 IN125 DEVICES 1 PLAIN 76	BAFFLE CUCUT DISTALL IMPINGEMENTUBESHEED MATERIAL EST MAX 1	UT, PCT SHE: ANCE FROM CI ENT BAFFLE: BLANK ARE E: FUBE COUNT	LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC	30.00 .764 NO .0 C COPPER 36
SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI	IN. 4.309 IN. 4.309 IN. 4.309 IN125 DEVICES 1  PLAIN 76 L FT 1.500	BAFFLE CUCUT DISTALL IMPINGEMENTUBESHEET MATERIAL EST MAX TUBE PITC	JT, PCT SHE: ANCE FROM CI ENT BAFFLE : BLANK ARE: TUBE COUNT	LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC IN.	30.00 .764 NO .0 C COPPER 36 .3125
SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI TUBE LGTH, EFF	IN. 4.309 IN. 4.309 IN. 4.309 IN125 DEVICES 1  PLAIN 76 FT 1.500 FT 1.436	BAFFLE CUCUT DISTALL IMPINGEMENTUBESHEET MATERIAL EST MAX TUBE PITCUBE OUTS	JT, PCT SHE: ANCE FROM CI ENT BAFFLE : F BLANK ARE: FUBE COUNT CH SIDE DIAM	LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC IN. IN.	30.00 .764 NO .0 C COPPER 36 .3125 .250
SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI TUBE LGTH, EFF	IN. 4.309 IN. 4.309 IN. 4.309 IN125 DEVICES 1  PLAIN 76 FT 1.500 FT 1.436 DEG 60	BAFFLE CUCUT DISTALL IMPINGEMENTUBESHEET MATERIAL EST MAX TUBE PITCUBE OUTS TUBE INST	JT, PCT SHE: ANCE FROM CI ENT BAFFLE : BLANK ARE: FUBE COUNT CH SIDE DIAM IDE DIAM	LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC IN. IN. IN.	30.00 .764 NO .0 C COPPER 36 .3125 .250 .214
SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI TUBE LGTH, EFF	IN. 4.309 IN. 4.309 IN. 4.309 IN125 DEVICES 1  PLAIN 76 FT 1.500 FT 1.436 DEG 60	BAFFLE CUCUT DISTALL IMPINGEMENTUBESHEET MATERIAL EST MAX TUBE PITCUBE OUTS TUBE INST	JT, PCT SHE: ANCE FROM CI ENT BAFFLE : BLANK ARE: FUBE COUNT CH SIDE DIAM IDE DIAM	LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC IN. IN. IN.	30.00 .764 NO .0 C COPPER 36 .3125 .250 .214
SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I  TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI TUBE LGTH, EFF TUBE LAYOUT	IN. 4.309 IN. 4.309 IN. 4.309 IN125 DEVICES 1  PLAIN 76 FT 1.500 FT 1.436 DEG 60 1.250	BAFFLE CUCUT DISTALL IMPINGEMENTUBESHEES  MATERIAL EST MAX STUBE PITCUBE OUTS TUBE INSSTUBE SURE	UT, PCT SHEE ANCE FROM CO ENT BAFFLE ENT BLANK ARE FUBE COUNT CH SIDE DIAM IDE DIAM FACE RATIO,	LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC IN. IN. IN. OUT/IN	30.00 .764 NO .0 C COPPER 36 .3125 .250 .214 1.184
SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I  TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI TUBE LGTH, EFF TUBE LAYOUT PITCH RATIO	IN. 4.309 IN. 4.309 IN. 4.309 IN125 DEVICES 1  PLAIN 76 FT 1.500 FT 1.436 DEG 60 1.250	BAFFLE CUCUT DISTALL IMPINGEMENTUBESHEES  MATERIAL EST MAX STUBE PITCUBE OUTS TUBE INSSTUBE SURE	UT, PCT SHEE ANCE FROM CO ENT BAFFLE ENT BLANK ARE FUBE COUNT CH SIDE DIAM IDE DIAM FACE RATIO,	LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC IN. IN. IN. OUT/IN	30.00 .764 NO .0 C COPPER 36 .3125 .250 .214 1.184
SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I  TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI TUBE LGTH, EFF TUBE LAYOUT PITCH RATIO	IN. 4.309 IN. 4.309 IN. 4.309 IN125 DEVICES 1  PLAIN 76 FT 1.500 FT 1.436 DEG 60 1.250 JT 1.0 1.0	BAFFLE CUCUT DISTAL  IMPINGEME TUBESHEET  MATERIAL EST MAX TUBE PITO TUBE OUTS TUBE INST	UT, PCT SHEE ANCE FROM CO ENT BAFFLE ENT BLANK ARE FUBE COUNT CH SIDE DIAM IDE DIAM FACE RATIO,	LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC IN. IN. IN. OUT/IN	30.00 .764 NO .0 C COPPER 36 .3125 .250 .214 1.184
SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I  TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI TUBE LGTH, EFF TUBE LAYOUT PITCH RATIO SHL NOZZ ID, IN&OU	IN. 4.309 IN. 4.309 IN. 4.309 IN125 DEVICES 1  PLAIN 76 FT 1.500 FT 1.436 DEG 60 1.250 JT 1.0 1.0	BAFFLE CUCUT DISTAL  IMPINGEME TUBESHEET  MATERIAL EST MAX TUBE PITO TUBE OUTS TUBE INST TUBE SURE TUBE NOZZ	JT, PCT SHE: ANCE FROM CI ENT BAFFLE : BLANK ARE: TUBE COUNT CH SIDE DIAM IDE DIAM FACE RATIO, Z ID, IN&OUT	LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC IN. IN. IN. OUT/IN I IN.	30.00 .764 NO .0 C COPPER 36 .3125 .250 .214 1.184
SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I  TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI TUBE LGTH, EFF TUBE LAYOUT PITCH RATIO SHL NOZZ ID, IN&OU  * CALCULATED ITE Washington University	IN. 4.309 IN. 4.309 IN. 4.309 IN125 DEVICES 1  PLAIN 76 FT 1.500 FT 1.436 DEG 60 1.250 JT 1.0 1.0  EMHEAT BALANCE ersity ChE433 he	BAFFLE CUCUT DISTAL  IMPINGEME TUBESHEET  MATERIAL EST MAX TUBE PITO TUBE OUTS TUBE INST TUBE SURE TUBE NOZZ	JT, PCT SHE: ANCE FROM CI ENT BAFFLE : BLANK ARE: TUBE COUNT CH SIDE DIAM IDE DIAM FACE RATIO, Z ID, IN&OUT	LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC IN. IN. IN. OUT/IN I IN.	30.00 .764 NO .0 C COPPER 36 .3125 .250 .214 1.184 .8 .8
SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I  TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI TUBE LGTH, EFF TUBE LAYOUT PITCH RATIO SHL NOZZ ID, IN&OU  * CALCULATED ITE	IN. 4.309 IN. 4.309 IN. 4.309 IN125 DEVICES 1  PLAIN 76 FT 1.500 FT 1.436 DEG 60 1.250 JT 1.0 1.0  EMHEAT BALANCE ersity ChE433 he	BAFFLE CUCUT DISTAL  IMPINGEME TUBESHEET  MATERIAL EST MAX TUBE PITO TUBE OUTS TUBE INST TUBE SURE TUBE NOZZ	JT, PCT SHE: ANCE FROM CI ENT BAFFLE : BLANK ARE: TUBE COUNT CH SIDE DIAM IDE DIAM FACE RATIO, Z ID, IN&OUT	LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC IN. IN. IN. OUT/IN I IN.	30.00 .764 NO .0 C COPPER 36 .3125 .250 .214 1.184 .8 .8
SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I  TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI TUBE LGTH, EFF TUBE LAYOUT PITCH RATIO SHL NOZZ ID, IN&OU  * CALCULATED ITE Washington Univeryoung model F302DY	IN. 4.309 IN. 4.309 IN. 4.309 IN. 125 DEVICES 1  PLAIN 76 FT 1.500 FT 1.436 DEG 60 1.250 JT 1.0 1.0  EMHEAT BALANCE PERSITY ChE433 he	BAFFLE CUCUT DISTAL  IMPINGEMENT  TUBESHEET  MATERIAL  EST MAX TUBE PITOL  TUBE OUTS  TUBE INST  TUBE SURE  TUBE NOZZ  E CODE = 8  eat exchange	JT, PCT SHE: ANCE FROM CI ENT BAFFLE: BLANK ARE: FUBE COUNT CH SIDE DIAM IDE DIAM FACE RATIO, Z ID, IN&OU'	LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC IN. IN. OUT/IN I IN. ent	30.00 .764 NO .0 C COPPER 36 .3125 .250 .214 1.184 .8 .8
SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I  TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI TUBE LGTH, EFF TUBE LAYOUT PITCH RATIO SHL NOZZ ID, IN&OU  * CALCULATED ITE Washington University	IN. 4.309 IN. 4.309 IN. 4.309 IN. 125 DEVICES 1  PLAIN 76 FT 1.500 FT 1.436 DEG 60 1.250 JT 1.0 1.0  EMHEAT BALANCE PERSITY ChE433 he	BAFFLE CUCUT DISTAL  IMPINGEMENT  TUBESHEET  MATERIAL  EST MAX TUBE PITOL  TUBE OUTS  TUBE INST  TUBE SURE  TUBE NOZZ  E CODE = 8  eat exchange	JT, PCT SHE: ANCE FROM CI ENT BAFFLE: BLANK ARE: FUBE COUNT CH SIDE DIAM IDE DIAM FACE RATIO, Z ID, IN&OU'	LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC IN. IN. OUT/IN I IN. ent	30.00 .764 NO .0 C COPPER 36 .3125 .250 .214 1.184 .8 .8
SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I  TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI TUBE LGTH, EFF TUBE LAYOUT PITCH RATIO SHL NOZZ ID, IN&OU  * CALCULATED ITE Washington Unive Young model F302DY S U P P L E	IN. 4.309 IN. 4.309 IN. 4.309 IN. 125 DEVICES 1  PLAIN 76 FT 1.500 FT 1.436 DEG 60 1.250 JT 1.0 1.0  EMHEAT BALANCE ersity ChE433 he	BAFFLE CUCUT DISTAL  IMPINGEME TUBESHEET  MATERIAL EST MAX TUBE PITO TUBE OUTS TUBE INST TUBE SURE TUBE NOZZ  CODE = 8 eat exchange  R Y E	JT, PCT SHE: ANCE FROM CI ENT BAFFLE: BLANK ARE: TUBE COUNT CH SIDE DIAM IDE DIAM FACE RATIO, Z ID, IN&OUT	LL I.D. ENTER, IN. INCLUDED A, %  LECTROLYTIC IN. IN. OUT/IN I IN. ent L T S	30.00 .764 NO .0 C COPPER 36 .3125 .250 .214 1.184 .8 .8
SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I  TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI TUBE LGTH, EFF TUBE LAYOUT PITCH RATIO SHL NOZZ ID, IN&OU  * CALCULATED ITE Washington University Young model F302DY S U P P L E  HT PARAMETERS	IN. 4.309 IN. 4.309 IN. 4.309 IN. 125 DEVICES 1  PLAIN 76 FT 1.500 FT 1.436 DEG 60 1.250 UT 1.0 1.0  EMHEAT BALANCE PERSITY ChE433 here EACH AP  M E N T A  SHELL TUBE	BAFFLE CUCUT DISTAL  IMPINGEME TUBESHEET  MATERIAL EST MAX TUBE PITO TUBE OUTS TUBE INST TUBE NOZZ  CODE = 8 eat exchange  R Y F	JT, PCT SHE: ANCE FROM CI ENT BAFFLE: BLANK ARE: TUBE COUNT CH SIDE DIAM IDE DIAM FACE RATIO, Z ID, IN&OUT	LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC IN. IN. OUT/IN I IN. ent L T S RMANCE	30.00 .764 NO .0 C COPPER 36 .3125 .250 .214 1.184 .8 .8
SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I  TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI TUBE LGTH, EFF TUBE LAYOUT PITCH RATIO SHL NOZZ ID, IN&OU  * CALCULATED ITE Washington Unive Young model F302DY S U P P L E	IN. 4.309 IN. 4.309 IN. 4.309 IN. 125 DEVICES 1  PLAIN 76 FT 1.500 FT 1.436 DEG 60 1.250 JT 1.0 1.0  EM-HEAT BALANCE ersity ChE433 here 74P  M E N T A  SHELL TUBE	BAFFLE CUCUT DISTAL  IMPINGEME TUBESHEET  MATERIAL EST MAX TUBE PITO TUBE OUTS TUBE INST TUBE NOZZ  CODE = 8 eat exchange  R Y F	JT, PCT SHE: ANCE FROM CI ENT BAFFLE: BLANK ARE: TUBE COUNT CH SIDE DIAM IDE DIAM FACE RATIO, Z ID, IN&OUT	LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC IN. IN. OUT/IN I IN. ent L T S RMANCE	30.00 .764 NO .0 C COPPER 36 .3125 .250 .214 1.184 .8 .8

			cne433b (			
PRANDTL NUMBER	6.1	4.1	NOMINA	L VEL, WINDO	W FT/S	.23
RYNLD NO, AVG	376.	503.	CROSSE			
RYNLD NO, IN BUN	346	667	MUNDOM	COEE	BTII/HR-FT2:	-F 339 1
DVNID NO OUT DIN	408	360	WINDOW		D10/1110 112	1 000.1
RYNLD NO, OUT BUN	400.	300.	CHET	TOTRE BLOW	0 00 000	<del>-</del>
FOULNG LAYER IN.	.0014	.0014	SHEL	LSIDE FLOW,	% OF TOTA.	Li
THERMAL RESISTANCE			HEAT T	RANSFER X-F	LOW	81.43
THERMAL RESISTANCE	, % OF T	OTAL				
SHELL TUBE FOU	LING ME'	TAL	MAIN C	ROSSFLOW	В	= 64.45
32.25 65.30 2	.37	.08	BUNDLE	TO SHELL B	YPASS C	= 16.17
PCT OVER DESIGN		.12	BAFFLE	TO SHELL L	EAKAGE E	= 15.41
PCT OVER DESIGN TOT FOUL RESIST		000217	TUBE P.	ASSLANE BYP	ASS F	= .00
DIFF RESIST	_	000011				
			SHET.	LSIDE HEAT '	TRANSFER F	A CTORS
DIAMETRAL CLEARA BUNDLE TO SHELL TUBE TO BAFFLE HOL	NCEC			=(BETA)(GAM		
DIAMETRAL CLEARA	NCES	F 0 0 0	TOTAL			
BUNDLE TO SHELL	IN.	.5000	BETA	(BAFF CUT F		
BAFFLE TO SHELL	IN.	.1000	END	(HT LOSS IN	END ZONE)	= .994
SHELL NOZZLE DAT.	A IN	OUT	SHEL	L PRESSURE	DROP, % OF	TOTAL
HT UNDR NOZ IN.	.25		WINDOW			= 8.9
HT OPP NOZ IN.	.25		END ZO	NE		= 3.4
VELOCITY FT/S	. 74	. 74	CROSS	FIOW		= 3.1
DENSITY LB/FT3	62 252	62 099	TNLET	NOZZI.E		= 42 6
SHELL NOZZLE DATA HT UNDR NOZ IN. HT OPP NOZ IN. VELOCITY FT/S DENSITY LB/FT3 NOZZ RHO*VSQ LB/FT	-63 33	33		NOZZE		- 42 1
DUND DUCKUSO ID/FT	-32 33	23	OOILEI	NOZZLE		- 42.1
BUND RHO*VSQ LB/FT	-52 22	23				
TUBE NOZZLE DATA	IN	OUT	WEIG	HT PER SHEL	L, LB	
TUBE NOZZLE DATA VELOCITY FT/S	IN .30	OUT .29	WEIG DRY	HT PER SHEL	L, LB =	150.
VELOCITY FT/S	.30	.29	DRY	HT PER SHEL	L, LB = =	
TUBE NOZZLE DATA VELOCITY FT/S DENSITY LB/FT3 PRESS. DROP %	.30 61.291	.29 62.151	DRY	HT PER SHEL	=	150. 165.
VELOCITY FT/S DENSITY LB/FT3 PRESS. DROP %	.30 61.291 3.9	.29 62.151 2.5	DRY WET		=	165.
VELOCITY FT/S DENSITY LB/FT3 PRESS. DROP % Washington Unive	.30 61.291 3.9 rsity Ch	.29 62.151 2.5	DRY WET		=	165. E0002 P 34
VELOCITY FT/S DENSITY LB/FT3 PRESS. DROP %	.30 61.291 3.9 rsity Ch	.29 62.151 2.5	DRY WET		=	165. E0002 P 34 9/23/ 3
VELOCITY FT/S DENSITY LB/FT3 PRESS. DROP % Washington Unive Young model F302DY	.30 61.291 3.9 rsity Ch	.29 62.151 2.5 E433 heat	DRY WET exchan	ger experim	= = ent	165. E0002 P 34 9/23/ 3 CASE 17
VELOCITY FT/S DENSITY LB/FT3 PRESS. DROP % Washington Unive	.30 61.291 3.9 rsity Ch	.29 62.151 2.5 E433 heat	DRY WET exchan	ger experim	= = ent ES, RATING	165. E0002 P 34 9/23/ 3 CASE 17
VELOCITY FT/S DENSITY LB/FT3 PRESS. DROP % Washington Unive Young model F302DY	.30 61.291 3.9 rsity Ch	.29 62.151 2.5 E433 heat	DRY WET exchan W, SEGM HOT T	ger experim ENTAL BAFFL: UBE SIDE	= = ent ES, RATING COLD SI	165.  E0002 P 34  9/23/ 3  CASE 17  HELL SIDE
VELOCITY FT/S DENSITY LB/FT3 PRESS. DROP % Washington Unive Young model F302DY	.30 61.291 3.9 rsity Ch	.29 62.151 2.5 E433 heat	DRY WET exchan W, SEGM HOT T	ger experim ENTAL BAFFL: UBE SIDE	= = ent ES, RATING COLD SI	165.  E0002 P 34  9/23/ 3  CASE 17  HELL SIDE
VELOCITY FT/S DENSITY LB/FT3 PRESS. DROP % Washington Unive Young model F302DY SIZE 4- 18 TYPE BE	.30 61.291 3.9 rsity Ch	.29 62.151 2.5 E433 heat	DRY WET exchan W, SEGM HOT T	ger experim ENTAL BAFFL UBE SIDE IBLE LIQ	= = ent ES, RATING COLD SI	165.  E0002 P 34 9/23/ 3 CASE 17  HELL SIDE 1 IBLE LIQ
VELOCITY FT/S DENSITY LB/FT3 PRESS. DROP % Washington Unive Young model F302DY	.30 61.291 3.9 rsity Ch	.29 62.151 2.5 E433 heat	DRY WET exchan W, SEGM HOT T	ger experim ENTAL BAFFL: UBE SIDE	= = ent ES, RATING COLD SI	165.  E0002 P 34  9/23/ 3  CASE 17  HELL SIDE
VELOCITY FT/S DENSITY LB/FT3 PRESS. DROP % Washington Unive Young model F302DY SIZE 4- 18 TYPE BE	.30 61.291 3.9 rsity Ch	.29 62.151 2.5 E433 heat	DRY WET exchan W, SEGM HOT T	ger experim ENTAL BAFFL UBE SIDE IBLE LIQ	= = ent ES, RATING COLD SI	165.  E0002 P 34 9/23/ 3 CASE 17  HELL SIDE 1 IBLE LIQ
VELOCITY FT/S DENSITY LB/FT3 PRESS. DROP % Washington Unive Young model F302DY SIZE 4- 18 TYPE BEST TOTAL FLOW RATE	.30 61.291 3.9 rsity Ch	.29 62.151 2.5 E433 heat	DRY WET  exchan  W, SEGM HOT T Tube SENS	ger experime ENTAL BAFFLE UBE SIDE IBLE LIQ .300	= = ent ES, RATING COLD SI Shell SENS:	165.  E0002 P 34 9/23/ 3 CASE 17  HELL SIDE  I IBLE LIQ .200
VELOCITY FT/S DENSITY LB/FT3 PRESS. DROP % Washington Unive Young model F302DY SIZE 4- 18 TYPE BEST TOTAL FLOW RATE TEMPERATURE	.30 61.291 3.9 rsity Chi 4P M, MULTI	.29 62.151 2.5 E433 heat	DRY WET  exchan  W, SEGM HOT T Tube SENS  IN 140.0	ger experime ENTAL BAFFLE UBE SIDE  IBLE LIQ .300 OUT 108.9*	= = = ent  ES, RATING COLD SI Shell SENS:  IN 70.0	165.  E0002 P 34 9/23/ 3 CASE 17  HELL SIDE 1 IBLE LIQ .200 OUT 116.6*
VELOCITY FT/S DENSITY LB/FT3 PRESS. DROP % Washington Unive Young model F302DY SIZE 4- 18 TYPE BE TOTAL FLOW RATE TEMPERATURE DENSITY	.30 61.291 3.9 rsity Chi 4P M, MULTI KLB/HR DEGF	.29 62.151 2.5 E433 heat	DRY WET  exchan  W, SEGM HOT T Tube SENS IN 140.0 1.2913	ger experime ENTAL BAFFLE UBE SIDE  IBLE LIQ .300 OUT 108.9* 61.7703	= = = ent  ES, RATING COLD SI Shell SENS:  IN 70.0 62.2515	165.  E0002 P 34 9/23/ 3 CASE 17  HELL SIDE 1 IBLE LIQ .200 OUT 116.6* 61.6588
VELOCITY FT/S DENSITY LB/FT3 PRESS. DROP % Washington Unive Young model F302DY SIZE 4- 18 TYPE BE TOTAL FLOW RATE TEMPERATURE DENSITY VISCOSITY	.30 61.291 3.9 rsity Ch 4P M, MULTI KLB/HR DEGF LB/FT3 CP	.29 62.151 2.5 E433 heat	DRY WET  exchan  W, SEGM HOT T Tube SENS  IN 140.0 1.2913 .4726	ger experime ENTAL BAFFLE UBE SIDE  IBLE LIQ .300 OUT 108.9* 61.7703 .6312	= = = ent  ES, RATING COLD SI Shell SENS:  IN 70.0 62.2515 .9783	165.  E0002 P 34 9/23/ 3 CASE 17  HELL SIDE  IBLE LIQ .200 OUT 116.6* 61.6588 .5846
VELOCITY FT/S DENSITY LB/FT3 PRESS. DROP % Washington Unive Young model F302DY SIZE 4- 18 TYPE BE TOTAL FLOW RATE TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT	.30 61.291 3.9 rsity Ch 4P M, MULTI KLB/HR DEGF LB/FT3 CP BTU/LB-	.29 62.151 2.5 E433 heat -PASS FLO	DRY WET  exchan  W, SEGM HOT T Tube SENS  IN 140.0 1.2913 .4726 .9973	ger experime ENTAL BAFFLE UBE SIDE  IBLE LIQ .300 OUT 108.9* 61.7703 .6312 .9981	= = = = = = = = = = = = = = = = = = =	165.  E0002 P 34 9/23/ 3 CASE 17  HELL SIDE  IBLE LIQ .200 OUT 116.6* 61.6588 .5846 .9977
VELOCITY FT/S DENSITY LB/FT3 PRESS. DROP % Washington Unive Young model F302DY SIZE 4- 18 TYPE BES  TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND.	.30 61.291 3.9 rsity Chi 4P M, MULTI KLB/HR DEGF LB/FT3 CP BTU/LB- BTU/HR-	.29 62.151 2.5 E433 heat -PASS FLC	DRY WET  exchan  W, SEGM HOT T Tube SENS  IN 140.0 1.2913 .4726	ger experime ENTAL BAFFLE UBE SIDE  IBLE LIQ .300 OUT 108.9* 61.7703 .6312 .9981 .3654	= = = ent  ES, RATING COLD SI Shell SENS:  IN 70.0 62.2515 .9783	165.  E0002 P 34 9/23/ 3 CASE 17  HELL SIDE  IBLE LIQ .200 OUT 116.6* 61.6588 .5846 .9977 .3672
VELOCITY FT/S DENSITY LB/FT3 PRESS. DROP % Washington Unive Young model F302DY SIZE 4- 18 TYPE BE TOTAL FLOW RATE TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT	.30 61.291 3.9 rsity Chi 4P M, MULTI KLB/HR DEGF LB/FT3 CP BTU/LB- BTU/HR-	.29 62.151 2.5 E433 heat -PASS FLC	DRY WET  exchan  W, SEGM HOT T Tube SENS  IN 140.0 1.2913 .4726 .9973 .3723	ger experime ENTAL BAFFLE UBE SIDE  IBLE LIQ .300 OUT 108.9* 61.7703 .6312 .9981 .3654 18.02	= = = ent  ES, RATING COLD SI Shell SENS:  IN 70.0 62.2515 .9783 1.0015 .3554	165.  E0002 P 34 9/23/ 3 CASE 17  HELL SIDE  IBLE LIQ .200 OUT 116.6* 61.6588 .5846 .9977 .3672 18.02
VELOCITY FT/S DENSITY LB/FT3 PRESS. DROP % Washington Unive Young model F302DY SIZE 4- 18 TYPE BES  TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS	.30 61.291 3.9 rsity Chi 4P M, MULTI  KLB/HR  DEGF LB/FT3 CP BTU/LB- BTU/HR- LB/LBMO	.29 62.151 2.5 E433 heat -PASS FLC	DRY WET  exchan  W, SEGM HOT T Tube SENS  IN 140.0 1.2913 .4726 .9973 .3723	ger experime ENTAL BAFFLE UBE SIDE  IBLE LIQ .300 OUT 108.9* 61.7703 .6312 .9981 .3654 18.02	= = = = = = = = = = = = = = = = = = =	165.  E0002 P 34 9/23/ 3 CASE 17  HELL SIDE  IBLE LIQ .200 OUT 116.6* 61.6588 .5846 .9977 .3672 18.02
VELOCITY FT/S DENSITY LB/FT3 PRESS. DROP % Washington Unive Young model F302DY SIZE 4- 18 TYPE BES  TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN	.30 61.291 3.9 rsity Chi 4P M, MULTI  KLB/HR  DEGF LB/FT3 CP BTU/LB- BTU/HR- LB/LBMO	.29 62.151 2.5 E433 heat -PASS FLC	DRY WET  exchan  W, SEGM HOT T Tube SENS  IN 140.0 1.2913 .4726 .9973 .3723	ger experime ENTAL BAFFLE UBE SIDE  IBLE LIQ .300 OUT 108.9* 61.7703 .6312 .9981 .3654 18.02 110.8	= = = = = = = = = = = = = = = = = = =	165.  E0002 P 34 9/23/ 3 CASE 17  HELL SIDE  IBLE LIQ .200 OUT 116.6* 61.6588 .5846 .9977 .3672 18.02
VELOCITY FT/S DENSITY LB/FT3 PRESS. DROP % Washington Unive Young model F302DY SIZE 4- 18 TYPE BES  TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S	.30 61.291 3.9 rsity Ch 4P M, MULTI  KLB/HR  DEGF LB/FT3 CP BTU/LB- BTU/HR- LB/LBMO  DEG  KIN CP	.29 62.151 2.5 E433 heat -PASS FLO  6 F FT-F L	DRY WET exchan W, SEGM HOT T Tube SENS IN 140.0 1.2913 .4726 .9973 .3723	ger experime ENTAL BAFFLE UBE SIDE  IBLE LIQ .300 OUT 108.9* 61.7703 .6312 .9981 .3654 18.02 110.8 .6190	= = = = = = = = = = = = = = = = = = =	165.  E0002 P 34 9/23/ 3 CASE 17  HELL SIDE  IBLE LIQ .200 OUT 116.6* 61.6588 .5846 .9977 .3672 18.02
VELOCITY FT/S DENSITY LB/FT3 PRESS. DROP % Washington Unive Young model F302DY SIZE 4- 18 TYPE BES  TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN	.30 61.291 3.9 rsity Ch 4P M, MULTI  KLB/HR  DEGF LB/FT3 CP BTU/LB- BTU/HR- LB/LBMO  DEG  KIN CP	.29 62.151 2.5 E433 heat -PASS FLO  6 F FT-F L	DRY WET exchan W, SEGM HOT T Tube SENS IN 140.0 1.2913 .4726 .9973 .3723	ger experime ENTAL BAFFLE UBE SIDE  IBLE LIQ .300 OUT 108.9* 61.7703 .6312 .9981 .3654 18.02 110.8	= = = = = = = = = = = = = = = = = = =	165.  E0002 P 34 9/23/ 3 CASE 17  HELL SIDE  IBLE LIQ .200 OUT 116.6* 61.6588 .5846 .9977 .3672 18.02
VELOCITY FT/S DENSITY LB/FT3 PRESS. DROP % Washington Unive Young model F302DY SIZE 4- 18 TYPE BES  TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S	.30 61.291 3.9 rsity Ch 4P M, MULTI  KLB/HR  DEGF LB/FT3 CP BTU/LB- BTU/HR- LB/LBMO  DEG  KIN CP	.29 62.151 2.5 E433 heat -PASS FLO  6 F FT-F L	DRY WET exchan W, SEGM HOT T Tube SENS IN 140.0 1.2913 .4726 .9973 .3723	ger experime ENTAL BAFFLE UBE SIDE  IBLE LIQ .300 OUT 108.9* 61.7703 .6312 .9981 .3654 18.02 110.8 .6190	= = = = = = = = = = = = = = = = = = =	165.  E0002 P 34 9/23/ 3 CASE 17  HELL SIDE  IBLE LIQ .200 OUT 116.6* 61.6588 .5846 .9977 .3672 18.02
VELOCITY FT/S DENSITY LB/FT3 PRESS. DROP % Washington Unive Young model F302DY SIZE 4- 18 TYPE BES  TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S	.30 61.291 3.9 rsity Chi 4P M, MULTI  KLB/HR  DEGF LB/FT3 CP BTU/LB- BTU/HR- LB/LBMO  DEG KIN CP IGN PSI	.29 62.151 2.5 E433 heat -PASS FLO  6 F FT-F L	DRY WET  exchan  W, SEGM HOT T Tube SENS  IN 140.0 1.2913 .4726 .9973 .3723 124.4 .5429 50.00	ger experime ENTAL BAFFLE UBE SIDE  IBLE LIQ .300 OUT 108.9* 61.7703 .6312 .9981 .3654 18.02 110.8 .6190 165.00	= = = = = = = = = = = = = = = = = = =	165.  E0002 P 34 9/23/ 3 CASE 17  HELL SIDE  IBLE LIQ .200 OUT 116.6* 61.6588 .5846 .9977 .3672 18.02
VELOCITY FT/S DENSITY LB/FT3 PRESS. DROP % Washington Unive Young model F302DY SIZE 4- 18 TYPE BES  TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & SE PRESSURE, IN & DES	.30 61.291 3.9 rsity Chi 4P M, MULTI  KLB/HR  DEGF LB/FT3 CP BTU/LB-: BTU/HR-: LB/LBMO:  DEG: KIN CP IGN PSI:	.29 62.151 2.5 E433 heat -PASS FLO  6 F FTT-F L F A ED PSI	DRY WET  exchan  W, SEGM HOT T Tube SENS  IN 140.0 1.2913 .4726 .9973 .3723 124.4 .5429 50.00 .02	ger experime ENTAL BAFFLE UBE SIDE  IBLE LIQ .300 OUT 108.9* 61.7703 .6312 .9981 .3654 18.02 110.8 .6190 165.00	= = = ent  ES, RATING COLD SI Shell SENS:  IN 70.0 62.2515 .9783 1.0015 .3554 93.3 .7436 50.00 .00	165.  E0002 P 34 9/23/ 3 CASE 17  HELL SIDE  IBLE LIQ .200 OUT 116.6* 61.6588 .5846 .9977 .3672 18.02 110.3 .6222 165.00

	che433b(70).OUT	
FOULING RESISTANCE HR-FT2-F/B	TU .00010 .	.00010
FILM COEFFICIENT BTU/HR-FT2		134.76
		201.70
TOTAL HEAT DUTY REQUIRED MEGBTU/H		.009316
EFF TEMP DIF, DEGF (LMTD= 30.5,F	= .62,BYPASS= .92,BAFF=1.00)	17.5
OVERALL COEFF REQUIRED BTU/HR-F	T2-F	74.64
CLEAN & FOULED COEFF BTU/HR-F	T2-F 75.55	74.36
SHELLS IN SERIES 1 PARALLEL 1	TOTAL EFF AREA FT2	7.1
PASSES, SHELL 1 TUBE 4		
SHELL DIAMETER IN. 3.820	TEMA SHELL TYPE E ; REAR F	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.	
	COI DISTANCE FROM CENTER, IN.	/ 04
SPACING, OUTLET IN. 4.309		
BAFFLE THICKNESS IN125	IMPINGEMENT BAFFLE INCLUDED	
PAIRS OF SEALING DEVICES 1	TUBESHEET BLANK AREA, %	.0
TUBE TYPE PLAIN	MATERIAL ELECTROLYTI	IC COPPER
NO. OF TUBES/SHELL 76	EST MAX TUBE COUNT	
TUBE LGTH, OVERALL FT 1.500		.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.	
* CALCULATED ITEMHEAT BALANCE		
* CALCULATED ITEMHEAT BALANCE Washington University ChE433 he		E0002 P 35
		E0002 P 35 9/23/ 3
Washington University ChE433 he		
Washington University ChE433 he Young model F302DY4P	at exchanger experiment	9/23/ 3
Washington University ChE433 he Young model F302DY4P		9/23/ 3
Washington University ChE433 he Young model F302DY4P  S U P P L E M E N T A	at exchanger experiment R Y R E S U L T S	9/23/ 3
Washington University ChE433 he Young model F302DY4P  S U P P L E M E N T A  HT PARAMETERS SHELL TUBE	at exchanger experiment  R Y R E S U L T S  SHELLSIDE PERFORMANCE	9/23/ 3 CASE 17
Washington University ChE433 he Young model F302DY4P  S U P P L E M E N T A  HT PARAMETERS SHELL TUBE WALL CORRECTION 1.025 .000	at exchanger experiment  R Y R E S U L T S  SHELLSIDE PERFORMANCE NOMINAL VEL, X-FLOW FT/S	9/23/ 3 CASE 17
Washington University ChE433 he Young model F302DY4P  S U P P L E M E N T A  HT PARAMETERS SHELL TUBE WALL CORRECTION 1.025 .000	at exchanger experiment  R Y R E S U L T S  SHELLSIDE PERFORMANCE NOMINAL VEL, X-FLOW FT/S NOMINAL VEL, WINDOW FT/S	9/23/ 3 CASE 17 .03 .05
Washington University ChE433 he Young model F302DY4P  S U P P L E M E N T A  HT PARAMETERS SHELL TUBE WALL CORRECTION 1.025 .000	at exchanger experiment  R Y R E S U L T S  SHELLSIDE PERFORMANCE NOMINAL VEL, X-FLOW FT/S NOMINAL VEL, WINDOW FT/S	9/23/ 3 CASE 17 .03 .05
Washington University ChE433 he Young model F302DY4P  S U P P L E M E N T A  HT PARAMETERS SHELL TUBE WALL CORRECTION 1.025 .000 PRANDTL NUMBER 5.0 3.6 RYNLD NO, AVG 100. 871.	at exchanger experiment  R Y R E S U L T S  SHELLSIDE PERFORMANCE NOMINAL VEL, X-FLOW FT/S NOMINAL VEL, WINDOW FT/S CROSSFLOW COEF BTU/HR-FT2	9/23/ 3 CASE 17 .03 .05 2-F 135.1
Washington University ChE433 he Young model F302DY4P  S U P P L E M E N T A  HT PARAMETERS SHELL TUBE WALL CORRECTION 1.025 .000 PRANDTL NUMBER 5.0 3.6 RYNLD NO, AVG 100. 871. RYNLD NO, IN BUN 76. 1000.	at exchanger experiment  R Y R E S U L T S  SHELLSIDE PERFORMANCE NOMINAL VEL, X-FLOW FT/S NOMINAL VEL, WINDOW FT/S CROSSFLOW COEF BTU/HR-FT2 WINDOW COEF BTU/HR-FT2	9/23/ 3 CASE 17 .03 .05 2-F 135.1
Washington University ChE433 he Young model F302DY4P  S U P P L E M E N T A  HT PARAMETERS SHELL TUBE WALL CORRECTION 1.025 .000 PRANDTL NUMBER 5.0 3.6 RYNLD NO, AVG 100. 871. RYNLD NO, IN BUN 76. 1000. RYNLD NO, OUT BUN 127. 749.	at exchanger experiment  R Y R E S U L T S  SHELLSIDE PERFORMANCE NOMINAL VEL, X-FLOW FT/S NOMINAL VEL, WINDOW FT/S CROSSFLOW COEF BTU/HR-FT2 WINDOW COEF BTU/HR-FT2	9/23/3 CASE 17 .03 .05 2-F 135.1 2-F 136.0
Washington University ChE433 he Young model F302DY4P  S U P P L E M E N T A  HT PARAMETERS SHELL TUBE WALL CORRECTION 1.025 .000 PRANDTL NUMBER 5.0 3.6 RYNLD NO, AVG 100. 871. RYNLD NO, IN BUN 76. 1000. RYNLD NO,OUT BUN 127. 749. FOULNG LAYER IN0014 .0014	at exchanger experiment  R Y R E S U L T S  SHELLSIDE PERFORMANCE NOMINAL VEL,X-FLOW FT/S NOMINAL VEL,WINDOW FT/S CROSSFLOW COEF BTU/HR-FT2 WINDOW COEF BTU/HR-FT2 SHELLSIDE FLOW, % OF TOTA	9/23/3 CASE 17 .03 .05 2-F 135.1 2-F 136.0
Washington University ChE433 he Young model F302DY4P  S U P P L E M E N T A  HT PARAMETERS SHELL TUBE WALL CORRECTION 1.025 .000 PRANDTL NUMBER 5.0 3.6 RYNLD NO, AVG 100. 871. RYNLD NO, IN BUN 76. 1000. RYNLD NO,OUT BUN 127. 749. FOULNG LAYER IN0014 .0014	at exchanger experiment  R Y R E S U L T S  SHELLSIDE PERFORMANCE NOMINAL VEL, X-FLOW FT/S NOMINAL VEL, WINDOW FT/S CROSSFLOW COEF BTU/HR-FT2 WINDOW COEF BTU/HR-FT2 SHELLSIDE FLOW, % OF TOTA	9/23/3 CASE 17 .03 .05 2-F 135.1 2-F 136.0
Washington University ChE433 he Young model F302DY4P  S U P P L E M E N T A  HT PARAMETERS SHELL TUBE WALL CORRECTION 1.025 .000 PRANDTL NUMBER 5.0 3.6 RYNLD NO, AVG 100. 871. RYNLD NO, IN BUN 76. 1000. RYNLD NO, OUT BUN 127. 749. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL	at exchanger experiment  R Y R E S U L T S  SHELLSIDE PERFORMANCE NOMINAL VEL, X-FLOW FT/S NOMINAL VEL, WINDOW FT/S CROSSFLOW COEF BTU/HR-FT2 WINDOW COEF BTU/HR-FT2  SHELLSIDE FLOW, % OF TOTA HEAT TRANSFER X-FLOW TUBE TO BAFFLE LEAKAGE	9/23/3 CASE 17 .03 .05 2-F 135.1 2-F 136.0 AL 80.51 A = 2.61
Washington University ChE433 he Young model F302DY4P  S U P P L E M E N T A  HT PARAMETERS SHELL TUBE WALL CORRECTION 1.025 .000 PRANDTL NUMBER 5.0 3.6 RYNLD NO, AVG 100. 871. RYNLD NO, IN BUN 76. 1000. RYNLD NO, OUT BUN 127. 749. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL	at exchanger experiment  R Y R E S U L T S  SHELLSIDE PERFORMANCE NOMINAL VEL, X-FLOW FT/S NOMINAL VEL, WINDOW FT/S CROSSFLOW COEF BTU/HR-FT2 WINDOW COEF BTU/HR-FT2  SHELLSIDE FLOW, % OF TOTA HEAT TRANSFER X-FLOW TUBE TO BAFFLE LEAKAGE	9/23/3 CASE 17 .03 .05 2-F 135.1 2-F 136.0 AL 80.51 A = 2.61
Washington University ChE433 he Young model F302DY4P  S U P P L E M E N T A  HT PARAMETERS SHELL TUBE WALL CORRECTION 1.025 .000 PRANDTL NUMBER 5.0 3.6 RYNLD NO, AVG 100. 871. RYNLD NO, IN BUN 76. 1000. RYNLD NO,OUT BUN 127. 749. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL	at exchanger experiment  R Y R E S U L T S  SHELLSIDE PERFORMANCE NOMINAL VEL, X-FLOW FT/S NOMINAL VEL, WINDOW FT/S CROSSFLOW COEF BTU/HR-FT2 WINDOW COEF BTU/HR-FT2  SHELLSIDE FLOW, % OF TOTA HEAT TRANSFER X-FLOW TUBE TO BAFFLE LEAKAGE MAIN CROSSFLOW	9/23/3 CASE 17 .03 .05 2-F 135.1 2-F 136.0 AL 80.51 A = 2.61 B = 68.64
Washington University ChE433 he Young model F302DY4P  S U P P L E M E N T A  HT PARAMETERS SHELL TUBE WALL CORRECTION 1.025 .000 PRANDTL NUMBER 5.0 3.6 RYNLD NO, AVG 100. 871. RYNLD NO, IN BUN 76. 1000. RYNLD NO,OUT BUN 127. 749. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 54.56 43.78 1.61 .05	at exchanger experiment  R Y R E S U L T S  SHELLSIDE PERFORMANCE NOMINAL VEL, X-FLOW FT/S NOMINAL VEL, WINDOW FT/S CROSSFLOW COEF BTU/HR-FT2 WINDOW COEF BTU/HR-FT2  SHELLSIDE FLOW, % OF TOTA HEAT TRANSFER X-FLOW TUBE TO BAFFLE LEAKAGE MAIN CROSSFLOW BUNDLE TO SHELL BYPASS	9/23/3 CASE 17 .03 .05 2-F 135.1 2-F 136.0 AL 80.51 A = 2.61 B = 68.64 C = 11.35
Washington University ChE433 he Young model F302DY4P  S U P P L E M E N T A  HT PARAMETERS SHELL TUBE WALL CORRECTION 1.025 .000 PRANDTL NUMBER 5.0 3.6 RYNLD NO, AVG 100. 871. RYNLD NO, IN BUN 76. 1000. RYNLD NO,OUT BUN 127. 749. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 54.56 43.78 1.61 .05 PCT OVER DESIGN38	at exchanger experiment  R Y R E S U L T S  SHELLSIDE PERFORMANCE NOMINAL VEL, X-FLOW FT/S NOMINAL VEL, WINDOW FT/S CROSSFLOW COEF BTU/HR-FT2 WINDOW COEF BTU/HR-FT2  SHELLSIDE FLOW, % OF TOTA HEAT TRANSFER X-FLOW TUBE TO BAFFLE LEAKAGE MAIN CROSSFLOW BUNDLE TO SHELL BYPASS BAFFLE TO SHELL LEAKAGE	9/23/3 CASE 17  .03 .05 2-F 135.1 2-F 136.0  AL 80.51 A = 2.61 B = 68.64 C = 11.35 E = 17.40
Washington University ChE433 he Young model F302DY4P  S U P P L E M E N T A  HT PARAMETERS SHELL TUBE WALL CORRECTION 1.025 .000 PRANDTL NUMBER 5.0 3.6 RYNLD NO, AVG 100. 871. RYNLD NO, IN BUN 76. 1000. RYNLD NO,OUT BUN 127. 749. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 54.56 43.78 1.61 .05 PCT OVER DESIGN38 TOT FOUL RESIST .000217	at exchanger experiment  R Y R E S U L T S  SHELLSIDE PERFORMANCE NOMINAL VEL, X-FLOW FT/S NOMINAL VEL, WINDOW FT/S CROSSFLOW COEF BTU/HR-FT2 WINDOW COEF BTU/HR-FT2 SHELLSIDE FLOW, % OF TOTA HEAT TRANSFER X-FLOW TUBE TO BAFFLE LEAKAGE MAIN CROSSFLOW BUNDLE TO SHELL BYPASS BAFFLE TO SHELL LEAKAGE TUBE PASSLANE BYPASS	9/23/3 CASE 17  .03 .05 2-F 135.1 2-F 136.0  AL 80.51 A = 2.61 B = 68.64 C = 11.35 E = 17.40
Washington University ChE433 he Young model F302DY4P  S U P P L E M E N T A  HT PARAMETERS SHELL TUBE WALL CORRECTION 1.025 .000 PRANDTL NUMBER 5.0 3.6 RYNLD NO, AVG 100. 871. RYNLD NO, IN BUN 76. 1000. RYNLD NO,OUT BUN 127. 749. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 54.56 43.78 1.61 .05 PCT OVER DESIGN38	at exchanger experiment  R Y R E S U L T S  SHELLSIDE PERFORMANCE NOMINAL VEL, X-FLOW FT/S NOMINAL VEL, WINDOW FT/S CROSSFLOW COEF BTU/HR-FT2 WINDOW COEF BTU/HR-FT2  SHELLSIDE FLOW, % OF TOTA HEAT TRANSFER X-FLOW TUBE TO BAFFLE LEAKAGE MAIN CROSSFLOW BUNDLE TO SHELL BYPASS BAFFLE TO SHELL LEAKAGE TUBE PASSLANE BYPASS	9/23/3 CASE 17  .03 .05 2-F 135.1 2-F 136.0  AL 80.51 A = 2.61 B = 68.64 C = 11.35 E = 17.40 F = .00
Washington University ChE433 he Young model F302DY4P  S U P P L E M E N T A  HT PARAMETERS SHELL TUBE WALL CORRECTION 1.025 .000 PRANDTL NUMBER 5.0 3.6 RYNLD NO, AVG 100. 871. RYNLD NO, IN BUN 76. 1000. RYNLD NO,OUT BUN 127. 749. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 54.56 43.78 1.61 .05 PCT OVER DESIGN38 TOT FOUL RESIST .000217 DIFF RESIST .000051	AT EXCHANGER EXPERIMENT  R Y R E S U L T S  SHELLSIDE PERFORMANCE NOMINAL VEL, X-FLOW FT/S NOMINAL VEL, WINDOW FT/S CROSSFLOW COEF BTU/HR-FT2 WINDOW COEF BTU/HR-FT2  SHELLSIDE FLOW, % OF TOTH HEAT TRANSFER X-FLOW TUBE TO BAFFLE LEAKAGE MAIN CROSSFLOW BUNDLE TO SHELL BYPASS BAFFLE TO SHELL LEAKAGE TUBE PASSLANE BYPASS SHELLSIDE HEAT TRANSFER F	9/23/3 CASE 17  .03 .05 2-F 135.1 2-F 136.0  AL 80.51 A = 2.61 B = 68.64 C = 11.35 E = 17.40 F = .00
Washington University ChE433 he Young model F302DY4P  S U P P L E M E N T A  HT PARAMETERS SHELL TUBE WALL CORRECTION 1.025 .000 PRANDTL NUMBER 5.0 3.6 RYNLD NO, AVG 100. 871. RYNLD NO, IN BUN 76. 1000. RYNLD NO,OUT BUN 127. 749. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 54.56 43.78 1.61 .05 PCT OVER DESIGN38 TOT FOUL RESIST .000217 DIFF RESIST000051	at exchanger experiment  R Y R E S U L T S  SHELLSIDE PERFORMANCE NOMINAL VEL, X-FLOW FT/S NOMINAL VEL, WINDOW FT/S CROSSFLOW COEF BTU/HR-FT2 WINDOW COEF BTU/HR-FT2  SHELLSIDE FLOW, % OF TOTA HEAT TRANSFER X-FLOW TUBE TO BAFFLE LEAKAGE MAIN CROSSFLOW BUNDLE TO SHELL BYPASS BAFFLE TO SHELL LEAKAGE TUBE PASSLANE BYPASS SHELLSIDE HEAT TRANSFER F TOTAL = (BETA) (GAMMA) (FIN)	9/23/3 CASE 17  .03 .05 2-F 135.1 2-F 136.0  AL 80.51 A = 2.61 B = 68.64 C = 11.35 E = 17.40 F = .00  FACTORS = .598
Washington University ChE433 he Young model F302DY4P  S U P P L E M E N T A  HT PARAMETERS SHELL TUBE WALL CORRECTION 1.025 .000 PRANDTL NUMBER 5.0 3.6 RYNLD NO, AVG 100. 871. RYNLD NO, IN BUN 76. 1000. RYNLD NO,OUT BUN 127. 749. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 54.56 43.78 1.61 .05 PCT OVER DESIGN38 TOT FOUL RESIST .000217 DIFF RESIST000051	at exchanger experiment  R Y R E S U L T S  SHELLSIDE PERFORMANCE NOMINAL VEL, X-FLOW FT/S NOMINAL VEL, WINDOW FT/S CROSSFLOW COEF BTU/HR-FT2 WINDOW COEF BTU/HR-FT2  SHELLSIDE FLOW, % OF TOTA HEAT TRANSFER X-FLOW TUBE TO BAFFLE LEAKAGE MAIN CROSSFLOW BUNDLE TO SHELL BYPASS BAFFLE TO SHELL LEAKAGE TUBE PASSLANE BYPASS SHELLSIDE HEAT TRANSFER F TOTAL = (BETA) (GAMMA) (FIN)	9/23/3 CASE 17  .03 .05 2-F 135.1 2-F 136.0  AL 80.51 A = 2.61 B = 68.64 C = 11.35 E = 17.40 F = .00  FACTORS = .598
Washington University ChE433 he Young model F302DY4P  S U P P L E M E N T A  HT PARAMETERS SHELL TUBE WALL CORRECTION 1.025 .000 PRANDTL NUMBER 5.0 3.6 RYNLD NO, AVG 100. 871. RYNLD NO, IN BUN 76. 1000. RYNLD NO,OUT BUN 127. 749. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 54.56 43.78 1.61 .05 PCT OVER DESIGN38 TOT FOUL RESIST .000217 DIFF RESIST .000217 DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000	at exchanger experiment  R Y R E S U L T S  SHELLSIDE PERFORMANCE NOMINAL VEL, X-FLOW FT/S NOMINAL VEL, WINDOW FT/S CROSSFLOW COEF BTU/HR-FT2 WINDOW COEF BTU/HR-FT2  SHELLSIDE FLOW, % OF TOTA HEAT TRANSFER X-FLOW TUBE TO BAFFLE LEAKAGE MAIN CROSSFLOW BUNDLE TO SHELL BYPASS BAFFLE TO SHELL LEAKAGE TUBE PASSLANE BYPASS SHELLSIDE HEAT TRANSFER F TOTAL = (BETA) (GAMMA) (FIN) BETA (BAFF CUT FACTOR)	9/23/3 CASE 17  .03 .05 2-F 135.1 2-F 136.0  AL 80.51 A = 2.61 B = 68.64 C = 11.35 E = 17.40 F = .00  FACTORS = .598 = .920
Washington University ChE433 he Young model F302DY4P  S U P P L E M E N T A  HT PARAMETERS SHELL TUBE WALL CORRECTION 1.025 .000 PRANDTL NUMBER 5.0 3.6 RYNLD NO, AVG 100. 871. RYNLD NO, IN BUN 76. 1000. RYNLD NO,OUT BUN 127. 749. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 54.56 43.78 1.61 .05 PCT OVER DESIGN38 TOT FOUL RESIST .000217 DIFF RESIST000051	at exchanger experiment  R Y R E S U L T S  SHELLSIDE PERFORMANCE NOMINAL VEL, X-FLOW FT/S NOMINAL VEL, WINDOW FT/S CROSSFLOW COEF BTU/HR-FT2 WINDOW COEF BTU/HR-FT2  SHELLSIDE FLOW, % OF TOTA HEAT TRANSFER X-FLOW TUBE TO BAFFLE LEAKAGE MAIN CROSSFLOW BUNDLE TO SHELL BYPASS BAFFLE TO SHELL BYPASS BAFFLE TO SHELL LEAKAGE TUBE PASSLANE BYPASS  SHELLSIDE HEAT TRANSFER F TOTAL = (BETA) (GAMMA) (FIN) BETA (BAFF CUT FACTOR) GAMMA (TUBE ROW ENTRY EFCT)	9/23/3 CASE 17  .03 .05 2-F 135.1 2-F 136.0  AL 80.51 A = 2.61 B = 68.64 C = 11.35 E = 17.40 F = .00  FACTORS = .598 = .920 0 = .650

SHELL NOZZLE DATA HT UNDR NOZ IN. HT OPP NOZ IN. VELOCITY FT/S DENSITY LB/FT3 NOZZ RHO*VSQ LB/FT-BUND RHO*VSQ LB/FT-	.25 .25 .16 .17 62.252 61.659 -82 1 1	WINDOW END ZONE CROSS FI INLET NO OUTLET N	E LOW DZZLE		TOTAL = 9.6 = 6.7 = 5.3 = 40.5 = 38.0
TUBE NOZZLE DATA VELOCITY FT/S DENSITY LB/FT3 PRESS. DROP %	.44 .44 61.291 61.770 6.3 4.0	DRY WET		=	150. 165.
Washington Unive Young model F302DY		at exchange	er experime		9/23/ 3 CASE 18
SIZE 4- 18 TYPE BE		HOT TUI Tube	NTAL BAFFLE BE SIDE BLE LIQ	S, RATING COLD SI Shell	HELL SIDE l
TOTAL FLOW RATE	KLB/HR		.300		.300
TEMPERATURE	DEGF	140.0		70.0	108.5*
DENSITY VISCOSITY					
SPECIFIC HEAT			.6813		
THERMAL COND. MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN		120.7	105.3	89.2	104.8
VISCOSITY, AVG & S. PRESSURE, IN & DES					
PRESSURE DROP, TOT					
VELOCITY, CALC & M.	AX ALLOWED FT/S	.29	10.00	.05	10.00
FOULING RESISTANCE	HR-FT2-F/B7	.00	0010	. (	00010
FILM COEFFICIENT	BTU/HR-FT2-	-F 201	1.64 	16	66.93
TOTAL HEAT DUTY RE	QUIRED MEGBTU/H	3			.011540
EFF TEMP DIF, DEGF	(LMTD = 31.5, F =	= .66,BYPAS	SS= .93,BAF	F=1.00)	19.4
OVERALL COEFF REQU					83.38
CLEAN & FOULED COE	FF BTU/HR-F	Γ2-F	84.81		83.20
SHELLS IN SERIES					
PASSES, SHELL					
SHELL DIAMETER IN.	3.820	TEMA SHELI	L TYPE E	; REAR HI	EAD FXTS
BAFFLE TYPE HOSPACING, CENTRAL					
SPACING, INLET	IN. 4.309				
SPACING, OUTLET					
BAFFLE THICKNESS					
PAIRS OF SEALING D	EVICES 1	TUBESHEET	BLANK AREA	, %	.0

			~ ~~~~~
TUBE TYPE		ATERIAL ELECTROLYTI	
NO. OF TUBES/SHELL		ST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT	1.500 T	UBE PITCH IN.	.3125
TUBE LGTH, EFF FT	1.436 T	UBE OUTSIDE DIAM IN.	.250
TUBE LAYOUT DEG		UBE INSIDE DIAM IN.	.214
PITCH RATIO	1.250 T	UBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT 1.0		UBE NOZZ ID, IN&OUT IN.	
* CALCULATED ITEMHEAT	BALANCE C	ODE = 8	
Washington University Ch			E0002 P 37
Young model F302DY4P	in 455 Heat	exchanger experiment	9/23/ 3
Toding moder F302D14F			CASE 18
			CASE 10
SUPPLEMEN	T A R	Y RESULTS	
HT PARAMETERS SHELL	TUBE	SHELLSIDE PERFORMANCE	
WALL CORRECTION 1.024	.000	NOMINAL VEL, X-FLOW FT/S	.04
PRANDTL NUMBER 5.2	3.7	NOMINAL VEL, WINDOW FT/S	.08
RYNLD NO, AVG 145. RYNLD NO, IN BUN 115. RYNLD NO, OUT BUN 178.	841.	CROSSFLOW COEF BTU/HR-FT2	-F 167.6
RYNLD NO, IN BUN 115.	1000.	WINDOW COEF BTU/HR-FT2	-F 168.7
RYNLD NO, OUT BUN 178.	694.		
FOULNG LAYER IN0014	.0014	SHELLSIDE FLOW, % OF TOTA	L
		HEAT TRANSFER X-FLOW	81.22
THERMAL RESISTANCE, % OF 3	готат.	TUBE TO BAFFLE LEAKAGE A	
SHELL TUBE FOULING ME			= 68.28
	.06		
		BUNDLE TO SHELL BYPASS C	
PCT OVER DESIGN		BAFFLE TO SHELL LEAKAGE E	
	.000217	TUBE PASSLANE BYPASS F	= .00
DIFF RESIST	.000025		
		SHELLSIDE HEAT TRANSFER F	
DIAMETRAL CLEARANCES		TOTAL = (BETA) (GAMMA) (FIN)	
BUNDLE TO SHELL IN.	.5000	BETA (BAFF CUT FACTOR)	
TUBE TO BAFFLE HOLE IN.	.0284	GAMMA (TUBE ROW ENTRY EFCT)	= .665
BAFFLE TO SHELL IN.	.1000	END (HT LOSS IN END ZONE)	= .994
SHELL NOZZLE DATA IN	TUO I	SHELL PRESSURE DROP, % OF	TOTAL
HT UNDR NOZ IN25	5	WINDOW	= 9.1
HT OPP NOZ IN25	5	END ZONE	= 5.4
		CROSS FLOW	= 4.4
DENSITY LB/FT3 62.252			= 41.5
NOZZ RHO*VSQ LB/FT-S2	3 3	OUTLET NOZZLE	= 39.5
BUND RHO*VSQ LB/FT-S2	) )	OUTHET NOZZEE	- 39.3
BUND KHO"VSQ LB/F1-S2 2	2 2		
TUBE NOZZLE DATA IN	N OUT	WEIGHT PER SHELL, LB	
VELOCITY FT/S .44			100.
DENSITY LB/FT3 61.291		WET =	165.
PRESS. DROP % 6.1			
	nE433 heat	exchanger experiment	E0002 P 38
Young model F302DY4P			9/23/ 3
			CASE 19
SIZE 4- 18 TYPE BEM, MULT	-PASS FLO	W, SEGMENTAL BAFFLES, RATING	
		HOT TUBE SIDE COLD S	HELL SIDE
		Tube Shel	1

Tube

Shell

		CHETJJD(	BLE LIQ	CENCT	מדם דדה
	MID /IID	251121	DUC TOTE TIÃ	251121	100 - PTE TTÄ
TOTAL FLOW RATE	KLB/ HK	T 3.1	.300 OUT	TNI	.400
TEMPERATURE	200	1 1 0 0	00T	IN	00T
TEMPERATURE	DEGF LB/FT3	140.0	96.4*	70.0	102.6*
DENSITY	LB/FT3			62.2515	61.8565
VISCOSITY	CP	.4726	.7187	.9783	.6730
SPECIFIC HEAT	BTU/LB-F	.9973	.9989	1.0015	.9985
THERMAL COND. MOLAR MASS	BTU/HR-FT-F	.3723	.3624	.3554	.3639
MOLAR MASS	LB/LBMOL		18.02		18.02
			10.02		
TEMP, AVG & SKIN VISCOSITY, AVG & S	DEGF	118.2	101.3	86.3	100.7
VISCOSITY, AVG & S	KIN CP	.5757	.6820	.8044	.6867
VISCOSITY, AVG & S PRESSURE, IN & DES	SIGN PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT	' & ALLOWED PSI	.02	10.00	.00	10.00
VELOCITY, CALC & M	MAX ALLOWED FT	/s .29	10.00	.06	10.00
FOULING RESISTANCE	HR-FT2-F/F	BTU .C	00010	.0	00010
FILM COEFFICIENT	BTU/HR-FT2	2-F 20	2.15		7.80
TOTAL HEAT DUTY RE	OUIRED MEGBTU/	HR			.013040
EFF TEMP DIF, DEGE			ASS= 94.BAF		20.1
OVERALL COEFF REQU				1 1.00/	90.72
CLEAN & FOULED COE	'FF BTH/HR-1	TT2 F	92 24	l	90.26
CHEAN & FOOLED COE	iff DIO/III I	112 F	JZ • Z =	•	30.20
SHELLS IN SERIES	1 DADATTET 1	יי∩יי∧ז כיכים	7 7007	ਵਾਧਾ 2	7 1
PASSES, SHELL	1 MIDE 4	TOTAL EFF	AREA	EMO/CHETT	7.1
SHELL DIAMETER IN.					
SHELL DIAMETER IN.	3.020	IEMA SHEI	T TIEF E	; KEAK HE	TAD LYI2
BAFFLE TYPE H	IODZ CECMENIII	CDOCC DAG	SSES PER SHE	TT DACC	1
SPACING, CENTRAL	TN 4 200	CRUSS FAS	THE DOMESTIC	T T LW22	20 00
SPACING, CENTRAL SPACING, INLET	IN. 4.309	CIM DICM	NCE EDOM CE	ишер ти	30.00
SPACING, INLET	IN. 4.309	COI DISIA	ANCE FROM CE	INIEK, IN.	. / 04
SPACING, OUTLET	IN. 4.309				
		TMDTNGDME	D. D. D. T. T. T	MATURER	110
			ENT BAFFLE I		
PAIRS OF SEALING I	IN125 DEVICES 1				NO .0
	DEVICES 1	TUBESHEET	BLANK AREA	4, %	.0
TUBE TYPE	DEVICES 1	TUBESHEET MATERIAL	BLANK AREA	4, %	.0 C COPPER
TUBE TYPE NO. OF TUBES/SHELI	PLAIN 76	TUBESHEET  MATERIAL  EST MAX T	BLANK AREA EI UBE COUNT	LECTROLYTIC	.0 C COPPER 36
TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI	PLAIN 76 FT 1.500	TUBESHEET  MATERIAL  EST MAX T  TUBE PITO	BLANK AREA EI CUBE COUNT	A, % LECTROLYTIC IN.	.0 C COPPER 36 .3125
TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI TUBE LGTH, EFF	PLAIN 76 . FT 1.500 FT 1.436	TUBESHEET  MATERIAL  EST MAX T  TUBE PITO  TUBE OUTS	BLANK AREA EI CUBE COUNT CH SIDE DIAM	LECTROLYTIC IN. IN.	.0 C COPPER 36 .3125 .250
TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI TUBE LGTH, EFF TUBE LAYOUT	PLAIN 76 . FT 1.500 FT 1.436 DEG 60	TUBESHEET  MATERIAL EST MAX T TUBE PITO TUBE OUTS TUBE INSI	E BLANK AREA  EI  CUBE COUNT  CH  SIDE DIAM  EDE DIAM	LECTROLYTIC IN. IN. IN.	.0 C COPPER 36 .3125 .250 .214
TUBE TYPE  NO. OF TUBES/SHELI  TUBE LGTH, OVERALI  TUBE LGTH, EFF  TUBE LAYOUT  PITCH RATIO	PLAIN 76 FT 1.500 FT 1.436 DEG 60 1.250	MATERIAL EST MAX T TUBE PITO TUBE OUTS TUBE INSI TUBE SURE	E BLANK AREA  EI  CUBE COUNT  CH  SIDE DIAM  FACE RATIO,	IN. IN. IN. OUT/IN	.0 C COPPER 36 .3125 .250 .214 1.184
TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI TUBE LGTH, EFF TUBE LAYOUT	PLAIN 76 FT 1.500 FT 1.436 DEG 60 1.250	MATERIAL EST MAX T TUBE PITO TUBE OUTS TUBE INSI TUBE SURE	E BLANK AREA  EI  CUBE COUNT  CH  SIDE DIAM  EDE DIAM	IN. IN. IN. OUT/IN	.0 C COPPER 36 .3125 .250 .214 1.184
TUBE TYPE  NO. OF TUBES/SHELI  TUBE LGTH, OVERALI  TUBE LGTH, EFF  TUBE LAYOUT  PITCH RATIO	PLAIN 76 FT 1.500 FT 1.436 DEG 60 1.250	MATERIAL EST MAX T TUBE PITO TUBE OUTS TUBE INSI TUBE SURE	E BLANK AREA  EI  CUBE COUNT  CH  SIDE DIAM  FACE RATIO,	IN. IN. IN. OUT/IN	.0 C COPPER 36 .3125 .250 .214 1.184
TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI TUBE LGTH, EFF TUBE LAYOUT PITCH RATIO SHL NOZZ ID, IN&OU  * CALCULATED ITE	PLAIN 76 FT 1.500 FT 1.436 DEG 60 1.250 JT 1.0 1.0	TUBESHEET  MATERIAL EST MAX T TUBE PITO TUBE OUTS TUBE INSI TUBE SURE TUBE NOZZ	EI BLANK AREA  CUBE COUNT  CH  SIDE DIAM  DE DIAM  FACE RATIO,  Z ID, IN&OUT	IN. IN. IN. OUT/IN IN.	.0 C COPPER 36 .3125 .250 .214 1.184
TUBE TYPE NO. OF TUBES/SHELD TUBE LGTH, OVERALD TUBE LGTH, EFF TUBE LAYOUT PITCH RATIO SHL NOZZ ID, IN&OU  * CALCULATED ITE Washington University	PLAIN 76 FT 1.500 FT 1.436 DEG 60 1.250 JT 1.0 1.0  CMHEAT BALANCE PERSITY ChE433 he	TUBESHEET  MATERIAL EST MAX T TUBE PITO TUBE OUTS TUBE INSI TUBE SURE TUBE NOZZ	EI BLANK AREA  CUBE COUNT  CH  SIDE DIAM  DE DIAM  FACE RATIO,  Z ID, IN&OUT	IN. IN. IN. OUT/IN IN.	.0 C COPPER 36 .3125 .250 .214 1.184 .8 .8
TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI TUBE LGTH, EFF TUBE LAYOUT PITCH RATIO SHL NOZZ ID, IN&OU  * CALCULATED ITE	PLAIN 76 FT 1.500 FT 1.436 DEG 60 1.250 JT 1.0 1.0  CMHEAT BALANCE PERSITY ChE433 he	TUBESHEET  MATERIAL EST MAX T TUBE PITO TUBE OUTS TUBE INSI TUBE SURE TUBE NOZZ	EI BLANK AREA  CUBE COUNT  CH  SIDE DIAM  DE DIAM  FACE RATIO,  Z ID, IN&OUT	IN. IN. IN. OUT/IN IN.	.0 C COPPER 36 .3125 .250 .214 1.184
TUBE TYPE NO. OF TUBES/SHELD TUBE LGTH, OVERALD TUBE LGTH, EFF TUBE LAYOUT PITCH RATIO SHL NOZZ ID, IN&OU  * CALCULATED ITE Washington University	PLAIN 76 FT 1.500 FT 1.436 DEG 60 1.250 JT 1.0 1.0  CMHEAT BALANCE PERSITY ChE433 he	TUBESHEET  MATERIAL EST MAX T TUBE PITO TUBE OUTS TUBE INSI TUBE SURE TUBE NOZZ	EI BLANK AREA  CUBE COUNT  CH  SIDE DIAM  DE DIAM  FACE RATIO,  Z ID, IN&OUT	IN. IN. IN. OUT/IN IN.	.0 C COPPER 36 .3125 .250 .214 1.184 .8 .8
TUBE TYPE  NO. OF TUBES/SHELI  TUBE LGTH, OVERALI  TUBE LGTH, EFF  TUBE LAYOUT  PITCH RATIO  SHL NOZZ ID, IN&OU  * CALCULATED ITE  Washington University  Young model F302DY	PLAIN 76 FT 1.500 FT 1.436 DEG 60 1.250 JT 1.0 1.0  CMHEAT BALANCE PERSITY ChE433 he	TUBESHEET  MATERIAL EST MAX TOBE PITO TUBE OUTS TUBE INST TUBE SURE TUBE NOZZ  E CODE = 8 eat exchange	EI BLANK AREA  CUBE COUNT  CH  SIDE DIAM  DE DIAM  FACE RATIO,  Z ID, IN&OUT	IN. IN. IN. OUT/IN IN.	.0 C COPPER 36 .3125 .250 .214 1.184 .8 .8
TUBE TYPE  NO. OF TUBES/SHELI  TUBE LGTH, OVERALI  TUBE LGTH, EFF  TUBE LAYOUT  PITCH RATIO  SHL NOZZ ID, IN&OU  * CALCULATED ITE  Washington University  Young model F302DY	PLAIN 76 FT 1.500 FT 1.436 DEG 60 1.250 JT 1.0 1.0  CMHEAT BALANCE PERSITY ChE433 here Example 1.449	TUBESHEET  MATERIAL EST MAX TOBE PITO TUBE OUTS TUBE INST TUBE SURE TUBE NOZZ  E CODE = 8 eat exchange	EI CUBE COUNT CH SIDE DIAM TACE RATIO, Z ID, IN&OUT	IN. IN. IN. OUT/IN IN.	.0 C COPPER 36 .3125 .250 .214 1.184 .8 .8
TUBE TYPE  NO. OF TUBES/SHELI  TUBE LGTH, OVERALI  TUBE LGTH, EFF  TUBE LAYOUT  PITCH RATIO  SHL NOZZ ID, IN&OU  * CALCULATED ITE  Washington University  Young model F302DY	PLAIN 76 FT 1.500 FT 1.436 DEG 60 1.250 JT 1.0 1.0  CMHEAT BALANCE PERSITY ChE433 here Example 1.449	TUBESHEET  MATERIAL EST MAX T TUBE PITO TUBE INST TUBE SURE TUBE NOZZ E CODE = 8 eat exchang	EI CUBE COUNT CH SIDE DIAM TACE RATIO, Z ID, IN&OUT	IN. IN. IN. OUT/IN IN. CHARLES IN.	.0 C COPPER 36 .3125 .250 .214 1.184 .8 .8
TUBE TYPE NO. OF TUBES/SHELD TUBE LGTH, OVERALD TUBE LGTH, EFF TUBE LAYOUT PITCH RATIO SHL NOZZ ID, IN&OU  * CALCULATED ITE Washington Unive Young model F302DY S U P P L E	PLAIN 76 FT 1.500 FT 1.436 DEG 60 1.250 JT 1.0 1.0  EMHEAT BALANCE Exity ChE433 here EAP M E N T A	TUBESHEET  MATERIAL EST MAX T TUBE PITO TUBE INST TUBE SURE TUBE NOZZ  E CODE = 8 eat exchang  R Y F	EI CUBE COUNT CH SIDE DIAM DE DIAM FACE RATIO, Z ID, IN&OUT	IN. IN. IN. OUT/IN IN. L T S RMANCE	.0 C COPPER 36 .3125 .250 .214 1.184 .8 .8
TUBE TYPE  NO. OF TUBES/SHELD  TUBE LGTH, OVERALD  TUBE LGTH, EFF  TUBE LAYOUT  PITCH RATIO  SHL NOZZ ID, IN&OU  * CALCULATED ITE  Washington Universely  Young model F302DY  S U P P L E  HT PARAMETERS	PLAIN 76 FT 1.500 FT 1.436 DEG 60 1.250 UT 1.0 1.0  CMHEAT BALANCE PERSITY CHE433 here EACH AP  M E N T A  SHELL TUBE	TUBESHEET  MATERIAL EST MAX T TUBE PITO TUBE OUTS TUBE INSI TUBE SURE TUBE NOZZ E CODE = 8 eat exchang  R Y F  SHELI NOMINAL	EI BLANK AREA  EI CUBE COUNT CH SIDE DIAM DE DIAM FACE RATIO, Z ID, IN&OUT Ger experime R E S U  LSIDE PERFOR	IN. IN. IN. OUT/IN IN. IN. A. A. & B. B	.0 C COPPER 36 .3125 .250 .214 1.184 .8 .8

		che433b(70)		
RYNLD NO, AVG	187. 821.	CROSSFLOW	COEF BTU/HR-FT	2-F 198.5
RYNLD NO, IN BUN	154. 1000.	WINDOW COE	EF BTU/HR-FT	2-F 199.9
RYNLD NO, OUT BUN	223. 658.			
FOULNG LAYER IN.			DE FLOW, % OF TOT	'AL
			SFER X-FLOW	
THERMAL RESISTANCE	% OF TOTAL			
SHELL TUBE FOU				
45.12 52.86 1				
PCT OVER DESIGN	51	BAFFLE IO	SHELL LEARAGE	E - 10.13
TOT FOUL RESIST		TUBE PASSI	LANE BYPASS	F = .00
DIFF RESIST				
DIAMETRAL CLEARA BUNDLE TO SHELL		SHELLSII	DE HEAT TRANSFER	
DIAMETRAL CLEARA	NCES	TOTAL = (BE	ETA) (GAMMA) (FIN)	
BUNDLE TO SHELL	IN5000	BETA (BAE	FF CUT FACTOR)	
TUBE TO BAFFLE HOL	E INU284	GAMMA (TUE		
BAFFLE TO SHELL	IN1000	END (HT	LOSS IN END ZONE	a) = .994
SHELL NOZZLE DAT			RESSURE DROP, % C	F TOTAL
HT UNDR NOZ IN.	.25	WINDOW		= 9.0
HT OPP NOZ IN.	.25	END ZONE		= 4.8
VELOCITY FT/S	.33 .33	CROSS FLOW	7	= 4.0
DENSITY LB/FT3				= 41.9
NOZZ RHO*VSQ LB/FT				= 40.4
BUND RHO*VSQ LB/FT				
~ ~ ~				
TUBE NOZZLE DATA	TN OUT	WEIGHT F	PER SHELL, LB	
VELOCITY FT/S			=	
DENSITY LB/FT3		WET	=	165.
PRESS. DROP %		МПТ		100.
INDOO. DIVOI 0			ownowimont	E0002 D 40
Washington Univo	reity ChE/133 hos	+ oxahanaar		
Washington Unive		t exchanger	CAPCITMCITC	0/22/2
Washington Unive Young model F302DY		t exchanger	CAPCILIMONE	9/23/ 3
Young model F302DY	4P			9/23/ 3 CASE 20
	4P M, MULTI-PASS FL	OW, SEGMENT <i>I</i>	AL BAFFLES, RATIN	9/23/ 3 CASE 20 IG
Young model F302DY	4P M, MULTI-PASS FL	OW, SEGMENTA HOT TUBE	AL BAFFLES, RATIN	9/23/ 3 CASE 20 IG SHELL SIDE
Young model F302DY	4P M, MULTI-PASS FL	OW, SEGMENTA HOT TUBE Tube	AL BAFFLES, RATIN SIDE COLD She	9/23/ 3 CASE 20 IG SHELL SIDE
Young model F302DY SIZE 4- 18 TYPE BE	4P M, MULTI-PASS FL	OW, SEGMENTA HOT TUBE Tube SENSIBLE	AL BAFFLES, RATIN SIDE COLD She L LIQ SEN	9/23/ 3 CASE 20 IG SHELL SIDE Ell ISIBLE LIQ
Young model F302DY	4P M, MULTI-PASS FL	OW, SEGMENTA HOT TUBE Tube SENSIBLE .30	AL BAFFLES, RATIN SIDE COLD She LIQ SEN	9/23/3 CASE 20 IG SHELL SIDE P11 ISIBLE LIQ .500
Young model F302DY SIZE 4- 18 TYPE BE TOTAL FLOW RATE	4P M, MULTI-PASS FL KLB/HR	OW, SEGMENTA HOT TUBE Tube SENSIBLE .30	AL BAFFLES, RATING SIDE COLD She LIQ SEN	9/23/3 CASE 20 IG SHELL SIDE 11 ISIBLE LIQ .500 OUT
Young model F302DY SIZE 4- 18 TYPE BE	4P M, MULTI-PASS FL KLB/HR	OW, SEGMENTA HOT TUBE Tube SENSIBLE .30	AL BAFFLES, RATIN SIDE COLD She LIQ SEN	9/23/3 CASE 20 IG SHELL SIDE 11 ISIBLE LIQ .500 OUT
Young model F302DY SIZE 4- 18 TYPE BE TOTAL FLOW RATE	4P M, MULTI-PASS FL KLB/HR DEGF	OW, SEGMENTA HOT TUBE Tube SENSIBLE .30 IN 140.0	AL BAFFLES, RATING SIDE COLD She SENDO OUT IN 92.9* 70.0	9/23/3 CASE 20 IG SHELL SIDE Ell ISIBLE LIQ .500 OUT 98.2*
Young model F302DY SIZE 4- 18 TYPE BE TOTAL FLOW RATE TEMPERATURE	4P M, MULTI-PASS FL  KLB/HR  DEGF LB/FT3	OW, SEGMENTA HOT TUBE Tube SENSIBLE .30 IN 140.0 61.2913 61	AL BAFFLES, RATING SIDE COLD She SENDO OUT IN 92.9* 70.0	9/23/ 3 CASE 20 IG SHELL SIDE 11 ISIBLE LIQ .500 OUT 98.2*
Young model F302DY SIZE 4- 18 TYPE BE TOTAL FLOW RATE TEMPERATURE DENSITY	4P M, MULTI-PASS FL  KLB/HR  DEGF LB/FT3 CP	OW, SEGMENTA HOT TUBE Tube SENSIBLE .30 IN 140.0 61.2913 61	AL BAFFLES, RATIN SIDE COLD She E LIQ SEN 00 OUT IN 92.9* 70.0 .9836 62.2515 .7470 .9783	9/23/3 CASE 20 IG SHELL SIDE 11 ISIBLE LIQ .500 OUT 98.2* 61.9152 .7052
Young model F302DY SIZE 4- 18 TYPE BE TOTAL FLOW RATE TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT	4P M, MULTI-PASS FL  KLB/HR  DEGF LB/FT3 CP BTU/LB-F	OW, SEGMENTA HOT TUBE TUBE SENSIBLE .30 IN 140.0 61.2913 61 .4726 .9973	AL BAFFLES, RATING SIDE COLD She SENDO OUT IN 92.9* 70.00 1.9836 62.2515 1.7470 1.9783 1.0015	9/23/3 CASE 20 IG SHELL SIDE 11 ISIBLE LIQ .500 OUT 98.2* 61.9152 .7052 .9988
Young model F302DY SIZE 4- 18 TYPE BE  TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND.	4P M, MULTI-PASS FL  KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F	OW, SEGMENTA HOT TUBE Tube SENSIBLE .30 IN 140.0 61.2913 61 .4726 .9973 .3723	AL BAFFLES, RATING SIDE COLD She SENDO OUT IN 92.9* 70.00 1.9836 62.2515 1.7470 1.9783 1.0015	9/23/3 CASE 20 IG SHELL SIDE 11 ISIBLE LIQ .500 OUT 98.2* 61.9152 .7052 .9988
Young model F302DY SIZE 4- 18 TYPE BE  TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND.	4P M, MULTI-PASS FL  KLB/HR  DEGF LB/FT3 CP BTU/LB-F	OW, SEGMENTA HOT TUBE Tube SENSIBLE .30 IN 140.0 61.2913 61 .4726 .9973 .3723	AL BAFFLES, RATIN SIDE COLD She E LIQ SEN OO IN 92.9* 70.0 .9836 62.2515 .7470 .9783 .9992 1.0015 .3615 .3554	9/23/3 CASE 20 IG SHELL SIDE 11 ISIBLE LIQ .500 OUT 98.2* 61.9152 .7052 .9988 .3628
Young model F302DY SIZE 4- 18 TYPE BE  TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS	4P M, MULTI-PASS FL  KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL	OW, SEGMENTA HOT TUBE Tube SENSIBLE .30 IN 140.0 61.2913 61 .4726 .9973 .3723	AL BAFFLES, RATIN SIDE COLD She E LIQ SEN 00 OUT IN 92.9* 70.0 .9836 62.2515 .7470 .9783 .9992 1.0015 .3615 .3554	9/23/3 CASE 20 IG SHELL SIDE E11 ISIBLE LIQ .500 OUT 98.2* 61.9152 .7052 .9988 .3628 18.02
Young model F302DY SIZE 4- 18 TYPE BE  TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN	4P M, MULTI-PASS FL  KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL  DEGF	OW, SEGMENTA HOT TUBE Tube SENSIBLE .30 IN 140.0 61.2913 61 .4726 .9973 .3723	AL BAFFLES, RATIN SIDE COLD She E LIQ SEN 00 OUT IN 92.9* 70.0 .9836 62.2515 .7470 .9783 .9992 1.0015 .3615 .3554 18.02	9/23/3 CASE 20 IG SHELL SIDE 11 ISIBLE LIQ .500 OUT 98.2* 61.9152 .7052 .9988 .3628 18.02
Young model F302DY SIZE 4- 18 TYPE BE  TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S	4P M, MULTI-PASS FL  KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL  DEGF  KIN CP	OW, SEGMENTA HOT TUBE Tube SENSIBLE .30 IN 140.0 61.2913 61 .4726 .9973 .3723	AL BAFFLES, RATIN SIDE COLD She E LIQ SEN 00 OUT IN 92.9* 70.0 .9836 62.2515 .7470 .9783 .9992 1.0015 .3615 .3554 18.02 	9/23/3 CASE 20 IG SHELL SIDE 11 ISIBLE LIQ .500 OUT 98.2* 61.9152 .7052 .9988 .3628 18.02 .97.6 .7096
Young model F302DY SIZE 4- 18 TYPE BE  TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN	4P M, MULTI-PASS FL  KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL  DEGF  KIN CP	OW, SEGMENTA HOT TUBE Tube SENSIBLE .30 IN 140.0 61.2913 61 .4726 .9973 .3723	AL BAFFLES, RATIN SIDE COLD She E LIQ SEN 00 OUT IN 92.9* 70.0 .9836 62.2515 .7470 .9783 .9992 1.0015 .3615 .3554 18.02 	9/23/3 CASE 20 IG SHELL SIDE 11 ISIBLE LIQ .500 OUT 98.2* 61.9152 7.052 99.88 3.628 18.02 
Young model F302DY SIZE 4- 18 TYPE BE  TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES	4P M, MULTI-PASS FL  KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL  DEGF KIN CP IGN PSIA	OW, SEGMENTA HOT TUBE Tube SENSIBLE .30 IN 140.0 61.2913 61 .4726 .9973 .3723	AL BAFFLES, RATING SIDE COLD She SENDO OUT IN 92.9* 70.00.9836 62.2515.7470 .9783.9992 1.0015.3615 .3554.18.02	9/23/3 CASE 20 IG SHELL SIDE 11 ISIBLE LIQ .500 OUT 98.2* 61.9152 .7052 .9988 .3628 18.02 .97.6 .7096 165.00
Young model F302DY  SIZE 4- 18 TYPE BE  TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES  PRESSURE DROP, TOT	4P M, MULTI-PASS FL  KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL  DEGF KIN CP IGN PSIA  & ALLOWED PSI	OW, SEGMENTA HOT TUBE Tube SENSIBLE .30 IN 140.0 61.2913 61 .4726 .9973 .3723	AL BAFFLES, RATIN SIDE COLD She E LIQ SEN 00 OUT IN 92.9* 70.0 .9836 62.2515 .7470 .9783 .9992 1.0015 .3615 .3554 18.02 98.3 84.1 .7043 .8251 .65.00 50.00	9/23/3 CASE 20 IG SHELL SIDE Ell ISIBLE LIQ .500 OUT 98.2* 61.9152 .7052 .9988 .3628 18.02 .7096 .7096 .7096 .7096
Young model F302DY SIZE 4- 18 TYPE BE  TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES	4P M, MULTI-PASS FL  KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL  DEGF KIN CP IGN PSIA  & ALLOWED PSI	OW, SEGMENTA HOT TUBE Tube SENSIBLE .30 IN 140.0 61.2913 61 .4726 .9973 .3723	AL BAFFLES, RATIN SIDE COLD She E LIQ SEN 00 OUT IN 92.9* 70.0 .9836 62.2515 .7470 .9783 .9992 1.0015 .3615 .3554 18.02 98.3 84.1 .7043 .8251 .65.00 50.00	9/23/3 CASE 20 IG SHELL SIDE Ell ISIBLE LIQ .500 OUT 98.2* 61.9152 .7052 .9988 .3628 18.02 .7096 .7096 .7096 .7096
Young model F302DY  SIZE 4- 18 TYPE BE  TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES  PRESSURE DROP, TOT	AP  M, MULTI-PASS FL  KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL  DEGF  KIN CP IGN PSIA  & ALLOWED PSI AX ALLOWED FT/S	OW, SEGMENTA HOT TUBE Tube SENSIBLE .30 IN 140.0 61.2913 61 .4726 .9973 .3723 	AL BAFFLES, RATIN SIDE COLD She E LIQ SEN 00 OUT IN 92.9* 70.0 .9836 62.2515 .7470 .9783 .9992 1.0015 .3615 .3554 18.02 	9/23/3 CASE 20 IG SHELL SIDE Ell ISIBLE LIQ .500 OUT 98.2* 61.9152 .7052 .9988 .3628 18.02 .7096 .7096 .7096 .7096

\_\_\_\_\_ TOTAL HEAT DUTY REQUIRED MEGBTU/HR .014099 EFF TEMP DIF, DEGF (LMTD= 31.4,F= .70,BYPASS= .94,BAFF=1.00) 20.6 OVERALL COEFF REQUIRED BTU/HR-FT2-F 95.98 CLEAN & FOULED COEFF BTU/HR-FT2-F 98.25 SHELLS IN SERIES 1 PARALLEL 1 TOTAL EFF AREA FT2 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 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 SPACING, OUTLET IN. 4.309
BAFFLE THICKNESS IN. .125 IMPINGEMENT BAFFLE INCLUDED PAIRS OF SEALING DEVICES 1 TUBESHEET BLANK AREA, % TUBE TYPE

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 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 TUBE SHELLSIDE PERFORMANCE

WALL CORRECTION 1.021 .000 NOMINAL VEL,X-FLOW FT/S .07

PRANDTL NUMBER 5.6 3.9 NOMINAL VEL,WINDOW FT/S .13

RYNLD NO, AVG 228. 807. CROSSFLOW COEF BTU/HR-FT2-F 227.9

RYNLD NO, IN BUN 192. 1000. WINDOW COEF BTU/HR-FT2-F 229.5

RYNLD NO,OUT BUN 267. 633. SHELLSIDE PERFORMANCE SHELLSIDE FLOW, % OF TOTAL
HEAT TRANSFER X-FLOW
THERMAL RESISTANCE, % OF TOTAL
SHELL TUBE FOULING METAL
T178 56.07 2.08 .07
PCT OVER DESIGN
TOT FOUL RESIST
TO FOULNG LAYER IN. .0014 .0014 SHELLSIDE FLOW, % OF TOTAL SHELLSIDE HEAT TRANSFER FACTORS SHELLSIDE HEAT TRANSFER FACTORS

TOTAL = (BETA) (GAMMA) (FIN) = .655 DIAMETRAL CLEARANCES DIAMETRAL CLEARANCES TOTAL = (BETA) (GAMMA) (FIN) = .655
BUNDLE TO SHELL IN. .5000 BETA (BAFF CUT FACTOR) = .920
TUBE TO BAFFLE HOLE IN. .0284 GAMMA (TUBE ROW ENTRY EFCT) = .712
BAFFLE TO SHELL IN. .1000 END (HT LOSS IN END ZONE) = .994 SHELL NOZZLE DATA IN OUT SHELL PRESSURE DROP, % OF TOTAL

		cne433b (	/U).OUT		
HT UNDR NOZ IN.	.25	WINDOW			= 8.9
HT OPP NOZ IN.	.25	END ZON	E		= 4.3
HT UNDR NOZ IN. HT OPP NOZ IN. VELOCITY FT/S	41 41	CROSS F	'T.∩W		= 3.7
DENCITY ID/ETT2	62 252 61 015	TNIET N	0771E		- 42.2
DENSITY LB/FT3	02.232 01.913	INTELN	VAZILE		= 4.3 = 3.7 = 42.2 = 40.9
NOZZ RHO*VSQ LB/FT	-S2 10 10	OOTLET	NOZZLE		= 40.9
BUND RHO*VSQ LB/FT	1-S2 7 7				
TUBE NOZZLE DATA	IN OUT	WEIGH	T PER SHEL	L, LB	
VELOCITY FT/S	.44 .44	DRY		=	150.
DENSITY LB/FT3				=	165.
PRESS. DROP %					200.
Washington Unive				~ ~ <del>+</del>	E0002 D 42
=	_	at exchang	er exberime	SIIC	
Young model F302DY	4 P				9/23/ 3
					CASE 21
SIZE 4- 18 TYPE BE	M, MULTI-PASS F	LOW, SEGME	NTAL BAFFLI	ES, RATING	
		HOT TU	BE SIDE	COLD SE	HELL SIDE
		m.h.o		Chall	
		SENST	BLE LIQ	SENS	TRIF LTO
TOTAL FLOW RATE	KI.B/HB		300		600
TOTAL FLOW RATE	RDD/ IIIC	TNI	OTIT	TN	OTITE
TEMPERATURE DENSITY	DECE	140 0	001	70.0	001
TEMPERATURE	DEGF	140.0	90.3^	70.0	94.8^
DENSITY	LB/FT3	61.2913	62.0168	62.2515	61.9592
VISCOSITY	CP	.4726	.7692	.9783	.7314
SPECIFIC HEAT	BTU/LB-F	.9973	.9994	1.0015	.9990
THERMAL COND.	BTU/HR-FT-F	.3723	.3608	.3554	.3620
MOLAR MASS	LB/LBMOL		18.02		1 0 0 0
	, -				
TEMP, AVG & SKIN	DEGE	115 1	95 9	82 4	95.2
VISCOSITY, AVG & S	VIN CD	5031	7229	9/15	7297
			.7228		
PRESSURE, IN & DES	IGN PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT	' & ALLOWED PSI	.02	10.00	.01	10.00
VELOCITY, CALC & M	AX ALLOWED FT/	s .29	10.00	.09	10.00
FOULING RESISTANCE	HR-FT2-F/B	TU .0	0010	. (	
FILM COEFFICIENT	BTU/HR-FT2	-F 20	2.96	25	55.30
TOTAL HEAT DUTY RE	OUTRED MEGRTU/H	R			.014891
EFF TEMP DIF, DEGF	-		SS- 01 BN	FF-1 00)	
			.54, DA	1-1.00)	100.31
OVERALL COEFF REQU			100 0		
CLEAN & FOULED COE	FF BTU/HR-F	J. Z – F.	103.3.	L	100.70
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 SHEL	L TYPE E	; REAR HE	EAD FXTS
BAFFLE TYPE H	ORZ SEGMENTL	CROSS PAS	SES PER SHI	ELL PASS	4
SPACING, CENTRAL					
SPACING, INLET	TN 4 300	כוות שומשא	NCE FROM C	ENTER IN	764
		COI DISIA	TACE LIVOR CI	714 T T T T T T T T T T T T T T T T T T T	. / 0 4
SPACING, OUTLET	1N. 4.3U9	TMDTNOT	N		370
BAFFLE THICKNESS	IN125	IMPINGEME	NT BAFFLE	LNCLUDED	NO
PAIRS OF SEALING D	EVICES 1	TUBESHEET	BLANK ARE	A, %	. 0

	C	ne433b(/0).001	
TUBE TYPE	PLAIN M	ATERIAL ELECTROLYTI	C COPPER
NO. OF TUBES/SHELL	76 ES	ST MAX TUBE COUNT	36
		JBE PITCH IN.	.3125
•		JBE OUTSIDE DIAM IN.	.250
TUBE LAYOUT DEG	60 T	JBE INSIDE DIAM IN.	.214
PITCH RATIO 1	L.250 T	JBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT 1.0		JBE NOZZ ID, IN&OUT IN.	
5112 NO22 12, 1N4001 1.0	1.0 1.	TEL NOBE ID, INCOOL IN.	
* CALCULATED ITEMHEAT E	BATANCE CO	NDF = 8	
			E0000 B 40
Washington University Ch	433 heat	exchanger experiment	E0002 P 43
Young model F302DY4P			9/23/ 3
			CASE 21
SUPPLEMEN	T A R	Y RESULTS	
	1 11 10		
HT PARAMETERS SHELL	TUBE	SHELLSIDE PERFORMANCE	
WALL CORRECTION 1.020	.000	NOMINAL VEL, X-FLOW FT/S	.08
PRANDTL NUMBER 5.7	3.9	NOMINAL VEL, WINDOW FT/S	.15
RYNLD NO, AVG 268.	797.	CROSSFLOW COEF BTU/HR-FT2	
RYNLD NO, IN BUN 231.	1000.	WINDOW COEF BTU/HR-FT2	2-F 258.0
RYNLD NO, OUT BUN 309.	615.		
FOULNG LAYER IN0014	.0014	SHELLSIDE FLOW, % OF TOTA	ΑL
		HEAT TRANSFER X-FLOW	81.46
MILEDWAL DEGLEMANCE O OF MC	\m		
THERMAL RESISTANCE, % OF TO		TUBE TO BAFFLE LEAKAGE	
SHELL TUBE FOULING MET	ΓAL	MAIN CROSSFLOW	3 = 65.28
39.00 58.74 2.18 .	.07	BUNDLE TO SHELL BYPASS C	c = 15.46
PCT OVER DESIGN	.40	BAFFLE TO SHELL LEAKAGE	
	000217		r = .00
		TODE PASSLANE DIPASS	00
DIFF RESIST .C	000039		
		SHELLSIDE HEAT TRANSFER E	FACTORS
DIAMETRAL CLEARANCES		TOTAL = (BETA) (GAMMA) (FIN)	= .677
BUNDLE TO SHELL IN.	.5000	BETA (BAFF CUT FACTOR)	= .920
TUBE TO BAFFLE HOLE IN.		GAMMA (TUBE ROW ENTRY EFCT)	
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 IN25		WINDOW	= 8.9
HT OPP NOZ IN25		END ZONE	= 3.9
VELOCITY FT/S .49	.49	CROSS FLOW	= 3.4
DENSITY LB/FT3 62.252	61.959	INLET NOZZLE	= 42.4
		OUTLET NOZZLE	= 41.3
		OOTHET NOBELL	11.0
BUND RHU^VSQ LB/F1-52 10	10		
TUBE NOZZLE DATA IN	OUT	WEIGHT PER SHELL, LB	
VELOCITY FT/S .44	.44	DRY =	150.
DENSITY LB/FT3 61.291			165.
	3.6		± 0 0 •
	E433 heat	exchanger experiment	
Young model F302DY4P			9/23/ 3
Toding Moder 1502D111			-, -, -
Toding Model 1302D111			
3	-PASS FIO	N SECMENTAL BARRIDS DATING	CASE 22
3	-PASS FLO	N, SEGMENTAL BAFFLES, RATING	CASE 22
3	-PASS FLO	HOT TUBE SIDE COLD S	CASE 22 G SHELL SIDE
3	-PASS FLOT	HOT TUBE SIDE COLD S Tube Shel	CASE 22 G SHELL SIDE
3	-PASS FLOT	HOT TUBE SIDE COLD S Tube Shel	CASE 22 G SHELL SIDE

TOTAL FLOW RATE	KLB/HR	che433b(			.700
TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS	LB/FT3 CP BTU/LB-F BTU/HR-FT-F	140.0 61.2913 .4726 .9973 .3723	62.0433 .7880 .9996 .3602	70.0 62.2515 .9783 1.0015 .3554	92.2* 61.9927 .7529 .9993 .3613
TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES	KIN CP	114.1 .5994	.7387	81.1 .8546	93.1 .7450
PRESSURE DROP, TOT VELOCITY, CALC & M					
FOULING RESISTANCE	BTU/HR-FT2-	-F 20	3.25		
TOTAL HEAT DUTY RE EFF TEMP DIF, DEGF OVERALL COEFF REQU CLEAN & FOULED COE	(LMTD= 30.6,F= IRED BTU/HR-FT	R = .72,BYP <i>I</i> [2-F	ASS= .94,BA	FF=1.00)	104.93
SHELLS IN SERIES PASSES, SHELL SHELL DIAMETER IN.	1 TUBE 4	EFFECTIVE	E AREA	FT2/SHELL	7.1
BAFFLE TYPE H SPACING, CENTRAL SPACING, INLET SPACING, OUTLET	IN. 4.309 IN. 4.309 IN. 4.309	BAFFLE CUCUT DISTA	JT, PCT SHE ANCE FROM C	LL I.D. ENTER, IN.	30.00
BAFFLE THICKNESS PAIRS OF SEALING D					
TUBE TYPE NO. OF TUBES/SHELL TUBE LGTH, OVERALL TUBE LGTH, EFF TUBE LAYOUT PITCH RATIO SHL NOZZ ID, IN&OU	FT 1.500 FT 1.436 DEG 60 1.250	EST MAX TUBE PITOTUBE OUTSTUBE INST	CUBE COUNT CH SIDE DIAM IDE DIAM FACE RATIO,	IN. IN. IN. OUT/IN	36 .3125 .250 .214 1.184
* CALCULATED ITE Washington Unive Young model F302DY	rsity ChE433 hea 4P	at exchang			E0002 P 45 9/23/ 3 CASE 22
HT PARAMETERS WALL CORRECTION PRANDTL NUMBER RYNLD NO, AVG	SHELL TUBE 1.019 .000 5.8 3.9	SHELI NOMINAI NOMINAI	JSIDE PERFO VEL,X-FLO VEL,WINDO	RMANCE W FT/S W FT/S	.18

			che433b(			
RYNLD NO, IN BUN			WINDOW	COEF	BTU/HR-FT2	-F 286.6
RYNLD NO, OUT BUN FOULNG LAYER IN.			SHELI	SIDE FLOW.	% OF TOTA	Т.
1002110 2111211 2111	• 0 0 1 1	•0011			LOM	
THERMAL RESISTANCE	. % OF TO	ЭТАТ.				
SHELL TUBE FOU						
36.56 61.09 2						
PCT OVER DESIGN						
TOT FOUL RESIST	(	100217	TIIRE DI	TO SHELL I	DASS F	= 00
DIFF RESIST			TODE IF	ADDIAND DIE	ADD	00
			SHELI	LSIDE HEAT	TRANSFER F.	ACTORS
DIAMETRAL CLEARA BUNDLE TO SHELL	NCES		TOTAL =	=(BETA)(GAM	MMA) (FIN)	= .699
BUNDLE TO SHELL	IN.	.5000	BETA	(BAFF CUT E	ACTOR)	= .920
TUBE TO BAFFLE HOL	E IN.	.0284	GAMMA			
BAFFLE TO SHELL					I END ZONE)	
SHELL NOZZLE DAT				L PRESSURE	DROP, % OF	
HT UNDR NOZ IN.						= 8.9
HT OPP NOZ IN.				ΝE		= 3.7
VELOCITY FT/S						= 3.3
DENSITY LB/FT3						= 42.6
NOZZ RHO*VSQ LB/FT			OUTLET	NOZZLE		= 41.6
BUND RHO*VSQ LB/FT	-S2 13	13				
TUBE NOZZLE DATA	TN	OIIT	WETGE	HT PER SHET	.T. T.B	
VELOCITY FT/S					=	150.
	61 201	62 013	ᅜᄺ		_	165
DENSITY LB/FT3			WET		=	165.
PRESS. DROP %	5.7	3.6		ger evnerin		
PRESS. DROP % Washington Unive	5.7 rsity Ch	3.6		ger experin	nent	E0002 P 46
PRESS. DROP %	5.7 rsity Ch	3.6		ger experin	nent	E0002 P 46 9/23/ 3
PRESS. DROP % Washington Unive Young model F302DY	5.7 rsity Chl 4P	3.6 E433 heat	c exchang		nent	E0002 P 46 9/23/ 3 CASE 23
PRESS. DROP % Washington Unive	5.7 rsity Chl 4P	3.6 E433 heat	c exchang	ENTAL BAFFI	ment JES, RATING	E0002 P 46 9/23/ 3 CASE 23
PRESS. DROP % Washington Unive Young model F302DY	5.7 rsity Chl 4P	3.6 E433 heat	exchang DW, SEGME HOT TU	ENTAL BAFFI JBE SIDE	ment LES, RATING COLD S	E0002 P 46 9/23/ 3 CASE 23 HELL SIDE
PRESS. DROP % Washington Unive Young model F302DY	5.7 rsity Chl 4P	3.6 E433 heat	exchang DW, SEGME HOT TU Tube	ENTAL BAFFI JBE SIDE	ment JES, RATING COLD S Shel	E0002 P 46 9/23/ 3 CASE 23 HELL SIDE
PRESS. DROP % Washington Unive Young model F302DY SIZE 4- 18 TYPE BE	5.7 rsity Chl 4P M, MULTI-	3.6 E433 heat	exchang  DW, SEGME  HOT TU  Tube  SENSI	ENTAL BAFFI JBE SIDE IBLE LIQ	ment  JES, RATING  COLD S  Shel  SENS	E0002 P 46 9/23/ 3 CASE 23 HELL SIDE 1 IBLE LIQ
PRESS. DROP % Washington Unive Young model F302DY	5.7 rsity Chl 4P M, MULTI-	3.6 E433 heat	DW, SEGME HOT TU Tube SENSI	ENTAL BAFFI JBE SIDE IBLE LIQ	ment LES, RATING COLD S Shell SENS	E0002 P 46 9/23/ 3 CASE 23 HELL SIDE 1 IBLE LIQ
PRESS. DROP % Washington Unive Young model F302DY SIZE 4- 18 TYPE BE	5.7 rsity Chl 4P M, MULTI-	3.6 E433 heat	DW, SEGME HOT TU Tube SENSI	ENTAL BAFFI JBE SIDE IBLE LIQ .300 OUT	ment LES, RATING COLD S Shell SENS	E0002 P 46 9/23/ 3 CASE 23 HELL SIDE 1 IBLE LIQ .800 OUT
PRESS. DROP % Washington Unive Young model F302DY SIZE 4- 18 TYPE BE TOTAL FLOW RATE	5.7 rsity Chi 4P M, MULTI- KLB/HR DEGF	3.6 E433 heat	DW, SEGME HOT TU Tube SENSI IN 140.0	ENTAL BAFFI JBE SIDE IBLE LIQ .300 OUT 86.5*	ment LES, RATING COLD S Shel SENS IN 70.0	E0002 P 46 9/23/ 3 CASE 23 HELL SIDE 1 IBLE LIQ .800 OUT 90.0*
PRESS. DROP % Washington Unive Young model F302DY SIZE 4- 18 TYPE BE TOTAL FLOW RATE TEMPERATURE	5.7 rsity Chi 4P M, MULTI- KLB/HR DEGF LB/FT3	3.6 E433 heat	DW, SEGME HOT TU Tube SENSI IN 140.0	ENTAL BAFFI JBE SIDE IBLE LIQ .300 OUT 86.5* 62.0635	ment  DES, RATING COLD S Shel SENS IN 70.0 62.2515	E0002 P 46 9/23/3 CASE 23 HELL SIDE 1 IBLE LIQ .800 OUT 90.0* 62.0196
PRESS. DROP % Washington Unive Young model F302DY SIZE 4- 18 TYPE BE TOTAL FLOW RATE TEMPERATURE DENSITY VISCOSITY	5.7 rsity Chi 4P M, MULTI- KLB/HR DEGF LB/FT3 CP	3.6 E433 heat	DW, SEGME HOT TU Tube SENSI IN 140.0 51.2913 .4726	ENTAL BAFFI JBE SIDE  IBLE LIQ .300 OUT 86.5* 62.0635 .8030	ment LES, RATING COLD S Shel SENS IN 70.0	E0002 P 46 9/23/3 CASE 23 HELL SIDE 1 IBLE LIQ .800 OUT 90.0* 62.0196 .7712
PRESS. DROP % Washington Unive Young model F302DY SIZE 4- 18 TYPE BE  TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT	5.7 rsity Chi 4P M, MULTI- KLB/HR DEGF LB/FT3 CP BTU/LB-I	3.6 E433 heat -PASS FLC	DW, SEGME HOT TU Tube SENSI IN 140.0 51.2913 .4726 .9973	ENTAL BAFFI JBE SIDE  IBLE LIQ .300 OUT .86.5* 62.0635 .8030 .9998	ment  DES, RATING COLD S Shel SENS  IN 70.0 62.2515 .9783 1.0015	E0002 P 46 9/23/3 CASE 23 HELL SIDE 1 IBLE LIQ .800 OUT 90.0* 62.0196 .7712 .9994
PRESS. DROP % Washington Unive Young model F302DY SIZE 4- 18 TYPE BE  TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND.	5.7 rsity Chi 4P M, MULTI- KLB/HR DEGF LB/FT3 CP BTU/LB-I	3.6 E433 heat -PASS FLO	DW, SEGME HOT TU Tube SENSI IN 140.0 51.2913 .4726 .9973	ENTAL BAFFI JBE SIDE  IBLE LIQ .300 OUT .86.5* 62.0635 .8030 .9998	ment LES, RATING COLD S Shel SENS IN 70.0 62.2515 .9783	E0002 P 46 9/23/3 CASE 23 HELL SIDE 1 IBLE LIQ .800 OUT 90.0* 62.0196 .7712 .9994
PRESS. DROP % Washington Unive Young model F302DY SIZE 4- 18 TYPE BE  TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS	5.7 rsity Chi 4P M, MULTI- KLB/HR DEGF LB/FT3 CP BTU/LB-I BTU/HR-I LB/LBMOI	3.6 E433 heat -PASS FLO	DW, SEGME HOT TU Tube SENSI IN 140.0 51.2913 .4726 .9973 .3723	ENTAL BAFFI JBE SIDE  IBLE LIQ .300 OUT 86.5* 62.0635 .8030 .9998 .3598 18.02	DES, RATING COLD S Shell SENS  IN 70.0 62.2515 .9783 1.0015 .3554	E0002 P 46 9/23/ 3 CASE 23 HELL SIDE 1 IBLE LIQ .800 OUT 90.0* 62.0196 .7712 .9994 .3607 18.02
PRESS. DROP % Washington Unive Young model F302DY SIZE 4- 18 TYPE BE  TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN	5.7 rsity Chi 4P M, MULTI- KLB/HR DEGF LB/FT3 CP BTU/LB-I BTU/HR-I LB/LBMOI	3.6 E433 heat -PASS FLO	DW, SEGME HOT TU Tube SENSI IN 140.0 51.2913 .4726 .9973 .3723	ENTAL BAFFI JBE SIDE  IBLE LIQ .300 OUT .86.5* 62.0635 .8030 .9998 .3598 .3598 .18.02	DES, RATING COLD S Shell SENS  IN 70.0 62.2515 .9783 1.0015 .3554	E0002 P 46 9/23/ 3 CASE 23 HELL SIDE 1 IBLE LIQ .800 OUT 90.0* 62.0196 .7712 .9994 .3607 18.02
PRESS. DROP % Washington Unive Young model F302DY SIZE 4- 18 TYPE BE  TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S	5.7 rsity Chi 4P M, MULTI- KLB/HR DEGF LB/FT3 CP BTU/LB-I BTU/HR-I LB/LBMOI DEGI KIN CP	3.6 E433 heat -PASS FLO	DW, SEGME HOT TU Tube SENSI IN 140.0 51.2913 .4726 .9973 .3723	ENTAL BAFFI JBE SIDE  IBLE LIQ .300 OUT .86.5* 62.0635 .8030 .9998 .3598 .18.02 92.2 .7524	DES, RATING COLD S Shell SENS  IN 70.0 62.2515 .9783 1.0015 .3554	E0002 P 46 9/23/3 CASE 23 HELL SIDE 1 IBLE LIQ .800 OUT 90.0* 62.0196 .7712 .9994 .3607 18.02
PRESS. DROP % Washington Unive Young model F302DY SIZE 4- 18 TYPE BE  TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN	5.7 rsity Chi 4P M, MULTI- KLB/HR DEGF LB/FT3 CP BTU/LB-I BTU/HR-I LB/LBMOI DEGI KIN CP	3.6 E433 heat -PASS FLO	DW, SEGME HOT TU Tube SENSI IN 140.0 51.2913 .4726 .9973 .3723	ENTAL BAFFI JBE SIDE  IBLE LIQ .300 OUT .86.5* 62.0635 .8030 .9998 .3598 .18.02 92.2 .7524	DES, RATING COLD S Shell SENS  IN 70.0 62.2515 .9783 1.0015 .3554	E0002 P 46 9/23/3 CASE 23 HELL SIDE 1 IBLE LIQ .800 OUT 90.0* 62.0196 .7712 .9994 .3607 18.02
PRESS. DROP % Washington Unive Young model F302DY SIZE 4- 18 TYPE BE  TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES	5.7 rsity Chi 4P M, MULTI- KLB/HR DEGF LB/FT3 CP BTU/LB-I BTU/HR-I LB/LBMOI  DEGI KIN CP IGN PSIA	3.6 E433 heat -PASS FLO	DW, SEGME HOT TU Tube SENSI IN 140.0 51.2913 .4726 .9973 .3723	ENTAL BAFFI JBE SIDE  IBLE LIQ .300 OUT .86.5* 62.0635 .8030 .9998 .3598 .3598 .18.02 92.2 .7524 .165.00	DES, RATING COLD S Shell SENS  IN 70.0 62.2515 .9783 1.0015 .3554	E0002 P 46 9/23/3 CASE 23 HELL SIDE 1 IBLE LIQ .800 OUT 90.0* 62.0196 .7712 .9994 .3607 18.02
PRESS. DROP % Washington Unive Young model F302DY SIZE 4- 18 TYPE BE  TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES  PRESSURE DROP, TOT	5.7 rsity Chi 4P M, MULTI- KLB/HR DEGF LB/FT3 CP BTU/LB-I BTU/HR-I LB/LBMOI DEGI KIN CP IGN PSIA	3.6 E433 heat -PASS FLO	DW, SEGME HOT TU Tube SENSI IN 140.0 51.2913 .4726 .9973 .3723	ENTAL BAFFI JBE SIDE  IBLE LIQ .300 OUT 86.5* 62.0635 .8030 .9998 .3598 18.02 92.2 .7524 165.00	Dent Dent Dent Dent Dent Dent Dent Dent	E0002 P 46 9/23/ 3 CASE 23  HELL SIDE  IBLE LIQ .800 OUT 90.0* 62.0196 .7712 .9994 .3607 18.02 91.4 .7592 165.00
PRESS. DROP % Washington Unive Young model F302DY SIZE 4- 18 TYPE BE  TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES	5.7 rsity Chi 4P M, MULTI- KLB/HR DEGF LB/FT3 CP BTU/LB-I BTU/HR-I LB/LBMOI DEGI KIN CP IGN PSIA	3.6 E433 heat -PASS FLO	DW, SEGME HOT TU Tube SENSI IN 140.0 51.2913 .4726 .9973 .3723	ENTAL BAFFI JBE SIDE  IBLE LIQ .300 OUT 86.5* 62.0635 .8030 .9998 .3598 18.02 92.2 .7524 165.00	Dent Dent Dent Dent Dent Dent Dent Dent	E0002 P 46 9/23/3 CASE 23  HELL SIDE  IBLE LIQ .800 OUT 90.0* 62.0196 .7712 .9994 .3607 18.02 91.4 .7592 165.00
PRESS. DROP % Washington Unive Young model F302DY SIZE 4- 18 TYPE BE  TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES  PRESSURE DROP, TOT	5.7 rsity Chi 4P M, MULTI- KLB/HR  DEGF LB/FT3 CP BTU/LB-I BTU/HR-I LB/LBMOI  DEGI KIN CP IGN PSIA & ALLOWI	3.6 E433 heat -PASS FLO FT-F E ED PSI ED FT/S	DW, SEGME HOT TU Tube SENSI IN 140.0 51.2913 .4726 .9973 .3723	ENTAL BAFFI JBE SIDE  IBLE LIQ .300 OUT 86.5* 62.0635 .8030 .9998 .3598 18.02 92.2 .7524 165.00 10.00 10.00	DES, RATING COLD S Shell SENS  IN 70.0 62.2515 .9783 1.0015 .3554	E0002 P 46 9/23/ 3 CASE 23  HELL SIDE  IBLE LIQ .800 OUT 90.0* 62.0196 .7712 .9994 .3607 18.02 91.4 .7592 165.00

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SHELLS IN SERIES	TOTAL HEAT DUTY REQUIRED MEGBTU/HR EFF TEMP DIF, DEGF (LMTD= 30.2,F= OVERALL COEFF REQUIRED BTU/HR-FT2 CLEAN & FOULED COEFF BTU/HR-FT2	.73,BYPASS= .94,BAFF=1.00) 20.7 2-F 108.35
SPACING, CENTRAL IN.	PASSES, SHELL 1 TUBE 4	EFFECTIVE AREA FT2/SHELL 7.1
NO. OF TUBES/SHELL FT 1.500 TUBE PITCH IN3125 TUBE LGTH, OVERALL FT 1.500 TUBE PITCH IN3125 TUBE LGTH, OVERALL FT 1.436 TUBE OUTSIDE DIAM IN250 TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN250 TUBE LAYOUT DEG 60 TUBE SURFACE RATIO, OUT/IN 1.184 SHL NOZZ ID, IN&OUT 1.0 1.0 TUBE NOZZ ID, IN&OUT IN8 .8  * CALCULATED ITEM-HEAT BALANCE CODE = 8 Washington University ChE433 heat exchanger experiment 2002 P 47 Young model F302DY4P	SPACING, CENTRAL IN. 4.309 E SPACING, INLET IN. 4.309 SPACING, OUTLET IN. 4.309 BAFFLE THICKNESS IN125	BAFFLE CUT, PCT SHELL I.D. 30.00 CUT DISTANCE FROM CENTER, IN764 IMPINGEMENT BAFFLE INCLUDED NO
Washington University Che433 heat exchanger experiment 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 SHELLSIDE PERFORMANCE WALL CORRECTION 1.019 .000 NOMINAL VEL, X-FLOW FT/S .10  PRANDTL NUMBER 5.9 4.0 NOMINAL VEL, WINDOW FT/S .20  RYNLD NO, AVG 348. 782. CROSSFLOW COEF BTU/HR-FT2-F 313.3  RYNLD NO, IN BUN 308. 1000. WINDOW COEF BTU/HR-FT2-F 315.3  RYNLD NO, OUT BUN 390. 589. FOULING LAYER IN0014 .0014 SHELLSIDE FLOW, % OF TOTAL HEAT TRANSFER X-FLOW 81.43  THERMAL RESISTANCE, % OF TOTAL TUBE TO BAFFLE LEAKAGE A = 3.87  SHELL TUBE FOULING METAL MAIN CROSSFLOW B = 64.64  34.41 63.16 2.35 .08 BUNDLE TO SHELL BYPASS C = 16.01  PCT OVER DESIGN .22 BAFFLE TO SHELL LEAKAGE E = 15.49  TOT FOUL RESIST .000217 TUBE PASSLANE BYPASS F = .00  DIFF RESIST .000020  SHELLSIDE HEAT TRANSFER FACTORS  DIAMETRAL CLEARANCES TOTAL (BETA) (GAMMA) (FIN) = .723  BUNDLE TO SHELL IN5000 BETA (BAFF CUT FACTOR) = .920  TUBE TO BAFFLE HOLE IN0284 GAMMA (TUBE ROW ENTRY EFCT) = .785  BAFFLE TO SHELL IN1000 END (HT LOSS IN END ZONE) = .994  SHELL NOZZLE DATA IN OUT SHELL PRESSURE DROP, % OF TOTAL	NO. OF TUBES/SHELL 76 EXTENSION TO TUBE LGTH, OVERALL FT 1.500 TO TUBE LGTH, EFF FT 1.436 TO TUBE LAYOUT DEG 60 TO TUBE LAYOUT 1.0 1.0 TO TUBE LAYOUT 1.0 T	EST MAX TUBE COUNT  TUBE PITCH  TUBE OUTSIDE DIAM  TUBE INSIDE DIAM  TUBE SURFACE RATIO, OUT/IN  TUBE NOZZ ID, IN&OUT IN.  8  8
WALL CORRECTION 1.019 .000 NOMINAL VEL, X-FLOW FT/S .10 PRANDTL NUMBER 5.9 4.0 NOMINAL VEL, WINDOW FT/S .20 RYNLD NO, AVG 348. 782. CROSSFLOW COEF BTU/HR-FT2-F 313.3 RYNLD NO, IN BUN 308. 1000. WINDOW COEF BTU/HR-FT2-F 315.3 RYNLD NO, OUT BUN 390. 589. FOULNG LAYER IN0014 .0014 SHELLSIDE FLOW, % OF TOTAL HEAT TRANSFER X-FLOW 81.43 THERMAL RESISTANCE, % OF TOTAL TUBE TO BAFFLE LEAKAGE A = 3.87 SHELL TUBE FOULING METAL MAIN CROSSFLOW B = 64.64 34.41 63.16 2.35 .08 BUNDLE TO SHELL BYPASS C = 16.01 PCT OVER DESIGN .22 BAFFLE TO SHELL LEAKAGE E = 15.49 TOT FOUL RESIST .0000217 TUBE PASSLANE BYPASS F = .00 DIAMETRAL CLEARANCES TOTAL = (BETA) (GAMMA) (FIN) = .723 BUNDLE TO SHELL IN5000 BETA (BAFF CUT FACTOR) = .920 TUBE TO BAFFLE HOLE IN0284 GAMMA (TUBE ROW ENTRY EFCT) = .785 BAFFLE TO SHELL IN1000 END (HT LOSS IN END ZONE) = .994  SHELL NOZZLE DATA IN OUT SHELL PRESSURE DROP, % OF TOTAL	Washington University ChE433 heat Young model F302DY4P	exchanger experiment E0002 P 47 9/23/ 3 CASE 23
THERMAL RESISTANCE, % OF TOTAL  SHELL TUBE FOULING METAL  34.41 63.16 2.35 .08  BUNDLE TO SHELL BYPASS C = 16.01  PCT OVER DESIGN  .22 BAFFLE TO SHELL LEAKAGE E = 15.49  TOT FOUL RESIST  .000217  DIFF RESIST  .000020  SHELLSIDE HEAT TRANSFER FACTORS  DIAMETRAL CLEARANCES  BUNDLE TO SHELL  IN5000  BETA (BAFF CUT FACTOR) = .920  TUBE TO BAFFLE HOLE IN0284  GAMMA (TUBE ROW ENTRY EFCT) = .785  BAFFLE TO SHELL  IN1000  SHELL PRESSURE DROP, % OF TOTAL	WALL CORRECTION 1.019 .000 PRANDTL NUMBER 5.9 4.0 RYNLD NO, AVG 348. 782. RYNLD NO, IN BUN 308. 1000. RYNLD NO, OUT BUN 390. 589.	NOMINAL VEL, X-FLOW FT/S .10  NOMINAL VEL, WINDOW FT/S .20  CROSSFLOW COEF BTU/HR-FT2-F 313.3  WINDOW COEF BTU/HR-FT2-F 315.3  SHELLSIDE FLOW, % OF TOTAL
TUBE TO BAFFLE HOLE IN0284 GAMMA (TUBE ROW ENTRY EFCT) = .785 BAFFLE TO SHELL IN1000 END (HT LOSS IN END ZONE) = .994  SHELL NOZZLE DATA IN OUT SHELL PRESSURE DROP, % OF TOTAL	SHELL TUBE FOULING METAL 34.41 63.16 2.35 .08 PCT OVER DESIGN .22 TOT FOUL RESIST .000217 DIFF RESIST .000020  DIAMETRAL CLEARANCES	TUBE TO BAFFLE LEAKAGE A = 3.87  MAIN CROSSFLOW B = 64.64  BUNDLE TO SHELL BYPASS C = 16.01  BAFFLE TO SHELL LEAKAGE E = 15.49  TUBE PASSLANE BYPASS F = .00  SHELLSIDE HEAT TRANSFER FACTORS  TOTAL = (BETA) (GAMMA) (FIN) = .723
	TUBE TO BAFFLE HOLE IN0284 BAFFLE TO SHELL IN1000 SHELL NOZZLE DATA IN OUT	GAMMA (TUBE ROW ENTRY EFCT) = .785 END (HT LOSS IN END ZONE) = .994 SHELL PRESSURE DROP, % OF TOTAL

HT OPP NOZ IN. VELOCITY FT/S	.65 .66	CROSS E	FLOW		= 3.5 = 3.1
DENSITY LB/FT3 NOZZ RHO*VSQ LB/FT BUND RHO*VSQ LB/FT	2-S2 26 26	OUTLET			= 42.7 = 41.8
TUBE NOZZLE DATA VELOCITY FT/S			HT PER SHEL		150.
DENSITY LB/FT3 PRESS. DROP %	61.291 62.064	WET			165.
Washington Unive	ersity ChE433 he 4P	at exchanç			9/23/ 3 CASE 24
SIZE 4- 18 TYPE BE	M, MULTI-PASS F		ENTAL BAFFL JBE SIDE		
				Shel	
		SENSI	BLE LIQ		
TOTAL FLOW RATE	KLB/HR		.300 OUT		.900
TEMPERATURE					
DENSITY					
VISCOSITY SPECIFIC HEAT			.8165		
THERMAL COND.					
MOLAR MASS		.3723	18.02		18.02
HOLIMIC PIMOO					
TEMP, AVG & SKIN					
VISCOSITY, AVG & S					
PRESSURE, IN & DES	IGN PSIA	50.00	165.00	50.00	165.00
		0.2	10.00	0.0	10.00
PRESSURE DROP, TOT VELOCITY, CALC & M					
VELOCITI, CALC & M	ALLOWED FI/	5 .29	10.00	•14	10.00
FOULING RESISTANCE	HR-FT2-F/B	TU . (	00010		00010
FILM COEFFICIENT					40.82
TOTAL HEAT DUTY RE					.016465
EFF TEMP DIF, DEGF			ASS= .94,BA	FF=1.00)	
OVERALL COEFF REQU			115 0	_	112.18
CLEAN & FOULED COE	FF BTU/HR-F	.T. Z – F.	115.2	/	111.91
SHELLS IN SERIES	1 PARALLEL 1	TOTAL EFF	F AREA	FT2	7.1
PASSES, SHELL					
SHELL DIAMETER IN.					
BAFFLE TYPE H					
SPACING, CENTRAL SPACING, INLET			ANCE FROM C		
SPACING, INLET SPACING, OUTLET		COI DISIF	ANCE FROM C.	ENIER, IN.	. / 04
BAFFLE THICKNESS		IMPTNGEME	ENT BAFFLE	INCLUDED	NO
PAIRS OF SEALING D			BLANK ARE		
				•	
TUBE TYPE	PLAIN	MATERIAL	E	LECTROLYTI	C COPPER

NO. OF TUBES/SHELL 76 E	ST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT 1.500 I		
TUBE LGTH, EFF FT 1.436 T		
TUBE LAYOUT DEG 60 I		
PITCH RATIO 1.250 I		
SHL NOZZ ID, IN&OUT 1.0 1.0 T		
* CALCULATED ITEMHEAT BALANCE C		
Washington University ChE433 heat	exchanger experiment	
Young model F302DY4P		9/23/ 3
		CASE 24
S U P P L E M E N T A R	Y RESULTS	
HT PARAMETERS SHELL TUBE		1.0
WALL CORRECTION 1.018 .000		
PRANDTL NUMBER 5.9 4.0 RYNLD NO, AVG 387. 777.	NOMINAL VEL, WINDOW FT/S	
RYNLD NO, AVG 387. ///.  RYNLD NO, IN BUN 346. 1000.		
RYNLD NO, IN BUN 346. 1000.  RYNLD NO, OUT BUN 431. 579.	WINDOW COEF BTU/HR-FTZ-	-F 344.3
		<del>,</del>
FOULNG LAYER IN0014 .0014	SHELLSIDE FLOW, & OF IOIAL	ы Ол ир
THERMAL RESISTANCE, % OF TOTAL		
SHELL TUBE FOULING METAL	MAIN CROSSELOW R	- 4.00 - 64.41
32.47 65.03 2.43 .08	MAIN CROSSILOW D	- 04.41 - 16.22
PCT OVER DESIGN24	BAFFIF TO SHELL BIFASS C	= 10.22 = 15.38
TOT FOUL RESIST .000217	TIBE PASSIANE BYPASS F	= 10.00
DIFF RESIST000022	TODE TASSEANE BITASS	00
	SHELLSIDE HEAT TRANSFER FA	ACTORS
	SHELLSIDE HEAT TRANSFER FA	
DIAMETRAL CLEARANCES	TOTAL = (BETA) (GAMMA) (FIN)	= .747
	TOTAL = (BETA) (GAMMA) (FIN) BETA (BAFF CUT FACTOR)	= .747 = .920
DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000	TOTAL = (BETA) (GAMMA) (FIN) BETA (BAFF CUT FACTOR) GAMMA (TUBE ROW ENTRY EFCT)	= .747 = .920 = .811
DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000 TUBE TO BAFFLE HOLE IN0284 BAFFLE TO SHELL IN1000	TOTAL = (BETA) (GAMMA) (FIN) BETA (BAFF CUT FACTOR) GAMMA (TUBE ROW ENTRY EFCT) END (HT LOSS IN END ZONE)	= .747 = .920 = .811 = .994
DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000 TUBE TO BAFFLE HOLE IN0284 BAFFLE TO SHELL IN1000 SHELL NOZZLE DATA IN OUT	TOTAL = (BETA) (GAMMA) (FIN) BETA (BAFF CUT FACTOR) GAMMA (TUBE ROW ENTRY EFCT) END (HT LOSS IN END ZONE)  SHELL PRESSURE DROP, % OF	= .747 = .920 = .811 = .994
DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000 TUBE TO BAFFLE HOLE IN0284 BAFFLE TO SHELL IN1000 SHELL NOZZLE DATA IN OUT	TOTAL = (BETA) (GAMMA) (FIN) BETA (BAFF CUT FACTOR) GAMMA (TUBE ROW ENTRY EFCT) END (HT LOSS IN END ZONE) SHELL PRESSURE DROP, % OF	= .747 = .920 = .811 = .994
DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000 TUBE TO BAFFLE HOLE IN0284 BAFFLE TO SHELL IN1000 SHELL NOZZLE DATA IN OUT	TOTAL = (BETA) (GAMMA) (FIN) BETA (BAFF CUT FACTOR) GAMMA (TUBE ROW ENTRY EFCT) END (HT LOSS IN END ZONE) SHELL PRESSURE DROP, % OF	= .747 = .920 = .811 = .994
DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000 TUBE TO BAFFLE HOLE IN0284 BAFFLE TO SHELL IN1000  SHELL NOZZLE DATA IN OUT HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .74	TOTAL = (BETA) (GAMMA) (FIN) BETA (BAFF CUT FACTOR) GAMMA (TUBE ROW ENTRY EFCT) END (HT LOSS IN END ZONE)  SHELL PRESSURE DROP, % OF WINDOW END ZONE CROSS FLOW	= .747 = .920 = .811 = .994
DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000 TUBE TO BAFFLE HOLE IN0284 BAFFLE TO SHELL IN1000  SHELL NOZZLE DATA IN OUT HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .74 .74 DENSITY LB/FT3 62.252 62.041	TOTAL = (BETA) (GAMMA) (FIN) BETA (BAFF CUT FACTOR) GAMMA (TUBE ROW ENTRY EFCT) END (HT LOSS IN END ZONE) SHELL PRESSURE DROP, % OF	= .747 = .920 = .811 = .994 TOTAL = 8.9 = 3.3 = 3.0 = 42.8
DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000 TUBE TO BAFFLE HOLE IN0284 BAFFLE TO SHELL IN1000  SHELL NOZZLE DATA IN OUT HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .74 .74 DENSITY LB/FT3 62.252 62.041 NOZZ RHO*VSQ LB/FT-S2 33 33	TOTAL = (BETA) (GAMMA) (FIN) BETA (BAFF CUT FACTOR) GAMMA (TUBE ROW ENTRY EFCT) END (HT LOSS IN END ZONE)  SHELL PRESSURE DROP, % OF WINDOW END ZONE CROSS FLOW	= .747 = .920 = .811 = .994 TOTAL = 8.9 = 3.3 = 3.0
DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000 TUBE TO BAFFLE HOLE IN0284 BAFFLE TO SHELL IN1000  SHELL NOZZLE DATA IN OUT HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .74 .74 DENSITY LB/FT3 62.252 62.041	TOTAL = (BETA) (GAMMA) (FIN) BETA (BAFF CUT FACTOR) GAMMA (TUBE ROW ENTRY EFCT) END (HT LOSS IN END ZONE)  SHELL PRESSURE DROP, % OF WINDOW END ZONE CROSS FLOW INLET NOZZLE	= .747 = .920 = .811 = .994 TOTAL = 8.9 = 3.3 = 3.0 = 42.8
DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000 TUBE TO BAFFLE HOLE IN0284 BAFFLE TO SHELL IN1000  SHELL NOZZLE DATA IN OUT HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .74 .74 DENSITY LB/FT3 62.252 62.041 NOZZ RHO*VSQ LB/FT-S2 33 33 BUND RHO*VSQ LB/FT-S2 22 23	TOTAL = (BETA) (GAMMA) (FIN) BETA (BAFF CUT FACTOR) GAMMA (TUBE ROW ENTRY EFCT) END (HT LOSS IN END ZONE)  SHELL PRESSURE DROP, % OF WINDOW END ZONE CROSS FLOW INLET NOZZLE OUTLET NOZZLE	= .747 = .920 = .811 = .994 TOTAL = 8.9 = 3.3 = 3.0 = 42.8
DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000 TUBE TO BAFFLE HOLE IN0284 BAFFLE TO SHELL IN1000  SHELL NOZZLE DATA IN OUT HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .74 .74 DENSITY LB/FT3 62.252 62.041 NOZZ RHO*VSQ LB/FT-S2 33 33 BUND RHO*VSQ LB/FT-S2 22 23	TOTAL = (BETA) (GAMMA) (FIN) BETA (BAFF CUT FACTOR) GAMMA (TUBE ROW ENTRY EFCT) END (HT LOSS IN END ZONE)  SHELL PRESSURE DROP, % OF WINDOW END ZONE CROSS FLOW INLET NOZZLE OUTLET NOZZLE WEIGHT PER SHELL, LB	= .747 = .920 = .811 = .994 TOTAL = 8.9 = 3.3 = 3.0 = 42.8 = 42.0
DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000 TUBE TO BAFFLE HOLE IN0284 BAFFLE TO SHELL IN1000  SHELL NOZZLE DATA IN OUT HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .74 .74 DENSITY LB/FT3 62.252 62.041 NOZZ RHO*VSQ LB/FT-S2 33 33 BUND RHO*VSQ LB/FT-S2 22 23  TUBE NOZZLE DATA IN OUT VELOCITY FT/S .444 .44	TOTAL = (BETA) (GAMMA) (FIN) BETA (BAFF CUT FACTOR) GAMMA (TUBE ROW ENTRY EFCT) END (HT LOSS IN END ZONE)  SHELL PRESSURE DROP, % OF WINDOW END ZONE CROSS FLOW INLET NOZZLE OUTLET NOZZLE  WEIGHT PER SHELL, LB DRY =	= .747 = .920 = .811 = .994 TOTAL = 8.9 = 3.3 = 3.0 = 42.8 = 42.0
DIAMETRAL CLEARANCES  BUNDLE TO SHELL IN5000  TUBE TO BAFFLE HOLE IN0284  BAFFLE TO SHELL IN1000  SHELL NOZZLE DATA IN OUT  HT UNDR NOZ IN25  HT OPP NOZ IN25  VELOCITY FT/S .74 .74  DENSITY LB/FT3 62.252 62.041  NOZZ RHO*VSQ LB/FT-S2 33 33  BUND RHO*VSQ LB/FT-S2 22 23  TUBE NOZZLE DATA IN OUT  VELOCITY FT/S .444 .44  DENSITY LB/FT3 61.291 62.081	TOTAL = (BETA) (GAMMA) (FIN) BETA (BAFF CUT FACTOR) GAMMA (TUBE ROW ENTRY EFCT) END (HT LOSS IN END ZONE)  SHELL PRESSURE DROP, % OF WINDOW END ZONE CROSS FLOW INLET NOZZLE OUTLET NOZZLE  WEIGHT PER SHELL, LB DRY =	= .747 = .920 = .811 = .994 TOTAL = 8.9 = 3.3 = 3.0 = 42.8 = 42.0
DIAMETRAL CLEARANCES  BUNDLE TO SHELL IN5000  TUBE TO BAFFLE HOLE IN0284  BAFFLE TO SHELL IN1000  SHELL NOZZLE DATA IN OUT  HT UNDR NOZ IN25  HT OPP NOZ IN25  VELOCITY FT/S .74 .74  DENSITY LB/FT3 62.252 62.041  NOZZ RHO*VSQ LB/FT-S2 33 33  BUND RHO*VSQ LB/FT-S2 22 23  TUBE NOZZLE DATA IN OUT  VELOCITY FT/S .444 .44  DENSITY LB/FT3 61.291 62.081  PRESS. DROP % 5.6 3.5	TOTAL = (BETA) (GAMMA) (FIN) BETA (BAFF CUT FACTOR) GAMMA (TUBE ROW ENTRY EFCT) END (HT LOSS IN END ZONE)  SHELL PRESSURE DROP, % OF WINDOW END ZONE CROSS FLOW INLET NOZZLE OUTLET NOZZLE  WEIGHT PER SHELL, LB DRY = WET =	= .747 = .920 = .811 = .994 TOTAL = 8.9 = 3.3 = 3.0 = 42.8 = 42.0
DIAMETRAL CLEARANCES  BUNDLE TO SHELL IN5000  TUBE TO BAFFLE HOLE IN0284  BAFFLE TO SHELL IN1000  SHELL NOZZLE DATA IN OUT  HT UNDR NOZ IN25  HT OPP NOZ IN25  VELOCITY FT/S .74 .74  DENSITY LB/FT3 62.252 62.041  NOZZ RHO*VSQ LB/FT-S2 33 33  BUND RHO*VSQ LB/FT-S2 22 23  TUBE NOZZLE DATA IN OUT  VELOCITY FT/S .44 .44  DENSITY LB/FT3 61.291 62.081  PRESS. DROP % 5.6 3.5  Washington University ChE433 heat	TOTAL = (BETA) (GAMMA) (FIN) BETA (BAFF CUT FACTOR) GAMMA (TUBE ROW ENTRY EFCT) END (HT LOSS IN END ZONE)  SHELL PRESSURE DROP, % OF WINDOW END ZONE CROSS FLOW INLET NOZZLE OUTLET NOZZLE  WEIGHT PER SHELL, LB DRY = WET =	= .747 = .920 = .811 = .994 TOTAL = 8.9 = 3.3 = 3.0 = 42.8 = 42.0
DIAMETRAL CLEARANCES  BUNDLE TO SHELL IN5000  TUBE TO BAFFLE HOLE IN0284  BAFFLE TO SHELL IN1000  SHELL NOZZLE DATA IN OUT  HT UNDR NOZ IN25  HT OPP NOZ IN25  VELOCITY FT/S .74 .74  DENSITY LB/FT3 62.252 62.041  NOZZ RHO*VSQ LB/FT-S2 33 33  BUND RHO*VSQ LB/FT-S2 22 23  TUBE NOZZLE DATA IN OUT  VELOCITY FT/S .444 .44  DENSITY LB/FT3 61.291 62.081  PRESS. DROP % 5.6 3.5	TOTAL = (BETA) (GAMMA) (FIN) BETA (BAFF CUT FACTOR) GAMMA (TUBE ROW ENTRY EFCT) END (HT LOSS IN END ZONE)  SHELL PRESSURE DROP, % OF WINDOW END ZONE CROSS FLOW INLET NOZZLE OUTLET NOZZLE  WEIGHT PER SHELL, LB DRY = WET =	= .747 = .920 = .811 = .994 TOTAL = 8.9 = 3.3 = 3.0 = 42.8 = 42.0
DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000 TUBE TO BAFFLE HOLE IN0284 BAFFLE TO SHELL IN1000  SHELL NOZZLE DATA IN OUT HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .74 .74 DENSITY LB/FT3 62.252 62.041 NOZZ RHO*VSQ LB/FT-S2 33 33 BUND RHO*VSQ LB/FT-S2 22 23  TUBE NOZZLE DATA IN OUT VELOCITY FT/S .44 .44 DENSITY LB/FT3 61.291 62.081 PRESS. DROP % 5.6 3.5 Washington University ChE433 heat Young model F302DY4P	TOTAL = (BETA) (GAMMA) (FIN) BETA (BAFF CUT FACTOR) GAMMA (TUBE ROW ENTRY EFCT) END (HT LOSS IN END ZONE)  SHELL PRESSURE DROP, % OF WINDOW END ZONE CROSS FLOW INLET NOZZLE OUTLET NOZZLE  WEIGHT PER SHELL, LB DRY = WET = exchanger experiment	= .747 = .920 = .811 = .994 TOTAL = 8.9 = 3.3 = 3.0 = 42.8 = 42.0
DIAMETRAL CLEARANCES  BUNDLE TO SHELL IN5000  TUBE TO BAFFLE HOLE IN0284  BAFFLE TO SHELL IN1000  SHELL NOZZLE DATA IN OUT  HT UNDR NOZ IN25  HT OPP NOZ IN25  VELOCITY FT/S .74 .74  DENSITY LB/FT3 62.252 62.041  NOZZ RHO*VSQ LB/FT-S2 33 33  BUND RHO*VSQ LB/FT-S2 22 23  TUBE NOZZLE DATA IN OUT  VELOCITY FT/S .44 .44  DENSITY LB/FT3 61.291 62.081  PRESS. DROP % 5.6 3.5  Washington University ChE433 heat	TOTAL = (BETA) (GAMMA) (FIN) BETA (BAFF CUT FACTOR) GAMMA (TUBE ROW ENTRY EFCT) END (HT LOSS IN END ZONE)  SHELL PRESSURE DROP, % OF WINDOW END ZONE CROSS FLOW INLET NOZZLE OUTLET NOZZLE  WEIGHT PER SHELL, LB DRY = WET =  exchanger experiment  W, SEGMENTAL BAFFLES, RATING	= .747 = .920 = .811 = .994 TOTAL = 8.9 = 3.3 = 3.0 = 42.8 = 42.0 150. 165. E0002 P 50 9/23/3 CASE 25
DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000 TUBE TO BAFFLE HOLE IN0284 BAFFLE TO SHELL IN1000  SHELL NOZZLE DATA IN OUT HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .74 .74 DENSITY LB/FT3 62.252 62.041 NOZZ RHO*VSQ LB/FT-S2 33 33 BUND RHO*VSQ LB/FT-S2 22 23  TUBE NOZZLE DATA IN OUT VELOCITY FT/S .44 .44 DENSITY LB/FT3 61.291 62.081 PRESS. DROP % 5.6 3.5 Washington University ChE433 heat Young model F302DY4P	TOTAL = (BETA) (GAMMA) (FIN) BETA (BAFF CUT FACTOR) GAMMA (TUBE ROW ENTRY EFCT) END (HT LOSS IN END ZONE)  SHELL PRESSURE DROP, % OF WINDOW END ZONE CROSS FLOW INLET NOZZLE OUTLET NOZZLE  WEIGHT PER SHELL, LB DRY = WET = exchanger experiment	= .747 = .920 = .811 = .994 TOTAL = 8.9 = 3.3 = 3.0 = 42.8 = 42.0
DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000 TUBE TO BAFFLE HOLE IN0284 BAFFLE TO SHELL IN1000  SHELL NOZZLE DATA IN OUT HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .74 .74 DENSITY LB/FT3 62.252 62.041 NOZZ RHO*VSQ LB/FT-S2 33 33 BUND RHO*VSQ LB/FT-S2 22 23  TUBE NOZZLE DATA IN OUT VELOCITY FT/S .44 .44 DENSITY LB/FT3 61.291 62.081 PRESS. DROP % 5.6 3.5 Washington University ChE433 heat Young model F302DY4P	TOTAL = (BETA) (GAMMA) (FIN) BETA (BAFF CUT FACTOR) GAMMA (TUBE ROW ENTRY EFCT) END (HT LOSS IN END ZONE)  SHELL PRESSURE DROP, % OF WINDOW END ZONE CROSS FLOW INLET NOZZLE OUTLET NOZZLE  WEIGHT PER SHELL, LB DRY = WET =  exchanger experiment  OW, SEGMENTAL BAFFLES, RATING HOT TUBE SIDE COLD SI Tube Shell	= .747 = .920 = .811 = .994 TOTAL = 8.9 = 3.3 = 3.0 = 42.8 = 42.0 150. 165. E0002 P 50 9/23/ 3 CASE 25 HELL SIDE
DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000 TUBE TO BAFFLE HOLE IN0284 BAFFLE TO SHELL IN1000  SHELL NOZZLE DATA IN OUT HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .74 .74 DENSITY LB/FT3 62.252 62.041 NOZZ RHO*VSQ LB/FT-S2 33 33 BUND RHO*VSQ LB/FT-S2 22 23  TUBE NOZZLE DATA IN OUT VELOCITY FT/S .44 .44 DENSITY LB/FT3 61.291 62.081 PRESS. DROP % 5.6 3.5 Washington University ChE433 heat Young model F302DY4P	TOTAL = (BETA) (GAMMA) (FIN) BETA (BAFF CUT FACTOR) GAMMA (TUBE ROW ENTRY EFCT) END (HT LOSS IN END ZONE)  SHELL PRESSURE DROP, % OF WINDOW END ZONE CROSS FLOW INLET NOZZLE OUTLET NOZZLE  WEIGHT PER SHELL, LB DRY = WET =  exchanger experiment  OW, SEGMENTAL BAFFLES, RATING HOT TUBE SIDE COLD SI Tube Shell	= .747 = .920 = .811 = .994 TOTAL = 8.9 = 3.3 = 3.0 = 42.8 = 42.0

che433b(70).OUT IN OUT IN OUT 140.0 114.7\* 70.0 120.5\* TEMPERATURE DEGF 140.0 114.7\* 70.0 120.5
DENSITY LB/FT3 61.2913 61.6869 62.2515 61.6008 DENSITY LB/FT3 61.2913 61.6869 62.2515 61.6008
VISCOSITY CP .4726 .5956 .9783 .5632
SPECIFIC HEAT BTU/LB-F .9973 .9978 1.0015 .9976
THERMAL COND. BTU/HR-FT-F .3723 .3668 .3554 .3681
MOLAR MASS LB/LBMOL 18.02 18.02 ----------TEMP, AVG & SKIN DEGF 127.4 113.5
VISCOSITY, AVG & SKIN CP .5285 .6028
PRESSURE, IN & DESIGN PSIA 50.00 165.00 95.3 .7279 112.9 .6061 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 FILM COEFFICIENT BTU/HR-FT2-F 206.23 .00010 135.28 -----TOTAL HEAT DUTY REQUIRED MEGBTU/HR .010094 EFF TEMP DIF, DEGF (LMTD= 30.4,F= .68,BYPASS= .91,BAFF=1.00) 18.7 OVERALL COEFF REQUIRED BTU/HR-FT2-F CLEAN & FOULED COEFF BTU/HR-FT2-F 76.55 SHELLS IN SERIES 1 PARALLEL 1 TOTAL EFF AREA FT2
PASSES, SHELL 1 TUBE 4 EFFECTIVE AREA FT2/SHELL SHELL DIAMETER IN. 3.820 TEMA SHELL TYPE E ; REAR HEAD FXTS BAFFLE TYPE HORZ SEGMENTL CROSS PASSES PER SHELL PASS SPACING, CENTRAL IN. 4.309 BAFFLE CUT, PCT SHELL I.D. SPACING, INLET IN. 4.309 CUT DISTANCE FROM CENTER, IN. .764 SPACING, OUTLET IN. 4.309
BAFFLE THICKNESS IN. .125 IMPINGEMENT BAFFLE INCLUDED 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 51 Young model F302DY4P 9/23/ 3 CASE 25 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 1.026 .000 NOMINAL VEL,X-FLOW FT/S .03
PRANDTL NUMBER 4.9 3.5 NOMINAL VEL,WINDOW FT/S .05
RYNLD NO, AVG 102. 1193. CROSSFLOW COEF BTU/HR-FT2-F 135.8
RYNLD NO, IN BUN 76. 1334. WINDOW COEF BTU/HR-FT2-F 136.7

RYNLD NO, OUT BUN	132. 1058.				
FOULNG LAYER IN.	.0014 .0014	SHEL	LSIDE FLOW,	% OF TOTAL	L
		HEAT T	RANSFER X-F	LOW	80.60
THERMAL RESISTANCE					
SHELL TUBE FOU					
55.06 43.25 1	L.63 .05	BUNDLE	TO SHELL BY	YPASS C	= 11.34
PCT OVER DESIGN	11	BAFFLE	TO SHELL LE	EAKAGE E	= 17.31
TOT FOUL RESIST			ASSLANE BYPA	ASS F	= .00
DIFF RESIST	000015				
		SHEL	LSIDE HEAT	FRANSFER FA	ACTORS
DIAMETRAL CLEARA BUNDLE TO SHELL	ANCES	TOTAL	= (BETA) (GAM	MA) (FIN)	= .598
TUBE TO BAFFLE HOI					
BAFFLE TO SHELL	IN100	O END	(HT LOSS IN	END ZONE)	= .994
SHELL NOZZLE DAT	ra ta on	ויי פטביו	T DDFQQIIDF I		TOTAT
HT UNDR NOZ IN.					0 -
HT OPP NOZ IN	25	END ZO	NF.		= 6.6
VELOCITY FT/S DENSITY LB/FT3 NOZZ RHO*VSQ LB/FT	.16 .1	7 CROSS	FLOW		= 5.2
DENSITY LB/FT3	62.252 61.60	1 INLET	NOZZLE		= 40.6
NOZZ RHO*VSO LB/F7	Γ-S2 1	1 OUTLET	' NOZZLE		= 38.0
BUND RHO*VSQ LB/F1	Γ-S2 1	1			
TUBE NOZZLE DATA	N OU	T WEIG	HT PER SHEL	L, LB	
VELOCITY FT/S DENSITY LB/FT3 PRESS DROP %	.59 .5	9 DRY		=	150.
DENSITY LB/FT3	61.291 61.68	87 WET		=	165.
-					
INDOO: DIGIT	7.3	0			
Washington Unive	ersity ChE433 h	0			E0002 P 52
INDOO: DIGIT	ersity ChE433 h	0		ent	E0002 P 52 9/23/ 3
Washington Univeryoung model F302D	ersity ChE433 h	neat exchan	iger experime	ent	E0002 P 52 9/23/ 3 CASE 26
Washington Unive	ersity ChE433 h	neat exchan	ger experime	ent ES, RATING	E0002 P 52 9/23/ 3 CASE 26
Washington Univeryoung model F302D	ersity ChE433 h	eat exchan FLOW, SEGM HOT T	ger experime ENTAL BAFFLE UBE SIDE	ent ES, RATING COLD SI	E0002 P 52 9/23/ 3 CASE 26 HELL SIDE
Washington Univeryoung model F302DY SIZE 4- 18 TYPE BE	ersity ChE433 h	FLOW, SEGM	nger experime MENTAL BAFFLE PUBE SIDE	ES, RATING COLD SH	E0002 P 52 9/23/ 3 CASE 26 HELL SIDE
Washington Univeryoung model F302DY SIZE 4- 18 TYPE BE	ersity ChE433 h	FLOW, SEGM	nger experime MENTAL BAFFLE PUBE SIDE	ES, RATING COLD SH	E0002 P 52 9/23/ 3 CASE 26 HELL SIDE
Washington Univeryoung model F302DY SIZE 4- 18 TYPE BE	ersity ChE433 h	FLOW, SEGM	nger experime MENTAL BAFFLE PUBE SIDE	ES, RATING COLD SH	E0002 P 52 9/23/ 3 CASE 26 HELL SIDE
Washington Univeryoung model F302DY SIZE 4- 18 TYPE BE	ersity ChE433 h (4P EM, MULTI-PASS KLB/HR	PLOW, SEGM HOT T Tube SENS	eger experiments  ENTAL BAFFLE  FUBE SIDE  EIBLE LIQ  .400  OUT	ES, RATING COLD SH Shell SENS:	E0002 P 52 9/23/3 CASE 26 HELL SIDE LIBLE LIQ .300 OUT
Washington Univeryoung model F302DY SIZE 4- 18 TYPE BE TOTAL FLOW RATE TEMPERATURE	ersity ChE433 h (4P EM, MULTI-PASS KLB/HR DEGF	FLOW, SEGM HOT T Tube SENS IN 140.0	MENTAL BAFFLE TUBE SIDE TIBLE LIQ .400 OUT 107.8*	ES, RATING COLD SI Shell SENSI IN 70.0	E0002 P 52 9/23/3 CASE 26 HELL SIDE 1 IBLE LIQ .300 OUT 112.9*
Washington Univeryoung model F302DY SIZE 4- 18 TYPE BE TOTAL FLOW RATE TEMPERATURE DENSITY	ersity ChE433 h (4P EM, MULTI-PASS  KLB/HR  DEGF LB/FT3	FLOW, SEGM HOT T Tube SENS IN 140.0 61.2913	MENTAL BAFFLE FUBE SIDE FIBLE LIQ FIBLE LIQ FOR OUT FOR 107.8* FOR 61.7853	ES, RATING COLD SH Shell SENS: IN 70.0 62.2515	E0002 P 52 9/23/3 CASE 26 HELL SIDE 1 IBLE LIQ .300 OUT 112.9* 61.7135
Washington Univeryoung model F302DY SIZE 4- 18 TYPE BE TOTAL FLOW RATE TEMPERATURE DENSITY VISCOSITY	ersity ChE433 h (4P  EM, MULTI-PASS  KLB/HR  DEGF  LB/FT3 CP	FLOW, SEGM HOT T Tube SENS IN 140.0 61.2913 .4726	MENTAL BAFFLE TUBE SIDE TIBLE LIQ TOTO OUT TOTO 8* 61.7853 TOTO 1088	ES, RATING COLD SH Shell SENS: IN 70.0 62.2515 .9783	E0002 P 52 9/23/3 CASE 26 HELL SIDE 1 IBLE LIQ .300 OUT 112.9* 61.7135 .6065
Washington Univeryoung model F302DY SIZE 4- 18 TYPE BE TOTAL FLOW RATE TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT	ersity ChE433 h (4P) EM, MULTI-PASS  KLB/HR  DEGF LB/FT3 CP BTU/LB-F	FLOW, SEGM HOT T Tube SENS IN 140.0 61.2913 .4726 .9973	MENTAL BAFFLE PUBE SIDE SIBLE LIQ .400 OUT 107.8* 61.7853 .6380 .9982	ES, RATING COLD SH Shell SENS:  IN 70.0 62.2515 .9783 1.0015	E0002 P 52 9/23/3 CASE 26 HELL SIDE LIBLE LIQ .300 OUT 112.9* 61.7135 .6065 .9979
Washington Univeryoung model F302DY SIZE 4- 18 TYPE BE TOTAL FLOW RATE TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND.	ersity ChE433 h (4P) EM, MULTI-PASS  KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F	FLOW, SEGM HOT T Tube SENS IN 140.0 61.2913 .4726 .9973	MENTAL BAFFLE SIDE SIBLE LIQ .400 OUT 107.8* 61.7853 .6380 .9982 .3652	ES, RATING COLD SH Shell SENS: IN 70.0 62.2515 .9783	E0002 P 52 9/23/3 CASE 26 HELL SIDE LIBLE LIQ .300 OUT 112.9* 61.7135 .6065 .9979 .3664
Washington Univeryoung model F302DY SIZE 4- 18 TYPE BE TOTAL FLOW RATE TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT	ersity ChE433 h (4P) EM, MULTI-PASS  KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F	FLOW, SEGM HOT T Tube SENS IN 140.0 61.2913 .4726 .9973 .3723	MENTAL BAFFLE PUBE SIDE SIBLE LIQ .400 OUT 107.8* 61.7853 .6380 .9982	ES, RATING COLD SE Shell SENS:  IN 70.0 62.2515 .9783 1.0015 .3554	E0002 P 52 9/23/3 CASE 26 HELL SIDE LIBLE LIQ .300 OUT 112.9* 61.7135 .6065 .9979 .3664 18.02
Washington Univeryoung model F302DY SIZE 4- 18 TYPE BE TOTAL FLOW RATE TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS	ersity ChE433 h (4P) EM, MULTI-PASS  KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL	FLOW, SEGM HOT T Tube SENS  IN 140.0 61.2913 .4726 .9973 .3723	MENTAL BAFFLE MUBE SIDE MIBLE LIQ MOUT MOT.8* 61.7853 MOS.880 MOS.8982 MOS.880	ES, RATING COLD SI Shell SENSI  IN 70.0 62.2515 .9783 1.0015 .3554	E0002 P 52 9/23/3 CASE 26 HELL SIDE IBLE LIQ .300 OUT 112.9* 61.7135 .6065 .9979 .3664 18.02
Washington Univeryoung model F302DY SIZE 4- 18 TYPE BE TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN	ersity ChE433 h (4P) EM, MULTI-PASS  KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL  DEGF	FLOW, SEGM HOT T Tube SENS  IN 140.0 61.2913 .4726 .9973 .3723	ENTAL BAFFLE UBE SIDE UBLE LIQ .400 OUT 107.8* 61.7853 .6380 .9982 .3652 18.02	ES, RATING COLD SI Shell SENS:  IN 70.0 62.2515 .9783 1.0015 .3554	E0002 P 52 9/23/3 CASE 26 HELL SIDE IBLE LIQ .300 OUT 112.9* 61.7135 .6065 .9979 .3664 18.02
Washington Univeryoung model F302DY SIZE 4- 18 TYPE BE TOTAL FLOW RATE TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS	Ersity ChE433 h (4P)  EM, MULTI-PASS  KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL  DEGF  SKIN CP	FLOW, SEGM HOT T Tube SENS  IN 140.0 61.2913 .4726 .9973 .3723	ENTAL BAFFLE UBE SIDE UBLE LIQ .400 OUT 107.8* 61.7853 .6380 .9982 .3652 18.02	ES, RATING COLD SI Shell SENS:  IN 70.0 62.2515 .9783 1.0015 .3554	E0002 P 52 9/23/3 CASE 26 HELL SIDE IBLE LIQ .300 OUT 112.9* 61.7135 .6065 .9979 .3664 18.02
Washington Univeryoung model F302DY SIZE 4- 18 TYPE BE TOTAL FLOW RATE TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS TEMP, AVG & SKIN VISCOSITY, AVG & S	Ersity ChE433 h (4P)  EM, MULTI-PASS  KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL  DEGF  SKIN CP	FLOW, SEGM HOT T Tube SENS  IN 140.0 61.2913 .4726 .9973 .3723	MENTAL BAFFLE SIDE SIBLE LIQ .400 OUT 107.8* 61.7853 .6380 .9982 .3652 18.02	ES, RATING COLD SI Shell SENS:  IN 70.0 62.2515 .9783 1.0015 .3554	E0002 P 52 9/23/3 CASE 26 HELL SIDE IBLE LIQ .300 OUT 112.9* 61.7135 .6065 .9979 .3664 18.02
Washington Univeryoung model F302DY SIZE 4- 18 TYPE BE TOTAL FLOW RATE TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS TEMP, AVG & SKIN VISCOSITY, AVG & S	ersity ChE433 h (4P) EM, MULTI-PASS  KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL  DEGF SKIN CP SIGN PSIA	FLOW, SEGM HOT T Tube SENS  IN 140.0 61.2913 .4726 .9973 .3723	MENTAL BAFFLE SIDE SIDE SIDE SIDE SIDE SIDE SIDE SID	ES, RATING COLD SE Shell SENS:  IN 70.0 62.2515 .9783 1.0015 .3554 91.4 .7592 50.00	E0002 P 52 9/23/3 CASE 26 HELL SIDE LIBLE LIQ .300 OUT 112.9* 61.7135 .6065 .9979 .3664 18.02  107.6 .6395 165.00
Washington Univeryoung model F302DY  SIZE 4- 18 TYPE BE  TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES	ersity ChE433 h 44P EM, MULTI-PASS  KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL  DEGF SKIN CP SIGN PSIA	FLOW, SEGM HOT T Tube SENS  IN 140.0 61.2913 .4726 .9973 .3723 123.9 .5456 50.00	MENTAL BAFFLE SIDE SIDE SIDE SIDE SIDE SIDE SIDE SID	ES, RATING COLD SE Shell SENS:  IN 70.0 62.2515 .9783 1.0015 .3554 91.4 .7592 50.00	E0002 P 52 9/23/3 CASE 26 HELL SIDE IBLE LIQ .300 OUT 112.9* 61.7135 .6065 .9979 .3664 18.02
Washington Univeryoung model F302DY  SIZE 4- 18 TYPE BE  TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES  PRESSURE DROP, TOTAL	Ersity Che433 h (4P) EM, MULTI-PASS  KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL  DEGF SKIN CP SIGN PSIA  F & ALLOWED PS MAX ALLOWED FT	FLOW, SEGM HOT T Tube SENS  IN 140.0 61.2913 .4726 .9973 .3723 123.9 .5456 50.00	ENTAL BAFFLE SIDE SIBLE LIQ .400 OUT 107.8* 61.7853 .6380 .9982 .3652 18.02 .6356 165.00 10.00 10.00	ES, RATING COLD SE Shell SENS:  IN 70.0 62.2515 .9783 1.0015 .3554 91.4 .7592 50.00	E0002 P 52 9/23/3 CASE 26 HELL SIDE IBLE LIQ .300 OUT 112.9* 61.7135 .6065 .9979 .3664 18.02
Washington Univeryoung model F302DN SIZE 4- 18 TYPE BE TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES PRESSURE DROP, TOTAL VELOCITY, CALC & M FOULING RESISTANCE	ERSITY ChE433 h  (4P)  EM, MULTI-PASS  KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL  DEGF  SKIN CP SIGN PSIA  F & ALLOWED PS  MAX ALLOWED FT  E HR-FT2-F/	FLOW, SEGM HOT T Tube SENS  IN 140.0 61.2913 .4726 .9973 .3723  123.9 .5456 50.00  SI .03 3/S .39	MIENTAL BAFFLE SIDE SIDE SIDE SIDE SIDE SIDE SIDE SID	ES, RATING COLD SE Shell SENS:  IN 70.0 62.2515 .9783 1.0015 .3554	E0002 P 52 9/23/3 CASE 26  HELL SIDE  IBLE LIQ .300 OUT 112.9* 61.7135 .6065 .9979 .3664 18.02 107.6 .6395 165.00  10.00 10.00
Washington Univeryoung model F302DY  SIZE 4- 18 TYPE BE  TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES  PRESSURE DROP, TOTAL	ERSITY ChE433 h  (4P)  EM, MULTI-PASS  KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL  DEGF  SKIN CP SIGN PSIA  F & ALLOWED PS  MAX ALLOWED FT  E HR-FT2-F/	FLOW, SEGM HOT T Tube SENS  IN 140.0 61.2913 .4726 .9973 .3723 123.9 .5456 50.00  SI .03 2/S .39	MENTAL BAFFLE SIDE SIDE SIDE SIDE SIDE SIDE SIDE SID	ES, RATING COLD SE Shell SENS:  IN 70.0 62.2515 .9783 1.0015 .3554 91.4 .7592 50.00 .00 .05	E0002 P 52 9/23/3 CASE 26  HELL SIDE  IBLE LIQ .300 OUT 112.9* 61.7135 .6065 .9979 .3664 18.02 107.6 .6395 165.00  10.00 10.00

OVERALL COEFF REQUIRED BTU/HR-FT2	.71,BYPASS= .93,BAFF=1.00) 21.2
PASSES, SHELL 1 TUBE 4	COTAL EFF AREA FT2 7.1 EFFECTIVE AREA FT2/SHELL 7.1 EMA SHELL TYPE E ; REAR HEAD FXTS
SPACING, CENTRAL IN. 4.309 E SPACING, INLET IN. 4.309 S SPACING, OUTLET IN. 4.309 BAFFLE THICKNESS IN125	CROSS PASSES PER SHELL PASS 4 BAFFLE CUT, PCT SHELL I.D. 30.00 CUT DISTANCE FROM CENTER, IN764  CMPINGEMENT BAFFLE INCLUDED NO CUBESHEET BLANK AREA, % .0
NO. OF TUBES/SHELL 76 EDITION TO TUBE LGTH, OVERALL FT 1.500 TO TUBE LGTH, EFF FT 1.436 TO TUBE LAYOUT DEG 60 TO FITCH RATIO 1.250	MATERIAL ELECTROLYTIC COPPER EST MAX TUBE COUNT 36 TUBE PITCH IN3125 TUBE OUTSIDE DIAM IN250 TUBE INSIDE DIAM IN214 TUBE SURFACE RATIO, OUT/IN 1.184 TUBE NOZZ ID, IN&OUT IN8 .8
* CALCULATED ITEMHEAT BALANCE Of Washington University ChE433 heat Young model F302DY4P  S U P P L E M E N T A R	exchanger experiment E0002 P 53 9/23/3 CASE 26
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.024 .000 PRANDTL NUMBER 5.1 3.6 RYNLD NO. AVG 148. 1155.	NOMINAL VEL, X-FLOW FT/S .04
RYNLD NO, IN BUN 115. 1334. RYNLD NO, OUT BUN 186. 988. FOULNG LAYER IN0014 .0014 THERMAL RESISTANCE, % OF TOTAL	SHELLSIDE FLOW, % OF TOTAL HEAT TRANSFER X-FLOW 81.24 TUBE TO BAFFLE LEAKAGE A = 2.88
RYNLD NO, IN BUN 115. 1334. RYNLD NO, OUT BUN 186. 988. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 49.69 48.41 1.83 .06	WINDOW COEF BTU/HR-FT2-F 170.1  SHELLSIDE FLOW, % OF TOTAL HEAT TRANSFER X-FLOW 81.24 TUBE TO BAFFLE LEAKAGE A = 2.88 MAIN CROSSFLOW B = 68.19 BUNDLE TO SHELL BYPASS C = 12.47 BAFFLE TO SHELL LEAKAGE E = 16.46 TUBE PASSLANE BYPASS F = .00
RYNLD NO, IN BUN 115. 1334. RYNLD NO, OUT BUN 186. 988. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 49.69 48.41 1.83 .06 PCT OVER DESIGN19 TOT FOUL RESIST .000217 DIFF RESIST .000222  DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000 TUBE TO BAFFLE HOLE IN0284 BAFFLE TO SHELL IN1000	WINDOW COEF BTU/HR-FT2-F 170.1  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81.24  TUBE TO BAFFLE LEAKAGE A = 2.88  MAIN CROSSFLOW B = 68.19  BUNDLE TO SHELL BYPASS C = 12.47  BAFFLE TO SHELL LEAKAGE E = 16.46  TUBE PASSLANE BYPASS F = .00  SHELLSIDE HEAT TRANSFER FACTORS  TOTAL = (BETA) (GAMMA) (FIN) = .614

	0.5	CITE 433D (			
VELOCITY FT/S	.25 .25	CROSS E	i.TOM		= 4.4
DENSITY LB/FT3	62.252 61.714	INLET N	IOZZLE		= 41.6
NOZZ RHO*VSQ LB/FT	'-s2 3 3	OUTLET	NOZZLE		= 39.5
BUND RHO*VSQ LB/FT	'-S2 2 2				
TUBE NOZZLE DATA VELOCITY FT/S	IN OUT	WEIGH	HT PER SHEL	L, LB	
VELOCITY FT/S	.59 .59	DRY		=	150.
DENSITY LB/FT3	61.291 61.785	WET		=	165.
PRESS. DROP %	7.6 4.8				
Washington Unive			ger experim	ent.	E0002 P 54
Young model F302DY	_		,		9/23/ 3
104119 110421 100211	- <u></u>				CASE 27
SIZE 4- 18 TYPE BE	MIII TI TI DACC E	TOW SECME	יאים אם דגיינוי	EC DAMINO	
512E 4- 10 11PE BE	M, MULII-PASS F				
		HOT TO	JBE SIDE	COTD SI	TETT SIDE
		Tube	BLE LIQ	Shel	L 
		SENSI	BLE LIQ	SENS	IBLE LIQ
TOTAL FLOW RATE	KLB/HR		.400 OUT		.400
TEMPERATURE DENSITY VISCOSITY		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	102.9*	70.0	107.1*
DENSITY	LB/FT3	61.2913	61.8529	62.2515	61.7956
VISCOSITY	CP	.4726	.6712 .9985	.9783	.6429
SPECIETO HEAT	R'I'II / I.R – F'	99/3	9985	1 ()()15	9987
THERMAL COND.	BTU/HR-FT-F	.3723	.3640	.3554	.3650
THERMAL COND. MOLAR MASS	LB/LBMOL		18.02		18.02
	, -		10.02		
TEMP, AVG & SKIN	DEGF	121.4	104.2	88.5	103.5
VISCOSITY, AVG & S		5583	6622	7843	6668
PRESSURE, IN & DES		50 00	.6622 165.00	50 00	165 00
INDSONE, IN & DEC	TON IDIA	30.00	100.00	30.00	103.00
PRESSURE DROP, TOT	יג אוורשבר דער איי	0.3	10 00	0.0	10 00
VELOCITY, CALC & M	TOWED EM/	.03	10.00	.00	10.00
VELOCITI, CALC & P.	IAX ALLOWED FI/		10.00	.00	10.00
FOULING RESISTANCE	י בריהט_ביי	חדד (	0010		00010
FILM COEFFICIENT			7 42	• \	99.74
FILM COEFFICIENT	B1U/ HR-F12				99.74
					.014814
TOTAL HEAT DUTY RE EFF TEMP DIF, DEGF	MEGBIU/H	K 70 DVD	04 53	DD 1 00)	.014814
			ASS= .94,BA	FF=1.00)	
OVERALL COEFF REQU			0.0	2	91.87
CLEAN & FOULED COE	FFF BTU/HR-F	"I'2-F"	93.93	3	91.89
					- 1
SHELLS IN SERIES	1 PARALLEL 1	TOTAL EFF	F AREA	FT2	7.1
PASSES, SHELL	1 TUBE 4	EFFECTIVE	E AREA	FT2/SHELL	7.1
SHELL DIAMETER IN.	3.820	TEMA SHEI	LL TYPE E	; REAR H	EAD FXTS
BAFFLE TYPE H	ORZ SEGMENTL	CROSS PAS	SSES PER SH	ELL PASS	4
SPACING, CENTRAL	IN. 4.309	BAFFLE CU	JT, PCT SHE	LL I.D.	30.00
			NICE EDOM CI	ENTER, IN.	.764
SPACING, INLET	IN. 4.309	CUT DISTA	ANCE FROM C		
SPACING, OUTLET	IN. 4.309 IN. 4.309				
SPACING, OUTLET BAFFLE THICKNESS	IN. 4.309 IN. 4.309 IN125	IMPINGEME	INT BAFFLE	INCLUDED	
SPACING, OUTLET BAFFLE THICKNESS	IN. 4.309 IN. 4.309 IN125	IMPINGEME	INT BAFFLE	INCLUDED	
SPACING, OUTLET	IN. 4.309 IN. 4.309 IN125	IMPINGEME	INT BAFFLE	INCLUDED	NO
SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING D	IN. 4.309 IN. 4.309 IN125 EVICES 1	IMPINGEME TUBESHEET	ENT BAFFLE	INCLUDED	NO . 0
SPACING, OUTLET BAFFLE THICKNESS	IN. 4.309 IN. 4.309 IN125 DEVICES 1 PLAIN	IMPINGEME TUBESHEET MATERIAL	INT BAFFLE	INCLUDED A, % LECTROLYTIO	NO . 0

TUBE LGTH, OVERALL FT TUBE LGTH, EFF FT TUBE LAYOUT DEC PITCH RATIO SHL NOZZ ID, IN&OUT  * CALCULATED ITEMHI Washington University	1.436 T G 60 T 1.250 T 1.0 1.0 T EAT BALANCE C	UBE INSIDE DIAM I UBE SURFACE RATIO, OUT UBE NOZZ ID, IN&OUT I	IN. IN. I/IN	.250 .214 1.184 .8
Young model F302DY4P				9/23/ 3 CASE 27
S U P P L E M E	N T A R	Y RESUL	T S	
HT PARAMETERS SHEET WALL CORRECTION 1.00 PRANDTL NUMBER 5 RYNLD NO, AVG 190 RYNLD NO, IN BUN 150 RYNLD NO, OUT BUN 230	23 .000 .3 3.7 2. 1129. 4. 1334. 4. 939.	NOMINAL VEL, WINDOW F CROSSFLOW COEF BTU/ WINDOW COEF BTU/	TT/S TT/S 'HR-FT2- 'HR-FT2-	.10 F 200.5 F 201.9
FOULNG LAYER IN002  THERMAL RESISTANCE, % OF SHELL TUBE FOULING 45.49 52.45 1.99  PCT OVER DESIGN TOT FOUL RESIST DIFF RESIST	OF TOTAL METAL .07 .02 .000217	TUBE TO BAFFLE LEAKAG MAIN CROSSFLOW BUNDLE TO SHELL BYPAS	SE A B SS C	= 3.14 = 67.06 = 13.69
DIAMETRAL CLEARANCES BUNDLE TO SHELL II TUBE TO BAFFLE HOLE II BAFFLE TO SHELL II	N5000 N0284	BETA (BAFF CUT FACTO	(FIN) OR) ( EFCT)	= .636 = .920 = .692
SHELL NOZZLE DATA HT UNDR NOZ IN. HT OPP NOZ IN. VELOCITY FT/S DENSITY LB/FT3 62 NOZZ RHO*VSQ LB/FT-S2 BUND RHO*VSQ LB/FT-S2	.25 .25 .33 .33 .252 61.796 6 6	END ZONE		= 8.9 = 4.7
TUBE NOZZLE DATA  VELOCITY FT/S  DENSITY LB/FT3 61  PRESS. DROP %  Washington University  Young model F302DY4P	.59 .59 .291 61.853 7.5 4.7	WEIGHT PER SHELL, I DRY WET exchanger experiment	=	150. 165. E0002 P 56 9/23/ 3 CASE 28
SIZE 4- 18 TYPE BEM, MI TOTAL FLOW RATE KLB.			COLD SH Shell	ELL SIDE

		che433b(	70).OUT		
TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS	DEGF LB/FT3 CP	140.0 61.2913 .4726	99.2* 61.9015 .6974	70.0 62.2515 .9783 1.0015 .3554	102.5* 61.8574 .6735 .9985 .3639
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES	DEGF	119.6	101.1	86.3	100.3
PRESSURE DROP, TOT VELOCITY, CALC & M	& ALLOWED PSI AX ALLOWED FT/	.03 'S .39	10.00	.01	10.00
FOULING RESISTANCE				22	00010
TOTAL HEAT DUTY RE EFF TEMP DIF, DEGF OVERALL COEFF REQU CLEAN & FOULED COE	(LMTD= 33.2,E	IR r= .75,BYP <i>I</i>	ASS= .94,BA	FF=1.00)	.016266 23.3 97.65 97.74
SHELLS IN SERIES PASSES, SHELL SHELL DIAMETER IN.	1 PARALLEL 1 1 TUBE 4 3.820	TOTAL EFF EFFECTIVE TEMA SHEI	F AREA E AREA LL TYPE E	FT2 FT2/SHELL ; REAR HE	7.1 7.1 EAD FXTS
BAFFLE TYPE H SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING D	IN. 4.309 IN. 4.309 IN. 4.309 IN. 125	BAFFLE CUCUT DISTA	JT, PCT SHE ANCE FROM C ENT BAFFLE	LL I.D. ENTER, IN. INCLUDED	30.00 .764 NO
TUBE TYPE  NO. OF TUBES/SHELL  TUBE LGTH, OVERALL  TUBE LGTH, EFF  TUBE LAYOUT  PITCH RATIO  SHL NOZZ ID, IN&OU	FT 1.500 FT 1.436 DEG 60 1.250	TUBE PITO TUBE OUTS TUBE INSI	CH SIDE DIAM IDE DIAM FACE RATIO,	IN. IN. IN. OUT/IN	36 .3125 .250 .214 1.184
* CALCULATED ITE Washington Unive Young model F302DY	rsity ChE433 he		ger experim	ent	E0002 P 57 9/23/ 3 CASE 28
S U P P L E	M E N T A	R Y F	R E S U	L T S	J1101 20
HT PARAMETERS WALL CORRECTION PRANDTL NUMBER RYNLD NO, AVG RYNLD NO, IN BUN RYNLD NO, OUT BUN		NOMINAI NOMINAI CROSSFI	SIDE PERFO VEL,X-FLO VEL,WINDO LOW COEF	W FT/S W FT/S BTU/HR-FT2-	.07 .13 -F 230.2 -F 231.8

	cne433b(70).00T	
FOULNG LAYER IN0014 .0014	SHELLSIDE FLOW, % OF T	OTAL
	HEAT TRANSFER X-FLOW	81.45
THERMAL RESISTANCE, % OF TOTAL	TUBE TO BAFFLE LEAKAGE	A = 3.37
SHELL TUBE FOULING METAL	MAIN CROSSFLOW	B = 66.04
42.13 55.68 2.12 .07	BUNDLE TO SHELL BYPASS	C = 14.73
PCT OVER DESIGN .08	BAFFLE TO SHELL LEAKAGE	E = 15.87
PCT OVER DESIGN .08 TOT FOUL RESIST .000217	TUBE PASSLANE BYPASS	F = .00
DIFF RESIST .000009		
	SHELLSIDE HEAT TRANSFE	R FACTORS
DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000 TUBE TO BAFFLE HOLE IN0284	TOTAL = (BETA) (GAMMA) (FIN	) = .658
BUNDLE TO SHELL IN5000	BETA (BAFF CUT FACTOR)	= .920
TUBE TO BAFFLE HOLE IN0284	GAMMA (TUBE ROW ENTRY EF	
BAFFLE TO SHELL IN1000		
SHELL NOZZLE DATA IN OUT	SHELL PRESSURE DROP. %	OF TOTAL = 8.9 = 4.2 = 3.7 = 42.4 = 40.9
	WINDOW	= 8.9
HT UNDR NOZ IN25 HT OPP NOZ IN25	END ZONE	= 4 2
VELOCITY FT/S .41 .41	CROSS FLOW	= 3.7
DENSITY LB/FT3 62.252 61.857	INLET NOZZLE	= 42 4
NOZZ RHO*VSQ LB/FT-S2 10 10	OUTLET NOZZLE	= 40 9
BUND RHO*VSQ LB/FT-S2 7 7	OOTHET NOZZHE	- 40.5
DOND KHO VSQ LD/F1 S2 / /		
TIDE NOTTE DATA IN OUT		
TUBE NOZZLE DATA IN OUT VELOCITY FT/S .59 .59	DDV	= 150.
DENSITY LB/FT3 61.291 61.902	MET	= 150. = 165.
PRESS. DROP % 7.4 4.6	MEI	- 105.
Washington University ChE433 heat	· ouchangen ourseniment	E0002 P 58
	exchanger experiment	9/23/ 3
Young model F302DY4P		
CIZE / 10 MVDE DEM MILIMI DACC EL	W CECMENIAL DARRIEC DAM	CASE 29
SIZE 4- 18 TYPE BEM, MULTI-PASS FLO		ING
	HOT TUBE SIDE COL	ING D SHELL SIDE
	HOT TUBE SIDE COL	ING D SHELL SIDE
	HOT TUBE SIDE COL	ING D SHELL SIDE
TOTAL FLOW RATE KLB/HR	HOT TUBE SIDE COL	ING D SHELL SIDE
TOTAL FLOW RATE KLB/HR	HOT TUBE SIDE COL	ING D SHELL SIDE
TOTAL FLOW RATE KLB/HR	HOT TUBE SIDE COL	ING D SHELL SIDE
TOTAL FLOW RATE KLB/HR  TEMPERATURE DEGF DENSITY LB/FT3	HOT TUBE SIDE COL Tube S SENSIBLE LIQ S .400 IN OUT I 140.0 96.4* 70 51.2913 61.9384 62.25	ING D SHELL SIDE hell ENSIBLE LIQ .600 N OUT .0 99.0* 15 61.9049
TOTAL FLOW RATE KLB/HR  TEMPERATURE DEGF DENSITY LB/FT3 VISCOSITY CP	HOT TUBE SIDE COL Tube S SENSIBLE LIQ S .400 IN OUT I 140.0 96.4* 70 51.2913 61.9384 62.25 .4726 .7188 .97	ING D SHELL SIDE hell ENSIBLE LIQ .600 N OUT .0 99.0* 15 61.9049 83 .6993
TOTAL FLOW RATE KLB/HR  TEMPERATURE DEGF DENSITY LB/FT3 VISCOSITY CP SPECIFIC HEAT BTU/LB-F	HOT TUBE SIDE COL Tube S SENSIBLE LIQ S .400 IN OUT I 140.0 96.4* 70 51.2913 61.9384 62.25 .4726 .7188 .97 .9973 .9989 1.00	ING D SHELL SIDE hell ENSIBLE LIQ .600 N OUT .0 99.0* 15 61.9049 83 .6993 15 .9987
TOTAL FLOW RATE KLB/HR  TEMPERATURE DEGF DENSITY LB/FT3 CP SPECIFIC HEAT BTU/LB-F THERMAL COND. BTU/HR-FT-F	HOT TUBE SIDE COL Tube S SENSIBLE LIQ S .400 IN OUT I 140.0 96.4* 70 51.2913 61.9384 62.25 .4726 .7188 .97 .9973 .9989 1.00 .3723 .3624 .35	ING D SHELL SIDE hell ENSIBLE LIQ .600 N OUT .0 99.0* 15 61.9049 83 .6993 15 .9987 54 .3630
TOTAL FLOW RATE KLB/HR  TEMPERATURE DEGF DENSITY LB/FT3 VISCOSITY CP SPECIFIC HEAT BTU/LB-F	HOT TUBE SIDE COL Tube S SENSIBLE LIQ S .400 IN OUT I 140.0 96.4* 70 51.2913 61.9384 62.25 .4726 .7188 .97 .9973 .9989 1.00 .3723 .3624 .35	ING D SHELL SIDE hell ENSIBLE LIQ .600 N OUT .0 99.0* 15 61.9049 83 .6993 15 .9987 54 .3630 18.02
TOTAL FLOW RATE KLB/HR  TEMPERATURE DEGF DENSITY LB/FT3 VISCOSITY CP SPECIFIC HEAT BTU/LB-F THERMAL COND. BTU/HR-FT-F MOLAR MASS LB/LBMOL	HOT TUBE SIDE COL Tube SI SENSIBLE LIQ SI .400 IN OUT II 140.0 96.4* 70 51.2913 61.9384 62.25 .4726 .7188 .97 .9973 .9989 1.00 .3723 .3624 .35 18.02	ING D SHELL SIDE hell ENSIBLE LIQ .600 N OUT .0 99.0* 15 61.9049 83 .6993 15 .9987 54 .3630 18.02
TOTAL FLOW RATE KLB/HR  TEMPERATURE DEGF DENSITY LB/FT3 VISCOSITY CP SPECIFIC HEAT BTU/LB-F THERMAL COND. BTU/HR-FT-F MOLAR MASS LB/LBMOL  TEMP, AVG & SKIN DEGF	HOT TUBE SIDE COL Tube S: SENSIBLE LIQ S: .400 IN OUT I: 140.0 96.4* 70 51.2913 61.9384 62.25 .4726 .7188 .97 .9973 .9989 1.00 .3723 .3624 .35 18.02	ING D SHELL SIDE hell ENSIBLE LIQ .600 N OUT .0 99.0* 15 61.9049 83 .6993 15 .9987 54 .3630 18.02
TOTAL FLOW RATE KLB/HR  TEMPERATURE DEGF DENSITY LB/FT3 VISCOSITY CP SPECIFIC HEAT BTU/LB-F THERMAL COND. BTU/HR-FT-F MOLAR MASS LB/LBMOL  TEMP, AVG & SKIN DEGF VISCOSITY, AVG & SKIN CP	HOT TUBE SIDE COL Tube S SENSIBLE LIQ S .400 IN OUT I 140.0 96.4* 70 51.2913 61.9384 62.25 .4726 .7188 .97 .9973 .9989 1.00 .3723 .3624 .35 18.02	ING D SHELL SIDE hell ENSIBLE LIQ .600 N OUT .0 99.0* 15 61.9049 83 .6993 15 .9987 54 .3630 18.025 97.8 14 .7086
TOTAL FLOW RATE KLB/HR  TEMPERATURE DEGF DENSITY LB/FT3 VISCOSITY CP SPECIFIC HEAT BTU/LB-F THERMAL COND. BTU/HR-FT-F MOLAR MASS LB/LBMOL  TEMP, AVG & SKIN DEGF	HOT TUBE SIDE COL Tube S SENSIBLE LIQ S .400 IN OUT I 140.0 96.4* 70 51.2913 61.9384 62.25 .4726 .7188 .97 .9973 .9989 1.00 .3723 .3624 .35 18.02	ING D SHELL SIDE hell ENSIBLE LIQ .600 N OUT .0 99.0* 15 61.9049 83 .6993 15 .9987 54 .3630 18.025 97.8 14 .7086
TOTAL FLOW RATE KLB/HR  TEMPERATURE DEGF DENSITY LB/FT3 VISCOSITY CP SPECIFIC HEAT BTU/LB-F THERMAL COND. BTU/HR-FT-F MOLAR MASS LB/LBMOL  TEMP, AVG & SKIN DEGF VISCOSITY, AVG & SKIN CP PRESSURE, IN & DESIGN PSIA	HOT TUBE SIDE COL Tube SI SENSIBLE LIQ SI .400 IN OUT II 140.0 96.4* 70 51.2913 61.9384 62.25 .4726 .7188 .97 .9973 .9989 1.00 .3723 .3624 .35 18.02	ING D SHELL SIDE hell ENSIBLE LIQ .600 N OUT .0 99.0* 15 61.9049 83 .6993 15 .9987 54 .3630 18.025 97.8 14 .7086 00 165.00
TOTAL FLOW RATE KLB/HR  TEMPERATURE DEGF DENSITY LB/FT3 6 VISCOSITY CP SPECIFIC HEAT BTU/LB-F THERMAL COND. BTU/HR-FT-F MOLAR MASS LB/LBMOL  TEMP, AVG & SKIN DEGF VISCOSITY, AVG & SKIN CP PRESSURE, IN & DESIGN PSIA  PRESSURE DROP, TOT & ALLOWED PSI	HOT TUBE SIDE COL Tube SI SENSIBLE LIQ SI .400 IN OUT II 140.0 96.4* 70 51.2913 61.9384 62.25 .4726 .7188 .97 .9973 .9989 1.00 .3723 .3624 .35 18.02	ING D SHELL SIDE hell ENSIBLE LIQ .600 N OUT .0 99.0* 15 61.9049 83 .6993 15 .9987 54 .3630 18.025 97.8 14 .7086 00 165.00
TOTAL FLOW RATE KLB/HR  TEMPERATURE DEGF DENSITY LB/FT3 VISCOSITY CP SPECIFIC HEAT BTU/LB-F THERMAL COND. BTU/HR-FT-F MOLAR MASS LB/LBMOL  TEMP, AVG & SKIN DEGF VISCOSITY, AVG & SKIN CP PRESSURE, IN & DESIGN PSIA	HOT TUBE SIDE COL Tube SI SENSIBLE LIQ SI .400 IN OUT II 140.0 96.4* 70 51.2913 61.9384 62.25 .4726 .7188 .97 .9973 .9989 1.00 .3723 .3624 .35 18.02	ING D SHELL SIDE hell ENSIBLE LIQ .600 N OUT .0 99.0* 15 61.9049 83 .6993 15 .9987 54 .3630 18.025 97.8 14 .7086 00 165.00
TOTAL FLOW RATE KLB/HR  TEMPERATURE DEGF DENSITY LB/FT3 CP SPECIFIC HEAT BTU/LB-F THERMAL COND. BTU/HR-FT-F MOLAR MASS LB/LBMOL  TEMP, AVG & SKIN DEGF VISCOSITY, AVG & SKIN CP PRESSURE, IN & DESIGN PSIA  PRESSURE DROP, TOT & ALLOWED PSI VELOCITY, CALC & MAX ALLOWED FT/S	HOT TUBE SIDE COL Tube SENSIBLE LIQ SENSIBLE	ING D SHELL SIDE hell ENSIBLE LIQ .600 N OUT .0 99.0* 15 61.9049 83 .6993 15 .9987 54 .3630 18.025 97.8 14 .7086 00 165.00  01 10.00 09 10.00
TOTAL FLOW RATE KLB/HR  TEMPERATURE DEGF DENSITY LB/FT3 CP SPECIFIC HEAT BTU/LB-F THERMAL COND. BTU/HR-FT-F MOLAR MASS LB/LBMOL  TEMP, AVG & SKIN DEGF VISCOSITY, AVG & SKIN CP PRESSURE, IN & DESIGN PSIA  PRESSURE DROP, TOT & ALLOWED PSI VELOCITY, CALC & MAX ALLOWED FT/S  FOULING RESISTANCE HR-FT2-F/BTU	HOT TUBE SIDE COL Tube SENSIBLE LIQ SENSIBLE	ING D SHELL SIDE hell ENSIBLE LIQ .600 N OUT .0 99.0* 15 61.9049 83 .6993 15 .9987 54 .3630 18.025 97.8 14 .7086 00 165.00  01 10.00 09 10.00
TOTAL FLOW RATE KLB/HR  TEMPERATURE DEGF DENSITY LB/FT3 6 VISCOSITY CP SPECIFIC HEAT BTU/LB-F THERMAL COND. BTU/HR-FT-F MOLAR MASS LB/LBMOL  TEMP, AVG & SKIN DEGF VISCOSITY, AVG & SKIN CP PRESSURE, IN & DESIGN PSIA  PRESSURE DROP, TOT & ALLOWED PSI VELOCITY, CALC & MAX ALLOWED FT/S  FOULING RESISTANCE HR-FT2-F/BTU FILM COEFFICIENT BTU/HR-FT2-F	HOT TUBE SIDE COL Tube SENSIBLE LIQ SENSIBLE	ING D SHELL SIDE hell ENSIBLE LIQ .600 N OUT .0 99.0* 15 61.9049 83 .6993 15 .9987 54 .3630 18.025 97.8 14 .7086 00 165.00  01 10.00 09 10.00
TOTAL FLOW RATE KLB/HR  TEMPERATURE DEGF DENSITY LB/FT3 6 VISCOSITY CP SPECIFIC HEAT BTU/LB-F THERMAL COND. BTU/HR-FT-F MOLAR MASS LB/LBMOL  TEMP, AVG & SKIN DEGF VISCOSITY, AVG & SKIN CP PRESSURE, IN & DESIGN PSIA  PRESSURE DROP, TOT & ALLOWED PSI VELOCITY, CALC & MAX ALLOWED FT/S  FOULING RESISTANCE HR-FT2-F/BTU FILM COEFFICIENT BTU/HR-FT2-F	HOT TUBE SIDE COL Tube SENSIBLE LIQ SENSIBLE	ING D SHELL SIDE hell ENSIBLE LIQ .600 N OUT .0 99.0* 15 61.9049 83 .6993 15 .9987 54 .3630 18.025 97.8 14 .7086 00 165.00  01 10.00 09 10.00 .00010 258.10
TOTAL FLOW RATE KLB/HR  TEMPERATURE DEGF DENSITY LB/FT3 6 VISCOSITY CP SPECIFIC HEAT BTU/LB-F THERMAL COND. BTU/HR-FT-F MOLAR MASS LB/LBMOL  TEMP, AVG & SKIN DEGF VISCOSITY, AVG & SKIN CP PRESSURE, IN & DESIGN PSIA  PRESSURE DROP, TOT & ALLOWED PSI VELOCITY, CALC & MAX ALLOWED FT/S  FOULING RESISTANCE HR-FT2-F/BTU FILM COEFFICIENT BTU/HR-FT2-F	HOT TUBE SIDE COL Tube SENSIBLE LIQ SENSIBLE	ING D SHELL SIDE hell ENSIBLE LIQ .600 N OUT .0 99.0* 15 61.9049 83 .6993 15 .9987 54 .3630 18.025 97.8 14 .7086 00 165.00  01 10.00 09 10.00

	che433b(70).OUT
EFF TEMP DIF, DEGF (LMTD= 33.2,F=	= .76,BYPASS= .94,BAFF=1.00) 23.8
OVERALL COEFF REQUIRED BTU/HR-F'	Γ2-F 102.45
CLEAN & FOULED COEFF BTU/HR-F'	r2-F 105.33 102.64
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, IN764
SPACING, OUTLET IN. 4.309	
BAFFLE THICKNESS IN125	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 LGTH, EFF FT 1.436	TUBE OUTSIDE DIAM IN250
TUBE LAYOUT DEG 60	TUBE INSIDE DIAM IN214
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 IN8 .8
* CALCULATED ITEMHEAT BALANCE	CODE = 8
Washington University ChE433 he	at exchanger experiment E0002 P 59
Young model F302DY4P	9/23/ 3
roung moder rough in	CASE 29
	CASE 27
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
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.021 .000	SHELLSIDE PERFORMANCE NOMINAL VEL, X-FLOW FT/S .08
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.021 .000 PRANDTL NUMBER 5.5 3.8	SHELLSIDE PERFORMANCE NOMINAL VEL,X-FLOW FT/S .08 NOMINAL VEL,WINDOW FT/S .15
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.021 .000	SHELLSIDE PERFORMANCE NOMINAL VEL,X-FLOW FT/S .08 NOMINAL VEL,WINDOW FT/S .15
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.021 .000 PRANDTL NUMBER 5.5 3.8	SHELLSIDE PERFORMANCE  NOMINAL VEL, X-FLOW FT/S .08  NOMINAL VEL, WINDOW FT/S .15  CROSSFLOW COEF BTU/HR-FT2-F 259.1
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.021 .000 PRANDTL NUMBER 5.5 3.8 RYNLD NO, AVG 275. 1095. RYNLD NO, IN BUN 231. 1334.	SHELLSIDE PERFORMANCE  NOMINAL VEL, X-FLOW FT/S .08  NOMINAL VEL, WINDOW FT/S .15  CROSSFLOW COEF BTU/HR-FT2-F 259.1
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.021 .000 PRANDTL NUMBER 5.5 3.8 RYNLD NO, AVG 275. 1095. RYNLD NO, IN BUN 231. 1334. RYNLD NO,OUT BUN 323. 877.	SHELLSIDE PERFORMANCE  NOMINAL VEL,X-FLOW FT/S .08  NOMINAL VEL,WINDOW FT/S .15  CROSSFLOW COEF BTU/HR-FT2-F 259.1  WINDOW COEF BTU/HR-FT2-F 260.8
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.021 .000 PRANDTL NUMBER 5.5 3.8 RYNLD NO, AVG 275. 1095. RYNLD NO, IN BUN 231. 1334. RYNLD NO,OUT BUN 323. 877.	SHELLSIDE PERFORMANCE  NOMINAL VEL,X-FLOW FT/S .08  NOMINAL VEL,WINDOW FT/S .15  CROSSFLOW COEF BTU/HR-FT2-F 259.1  WINDOW COEF BTU/HR-FT2-F 260.8  SHELLSIDE FLOW, % OF TOTAL
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.021 .000 PRANDTL NUMBER 5.5 3.8 RYNLD NO, AVG 275. 1095. RYNLD NO, IN BUN 231. 1334. RYNLD NO,OUT BUN 323. 877. FOULNG LAYER IN0014 .0014	SHELLSIDE PERFORMANCE  NOMINAL VEL,X-FLOW FT/S .08  NOMINAL VEL,WINDOW FT/S .15  CROSSFLOW COEF BTU/HR-FT2-F 259.1  WINDOW COEF BTU/HR-FT2-F 260.8  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81.46
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.021 .000 PRANDTL NUMBER 5.5 3.8 RYNLD NO, AVG 275. 1095. RYNLD NO, IN BUN 231. 1334. RYNLD NO,OUT BUN 323. 877. FOULNG LAYER IN0014 .0014 THERMAL RESISTANCE, % OF TOTAL	SHELLSIDE PERFORMANCE  NOMINAL VEL, X-FLOW FT/S .08  NOMINAL VEL, WINDOW FT/S .15  CROSSFLOW COEF BTU/HR-FT2-F 259.1  WINDOW COEF BTU/HR-FT2-F 260.8  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81.46  TUBE TO BAFFLE LEAKAGE A = 3.57
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.021 .000 PRANDTL NUMBER 5.5 3.8 RYNLD NO, AVG 275. 1095. RYNLD NO, IN BUN 231. 1334. RYNLD NO,OUT BUN 323. 877. FOULNG LAYER IN0014 .0014 THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL	SHELLSIDE PERFORMANCE  NOMINAL VEL, X-FLOW FT/S .08  NOMINAL VEL, WINDOW FT/S .15  CROSSFLOW COEF BTU/HR-FT2-F 259.1  WINDOW COEF BTU/HR-FT2-F 260.8  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81.46  TUBE TO BAFFLE LEAKAGE A = 3.57  MAIN CROSSFLOW B = 65.24
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.021 .000 PRANDTL NUMBER 5.5 3.8 RYNLD NO, AVG 275. 1095. RYNLD NO, IN BUN 231. 1334. RYNLD NO,OUT BUN 323. 877. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 39.32 58.38 2.23 .07	SHELLSIDE PERFORMANCE  NOMINAL VEL, X-FLOW FT/S .08  NOMINAL VEL, WINDOW FT/S .15  CROSSFLOW COEF BTU/HR-FT2-F 259.1  WINDOW COEF BTU/HR-FT2-F 260.8  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81.46  TUBE TO BAFFLE LEAKAGE A = 3.57  MAIN CROSSFLOW B = 65.24  BUNDLE TO SHELL BYPASS C = 15.50
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.021 .000 PRANDTL NUMBER 5.5 3.8 RYNLD NO, AVG 275. 1095. RYNLD NO, IN BUN 231. 1334. RYNLD NO,OUT BUN 323. 877. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 39.32 58.38 2.23 .07	SHELLSIDE PERFORMANCE  NOMINAL VEL, X-FLOW FT/S .08  NOMINAL VEL, WINDOW FT/S .15  CROSSFLOW COEF BTU/HR-FT2-F 259.1  WINDOW COEF BTU/HR-FT2-F 260.8  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81.46  TUBE TO BAFFLE LEAKAGE A = 3.57  MAIN CROSSFLOW B = 65.24  BUNDLE TO SHELL BYPASS C = 15.50
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.021 .000 PRANDTL NUMBER 5.5 3.8 RYNLD NO, AVG 275. 1095. RYNLD NO, IN BUN 231. 1334. RYNLD NO,OUT BUN 323. 877. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 39.32 58.38 2.23 .07 PCT OVER DESIGN .19 TOT FOUL RESIST .000217	SHELLSIDE PERFORMANCE  NOMINAL VEL, X-FLOW FT/S .08  NOMINAL VEL, WINDOW FT/S .15  CROSSFLOW COEF BTU/HR-FT2-F 259.1  WINDOW COEF BTU/HR-FT2-F 260.8  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81.46  TUBE TO BAFFLE LEAKAGE A = 3.57  MAIN CROSSFLOW B = 65.24  BUNDLE TO SHELL BYPASS C = 15.50  BAFFLE TO SHELL LEAKAGE E = 15.70  TUBE PASSLANE BYPASS F = .00
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.021 .000 PRANDTL NUMBER 5.5 3.8 RYNLD NO, AVG 275. 1095. RYNLD NO, IN BUN 231. 1334. RYNLD NO,OUT BUN 323. 877. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 39.32 58.38 2.23 .07	SHELLSIDE PERFORMANCE  NOMINAL VEL, X-FLOW FT/S .08  NOMINAL VEL, WINDOW FT/S .15  CROSSFLOW COEF BTU/HR-FT2-F 259.1  WINDOW COEF BTU/HR-FT2-F 260.8  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81.46  TUBE TO BAFFLE LEAKAGE A = 3.57  MAIN CROSSFLOW B = 65.24  BUNDLE TO SHELL BYPASS C = 15.50  BAFFLE TO SHELL LEAKAGE E = 15.70  TUBE PASSLANE BYPASS F = .00
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.021 .000 PRANDTL NUMBER 5.5 3.8 RYNLD NO, AVG 275. 1095. RYNLD NO, IN BUN 231. 1334. RYNLD NO,OUT BUN 323. 877. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 39.32 58.38 2.23 .07 PCT OVER DESIGN .19 TOT FOUL RESIST .000217	SHELLSIDE PERFORMANCE  NOMINAL VEL, X-FLOW FT/S .08  NOMINAL VEL, WINDOW FT/S .15  CROSSFLOW COEF BTU/HR-FT2-F 259.1  WINDOW COEF BTU/HR-FT2-F 260.8  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81.46  TUBE TO BAFFLE LEAKAGE A = 3.57  MAIN CROSSFLOW B = 65.24  BUNDLE TO SHELL BYPASS C = 15.50  BAFFLE TO SHELL LEAKAGE E = 15.70  TUBE PASSLANE BYPASS F = .00
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.021 .000 PRANDTL NUMBER 5.5 3.8 RYNLD NO, AVG 275. 1095. RYNLD NO, IN BUN 231. 1334. RYNLD NO,OUT BUN 323. 877. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 39.32 58.38 2.23 .07 PCT OVER DESIGN .19 TOT FOUL RESIST .000217 DIFF RESIST .000018	SHELLSIDE PERFORMANCE  NOMINAL VEL, X-FLOW FT/S .08  NOMINAL VEL, WINDOW FT/S .15  CROSSFLOW COEF BTU/HR-FT2-F 259.1  WINDOW COEF BTU/HR-FT2-F 260.8  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81.46  TUBE TO BAFFLE LEAKAGE A = 3.57  MAIN CROSSFLOW B = 65.24  BUNDLE TO SHELL BYPASS C = 15.50  BAFFLE TO SHELL LEAKAGE E = 15.70  TUBE PASSLANE BYPASS F = .00
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.021 .000 PRANDTL NUMBER 5.5 3.8 RYNLD NO, AVG 275. 1095. RYNLD NO, IN BUN 231. 1334. RYNLD NO,OUT BUN 323. 877. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 39.32 58.38 2.23 .07 PCT OVER DESIGN .19 TOT FOUL RESIST .000217 DIFF RESIST .000018	SHELLSIDE PERFORMANCE  NOMINAL VEL, X-FLOW FT/S .08  NOMINAL VEL, WINDOW FT/S .15  CROSSFLOW COEF BTU/HR-FT2-F 259.1  WINDOW COEF BTU/HR-FT2-F 260.8  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81.46  TUBE TO BAFFLE LEAKAGE A = 3.57  MAIN CROSSFLOW B = 65.24  BUNDLE TO SHELL BYPASS C = 15.50  BAFFLE TO SHELL LEAKAGE E = 15.70  TUBE PASSLANE BYPASS F = .00  SHELLSIDE HEAT TRANSFER FACTORS  TOTAL = (BETA) (GAMMA) (FIN) = .680
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.021 .000 PRANDTL NUMBER 5.5 3.8 RYNLD NO, AVG 275. 1095. RYNLD NO, IN BUN 231. 1334. RYNLD NO,OUT BUN 323. 877. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 39.32 58.38 2.23 .07 PCT OVER DESIGN .19 TOT FOUL RESIST .000217 DIFF RESIST .000018  DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000	SHELLSIDE PERFORMANCE  NOMINAL VEL, X-FLOW FT/S .08  NOMINAL VEL, WINDOW FT/S .15  CROSSFLOW COEF BTU/HR-FT2-F 259.1  WINDOW COEF BTU/HR-FT2-F 260.8  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81.46  TUBE TO BAFFLE LEAKAGE A = 3.57  MAIN CROSSFLOW B = 65.24  BUNDLE TO SHELL BYPASS C = 15.50  BAFFLE TO SHELL LEAKAGE E = 15.70  TUBE PASSLANE BYPASS F = .00  SHELLSIDE HEAT TRANSFER FACTORS  TOTAL = (BETA) (GAMMA) (FIN) = .680  BETA (BAFF CUT FACTOR) = .920
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.021 .000 PRANDTL NUMBER 5.5 3.8 RYNLD NO, AVG 275. 1095. RYNLD NO, IN BUN 231. 1334. RYNLD NO,OUT BUN 323. 877. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 39.32 58.38 2.23 .07 PCT OVER DESIGN .19 TOT FOUL RESIST .000217 DIFF RESIST .000018  DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000 TUBE TO BAFFLE HOLE IN0284	SHELLSIDE PERFORMANCE  NOMINAL VEL, X-FLOW FT/S .08  NOMINAL VEL, WINDOW FT/S .15  CROSSFLOW COEF BTU/HR-FT2-F 259.1  WINDOW COEF BTU/HR-FT2-F 260.8  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81.46  TUBE TO BAFFLE LEAKAGE A = 3.57  MAIN CROSSFLOW B = 65.24  BUNDLE TO SHELL BYPASS C = 15.50  BAFFLE TO SHELL LEAKAGE E = 15.70  TUBE PASSLANE BYPASS F = .00  SHELLSIDE HEAT TRANSFER FACTORS  TOTAL = (BETA) (GAMMA) (FIN) = .680  BETA (BAFF CUT FACTOR) = .920  GAMMA (TUBE ROW ENTRY EFCT) = .740
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.021 .000 PRANDTL NUMBER 5.5 3.8 RYNLD NO, AVG 275. 1095. RYNLD NO, IN BUN 231. 1334. RYNLD NO,OUT BUN 323. 877. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 39.32 58.38 2.23 .07 PCT OVER DESIGN .19 TOT FOUL RESIST .000217 DIFF RESIST .000018  DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000 TUBE TO BAFFLE HOLE IN0284	SHELLSIDE PERFORMANCE  NOMINAL VEL, X-FLOW FT/S .08  NOMINAL VEL, WINDOW FT/S .15  CROSSFLOW COEF BTU/HR-FT2-F 259.1  WINDOW COEF BTU/HR-FT2-F 260.8  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81.46  TUBE TO BAFFLE LEAKAGE A = 3.57  MAIN CROSSFLOW B = 65.24  BUNDLE TO SHELL BYPASS C = 15.50  BAFFLE TO SHELL LEAKAGE E = 15.70  TUBE PASSLANE BYPASS F = .00  SHELLSIDE HEAT TRANSFER FACTORS  TOTAL = (BETA) (GAMMA) (FIN) = .680  BETA (BAFF CUT FACTOR) = .920
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HT PARAMETERS SHELL TUBE WALL CORRECTION 1.021 .000 PRANDTL NUMBER 5.5 3.8 RYNLD NO, AVG 275. 1095. RYNLD NO, IN BUN 231. 1334. RYNLD NO,OUT BUN 323. 877. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 39.32 58.38 2.23 .07 PCT OVER DESIGN .19 TOT FOUL RESIST .000217 DIFF RESIST .000018  DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000 TUBE TO BAFFLE HOLE IN0284 BAFFLE TO SHELL IN1000	SHELLSIDE PERFORMANCE  NOMINAL VEL, X-FLOW FT/S .08  NOMINAL VEL, WINDOW FT/S .15  CROSSFLOW COEF BTU/HR-FT2-F 259.1  WINDOW COEF BTU/HR-FT2-F 260.8  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81.46  TUBE TO BAFFLE LEAKAGE A = 3.57  MAIN CROSSFLOW B = 65.24  BUNDLE TO SHELL BYPASS C = 15.50  BAFFLE TO SHELL LEAKAGE E = 15.70  TUBE PASSLANE BYPASS F = .00  SHELLSIDE HEAT TRANSFER FACTORS  TOTAL = (BETA) (GAMMA) (FIN) = .680  BETA (BAFF CUT FACTOR) = .920  GAMMA (TUBE ROW ENTRY EFCT) = .740  END (HT LOSS IN END ZONE) = .994
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HT PARAMETERS SHELL TUBE WALL CORRECTION 1.021 .000 PRANDTL NUMBER 5.5 3.8 RYNLD NO, AVG 275. 1095. RYNLD NO, IN BUN 231. 1334. RYNLD NO,OUT BUN 323. 877. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 39.32 58.38 2.23 .07 PCT OVER DESIGN .19 TOT FOUL RESIST .000217 DIFF RESIST .000018  DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000 TUBE TO BAFFLE HOLE IN0284 BAFFLE TO SHELL IN1000	SHELLSIDE PERFORMANCE  NOMINAL VEL, X-FLOW FT/S .08  NOMINAL VEL, WINDOW FT/S .15  CROSSFLOW COEF BTU/HR-FT2-F 259.1  WINDOW COEF BTU/HR-FT2-F 260.8  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81.46  TUBE TO BAFFLE LEAKAGE A = 3.57  MAIN CROSSFLOW B = 65.24  BUNDLE TO SHELL BYPASS C = 15.50  BAFFLE TO SHELL LEAKAGE E = 15.70  TUBE PASSLANE BYPASS F = .00  SHELLSIDE HEAT TRANSFER FACTORS  TOTAL = (BETA) (GAMMA) (FIN) = .680  BETA (BAFF CUT FACTOR) = .920  GAMMA (TUBE ROW ENTRY EFCT) = .740  END (HT LOSS IN END ZONE) = .994  SHELL PRESSURE DROP, % OF TOTAL  WINDOW = 8.9
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.021 .000 PRANDTL NUMBER 5.5 3.8 RYNLD NO, AVG 275. 1095. RYNLD NO, IN BUN 231. 1334. RYNLD NO,OUT BUN 323. 877. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 39.32 58.38 2.23 .07 PCT OVER DESIGN .19 TOT FOUL RESIST .000217 DIFF RESIST .000018  DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000 TUBE TO BAFFLE HOLE IN0284 BAFFLE TO SHELL IN1000  SHELL NOZZLE DATA IN OUT HT UNDR NOZ IN25	SHELLSIDE PERFORMANCE  NOMINAL VEL, X-FLOW FT/S .08  NOMINAL VEL, WINDOW FT/S .15  CROSSFLOW COEF BTU/HR-FT2-F 259.1  WINDOW COEF BTU/HR-FT2-F 260.8  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81.46  TUBE TO BAFFLE LEAKAGE A = 3.57  MAIN CROSSFLOW B = 65.24  BUNDLE TO SHELL BYPASS C = 15.50  BAFFLE TO SHELL LEAKAGE E = 15.70  TUBE PASSLANE BYPASS F = .00  SHELLSIDE HEAT TRANSFER FACTORS  TOTAL = (BETA) (GAMMA) (FIN) = .680  BETA (BAFF CUT FACTOR) = .920  GAMMA (TUBE ROW ENTRY EFCT) = .740  END (HT LOSS IN END ZONE) = .994  SHELL PRESSURE DROP, % OF TOTAL  WINDOW = 8.9  END ZONE = 3.9

		che433b(	/0).OUT		
DENSITY LB/FT3	62.252 61.905	INLET N	OZZLE		= 42.5
NOZZ RHO*VSQ LB/FT	-S2 14 15	OUTLET	NOZZLE		= 41.3
BUND RHO*VSQ LB/FT					
BOND KHO VSQ LB/FI	-32 10 10				
TUBE NOZZLE DATA					
VELOCITY FT/S	.59 .58	DRY		=	150.
DENSITY LB/FT3				=	
PRESS. DROP %					100.
Washington Unive	_	at exchang	er experime	ent	
Young model F302DY	4 P				9/23/ 3
					CASE 30
SIZE 4- 18 TYPE BE	M. MIII.TT-PASS F	TOW SEGME	NTAL BAFFLE	S RATING	
	11, 110111 11100 1				
			BE SIDE		
		Tube		Shell	L
		SENSI	BLE LIQ	SENSI	IBLE LIQ
TOTAL FLOW RATE	KLB/HR		.400		.700
	,	TN	OUT	TM	
	5565				
TEMPERATURE					
DENSITY	LB/FT3	61.2913	61.9687	62.2515	61.9415
VISCOSITY	CP	.4726	.7374	.9783	.7206
SPECIFIC HEAT					
THERMAL COND.					
		. 3 / 2 3			
MOLAR MASS	TB/TBMOT		18.02		18.02
TEMP, AVG & SKIN	DEGF	117.0	96.4	83.1	95.6
VISCOSITY, AVG & S	KIN CP	.5823	.7189	.8348	.7253
PRESSURE, IN & DES			165.00		
TRESSORE, IN & DES	IGN IDIA	30.00	103.00	30.00	103.00
PRESSURE DROP, TOT					
VELOCITY, CALC & M	AX ALLOWED FT/	s .39	10.00	.11	10.00
FOULING RESISTANCE	HR-FT2-F/B	TU .O	0010	. (	00010
FILM COEFFICIENT					36.88
TIDA CODITICIDAT					70.00
TOTAL HEAT DUTY RE					.018329
EFF TEMP DIF, DEGF	(LMTD = 33.0, F	= .77,BYPA	SS= .94,BAE	FF=1.00)	23.9
OVERALL COEFF REQU	IRED BTU/HR-F	T2-F			107.51
CLEAN & FOULED COE					
CLLIM & ICOLLD COL	II DIO/III I	12 1	103.03	,	100.92
QUELT Q 731 2	1 DADATTE 1	moma: ===	1 7 0 0 7	DE 0	<b>-</b> 4
SHELLS IN SERIES					
PASSES, SHELL	1 TUBE 4	EFFECTIVE	AREA	FT2/SHELL	7.1
SHELL DIAMETER IN.	3.820	TEMA SHEL	L TYPE E	; REAR HE	EAD FXTS
BAFFLE TYPE H	OD7 CECMENTET	CDOGG DAG	CEC DED CUE	TT DACC	Λ
SPACING, CENTRAL					
SPACING, INLET		CUT DISTA	NCE FROM CE	ENTER, IN.	.764
SPACING, OUTLET	IN. 4.309				
BAFFLE THICKNESS		IMPINGEME	NT BAFFIE I	NCLUDED	NO
PAIRS OF SEALING D					
TATES OF SEATING D	EVICEO I	TADESUEFT	DIAM AKER	2, 0	. 0
TUBE TYPE	PLAIN	MATERIAL	EI	LECTROLYTIC	COPPER
TUBE TYPE NO. OF TUBES/SHELL	76	EST MAX T	UBE COUNT		36
TUBE LGTH, OVERALL	FT 1.500	TUBE PITC	H	IN.	.3125
,					=

TUBE LGTH, EFF TUBE LAYOUT PITCH RATIO SHL NOZZ ID, IN&OUT	DEG 60 1.250	TU TU	JBE INSIDE I JBE SURFACE	DIAM RATIO, OU	IN. JT/IN		.214 1.184
* CALCULATED ITEM Washington Univer Young model F302DY	rsity ChE433 h			experiment		9/2	02 P 61 23/ 3 SE 30
S U P P L E M	M E N T A	R	Y R E	S U L	T S		
HT PARAMETERS WALL CORRECTION PRANDTL NUMBER RYNLD NO, AVG RYNLD NO, IN BUN RYNLD NO,OUT BUN	1.020 .000 5.6 3.8 315. 1083 269. 1334	3	NOMINAL VEI NOMINAL VEI CROSSFLOW ( WINDOW COEF	L,X-FLOW L,WINDOW COEF BTU F BTU	FT/S FT/S J/HR-FT2- J/HR-FT2-	-F 2	.18 288.0 289.8
FOULNG LAYER IN.	.0014 .0014	1	SHELLSIDE	E FLOW, %	OF TOTAL	L	
THERMAL RESISTANCE, SHELL TUBE FOUL 36.85 60.75 2. PCT OVER DESIGN TOT FOUL RESIST DIFF RESIST	% OF TOTAL LING METAL .32 .08 55	5	TUBE TO BAR MAIN CROSSE BUNDLE TO S BAFFLE TO S	FFLE LEAKA FLOW SHELL BYPA SHELL LEAK	AGE A B ASS C KAGE E	= = ( = :	3.74 64.89 15.79 15.57
			SHELLSIDE	E HEAT TRA	NSFER FA	ACTO	RS
DIAMETRAL CLEARAN BUNDLE TO SHELL	ICES		TOTAL = (BET	ra) (gamma)	(FIN)	=	.704
TUBE TO BAFFLE HOLE							
BAFFLE TO SHELL							
SHELL NOZZLE DATA	IO NT A	ΙT	SHELL PRE	ESSURE DRO	)P. % OF	тота	ΔΤ.
HT UNDR NOZ IN.	.25		WINDOW	2000112 2110	,	=	8.9
HT OPP NOZ IN.	.25		END ZONE			=	3.7
HT UNDR NOZ IN. HT OPP NOZ IN. VELOCITY FT/S DENSITY LB/FT3	.57 .5	58	CROSS FLOW			=	3.2
DENSITY LB/FT3	62.252 61.94	12	INLET NOZZI	LE		=	42.7
NOZZ RHO*VSQ LB/FT- BUND RHO*VSQ LB/FT-	22 20 2	20 L3	OUTLET NOZZ	ZLE		=	41.6
TUBE NOZZLE DATA				ER SHELL,	LB		
VELOCITY FT/S					=		150.
	61.291 61.96		WET		=		165.
PRESS. DROP %	7.2 4.					TO 0	00 D C0
Washington Univer Young model F302DY	-	leat	exchanger e	experiment		9/2	02 P 62 23/ 3 SE 31
SIZE 4- 18 TYPE BEN	1, MULTI-PASS	FLOW	HOT TUBE S Tube	SIDE	COLD SI Sheli	l	
TOTAL FLOW RATE	KLB/HR		SENSIBLE .400	LIQ )	SENS	.800	_
	,		IN	OUT	IN		OUT
TEMPERATURE	DEGF		140.0	92.3*	70.0		93.8*

		che433b(7	() OIIT		
DENSITY VISCOSITY SPECIFIC HEAT	T.B/FT3	61 2913	61 9911	62 2515	61 9723
VISCOSITY	CP	4726	7519	9783	7397
SPECIFIC HEAT	BTII/I.B-F	9973	9993	1 0015	9991
THERMAI COND	BTII/HR-FT-F	3723	3613	3554	.3617
MOLAR MASS	I.B / I.BMOI.	.5725	18 02	. 5554	
THERMAL COND. MOLAR MASS	по/ почоп		10.02		18.02
TEMP. AVG & SKIN	DEGE	116.2	94.6	81.9	
TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES	SKIN CP	- 5873	. 7330	. 8466	. 7399
PRESSURE. IN & DES	STGN PSTA	50.00	165.00	50.00	165.00
11.20001.2, 11. 4 220		00.00	100.00	00.00	100.00
PRESSURE DROP, TOT	' & ALLOWED PS	I .04	10.00	.01	10.00
PRESSURE DROP, TOT VELOCITY, CALC & M	MAX ALLOWED FT	/s .39	10.00	.12	10.00
•					
FOULING RESISTANCE	HR-FT2-F/I	BTU .00	0010	. (	00010
FOULING RESISTANCE FILM COEFFICIENT	BTU/HR-FT:	2-F 208	3.64	31	15.69
TOTAL HEAT DUTY RE					.019035
EFF TEMP DIF, DEGE	(LMTD = 32.8, 1)	F = .78, BYPAS	SS= .94,BA	AFF=1.00)	24.1
OVERALL COEFF REQU	JIRED BTU/HR-1	FT2-F			110.45
CLEAN & FOULED COE	EFF BTU/HR-1	FT2-F	113.9	7	110.73
SHELLS IN SERIES PASSES, SHELL	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 SHEL	L TYPE E	; REAR HE	EAD FXTS
BAFFLE TYPE E SPACING, CENTRAL	IORZ SEGMENTL	CROSS PASS	SES PER SH	IELL PASS	4
SPACING, CENTRAL SPACING, INLET	IN. 4.309	BAFFLE CU'			
SPACING, INLET	IN. 4.309	CUT DISTAI	NCE FROM C	CENTER, IN.	. / 64
SPACING, OUTLET	IN. 4.309	T1/D T1/GE1/E1			170
BAFFLE THICKNESS PAIRS OF SEALING D	IN125	IMPINGEMEN	NT BAFFLE	INCLUDED	NO
PAIRS OF SEALING L	EVICES I	TUBESHEET	BLANK ARE	iA, 8	. 0
שוופב שעפב	DT 7, T N	ΜΛΨΕΡΤΛΤ	<u>г</u>	LECTROLYTIC	CODDED
TUBE TYPE NO. OF TUBES/SHELI	. 76	EST MAY TI	TRE COUNT	IDECTRODITION (	36
TURE LOTH OVERALL	, FT 1500	TIBE PITCE	3DD COON1	TM	3125
TUBE LGTH, OVERALI TUBE LGTH, EFF	FT 1.300	TUBE CUTS	LDE DIVM	IN.	250
TUBE LAYOUT	DEG 60				.214
PITCH RATIO		TUBE SURFA			
SHL NOZZ ID, IN&OU					
0111 11011 1D, 111400	1.0 1.0	1022 11022	12, 111400	1111	
* CALCULATED ITE	MHEAT BALANCI	E CODE = 8			
Washington Unive			er experim	nent	E0002 P 63
Young model F302DY		_	-		9/23/ 3
					CASE 31
S U P P L E	M E N T A	R Y R	E S U	L T S	
HT PARAMETERS	SHELL TUBE		SIDE PERFO	RMANCE	
WALL CORRECTION	1.019 .000		VEL, X-FLC		.10
PRANDTL NUMBER	5.7 3.9			W FT/S	.20
RYNLD NO, AVG	356. 1073.	CROSSFLO	OW COEF	BTU/HR-FT2-	-F 317.0
RYNLD NO. IN BUN	308. 1334.	WINDOW (	COEF	BTU/HR-FT2-	-F 318.9
RYNLD NO, OUT BUN					
FOULNG LAYER IN.	.0014 .0014	SHELLS	SIDE FLOW,	% OF TOTAL	

				RANSFER X-FI	T OM	01 12
THERMAL RESISTANCE,	° OF EOE	\ T				
SHELL TUBE FOUL	7 OF IOIA	<del>√</del> ⊥	TOBE I	O BAFFLE LEA	ANAGE A	= 64.61
34.68 62.84 2.	ING METAL	J T	MAIN C	KUSSFLUW	В	= 64.61
34.68 62.84 2.	40 .08	0.0	BONDLE	TO SHELL BY	YPASS C	= 16.04
PCT OVER DESIGN	0.00	.26	BAFFLF	TO SHELL LE	EAKAGE E	= 15.46
PCT OVER DESIGN TOT FOUL RESIST DIFF RESIST	.000	)21/	TUBE F	ASSLANE BYPA	ASS F	= .00
DIFF RESIST	.000	0023				
				LSIDE HEAT		
DIAMETRAL CLEARAN	ICES			= (BETA) (GAMN		
BUNDLE TO SHELL	IN	.5000	BETA	(BAFF CUT FA	ACTOR)	= .920
TUBE TO BAFFLE HOLE	III.	.0284				
BAFFLE TO SHELL	IN.	.1000	END	(HT LOSS IN	END ZONE)	= .994
SHELL NOZZLE DATA					DROP, % OF	
HT UNDR NOZ IN.	.25		WINDOW	I		= 8.9
HT OPP NOZ IN.	.25		END ZC	NE		= 3.5
VELOCITY FT/S	.65	.66	CROSS	FLOW		= 3.1
DENSITY LB/FT3	62.252 61	L.972	INLET	NOZZLE		= 42.8
HT UNDR NOZ IN.  HT OPP NOZ IN.  VELOCITY FT/S  DENSITY LB/FT3  NOZZ RHO*VSQ LB/FT-  BUND BHO*VSQ LB/FT-	·S2 26	26	OUTLET	NOZZLE		= 42.8 = 41.8
BUND RHO*VSQ LB/FT-	·S2 18	18				
TUBE NOZZLE DATA VELOCITY FT/S	IN	OUT	WEIG	HT PER SHELI	L, LB	
VELOCITY FT/S	.59	.58	DRY		=	150.
DENSITY LB/FT3	61.291 61	L.991	WET		=	165.
PRESS. DROP %	7.1	4.5				
Washington Univer	sity ChE43	33 heat	exchar	nger experime	ent	E0002 P 64
Young model F302DY4	P					9/23/ 3
						CASE 32
SIZE 4- 18 TYPE BEM	I, MULTI-PA	ASS FLO	W, SEGM	IENTAL BAFFLI	ES, RATING	
SIZE 4- 18 TYPE BEM	I, MULTI-PA	ASS FLO				
SIZE 4- 18 TYPE BEM	I, MULTI-PA		HOT I	UBE SIDE	COLD S	HELL SIDE
			HOT I	UBE SIDE	COLD S	HELL SIDE
			HOT I	UBE SIDE	COLD S	HELL SIDE
SIZE 4- 18 TYPE BEM			HOT I	UBE SIDE	COLD S	HELL SIDE
TOTAL FLOW RATE	KLB/HR		HOT Tube SENS	CUBE SIDE  SIBLE LIQ  .400  OUT	COLD S Shel SENS	HELL SIDE 1 IBLE LIQ .900 OUT
TOTAL FLOW RATE	KLB/HR		HOT Tube SENS	CUBE SIDE  SIBLE LIQ  .400  OUT	COLD S Shel SENS	HELL SIDE 1 IBLE LIQ .900 OUT
TOTAL FLOW RATE TEMPERATURE DENSITY	KLB/HR		HOT Tube SENS	CUBE SIDE  SIBLE LIQ  .400  OUT	COLD S Shel SENS	HELL SIDE 1 IBLE LIQ .900 OUT
TOTAL FLOW RATE TEMPERATURE DENSITY VISCOSITY	KLB/HR DEGF LB/FT3 CP	6.	HOT Tube SENS  IN 140.0 1.2913 .4726	CUBE SIDE  SIBLE LIQ  .400  OUT  90.7*  62.0118  .7658	COLD S	HELL SIDE 1 IBLE LIQ .900 OUT 91.9* 61.9966 .7555
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT	KLB/HR  DEGF  LB/FT3  CP  BTU/LB-F	6.	HOT Tube SENS  IN 140.0 1.2913 .4726 .9973	CUBE SIDE  SIBLE LIQ  .400  OUT  90.7*  62.0118  .7658  .9994	COLD S	HELL SIDE  1  IBLE LIQ  .900  OUT  91.9*  61.9966  .7555  .9993
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND.	KLB/HR  DEGF LB/FT3 CP  BTU/LB-F  BTU/HR-FT-	6.	HOT Tube SENS  IN 140.0 1.2913 .4726 .9973	CUBE SIDE  SIBLE LIQ  .400  OUT  90.7* 62.0118  .7658  .9994 .3609	COLD S	HELL SIDE  1  IBLE LIQ     .900      OUT     91.9* 61.9966     .7555     .9993     .3612
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT	KLB/HR  DEGF LB/FT3 CP  BTU/LB-F  BTU/HR-FT-	6.	HOT Tube SENS  IN 140.0 1.2913 .4726 .9973 .3723	CUBE SIDE  SIBLE LIQ  .400  OUT  90.7*  62.0118  .7658  .9994	COLD S	HELL SIDE  1  IBLE LIQ  .900  OUT  91.9*  61.9966  .7555  .9993
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT- LB/LBMOL	6. -F	HOT Tube SENS  IN 140.0 1.2913 .4726 .9973 .3723	CUBE SIDE  SIBLE LIQ  .400  OUT  90.7* 62.0118  .7658  .9994  .3609  18.02	COLD S	HELL SIDE  1  IBLE LIQ .900 OUT 91.9* 61.9966 .7555 .9993 .3612 18.02
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN	KLB/HR  DEGF  LB/FT3  CP  BTU/LB-F  BTU/HR-FT- LB/LBMOL  DEGF	6. -F	HOT Tube SENS  IN 140.0 1.2913 .4726 .9973 .3723	CUBE SIDE  SIBLE LIQ  .400  OUT  90.7* 62.0118  .7658  .9994  .3609  18.02	COLD S	HELL SIDE  1  IBLE LIQ .900 OUT 91.9* 61.9966 .7555 .9993 .3612 18.02 92.2
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & SK	KLB/HR  DEGF  LB/FT3  CP  BTU/LB-F  BTU/HR-FT-  LB/LBMOL  DEGF  IN CP	6. -F	HOT Tube SENS  IN 140.0 1.2913 .4726 .9973 .3723	CUBE SIDE  SIBLE LIQ  .400  OUT  90.7* 62.0118  .7658  .9994  .3609  18.02	COLD S	HELL SIDE  1  IBLE LIQ .900 OUT 91.9* 61.9966 .7555 .9993 .3612 18.02 92.2
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN	KLB/HR  DEGF  LB/FT3  CP  BTU/LB-F  BTU/HR-FT-  LB/LBMOL  DEGF  IN CP	6. -F	HOT Tube SENS  IN 140.0 1.2913 .4726 .9973 .3723	CUBE SIDE  SIBLE LIQ  .400  OUT  90.7* 62.0118  .7658  .9994  .3609  18.02	COLD S	HELL SIDE  1  IBLE LIQ .900 OUT 91.9* 61.9966 .7555 .9993 .3612 18.02 92.2
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & SK PRESSURE, IN & DESI	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT- LB/LBMOL  DEGF IN CP GN PSIA	6: -F	HOT Tube SENS  IN 140.0 1.2913 .4726 .9973 .3723 115.3 .5920 50.00	CUBE SIDE  SIBLE LIQ  .400  OUT  90.7* 62.0118  .7658  .9994  .3609  18.02   93.1  .7456  165.00	COLD S	HELL SIDE  1  IBLE LIQ .900 OUT 91.9* 61.9966 .7555 .9993 .3612 18.02 92.2 .7529 165.00
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & SK PRESSURE, IN & DESI	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT- LB/LBMOL  DEGF IN CP GN PSIA	6: -F	HOT Tube SENS  IN 140.0 1.2913 .4726 .9973 .3723 115.3 .5920 50.00	CUBE SIDE  SIBLE LIQ  .400  OUT  90.7* 62.0118  .7658  .9994  .3609  18.02   93.1  .7456  165.00	COLD S	HELL SIDE  1  IBLE LIQ .900 OUT 91.9* 61.9966 .7555 .9993 .3612 18.02 92.2 .7529 165.00
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & SK PRESSURE, IN & DESI	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT- LB/LBMOL  DEGF IN CP GN PSIA	6: -F	HOT Tube SENS  IN 140.0 1.2913 .4726 .9973 .3723 115.3 .5920 50.00	CUBE SIDE  SIBLE LIQ  .400  OUT  90.7* 62.0118  .7658  .9994  .3609  18.02   93.1  .7456  165.00	COLD S	HELL SIDE  1  IBLE LIQ .900 OUT 91.9* 61.9966 .7555 .9993 .3612 18.02 92.2 .7529 165.00
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & SK PRESSURE, IN & DESI PRESSURE DROP, TOT VELOCITY, CALC & MA	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT- LB/LBMOL  DEGF CIN CP GN PSIA  & ALLOWED  X ALLOWED	6. -F PSI FT/S	HOT Tube SENS  IN 140.0 1.2913 .4726 .9973 .3723 115.3 .5920 50.00 .04 .39	CUBE SIDE  SIBLE LIQ  .400  OUT  90.7* 62.0118  .7658  .9994  .3609  18.02   93.1  .7456  165.00  10.00  10.00	COLD S	HELL SIDE  1  IBLE LIQ .900 OUT 91.9* 61.9966 .7555 .9993 .3612 18.02 92.2 .7529 165.00  10.00 10.00
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & SK PRESSURE, IN & DESI PRESSURE DROP, TOT VELOCITY, CALC & MA FOULING RESISTANCE	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-LB/LBMOL  DEGF IN CP GN PSIA & ALLOWED X ALLOWED	6. -F PSI FT/S 2-F/BTU	HOT Tube SENS  IN 140.0 1.2913 .4726 .9973 .3723 115.3 .5920 50.00	CUBE SIDE  SIBLE LIQ  .400  OUT  90.7* 62.0118  .7658  .9994  .3609  18.02   93.1  .7456  165.00  10.00  10.00  10.00	COLD S	HELL SIDE  1  IBLE LIQ .900 OUT 91.9* 61.9966 .7555 .9993 .3612 18.02 92.2 .7529 165.00
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & SK PRESSURE, IN & DESI PRESSURE DROP, TOT VELOCITY, CALC & MA  FOULING RESISTANCE FILM COEFFICIENT	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT- LB/LBMOL  DEGF CIN CP GN PSIA & ALLOWED  X ALLOWED  HR-FT2 BTU/HE	PSI FT/S 2-F/BTU R-FT2-F	HOT Tube SENS  IN 140.0 1.2913 .4726 .9973 .3723 115.3 .5920 50.00 .04 .39	CUBE SIDE  SIBLE LIQ  .400  OUT  90.7* 62.0118  .7658  .9994  .3609  18.02   93.1  .7456  165.00  10.00  10.00  10.00	COLD S	HELL SIDE  1  IBLE LIQ .900 OUT 91.9* 61.9966 .7555 .9993 .3612 18.02 92.2 .7529 165.00  10.00 10.00
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & SK PRESSURE, IN & DESI PRESSURE DROP, TOT VELOCITY, CALC & MA  FOULING RESISTANCE FILM COEFFICIENT	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT- LB/LBMOL  DEGF CIN CP GN PSIA & ALLOWED  X ALLOWED  HR-FT2 BTU/HF	PSI FT/S 2-F/BTU R-FT2-F	HOT Tube SENS  IN 140.0 1.2913 .4726 .9973 .3723 115.3 .5920 50.00 .04 .39	CUBE SIDE  SIBLE LIQ  .400  OUT  90.7* 62.0118  .7658  .9994  .3609  18.02   93.1  .7456  165.00  10.00  10.00  00010  208.78	COLD S	HELL SIDE  1  IBLE LIQ .900 OUT 91.9* 61.9966 .7555 .9993 .3612 18.02 92.2 .7529 165.00  10.00 10.00
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & SK PRESSURE, IN & DESI PRESSURE DROP, TOT VELOCITY, CALC & MA  FOULING RESISTANCE FILM COEFFICIENT	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT- LB/LBMOL  DEGF SIN CP GN PSIA & ALLOWED  HR-FT2 BTU/HF	PSI FT/S 2-F/BTU R-FT2-F 	HOT Tube SENS  IN 140.0 1.2913 .4726 .9973 .3723 115.3 .5920 50.00 .04 .39	CUBE SIDE  SIBLE LIQ  .400  OUT  90.7* 62.0118  .7658  .9994  .3609  18.02   93.1  .7456  165.00  10.00  10.00  00010  008.78	COLD S	HELL SIDE  1  IBLE LIQ .900 OUT 91.9* 61.9966 .7555 .9993 .3612 18.02 92.2 .7529 165.00  10.00 10.00  00010 44.92 .019693

		che433b(70).OUT
OVERALL COEFF REQUIRED	BTU/HR-F1	T2-F 114.02
CLEAN & FOULED COEFF	BTU/HR-F1	[2-F 117.62 114.14
SHELLS IN SERIES 1 PARAL	т.в.т. 1	TOTAL EFF AREA FT2 7.1
		EFFECTIVE AREA FT2/SHELL 7.1
SHELL DIAMETER IN.	3.820	TEMA SHELL TYPE E ; REAR HEAD FXTS
BAFFLE TYPE HORZ SE	GMENTL	CROSS PASSES PER SHELL PASS 4
SPACING, CENTRAL IN.	4.309	BAFFLE CUT, PCT SHELL I.D. 30.00
SPACING, INLET IN.		CUT DISTANCE FROM CENTER, IN764
SPACING, OUTLET IN.		our profiled ritter observer, ritter von
		IMPINOEMENE DARRIE INGLIDED NO
BAFFLE THICKNESS IN.		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		TUBE PITCH IN3125
TUBE LGTH, EFF FT		TUBE OUTSIDE DIAM IN250
TUBE LAYOUT DEG		TUBE INSIDE DIAM IN214
	1.250	TUBE SURFACE RATIO, OUT/IN 1.184
SHL NOZZ ID, IN&OUT 1.0	1.0	TUBE NOZZ ID, IN&OUT IN8 .8
* CALCULATED ITEMHEAT	BALANCE	CODE = 8
Washington University C	hF433 he	at exchanger experiment E0002 P 65
Young model F302DY4P	111133 1100	9/23/ 3
found model F302D14P		
		CASE 32
SUPPLEMEN	T A F	RYRESULTS
HT PARAMETERS SHELL	TUBE	SHELLSIDE PERFORMANCE
WALL CORRECTION 1.018	.000	NOMINAL VEL, X-FLOW FT/S .12
	3.9	
RYNLD NO, AVG 395.		
RYNLD NO, IN BUN 346.		
RYNLD NO, OUT BUN 448.		
FOULNG LAYER IN0014	.0014	SHELLSIDE FLOW, % OF TOTAL
		HEAT TRANSFER X-FLOW 81.43
THERMAL RESISTANCE, % OF	TOTAL	TUBE TO BAFFLE LEAKAGE A = 4.03
		MAIN CROSSFLOW B = 64.41
		THILL CROOLING
32.12 04.12 2.41	0.0	DINDLE MO CHELL DYDACC C - 16 21
		BUNDLE TO SHELL BYPASS C = 16.21
PCT OVER DESIGN TOT FOUL RESIST	.10 .000217	BAFFLE TO SHELL LEAKAGE E = 15.35 TUBE PASSLANE BYPASS F = .00
	.10 .000217	BAFFLE TO SHELL LEAKAGE E = 15.35 TUBE PASSLANE BYPASS F = .00
PCT OVER DESIGN TOT FOUL RESIST DIFF RESIST	.10 .000217 .000009	BAFFLE TO SHELL LEAKAGE E = 15.35 TUBE PASSLANE BYPASS F = .00 SHELLSIDE HEAT TRANSFER FACTORS
PCT OVER DESIGN TOT FOUL RESIST DIFF RESIST	.10 .000217 .000009	BAFFLE TO SHELL LEAKAGE E = 15.35 TUBE PASSLANE BYPASS F = .00 SHELLSIDE HEAT TRANSFER FACTORS
PCT OVER DESIGN TOT FOUL RESIST DIFF RESIST	.10 .000217 .000009	BAFFLE TO SHELL LEAKAGE E = 15.35 TUBE PASSLANE BYPASS F = .00 SHELLSIDE HEAT TRANSFER FACTORS
PCT OVER DESIGN TOT FOUL RESIST DIFF RESIST  DIAMETRAL CLEARANCES BUNDLE TO SHELL IN.	.10 .000217 .000009	BAFFLE TO SHELL LEAKAGE E = 15.35 TUBE PASSLANE BYPASS F = .00  SHELLSIDE HEAT TRANSFER FACTORS TOTAL = (BETA) (GAMMA) (FIN) = .752 BETA (BAFF CUT FACTOR) = .920
PCT OVER DESIGN TOT FOUL RESIST DIFF RESIST  DIAMETRAL CLEARANCES BUNDLE TO SHELL IN. TUBE TO BAFFLE HOLE IN.	.10 .000217 .000009	BAFFLE TO SHELL LEAKAGE E = 15.35 TUBE PASSLANE BYPASS F = .00  SHELLSIDE HEAT TRANSFER FACTORS TOTAL = (BETA) (GAMMA) (FIN) = .752 BETA (BAFF CUT FACTOR) = .920 GAMMA (TUBE ROW ENTRY EFCT) = .817
PCT OVER DESIGN TOT FOUL RESIST DIFF RESIST  DIAMETRAL CLEARANCES BUNDLE TO SHELL IN. TUBE TO BAFFLE HOLE IN.	.10 .000217 .000009	BAFFLE TO SHELL LEAKAGE E = 15.35 TUBE PASSLANE BYPASS F = .00  SHELLSIDE HEAT TRANSFER FACTORS TOTAL = (BETA) (GAMMA) (FIN) = .752 BETA (BAFF CUT FACTOR) = .920
PCT OVER DESIGN TOT FOUL RESIST DIFF RESIST  DIAMETRAL CLEARANCES BUNDLE TO SHELL IN. TUBE TO BAFFLE HOLE IN. BAFFLE TO SHELL IN.	.10 .000217 .000009 .5000 .0284 .1000	BAFFLE TO SHELL LEAKAGE E = 15.35 TUBE PASSLANE BYPASS F = .00  SHELLSIDE HEAT TRANSFER FACTORS TOTAL = (BETA) (GAMMA) (FIN) = .752 BETA (BAFF CUT FACTOR) = .920 GAMMA (TUBE ROW ENTRY EFCT) = .817 END (HT LOSS IN END ZONE) = .994
PCT OVER DESIGN TOT FOUL RESIST DIFF RESIST  DIAMETRAL CLEARANCES BUNDLE TO SHELL IN. TUBE TO BAFFLE HOLE IN. BAFFLE TO SHELL IN.	.10 .000217 .000009 .5000 .0284 .1000	BAFFLE TO SHELL LEAKAGE E = 15.35 TUBE PASSLANE BYPASS F = .00  SHELLSIDE HEAT TRANSFER FACTORS TOTAL = (BETA) (GAMMA) (FIN) = .752 BETA (BAFF CUT FACTOR) = .920 GAMMA (TUBE ROW ENTRY EFCT) = .817
PCT OVER DESIGN TOT FOUL RESIST DIFF RESIST  DIAMETRAL CLEARANCES BUNDLE TO SHELL IN. TUBE TO BAFFLE HOLE IN. BAFFLE TO SHELL IN. SHELL NOZZLE DATA	.10 .000217 .000009 .5000 .0284 .1000	BAFFLE TO SHELL LEAKAGE E = 15.35  TUBE PASSLANE BYPASS F = .00  SHELLSIDE HEAT TRANSFER FACTORS  TOTAL = (BETA) (GAMMA) (FIN) = .752  BETA (BAFF CUT FACTOR) = .920  GAMMA (TUBE ROW ENTRY EFCT) = .817  END (HT LOSS IN END ZONE) = .994  SHELL PRESSURE DROP, % OF TOTAL
PCT OVER DESIGN TOT FOUL RESIST DIFF RESIST  DIAMETRAL CLEARANCES BUNDLE TO SHELL IN. TUBE TO BAFFLE HOLE IN. BAFFLE TO SHELL IN. SHELL NOZZLE DATA IN. HT UNDR NOZ IN	.10 .000217 .000009 .5000 .0284 .1000	BAFFLE TO SHELL LEAKAGE E = 15.35 TUBE PASSLANE BYPASS F = .00  SHELLSIDE HEAT TRANSFER FACTORS TOTAL = (BETA) (GAMMA) (FIN) = .752 BETA (BAFF CUT FACTOR) = .920 GAMMA (TUBE ROW ENTRY EFCT) = .817 END (HT LOSS IN END ZONE) = .994  SHELL PRESSURE DROP, % OF TOTAL WINDOW = 8.9
PCT OVER DESIGN TOT FOUL RESIST DIFF RESIST  DIAMETRAL CLEARANCES BUNDLE TO SHELL IN. TUBE TO BAFFLE HOLE IN. BAFFLE TO SHELL IN.  SHELL NOZZLE DATA IN. HT UNDR NOZ IN	.10 .000217 .000009 .5000 .0284 .1000 N OUT	BAFFLE TO SHELL LEAKAGE E = 15.35 TUBE PASSLANE BYPASS F = .00  SHELLSIDE HEAT TRANSFER FACTORS TOTAL =(BETA) (GAMMA) (FIN) = .752 BETA (BAFF CUT FACTOR) = .920 GAMMA (TUBE ROW ENTRY EFCT) = .817 END (HT LOSS IN END ZONE) = .994  SHELL PRESSURE DROP, % OF TOTAL WINDOW = 8.9 END ZONE = 3.3
PCT OVER DESIGN TOT FOUL RESIST DIFF RESIST  DIAMETRAL CLEARANCES BUNDLE TO SHELL IN. TUBE TO BAFFLE HOLE IN. BAFFLE TO SHELL IN.  SHELL NOZZLE DATA IN. HT UNDR NOZ IN2 HT OPP NOZ IN2 VELOCITY FT/S .7	.10 .000217 .000009 .5000 .0284 .1000 N OUT 5	BAFFLE TO SHELL LEAKAGE E = 15.35 TUBE PASSLANE BYPASS F = .00  SHELLSIDE HEAT TRANSFER FACTORS TOTAL = (BETA) (GAMMA) (FIN) = .752 BETA (BAFF CUT FACTOR) = .920 GAMMA (TUBE ROW ENTRY EFCT) = .817 END (HT LOSS IN END ZONE) = .994  SHELL PRESSURE DROP, % OF TOTAL WINDOW = 8.9 END ZONE = 3.3 CROSS FLOW = 3.0
PCT OVER DESIGN TOT FOUL RESIST DIFF RESIST  DIAMETRAL CLEARANCES BUNDLE TO SHELL IN. TUBE TO BAFFLE HOLE IN. BAFFLE TO SHELL IN.  SHELL NOZZLE DATA IN. HT UNDR NOZ IN	.10 .000217 .000009 .5000 .0284 .1000 N OUT 5	BAFFLE TO SHELL LEAKAGE E = 15.35 TUBE PASSLANE BYPASS F = .00  SHELLSIDE HEAT TRANSFER FACTORS TOTAL = (BETA) (GAMMA) (FIN) = .752 BETA (BAFF CUT FACTOR) = .920 GAMMA (TUBE ROW ENTRY EFCT) = .817 END (HT LOSS IN END ZONE) = .994  SHELL PRESSURE DROP, % OF TOTAL WINDOW = 8.9 END ZONE = 3.3 CROSS FLOW = 3.0

		che433b(	/U).OUT		
NOZZ RHO*VSQ LB/F	r-s2 33 33				= 42.0
BUND RHO*VSQ LB/F7					
~ '					
TUBE NOZZLE DATA	IN OUT	' WEIGH	HT PER SHEL	L, LB	
VELOCITY FT/S					150.
DENSITY LB/FT3				=	
PRESS. DROP %					100.
Washington Unive			rer experim	≏n†	E0002 P 66
Young model F302D	_	ac exeman	ger experim	211 C	9/23/ 3
Tourig model 1302D	111				CASE 33
SIZE 4- 18 TYPE BE	ZM MIITTT-DAGG E	TOW SECME	יאיז אי דעיווי	ZG DATING	
SIZE 4 TO TITE BI	M, MODII IASS F		JBE SIDE		
		Tube		Shell	
	III D /IID		IBLE LIQ		
TOTAL FLOW RATE			.500		.200
			OUT		
TEMPERATURE					
DENSITY					
VISCOSITY			.5728		
SPECIFIC HEAT					
THERMAL COND.		.3723			
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN					
VISCOSITY, AVG & S					
PRESSURE, IN & DES	BIGN PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TO					
VELOCITY, CALC & N	MAX ALLOWED FT/	S .49	10.00	.03	10.00
FOULING RESISTANCE					00010
FILM COEFFICIENT	BTU/HR-FT2	) [ ]	L0.68	1.	35.78
		:-F Z]			
TOTAL HEAT DUTY RE		 IR			.010598
EFF TEMP DIF, DEG	(LMTD= 30.1, F	 IR '= .71,BYP	ASS= .91,BA		19.5
	(LMTD= 30.1, F	 IR '= .71,BYP		FF=1.00)	19.5 76.25
EFF TEMP DIF, DEG	F (LMTD= 30.1,F JIRED BTU/HR-F	IR '= .71,BYP <i>I</i> 'T2-F			19.5 76.25
EFF TEMP DIF, DEGI OVERALL COEFF REQU CLEAN & FOULED COE	F (LMTD= 30.1,F JIRED BTU/HR-F EFF BTU/HR-F		77.42	FF=1.00)	19.5 76.25 76.19
EFF TEMP DIF, DEGI OVERALL COEFF REQU CLEAN & FOULED COE SHELLS IN SERIES	F (LMTD= 30.1,F  JIRED BTU/HR-F  EFF BTU/HR-F  1 PARALLEL 1		77.42 F AREA	FF=1.00) 2 FT2	19.5 76.25 76.19
EFF TEMP DIF, DEGIOVERALL COEFF REQUIRED COEFF REQUIRED COEFF REQUIRED COEFF REGION & FOULED COEFF RESEARCH SHELLS IN SERIES PASSES, SHELL	F (LMTD= 30.1,F JIRED BTU/HR-F EFF BTU/HR-F 1 PARALLEL 1 1 TUBE 4	IR P= .71,BYPF T2-F T2-F TOTAL EFF EFFECTIVE	77.42 F AREA E AREA	FF=1.00)  2  FT2  FT2/SHELL	19.5 76.25 76.19 7.1 7.1
EFF TEMP DIF, DEGI OVERALL COEFF REQU CLEAN & FOULED COE SHELLS IN SERIES	F (LMTD= 30.1,F JIRED BTU/HR-F EFF BTU/HR-F 1 PARALLEL 1 1 TUBE 4	IR P= .71,BYPF T2-F T2-F TOTAL EFF EFFECTIVE	77.42 F AREA E AREA	FF=1.00)  2  FT2  FT2/SHELL	19.5 76.25 76.19 7.1 7.1
EFF TEMP DIF, DEGIOVERALL COEFF REQUIRED COESTION & FOULED COESTICLS IN SERIES PASSES, SHELL SHELL DIAMETER IN A	F (LMTD= 30.1, F JIRED BTU/HR-F EFF BTU/HR-F  1 PARALLEL 1 1 TUBE 4 . 3.820	IR  T= .71,BYPF  T2-F  T0TAL EFF  EFFECTIVE  TEMA SHEI	77.42 F AREA E AREA LL TYPE E	FF=1.00)  FT2  FT2/SHELL  ; REAR H	19.5 76.25 76.19 7.1 7.1 EAD FXTS
EFF TEMP DIF, DEGIOVERALL COEFF REQUIRED COEFF REQUIRED COEFF REQUIRED COEFF REGION & FOULED COEFF RESEARCH SHELLS IN SERIES PASSES, SHELL	F (LMTD= 30.1, F) JIRED BTU/HR-F EFF BTU/HR-F  1 PARALLEL 1 1 TUBE 4 . 3.820	IR  T= .71,BYPF  T2-F  T0TAL EFF  EFFECTIVE  TEMA SHEI	77.42 F AREA E AREA LL TYPE E	FF=1.00)  FT2  FT2/SHELL  ; REAR H	19.5 76.25 76.19 7.1 7.1 EAD FXTS
EFF TEMP DIF, DEGIOVERALL COEFF REQUIRED COESTION & FOULED COESTICLS IN SERIES PASSES, SHELL SHELL DIAMETER IN A	F (LMTD= 30.1, F  JIRED BTU/HR-F  EFF BTU/HR-F  1 PARALLEL 1 1 TUBE 4 . 3.820  HORZ SEGMENTL	TEMA SHEIL	77.42 F AREA E AREA LL TYPE E SSES PER SHI	FF=1.00)  FT2  FT2/SHELL  ; REAR HI	19.5 76.25 76.19 7.1 7.1 EAD FXTS
EFF TEMP DIF, DEGIOUS OVERALL COEFF REQUIRED COEFF REQUIRED COEFF REQUIRED COEFF REQUIRED COEFF REALL SHELL SHELL DIAMETER IN THE SHELL DIAMETER IN THE SHELL TYPE	F (LMTD= 30.1, F  JIRED BTU/HR-F  EFF BTU/HR-F  1 PARALLEL 1 1 TUBE 4 . 3.820  HORZ SEGMENTL IN. 4.309	TOTAL EFF EFFECTIVE TEMA SHEI CROSS PAS	77.42 F AREA E AREA LL TYPE E SSES PER SHI	FF=1.00)  FT2  FT2/SHELL  ; REAR HI  ELL PASS  LL I.D.	19.5 76.25 76.19 7.1 7.1 EAD FXTS
EFF TEMP DIF, DEGINOVERALL COEFF REQUIRED COEFF REQ	F (LMTD= 30.1, F  JIRED BTU/HR-F  EFF BTU/HR-F  1 PARALLEL 1 1 TUBE 4 . 3.820  HORZ SEGMENTL IN. 4.309 IN. 4.309 IN. 4.309	IR  T2-F  T2-F  TOTAL EFF  EFFECTIVE  TEMA SHEI  CROSS PAS  BAFFLE CU  CUT DISTA	77.42 F AREA E AREA LL TYPE E ESSES PER SHI JT, PCT SHEI ANCE FROM CI	FF=1.00)  2  FT2  FT2/SHELL  ; REAR HI  ELL PASS  LL I.D.  ENTER, IN.	19.5 76.25 76.19 7.1 7.1 EAD FXTS 4 30.00 .764
EFF TEMP DIF, DEGI OVERALL COEFF REQU CLEAN & FOULED COE SHELLS IN SERIES PASSES, SHELL SHELL DIAMETER IN BAFFLE TYPE IN SPACING, CENTRAL SPACING, INLET	F (LMTD= 30.1, F  JIRED BTU/HR-F  EFF BTU/HR-F  1 PARALLEL 1 1 TUBE 4 . 3.820  HORZ SEGMENTL IN. 4.309 IN. 4.309 IN. 4.309	IR  T2-F  T2-F  TOTAL EFF  EFFECTIVE  TEMA SHEI  CROSS PAS  BAFFLE CU  CUT DISTA	77.42 F AREA E AREA LL TYPE E ESSES PER SHI JT, PCT SHEI ANCE FROM CI	FF=1.00)  2  FT2  FT2/SHELL  ; REAR HI  ELL PASS  LL I.D.  ENTER, IN.	19.5 76.25 76.19 7.1 7.1 EAD FXTS 4 30.00 .764
EFF TEMP DIF, DEGINOVERALL COEFF REQUIRED COEFF REQ	F (LMTD= 30.1, F  JIRED BTU/HR-F  EFF BTU/HR-F  1 PARALLEL 1 1 TUBE 4 . 3.820  HORZ SEGMENTL IN. 4.309 IN. 4.309 IN. 4.309 IN. 125	IR  T2-F  T2-F  TOTAL EFF  EFFECTIVE  TEMA SHEI  CROSS PAS  BAFFLE CU  CUT DISTA	77.42 F AREA E AREA LL TYPE E SSES PER SHI JT, PCT SHEE ANCE FROM CI	FF=1.00)  2  FT2  FT2/SHELL  ; REAR HI  ELL PASS  LL I.D.  ENTER, IN.	19.5 76.25 76.19 7.1 7.1 7.1 EAD FXTS 4 30.00 .764
EFF TEMP DIF, DEGINOVERALL COEFF REQUIRED COEFF REQ	F (LMTD= 30.1, F  JIRED BTU/HR-F  EFF BTU/HR-F  1 PARALLEL 1 1 TUBE 4 . 3.820  HORZ SEGMENTL IN. 4.309 IN. 4.309 IN. 4.309 IN. 125	IR  T2-F  T2-F  TOTAL EFF  EFFECTIVE  TEMA SHEI  CROSS PAS  BAFFLE CU  CUT DISTA	77.42 F AREA E AREA LL TYPE E SSES PER SHI JT, PCT SHEE ANCE FROM CI	FF=1.00)  2  FT2  FT2/SHELL  ; REAR HI  ELL PASS  LL I.D.  ENTER, IN.	19.5 76.25 76.19 7.1 7.1 FXTS 4 30.00 .764
EFF TEMP DIF, DEGION OVERALL COEFF REQUIRED COEFF R	F (LMTD= 30.1, F  JIRED BTU/HR-F  EFF BTU/HR-F  1 PARALLEL 1 1 TUBE 4 . 3.820  HORZ SEGMENTL IN. 4.309 IN. 4.309 IN. 4.309 IN. 125 DEVICES 1	IR C= .71,BYPF T2-F T0TAL EFF EFFECTIVE TEMA SHEI CROSS PAS BAFFLE CU CUT DISTF	77.42 F AREA E AREA LL TYPE E SSES PER SHI JT, PCT SHE ANCE FROM CI ENT BAFFLE : F BLANK AREA	FF=1.00)  FT2  FT2/SHELL  ; REAR HI  ELL PASS  LL I.D.  ENTER, IN.  INCLUDED  A, %	19.5 76.25 76.19 7.1 7.1 EAD FXTS 4 30.00 .764 NO
EFF TEMP DIF, DEGINOVERALL COEFF REQUIRED COEFF REQ	F (LMTD= 30.1, F  JIRED BTU/HR-F  EFF BTU/HR-F  1 PARALLEL 1 1 TUBE 4 . 3.820  HORZ SEGMENTL IN. 4.309 IN. 4.309 IN. 4.309 IN. 125 DEVICES 1	IR T= .71,BYPF T2-F T0TAL EFF EFFECTIVE TEMA SHEI CROSS PAS BAFFLE CU CUT DISTF IMPINGEME TUBESHEET	77.42 F AREA E AREA LL TYPE E SSES PER SHI JT, PCT SHEI ANCE FROM CI ENT BAFFLE : BLANK AREA	FF=1.00)  FT2  FT2/SHELL  ; REAR HI  ELL PASS  LL I.D.  ENTER, IN.  INCLUDED  A, %  LECTROLYTIC	19.5 76.25 76.19 7.1 7.1 EAD FXTS 4 30.00 .764 NO .0
EFF TEMP DIF, DEGINOVERALL COEFF REQUING CLEAN & FOULED CONSIDER FOR SHELLS IN SERIES PASSES, SHELL SHELL DIAMETER IN SHELL DIAMETER IN SHELL DIAMETER IN SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING INTUBE TYPE	F (LMTD= 30.1, F  JIRED BTU/HR-F  EFF BTU/HR-F  1 PARALLEL 1 1 TUBE 4 . 3.820  HORZ SEGMENTL IN. 4.309 IN. 4.309 IN. 4.309 IN. 125 DEVICES 1  PLAIN T6	TOTAL EFFECTIVE TEMA SHEIL CROSS PASS BAFFLE CUT DISTAL IMPINGEME TUBESHEET MATERIAL EST MAX TOTAL TEMA TEMA TEMA TEMA TEMA TEMA TEMA TEMA	77.42 F AREA E AREA LL TYPE E  SSES PER SHI JT, PCT SHEI ANCE FROM CI ENT BAFFLE : F BLANK AREA  FUBE COUNT	FF=1.00)  FT2  FT2/SHELL  ; REAR HI  ELL PASS  LL I.D.  ENTER, IN.  INCLUDED  A, %  LECTROLYTIC	19.5 76.25 76.19 7.1 7.1 EAD FXTS 4 30.00 .764 NO .0
EFF TEMP DIF, DEGINOVERALL COEFF REQUING CLEAN & FOULED CONSIDER FOR SHELLS IN SERIES PASSES, SHELL SHELL DIAMETER IN THE SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING INTUBE TYPE NO. OF TUBES/SHELL	F (LMTD= 30.1, F  JIRED BTU/HR-F  EFF BTU/HR-F  1 PARALLEL 1 1 TUBE 4 . 3.820  HORZ SEGMENTL IN. 4.309 IN. 4.309 IN. 4.309 IN. 125 DEVICES 1  PLAIN 76 L FT 1.500	IR  T= .71,BYPF  T2-F  T0TAL EFF  EFFECTIVE  TEMA SHEI  CROSS PAS  BAFFLE CU  CUT DISTE  IMPINGEME  TUBESHEET  MATERIAL  EST MAX TUBE PITC	77.42 F AREA E AREA LL TYPE E SSES PER SHI JT, PCT SHEI ANCE FROM CI ENT BAFFLE I F BLANK AREA EUBE COUNT	FF=1.00)  FT2  FT2/SHELL  ; REAR HI  ELL PASS  LL I.D.  ENTER, IN.  INCLUDED  A, %  LECTROLYTIC  IN.	19.5 76.25 76.19  7.1 7.1 7.1 EAD FXTS  4 30.00 .764  NO .0  C COPPER 36 .3125

TUBE LAYOUT	DEG	60 T	UBE INS:	IDE DIAM	IN.	.214
PITCH RATIO	1	.250 T	UBE SURI	FACE RATIO	, OUT/IN	1.184
SHL NOZZ ID, IN&OU	T 1.0	1.0 T	UBE NOZ	Z ID, IN&O	UT IN.	.8 .8
* CALCULATED ITE						
Washington Unive	-	433 heat	exchan	ger experi	ment	
Young model F302DY	4P					9/23/ 3
						CASE 33
S U P P L E	M E N	T A R	Y I	RESU	L T S	
HT PARAMETERS	CHELL	MIIDE	QUET :		ODMANICE	
WALL CORRECTION						0.3
PRANDTL NUMBER						
RYNLD NO, AVG						
RYNLD NO, IN BUN						
RYNLD NO, OUT BUN			WINDOW	COEF	DIU/HK-FI	2-6 137.2
RINLD NO, OUI BUN	130.	13/0.	CHET	CIDE ELOM	% OF TOT	7\ T
FOULNG LAYER IN.	.0014	.0014		PANCEED A-	, 6 OF IOI.	90 66 АП
THERMAL RESISTANCE	° OF EO	m 7. T	HEAT II	RANSFER A-	F LOW	00.00
SHELL TUBE FOU						
55.48 42.81 1	LING MET.	AL	MAIN CI	ROSSFLOW	DUDAGG	B = 68.79
55.48 42.81 1	. 65 .	0.5	BONDLE	TO SHELL	BYPASS	C = 11.34
PCT OVER DESIGN TOT FOUL RESIST						
			TOBE PA	ASSLANE BY	PASS	F = .00
DIFF RESIST			QUET :			
DIAMETRAL CLEARA	NODO		SHEL	LSIDE HEAT	TRANSFER	FACTORS
DIAMETRAL CLEARA	NCES	F 0 0 0	TOTAL =	=(BETA)(GA	MMA) (FIN)	= .598
BUNDLE TO SHELL						
TUBE TO BAFFLE HOL						
BAFFLE TO SHELL	IN.	.1000	END	(HT LOSS I	N END ZONE	) = .994
SHELL NOZZLE DAT	'A TN	ОПТ	SHELL	. PRESSURE	DROP. % O	F TOTAL
HT OPP NOZ IN.	. 25		END ZOI	JF.		= 6.6
VELOCITY FT/S	.16	. 17	CROSS 1	TLOW		= 5.1
HT UNDR NOZ IN. HT OPP NOZ IN. VELOCITY FT/S DENSITY LB/FT3	62 252	61 562	INLET	JOZZIE		= 40.8
NOZZ RHO*VSQ LB/FT	-S2 1	1	OUTLET	NOZZLE		= 38.0
BUND RHO*VSQ LB/FT			001221	1.02222		00.0
	_	_				
TUBE NOZZLE DATA	IN	OUT	WEIGH	HT PER SHE	LL, LB	
VELOCITY FT/S	.74	.73	DRY		=	150.
DENSITY LB/FT3	61.291	61.627	WET		=	165.
PRESS. DROP %	8.6	5.4				
Washington Unive	rsity ChE	433 heat	exchan	ger experi	ment	E0002 P 68
Young model F302DY	-			_		9/23/ 3
-						CASE 34
SIZE 4- 18 TYPE BE	M, MULTI-	PASS FLO	W, SEGMI	ENTAL BAFF	LES, RATIN	G
			HOT TO	JBE SIDE	COLD	SHELL SIDE
			Tube		She	11
			SENS	IBLE LIQ	SEN	SIBLE LIQ
TOTAL FLOW RATE	KLB/HR			.500		.300
			IN	OUT	IN	OUT
TEMPERATURE	DEGF		140.0	112.5*	70.0	115.8*
DENSITY	LB/FT3	6	1.2913	61.7191	62.2515	61.6708

VISCOSITY CP SPECIFIC HEAT BT THERMAL COND. BT MOLAR MASS LB	U/LB-F U/HR-FT-F	.9973 .9979	1.0015 .3554	.9978 .3670 L8.02
TEMP, AVG & SKIN VISCOSITY, AVG & SKIN PRESSURE, IN & DESIGN	CP	126.2 110.2 .5339 .6226	92.9 .7469	109.6 .6266
PRESSURE DROP, TOT & VELOCITY, CALC & MAX				
FOULING RESISTANCE FILM COEFFICIENT	BTU/HR-FT2-			
TOTAL HEAT DUTY REQUI EFF TEMP DIF, DEGF ( OVERALL COEFF REQUIRE CLEAN & FOULED COEFF	RED MEGBTU/HELMTD= 32.5,F=D BTU/HR-FT	R = .75,BYPASS= .93,BA [2-F	8	
SHELLS IN SERIES 1 P PASSES, SHELL 1 T SHELL DIAMETER IN.	UBE 4	EFFECTIVE AREA	FT2/SHELL	7.1
BAFFLE TYPE HORZ SPACING, CENTRAL IN. SPACING, INLET IN. SPACING, OUTLET IN. BAFFLE THICKNESS IN. PAIRS OF SEALING DEVI	4.309 4.309 4.309 .125	CROSS PASSES PER SH BAFFLE CUT, PCT SHE CUT DISTANCE FROM C IMPINGEMENT BAFFLE TUBESHEET BLANK ARE	LL I.D. SENTER, IN.	30.00
TUBE TYPE  NO. OF TUBES/SHELL  TUBE LGTH, OVERALL F  TUBE LGTH, EFF F  TUBE LAYOUT D  PITCH RATIO  SHL NOZZ ID, IN&OUT	76 T 1.500 T 1.436 EG 60 1.250	TUBE OUTSIDE DIAM TUBE INSIDE DIAM TUBE SURFACE RATIO,	IN. IN. IN. OUT/IN	36 .3125 .250 .214
* CALCULATED ITEM Washington Universi Young model F302DY4P		CODE = 8 at exchanger experim	9/2	02 P 69 23/ 3 SE 34
S U P P L E M			L T S	,u ,J
WALL CORRECTION 1. PRANDTL NUMBER RYNLD NO, AVG 1 RYNLD NO, IN BUN 1 RYNLD NO, OUT BUN 1	5.0 3.5 51. 1476. 15. 1667. 91. 1294.	NOMINAL VEL, WINDO CROSSFLOW COEF WINDOW COEF	W FT/S W FT/S BTU/HR-FT2-F 1	.08 L70.0
FOULNG LAYER IN0	014 .0014	SHELLSIDE FLOW, HEAT TRANSFER X-F		31.26

SHELL TUBE FOUNT TOT FOUL RESIST DIFF RESIST	1.86 .06 .06 .000217	MAIN CH BUNDLE BAFFLE TUBE PA	ROSSFLOW TO SHELL BY	B YPASS C	= 68.14 = 12.53
		SHELI	LSIDE HEAT T	RANSFER F	ACTORS
DIAMETRAL CLEAR	ANCES	TOTAL =	=(BETA)(GAMM	MA) (FIN)	= .615
BUNDLE TO SHELL	IN5000	BETA	(BAFF CUT FA	CTOR)	= .920
TUBE TO BAFFLE HO					
BAFFLE TO SHELL	IN1000	END	(HT LOSS IN	END ZONE)	= .994
SHELL NOZZLE DAT			L PRESSURE D	DROP, % OF	TOTAL
HT UNDR NOZ IN.	.25	WINDOW			= 9.1
HT OPP NOZ IN.	.25	END ZOI	NE		= 5.3
VELOCITY FT/S	.25 .25	CROSS I	FLOW		= 4.4
DENSITY LB/FT3	62.252 61.671	INLET 1	NOZZLE		= 41.8
VELOCITY FT/S DENSITY LB/FT3 NOZZ RHO*VSQ LB/FT	r-s2 3 3	OUTLET	NOZZLE		= 39.5
BUND RHO*VSQ LB/F	r-s2 2 2				
TUBE NOZZLE DATA	A IN OUT	WEIGH	HT PER SHELI	L, LB	
VELOCITY FT/S	.74 .73	DRY		=	150.
DENSITY LB/FT3	61.291 61.719	WET		=	165.
PRESS. DROP %	8.5 5.4				
Washington Unive	ersity ChE433 he	at exchang	ger experime	ent	E0002 P 70
Young model F302D	Y4P				9/23/ 3
					CASE 35
SIZE 4- 18 TYPE BE	T PPKG-TTIIM ME	TOM SECMI	ZNITAT DARRIE	O DAMINIC	
SIZE 4 TO TITE DI	im, Modil IASS I				
	in, Modii 1855 r	HOT TO	JBE SIDE	COLD S	HELL SIDE
5120 4 10 1110 51		HOT TU Tube	JBE SIDE	COLD S Shel	HELL SIDE 1
		HOT TU Tube SENSI	JBE SIDE IBLE LIQ	COLD S Shel SENS	HELL SIDE l IBLE LIQ
TOTAL FLOW RATE	KLB/HR	HOT TU Tube SENS	JBE SIDE IBLE LIQ .500	COLD S Shel SENS	HELL SIDE 1 IBLE LIQ .400
TOTAL FLOW RATE	KLB/HR	HOT TU Tube SENS	JBE SIDE IBLE LIQ .500	COLD S Shel SENS	HELL SIDE 1 IBLE LIQ .400
TOTAL FLOW RATE TEMPERATURE	KLB/HR DEGF	HOT TUDE SENS: IN 140.0	UBE SIDE  IBLE LIQ  .500  OUT  107.8*	COLD S Shel SENS IN 70.0	HELL SIDE  1 IBLE LIQ .400 OUT 110.2*
TOTAL FLOW RATE TEMPERATURE DENSITY	KLB/HR DEGF LB/FT3	HOT TUDE SENS:  IN 140.0 61.2913	JBE SIDE  IBLE LIQ  .500  OUT  107.8*  61.7855	COLD S Shel SENS IN 70.0 62.2515	HELL SIDE  1 IBLE LIQ .400 OUT 110.2* 61.7515
TOTAL FLOW RATE TEMPERATURE DENSITY VISCOSITY	KLB/HR DEGF LB/FT3 CP	HOT TO Tube SENS:  IN 140.0 61.2913 .4726	JBE SIDE  IBLE LIQ .500 OUT 107.8* 61.7855 .6381	COLD S	HELL SIDE  1  IBLE LIQ  .400  OUT  110.2*  61.7515  .6228
TOTAL FLOW RATE  TEMPERATURE  DENSITY  VISCOSITY  SPECIFIC HEAT	KLB/HR  DEGF LB/FT3 CP BTU/LB-F	HOT TUDE SENS:  IN 140.0 61.2913 .4726 .9973	JBE SIDE  IBLE LIQ .500 OUT 107.8* 61.7855 .6381 .9982	COLD S Shel SENS  IN 70.0 62.2515 .9783 1.0015	HELL SIDE  1  IBLE LIQ .400 OUT 110.2* 61.7515 .6228 .9980
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND.	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F	HOT TU Tube SENS: IN 140.0 61.2913 .4726 .9973 .3723	JBE SIDE  IBLE LIQ .500 OUT 107.8* 61.7855 .6381 .9982 .3652	COLD S Shel SENS  IN 70.0 62.2515 .9783 1.0015 .3554	HELL SIDE  1  IBLE LIQ  .400  OUT  110.2*  61.7515  .6228  .9980  .3657
TOTAL FLOW RATE  TEMPERATURE  DENSITY  VISCOSITY  SPECIFIC HEAT	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F	HOT TU Tube SENS: IN 140.0 61.2913 .4726 .9973 .3723	JBE SIDE  IBLE LIQ .500 OUT 107.8* 61.7855 .6381 .9982	COLD S Shel SENS  IN 70.0 62.2515 .9783 1.0015 .3554	HELL SIDE  1  IBLE LIQ  .400  OUT  110.2*  61.7515  .6228  .9980  .3657
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL	IN 140.0 61.2913 .4726 .9973 .3723	JBE SIDE  IBLE LIQ .500 OUT 107.8* 61.7855 .6381 .9982 .3652	COLD S	HELL SIDE  1  IBLE LIQ  .400  OUT  110.2* 61.7515  .6228  .9980  .3657  18.02
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND.	KLB/HR  DEGF  LB/FT3  CP  BTU/LB-F  BTU/HR-FT-F  LB/LBMOL  DEGF	HOT TUDE SENS:  IN 140.0 61.2913 .4726 .9973 .3723	JBE SIDE  IBLE LIQ .500 OUT 107.8* 61.7855 .6381 .9982 .3652 18.02	COLD S	HELL SIDE  1  IBLE LIQ .400 OUT 110.2* 61.7515 .6228 .9980 .3657 18.02 105.6
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN	KLB/HR  DEGF  LB/FT3  CP  BTU/LB-F  BTU/HR-FT-F  LB/LBMOL  DEGF  SKIN CP	IN 140.0 61.2913 .4726 .9973 .3723	JBE SIDE  IBLE LIQ .500 OUT 107.8* 61.7855 .6381 .9982 .3652 18.02 106.3 .6479	COLD S	HELL SIDE  1  IBLE LIQ .400 OUT 110.2* 61.7515 .6228 .9980 .3657 18.02 105.6 .6526
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL  DEGF SKIN CP SIGN PSIA	IN 140.0 61.2913 .4726 .9973 .3723	JBE SIDE  IBLE LIQ .500 OUT 107.8* 61.7855 .6381 .9982 .3652 18.02 106.3 .6479 165.00	COLD S	HELL SIDE  1  IBLE LIQ .400 OUT 110.2* 61.7515 .6228 .9980 .3657 18.02 105.6 .6526 165.00
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL  DEGF SKIN CP SIGN PSIA	IN 140.0 61.2913 .4726 .9973 .3723 123.9 .5456 50.00	JBE SIDE  IBLE LIQ .500 OUT 107.8* 61.7855 .6381 .9982 .3652 18.02 106.3 .6479 165.00	COLD S	HELL SIDE  IBLE LIQ .400 OUT 110.2* 61.7515 .6228 .9980 .3657 18.02 105.6 .6526 165.00
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES  PRESSURE DROP, TOTAL	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL  DEGF SKIN CP SIGN PSIA  F & ALLOWED PSI MAX ALLOWED FT/	HOT TU Tube SENS:  IN 140.0 61.2913 .4726 .9973 .3723 123.9 .5456 50.00 .05 s .49	JBE SIDE  JBLE LIQ .500 OUT 107.8* 61.7855 .6381 .9982 .3652 18.02 106.3 .6479 165.00  10.00 10.00	COLD S	HELL SIDE  I IBLE LIQ .400 OUT 110.2* 61.7515 .6228 .9980 .3657 18.02 105.6 .6526 165.00  10.00 10.00
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL  DEGF SKIN CP SIGN PSIA F & ALLOWED PSI MAX ALLOWED FT/	HOT TU  Tube SENS:  IN 140.0 61.2913 .4726 .9973 .3723 123.9 .5456 50.00 .05 S .49	JBE SIDE  IBLE LIQ .500 OUT 107.8* 61.7855 .6381 .9982 .3652 18.02 106.3 .6479 165.00 10.00 10.00	COLD S	HELL SIDE  I IBLE LIQ .400 OUT 110.2* 61.7515 .6228 .9980 .3657 18.02 105.6 .6526 165.00  10.00 10.00
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES  PRESSURE DROP, TOTAL VELOCITY, CALC & ME  FOULING RESISTANCE FILM COEFFICIENT	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL  DEGF SKIN CP SIGN PSIA  F & ALLOWED PSI MAX ALLOWED FT/ E HR-FT2-F/B BTU/HR-FT2	HOT TU Tube SENS:  IN 140.0 61.2913 .4726 .9973 .3723  123.9 .5456 50.00  .05 S .49  TU .0 -F .22	JBE SIDE  IBLE LIQ .500 OUT 107.8* 61.7855 .6381 .9982 .3652 18.02 106.3 .6479 165.00 10.00 10.00	COLD S	HELL SIDE  IBLE LIQ .400 OUT 110.2* 61.7515 .6228 .9980 .3657 18.02 105.6 .6526 165.00  10.00 10.00 00010 001.16
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES  PRESSURE DROP, TOTAL FOULING RESISTANCE FILM COEFFICIENT  TOTAL HEAT DUTY RE	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL  DEGF SKIN CP SIGN PSIA  F & ALLOWED PSI MAX ALLOWED FT/ E HR-FT2-F/B BTU/HR-FT2	HOT TU Tube SENS:  IN 140.0 61.2913 .4726 .9973 .3723  123.9 .5456 50.00  .05 S .49  TU .0 F .23 R	JBE SIDE  IBLE LIQ .500 OUT 107.8* 61.7855 .6381 .9982 .3652 18.02 106.3 .6479 165.00  10.00 10.00 10.00	COLD S	HELL SIDE  IBLE LIQ .400 OUT 110.2* 61.7515 .6228 .9980 .3657 18.02 105.6 .6526 165.00  10.00 10.00 00010 01.16 .016069
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES  PRESSURE DROP, TOTAL VELOCITY, CALC & ME  FOULING RESISTANCE FILM COEFFICIENT	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL  DEGF SKIN CP SIGN PSIA  F & ALLOWED PSI MAX ALLOWED FT/ E HR-FT2-F/B BTU/HR-FT2	HOT TU Tube SENS:  IN 140.0 61.2913 .4726 .9973 .3723  123.9 .5456 50.00  .05 S .49  TU .0 -F .22 R = .76,BYP2	JBE SIDE  IBLE LIQ .500 OUT 107.8* 61.7855 .6381 .9982 .3652 18.02 106.3 .6479 165.00  10.00 10.00 10.00	COLD S	HELL SIDE  IBLE LIQ .400 OUT 110.2* 61.7515 .6228 .9980 .3657 18.02 105.6 .6526 165.00  10.00 10.00 00010 01.16 .016069

	che433b(70).OUT
CLEAN & FOULED COEFF BTU/HR-FT2	95.35 93.26
SHELLS IN SERIES 1 PARALLEL 1 T	OTAL EFF AREA FT2 7.1
PASSES, SHELL 1 TUBE 4 E	FFECTIVE AREA FT2/SHELL 7.1
	EMA SHELL TYPE E ; REAR HEAD FXTS
BAFFLE TYPE HORZ SEGMENTL C	ROSS PASSES PER SHELL PASS 4
SPACING, CENTRAL IN. 4.309 B	SAFFLE CUT, PCT SHELL I.D. 30.00
SPACING, INLET IN. 4.309 C	CUT DISTANCE FROM CENTER, IN764
SPACING, OUTLET IN. 4.309	
BAFFLE THICKNESS IN125 I	MPINGEMENT BAFFLE INCLUDED NO
	UBESHEET BLANK AREA, % .0
TUBE TYPE PLAIN M. NO. OF TUBES/SHELL 76 E	MATERIAL ELECTROLYTIC COPPER
NO. OF TUBES/SHELL 76 E	ST MAX TUBE COUNT 36
TUBE LGTH, OVERALL FT 1.500 1	SST MAX TUBE COUNT 36 PUBE PITCH IN3125
TUBE LGTH, EFF FT 1.436 1	UBE OUTSIDE DIAM IN250
TUBE LAYOUT DEG 60 T	CUBE INSIDE DIAM IN214 CUBE SURFACE RATIO, OUT/IN 1.184
PITCH RATIO 1.250 T	UBE SURFACE RATIO, OUT/IN 1.184
SHL NOZZ ID, IN&OUT 1.0 1.0 T	UBE NOZZ ID, IN&OUT IN8 .8
* CALCULATED ITEMHEAT BALANCE C	
	exchanger experiment E0002 P 71
Young model F302DY4P	9/23/ 3
	CASE 35
S U P P L E M E N T A R	Y RESULTS
HT PARAMETERS SHELL TURE	SHELLSIDE PERFORMANCE
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.024 .000	SHELLSIDE PERFORMANCE NOMINAL VELLX-FLOW FT/S .05
WALL CORRECTION 1.024 .000	NOMINAL VEL, X-FLOW FT/S .05
WALL CORRECTION 1.024 .000 PRANDTL NUMBER 5.2 3.6	NOMINAL VEL, X-FLOW FT/S .05 NOMINAL VEL, WINDOW FT/S .10
WALL CORRECTION       1.024       .000         PRANDTL NUMBER       5.2       3.6         RYNLD NO, AVG       195.       1444.	NOMINAL VEL, X-FLOW FT/S .05  NOMINAL VEL, WINDOW FT/S .10  CROSSFLOW COEF BTU/HR-FT2-F 201.9
WALL CORRECTION 1.024 .000 PRANDTL NUMBER 5.2 3.6 RYNLD NO, AVG 195. 1444. RYNLD NO, IN BUN 154. 1667.	NOMINAL VEL, X-FLOW FT/S .05 NOMINAL VEL, WINDOW FT/S .10
WALL CORRECTION 1.024 .000 PRANDTL NUMBER 5.2 3.6 RYNLD NO, AVG 195. 1444. RYNLD NO, IN BUN 154. 1667. RYNLD NO,OUT BUN 242. 1235. FOULNG LAYER IN0014 .0014	NOMINAL VEL, X-FLOW FT/S .05  NOMINAL VEL, WINDOW FT/S .10  CROSSFLOW COEF BTU/HR-FT2-F 201.9  WINDOW COEF BTU/HR-FT2-F 203.3  SHELLSIDE FLOW, % OF TOTAL
WALL CORRECTION 1.024 .000 PRANDTL NUMBER 5.2 3.6 RYNLD NO, AVG 195. 1444. RYNLD NO, IN BUN 154. 1667. RYNLD NO, OUT BUN 242. 1235. FOULNG LAYER IN0014 .0014	NOMINAL VEL, X-FLOW FT/S .05  NOMINAL VEL, WINDOW FT/S .10  CROSSFLOW COEF BTU/HR-FT2-F 201.9  WINDOW COEF BTU/HR-FT2-F 203.3  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81.40
WALL CORRECTION 1.024 .000 PRANDTL NUMBER 5.2 3.6 RYNLD NO, AVG 195. 1444. RYNLD NO, IN BUN 154. 1667. RYNLD NO,OUT BUN 242. 1235. FOULNG LAYER IN0014 .0014 THERMAL RESISTANCE, % OF TOTAL	NOMINAL VEL, X-FLOW FT/S .05  NOMINAL VEL, WINDOW FT/S .10  CROSSFLOW COEF BTU/HR-FT2-F 201.9  WINDOW COEF BTU/HR-FT2-F 203.3  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81.40  TUBE TO BAFFLE LEAKAGE A = 3.16
WALL CORRECTION 1.024 .000 PRANDTL NUMBER 5.2 3.6 RYNLD NO, AVG 195. 1444. RYNLD NO, IN BUN 154. 1667. RYNLD NO,OUT BUN 242. 1235. FOULNG LAYER IN0014 .0014 THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL	NOMINAL VEL, X-FLOW FT/S .05  NOMINAL VEL, WINDOW FT/S .10  CROSSFLOW COEF BTU/HR-FT2-F 201.9  WINDOW COEF BTU/HR-FT2-F 203.3  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81.40  TUBE TO BAFFLE LEAKAGE A = 3.16  MAIN CROSSFLOW B = 67.00
WALL CORRECTION 1.024 .000 PRANDTL NUMBER 5.2 3.6 RYNLD NO, AVG 195. 1444. RYNLD NO, IN BUN 154. 1667. RYNLD NO,OUT BUN 242. 1235. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 45.84 52.07 2.02 .07	NOMINAL VEL, X-FLOW FT/S .05  NOMINAL VEL, WINDOW FT/S .10  CROSSFLOW COEF BTU/HR-FT2-F 201.9  WINDOW COEF BTU/HR-FT2-F 203.3  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81.40  TUBE TO BAFFLE LEAKAGE A = 3.16  MAIN CROSSFLOW B = 67.00  BUNDLE TO SHELL BYPASS C = 13.76
WALL CORRECTION 1.024 .000 PRANDTL NUMBER 5.2 3.6 RYNLD NO, AVG 195. 1444. RYNLD NO, IN BUN 154. 1667. RYNLD NO,OUT BUN 242. 1235. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 45.84 52.07 2.02 .07	NOMINAL VEL, X-FLOW FT/S .05  NOMINAL VEL, WINDOW FT/S .10  CROSSFLOW COEF BTU/HR-FT2-F 201.9  WINDOW COEF BTU/HR-FT2-F 203.3  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81.40  TUBE TO BAFFLE LEAKAGE A = 3.16  MAIN CROSSFLOW B = 67.00  BUNDLE TO SHELL BYPASS C = 13.76
WALL CORRECTION 1.024 .000 PRANDTL NUMBER 5.2 3.6 RYNLD NO, AVG 195. 1444. RYNLD NO, IN BUN 154. 1667. RYNLD NO,OUT BUN 242. 1235. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 45.84 52.07 2.02 .07 PCT OVER DESIGN35 TOT FOUL RESIST .000217	NOMINAL VEL, X-FLOW FT/S .05  NOMINAL VEL, WINDOW FT/S .10  CROSSFLOW COEF BTU/HR-FT2-F 201.9  WINDOW COEF BTU/HR-FT2-F 203.3  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81.40  TUBE TO BAFFLE LEAKAGE A = 3.16  MAIN CROSSFLOW B = 67.00
WALL CORRECTION 1.024 .000 PRANDTL NUMBER 5.2 3.6 RYNLD NO, AVG 195. 1444. RYNLD NO, IN BUN 154. 1667. RYNLD NO,OUT BUN 242. 1235. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 45.84 52.07 2.02 .07	NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F 201.9 WINDOW COEF BTU/HR-FT2-F 203.3  SHELLSIDE FLOW, % OF TOTAL HEAT TRANSFER X-FLOW  TUBE TO BAFFLE LEAKAGE A = 3.16 MAIN CROSSFLOW  B = 67.00 BUNDLE TO SHELL BYPASS C = 13.76 BAFFLE TO SHELL LEAKAGE E = 16.08 TUBE PASSLANE BYPASS F = .00
WALL CORRECTION 1.024 .000 PRANDTL NUMBER 5.2 3.6 RYNLD NO, AVG 195. 1444. RYNLD NO, IN BUN 154. 1667. RYNLD NO,OUT BUN 242. 1235. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 45.84 52.07 2.02 .07 PCT OVER DESIGN35 TOT FOUL RESIST .000217 DIFF RESIST .000038	NOMINAL VEL, X-FLOW FT/S .05  NOMINAL VEL, WINDOW FT/S .10  CROSSFLOW COEF BTU/HR-FT2-F 201.9  WINDOW COEF BTU/HR-FT2-F 203.3  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81.40  TUBE TO BAFFLE LEAKAGE A = 3.16  MAIN CROSSFLOW B = 67.00  BUNDLE TO SHELL BYPASS C = 13.76  BAFFLE TO SHELL LEAKAGE E = 16.08  TUBE PASSLANE BYPASS F = .00
WALL CORRECTION 1.024 .000 PRANDTL NUMBER 5.2 3.6 RYNLD NO, AVG 195. 1444. RYNLD NO, IN BUN 154. 1667. RYNLD NO,OUT BUN 242. 1235. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 45.84 52.07 2.02 .07 PCT OVER DESIGN35 TOT FOUL RESIST .000217 DIFF RESIST .000038	NOMINAL VEL, X-FLOW FT/S .05  NOMINAL VEL, WINDOW FT/S .10  CROSSFLOW COEF BTU/HR-FT2-F 201.9  WINDOW COEF BTU/HR-FT2-F 203.3  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81.40  TUBE TO BAFFLE LEAKAGE A = 3.16  MAIN CROSSFLOW B = 67.00  BUNDLE TO SHELL BYPASS C = 13.76  BAFFLE TO SHELL LEAKAGE E = 16.08  TUBE PASSLANE BYPASS F = .00
WALL CORRECTION 1.024 .000 PRANDTL NUMBER 5.2 3.6 RYNLD NO, AVG 195. 1444. RYNLD NO, IN BUN 154. 1667. RYNLD NO,OUT BUN 242. 1235. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 45.84 52.07 2.02 .07 PCT OVER DESIGN35 TOT FOUL RESIST .000217 DIFF RESIST .000217 DIFF RESIST000038  DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000	NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F 201.9  WINDOW COEF BTU/HR-FT2-F 203.3  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW  TUBE TO BAFFLE LEAKAGE A = 3.16  MAIN CROSSFLOW  B = 67.00  BUNDLE TO SHELL BYPASS C = 13.76  BAFFLE TO SHELL LEAKAGE E = 16.08  TUBE PASSLANE BYPASS F = .00  SHELLSIDE HEAT TRANSFER FACTORS  TOTAL = (BETA) (GAMMA) (FIN) = .638  BETA (BAFF CUT FACTOR) = .920
WALL CORRECTION 1.024 .000 PRANDTL NUMBER 5.2 3.6 RYNLD NO, AVG 195. 1444. RYNLD NO, IN BUN 154. 1667. RYNLD NO,OUT BUN 242. 1235. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 45.84 52.07 2.02 .07 PCT OVER DESIGN35 TOT FOUL RESIST .000217 DIFF RESIST .000217 DIFF RESIST000038  DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000 TUBE TO BAFFLE HOLE IN0284	NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F 201.9  WINDOW COEF BTU/HR-FT2-F 203.3  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW  TUBE TO BAFFLE LEAKAGE A = 3.16  MAIN CROSSFLOW  B = 67.00  BUNDLE TO SHELL BYPASS C = 13.76  BAFFLE TO SHELL LEAKAGE E = 16.08  TUBE PASSLANE BYPASS F = .00  SHELLSIDE HEAT TRANSFER FACTORS  TOTAL = (BETA) (GAMMA) (FIN) = .638  BETA (BAFF CUT FACTOR) = .920  GAMMA (TUBE ROW ENTRY EFCT) = .694
WALL CORRECTION 1.024 .000 PRANDTL NUMBER 5.2 3.6 RYNLD NO, AVG 195. 1444. RYNLD NO, IN BUN 154. 1667. RYNLD NO, OUT BUN 242. 1235. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 45.84 52.07 2.02 .07 PCT OVER DESIGN35 TOT FOUL RESIST .000217 DIFF RESIST .000217 DIFF RESIST000038  DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000 TUBE TO BAFFLE HOLE IN0284 BAFFLE TO SHELL IN1000	NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F 201.9 WINDOW COEF BTU/HR-FT2-F 203.3  SHELLSIDE FLOW, % OF TOTAL HEAT TRANSFER X-FLOW  TUBE TO BAFFLE LEAKAGE A = 3.16 MAIN CROSSFLOW  B = 67.00 BUNDLE TO SHELL BYPASS C = 13.76 BAFFLE TO SHELL LEAKAGE E = 16.08 TUBE PASSLANE BYPASS F = .00  SHELLSIDE HEAT TRANSFER FACTORS TOTAL = (BETA) (GAMMA) (FIN) = .638 BETA (BAFF CUT FACTOR) = .920 GAMMA (TUBE ROW ENTRY EFCT) = .694 END (HT LOSS IN END ZONE) = .994
WALL CORRECTION 1.024 .000 PRANDTL NUMBER 5.2 3.6 RYNLD NO, AVG 195. 1444. RYNLD NO, IN BUN 154. 1667. RYNLD NO, OUT BUN 242. 1235. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 45.84 52.07 2.02 .07 PCT OVER DESIGN35 TOT FOUL RESIST .000217 DIFF RESIST .000217 DIFF RESIST000038  DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000 TUBE TO BAFFLE HOLE IN0284 BAFFLE TO SHELL IN1000	NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F 201.9 WINDOW COEF BTU/HR-FT2-F 203.3  SHELLSIDE FLOW, % OF TOTAL HEAT TRANSFER X-FLOW  TUBE TO BAFFLE LEAKAGE A = 3.16 MAIN CROSSFLOW  B = 67.00 BUNDLE TO SHELL BYPASS C = 13.76 BAFFLE TO SHELL LEAKAGE E = 16.08 TUBE PASSLANE BYPASS F = .00  SHELLSIDE HEAT TRANSFER FACTORS TOTAL = (BETA) (GAMMA) (FIN) = .638 BETA (BAFF CUT FACTOR) = .920 GAMMA (TUBE ROW ENTRY EFCT) = .694 END (HT LOSS IN END ZONE) = .994  SHELL PRESSURE DROP, % OF TOTAL
WALL CORRECTION 1.024 .000 PRANDTL NUMBER 5.2 3.6 RYNLD NO, AVG 195. 1444. RYNLD NO, IN BUN 154. 1667. RYNLD NO,OUT BUN 242. 1235. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 45.84 52.07 2.02 .07 PCT OVER DESIGN35 TOT FOUL RESIST .000217 DIFF RESIST .000217 DIFF RESIST000038  DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000 TUBE TO BAFFLE HOLE IN0284 BAFFLE TO SHELL IN1000  SHELL NOZZLE DATA IN OUT HT UNDR NOZ IN25	NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F 201.9  WINDOW COEF BTU/HR-FT2-F 203.3  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81.40  TUBE TO BAFFLE LEAKAGE A = 3.16  MAIN CROSSFLOW B = 67.00  BUNDLE TO SHELL BYPASS C = 13.76  BAFFLE TO SHELL LEAKAGE E = 16.08  TUBE PASSLANE BYPASS F = .00  SHELLSIDE HEAT TRANSFER FACTORS  TOTAL = (BETA) (GAMMA) (FIN) = .638  BETA (BAFF CUT FACTOR) = .920  GAMMA (TUBE ROW ENTRY EFCT) = .694  END (HT LOSS IN END ZONE) = .994  SHELL PRESSURE DROP, % OF TOTAL  WINDOW = 8.9
WALL CORRECTION 1.024 .000 PRANDTL NUMBER 5.2 3.6 RYNLD NO, AVG 195. 1444. RYNLD NO, IN BUN 154. 1667. RYNLD NO,OUT BUN 242. 1235. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 45.84 52.07 2.02 .07 PCT OVER DESIGN35 TOT FOUL RESIST .000217 DIFF RESIST .000217 DIFF RESIST .00038  DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000 TUBE TO BAFFLE HOLE IN0284 BAFFLE TO SHELL IN1000  SHELL NOZZLE DATA IN OUT HT UNDR NOZ IN25 HT OPP NOZ IN25	NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F 201.9  WINDOW COEF BTU/HR-FT2-F 203.3  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW  TUBE TO BAFFLE LEAKAGE A = 3.16  MAIN CROSSFLOW  B = 67.00  BUNDLE TO SHELL BYPASS C = 13.76  BAFFLE TO SHELL LEAKAGE E = 16.08  TUBE PASSLANE BYPASS F = .00  SHELLSIDE HEAT TRANSFER FACTORS  TOTAL = (BETA) (GAMMA) (FIN) = .638  BETA (BAFF CUT FACTOR) = .920  GAMMA (TUBE ROW ENTRY EFCT) = .694  END (HT LOSS IN END ZONE) = .994  SHELL PRESSURE DROP, % OF TOTAL  WINDOW = 8.9  END ZONE = 4.6
WALL CORRECTION 1.024 .000 PRANDTL NUMBER 5.2 3.6 RYNLD NO, AVG 195. 1444. RYNLD NO, IN BUN 154. 1667. RYNLD NO, OUT BUN 242. 1235. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 45.84 52.07 2.02 .07 PCT OVER DESIGN35 TOT FOUL RESIST .000217 DIFF RESIST .000217 DIFF RESIST .000038  DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000 TUBE TO BAFFLE HOLE IN0284 BAFFLE TO SHELL IN1000  SHELL NOZZLE DATA IN OUT HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .33 .33	NOMINAL VEL, X-FLOW FT/S .05  NOMINAL VEL, WINDOW FT/S .10  CROSSFLOW COEF BTU/HR-FT2-F 201.9  WINDOW COEF BTU/HR-FT2-F 203.3  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81.40  TUBE TO BAFFLE LEAKAGE A = 3.16  MAIN CROSSFLOW B = 67.00  BUNDLE TO SHELL BYPASS C = 13.76  BAFFLE TO SHELL LEAKAGE E = 16.08  TUBE PASSLANE BYPASS F = .00  SHELLSIDE HEAT TRANSFER FACTORS  TOTAL = (BETA) (GAMMA) (FIN) = .638  BETA (BAFF CUT FACTOR) = .920  GAMMA (TUBE ROW ENTRY EFCT) = .694  END (HT LOSS IN END ZONE) = .994  SHELL PRESSURE DROP, % OF TOTAL  WINDOW = 8.9  END ZONE = 4.6  CROSS FLOW = 3.9
WALL CORRECTION 1.024 .000 PRANDTL NUMBER 5.2 3.6 RYNLD NO, AVG 195. 1444. RYNLD NO, IN BUN 154. 1667. RYNLD NO,OUT BUN 242. 1235. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 45.84 52.07 2.02 .07 PCT OVER DESIGN35 TOT FOUL RESIST .000217 DIFF RESIST .000217 DIFF RESIST .00038  DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000 TUBE TO BAFFLE HOLE IN0284 BAFFLE TO SHELL IN1000  SHELL NOZZLE DATA IN OUT HT UNDR NOZ IN25 HT OPP NOZ IN25	NOMINAL VEL, X-FLOW FT/S .05  NOMINAL VEL, WINDOW FT/S .10  CROSSFLOW COEF BTU/HR-FT2-F 201.9  WINDOW COEF BTU/HR-FT2-F 203.3  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81.40  TUBE TO BAFFLE LEAKAGE A = 3.16  MAIN CROSSFLOW B = 67.00  BUNDLE TO SHELL BYPASS C = 13.76  BAFFLE TO SHELL LEAKAGE E = 16.08  TUBE PASSLANE BYPASS F = .00  SHELLSIDE HEAT TRANSFER FACTORS  TOTAL = (BETA) (GAMMA) (FIN) = .638  BETA (BAFF CUT FACTOR) = .920  GAMMA (TUBE ROW ENTRY EFCT) = .694  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 = 42.2

che433b(70).OUT
BUND RHO\*VSQ LB/FT-S2 4 4

TUBE NOZZLE DATA	IN C	OUT WEIGH	HT PER SHEL		
VELOCITY FT/S	.74 .	73 DRY			150.
DENSITY LB/FT3	61.291 61.7	85 WET		=	165.
PRESS. DROP %	8.4 5	3.3			
Washington Unive	rsity ChE433	heat exchange	ger experim	ent	E0002 P 72
Young model F302DY			_		9/23/ 3
_					CASE 36
SIZE 4- 18 TYPE BE	M, MULTI-PASS	FLOW, SEGM	ENTAL BAFFL	ES, RATING	
			UBE SIDE		
				Shell	L
			IBLE LIQ		
TOTAL FLOW RATE	KLB/HR		.500		.500
	·	IN	OUT	IN	OUT
TEMPERATURE	DEGF				
DENSITY					
VISCOSITY			.6617		
SPECIFIC HEAT					
THERMAL COND.					
MOLAR MASS			18.02		18.02
TEMP, AVG & SKIN	DEGF	122.1	103.2	87.8	102.4
VISCOSITY, AVG & S	KIN CP	.5547	.6692	.7904	.6745
PRESSURE, IN & DES	IGN PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT	& ALLOWED F	SI .05	10.00	.01	10.00
VELOCITY, CALC & M	AX ALLOWED F	T/S .49	10.00	.08	10.00
FOULING RESISTANCE					00010
FILM COEFFICIENT	BTU/HR-F	TT2-F 2:	12.48	23	31.13
TOTAL HEAT DUTY RE					.017835
EFF TEMP DIF, DEGF			ASS= .94,BA	FF=1.00)	
OVERALL COEFF REQU					99.16
CLEAN & FOULED COE	FF BTU/HF	R-FT2-F	101.7	1	99.27
SHELLS IN SERIES	1 מדדגמגמ 1			Em 2	7 1
PASSES, SHELL					
SHELL DIAMETER IN.			LL TYPE E		
SHELL DIAMETER IN.	3.020	IEMA SHE		, KLAK NI	TAD FAIS
BAFFLE TYPE H	OP7 SECMENTI	CDOGG DAG	CCEC DED CHI	TII DNGG	Λ
SPACING, CENTRAL					
SPACING, INLET			ANCE FROM C		
SPACING, OUTLET			ANCE FROM C	INIER, IN.	. / 04
BAFFLE THICKNESS			באת האביבי בי	TNCTIDED	NO
PAIRS OF SEALING D			r blank are		.0
PAIRS OF SEALING D	EAICES I	. IUDESREE.	I DLANK AKE	A, 6	. 0
TUBE TYPE	PLAIN	ј МАТЕВТАТ.	E:	LECTROLYTI	COPPER
NO. OF TUBES/SHELL			TUBE COUNT		36
TUBE LGTH, OVERALL			CH COONT		
TUBE LGTH, EFF					
TUBE LAYOUT			IDE DIAM		.214

PITCH RATIO SHL NOZZ ID, IN&OU		1.250 T	UBE SUR	(70).OUT FACE RATIO, Z ID, IN&OU		1.184
* CALCULATED ITE						
Washington Unive Young model F302DY	_	E433 heat	exchan	ger experim	ent	E0002 P 73 9/23/ 3 CASE 36
S U P P L E	M E N	T A R	Y	R E S U	L T S	07101 30
HT PARAMETERS	SHELL	TUBE		LSIDE PERFO		
WALL CORRECTION	1.022	.000		L VEL, X-FLO		.07
PRANDTL NUMBER	5.3	3.6		L VEL, WINDO		
RYNLD NO, AVG		1420.		LOW COEF		
RYNLD NO, IN BUN	192.		WINDOW	COEF	BTU/HR-FT2	-F 233.6
RYNLD NO, OUT BUN		1191.	21177		0 05 5057	-
FOULNG LAYER IN.	.0014	.0014		LSIDE FLOW,		
	0 0 7 7			RANSFER X-F		81.45
THERMAL RESISTANCE				O BAFFLE LE		
SHELL TUBE FOU		ral 07		ROSSFLOW		= 65.97
42.47 55.31 2		.07		TO SHELL B		
PCT OVER DESIGN		.10		TO SHELL L		
TOT FOUL RESIST DIFF RESIST		000217	TUBE P	ASSLANE BYP	ASS F	= .00
DIFF RESISI	. (	000011	CHET	LSIDE HEAT '	TDANCEED E	A CTIOD C
DIAMETRAL CLEARA	NCEC			= (BETA) (GAM)		
BUNDLE TO SHELL		.5000		(BAFF CUT F		
TUBE TO BAFFLE HOL				(TUBE ROW E		
BAFFLE TO SHELL		.1000		(HT LOSS IN		
DAFFLE TO SHELL	TIN •	.1000	END	(HI LOSS IN	END ZONE)	994
SHELL NOZZLE DAT	A IN	OUT	SHEL	L PRESSURE	DROP, % OF	TOTAL
HT UNDR NOZ IN.	.25		WINDOW			= 8.9
HT OPP NOZ IN.	.25		END ZO	NE		= 4.2
VELOCITY FT/S	.41	.41	CROSS	FLOW		= 3.6
DENSITY LB/FT3	62.252	61.815	INLET	NOZZLE		= 42.5
NOZZ RHO*VSQ LB/FT	-S2 10	10	OUTLET	NOZZLE		= 40.9
BUND RHO*VSQ LB/FT	-s2 7	7				
TUBE NOZZLE DATA	IN	OUT	WETC	HT PER SHEL	т тр	
VELOCITY FT/S			DRY	ni fek Shel.	ш <b>,</b> шв =	150.
DENSITY LB/FT3					=	165.
PRESS. DROP %	8.4		VVLL		_	105.
Washington Unive			ovchan	ger evnerim	ent	E0002 P 74
Young model F302DY		1433 Heac	excitati	iger experim	enc	9/23/ 3
Tourig moder F302D1	41					CASE 37
SIZE 4- 18 TYPE BE	M. MIII.TT-	-PASS FLO	W. SEGM	FNTAL BAFFL	ES. RATING	
	11, 110111	11100 110		UBE SIDE	COLD S	
			Tube		Shel	
				IBLE LIQ		IBLE LIQ
TOTAL FLOW RATE	KLB/HR		22110	.500	22110	.600
			IN	OUT	IN	OUT
TEMPERATURE	DEGF		140.0			102.1*
DENSITY	LB/FT3	6		61.8722		
VISCOSITY	CP	ŭ		.6813	.9783	
	<del>-</del> =			. 3020		

SPECIFIC HEAT BTU/LB-F THERMAL COND. BTU/HR-FT-F		
MOLAR MASS LB/LBMOL		18.02
TEMP, AVG & SKIN DEGF	120.7	33.0
VISCOSITY, AVG & SKIN CP PRESSURE, IN & DESIGN PSIA	50.00 165.00	50.00 165.00
PRESSURE DROP, TOT & ALLOWED PSI		
VELOCITY, CALC & MAX ALLOWED FT/S	5 .49 10.00	.09 10.00
FOULING RESISTANCE HR-FT2-F/B! FILM COEFFICIENT BTU/HR-FT2-		
TOTAL HEAT DUTY REQUIRED MEGBTU/H	R	.019233
EFF TEMP DIF, DEGF (LMTD= 34.6,F=		
OVERALL COEFF REQUIRED BTU/HR-F'S CLEAN & FOULED COEFF BTU/HR-F'S	F2-F	104.17
CLEAN & FOULED COEFF BTU/HR-F"	107.0	8 104.31
SHELLS IN SERIES 1 PARALLEL 1		
PASSES, SHELL 1 TUBE 4		
SHELL DIAMETER IN. 3.820	TEMA SHELL TYPE E	; REAR HEAD FXTS
BAFFLE TYPE HORZ SEGMENTL		
SPACING, CENTRAL IN. 4.309		
SPACING, INLET IN. 4.309	CUT DISTANCE FROM C	ENTER, IN764
SPACING, OUTLET IN. 4.309 BAFFLE THICKNESS IN125		
PAIRS OF SEALING DEVICES 1	IMPINGEMENT BAFFLE TUBESHEET BLANK ARE.	INCLUDED NO .0
	MATERIAL E	
NO. OF TUBES/SHELL 76	EST MAX TUBE COUNT	
TUBE LGTH, OVERALL FT 1.500 TUBE LGTH, EFF FT 1.436		
TUBE LAYOUT DEG 60	TUBE INSIDE DIAM	
	TUBE SURFACE RATIO,	
SHL NOZZ ID, IN&OUT 1.0 1.0		
* CALCULATED ITEMHEAT BALANCE		-n+ E0002 D 75
Washington University ChE433 hear Young model F302DY4P	at exchanger experim	9/23/ 3
Toding Model F302D141		CASE 37
S U P P L E M E N T A I	RY RESU	
HT PARAMETERS SHELL TUBE	SHELLSIDE PERFO	RMANCE
WALL CORRECTION 1.021 .000		W FT/S .08
PRANDTL NUMBER 5.4 3.7		W FT/S .15
RYNLD NO, AVG 280. 1402.	CROSSFLOW COEF	BTU/HR-FT2-F 261.3
RYNLD NO, IN BUN 231. 1667.	WINDOW COEF	BTU/HR-FT2-F 262.9
RYNLD NO, OUT BUN 334. 1156. FOULNG LAYER IN0014 .0014	CHELLCIPE BLOS	° 00 0000
FOULNG LAYER IN	SHELLSIDE FLOW, HEAT TRANSFER X-F	
THERMAL RESISTANCE, % OF TOTAL		$\begin{array}{ccc} \text{LOW} & & 81.46 \\ \text{AKAGE} & \text{A} = & 3.59 \end{array}$
INDIAN INDIANTAL		

SHELL TUBE FOU 39.63 58.03 2 PCT OVER DESIGN TOT FOUL RESIST DIFF RESIST  DIAMETRAL CLEARA	.26 .07 .14 .000217 .000013	BUNDLE BAFFLE TUBE PA SHELI TOTAL =	TO SHELL LE ASSLANE BYPA ASIDE HEAT T F(BETA) (GAMM	PASS C AKAGE E SS F RANSFER FA A) (FIN)	= 15.53 = 15.68 = .00 ACTORS = .683
BUNDLE TO SHELL	IN5000	BETA (	BAFF CUT FA	CTOR)	= .920
TUBE TO BAFFLE HOL					
BAFFLE TO SHELL	IN1000	END (	HT LOSS IN	END ZONE)	= .994
SHELL NOZZLE DAT			PRESSURE D	ROP, % OF	
HT UNDR NOZ IN.			ΙΕ		= 8.9
HT OPP NOZ IN.					
VELOCITY FT/S	.49 .49	CROSS F	LOW		= 3.4
DENSITY LB/FT3 NOZZ RHO*VSQ LB/FT	62.252 61.864	INTEL V	IOZZLE NOZZLE		= 42.6
BUND RHO*VSQ LB/FT	$\frac{-52}{10}$ 10 10	OUTLET	NOZZLE		= 41.3
TUBE NOZZLE DATA	. IN OUT	WEIGH	IT PER SHELL		
VELOCITY FT/S					150.
DENSITY LB/FT3				=	165.
PRESS. DROP %					
Washington Unive		t exchang	ger experime	nt	
Young model F302DY	41				9/23/ 3 CASE 38
CIED 4 10 MVDD DD					
SIZE 4- 18 TIPE BE	M, MULTI-PASS FL	OW, SEGME	NTAL BAFFLE	S, RATING	
SIZE 4- 18 TYPE BE	M, MULTI-PASS FL		NTAL BAFFLE BE SIDE		
SIZE 4- 18 TYPE BE		HOT TU	BE SIDE	COLD SI	HELL SIDE
		HOT TU	BE SIDE	COLD SI	HELL SIDE
TOTAL FLOW RATE		HOT TU	BE SIDE	COLD SI	HELL SIDE
TOTAL FLOW RATE	KLB/HR	HOT TU Tube SENSI IN	BLE LIQ .500 OUT	COLD SHELL SENSI	HELL SIDE L IBLE LIQ .700 OUT
TOTAL FLOW RATE TEMPERATURE	KLB/HR DEGF	HOT TU Tube SENSI IN 140.0	BLE LIQ .500 OUT 99.1*	COLD SENSI	HELL SIDE  IBLE LIQ  .700  OUT  99.1*
TOTAL FLOW RATE TEMPERATURE DENSITY	KLB/HR DEGF LB/FT3	HOT TU  Tube  SENSI  IN  140.0 61.2913	BE SIDE  BLE LIQ .500 OUT 99.1* 61.9029	COLD SH Shell SENS: IN 70.0 62.2515	HELL SIDE  IBLE LIQ  .700  OUT  99.1*  61.9031
TOTAL FLOW RATE TEMPERATURE DENSITY VISCOSITY	KLB/HR  DEGF  LB/FT3  CP	HOT TU  Tube  SENSI  IN  140.0 61.2913 .4726	BE SIDE  BLE LIQ .500 OUT 99.1* 61.9029 .6981	COLD SH Shell SENS: IN 70.0 62.2515 .9783	HELL SIDE  1  1BLE LIQ  .700  OUT  99.1*  61.9031  .6983
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT	KLB/HR  DEGF LB/FT3 CP BTU/LB-F	HOT TU Tube SENSI IN 140.0 61.2913 .4726 .9973	BLE LIQ .500 OUT 99.1* 61.9029 .6981 .9987	COLD SE Shell SENS:  IN 70.0 62.2515 .9783 1.0015	HELL SIDE  IBLE LIQ  .700  OUT  99.1*  61.9031  .6983  .9987
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND.	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F	HOT TU Tube SENSI IN 140.0 61.2913 .4726 .9973	BLE LIQ .500 OUT 99.1* 61.9029 .6981 .9987 .3630	COLD SE Shell SENS:  IN 70.0 62.2515 .9783 1.0015	HELL SIDE  IBLE LIQ  .700  OUT  99.1*  61.9031  .6983  .9987  .3630
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND.	KLB/HR  DEGF LB/FT3 CP BTU/LB-F	HOT TU Tube SENSI IN 140.0 61.2913 .4726 .9973	BLE LIQ .500 OUT 99.1* 61.9029 .6981 .9987	COLD SE Shell SENS:  IN 70.0 62.2515 .9783 1.0015	HELL SIDE  IBLE LIQ  .700  OUT  99.1*  61.9031  .6983  .9987
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN	KLB/HR  DEGF  LB/FT3  CP  BTU/LB-F  BTU/HR-FT-F  LB/LBMOL  DEGF	HOT TU Tube SENSI  IN 140.0 61.2913 .4726 .9973 .3723	BE SIDE  BLE LIQ .500 OUT 99.1* 61.9029 .6981 .9987 .3630 18.02	COLD SE Shell SENS:  IN 70.0 62.2515 .9783 1.0015 .3554	HELL SIDE  IBLE LIQ .700 OUT 99.1* 61.9031 .6983 .9987 .3630 18.02
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL  DEGF  KIN CP	HOT TU  Tube SENSI  IN 140.0 61.2913 .4726 .9973 .3723 119.6 .5683	BLE LIQ .500 OUT 99.1* 61.9029 .6981 .9987 .3630 18.02	IN 70.0 62.2515 .9783 1.0015 .3554	HELL SIDE  IBLE LIQ .700 OUT 99.1* 61.9031 .6983 .9987 .3630 18.02 97.6 .7100
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL  DEGF  KIN CP	HOT TU  Tube SENSI  IN 140.0 61.2913 .4726 .9973 .3723 119.6 .5683	BLE LIQ .500 OUT 99.1* 61.9029 .6981 .9987 .3630 18.02	IN 70.0 62.2515 .9783 1.0015 .3554	HELL SIDE  IBLE LIQ .700 OUT 99.1* 61.9031 .6983 .9987 .3630 18.02 97.6 .7100
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL  DEGF KIN CP IGN PSIA	HOT TU Tube SENSI  IN 140.0 61.2913 .4726 .9973 .3723 119.6 .5683 50.00	BLE LIQ .500 OUT 99.1* 61.9029 .6981 .9987 .3630 18.02	COLD SE Shell SENS: IN 70.0 62.2515 .9783 1.0015 .3554	HELL SIDE  IBLE LIQ .700 OUT 99.1* 61.9031 .6983 .9987 .3630 18.02 97.6 .7100 165.00
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL  DEGF KIN CP IGN PSIA	HOT TU Tube SENSI  IN 140.0 61.2913 .4726 .9973 .3723 119.6 .5683 50.00	BLE LIQ .500 OUT 99.1* 61.9029 .6981 .9987 .3630 18.02 	COLD SE Shell SENS:  IN 70.0 62.2515 .9783 1.0015 .3554	HELL SIDE  IBLE LIQ  .700  OUT  99.1* 61.9031  .6983  .9987  .3630  18.02   97.6  .7100  165.00
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES  PRESSURE DROP, TOT	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL  DEGF KIN CP IGN PSIA  & ALLOWED PSI IAX ALLOWED FT/S	HOT TU Tube SENSI  IN 140.0 61.2913 .4726 .9973 .3723  119.6 .5683 50.00 .05 .49	BLE LIQ .500 OUT 99.1* 61.9029 .6981 .9987 .3630 18.02 	COLD SE Shell SENS:  IN 70.0 62.2515 .9783 1.0015 .3554	HELL SIDE  IBLE LIQ .700 OUT 99.1* 61.9031 .6983 .9987 .3630 18.02 97.6 .7100 165.00
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES  PRESSURE DROP, TOT VELOCITY, CALC & M	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL  DEGF KIN CP IGN PSIA  & ALLOWED PSI AX ALLOWED FT/S  HR-FT2-F/BT BTU/HR-FT2-	HOT TU Tube SENSI  IN 140.0 61.2913 .4726 .9973 .3723 119.6 .5683 50.00  .05 .49  U .0 F .21	BE SIDE  BLE LIQ .500 OUT 99.1* 61.9029 .6981 .9987 .3630 18.02 98.4 .7036 165.00  10.00 10.00 00010 3.06	COLD SE Shell SENS:  IN 70.0 62.2515 .9783 1.0015 .3554	HELL SIDE  IBLE LIQ .700 OUT 99.1* 61.9031 .6983 .9987 .3630 18.02 97.6 .7100 165.00
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES  PRESSURE DROP, TOT VELOCITY, CALC & M  FOULING RESISTANCE FILM COEFFICIENT	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL  DEGF KIN CP IGN PSIA  & ALLOWED PSI IAX ALLOWED FT/S  HR-FT2-F/BT BTU/HR-FT2-	HOT TU Tube SENSI  IN 140.0 61.2913 .4726 .9973 .3723  119.6 .5683 50.00  .05 .49  U .0 F .21	BE SIDE  BLE LIQ .500 OUT 99.1* 61.9029 .6981 .9987 .3630 18.02 98.4 .7036 165.00  10.00 10.00 00010 3.06	COLD SE Shell SENS:  IN 70.0 62.2515 .9783 1.0015 .3554	HELL SIDE  IBLE LIQ  .700  OUT  99.1* 61.9031  .6983  .9987  .3630  18.02   97.6  .7100  165.00  10.00  10.00  20010  39.37
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES  PRESSURE DROP, TOT VELOCITY, CALC & M  FOULING RESISTANCE FILM COEFFICIENT  TOTAL HEAT DUTY RE	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL  DEGF KIN CP IGN PSIA  & ALLOWED PSI IAX ALLOWED FT/S  HR-FT2-F/BT BTU/HR-FT2- QUIRED MEGBTU/HR	HOT TU Tube SENSI  IN 140.0 61.2913 .4726 .9973 .3723  119.6 .5683 50.00  .05 .49  U .0 F .21	BE SIDE  BLE LIQ .500 OUT 99.1* 61.9029 .6981 .9987 .3630 18.02 98.4 .7036 165.00  10.00 10.00 10.00	COLD SE Shell SENS:  IN 70.0 62.2515 .9783 1.0015 .3554	HELL SIDE  IBLE LIQ  .700  OUT  99.1* 61.9031  .6983  .9987  .3630  18.02   97.6  .7100  165.00  10.00  10.00  20010  39.37  .020384
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES  PRESSURE DROP, TOT VELOCITY, CALC & M  FOULING RESISTANCE FILM COEFFICIENT  TOTAL HEAT DUTY RE EFF TEMP DIF, DEGF	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL  DEGF KIN CP IGN PSIA  & ALLOWED PSI AX ALLOWED FT/S  HR-FT2-F/BT BTU/HR-FT2- QUIRED MEGBTU/HR (LMTD= 34.7,F=	HOT TU Tube SENSI  IN 140.0 61.2913 .4726 .9973 .3723  119.6 .5683 50.00  .05 .49  U .0 F .2180,BYPF	BE SIDE  BLE LIQ .500 OUT 99.1* 61.9029 .6981 .9987 .3630 18.02 98.4 .7036 165.00  10.00 10.00 10.00	COLD SE Shell SENS:  IN 70.0 62.2515 .9783 1.0015 .3554	HELL SIDE  IBLE LIQ .700 OUT 99.1* 61.9031 .6983 .9987 .3630 18.02 97.6 .7100 165.00  10.00 10.00 00010 39.37 .020384 26.2
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES  PRESSURE DROP, TOT VELOCITY, CALC & M  FOULING RESISTANCE FILM COEFFICIENT  TOTAL HEAT DUTY RE	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL  DEGF KIN CP IGN PSIA  & ALLOWED PSI AX ALLOWED FT/S  HR-FT2-F/BT BTU/HR-FT2- QUIRED MEGBTU/HR (LMTD= 34.7,F=	HOT TU Tube SENSI  IN 140.0 61.2913 .4726 .9973 .3723  119.6 .5683 50.00  .05 .49  U .0 F .2180,BYPF 2-F	BLE LIQ .500 OUT 99.1* 61.9029 .6981 .9987 .3630 18.02 	COLD SE Shell SENS:  IN 70.0 62.2515 .9783 1.0015 .3554	HELL SIDE  IBLE LIQ  .700  OUT  99.1* 61.9031  .6983  .9987  .3630  18.02   97.6  .7100  165.00  10.00  10.00  20010  39.37  .020384

PASSES, SHELL 1 TUBE 4 E	OTAL EFF AREA FT2 7.1  FFFECTIVE AREA FT2/SHELL 7.1  EMA SHELL TYPE E ; REAR HEAD FXTS
SPACING, CENTRAL IN. 4.309 B SPACING, INLET IN. 4.309 C SPACING, OUTLET IN. 4.309	ROSS PASSES PER SHELL PASS 4 DAFFLE CUT, PCT SHELL I.D. 30.00 CUT DISTANCE FROM CENTER, IN764
BAFFLE THICKNESS IN125 I	MPINGEMENT BAFFLE INCLUDED NO UBESHEET BLANK AREA, % .0
NO OF TUBES/SHELL 76 E	NATERIAL ELECTROLYTIC COPPER ST MAX TUBE COUNT 36
TUBE LGTH, EFF FT 1.436 T	ST MAX TUBE COUNT 36 PUBE PITCH IN3125 PUBE OUTSIDE DIAM IN250 PUBE INSIDE DIAM IN214
PITCH RATIO 1.250 T	TUBE INSIDE DIAM IN214 TUBE SURFACE RATIO, OUT/IN 1.184 TUBE NOZZ ID, IN&OUT IN8 .8
	CODE = 8 c exchanger experiment E0002 P 77
Young model F302DY4P	9/23/ 3 CASE 38
S U P P L E M E N T A R	
HT PARAMETERS SHELL TUBE	SHELLSIDE PERFORMANCE
WALL CORRECTION 1.020 .000	NOMINAL VEL, X-FLOW FT/S .09
PRANDTL NUMBER 5.5 3.7	NOMINAL VEL, WINDOW FT/S .18
RYNLD NO, AVG 321. 1386.	CROSSFLOW COEF BTU/HR-FT2-F 290.5
RYNLD NO, IN BUN 269. 1667.	WINDOW COEF BTU/HR-FT2-F 292.3
RYNLD NO, OUT BUN 377. 1129.	
FOULNG LAYER IN0014 .0014	SHELLSIDE FLOW, % OF TOTAL HEAT TRANSFER X-FLOW 81.44
TUEDVAL DEGLETANCE ( OF TOTAL	HEAT TRANSFER X-FLOW 81.44
THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL	TUBE TO BAFFLE LEAKAGE A = 3.77
SHELL TUBE FOULING METAL	MAIN CROSSFLOW B = 64.87 BUNDLE TO SHELL BYPASS C = 15.82
3/.15 00.41 2.30 .08	BAFFLE TO SHELL LEAKAGE E = 15.55
TOT FOUL RESIST .000217 DIFF RESIST .000001	TUBE PASSLANE BYPASS F = .00
	SHELLSIDE HEAT TRANSFER FACTORS
DIAMETRAL CLEARANCES	TOTAL = (BETA) (GAMMA) (FIN) = $.707$
BUNDLE TO SHELL IN5000	
	GAMMA (TUBE ROW ENTRY EFCT) = .768
BAFFLE TO SHELL IN1000	END (HT LOSS IN END ZONE) = .994
	SHELL PRESSURE DROP, % OF TOTAL
HT UNDR NOZ IN25	WINDOW = 8.9
HT OPP NOZ IN25	END ZONE = 3.6
VELOCITY FT/S .57 .58	CROSS FLOW = 3.2
DENSITY LB/FT3 62.252 61.903	
NOZZ RHO*VSQ LB/FT-S2         20         20           BUND RHO*VSQ LB/FT-S2         13         13	OUTLET NOZZLE = 41.5

TUBE NOZZLE DATA VELOCITY FT/S DENSITY LB/FT3 PRESS. DROP % Washington Unive	.74 .73 61.291 61.903 8.3 5.3 ersity ChE433 he	3 DRY 3 WET 2		=	165. E0002 P 78
Young model F302DY	74P				9/23/ 3 CASE 39
SIZE 4- 18 TYPE BE	EM. MIILTT-PASS I	FIOW, SEGME	NTAL BAFFLI		
	,		JBE SIDE		
		Tube		Shell	
			BLE LIQ		
TOTAL FLOW RATE	KLB/HR		.500		.800
			OUT		
TEMPERATURE					
DENSITY VISCOSITY					
SPECIFIC HEAT					
THERMAL COND.					
MOLAR MASS			18.02	• 5551	18.02
	,				
TEMP, AVG & SKIN	DEGF	118.6	96.6	83.3	95.7
VISCOSITY, AVG & S	SKIN CP	.5735	.7178	.8325	.7247
PRESSURE, IN & DES	SIGN PSIA	50.00	165.00	50.00	165.00
				-	40.00
PRESSURE DROP, TO					
VELOCITY, CALC & N	MAX ALLOWED FT	/5 .49	10.00	•12	10.00
FOULING RESISTANCE	HR-FT2-F/I	3TU .(	00010	. (	00010
FILM COEFFICIENT					L8.55
TOTAL HEAT DUTY RE					.021329
EFF TEMP DIF, DEG			ASS= .94,BA	FF=1.00)	
OVERALL COEFF REQU					112.47
CLEAN & FOULED COR	EFF BTU/HR-1	FT2-F	115.9	6	112.63
SHELLS IN SERIES	1 זייי דער אר דייי דער אר		2 7 10 12 7	Em 0	7 1
PASSES, SHELL					
SHELL DIAMETER IN.					
		12111 21121		, 112111 111	1112
BAFFLE TYPE	HORZ SEGMENTL	CROSS PAS	SSES PER SHI	ELL PASS	4
SPACING, CENTRAL	T 1 1 0 0 0	בארבור כו	IT. POT SHE	r.t. t D	30.00
SPACING, INLET	IN. 4.309	CUT DISTA			
SPACING, OUTLET	IN. 4.309 IN. 4.309	CUT DISTA	ANCE FROM CI	ENTER, IN.	.764
SPACING, OUTLET BAFFLE THICKNESS	IN. 4.309 IN. 4.309 IN125	CUT DISTA	ANCE FROM CI	ENTER, IN.	.764 NO
SPACING, OUTLET	IN. 4.309 IN. 4.309 IN125	CUT DISTA	ANCE FROM CI	ENTER, IN.	.764
SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I	IN. 4.309 IN. 4.309 IN125 DEVICES 1	CUT DISTA	ANCE FROM CI	ENTER, IN. INCLUDED A, %	.764 NO .0
SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I TUBE TYPE	IN. 4.309 IN. 4.309 IN125 DEVICES 1 PLAIN	CUT DISTAINPINGEME TUBESHEET MATERIAL	ANCE FROM CI ENT BAFFLE : BLANK AREA	ENTER, IN. INCLUDED A, % LECTROLYTIC	.764 NO .0 C COPPER
SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I TUBE TYPE NO. OF TUBES/SHELI	IN. 4.309 IN. 4.309 IN125 DEVICES 1 PLAIN To 76	CUT DISTAINT OF TUBESHEET MATERIAL EST MAX TO	ANCE FROM CI ENT BAFFLE : BLANK AREZ EI EUBE COUNT	ENTER, IN. INCLUDED A, % LECTROLYTIC	.764 NO .0 C COPPER 36
SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI	IN. 4.309 IN. 4.309 IN125 DEVICES 1 PLAIN 76 L FT 1.500	CUT DISTAINED IMPINGEMENTUBESHEET  MATERIAL EST MAX TUBE PITC	ANCE FROM CIENT BAFFLE : BLANK AREZ CUBE COUNT	ENTER, IN. INCLUDED A, % LECTROLYTIC IN.	.764 NO .0 C COPPER 36 .3125
SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I TUBE TYPE NO. OF TUBES/SHELI	IN. 4.309 IN. 4.309 IN125 DEVICES 1  PLAIN 76 FT 1.500 FT 1.436	CUT DISTALL IMPINGEMENTUBESHEED MATERIAL EST MAX TUBE PITCE	ANCE FROM CI	ENTER, IN. INCLUDED A, % LECTROLYTIC IN. IN.	.764 NO .0 C COPPER 36 .3125 .250
SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I  TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI TUBE LGTH, EFF	IN. 4.309 IN. 4.309 IN125 DEVICES 1  PLAIN 76 FT 1.500 FT 1.436 DEG 60	IMPINGEME TUBESHEET  MATERIAL EST MAX TUBE PITC TUBE OUTS TUBE INST	ANCE FROM CIENT BAFFLE : BLANK AREA  CUBE COUNT CH SIDE DIAM IDE DIAM	ENTER, IN. INCLUDED A, % LECTROLYTIC IN. IN. IN.	.764 NO .0 C COPPER 36 .3125 .250 .214

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 79 Young model F302DY4P 9/23/ 3 CASE 39 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 1.020 .000 NOMINAL VEL, X-FLOW FT/S 

 WALL CORRECTION
 1.020
 .000
 NOMINAL VEL, X-FLOW FT/S
 .10

 PRANDTL NUMBER
 5.6
 3.8
 NOMINAL VEL, WINDOW FT/S
 .20

 RYNLD NO, AVG
 362.
 1374.
 CROSSFLOW COEF BTU/HR-FT2-F 319.8

 RYNLD NO, IN BUN
 308.
 1667.
 WINDOW COEF BTU/HR-FT2-F 321.8

 RYNLD NO, OUT BUN 420. 1106. RYNLD NO, OUT BUN 420. 1106.

FOULNG LAYER IN. .0014 .0014 SHELLSIDE FLOW, % OF TOTAL

HEAT TRANSFER X-FLOW 81.44

THERMAL RESISTANCE, % OF TOTAL TUBE TO BAFFLE LEAKAGE A = 3.92

SHELL TUBE FOULING METAL MAIN CROSSFLOW B = 64.59

34.96 62.52 2.44 .08 BUNDLE TO SHELL BYPASS C = 16.06

PCT OVER DESIGN .14 BAFFLE TO SHELL LEAKAGE E = 15.44 PCT OVER DESIGN .14 BAFFLE TO SHELL LEAKAGE E = 15.44 TOT FOUL RESIST .000217 TUBE PASSLANE BYPASS F = .00 DIFF RESIST .000012 SHELLSIDE HEAT TRANSFER FACTORS SHELLSIDE HEAT TRANSFER FACTORS

DIAMETRAL CLEARANCES

TOTAL = (BETA) (GAMMA) (FIN) = .731

BUNDLE TO SHELL IN. .5000 BETA (BAFF CUT FACTOR) = .920

TUBE TO BAFFLE HOLE IN. .0284 GAMMA (TUBE ROW ENTRY EFCT) = .795

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 .25 WINDOW .25 END ZONE HT OPP NOZ IN. .25 END ZONE
VELOCITY FT/S .65 .66 CROSS FLOW DENSITY LB/FT3 62.252 61.935 INLET NOZZLE = 42.8 NOZZ RHO\*VSQ LB/FT-S2 26 26 OUTLET NOZZLE BUND RHO\*VSQ LB/FT-S2 18 18 TUBE NOZZLE DATA IN OUT WEIGHT PER SHELL, LB VELOCITY FT/S .74 .73 DRY 150. DENSITY LB/FT3 61.291 61.928 WET 165. PRESS. DROP % 8.3 5.2 Washington University ChE433 heat exchanger experiment E0002 P 80 Young model F302DY4P 9/23/ 3 CASE 40 SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING HOT TUBE SIDE COLD SHELL SIDE Shell Tube SENSIBLE LIQ SENSIBLE LIQ
.500 .900
IN OUT IN OUT
140.0 95.5\* 70.0 94.7\* TOTAL FLOW RATE KLB/HR TEMPERATURE DEGF 140.0 95.5\* 70.0 94.75
DENSITY LB/FT3 61.2913 61.9507 62.2515 61.9609
VISCOSITY CP .4726 .7262 .9783 .7325
SPECIFIC HEAT BTU/LB-F .9973 .9990 1.0015 .9991

THERMAL COND. BTU MOLAR MASS LB/	/HR-FT-F LBMOL	che433b(70)	.3621	.3554	.3619 18.02
TEMP, AVG & SKIN VISCOSITY, AVG & SKIN PRESSURE, IN & DESIGN	DEGF CP PSIA	117.7 .5784 50.00	94.9 .7306 165.00	82.3 .8422 50.00	94.0 .7380 165.00
PRESSURE DROP, TOT & A VELOCITY, CALC & MAX A	LLOWED PSI LLOWED FT/S	.05	10.00	.02	10.00
FOULING RESISTANCE FILM COEFFICIENT	HR-FT2-F/BTU BTU/HR-FT2-F	213.	38	.00	
TOTAL HEAT DUTY REQUIRE FF TEMP DIF, DEGF (LOVERALL COEFF REQUIRED CLEAN & FOULED COEFF	ED MEGBTU/HR MTD= 34.4,F=	.82,BYPASS	= .95,BAFF=	1.00)	.022213 26.7 116.30 116.12
SHELLS IN SERIES 1 PAPASSES, SHELL 1 TUSHELL DIAMETER IN.	RALLEL 1 TBE 4 E	COTAL EFF A	REA FT REA FT TYPE E ;	2 2/SHELL REAR HE	7.1 7.1 AD FXTS
BAFFLE TYPE HORZ SPACING, CENTRAL IN. SPACING, INLET IN. SPACING, OUTLET IN. BAFFLE THICKNESS IN. PAIRS OF SEALING DEVICE	4 000 -				0.0.00
TUBE TYPE  NO. OF TUBES/SHELL  TUBE LGTH, OVERALL FT  TUBE LGTH, EFF FT  TUBE LAYOUT DE  PITCH RATIO  SHL NOZZ ID, IN&OUT	PLAIN M 76 E	MATERIAL EST MAX TUB	ELEC E COUNT	TROLYTIC	COPPER 36
* CALCULATED ITEMH Washington Universit Young model F302DY4P  S U P P L E M E	y ChE433 heat	exchanger			E0002 P 81 9/23/ 3 CASE 40
PRANDTL NUMBER 5 RYNLD NO, AVG 40	19 .000 .7 3.8 2. 1362. 6. 1667. 2. 1085.	NOMINAL VI NOMINAL VI CROSSFLOW WINDOW CO.	DE PERFORMA: EL, X-FLOW EL, WINDOW COEF BTU EF BTU DE FLOW, %	FT/S FT/S /HR-FT2-F /HR-FT2-F	351.7
THERMAL RESISTANCE, % SHELL TUBE FOULING		TUBE TO B	SFER X-FLOW AFFLE LEAKA SFLOW	GE A =	

32.97 64.43 2	.52 .0	8	BUNDLE	TO SHELL BY	YPASS C	= 16.20
PCT OVER DESIGN TOT FOUL RESIST	0.0	15	BAFFLE	TO SHELL LE	EAKAGE E	= 15.33
			TUBE PA	ASSLANE BYPA	ASS F	= .00
DIFF RESIST	00	0013	CUETT	LSIDE HEAT T	PDAMCEED E	$\lambda$ CTODS
DIAMETRAL CLEARA	NCES		_	=(BETA)(GAMN	_	
BUNDLE TO SHELL	IN.	.5000		(BAFF CUT FA		
TUBE TO BAFFLE HOL						
BAFFLE TO SHELL		.1000		(HT LOSS IN		
SHELL NOZZLE DAT		OUT		L PRESSURE I	DROP, % OF	
HT UNDR NOZ IN.	.25		WINDOW			= 8.9
HT OPP NOZ IN.	.25		END ZON			= 3.3
VELOCITY FT/S DENSITY LB/FT3	.74		CROSS E			= 3.0 = 42.9
						= 42.9
NOZZ RHO*VSQ LB/FT BUND RHO*VSQ LB/FT	-S2 33	33	OUTLET	NOZZLE		= 42.0
ROND KHO, APO TR/ L.I.	-52 22	23				
TUBE NOZZLE DATA	IN	OUT	WEIGH	HT PER SHELI	L, LB	
TUBE NOZZLE DATA VELOCITY FT/S	.74	.73	DRY		= =	150.
DENSITY LB/FT3	61.291 6	1.951	WET		=	
PRESS. DROP %						
Washington Unive	rsity ChE4	33 heat	exchang	ger experime	ent	E0002 P 82
Young model F302DY	4 P					9/23/ 3
						CASE 41
SIZE 4- 18 TYPE BE	M, MULTI-P.	ASS FLO	W, SEGME	ENTAL BAFFLE	ES, RATING	
	•					
	,		HOT TU	JBE SIDE	COLD S	HELL SIDE
	,		HOT TU	JBE SIDE	COLD S	HELL SIDE l
			HOT TU	JBE SIDE	COLD S	HELL SIDE l IBLE LIQ
TOTAL FLOW RATE			HOT TU Tube SENSI	JBE SIDE IBLE LIQ .600	COLD S Shel SENS	HELL SIDE l IBLE LIQ .200
TOTAL FLOW RATE	KLB/HR		HOT TU Tube SENSI IN	JBE SIDE  IBLE LIQ  .600  OUT	COLD S Shel SENS IN	HELL SIDE 1 IBLE LIQ .200 OUT
TOTAL FLOW RATE TEMPERATURE	KLB/HR DEGF		HOT TU Tube SENSI IN 140.0	JBE SIDE  IBLE LIQ  .600  OUT  121.7*	COLD S. Shel. SENS IN 70.0	HELL SIDE  1  IBLE LIQ  .200  OUT  124.8*
TOTAL FLOW RATE TEMPERATURE DENSITY	KLB/HR DEGF LB/FT3		HOT TU Tube SENSI IN 140.0 1.2913	JBE SIDE  IBLE LIQ  .600  OUT  121.7*  61.5830	COLD S. Shel SENS IN 70.0 62.2515	HELL SIDE  1  IBLE LIQ  .200  OUT  124.8*  61.5352
TOTAL FLOW RATE TEMPERATURE DENSITY VISCOSITY	KLB/HR DEGF LB/FT3 CP	6	HOT TU Tube SENSI IN 140.0 1.2913 .4726	JBE SIDE  IBLE LIQ  .600  OUT  121.7*  61.5830  .5570	COLD S. Shel. SENS  IN 70.0 62.2515 .9783	HELL SIDE  1  IBLE LIQ .200 OUT 124.8* 61.5352 .5409
TOTAL FLOW RATE  TEMPERATURE  DENSITY  VISCOSITY  SPECIFIC HEAT	KLB/HR  DEGF LB/FT3 CP BTU/LB-F	6	HOT TU Tube SENSI IN 140.0 1.2913 .4726 .9973	JBE SIDE  JBLE LIQ  .600  OUT  121.7*  61.5830  .5570  .9976	COLD S. Shel. SENS  IN 70.0 62.2515 .9783 1.0015	HELL SIDE  1  IBLE LIQ .200 OUT 124.8* 61.5352 .5409 .9975
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND.	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT	6	HOT TU Tube SENSI IN 140.0 1.2913 .4726	JBE SIDE  IBLE LIQ .600 OUT 121.7* 61.5830 .5570 .9976 .3684	COLD S. Shel. SENS  IN 70.0 62.2515 .9783	HELL SIDE  1  IBLE LIQ .200 OUT 124.8* 61.5352 .5409 .9975 .3691
TOTAL FLOW RATE  TEMPERATURE  DENSITY  VISCOSITY  SPECIFIC HEAT	KLB/HR  DEGF LB/FT3 CP BTU/LB-F	6	HOT TU Tube SENSI IN 140.0 1.2913 .4726 .9973	JBE SIDE  JBLE LIQ  .600  OUT  121.7*  61.5830  .5570  .9976	COLD S. Shel. SENS  IN 70.0 62.2515 .9783 1.0015	HELL SIDE  1  IBLE LIQ .200 OUT 124.8* 61.5352 .5409 .9975
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND.	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT LB/LBMOL	6 - F	IN 140.0 1.2913 .4726 .9973 .3723	JBE SIDE  IBLE LIQ .600 OUT 121.7* 61.5830 .5570 .9976 .3684 18.02	COLD S. Shel. SENS  IN 70.0 62.2515 .9783 1.0015 .3554	HELL SIDE  1  IBLE LIQ .200 OUT 124.8* 61.5352 .5409 .9975 .3691 18.02
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS	KLB/HR  DEGF  LB/FT3  CP  BTU/LB-F  BTU/HR-FT  LB/LBMOL  DEGF	6 - F	IN 140.0 1.2913 .4726 .9973 .3723	JBE SIDE  IBLE LIQ .600 OUT 121.7* 61.5830 .5570 .9976 .3684 18.02 116.7 .5843	COLD S:     Shel.     SENS      IN     70.0 62.2515     .9783 1.0015     .3554	HELL SIDE  1  IBLE LIQ .200 OUT 124.8* 61.5352 .5409 .9975 .3691 18.02 116.1 .5876
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN	KLB/HR  DEGF  LB/FT3  CP  BTU/LB-F  BTU/HR-FT  LB/LBMOL  DEGF  KIN CP	6 -F	IN 140.0 1.2913 .4726 .9973 .3723	JBE SIDE  IBLE LIQ .600 OUT 121.7* 61.5830 .5570 .9976 .3684 18.02	COLD S:     Shel.     SENS      IN     70.0 62.2515     .9783 1.0015     .3554	HELL SIDE  1  IBLE LIQ .200 OUT 124.8* 61.5352 .5409 .9975 .3691 18.02 116.1 .5876
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT LB/LBMOL  DEGF KIN CP IGN PSIA	6 -F	IN 140.0 1.2913 .4726 .9973 .3723 130.8 .5121 50.00	JBE SIDE  JBLE LIQ  .600  OUT  121.7* 61.5830  .5570  .9976  .3684  18.02   116.7  .5843  165.00	COLD S. Shel. SENS  IN 70.0 62.2515 .9783 1.0015 .3554  97.4 .7111 50.00	HELL SIDE  1  IBLE LIQ .200 OUT 124.8* 61.5352 .5409 .9975 .3691 18.02 116.1 .5876 165.00
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES  PRESSURE DROP, TOT	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT LB/LBMOL  DEGF KIN CP IGN PSIA	6 -F PSI	IN 140.0 1.2913 .4726 .9973 .3723 130.8 .5121 50.00	JBE SIDE  JBLE LIQ  .600  OUT  121.7* 61.5830  .5570  .9976  .3684  18.02   116.7  .5843  165.00	COLD S:     Shel.     SENS  IN     70.0 62.2515     .9783 1.0015     .3554  97.4 .7111 50.00	HELL SIDE  1  IBLE LIQ .200 OUT 124.8* 61.5352 .5409 .9975 .3691 18.02 116.1 .5876 165.00
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT LB/LBMOL  DEGF KIN CP IGN PSIA	6 -F PSI	IN 140.0 1.2913 .4726 .9973 .3723 130.8 .5121 50.00	JBE SIDE  JBLE LIQ  .600  OUT  121.7* 61.5830  .5570  .9976  .3684  18.02   116.7  .5843  165.00	COLD S:     Shel.     SENS  IN     70.0 62.2515     .9783 1.0015     .3554  97.4 .7111 50.00	HELL SIDE  1  IBLE LIQ .200 OUT 124.8* 61.5352 .5409 .9975 .3691 18.02 116.1 .5876 165.00
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES  PRESSURE DROP, TOT VELOCITY, CALC & M	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT LB/LBMOL  DEGF KIN CP IGN PSIA & ALLOWED AX ALLOWED	6 -F PSI FT/S	IN 140.0 1.2913 .4726 .9973 .3723 130.8 .5121 50.00 .07 .59	JBE SIDE  JBLE LIQ  .600  OUT  121.7* 61.5830  .5570  .9976  .3684  18.02   116.7  .5843  165.00  10.00  10.00	COLD S. Shel. SENS  IN 70.0 62.2515 .9783 1.0015 .3554  97.4 .7111 50.00 .00 .03	HELL SIDE  1  IBLE LIQ .200 OUT 124.8* 61.5352 .5409 .9975 .3691 18.02 116.1 .5876 165.00
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES  PRESSURE DROP, TOT	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT LB/LBMOL  DEGF KIN CP IGN PSIA & ALLOWED AX ALLOWED HR-FT	6 -F PSI FT/S 2-F/BTU	IN 140.0 1.2913 .4726 .9973 .3723 130.8 .5121 50.00 .07 .59	JBE SIDE  JBLE LIQ  .600  OUT  121.7* 61.5830  .5570  .9976  .3684  18.02   116.7  .5843  165.00  10.00  10.00	COLD S:     Shel.     SENS  IN     70.0 62.2515     .9783 1.0015     .3554  97.4     .7111 50.00  .00     .03	HELL SIDE  1  IBLE LIQ .200  OUT 124.8* 61.5352 .5409 .9975 .3691 18.02 116.1 .5876 165.00  10.00 10.00
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES  PRESSURE DROP, TOT VELOCITY, CALC & M  FOULING RESISTANCE	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT LB/LBMOL  DEGF KIN CP IGN PSIA & ALLOWED AX ALLOWED HR-FT BTU/H	6 -F PSI FT/S 2-F/BTU R-FT2-F	HOT TU Tube SENSI  IN 140.0 1.2913 .4726 .9973 .3723 130.8 .5121 50.00 .07 .59	JBE SIDE  JBLE LIQ  .600  OUT  121.7* 61.5830  .5570  .9976  .3684  18.02   116.7  .5843  165.00  10.00  10.00	COLD S. Shel. SENS  IN 70.0 62.2515 .9783 1.0015 .3554  97.4 .7111 50.00 .00 .03	HELL SIDE  1  IBLE LIQ .200 OUT 124.8* 61.5352 .5409 .9975 .3691 18.02 116.1 .5876 165.00  10.00 10.00
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES  PRESSURE DROP, TOT VELOCITY, CALC & M  FOULING RESISTANCE FILM COEFFICIENT  TOTAL HEAT DUTY RE	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT LB/LBMOL  DEGF KIN CP IGN PSIA & ALLOWED AX ALLOWED HR-FT BTU/H	PSI FT/S 2-F/BTU R-FT2-F  BTU/HR	HOT TU Tube SENSI  IN 140.0 1.2913 .4726 .9973 .3723 130.8 .5121 50.00 .07 .59	JBE SIDE  JBLE LIQ  .600  OUT  121.7* 61.5830  .5570  .9976  .3684  18.02  116.7  .5843  165.00  10.00  10.00  10.00  10.00	COLD S. Shel. SENS  IN 70.0 62.2515 .9783 1.0015 .3554  97.4 .7111 50.00 .00 .03	HELL SIDE  1  IBLE LIQ .200 OUT 124.8* 61.5352 .5409 .9975 .3691 18.02 116.1 .5876 165.00  10.00 10.00 10.00 00010 36.13 .010952
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES  PRESSURE DROP, TOT VELOCITY, CALC & M  FOULING RESISTANCE FILM COEFFICIENT  TOTAL HEAT DUTY RE EFF TEMP DIF, DEGF	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT LB/LBMOL  DEGF KIN CP IGN PSIA & ALLOWED AX ALLOWED HR-FT BTU/H QUIRED MEG (LMTD= 2	PSI FT/S 2-F/BTU R-FT2-F  BTU/HR 9.8,F=	HOT TU Tube SENSI  IN 140.0 1.2913 .4726 .9973 .3723 130.8 .5121 50.00 .07 .59 .0 2174,BYPF	JBE SIDE  JBLE LIQ  .600  OUT  121.7* 61.5830  .5570  .9976  .3684  18.02  116.7  .5843  165.00  10.00  10.00  10.00  10.00	COLD S. Shel. SENS  IN 70.0 62.2515 .9783 1.0015 .3554  97.4 .7111 50.00 .00 .03	HELL SIDE  I IBLE LIQ .200 OUT 124.8* 61.5352 .5409 .9975 .3691 18.02 116.1 .5876 165.00 10.00 10.00 10.00 00010 36.13 .010952 19.8
TOTAL FLOW RATE  TEMPERATURE DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES  PRESSURE DROP, TOT VELOCITY, CALC & M  FOULING RESISTANCE FILM COEFFICIENT  TOTAL HEAT DUTY RE	KLB/HR  DEGF LB/FT3 CP BTU/LB-F BTU/HR-FT LB/LBMOL  DEGF KIN CP IGN PSIA & ALLOWED AX ALLOWED AX ALLOWED URED MEG (LMTD= 2 IRED BTU	PSI FT/S 2-F/BTU R-FT2-F  BTU/HR 9.8,F= /HR-FT2	HOT TU Tube SENSI  IN 140.0 1.2913 .4726 .9973 .3723 130.8 .5121 50.00 .07 .59 .00 .174,BYPF-F	JBE SIDE  JBLE LIQ  .600  OUT  121.7* 61.5830  .5570  .9976  .3684  18.02  116.7  .5843  165.00  10.00  10.00  10.00  10.00	COLD S:     Shel     SENS      IN     70.0 62.2515     .9783 1.0015     .3554  97.4     .7111 50.00     .00     .03	HELL SIDE  1  IBLE LIQ .200 OUT 124.8* 61.5352 .5409 .9975 .3691 18.02 116.1 .5876 165.00  10.00 10.00 10.00 00010 36.13 .010952

	che433b(70).OUT	
SHELLS IN SERIES 1 PARALLEL 1	TOTAL EFF AREA FT2	7.1
	EFFECTIVE AREA FT2/SHELL	
SHELL DIAMETER IN. 3.820	TEMA SHELL TYPE E ; REAR HEA	
SHELL DIAMETER IN. 5.020	TEMA SHELL TIPE E , KEAK HEA	AD LVI2
BAFFLE TYPE HORZ SEGMENTL	CROSS PASSES PER SHELL PASS	
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 IN125	IMPINGEMENT BAFFLE INCLUDED	NO
PAIRS OF SEALING DEVICES 1		
PAIRS OF SEALING DEVICES I	TUBESHEET BLANK AREA, %	.0
TUBE TYPE PLAIN	MATERIAL ELECTROLYTIC	
NO. OF TUBES/SHELL 76	EST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT 1.500	TUBE PITCH IN.	
TUBE LGTH, EFF FT 1.436	TUBE OUTSIDE DIAM IN.	
TUBE LAYOUT DEG 60	TUBE INSIDE DIAM IN.	.214
PITCH RATIO 1.250	TUBE SURFACE RATIO, OUT/IN	
SHL NOZZ ID, IN&OUT 1.0 1.0	TUBE NOZZ ID, IN&OUT IN.	.8 .8
* CALCULATED ITEMHEAT BALANCE	CODE = 8	
Washington University ChE433 hea	at exchanger experiment	E0002 P 83
Young model F302DY4P		9/23/ 3
		CASE 41
SUPPLEMENTAF	R Y R E S U L T S	
HT PARAMETERS SHELL TUBE	SHELLSIDE PERFORMANCE	
WALL CORRECTION 1.027 .000		0.3
PRANDTL NUMBER 4.7 3.3		
RYNLD NO, AVG 105. 1846.		
RYNLD NO, IN BUN 76. 2000.		F 137.5
RYNLD NO, OUT BUN 138. 1698.		
FOULNG LAYER IN0014 .0014	SHELLSIDE FLOW, % OF TOTAL	
	HEAT TRANSFER X-FLOW	
THERMAL RESISTANCE, % OF TOTAL		
SHELL TUBE FOULING METAL		
55.86 42.42 1.67 .06		
PCT OVER DESIGN44	BAFFLE TO SHELL LEAKAGE E =	= 17.20
TOT FOUL RESIST .000217	TUBE PASSLANE BYPASS F =	= .00
DIFF RESIST000057		
,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	SHELLSIDE HEAT TRANSFER FAC	TTORS
DIAMETRAL CLEARANCES	DOUBL - (DOUB) (CANNA) (DIN)	- 500
BUNDLE TO SHELL IN5000		
TUBE TO BAFFLE HOLE IN0284	GAMMA (TUBE ROW ENTRY EFCT) =	= .650
BAFFLE TO SHELL IN1000	END (HT LOSS IN END ZONE) =	= .994
	,	
SHELL NOZZLE DATA IN OUT	CHELL DDECCTIDE DDOD 6 OF 1	r∩πa τ
HT UNDR NOZ IN25		= 9.5
HT OPP NOZ IN25		= 6.5
VELOCITY FT/S .16 .17	CROSS FLOW =	= 5.1
DENSITY LB/FT3 62.252 61.535	INLET NOZZLE	= 40.9
NOZZ RHO*VSQ LB/FT-S2 1 1	OUTLET NOZZLE	= 38.0
BUND RHO*VSQ LB/FT-S2 1 1		50.0

TUBE NOZ	ZLE DATA	IN	OUT	WEIGHT	PER	SHELL,	LB		
VELOCITY	FT/S	.89	.88	DRY				=	150.
DENSITY	LB/FT3	61.291	61.583	WET				=	165.
PRESS. DROI	P %	8.7	5.5						

## \*\*\* SPECIAL MESSAGES AND WARNINGS \*\*\*

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

Washington Univer Young model F302DY		at exchang	er experime	ent	E0002 P 8 9/23/ 3 CASE 42
SIZE 4- 18 TYPE BEI		HOT TU	NTAL BAFFLE BE SIDE BLE LIQ	COLD SH	HELL SIDE
		SENSI	BLE LIO	SENSI	IBLE LIO
TOTAL FLOW RATE	KLB/HR		.600		.300
TOTAL FLOW RATE TEMPERATURE	•	IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	116.0*	70.0	118.0*
DENSITY	LB/FT3	61.2913	61.6684	62.2515	61.6386
VISCOSITY			.5883		
SPECIFIC HEAT	BTU/LB-F	.9973	.9978	1.0015	.9977
SPECIFIC HEAT THERMAL COND. MOLAR MASS	BTU/HR-FT-F	.3723	.9978 .3671	1.0015 .3554	.3675
MOLAR MASS	LB/LBMOL		18.02		
	,				
TEMP, AVG & SKIN	DEGF	128.0			
VISCOSITY, AVG & SI	KIN CP	.5255	.6129	.7380	.6170
PRESSURE, IN & DES	IGN PSIA	50.00	.6129 165.00	50.00	165.00
,					
PRESSURE DROP, TOT	& ALLOWED PSI	.07	10.00	.00	10.00
VELOCITY, CALC & MA					
,					
FOULING RESISTANCE	HR-FT2-F/B	TU .0	0010	.(	00010
FOULING RESISTANCE FILM COEFFICIENT	BTU/HR-FT2	-F 21	5.59	17	70.15
TOTAL HEAT DUTY REG	QUIRED MEGBTU/H	IR			.014384
EFF TEMP DIF, DEGF	(LMTD= 32.5, F	'= .77,BYPA	SS= .92,BAH	FF=1.00)	23.1
OVERALL COFFE REOIL	TRED BTH/HR-E	ייי 2 – די			87.08
CLEAN & FOULED COE	FF BTU/HR-F	T2-F	88.47	7	86.76
SHELLS IN SERIES	1 PARALLEL 1	TOTAL EFF	' AREA	FT2	7.1
PASSES, SHELL					
SHELL DIAMETER IN.					
BAFFLE TYPE HO	ORZ SEGMENTL	CROSS PAS	SES PER SH	ELL PASS	4
SPACING, CENTRAL	IN. 4.309	BAFFLE CU	T, PCT SHEI	LL I.D.	30.00
SPACING, INLET	IN. 4.309	CUT DISTA	NCE FROM CE	ENTER, IN.	.764
SPACING, OUTLET	IN. 4.309				
BAFFLE THICKNESS	IN125	IMPINGEME	NT BAFFLE	INCLUDED	NO
BAFFLE THICKNESS PAIRS OF SEALING D	EVICES 1	TUBESHEET	BLANK ARE	A, %	.0

		che433b(70).OUT	
TUBE TYPE	PLAIN M	ATERIAL ELECTROL	YTIC COPPER
NO. OF TUBES/SHELL	76 E	ST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT	1.500 T	UBE PITCH IN.	.3125
TUBE LGTH, EFF FT	1.436 T	UBE OUTSIDE DIAM IN.	.250
TUBE LAYOUT DEG			.214
PITCH RATIO			
SHL NOZZ ID, IN&OUT 1.0		•	.8 .8
SHL NOZZ ID, IN&OUT 1.0	1.0 1	OBE NOZZ ID, IN&OUT IN.	.0 .0
* CALCULATED ITEMHEAT			
	hE433 heat	exchanger experiment	
Young model F302DY4P			9/23/ 3
			CASE 42
SUPPLEMEN	T A R	Y RESULT	S
HT PARAMETERS SHELL	TUBE	SHELLSIDE PERFORMANCE	
WALL CORRECTION 1.025	.000	NOMINAL VEL, X-FLOW FT/S	.04
PRANDTL NUMBER 4.9		NOMINAL VEL, WINDOW FT/S	
RYNLD NO, AVG 153.		CROSSFLOW COEF BTU/HR-	
RYNLD NO, IN BUN 115.		WINDOW COEF BTU/HR-	
RYNLD NO, OUT BUN 195.		WINDOW COEF BIO/HK-	F12-F 1/1.9
		0.000	O
FOULNG LAYER IN0014	.0014		
		HEAT TRANSFER X-FLOW	
THERMAL RESISTANCE, % OF		TUBE TO BAFFLE LEAKAGE	
SHELL TUBE FOULING M		MAIN CROSSFLOW	
50.42 47.64 1.88			
PCT OVER DESIGN	38	BAFFLE TO SHELL LEAKAGE	E = 16.41
TOT FOUL RESIST	.000217	TUBE PASSLANE BYPASS	F = .00
DIFF RESIST -	.000043		
		SHELLSIDE HEAT TRANSFE	R FACTORS
DIAMETRAL CLEARANCES		TOTAL = (BETA) (GAMMA) (FIN	) = .616
BUNDLE TO SHELL IN.		BETA (BAFF CUT FACTOR)	
	.0284	GAMMA (TUBE ROW ENTRY EF	
	.1000	END (HT LOSS IN END ZO	·
DATIBLIO SHEEL IN.	.1000	LID (III LOSS IN LINE ZO	ND) JJ4
CHELL MORRIE DAMA TI	NI OIIM	SHELL PRESSURE DROP, %	
		WINDOW	= 9.1
HT OPP NOZ IN2		END ZONE	= 5.2
VELOCITY FT/S .2			= 4.3
DENSITY LB/FT3 62.25			= 41.8
NOZZ RHO*VSQ LB/FT-S2		OUTLET NOZZLE	= 39.5
BUND RHO*VSQ LB/FT-S2	2 2		
TUBE NOZZLE DATA I	N OUT	WEIGHT PER SHELL, LB	
VELOCITY FT/S .8			= 150.
DENSITY LB/FT3 61.29			= 165.
PRESS. DROP % 8.			
• • • • • • • • • • • • • • • • • • • •			

<sup>\*\*\*</sup> 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 86 Young model F302DY4P 9/23/3

CASE 43

					CASE 43
SIZE 4- 18 TYPE BE	M, MULTI-PASS H	FLOW, SEGME	ENTAL BAFFL	ES, RATING	
		HOT TU	JBE SIDE	COLD SI	HELL SIDE
		Tube		Shell	L
		SENSI	IBLE LIQ	SENS	IBLE LIQ
TOTAL FLOW RATE	KLB/HR		.600		.400
	KLB/HR	IN	OUT	IN	OUT
TEMPERATURE					
DENSITY					
VISCOSITY					
SPECIFIC HEAT					
THERMAL COND.					
MOLAR MASS	TR/TRMOT		18.02		18.02
TEMP, AVG & SKIN	DEGE				
VISCOSITY, AVG & S					
PRESSURE, IN & DES					
INDOONE, IN & DES	ION IOIA	30.00	103.00	30.00	100.00
PRESSURE DROP, TOT	& ALLOWED PS	т .07	10.00	- 0.0	10.00
VELOCITY, CALC & M					
veedelli, died a ii	1111 111110 1117	• • • • • • • • • • • • • • • • • • • •	10.00	• 0 0	10.00
FOULING RESISTANCE	HR-FT2-F/F	3TU . (	00010	. (	00010
FILM COEFFICIENT					
					,
TOTAL HEAT DUTY RE	OUTRED MEGRTU/	HR			.016969
EFF TEMP DIF, DEGF			ASS= 93 BA	FF=1 00)	
OVERALL COEFF REQU			100 . 70 / 211	11 1.00)	94.45
CLEAN & FOULED COE			96 5	7	94.44
CHEAN & FOOLED COE	rr bio/iik i	rız r	50.5	,	24.44
SHELLS IN SERIES	1 PARAT.T.ET. 1	TOTAL EFF	T AREA	FT2	7 1
PASSES, SHELL					
SHELL DIAMETER IN.					
SHELL DIAMETER IN.	3.020	TEMA SHEI		, INDAIN III	LAD FAIS
BAFFLE TYPE H	ORZ SEGMENTI.	CROSS PAS	SSES PER SH	EI.I. PASS	Д
SPACING, CENTRAL					
SPACING, INLET			ANCE FROM C		
SPACING, OUTLET		COI DIDII	ANCE TROP C	DIVIDIT, IIV.	. 704
BAFFLE THICKNESS		TMDTNCEME	מוס א המוד	TNCTUDED	NO
			ENT BAFFLE		
PAIRS OF SEALING D	EVICES I	TUBESHEET	I BLANK ARE.	A, 6	.0
TUBE TYPE	PLAIN	ΜλͲΕΌΤλΤ	E'	T ECTENT VTT	CODDED
NO. OF TUBES/SHELL					36
TUBE LGTH, OVERALL	/ b	EOI MAY J	LUDE COUNT	TNI	
TUBE LGTH, EFF					
TUBE LAYOUT	DEG 60	TUBE INSI	LDE DIAM	TN.	.214
PITCH RATIO					
SHL NOZZ ID, IN&OU					

Washington University ChE433 heat exchanger experiment E0002 P 87

9/23/ 3

\* CALCULATED ITEM--HEAT BALANCE CODE = 8

Young model F302DY4P

S U P P L E M E N T A R	Y RESULTS	CASE 43
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.024 .000 PRANDTL NUMBER 5.1 3.5 RYNLD NO, AVG 198. 1764. RYNLD NO, IN BUN 154. 2000. RYNLD NO,OUT BUN 247. 1540. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 46.18 51.70 2.05 .07 PCT OVER DESIGN01 TOT FOUL RESIST .000217 DIFF RESIST000001	CHELLCIDE DEDEODMANCE	
WALL CORRECTION 1 024 000	NOMINAL VEL Y-FLOW FT/S	0.5
PRANDTI NUMBER 5 1 3 5	NOMINAL VEL, X FLOW FT/S	10
RYNID NO AVG 198 1764	CROSSFIOW COEF BTIL/HR-FT2-F	203 0
RYNID NO TN BIIN 154 2000	WINDOW COFF BTIL/HR-FT2-F	203.0
RYNLD NO.OUT BUN 247. 1540.	WINDOW COLL BIO/III( 112 1	204.4
FOULNG LAYER IN0014 .0014	SHELLSIDE FLOW, % OF TOTAL	
	HEAT TRANSFER X-FLOW	81.41
THERMAL RESISTANCE, % OF TOTAL	TUBE TO BAFFLE LEAKAGE A =	3.17
SHELL TUBE FOULING METAL	MAIN CROSSFLOW B =	66.96
46.18 51.70 2.05 .07	BUNDLE TO SHELL BYPASS C =	13.82
PCT OVER DESIGN01	BAFFLE TO SHELL LEAKAGE E =	16.06
TOT FOUL RESIST .000217	TUBE PASSLANE BYPASS F =	.00
DIFF RESIST000001		
DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000	TOTAL = (BETA) (GAMMA) (FIN) =	.639
BUNDLE TO SHELL IN5000	BETA (BAFF CUT FACTOR) =	.920
TUBE TO BAFFLE HOLE IN0284	GAMMA (TUBE ROW ENTRY EFCT) =	.695
TUBE TO BAFFLE HOLE IN0284 BAFFLE TO SHELL IN1000	END (HT LOSS IN END ZONE) =	.994
SHELL NOZZLE DATA IN OUT HT UNDR NOZ IN25 HT OPP NOZ IN25	SHELL PRESSURE DROP, % OF T	OTAL
HT UNDR NOZ IN25	WINDOW =	8.9
HT OPP NOZ IN25	END ZONE =	4.6
VELOCITY FT/S .33 .33	CROSS FLOW =	3.9
DENSITY LB/FT3 62.252 61.719	INLET NOZZLE =	42.3
NOZZ RHO*VSQ LB/FT-S2 6 6	OUTLET NOZZLE =	40.3
SHELL NOZZLE DATA IN OUT HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .33 .33 DENSITY LB/FT3 62.252 61.719 NOZZ RHO*VSQ LB/FT-S2 6 6 BUND RHO*VSQ LB/FT-S2 4 4		
THE NOTTE DATA IN OHE	WEICHT DED CHEIL ID	
TUBE NOZZLE DATA IN OUT VELOCITY FT/S .89 .88	DRY =	150
DENGITY IR/FT3 61 201 61 731	WET -	165
VELOCITY FT/S .89 .88 DENSITY LB/FT3 61.291 61.731 PRESS. DROP % 8.6 5.4	MET _	100.
11,200. 21,01		
*** SPECIAL MESSAGES AND WARNINGS *	**	
WARNINGTUBESIDE FLUID HAS PASSED	THROUGH TRANSITION ZONE CONS	TDEB
RERUNNING WITH ITEM 132 IN		IDDIC
Washington University ChE433 heat		0002 P 88
Young model F302DY4P		9/23/ 3
1009 110001 1000111		CASE 44
SIZE 4- 18 TYPE BEM, MULTI-PASS FLO		
	HOT TUBE SIDE COLD SHE	LL SIDE
	Tube Shell	
	SENSIBLE LIQ SENSIB	LE LIO
TOTAL FLOW RATE KLB/HR	<del>-</del>	£
•	IN OUT IN	OUT

TEMPERATURE DEGF 140.0 108.3\* 70.0 108.0\* DENSITY LB/FT3 61.2913 61.7788 62.2515 61.7823

VISCOSITY CP SPECIFIC HEAT BTU THERMAL COND. BTU	/LB-F	.9973	.6350 .9981	1.0015	.9982
MOLAR MASS LB/					
TEMP, AVG & SKIN VISCOSITY, AVG & SKIN PRESSURE, IN & DESIGN	CP	124.1 .5444	104.8 .6577	89.0	104.0 .6632
PRESSURE DROP, TOT & A VELOCITY, CALC & MAX A					
FOULING RESISTANCE FILM COEFFICIENT		-F 216	5.70		
TOTAL HEAT DUTY REQUIR EFF TEMP DIF, DEGF (L OVERALL COEFF REQUIRED CLEAN & FOULED COEFF	ED MEGBTU/HE MTD= 35.0,F= BTU/HR-FT	R = .81,BYPAS F2-F	SS= .94,BAI		100.39
SHELLS IN SERIES 1 PA PASSES, SHELL 1 TU SHELL DIAMETER IN.	BE 4	EFFECTIVE	AREA	FT2/SHELL	7.1
BAFFLE TYPE HORZ SPACING, CENTRAL IN. SPACING, INLET IN. SPACING, OUTLET IN. BAFFLE THICKNESS IN. PAIRS OF SEALING DEVICE	4.309 4.309 4.309 .125	IMPINGEMEN	PCT SHEI ICE FROM CE IT BAFFLE	LL I.D. ENTER, IN.	30.00 .764 NO
TUBE TYPE NO. OF TUBES/SHELL TUBE LGTH, OVERALL FT TUBE LGTH, EFF FT TUBE LAYOUT DE PITCH RATIO SHL NOZZ ID, IN&OUT	76 1.500 1.436 G 60 1.250		JBE COUNT  JE DIAM  DE DIAM  ACE RATIO,	IN. IN. IN. OUT/IN	36 .3125 .250 .214 1.184
* CALCULATED ITEMH Washington Universit Young model F302DY4P			er experime	ent	E0002 P 89 9/23/ 3 CASE 44
S U P P L E M E	N T A F	R Y R	E S U	L T S	3110L 11
HT PARAMETERS SHE WALL CORRECTION 1.0 PRANDTL NUMBER 5 RYNLD NO, AVG 24 RYNLD NO, IN BUN 19 RYNLD NO,OUT BUN 29 FOULNG LAYER IN00	23 .000 .2 3.6 1. 1737. 2. 2000. 6. 1489.	NOMINAL NOMINAL CROSSFLO WINDOW O	VEL, WINDOW OW COEF F	N FT/S N FT/S BTU/HR-FT2- BTU/HR-FT2- % OF TOTAI	.13 -F 233.4 -F 234.9

THERMAL RESISTANCE, % OF TOTAL	TUBE TO BAFFLE LEAKAGE	A =	3.40
SHELL TUBE FOULING METAL	MAIN CROSSFLOW	B =	65.91
42.79 54.96 2.18 .07	BUNDLE TO SHELL BYPASS	C =	14.86
PCT OVER DESIGN .	21 BAFFLE TO SHELL LEAKAGE	E =	15.82
TOT FOUL RESIST .0002	17 TUBE PASSLANE BYPASS	F =	.00
DIFF RESIST .0000	21		
	SHELLSIDE HEAT TRANSFER		
DIAMETRAL CLEARANCES	TOTAL = (BETA) (GAMMA) (FIN)  000 BETA (BAFF CUT FACTOR)	=	.662
BUNDLE TO SHELL IN5	000 BETA (BAFF CUT FACTOR)	=	.920
TUBE TO BAFFLE HOLE IN0	284 GAMMA (TUBE ROW ENTRY EFCT	]) =	.720
BAFFLE TO SHELL IN1	000 END (HT LOSS IN END ZONE	]) =	.994
SHELL NOZZLE DATA IN	OUT SHELL PRESSURE DROP % C		TΣT.
HT UNDR NOZ IN25 HT OPP NOZ IN25	WINDOW END ZONE	=	8.9 4.2
HT UNDR NOZ IN25 HT OPP NOZ IN25	WINDOW END ZONE	=	8.9 4.2
HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .41 DENSITY LB/FT3 62.252 61.	WINDOW END ZONE .41 CROSS FLOW 782 INLET NOZZLE	= = =	8.9 4.2 3.6 42.5
HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .41 DENSITY LB/FT3 62.252 61. NOZZ RHO*VSQ LB/FT-S2 10	WINDOW END ZONE .41 CROSS FLOW 782 INLET NOZZLE 10 OUTLET NOZZLE	= = =	8.9 4.2 3.6 42.5
HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .41 DENSITY LB/FT3 62.252 61.	WINDOW END ZONE .41 CROSS FLOW 782 INLET NOZZLE 10 OUTLET NOZZLE	= = =	8.9 4.2 3.6 42.5
HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .41 DENSITY LB/FT3 62.252 61. NOZZ RHO*VSQ LB/FT-S2 10 BUND RHO*VSQ LB/FT-S2 7	WINDOW END ZONE .41 CROSS FLOW 782 INLET NOZZLE 10 OUTLET NOZZLE 7	= = = =	8.9 4.2 3.6 42.5
HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .41 DENSITY LB/FT3 62.252 61. NOZZ RHO*VSQ LB/FT-S2 10 BUND RHO*VSQ LB/FT-S2 7	WINDOW END ZONE .41 CROSS FLOW 782 INLET NOZZLE 10 OUTLET NOZZLE 7 OUT WEIGHT PER SHELL, LB	= = =	8.9 4.2 3.6 42.5 40.8
HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .41 DENSITY LB/FT3 62.252 61. NOZZ RHO*VSQ LB/FT-S2 10 BUND RHO*VSQ LB/FT-S2 7  TUBE NOZZLE DATA IN VELOCITY FT/S .89	WINDOW END ZONE .41 CROSS FLOW 782 INLET NOZZLE 10 OUTLET NOZZLE 7 OUT WEIGHT PER SHELL, LB .88 DRY	= = = =	8.9 4.2 3.6 42.5 40.8
HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .41 DENSITY LB/FT3 62.252 61. NOZZ RHO*VSQ LB/FT-S2 10 BUND RHO*VSQ LB/FT-S2 7 TUBE NOZZLE DATA IN	WINDOW END ZONE .41 CROSS FLOW 782 INLET NOZZLE 10 OUTLET NOZZLE 7  OUT WEIGHT PER SHELL, LB .88 DRY = 779 WET =	= = = =	8.9 4.2 3.6 42.5 40.8

# \*\*\* 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

			HOT TU	UBE SIDE	COLD SH	HELL SIDE
			Tube		Shell	L
			SENS	IBLE LIQ	SENSI	BLE LIQ
TOTAL FLOW RATE	KLB/HR			.600		.600
			IN	OUT	IN	OUT
TEMPERATURE	DEGF		140.0	105.5*	70.0	104.5*
DENSITY	LB/FT3	(	61.2913	61.8175	62.2515	61.8314
VISCOSITY	CP		.4726	.6534	.9783	.6603
SPECIFIC HEAT	BTU/LB-F		.9973	.9983	1.0015	.9984
THERMAL COND.	BTU/HR-FT-	F	.3723	.3646	.3554	.3643
MOLAR MASS	LB/LBMOL			18.02		18.02
TEMP, AVG & SKIN	DEGF		122.7	102.2	87.2	101.4
VISCOSITY, AVG & S	KIN CP		.5516	.6756	.7960	.6816
PRESSURE, IN & DES	IGN PSIA		50.00	165.00	50.00	165.00
PRESSURE DROP, TOT	& ALLOWED	PSI	.07	10.00	.01	10.00
VELOCITY, CALC & M	MAX ALLOWED	FT/S	.59	10.00	.09	10.00

FILM COEFFICIENT	BTU/HR-FT2-F	.00010 217.00	.00010 261.95
TOTAL HEAT DUTY REQUIRE EFF TEMP DIF, DEGF (LM OVERALL COEFF REQUIRED CLEAN & FOULED COEFF	TD= 35.5,F= BTU/HR-FT2	-F	.020665 .00) 27.3 105.95 105.77
SHELLS IN SERIES 1 PAR PASSES, SHELL 1 TUB SHELL DIAMETER IN.	E 4 E	FFECTIVE AREA FT2/	SHELL 7.1
BAFFLE TYPE HORZ SPACING, CENTRAL IN. SPACING, INLET IN. SPACING, OUTLET IN. BAFFLE THICKNESS IN. PAIRS OF SEALING DEVICE	4.309 B. 4.309 C 4.309 .125 I	ROSS PASSES PER SHELL PAFFLE CUT, PCT SHELL I. UT DISTANCE FROM CENTER MPINGEMENT BAFFLE INCLU UBESHEET BLANK AREA, %	D. 30.00 R, IN764 JDED NO
TUBE TYPE  NO. OF TUBES/SHELL  TUBE LGTH, OVERALL FT  TUBE LGTH, EFF FT  TUBE LAYOUT DEG  PITCH RATIO  SHL NOZZ ID, IN&OUT 1	1.500 T 1.436 T 60 T 1.250 T	UBE INSIDE DIAM IN UBE SURFACE RATIO, OUT/	36 N3125 N250 N214 'IN 1.184
* CALCULATED ITEMHE			
Young model F302DY4P		exchanger experiment Y R E S U L T	9/23/ 3 CASE 45
=	N T A R L TUBE 2 .000 3 3.6 . 1714 2000 1447. 4 .0014	Y R E S U L T  SHELLSIDE PERFORMANC  NOMINAL VEL, X-FLOW FT  NOMINAL VEL, WINDOW FT  CROSSFLOW COEF BTU/H  WINDOW COEF BTU/H  SHELLSIDE FLOW, % OF	9/23/3 CASE 45 T S CE T/S .08 T/S .15 HR-FT2-F 263.0 HR-FT2-F 264.7
Young model F302DY4P  S U P P L E M E  HT PARAMETERS SHEL WALL CORRECTION 1.02 PRANDTL NUMBER 5. RYNLD NO, AVG 284 RYNLD NO, IN BUN 231 RYNLD NO,OUT BUN 342	N T A R  L TUBE 2 .000 3 3.6 . 1714 2000 1447. 4 .0014  F TOTAL METAL .0817 .000217000016	Y R E S U L T  SHELLSIDE PERFORMANC  NOMINAL VEL, X-FLOW FT  NOMINAL VEL, WINDOW FT  CROSSFLOW COEF BTU/H  WINDOW COEF BTU/H  SHELLSIDE FLOW, % OF  HEAT TRANSFER X-FLOW  TUBE TO BAFFLE LEAKAGE  MAIN CROSSFLOW  BUNDLE TO SHELL BYPASS  BAFFLE TO SHELL LEAKAGE  TUBE PASSLANE BYPASS	9/23/3 CASE 45 T S  CE T/S .08 T/S .15 HR-FT2-F 263.0 HR-FT2-F 264.7  F TOTAL  81.46 A = 3.61 B = 65.19 C = 15.55 GE E = 15.66 F = .00

SHELL NOZZLE DATA	IN	OUT	SHELL PRESSURE DROP,	% OF	TOT	AL
HT UNDR NOZ IN.	.25		WINDOW		=	8.9
HT OPP NOZ IN.	.25		END ZONE		=	3.8
VELOCITY FT/S	.49	.49	CROSS FLOW		=	3.4
DENSITY LB/FT3	62.252	61.831	INLET NOZZLE		=	42.7
NOZZ RHO*VSQ LB/FT-S	52 14	15	OUTLET NOZZLE		=	41.2
BUND RHO*VSQ LB/FT-S	32 10	10				
TUBE NOZZLE DATA	IN	OUT	WEIGHT PER SHELL, LB			
VELOCITY FT/S	.89	.88	DRY	=		150.
DENSITY LB/FT3	61.291	61.817	WET	=		165.
PRESS. DROP %	8.5	5.3				

## \*\*\* 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 TO TITE DE	M, MODII IASS I				
		HOT TU	JBE SIDE	COLD SH	ELL SIDE
		Tube		Shell	
		CENCI	DIE IIO	CENCT	DIE IIO
TOTAL FLOW RATE	KLB/HR		.600		.700
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	103.2*	70.0	101.4*
DENSITY	LB/FT3	61.2913	61.8481	62.2515	61.8722
VISCOSITY	CP	.4726	.6687	.9783	.6813
SPECIFIC HEAT					
THERMAL COND.	BTU/HR-FT-F	.3723	.3640	.3554	.3636
MOLAR MASS			18.02		18.02
TEMP, AVG & SKIN	DEGE				
VISCOSITY, AVG & S	KIN CÞ	5574	6915	8098	6980
PRESSURE, IN & DES					
INDOONE, IN a DEC	1011 10121	30.00	100.00	30.00	100.00
PRESSURE DROP, TOT	& ALLOWED PSI	.07	10.00	.01	10.00
VELOCITY, CALC & M					
FOULING RESISTANCE	HR-FT2-F/R	יייי (	00010	0	0010
FILM COEFFICIENT					
					1.50
TOTAL HEAT DUTY RE	OUIRED MEGBTU/H	R			.022008
EFF TEMP DIF, DEGF	_		ASS= .94,BAI	FF=1.00)	
OVERALL COEFF REQU					110.42
CLEAN & FOULED COE					
	,	_			
SHELLS IN SERIES	1 PARALLEL 1	TOTAL EFE	AREA	FT2	7.1
PASSES, SHELL					

	che433b(70).OUT
SHELL DIAMETER IN. 3.820	che433b(70).OUT FEMA SHELL TYPE E ; REAR HEAD FXTS
BAFFLE TYPE HORZ SEGMENTI. (	CROSS PASSES PER SHELL PASS 4
CDACING CENTRAL IN 4 300	CROSS PASSES PER SHELL PASS 4 BAFFLE CUT, PCT SHELL I.D. 30.00
SPACING, INLET IN. 4.309	CUT DISTANCE FROM CENTER, IN764
SPACING, OUTLET IN. 4.309	
BAFFLE THICKNESS IN125	IMPINGEMENT BAFFLE INCLUDED NO
PAIRS OF SEALING DEVICES 1	TUBESHEET BLANK AREA, % .0
TUBE TYPE PLAIN INO. OF TUBES/SHELL 76	MATERIAL ELECTROLYTIC COPPER
NO. OF TUBES/SHELL 76	EST MAX TUBE COUNT 36
TUBE LOTH, OVERALL FT 1 500	TUBE PITCH IN3125
TUBE LGTH, EFF FT 1.436	TUBE OUTSIDE DIAM IN250
TIDE LAVOUR DEC. 60	TIDE THOUSE DIAM IN 214
TUBE LATUUT DEG 60	TUBE INSIDE DIAMIN236TUBE SURFACE RATIO, OUT/IN1.184
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 IN8 .8
* CALCULATED ITEMHEAT BALANCE (	CODE = 8
Washington University ChE433 hea	t exchanger experiment E0002 P 93
Young model F302DY4P	9/23/ 3
	CASE 46
SUPPLEMENTAR	
WE DIDINGTON OVER THE	auerrathe beneadyruae
HT PARAMETERS SHELL TUBE	SHELLSIDE PERFORMANCE
WALL CORRECTION 1.021 .000	NOMINAL VEL, X-FLOW FT/S .09 NOMINAL VEL, WINDOW FT/S .18
PRANDTL NUMBER 5.4 3.7	NOMINAL VEL, WINDOW FT/S .18
RYNLD NO, AVG 325. 1696.	CROSSFLOW COEF BTU/HR-FT2-F 292.5 WINDOW COEF BTU/HR-FT2-F 294.4
RYNLD NO, IN BUN 269. 2000.	WINDOW COEF BTU/HR-FT2-F 294.4
RYNLD NO, OUT BUN 387. 1414.	
FOULNG LAYER IN0014 .0014	SHELLSIDE FLOW, % OF TOTAL
	HEAT TRANSFER X-FLOW 81.45
THEDMAI DESISTANCE & OF TOTAL	TUBE TO BAFFLE LEAKAGE A = 3.78
SHELL TUBE FOULING METAL	MAIN CROSSFLOW B = 64.85
SHELL TUBE FOULING METAL	BUNDLE TO SHELL BYPASS C = 15.83
37.43 60.10 2.39 .08	BUNDLE TO SHELL BYPASS C = 15.83
PCT OVER DESIGN11	BAFFLE TO SHELL LEAKAGE E = 15.53
TOT FOUL RESIST .000217	BUNDLE TO SHELL BIPASS C = 13.03  BAFFLE TO SHELL LEAKAGE E = 15.53  TUBE PASSLANE BYPASS F = .00
DIFF RESIST000010	
	SHELLSIDE HEAT TRANSFER FACTORS
DIAMETRAL CLEARANCES	TOTAL = (BETA) (GAMMA) (FIN) = .710 BETA (BAFF CUT FACTOR) = .920
BUNDLE TO SHELL IN5000	BETA (BAFF CUT FACTOR) = .920
TUBE TO BAFFLE HOLE IN 0284	(
TOBE TO BITTER HOLE IN OZOT	GAMMA (TIBE ROW ENTRY EFCT) = $771$
DARRIE TO CHRIT IN 1000	GAMMA (TUBE ROW ENTRY EFCT) = .771
BAFFLE TO SHELL IN1000	GAMMA (TUBE ROW ENTRY EFCT) = .771 END (HT LOSS IN END ZONE) = .994
	END (HT LOSS IN END ZONE) = .994
SHELL NOZZLE DATA IN OUT	END (HT LOSS IN END ZONE) = .994  SHELL PRESSURE DROP, % OF TOTAL
SHELL NOZZLE DATA IN OUT	END (HT LOSS IN END ZONE) = .994  SHELL PRESSURE DROP, % OF TOTAL WINDOW = 8.9
SHELL NOZZLE DATA IN OUT HT UNDR NOZ IN25 HT OPP NOZ IN25	END (HT LOSS IN END ZONE) = .994  SHELL PRESSURE DROP, % OF TOTAL WINDOW = 8.9 END ZONE = 3.6
SHELL NOZZLE DATA IN OUT HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .57 .58	SHELL PRESSURE DROP, % OF TOTAL WINDOW = 8.9 END ZONE = 3.6 CROSS FLOW = 3.2
SHELL NOZZLE DATA IN OUT HT UNDR NOZ IN25 HT OPP NOZ IN25	END (HT LOSS IN END ZONE) = .994  SHELL PRESSURE DROP, % OF TOTAL  WINDOW = 8.9  END ZONE = 3.6  CROSS FLOW = 3.2  INLET NOZZLE = 42.8
SHELL NOZZLE DATA IN OUT HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .57 .58 DENSITY LB/FT3 62.252 61.872 NOZZ RHO*VSO LB/FT-S2 20 20	END (HT LOSS IN END ZONE) = .994  SHELL PRESSURE DROP, % OF TOTAL  WINDOW = 8.9  END ZONE = 3.6  CROSS FLOW = 3.2  INLET NOZZLE = 42.8
SHELL NOZZLE DATA IN OUT HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .57 .58 DENSITY LB/FT3 62.252 61.872 NOZZ RHO*VSO LB/FT-S2 20 20	SHELL PRESSURE DROP, % OF TOTAL WINDOW = 8.9 END ZONE = 3.6 CROSS FLOW = 3.2 INLET NOZZLE = 42.8
SHELL NOZZLE DATA IN OUT HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .57 .58 DENSITY LB/FT3 62.252 61.872	END (HT LOSS IN END ZONE) = .994  SHELL PRESSURE DROP, % OF TOTAL  WINDOW = 8.9  END ZONE = 3.6  CROSS FLOW = 3.2  INLET NOZZLE = 42.8
SHELL NOZZLE DATA IN OUT HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .57 .58 DENSITY LB/FT3 62.252 61.872 NOZZ RHO*VSQ LB/FT-S2 20 20 BUND RHO*VSQ LB/FT-S2 13 13	SHELL PRESSURE DROP, % OF TOTAL WINDOW = 8.9 END ZONE = 3.6 CROSS FLOW = 3.2 INLET NOZZLE = 42.8 OUTLET NOZZLE = 41.5
SHELL NOZZLE DATA IN OUT HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .57 .58 DENSITY LB/FT3 62.252 61.872 NOZZ RHO*VSO LB/FT-S2 20 20	SHELL PRESSURE DROP, % OF TOTAL WINDOW = 8.9 END ZONE = 3.6 CROSS FLOW = 3.2 INLET NOZZLE = 42.8 OUTLET NOZZLE = 41.5

DENSITY LB/FT3 61.291 61.848 WET = 165.

PRESS. DROP % 8.4 5.3

#### \*\*\* 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 94 Young model F302DY4P 9/23/ 3

CASE 47 SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING HOT TUBE SIDE COLD SHELL SIDE Tube Shell SENSIBLE LIQ SENSIBLE LIO TOTAL FLOW RATE KLB/HR .600 IN OUT IN .800 IN IN OUT 140.0 101.4\* TEMPERATURE DEGF 140.0 101.4\* 70.0 98.9\*
DENSITY LB/FT3 61.2913 61.8734 62.2515 61.9058
VISCOSITY CP .4726 .6819 .9783 .6998
SPECIFIC HEAT BTU/LB-F .9973 .9986 1.0015 .9987
THERMAL COND. BTU/HR-FT-F .3723 .3636 .3554 .3630
MOLAR MASS LB/LBMOL 18.02 18.02 98.9\* -----TEMP, AVG & SKIN DEGF 120.7 98.1 84.5 97.2 VISCOSITY, AVG & SKIN CP .5624 .7057 .8217 .7127 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 .12 10.00 FOULING RESISTANCE HR-FT2-F/BTU ...

COEFFICIENT BTU/HR-FT2-F 217.50 .00010 .00010 320.86 -----TOTAL HEAT DUTY REQUIRED MEGBTU/HR EFF TEMP DIF, DEGF (LMTD= 36.0,F= .83,BYPASS= .94,BAFF=1.00) 28.3 OVERALL COEFF REQUIRED BTU/HR-FT2-F 114.25 117.72 CLEAN & FOULED COEFF BTU/HR-FT2-F SHELLS IN SERIES 1 PARALLEL 1 TOTAL EFF AREA FT2 FT2/SHELL PASSES, SHELL 1 TUBE 4 EFFECTIVE AREA SHELL DIAMETER IN. 3.820 TEMA SHELL TYPE E ; REAR HEAD FXTS BAFFLE TYPE HORZ SEGMENTL CROSS PASSES PER SHELL PASS 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. BAFFLE THICKNESS IN. 4.309 .125 IMPINGEMENT BAFFLE INCLUDED PAIRS OF SEALING DEVICES 1 TUBESHEET BLANK AREA, % TUBE TYPE PLAIN MATERIAL ELECTROLYTIC COPPER NO. OF TUBES/SHELL 76 EST MAX TUBE COUNT 36 36

TUBE LGTH, OVERALL FT 1.500 T	UBE PITCH IN.	.3125
TUBE LGTH, EFF FT 1.436 T		
TUBE LAYOUT DEG 60 T		
PITCH RATIO 1.250 T		
SHL NOZZ ID, IN&OUT 1.0 1.0 T		
	,	
* CALCULATED ITEMHEAT BALANCE C	ODE = 8	
Washington University ChE433 heat		E0002 P 95
Young model F302DY4P		9/23/ 3
		CASE 47
S U P P L E M E N T A R		
HT PARAMETERS SHELL TUBE	SHELLSIDE PERFORMANCE	
WALL CORRECTION 1.020 .000		.10
PRANDTL NUMBER 5.5 3.7		
RYNLD NO, AVG 366. 1681.	CROSSFLOW COEF BTU/HR-FT2-	F 322.2
RYNLD NO, IN BUN 308. 2000.		
RYNLD NO, OUT BUN 430. 1386.		
FOULNG LAYER IN0014 .0014	SHELLSIDE FLOW, % OF TOTAL	
	HEAT TRANSFER X-FLOW	81.44
THERMAL RESISTANCE, % OF TOTAL	TUBE TO BAFFLE LEAKAGE A	= 3.93
SHELL TUBE FOULING METAL		
35.22 62.21 2.48 .08	BUNDLE TO SHELL BYPASS C	= 16.07
PCT OVER DESIGN .05		
TOT FOUL RESIST .000217	TUBE PASSLANE BYPASS F	= .00
DIFF RESIST .000004		
	SHELLSIDE HEAT TRANSFER FA	CTORS
DIAMETRAL CLEARANCES	TOTAL = (BETA) (GAMMA) (FIN)	= .734
BUNDLE TO SHELL IN5000		
TUBE TO BAFFLE HOLE IN0284	GAMMA (TUBE ROW ENTRY EFCT)	= .798
BAFFLE TO SHELL IN1000	END (HT LOSS IN END ZONE)	= .994
SHELL NOZZLE DATA IN OUT		
HT UNDR NOZ IN25	WINDOW	= 8.9
HT OPP NOZ IN25	END ZONE	= 3.4
HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .65 .66 DENSITY LB/FT3 62.252 61.906	CROSS FLOW	= 3.1
DENSITY LB/FT3 62.252 61.906	INLET NOZZLE	= 42.9
NOZZ RHO*VSQ LB/FT-S2 26 26	OUTLET NOZZLE	= 41.8
BUND RHO*VSQ LB/FT-S2 18 18		
	WEIGHT PER SHELL, LB	
VELOCITY FT/S .89 .88	DRY =	150.
DENSITY LB/FT3 61.291 61.873	WET =	165.
PRESS. DROP % 8.4 5.3		

# \*\*\* 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 96 Young model F302DY4P 9/23/3

					CASE 48
SIZE 4- 18 TYPE BE					
			BE SIDE		
		SENSI	BLE LIQ	SENS	IBLE LIQ
TOTAL FLOW RATE	KLB/HR		.600		.900
		IN	.600 OUT	IN	OUT
TEMPERATURE	DEGF				
DENSITY	LB/FT3	61.2913	61.8981	62.2515	61.9318
VISCOSITY					
SPECIFIC HEAT					
THERMAL COND.					
MOLAR MASS		.5725	18.02	. 5551	18.02
HODAK PIASS	пр/ приоп				10.02
TEMP, AVG & SKIN	DECE				
VISCOSITY, AVG & SKIN					
PRESSURE, IN & DES	IGN PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT	c allowed Dol	. 07	10.00	0.0	10.00
VELOCITY, CALC & M	AX ALLOWED FT/	5 .59	10.00	. 14	10.00
	==0 = /=		0.01.0		0.001.0
FOULING RESISTANCE					
FILM COEFFICIENT					50.94
					004041
TOTAL HEAT DUTY RE					.024241
EFF TEMP DIF, DEGF			SS= .95,BA	FF=1.00)	
OVERALL COEFF REQU					118.57
CLEAN & FOULED COE	FF BTU/HR-F	TZ-F	121.5	6	117.88
				_	
SHELLS IN SERIES					
PASSES, SHELL					
SHELL DIAMETER IN.	3.820	TEMA SHEL	L TYPE E	; REAR H	EAD FXTS
BAFFLE TYPE H					
SPACING, CENTRAL					
SPACING, INLET		CUT DISTA	NCE FROM C	ENTER, IN.	.764
SPACING, OUTLET					
BAFFLE THICKNESS	IN125	IMPINGEME	NT BAFFLE	INCLUDED	NO
PAIRS OF SEALING D	EVICES 1	TUBESHEET	BLANK ARE	A, %	.0
TUBE TYPE	PLAIN	MATERIAL	E	LECTROLYTI	C COPPER
NO. OF TUBES/SHELL					36
TUBE LGTH, OVERALL	FT 1.500	TUBE PITC	H	IN.	.3125
TUBE LGTH, EFF				IN.	.250
TUBE LAYOUT					.214
PITCH RATIO					
SHL NOZZ ID, IN&OU					
,	•		,	-	
* CALCULATED ITE	MHEAT BALANCE	CODE = 8			
Washington Unive			er experim	ent	E0002 P 97
Young model F302DY	=			- · <del>-</del>	9/23/ 3
					CASE 48
SUPPLE	м ғ. м т д	R Y P	E S II	т, т с	01101 10
	L IN T V	1, 1	. 1 5 0	1 1 0	

HT PARAMETERS	SHELL	TUBE	SHELLSIDE PERFORMANCE		
WALL CORRECTION	1.019	.000	NOMINAL VEL, X-FLOW FT/S		
PRANDTL NUMBER	5.6	3.7	NOMINAL VEL, WINDOW FT/S		.23
RYNLD NO, AVG	407.	1667.	CROSSFLOW COEF BTU/HR-FT WINDOW COEF BTU/HR-FT	Г2-F	352.4
RYNLD NO, IN BUN	346.	2000.	WINDOW COEF BTU/HR-F7	Г2-F	354.4
RYNLD NO, OUT BUN	474.	1360.			
FOILING LAYER IN	0014	0014	SHELLSIDE FLOW, % OF TO	ГАТ.	
1001110 1111111 111 <b>.</b>	• • • • • •		HEAT TRANSFER X-FLOW		81 44
THERMAI RESISTANCE	% OF T(		TUBE TO BAFFLE LEAKAGE		
			MAIN CROSSFLOW		
	_		BUNDLE TO SHELL BYPASS		
PCI OVER DESIGN		56	BAFFLE IO SHELL LEAKAGE	E -	13.32
TOT FOUL RESIST	• '	000217	BAFFLE TO SHELL LEAKAGE TUBE PASSLANE BYPASS	F. =	.00
DIFF RESIST		000049			
			SHELLSIDE HEAT TRANSFER	F'AC'I'	ORS
DIAMETRAL CLEARA	NCES		TOTAL = (BETA) (GAMMA) (FIN) BETA (BAFF CUT FACTOR)	=	.760
			GAMMA (TUBE ROW ENTRY EFC		
BAFFLE TO SHELL	IN.	.1000	END (HT LOSS IN END ZONE	<b>∃</b> ) =	.994
SHELL NOZZLE DAT	A IN	OUT	SHELL PRESSURE DROP, % (	OF TO	TAL
HT UNDR NOZ IN.	.25		WINDOW	=	8.9
HT OPP NOZ IN.	.25		END ZONE	=	3.3
VELOCITY FT/S	.74	.74	CROSS FLOW	=	3.0
DENSITY LB/FT3	62.252	61.932	INLET NOZZLE	=	43.0
NOZZ RHO*VSQ LB/FT	-s2 33	33	WINDOW END ZONE CROSS FLOW INLET NOZZLE OUTLET NOZZLE	=	41.9
BUND RHO*VSQ LB/FT	-S2 22	23			
_					
TUBE NOZZLE DATA	IN	OUT	WEIGHT PER SHELL, LB		
VELOCITY FT/S			DRY =	=	150.
DENSITY LB/FT3				=	165.
PRESS. DROP %					100.
	<b>.</b> 1	J. J			

# \*\*\* 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

		HOT TO	UBE SIDE	COLD SHELL SIDE		
		Tube		Shell		
		SENS	IBLE LIQ	SENS	IBLE LIQ	
TOTAL FLOW RATE	KLB/HR		.700		.200	
		IN	OUT	IN	OUT	
TEMPERATURE	DEGF	140.0	123.9*	70.0	126.3*	
DENSITY	LB/FT3	61.2913	61.5497	62.2515	61.5119	
VISCOSITY	CP	.4726	.5457	.9783	.5335	
SPECIFIC HEAT	BTU/LB-F	.9973	.9975	1.0015	.9974	

THERMAL COND. B		che433b(7			.3694 18.02
TEMP, AVG & SKIN VISCOSITY, AVG & SKI PRESSURE, IN & DESIG	DEGF N CP	131.9 .5071	118.4 .5745	98.2 .7054	117.8 .5778
PRESSURE DROP, TOT & VELOCITY, CALC & MAX	ALLOWED PSI ALLOWED FT/S	.09	10.00	.00	10.00
FOULING RESISTANCE FILM COEFFICIENT		F 237	7.96		00010 36.54
TOTAL HEAT DUTY REQUEFF TEMP DIF, DEGFOVERALL COEFF REQUIR CLEAN & FOULED COEFF	IRED MEGBTU/HR (LMTD= 29.3,F=	.76,BYPAS	SS= .89,BAI	FF=1.00)	.011252 19.7 79.95 80.38
SHELLS IN SERIES 1 PASSES, SHELL 1 SHELL DIAMETER IN.	TUBE 4	EFFECTIVE	AREA	FT2/SHELL	7.1
BAFFLE TYPE HOR SPACING, CENTRAL IN SPACING, INLET IN SPACING, OUTLET IN BAFFLE THICKNESS IN PAIRS OF SEALING DEV	4.309 1 4.309 4 4.309 .	BAFFLE CUT CUT DISTAN IMPINGEMEN	F, PCT SHEINCE FROM CH NT BAFFLE	LL I.D. ENTER, IN.	30.00 .764 NO
TUBE TYPE NO. OF TUBES/SHELL TUBE LGTH, OVERALL TUBE LGTH, EFF TUBE LAYOUT PITCH RATIO SHL NOZZ ID, IN&OUT	76 1 FT 1.500 5 FT 1.436 5 DEG 60 5	EST MAX TU TUBE PITCH TUBE OUTSI TUBE INSII TUBE SURFA	IDE DIAM DE DIAM	IN. IN. IN. OUT/IN	36 .3125 .250 .214 1.184
* CALCULATED ITEM- Washington Univers Young model F302DY4P	ity ChE433 hea	t exchange	_		E0002 P 99 9/23/ 3 CASE 49
HT PARAMETERS S WALL CORRECTION 1	HELL TUBE .028 .979 4.7 3.3 106. 2175. 76. 2334. 140. 2021.	SHELLS NOMINAL NOMINAL CROSSFLO WINDOW SHELLS	SIDE PERFORMATION VEL, WINDOW COEF FOR SIDE FLOW,	RMANCE N FT/S N FT/S BTU/HR-FT2- BTU/HR-FT2- % OF TOTAL	-F 137.1 -F 137.9
THERMAL RESISTANCE, SHELL TUBE FOULI			ANSFER X-F1 BAFFLE LEA DSSFLOW	AKAGE A	80.75 = 2.63 = 68.90

		BUNDLE TO SHELL BYPASS C		
PCT OVER DESIGN	.54	BAFFLE TO SHELL LEAKAGE E	=	17.15
TOT FOUL RESIST	.000217	BAFFLE TO SHELL LEAKAGE E TUBE PASSLANE BYPASS F	' =	.00
DIFF RESIST	.000067			
		SHELLSIDE HEAT TRANSFER F		
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
		END (HT LOSS IN END ZONE)		
SHELL NOZZLE DATA	IN OUT	SHELL PRESSURE DROP, % OF	TOT	TAL
HT UNDR NOZ IN	25	WINDOW		9.5
HT OPP NOZ IN.	25	END ZONE	=	6.5
VELOCITY FT/S .:	.17	CROSS FLOW INLET NOZZLE	=	5.1
DENSITY LB/FT3 62.25	52 61.512	INLET NOZZLE	=	40.9
NOZZ RHO*VSQ LB/FT-S2	1 1	OUTLET NOZZLE	=	38.0
BUND RHO*VSQ LB/FT-S2	1 1			
TUBE NOZZLE DATA	IN OUT	WEIGHT PER SHELL, LB		
VELOCITY FT/S 1.0				150.
DENSITY LB/FT3 61.29	91 61.550	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 215.71 BTU/HR-FT2-F HEAT TRANSFER COEFF. AT RE = 10000 IS 1231.08 BTU/HR-FT2-F

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

			HOT TU	UBE SIDE	COLD SH	HELL SIDE
			Tube		Shell	L
			SENS	IBLE LIQ	SENSI	BLE LIQ
TOTAL FLOW RATE	KLB/HR			.700		.300
			IN	OUT	IN	OUT
TEMPERATURE	DEGF		140.0	118.6*	70.0	119.9*
DENSITY	LB/FT3	6	51.2913	61.6298	62.2515	61.6101
VISCOSITY	CP		.4726	.5737	.9783	.5665
SPECIFIC HEAT	BTU/LB-F		.9973	.9977	1.0015	.9976
THERMAL COND.	BTU/HR-FT-	F	.3723	.3677	.3554	.3680
MOLAR MASS	LB/LBMOL			18.02		18.02
TEMP, AVG & SKIN	DEGF		129.3	113.6	95.0	112.9
VISCOSITY, AVG & S	KIN CP		.5193	.6023	.7303	.6064
PRESSURE, IN & DES	SIGN PSIA		50.00	165.00	50.00	165.00
PRESSURE DROP, TOT	& ALLOWED	PSI	.09	10.00	.00	10.00
VELOCITY, CALC & M	MAX ALLOWED	FT/S	.68	10.00	.05	10.00

FOULING RESISTANCE FILM COEFFICIENT	BTU/HR-FT2-I		.00010 170.93
	MTD= 32.3,F=	.78,BYPASS= .92,BAFF=1.00	
PASSES, SHELL 1 TUI	BE 4 I	TOTAL EFF AREA FT2 EFFECTIVE AREA FT2/SH TEMA SHELL TYPE E ; REF	HELL 7.1
BAFFLE TYPE HORZ SPACING, CENTRAL IN. SPACING, INLET IN. SPACING, OUTLET IN. BAFFLE THICKNESS IN. PAIRS OF SEALING DEVICE	4.309 4.309 4.309 .125	CROSS PASSES PER SHELL PAS BAFFLE CUT, PCT SHELL I.D. CUT DISTANCE FROM CENTER, IMPINGEMENT BAFFLE INCLUDE FUBESHEET BLANK AREA, %	30.00 IN764 ED NO
TUBE LAYOUT DEC PITCH RATIO	1.500 5 1.436 5 60 5 1.250 5	MATERIAL ELECTROI EST MAX TUBE COUNT FUBE PITCH IN. FUBE OUTSIDE DIAM IN. FUBE INSIDE DIAM IN. FUBE SURFACE RATIO, OUT/IN FUBE NOZZ ID, IN&OUT IN.	36 .3125 .250 .214 1.184
Young model F302DY4P	y ChE433 heat	CODE = 8 t exchanger experiment Y R E S U L T	9/23/ 3 CASE 50
WALL CORRECTION 1.02		SHELLSIDE PERFORMANCE	
RYNLD NO, IN BUN 115 RYNLD NO, OUT BUN 195	.9 3.4 4. 2124. 5. 2334. 9. 1923.	NOMINAL VEL, WINDOW FT/S CROSSFLOW COEF BTU/HR- WINDOW COEF BTU/HR-	S .08 -FT2-F 171.6 -FT2-F 172.7
RYNLD NO, AVG 156 RYNLD NO, IN BUN 119 RYNLD NO,OUT BUN 199 FOULNG LAYER IN003 THERMAL RESISTANCE, % 0 SHELL TUBE FOULING 52.19 45.78 1.96	.9 3.4 4. 2124. 5. 2334. 9. 1923. 14 .0014 DF TOTAL METAL .06 .17 .000217	NOMINAL VEL, WINDOW FT/S CROSSFLOW COEF BTU/HR-	S .08 -FT2-F 171.6 -FT2-F 172.7 FOTAL 81.28 A = 2.92 B = 68.09 C = 12.60

SHELL NOZZLE DATA	IN OUT	SHELL PRESSURE DROP, %	OF	TOTAL
HT UNDR NOZ IN.	.25	WINDOW		= 9.1
HT OPP NOZ IN.	.25	END ZONE		= 5.2
VELOCITY FT/S	.25 .25	CROSS FLOW		= 4.3
DENSITY LB/FT3 62.	.252 61.610	INLET NOZZLE		= 41.9
NOZZ RHO*VSQ LB/FT-S2	3 3	OUTLET NOZZLE		= 39.5
BUND RHO*VSQ LB/FT-S2	2 2			
TUBE NOZZLE DATA	IN OUT	WEIGHT PER SHELL, LB		
VELOCITY FT/S	1.03 1.03	DRY	=	150.
DENSITY LB/FT3 61.	.291 61.630	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 217.48 BTU/HR-FT2-F HEAT TRANSFER COEFF. AT RE = 10000 IS 1237.51 BTU/HR-FT2-F

Washington University ChE433 heat exchanger experiment E0002 P102 Young model F302DY4P 9/23/3 CASE 51

SIZE 4- 18 TYPE BEI	M, MULTI-PASS	FLOW, SEGME	ENTAL BAFFLE	S, RATING		
		HOT TU	JBE SIDE	COLD SH	HELL SIDE	
				Shell		
		SENSI	BLE LIQ	SENSI	BLE LIQ	
TOTAL FLOW RATE					.400	
		IN	OUT	IN	OUT	
TEMPERATURE	DEGF	140.0	114.5*	70.0	114.5*	
DENSITY	LB/FT3	61.2913	61.6895	62.2515	61.6898	
VISCOSITY	CP	.4726	.5967	.9783	.5968	
SPECIFIC HEAT	BTU/LB-F	.9973	.9978	1.0015	.9978	
THERMAL COND.	BTU/HR-FT-F	.3723	.3667	.3554	.3667	
MOLAR MASS	LB/LBMOL		18.02		18.02	
TEMP, AVG & SKIN	DEGF	127.3	109.6	92.3	108.9	
VISCOSITY, AVG & SI	KIN CP	.5290	.6262	.7523	.6311	
PRESSURE, IN & DES	IGN PSIA	50.00	165.00	50.00	165.00	
PRESSURE DROP, TOT	& ALLOWED P	SI .09	10.00	.00	10.00	
VELOCITY, CALC & M	AX ALLOWED F'	T/S .68	10.00	.06	10.00	
FOULING RESISTANCE	HR-FT2-F	/BTU .0	00010	. (	00010	
FILM COEFFICIENT	BTU/HR-F	T2-F 22	29.67	20	03.24	
TOTAL HEAT DUTY REG	QUIRED MEGBTU	/HR			.017788	
EFF TEMP DIF, DEGF	(LMTD= 34.1	,F= .80,BYPA	ASS= .93,BAF	F=1.00)	25.5	
OVERALL COEFF REQUI	IRED BTU/HR	-FT2-F			97.60	
CLEAN & FOULED COE	FF BTU/HR	-FT2-F	99.86		97.62	

	che433b(70).OUT	
SHELLS IN SERIES 1 PARALLEL 1	TOTAL EFF AREA FT2	7.1
PASSES, SHELL 1 TUBE 4		
SHELL DIAMETER IN. 3.820		
SHELL DIAMETER IN. 3.020	TEMA SHELL TIPE E ; KEAK HE	AD FAIS
BAFFLE TYPE HORZ SEGMENTL	CROSS PASSES PER SHELL PASS	
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 IN125	IMPINGEMENT BAFFLE INCLUDED	NO
PAIRS OF SEALING DEVICES 1	TUBESHEET BLANK AREA, %	
PAIRS OF SEALING DEVICES I	TODESHEET DLANK AKEA, 6	. 0
TUBE TYPE PLAIN	MATERIAL ELECTROLYTIC	
NO. OF TUBES/SHELL 76	EST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT 1.500	TUBE PITCH IN.	
TUBE LGTH, EFF FT 1.436	TUBE OUTSIDE DIAM IN.	.250
TUBE LAYOUT DEG 60	TUBE INSIDE DIAM IN.	.214
PITCH RATIO 1.250		
SHL NOZZ ID, IN&OUT 1.0 1.0	TUBE NOZZ ID, IN&OUT IN.	.8 .8
* CALCULATED ITEMHEAT BALANCE	CODE = 8	
Washington University ChE433 he	at exchanger experiment	E0002 P103
Young model F302DY4P		9/23/ 3
, and the second		CASE 51
S U P P L E M E N T A	RY RESULTS	01102 01
	K I K E S O E I S	
UM DADAMEMEDO CUELT MUDE	QUELLATER DEPENDANCE	
HT PARAMETERS SHELL TUBE		
WALL CORRECTION 1.025 .972		
PRANDTL NUMBER 5.0 3.5	NOMINAL VEL, WINDOW FT/S	.10
RYNLD NO, AVG 200. 2085.	CROSSFLOW COEF BTU/HR-FT2-	F 204.0
RYNLD NO, IN BUN 154. 2334.		F 205.4
RYNLD NO, OUT BUN 252. 1849.		
FOULNG LAYER IN0014 .0014		
FOOLING LAIER IN0014 .0014		
	HEAT TRANSFER X-FLOW	
THERMAL RESISTANCE, % OF TOTAL		= 3.19
SHELL TUBE FOULING METAL	MAIN CROSSFLOW B	= 66.93
47.49 50.32 2.12 .07	BUNDLE TO SHELL BYPASS C	= 13.86
PCT OVER DESIGN .02	BAFFLE TO SHELL LEAKAGE E	= 16.03
TOT FOUL RESIST .000217		
DIFF RESIST .000002		• • • •
DIFF RESIST		СШОРС
	SHELLSIDE HEAT TRANSFER FA	
DIAMETRAL CLEARANCES		
BUNDLE TO SHELL IN5000		
TUBE TO BAFFLE HOLE IN0284	GAMMA (TUBE ROW ENTRY EFCT)	= .696
BAFFLE TO SHELL IN1000	END (HT LOSS IN END ZONE)	= .994
	,	
SHELL NOZZLE DATA IN OUT	SHELL PRESSURE DROP & OF	Т∩ТЪТ.
HT UNDR NOZ IN25		= 8.9
HT OPP NOZ IN25		= 4.6
VELOCITY FT/S .33 .33	CROSS FLOW	= 3.9
DENSITY LB/FT3 62.252 61.690	INLET NOZZLE	= 42.3
NOZZ RHO*VSQ LB/FT-S2 6 6	OHMIEM MORRIE	_ 10 2
· · · · · · · · · · · · · · · · · · ·	OUILEI NOZZLE	- 40.3
BUND RHO*VSQ LB/FT-S2 4 4		= 40.3

		che433b(	70).OUT		
TUBE NOZZLE DATA		_	HT PER SHEL		
	1.03 1.03				150.
DENSITY LB/FT3				=	165.
PRESS. DROP %	8.7 5.	5			
*** SPECIAL MESSAG	FS AND WARNING	S ***			
	LO IND WINNING	O			
WARNINGTUBESIDE	FLUID HAS PASSI	ED THROUGH	TRANSITION	ZONE. CON	ISIDER
	WITH ITEM 132				
HEAT TRAN	SFER COEFF. AT	RE = 2000	) IS 218.7	6 BTU/HR-FT	2-F
HEAT TRAN	SFER COEFF. AT	RE = 10000	) IS 1241.99	9 BTU/HR-FT	22-F
Washington Unive	ersity ChE433 h	eat exchang	ger experime	ent	E0002 P104
Young model F302DY	4P				9/23/ 3
					CASE 52
SIZE 4- 18 TYPE BE	M, MULTI-PASS				
			JBE SIDE		
		Tube		Shell	
	/	SENSI	IBLE LIQ	SENSI	BLE LIQ
TOTAL FLOW RATE	KLB/HR		.700	T.).	.500
	DEGF		OUT 111.3*	IN 70.0	OUT 110.1*
			61.7354		
	CP		.6158		.6236
SPECIFIC HEAT	~ <del>-</del>		.9980		
THERMAL COND.					
	LB/LBMOL	.3723	18.02	. 3331	18.02
IIO EIIIC III IO O	ED/ EDITOE		10.02		10.02
TEMP, AVG & SKIN	DEGF				
TEMP, AVG & SKIN VISCOSITY, AVG & S		125.7	106.4	90.0	105.6

TEMP, AVG & SKIN DEGF VISCOSITY, AVG & SKIN CP PRESSURE, IN & DESIGN PSIA	.5368 .6470	.7712 .6525
PRESSURE DROP, TOT & ALLOWED PSI VELOCITY, CALC & MAX ALLOWED FT/		
FOULING RESISTANCE HR-FT2-F/B FILM COEFFICIENT BTU/HR-FT2		233.71
TOTAL HEAT DUTY REQUIRED MEGBTU/H EFF TEMP DIF, DEGF (LMTD= 35.3,F OVERALL COEFF REQUIRED BTU/HR-F CLEAN & FOULED COEFF BTU/HR-F	IR '= .82,BYPASS= .94,BAI 'T2-F	.020018 FF=1.00) 27.1 103.37
SHELLS IN SERIES 1 PARALLEL 1 PASSES, SHELL 1 TUBE 4 SHELL DIAMETER IN. 3.820	EFFECTIVE AREA	FT2/SHELL 7.1
SPACING, CENTRAL IN. 4.309	CROSS PASSES PER SHI BAFFLE CUT, PCT SHE CUT DISTANCE FROM CH	LL I.D. 30.00
BAFFLE THICKNESS IN125	IMPINGEMENT BAFFLE	INCLUDED NO

PAIRS OF SEALING DEVICES 1	FUBESHEET BLANK AREA, % .0
TUBE TYPE PLAIN 1	MATERIAL ELECTROLYTIC COPPER
NO. OF TUBES/SHELL 76	EST MAX TUBE COUNT 36
TUBE LGTH, OVERALL FT 1.500	TUBE PITCH IN3125
TUBE LGTH, EFF FT 1.436	TUBE OUTSIDE DIAM IN250
TIBE LAYOUT DEG 60 '	TURE THAT THE 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 IN8 .8
	,
* CALCULATED ITEMHEAT BALANCE	CODE = 8
	t exchanger experiment E0002 P105
Young model F302DY4P	9/23/ 3
104119 110401 1041111	CASE 52
SUPPLEMENTAR	
HT PARAMETERS SHELL TUBE	SHELLSIDE PERFORMANCE
WALL CORRECTION 1.024 .969	NOMINAL VEL, X-FLOW FT/S .07
PRANDTI NUMBER 5.2 3.5	NOMINAL VELLWINDOW FT/S .13
RYNLD NO. AVG 244. 2055.	CROSSFLOW COEF BTU/HR-FT2-F 234.6 WINDOW COEF BTU/HR-FT2-F 236.2
RYNLD NO, IN BUN 192. 2334.	WINDOW COEF BTU/HR-FT2-F 236.2
RYNID NO.OUT BUN 302. 1791.	
FOULNG LAYER IN0014 .0014	SHELLSIDE FLOW. % OF TOTAL
	SHELLSIDE FLOW, % OF TOTAL HEAT TRANSFER X-FLOW 81.47
THERMAL RESISTANCE, % OF TOTAL	TUBE TO BAFFLE LEAKAGE A = 3.42
SHELL TUBE FOULING METAL	MAIN CROSSFLOW B = 65.87
43.72 53.96 2.24 .07	BUNDLE TO SHELL BYPASS C = 14.90
PCT OVER DESIGN03	BAFFLE TO SHELL LEAKAGE E = 15.80
TOT FOUL RESIST .000217	TUBE PASSLANE BYPASS F = .00
DIFF RESIST000003	
	SHELLSIDE HEAT TRANSFER FACTORS
DIAMETRAL CLEARANCES	TOTAL = (BETA) (GAMMA) (FIN) = .664
BUNDLE TO SHELL IN5000	BETA (BAFF CUT FACTOR) = .920
	GAMMA (TUBE ROW ENTRY EFCT) = .722
BAFFLE TO SHELL IN1000	
SHELL NOZZLE DATA IN OUT	SHELL PRESSURE DROP, % OF TOTAL
HT UNDR NOZ IN25	WINDOW = 8.9
HT OPP NOZ IN25	END ZONE = 4.1
	CROSS FLOW = 3.6
DENSITY LB/FT3 62.252 61.753	
NOZZ RHO*VSQ LB/FT-S2 10 10	OUTLET NOZZLE = 40.8
BUND RHO*VSQ LB/FT-S2 7 7	
	WEIGHT PER SHELL, LB
VELOCITY FT/S 1.03 1.03	DRY = $150.$
DENSITY LB/FT3 61.291 61.735	WET = $165.$
PRESS. DROP % 8.7 5.5	

WARNING--TUBESIDE FLUID HAS PASSED THROUGH TRANSITION ZONE. CONSIDER

RERUNNING WITH ITEM 132 IN EFFECT.

HEAT TRANSFER COEFF. AT RE = 2000 IS 219.69 BTU/HR-FT2-F HEAT TRANSFER COEFF. AT RE = 10000 IS 1245.26 BTU/HR-FT2-F

Washington University ChE433 heat exchanger experiment E0002 P106 Young model F302DY4P 9/23/3

CASE 53

					CASE 53
SIZE 4- 18 TYPE BE	M, MULTI-PASS				
		HOT TU	JBE SIDE	COLD SH	ELL SIDE
		rube		Sherr	
		SENSI	BLE LIQ	SENSI	BLE LIQ
TOTAL FLOW RATE	KLB/HR		.700		.600
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	108.8*	70.0	106.4*
DENSITY	LB/FT3	61.2913	61.7718	62.2515	61.8051
VISCOSITY	CP	.4726	.6318	.9783	.6474
SPECIFIC HEAT	BTU/LB-F	.9973	.9981	62.2515 .9783 1.0015	.9983
THERMAL COND.	BTU/HR-FT-F	.3723	.3654	.3554	.3648
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	124.4	103.7	88.2	102.9
VISCOSITY, AVG & S		.5432	.6652	.7874	.6713
PRESSURE, IN & DES		50.00	165.00	50.00	165.00
,					
PRESSURE DROP, TOT	' & ALLOWED PS	I .09	10.00	.01	10.00
VELOCITY, CALC & M	MAX ALLOWED FT	'/S .68	10.00	.09	10.00
,		,			
FOULING RESISTANCE	HR-FT2-F/	BTU . (	00010	.0	0010
FILM COEFFICIENT	BTU/HR-FT	'2-F 22	24.37		3.39
TOTAL HEAT DUTY RE					.021812
EFF TEMP DIF, DEGF			ASS= .94,BA	FF=1.00)	
OVERALL COEFF REQU			,	,	107.90
CLEAN & FOULED COE			110.9	8	108.05
SHELLS IN SERIES	1 PARALLEL 1	TOTAL EFE	F AREA	FT2	7.1
PASSES, SHELL	1 TUBE 4	EFFECTIVE	E AREA	FT2/SHELL	7.1
SHELL DIAMETER IN.					
	****			,	
BAFFLE TYPE H	IORZ SEGMENTL	CROSS PAS	SSES PER SH	ELL PASS	4
SPACING, CENTRAL	IN. 4.309	BAFFLE CU	JT. PCT SHE	LL I.D.	30.00
SPACING, INLET				ENTER, IN.	
SPACING, OUTLET	TN. 4.309				
BAFFLE THICKNESS		TMPTNGEME	ENT BAFFLE	TNCLUDED	NO
PAIRS OF SEALING D					.0
	701000 1	1022011221			• 0
TUBE TYPE	PT.ATN	МАТЕВТАТ.	.a	LECTROLYTIC	COPPER
NO. OF TUBES/SHELL	. 76	EST MAX T			36
TIDE TOTU OVEDATI	ET 1 500	שנוסע סדיים	טי	TN	3125
TIBE LOTH EFF	. 11 1.000	TUDE CIEC	TTDE DIAM	T	•
1000 10111, 111	H., I 71 X W	THEFT OFFICE		1 1/1	250
' '  Rh:  .AY()  ' '	DEG 60	TUBE OUTS	DE DIAM	IN.	.250
TUBE LAYOUT	DEG 60	TUBE OUTS	DE DIAM	IN. IN.	.250 .214
PITCH RATIO	FT 1.436 DEG 60 1.250 TT 1.0 1.0	TUBE INSI	IDE DIAM  FACE RATIO,	IN. IN. OUT/IN	.250 .214 1.184

\* CALCULATED ITEM--HEAT BALANCE CODE = 8

* CALCULATED ITEMHEAT BALANCE (		E0000 D107
Washington University ChE433 heat	exchanger experiment	
Young model F302DY4P		9/23/ 3
		CASE 53
SUPPLEMENTAR	Y RESULTS	
	SHELLSIDE PERFORMANCE	
WALL CORRECTION 1.023 .967		
PRANDTL NUMBER 5.3 3.6	NOMINAL VEL, WINDOW FT/S	
RYNLD NO, AVG 287. 2031.	CROSSFLOW COEF BTU/HR-FT2-	
RYNLD NO, IN BUN 231. 2334.	WINDOW COEF BTU/HR-FT2-	-F 266.1
RYNLD NO, OUT BUN 349. 1746.		
FOULNG LAYER IN0014 .0014		
	HEAT TRANSFER X-FLOW	81.47
THERMAL RESISTANCE, % OF TOTAL	TUBE TO BAFFLE LEAKAGE A	= 3.62
SHELL TUBE FOULING METAL	MAIN CROSSFLOW B	= 65.18
40.56 57.01 2.34 .08		= 15.56
PCT OVER DESIGN .14	BAFFLE TO SHELL LEAKAGE E	= 15.64
PCT OVER DESIGN .14 TOT FOUL RESIST .000217	TUBE PASSLANE BYPASS F	= .00
DIFF RESIST .000013		
	SHELLSIDE HEAT TRANSFER FA	ACTORS
DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000 TUBE TO BAFFLE HOLE IN0284	TOTAL = (BETA) (GAMMA) (FIN)	= .687
BUNDLE TO SHELL IN5000	BETA (BAFF CUT FACTOR)	
TUBE TO BAFFLE HOLE IN0284	GAMMA (TIBE ROW ENTRY EFCT)	
BAFFLE TO SHELL IN1000		
EMITED TO SHEED IN 1000	IND (III 1000 IN 1ND 20N1)	• 551
SHELL NOZZLE DATA IN OUT	SHELL PRESSURE DROP & OF	Ψ∩ΨΔΙ.
HT UNDR NOZ IN25		= 8.9
HT OPP NOZ IN25	END ZONE	= 3.8
VELOCITY FT/S .49 .49	CROSS FLOW	
DENSITY LB/FT3 62.252 61.805	TNIED NORTE	= 3.4 = 42.7
NOZZ RHO*VSQ LB/FT-S2 14 15	OUTLET NOZZLE	= 41.2
BUND RHO*VSQ LB/FT-S2 10 10		
	WEIGHT PER SHELL, LB	4 = 0
	DRY =	
DENSITY LB/FT3 61.291 61.772	WET =	165.
PRESS. DROP % 8.6 5.4		
*** SPECIAL MESSAGES AND WARNINGS *	* * *	
WARNINGTUBESIDE FLUID HAS PASSED	THROUGH TRANSITION ZONE. COM	NSIDER
RERUNNING WITH ITEM 132 IN	N EFFECT.	
HEAT TRANSFER COEFF. AT RE	E = 2000  IS 220.42  BTU/HR-F	Γ2-F
HEAT TRANSFER COEFF. AT RE	E = 10000  IS  1247.62  BTU/HR-FS	Γ2-F
Washington University ChE433 heat	exchanger experiment	E0002 P108
Young model F302DY4P		9/23/ 3

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

CASE 54

HOT TUBE SIDE COLD SHELL SIDE

		che433b(			
		Tube		Shell	1
TOTAL FLOW RATE		SENSI	BLE LIQ	SENS	IBLE LIQ
TOTAL FLOW RATE	KT.B/HR		. 700		. 700
101112 12011 14112	1122/ 1111	TN	OTIT!	TM	OTIT
	DECE	1.40.0	106.6*	70.0	102 4+
TEMPERATURE					
DENSITY					
VISCOSITY	CP	.4726	.6461	.9783	.6678
SPECIFIC HEAT	BTU/LB-F	.9973	.9982	1.0015	.9984
THERMAL COND.					
MOLAR MASS		•0720	18.02		18.02
MOLAR MASS	LB/ LBMOL		10.02		
TEMP, AVG & SKIN	DEGF	123.3	101.4	86.7	100.5
VISCOSITY, AVG & S	SKIN CP	.5487	.6814	.8010	.6880
PRESSURE, IN & DES	SIGN PSIA	50.00	165.00	50.00	165.00
,					
PRESSURE DROP, TOT					
VELOCITY, CALC & N	MAX ALLOWED FT/	/S .68	10.00	.11	10.00
FOULING RESISTANCE	. up_em2_e/:	יוחכו (	0.001.0	,	00010
FILM COEFFICIENT	B'I'U/HR-F''I'2				93.05
TOTAL HEAT DUTY RE					.023346
			04 D7	BB 1 00\	
EFF TEMP DIF, DEGI			ASS= .94,BA	F.E.=1.00)	
OVERALL COEFF REQU					112.42
CLEAN & FOULED COR	EFF BTU/HR-E	FT2-F	115.2	7	112.05
				_	
SHELLS IN SERIES					
PASSES, SHELL	1 TUBE 4	EFFECTIVE	E AREA	FT2/SHELL	7.1
PASSES, SHELL SHELL DIAMETER IN.			E AREA LL TYPE E		
SHELL DIAMETER IN.	3.820	TEMA SHEI	LL TYPE E	; REAR HI	EAD FXTS
SHELL DIAMETER IN. BAFFLE TYPE	. 3.820 HORZ SEGMENTL	TEMA SHEI	LL TYPE E	; REAR H	EAD FXTS
SHELL DIAMETER IN.  BAFFLE TYPE  SPACING, CENTRAL	3.820 HORZ SEGMENTL IN. 4.309	TEMA SHEI	LL TYPE E	; REAR H	EAD FXTS
SHELL DIAMETER IN. BAFFLE TYPE	3.820 HORZ SEGMENTL IN. 4.309	TEMA SHEI CROSS PAS BAFFLE CU	LL TYPE E	; REAR HI ELL PASS LL I.D.	EAD FXTS 4 30.00
SHELL DIAMETER IN.  BAFFLE TYPE F SPACING, CENTRAL SPACING, INLET	3.820 HORZ SEGMENTL IN. 4.309 IN. 4.309	TEMA SHEI CROSS PAS BAFFLE CU	LL TYPE E SSES PER SH JT, PCT SHE	; REAR HI ELL PASS LL I.D.	EAD FXTS 4 30.00
BAFFLE TYPE F SPACING, CENTRAL SPACING, INLET SPACING, OUTLET	3.820  HORZ SEGMENTL  IN. 4.309  IN. 4.309  IN. 4.309	TEMA SHEI  CROSS PAS  BAFFLE CU  CUT DISTA	LL TYPE E  SSES PER SHI  JT, PCT SHE  ANCE FROM C	; REAR HIELL PASS LL I.D. ENTER, IN.	EAD FXTS 4 30.00 .764
SHELL DIAMETER IN.  BAFFLE TYPE SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS	3.820  HORZ SEGMENTL IN. 4.309 IN. 4.309 IN. 4.309 IN. 125	TEMA SHEI  CROSS PAS BAFFLE CU CUT DISTA	LL TYPE E  SSES PER SHI  JT, PCT SHEI  ANCE FROM CI  ENT BAFFLE	; REAR HI ELL PASS LL I.D. ENTER, IN. INCLUDED	EAD FXTS  4  30.00  .764  NO
BAFFLE TYPE F SPACING, CENTRAL SPACING, INLET SPACING, OUTLET	3.820  HORZ SEGMENTL IN. 4.309 IN. 4.309 IN. 4.309 IN. 125	TEMA SHEI  CROSS PAS BAFFLE CU CUT DISTA	LL TYPE E  SSES PER SHI  JT, PCT SHE  ANCE FROM C	; REAR HI ELL PASS LL I.D. ENTER, IN. INCLUDED	EAD FXTS  4  30.00  .764  NO
SHELL DIAMETER IN.  BAFFLE TYPE SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS	3.820  HORZ SEGMENTL IN. 4.309 IN. 4.309 IN. 4.309 IN. 125	TEMA SHEI  CROSS PAS BAFFLE CU  CUT DISTA  IMPINGEME TUBESHEET	CL TYPE E  SSES PER SHI  JT, PCT SHE  ANCE FROM CI  ENT BAFFLE  F BLANK ARE	; REAR HI ELL PASS LL I.D. ENTER, IN. INCLUDED	4 30.00 .764 NO .0
SHELL DIAMETER IN.  BAFFLE TYPE F SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING INTER TUBE TYPE	3.820  HORZ SEGMENTL IN. 4.309 IN. 4.309 IN. 125 DEVICES 1  PLAIN	TEMA SHEI  CROSS PAS BAFFLE CU CUT DISTA  IMPINGEME TUBESHEET  MATERIAL	CL TYPE E  SSES PER SHI  JT, PCT SHE  ANCE FROM CI  ENT BAFFLE  F BLANK ARE  E:	; REAR HIELL PASS LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC	4 30.00 .764 NO .0
SHELL DIAMETER IN.  BAFFLE TYPE F SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING INTUBE TYPE NO. OF TUBES/SHELI	3.820  HORZ SEGMENTL IN. 4.309 IN. 4.309 IN. 125 DEVICES 1  PLAIN T 76	TEMA SHEI  CROSS PAS BAFFLE CU CUT DISTA  IMPINGEME TUBESHEES  MATERIAL EST MAX SE	EL TYPE E  SSES PER SHI  JT, PCT SHE  ANCE FROM CI  ENT BAFFLE  F BLANK ARE  EI  FUBE COUNT	; REAR HI ELL PASS LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC	4 30.00 .764 NO .0 C COPPER 36
BAFFLE TYPE F SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI	3.820  HORZ SEGMENTL IN. 4.309 IN. 4.309 IN125 DEVICES 1  PLAIN 76 L FT 1.500	TEMA SHEI  CROSS PAS BAFFLE CU CUT DISTA  IMPINGEME TUBESHEES  MATERIAL EST MAX STUBE PITCE	EL TYPE E  SSES PER SHI  JT, PCT SHE  ANCE FROM CI  ENT BAFFLE  F BLANK ARE  EI  TUBE COUNT  CH	; REAR HI ELL PASS LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC	4 30.00 .764  NO .0  C COPPER 36 .3125
SHELL DIAMETER IN.  BAFFLE TYPE F SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I  TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI TUBE LGTH, EFF	3.820  HORZ SEGMENTL IN. 4.309 IN. 4.309 IN125 DEVICES 1  PLAIN L 76 L FT 1.500 FT 1.436	TEMA SHEI  CROSS PAS BAFFLE CU CUT DISTA  IMPINGEME TUBESHEET  MATERIAL EST MAX TUBE PITC TUBE OUTS	CL TYPE E  SSES PER SHI  JT, PCT SHE  ANCE FROM CI  ENT BAFFLE  F BLANK ARE  FUBE COUNT  CH  SIDE DIAM	; REAR HI ELL PASS LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC IN. IN.	A 30.00 .764 NO .0 C COPPER 36 .3125 .250
BAFFLE TYPE SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I  TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI TUBE LGTH, EFF TUBE LAYOUT	3.820  HORZ SEGMENTL IN. 4.309 IN. 4.309 IN125 DEVICES 1  PLAIN T 76 FT 1.500 FT 1.436 DEG 60	TEMA SHEIL  CROSS PASS BAFFLE CU CUT DISTA  IMPINGEME TUBESHEET  MATERIAL EST MAX TUBE PITC TUBE OUTS TUBE INST	SSES PER SHOOM COME TO SHOOM C	; REAR HI ELL PASS LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC IN. IN. IN.	A 30.00 .764 NO .0 C COPPER 36 .3125 .250 .214
SHELL DIAMETER IN.  BAFFLE TYPE F SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I  TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI TUBE LGTH, EFF	3.820  HORZ SEGMENTL IN. 4.309 IN. 4.309 IN125 DEVICES 1  PLAIN T 76 FT 1.500 FT 1.436 DEG 60	TEMA SHEIL  CROSS PASS BAFFLE CU CUT DISTA  IMPINGEME TUBESHEET  MATERIAL EST MAX TUBE PITC TUBE OUTS TUBE INST	CL TYPE E  SSES PER SHI  JT, PCT SHE  ANCE FROM CI  ENT BAFFLE  F BLANK ARE  FUBE COUNT  CH  SIDE DIAM	; REAR HI ELL PASS LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC IN. IN. IN.	A 30.00 .764 NO .0 C COPPER 36 .3125 .250 .214
BAFFLE TYPE SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I  TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI TUBE LGTH, EFF TUBE LAYOUT PITCH RATIO	3.820  HORZ SEGMENTL IN. 4.309 IN. 4.309 IN125 DEVICES 1  PLAIN 76 FT 1.500 FT 1.436 DEG 60 1.250	CROSS PASS BAFFLE CUT DISTAL IMPINGEMENTUBESHEET MATERIAL EST MAX TUBE PITCUBE OUTS TUBE INSTITUBE SURE	SSES PER SHI JT, PCT SHE ANCE FROM CI ENT BAFFLE BLANK ARE UBE COUNT CH SIDE DIAM IDE DIAM FACE RATIO,	; REAR HI ELL PASS LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC IN. IN. IN. OUT/IN	A 30.00 .764 NO .0 C COPPER 36 .3125 .250 .214 1.184
BAFFLE TYPE SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I  TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI TUBE LGTH, EFF TUBE LAYOUT	3.820  HORZ SEGMENTL IN. 4.309 IN. 4.309 IN125 DEVICES 1  PLAIN 76 FT 1.500 FT 1.436 DEG 60 1.250	CROSS PASS BAFFLE CUT DISTAL IMPINGEMENTUBESHEET MATERIAL EST MAX TUBE PITCUBE OUTS TUBE INSTITUBE SURE	SSES PER SHOOM COME TO SHOOM C	; REAR HI ELL PASS LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC IN. IN. IN. OUT/IN	A 30.00 .764 NO .0 C COPPER 36 .3125 .250 .214 1.184
BAFFLE TYPE SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I  TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI TUBE LGTH, EFF TUBE LAYOUT PITCH RATIO	3.820  HORZ SEGMENTL IN. 4.309 IN. 4.309 IN125 DEVICES 1  PLAIN To 76 To FT 1.500 FT 1.436 DEG 60 1.250 JT 1.0 1.0	CROSS PASS BAFFLE CUCUT DISTAL IMPINGEMENTUBESHEES MATERIAL EST MAX STUBE PITOTUBE OUTS TUBE INSTUBE INSTUBE INSTUBE NOZZ	SSES PER SHI JT, PCT SHE ANCE FROM CI ENT BAFFLE BLANK ARE UBE COUNT CH SIDE DIAM IDE DIAM FACE RATIO,	; REAR HI ELL PASS LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC IN. IN. IN. OUT/IN	A 30.00 .764 NO .0 C COPPER 36 .3125 .250 .214 1.184
BAFFLE TYPE SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I  TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI TUBE LGTH, EFF TUBE LAYOUT PITCH RATIO SHL NOZZ ID, IN&OU  * CALCULATED ITE	3.820  HORZ SEGMENTL IN. 4.309 IN. 4.309 IN125 DEVICES 1  PLAIN 76 FT 1.500 FT 1.436 DEG 60 1.250 JT 1.0 1.0	TEMA SHEI  CROSS PAS BAFFLE CU CUT DISTA  IMPINGEME TUBESHEES  MATERIAL EST MAX STUBE PITO TUBE OUTS TUBE INSS TUBE SURE TUBE NOZZ  E CODE = 8	EL TYPE E  SSES PER SHI  JT, PCT SHE  ANCE FROM CI  ENT BAFFLE  F BLANK ARE  FUBE COUNT  CH  SIDE DIAM  IDE DIAM  FACE RATIO,  Z ID, IN&OU	; REAR HI ELL PASS LL I.D. ENTER, IN. INCLUDED A, %  LECTROLYTIC IN. IN. IN. OUT/IN I IN.	A 30.00 .764 NO .0 C COPPER 36 .3125 .250 .214 1.184 .8 .8
BAFFLE TYPE SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I  TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI TUBE LGTH, EFF TUBE LAYOUT PITCH RATIO SHL NOZZ ID, IN&OU  * CALCULATED ITE Washington University	3.820  HORZ SEGMENTL IN. 4.309 IN. 4.309 IN125 DEVICES 1  PLAIN 76 L FT 1.500 FT 1.436 DEG 60 1.250 JT 1.0 1.0  EMHEAT BALANCE ersity ChE433 he	TEMA SHEI  CROSS PAS BAFFLE CU CUT DISTA  IMPINGEME TUBESHEES  MATERIAL EST MAX STUBE PITO TUBE OUTS TUBE INSS TUBE SURE TUBE NOZZ  E CODE = 8	EL TYPE E  SSES PER SHI  JT, PCT SHE  ANCE FROM CI  ENT BAFFLE  F BLANK ARE  FUBE COUNT  CH  SIDE DIAM  IDE DIAM  FACE RATIO,  Z ID, IN&OU	; REAR HI ELL PASS LL I.D. ENTER, IN. INCLUDED A, %  LECTROLYTIC IN. IN. IN. OUT/IN I IN.	A 30.00 .764 NO .0 C COPPER 36 .3125 .250 .214 1.184 .8 .8
BAFFLE TYPE SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I  TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI TUBE LGTH, EFF TUBE LAYOUT PITCH RATIO SHL NOZZ ID, IN&OU  * CALCULATED ITE	3.820  HORZ SEGMENTL IN. 4.309 IN. 4.309 IN125 DEVICES 1  PLAIN 76 L FT 1.500 FT 1.436 DEG 60 1.250 JT 1.0 1.0  EMHEAT BALANCE ersity ChE433 he	TEMA SHEI  CROSS PAS BAFFLE CU CUT DISTA  IMPINGEME TUBESHEES  MATERIAL EST MAX STUBE PITO TUBE OUTS TUBE INSS TUBE SURE TUBE NOZZ  E CODE = 8	EL TYPE E  SSES PER SHI  JT, PCT SHE  ANCE FROM CI  ENT BAFFLE  F BLANK ARE  FUBE COUNT  CH  SIDE DIAM  IDE DIAM  FACE RATIO,  Z ID, IN&OU	; REAR HI ELL PASS LL I.D. ENTER, IN. INCLUDED A, %  LECTROLYTIC IN. IN. IN. OUT/IN I IN.	A 30.00 .764 NO .0 C COPPER 36 .3125 .250 .214 1.184 .8 8
BAFFLE TYPE F SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I  TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI TUBE LAYOUT PITCH RATIO SHL NOZZ ID, IN&OU  * CALCULATED ITE Washington Univeryoung model F302DY	3.820  HORZ SEGMENTL IN. 4.309 IN. 4.309 IN125 DEVICES 1  PLAIN 76 FT 1.500 FT 1.436 DEG 60 1.250 JT 1.0 1.0  EM-HEAT BALANCE PRINT CAP	TEMA SHEI  CROSS PAS BAFFLE CU CUT DISTA  IMPINGEME TUBESHEET  MATERIAL EST MAX TUBE PITO TUBE OUTS TUBE INST TUBE SURE TUBE NOZZ  E CODE = 8	SSES PER SHI JT, PCT SHE ANCE FROM CI ENT BAFFLE F BLANK ARE FUBE COUNT CH SIDE DIAM IDE DIAM FACE RATIO, Z ID, IN&OU	; REAR HI ELL PASS LL I.D. ENTER, IN. INCLUDED A, %  LECTROLYTIC IN. IN. OUT/IN I IN. OUT/IN I IN.	A 30.00 .764 NO .0 C COPPER 36 .3125 .250 .214 1.184 .8 .8
BAFFLE TYPE SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I  TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI TUBE LGTH, EFF TUBE LAYOUT PITCH RATIO SHL NOZZ ID, IN&OU  * CALCULATED ITE Washington University	3.820  HORZ SEGMENTL IN. 4.309 IN. 4.309 IN125 DEVICES 1  PLAIN 76 FT 1.500 FT 1.436 DEG 60 1.250 JT 1.0 1.0  EM-HEAT BALANCE PRINT CAP	TEMA SHEI  CROSS PAS BAFFLE CU CUT DISTA  IMPINGEME TUBESHEET  MATERIAL EST MAX TUBE PITO TUBE OUTS TUBE INST TUBE SURE TUBE NOZZ  E CODE = 8	SSES PER SHI JT, PCT SHE ANCE FROM CI ENT BAFFLE F BLANK ARE FUBE COUNT CH SIDE DIAM IDE DIAM FACE RATIO, Z ID, IN&OU	; REAR HI ELL PASS LL I.D. ENTER, IN. INCLUDED A, %  LECTROLYTIC IN. IN. OUT/IN I IN. OUT/IN I IN.	A 30.00 .764 NO .0 C COPPER 36 .3125 .250 .214 1.184 .8 8
BAFFLE TYPE SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I  TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI TUBE LGTH, EFF TUBE LAYOUT PITCH RATIO SHL NOZZ ID, IN&OU  * CALCULATED ITE Washington Unive Young model F302DY	3.820  HORZ SEGMENTL IN. 4.309 IN. 4.309 IN125 DEVICES 1  PLAIN To 76 To FT 1.500 FT 1.436 DEG 60 1.250 JT 1.0 1.0  EMHEAT BALANCE PERSITY ChE433 here Exity ChE433 here Exity ChE433 here Exity ChE433 here Exity ChE433 here	TEMA SHEI  CROSS PAS BAFFLE CU CUT DISTA  IMPINGEME TUBESHEET  MATERIAL EST MAX TUBE PITO TUBE OUTS TUBE INST TUBE INST TUBE NOZZ E CODE = 8 eat exchang	SSES PER SHIUT, PCT SHEANCE FROM CILL TYPE ENT SHEANCE FROM CILL TO BLANK AREADED FOR THE SIDE DIAM IDE DIAM FACE RATIO, IN & OUT OF THE SIDE DIAM FACE RATIO DIAM FACE RATI	; REAR HI ELL PASS LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC IN. IN. IN. OUT/IN T IN. ent L T S	A 30.00 .764 NO .0 C COPPER 36 .3125 .250 .214 1.184 .8 8
BAFFLE TYPE SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I  TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI TUBE LGTH, EFF TUBE LAYOUT PITCH RATIO SHL NOZZ ID, IN&OU  * CALCULATED ITE Washington Unive Young model F302DY  S U P P L E  HT PARAMETERS	HORZ SEGMENTL IN. 4.309 IN. 4.309 IN. 4.309 IN125 DEVICES 1  PLAIN To 76 E FT 1.500 FT 1.436 DEG 60 1.250 JT 1.0 1.0  EMHEAT BALANCE PERSITY ChE433 here EACH TO TA  SHELL TUBE	TEMA SHEI  CROSS PAS BAFFLE CU CUT DISTA  IMPINGEME TUBESHEES  MATERIAL EST MAX S TUBE PITO TUBE OUTS TUBE INSS TUBE NOZZ  E CODE = 8 eat exchang  R Y F	SSES PER SHI UT, PCT SHE ANCE FROM CI ENT BAFFLE I BLANK ARE I BLA	; REAR HI ELL PASS LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC IN. IN. OUT/IN T IN. ent L T S RMANCE	A 30.00 .764 NO .0 C COPPER 36 .3125 .250 .214 1.184 .8 8 E0002 P109 9/23/ 3 CASE 54
BAFFLE TYPE SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING I  TUBE TYPE NO. OF TUBES/SHELI TUBE LGTH, OVERALI TUBE LGTH, EFF TUBE LAYOUT PITCH RATIO SHL NOZZ ID, IN&OU  * CALCULATED ITE Washington Unive Young model F302DY	HORZ SEGMENTL IN. 4.309 IN. 4.309 IN. 4.309 IN125 DEVICES 1  PLAIN To 76 E FT 1.500 FT 1.436 DEG 60 1.250 JT 1.0 1.0  EMHEAT BALANCE PERSITY ChE433 here EACH TO TA  SHELL TUBE	TEMA SHEI  CROSS PAS BAFFLE CU CUT DISTA  IMPINGEME TUBESHEES  MATERIAL EST MAX S TUBE PITO TUBE OUTS TUBE INSS TUBE NOZZ  E CODE = 8 eat exchang  R Y F	SSES PER SHI UT, PCT SHE ANCE FROM CI ENT BAFFLE I BLANK ARE I BLA	; REAR HI ELL PASS LL I.D. ENTER, IN. INCLUDED A, % LECTROLYTIC IN. IN. OUT/IN T IN. ent L T S RMANCE	A 30.00 .764 NO .0 C COPPER 36 .3125 .250 .214 1.184 .8 8

			cne433b(/U).OUT		
			NOMINAL VEL, WINDOW FT/S		
RYNLD NO, AVG	329.	2010.	CROSSFLOW COEF BTU/HR-F	T2-F	294.2
			WINDOW COEF BTU/HR-F	T2-F	296.0
RYNLD NO, OUT BUN	394.	1707.			
FOULNG LAYER IN.	.0014	.0014	SHELLSIDE FLOW, % OF TO	TAL	
			HEAT TRANSFER X-FLOW		
THERMAL RESISTANCE	, % OF TO	TAL	TUBE TO BAFFLE LEAKAGE	A =	3.80
SHELL TUBE FOU	LING MET	AL	MAIN CROSSFLOW	B =	64.84
			BUNDLE TO SHELL BYPASS		
PCT OVER DESIGN		33	BAFFLE TO SHELL LEAKAGE TUBE PASSLANE BYPASS	E =	15.52
TOT FOUL RESIST	.0	00217	TUBE PASSLANE BYPASS	F =	.00
DIFF RESIST	0	00029			
			SHELLSIDE HEAT TRANSFER	FACT	ORS
DIAMETRAL CLEARA	NCES		TOTAL = (BETA) (GAMMA) (FIN)		
BUNDLE TO SHELL	IN.	.5000	BETA (BAFF CUT FACTOR)	=	.920
TUBE TO BAFFLE HOL	E IN.	.0284	GAMMA (TUBE ROW ENTRY EFC	T) =	.774
BAFFLE TO SHELL	IN.	.1000	END (HT LOSS IN END ZON	E) =	.994
SHELL NOZZLE DAT	A IN	OUT	SHELL PRESSURE DROP, %	OF TO	TAL
HT UNDR NOZ IN.	.25		WINDOW	=	8.9
HT OPP NOZ IN.	.25		WINDOW END ZONE CROSS FLOW INLET NOZZLE OUTLET NOZZLE	=	3.6
VELOCITY FT/S	.57	.58	CROSS FLOW	=	3.2
DENSITY LB/FT3	62.252	61.846	INLET NOZZLE	=	42.9
NOZZ RHO*VSQ LB/FT	-S2 20	20	OUTLET NOZZLE	=	41.5
BUND RHO*VSQ LB/FT	-s2 13	13			
~					
TUBE NOZZLE DATA	IN	OUT	WEIGHT PER SHELL, LB		
VELOCITY FT/S					150.
DENSITY LB/FT3			DRY WET	=	165.
PRESS. DROP %					<del>-</del>

# \*\*\* 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 220.97 BTU/HR-FT2-F HEAT TRANSFER COEFF. AT RE = 10000 IS 1249.62 BTU/HR-FT2-F

Washington University ChE433 heat exchanger experiment E0002 P110 Young model F302DY4P 9/23/3 CASE 55

		HOT T	UBE SIDE	COLD S	HELL SIDE	
		Tube		Shell		
		SENS	IBLE LIQ	SENS	IBLE LIQ	
TOTAL FLOW RATE	KLB/HR		.700		.800	
		IN	OUT	IN	OUT	
TEMPERATURE	DEGF	140.0	104.8*	70.0	100.8*	
DENSITY	LB/FT3	61.2913	61.8272	62.2515	61.8813	
VISCOSITY	CP	.4726	.6582	.9783	.6862	
SPECIFIC HEAT	BTU/LB-F	.9973	.9984	1.0015	.9986	
THERMAL COND.	BTU/HR-FT-F	.3723	.3644	.3554	.3634	

MOLAR MASS LB/LBMOL	che433b(70	).OUT 18.02	18.02
TEMP, AVG & SKIN DEGF VISCOSITY, AVG & SKIN CP PRESSURE, IN & DESIGN PSIA	122.4 .5534	99.5 .6958 .	85.4 98.5 8130 .7029
PRESSURE DROP, TOT & ALLOWED PSI VELOCITY, CALC & MAX ALLOWED FT/S			
FOULING RESISTANCE HR-FT2-F/B' FILM COEFFICIENT BTU/HR-FT2-	-F 221		
TOTAL HEAT DUTY REQUIRED MEGBTU/HI EFF TEMP DIF, DEGF (LMTD= 37.0,F) OVERALL COEFF REQUIRED BTU/HR-F) CLEAN & FOULED COEFF BTU/HR-F)	R = .85,BYPAS T2-F		116.08
SHELLS IN SERIES 1 PARALLEL 1 PASSES, SHELL 1 TUBE 4 SHELL DIAMETER IN. 3.820	EFFECTIVE A	AREA FT2/	SHELL 7.1
BAFFLE TYPE HORZ SEGMENTL SPACING, CENTRAL IN. 4.309 SPACING, INLET IN. 4.309 SPACING, OUTLET IN. 4.309 BAFFLE THICKNESS IN125 PAIRS OF SEALING DEVICES 1	BAFFLE CUT, CUT DISTANCE IMPINGEMENT	PCT SHELL I. CE FROM CENTER BAFFLE INCLU	D. 30.00 s, IN764
TUBE LGTH, OVERALL FT 1.500	EST MAX TURE TUBE PITCH TUBE OUTSING TUBE INSIDER TUBE SURFACE	BE COUNT IN DE DIAM IN DE DIAM IN DE RATIO, OUT/	36 3125 250 214 310 311 312 311 312 311 312 311 312 312
* CALCULATED ITEMHEAT BALANCE Washington University ChE433 heavyoung model F302DY4P		e experiment	E0002 P111 9/23/ 3 CASE 55
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.021 .000 PRANDTL NUMBER 5.5 3.6 RYNLD NO, AVG 370. 1993. RYNLD NO, IN BUN 308. 2334. RYNLD NO,OUT BUN 439. 1676. FOULNG LAYER IN0014 .0014	SHELLS: NOMINAL V NOMINAL V CROSSFLOV WINDOW CO	IDE PERFORMANC VEL,X-FLOW FT VEL,WINDOW FT V COEF BTU/H	EE 2/S .10 2/S .20 2/R-FT2-F 324.1 2/R-FT2-F 326.0
THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 35.47 61.93 2.51 .08	TUBE TO E	BAFFLE LEAKAGE SSFLOW	A = 3.95  B = 64.56  C = 16.08

	ch	ne433b(70).OUT		
PCT OVER DESIGN	24 F	BAFFLE TO SHELL LEAKAGE E	= 1	5.40
TOT FOUL RESIST .0002				
DIFF RESIST0000				
		SHELLSIDE HEAT TRANSFER FA		
DIAMETRAL CLEARANCES	7	TOTAL = (BETA) (GAMMA) (FIN)	=	.736
BUNDLE TO SHELL IN5	000 F	BETA (BAFF CUT FACTOR)	=	.920
TUBE TO BAFFLE HOLE IN0	284 (	GAMMA (TUBE ROW ENTRY EFCT)	=	.800
BAFFLE TO SHELL IN1				
SHELL NOZZLE DATA IN	OUT	SHELL PRESSURE DROP, % OF	TOTA	L
HT UNDR NOZ IN25	V	WINDOW	=	8.9
HT OPP NOZ IN25	F	END ZONE	=	3.4
HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .65	.66	CROSS FLOW	=	3.1
DENSITY LB/FT3 62.252 61. NOZZ RHO*VSQ LB/FT-S2 26	881 3	INLET NOZZLE	=	43.0
NOZZ RHO*VSQ LB/FT-S2 26	26 (	OUTLET NOZZLE	=	41.7
BUND RHO*VSQ LB/FT-S2 18				
TUBE NOZZLE DATA IN	OUT	WEIGHT PER SHELL, LB		
VELOCITY FT/S 1.03 1	.03 I	DRY =		150.
DENSITY LB/FT3 61.291 61.	827 V	WET =		165.
PRESS. DROP % 8.6				
*** SPECIAL MESSAGES AND WARNI	NGS **	*		

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

Washington University ChE433 heat exchanger experiment E0002 P112 9/23/ 3 Young model F302DY4P CASE 56

SIZE	1 _	1 2	TVDF	BEM	MULTI-PASS	EI OM	SECMENTAI	BYELLC	PATTNC
SIVE	4 -	Τ0	LIPL	BEM,	MOTIT-LASS	f LOW,	SEGMENIAL	BALLTES,	RAIING

		HOT TO	UBE SIDE	COLD SI	HELL SIDE
		Tube		Shell	L
		SENS	IBLE LIQ	SENS	BLE LIQ
TOTAL FLOW RATE	KLB/HR		.700		.900
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	103.0*	70.0	98.7*
DENSITY	LB/FT3	61.2913	61.8512	62.2515	61.9085
VISCOSITY	CP	.4726	.6703	.9783	.7013
SPECIFIC HEAT	BTU/LB-F	.9973	.9985	1.0015	.9988
THERMAL COND.	BTU/HR-FT-F	.3723	.3640	.3554	.3629
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	121.5	97.8	84.4	96.8
VISCOSITY, AVG & S	KIN CP	.5580	.7085	.8227	.7161
PRESSURE, IN & DES	IGN PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT	& ALLOWED PS	I .09	10.00	.02	10.00
VELOCITY, CALC & M	AX ALLOWED FT	/s .68	10.00	.14	10.00
FOULING RESISTANCE	HR-FT2-F/	BTU .	00010	. (	00010
FILM COEFFICIENT	BTU/HR-FT	2-F 22	21.45	3.5	53.15

\_\_\_\_\_

TOTAL HEAT DUTY REQUIRED MEGBTU/HR EFF TEMP DIF, DEGF (LMTD= 37.0,F= OVERALL COEFF REQUIRED BTU/HR-FT	.85,BYPASS= .96,BAFF=1.00)	.025839 30.2 119.79
CLEAN & FOULED COEFF BTU/HR-FT	2-F 123.24	119.47
SHELLS IN SERIES 1 PARALLEL 1		
PASSES, SHELL 1 TUBE 4 SHELL DIAMETER IN. 3.820	TEMA SHELL TYPE E ; REAR HEA	AD FXTS
	CROSS PASSES PER SHELL PASS	
	BAFFLE CUT, PCT SHELL I.D. CUT DISTANCE FROM CENTER, IN.	
BAFFLE THICKNESS IN125		
	TUBESHEET BLANK AREA, %	.0
	MATERIAL ELECTROLYTIC EST MAX TUBE COUNT	
TUBE LGTH, OVERALL FT 1.500	EST MAX TUBE COUNT TUBE PITCH IN.	.3125
TUBE LGTH, EFF FT 1.436	TUBE OUTSIDE DIAM IN.	.250
	TUBE INSIDE DIAM IN.	.214
PITCH RATIO 1.250	TUBE SUBFACE RATIO OUT/IN	
SHL NOZZ ID, IN&OUT 1.0 1.0	TUBE NO77 ID INCOUT IN	2 2
and hold 12, indeed 1.0 1.0	iozz nożz iż, inacci in.	•
* CALCULATED ITEMHEAT BALANCE		-0000 -440
Washington University ChE433 hea		E0002 P113
Young model F302DY4P		9/23/ 3
		CASE 56
SUPPLEMENTAR	YRESULTS	
HT PARAMETERS SHELL TUBE	SHELLSIDE PERFORMANCE	
WALL CORRECTION 1 020 000	NOMINAI VEI Y-FIOM FT/S	.12
PRANDTI NIIMBER 5 5 3 7	NOMINAL VELLWINDOW FT/S	23
RYNID NO. AVG. 412 1977	CROSSFLOW COEF RTII/HR-FT2-F	354 6
PVNID NO TN BIIN 3/6 233/	WINDOW COFF BTH/HP-FT2-F	356.7
PYNID NO OUT BIIN 483 1646	WINDOW CODI BIO/III( 112 1	330.7
PRANDTL NUMBER 5.5 3.7  RYNLD NO, AVG 412. 1977.  RYNLD NO, IN BUN 346. 2334.  RYNLD NO, OUT BUN 483. 1646.  FOULNG LAYER IN0014 .0014	SHELLSIDE FLOW, % OF TOTAL	
	HEAT TRANSFER X-FLOW	81.44
THERMAL RESISTANCE, % OF TOTAL	TUBE TO BAFFLE LEAKAGE A =	= 4.08
SHELL TUBE FOULING METAL	MAIN CROSSFLOW B =	64.45
33.45 63.87 2.59 .09	BUNDLE TO SHELL BYPASS C =	16 17
	BAFFLE TO SHELL LEAKAGE E =	
PCT OVER DESIGN26 TOT FOUL RESIST .000217	TUBE PASSLANE BYPASS F =	- 13.30
DIFF RESIST000022	TUBE PASSLANE BIPASS F -	00
	SHELLSIDE HEAT TRANSFER FAC	TORS
DIAMETRAI, CLEARANCES	TOTAL = (RETA) (CAMMA) (FIN) =	762
DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000	RETA (RAFE CUT EXCTOD) -	920
TUBE TO BAFFLE HOLE IN0284	GAMMA (TUBE ROW ENTRY EFCT) =	- 820
BAFFLE TO SHELL IN1000	FWD (UI TOSS IN FWD ZONF) =	. 994
SHELL NOZZIE DATA IN OUT		
SHELL NOZZLE DATA IN OOT	SHELL PRESSURE DROP, % OF T	OTAL
HT UNDR NOZ IN25	SHELL PRESSURE DROP, % OF TWINDOW =	COTAL 8.9

HT OPP NOZ IN.	.25		END ZONE	=	3.2
VELOCITY FT/S	.74	.74	CROSS FLOW	=	3.0
DENSITY LB/FT3	62.252	61.908	INLET NOZZLE	=	43.0
NOZZ RHO*VSQ LB/FT-	-s2 33	33	OUTLET NOZZLE	=	41.9
BUND RHO*VSQ LB/FT-	-S2 22	23			
TUBE NOZZLE DATA	IN	OUT	WEIGHT PER SHELL, LB		
VELOCITY FT/S	1.03	1.02	DRY	=	150.
DENSITY LB/FT3	61.291	61.851	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.

Washington University ChE433 heat exchanger experiment E0002 P114 Young model F302DY4P 9/23/3

Young model F302DY4	1 P				9/23/ 3
					CASE 57
SIZE 4- 18 TYPE BEN	M, MULTI-PASS F	LOW, SEGME	NTAL BAFFLE	ES, RATING	
		HOT TU	JBE SIDE	COLD SH	HELL SIDE
		Tube		Shell	
		SENSI	BLE LIQ	SENSI	BLE LIQ
TOTAL FLOW RATE	KLB/HR		.800		.200
TOTAL FLOW RATE		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	125.5*	70.0	127.8*
DENSITY	LB/FT3	61.2913	61.5244	62.2515	61.4884
VISCOSITY	CP	.4726	.5375	.9783	.5262
SPECIFIC HEAT		.9973	.9974	1.0015	.9974
THERMAL COND.					
MOLAR MASS					
			18.02		
TEMP, AVG & SKIN	DEGF	132.8	120.5	98.9	119.8
VISCOSITY, AVG & SF	KIN CP	.5034	.5635	.6998	.5670
VISCOSITY, AVG & SP PRESSURE, IN & DESI	IGN PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT	& ALLOWED PSI	.11	10.00	.00	10.00
VELOCITY, CALC & MA	AX ALLOWED FT/	s .78	10.00	.03	10.00
FOULING RESISTANCE					
FILM COEFFICIENT					37.00
TOTAL HEAT DUTY REQ					.011552
EFF TEMP DIF, DEGF			ASS= .87,BAE	FF=1.00)	
OVERALL COEFF REQUI					85.83
CLEAN & FOULED COEF	FF BTU/HR-F	T2-F	86.94	l	85.52
SHELLS IN SERIES 1	PARALLEL 1	TOTAL EFF	AREA	FT2	7.1
PASSES, SHELL 1					
SHELL DIAMETER IN.	3.820	TEMA SHEI	L TYPE E	; REAR HE	AD FXTS
BAFFLE TYPE HO	ORZ SEGMENTL	CROSS PAS	SSES PER SHE	ELL PASS	4

	(	che433b(70).OUT	
SPACING, CENTRAL IN. 4	.309 B	BAFFLE CUT, PCT SHELL I.D.	30.00
SPACING, INLET IN. 4		CUT DISTANCE FROM CENTER, 1	
SPACING, OUTLET IN. 4		of biolimon from childry	. 701
BAFFLE THICKNESS IN.		MPINGEMENT BAFFLE INCLUDED	
PAIRS OF SEALING DEVICES	1 T	UBESHEET BLANK AREA, %	.0
TUBE TYPE P	LAIN M	MATERIAL ELECTROLY	TIC COPPER
NO. OF TUBES/SHELL	76 E	ST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT 1			.3125
TUBE LGTH, EFF FT 1			.250
TUBE LAYOUT DEG		UBE INSIDE DIAM IN.	
PITCH RATIO 1			
SHL NOZZ ID, IN&OUT 1.0	1.0 T	UBE NOZZ ID, IN&OUT IN.	.8 .8
* CALCULATED ITEMHEAT B	BALANCE C	CODE = 8	
Washington University ChE	3433 heat	exchanger experiment	E0002 P115
Young model F302DY4P			9/23/ 3
3			CASE 57
SUPPLEMEN	T 7 D	Y RESULTS	
	IAI		)
HT PARAMETERS SHELL			
WALL CORRECTION 1.030			
PRANDTL NUMBER 4.7	3.3		
RYNLD NO, AVG 107.	2504.	CROSSFLOW COEF BTU/HR-F	FT2-F 137.5
RYNLD NO, IN BUN 76.	2667.	WINDOW COEF BTU/HR-F	FT2-F 138.4
RYNLD NO, OUT BUN 142.			
FOULNG LAYER IN0014		SHELLSIDE FLOW, % OF TO	OTAL
		HEAT TRANSFER X-FLOW	
THERMAL RESISTANCE, % OF TO	\T A T		
SHELL TUBE FOULING MET			
61.73 36.36 1.85 .			
PCT OVER DESIGN			
TOT FOUL RESIST .0		TUBE PASSLANE BYPASS	F = .00
DIFF RESIST0	00042		
		SHELLSIDE HEAT TRANSFER	R FACTORS
DIAMETRAL CLEARANCES		TOTAL = (BETA) (GAMMA) (FIN)	= .598
BUNDLE TO SHELL IN.		BETA (BAFF CUT FACTOR)	= .920
TUBE TO BAFFLE HOLE IN.			
BAFFLE TO SHELL IN.			
Entitle 10 ones in.	.1000		• 551
OUDIT NORTH DAMA IN	OHE	GILLI DEGGLIDE DOOD 0	
SHELL NOZZLE DATA IN			
HT UNDR NOZ IN25			= 9.5
HT OPP NOZ IN25			= 6.4
VELOCITY FT/S .16	.17	CROSS FLOW	= 5.1
DENSITY LB/FT3 62.252	61.488	INLET NOZZLE	= 41.0
NOZZ RHO*VSQ LB/FT-S2 1	1	OUTLET NOZZLE	= 38.1
BUND RHO*VSQ LB/FT-S2 1			
~ ,			
TUBE NOZZLE DATA IN	OTIT	WEIGHT PER SHELL IR	
VELOCITY FT/S 1.18			= 150.
DENSITY LB/FT3 61.291		M F. T.	= 165.
PRESS. DROP % 9.0	5.7		

## \*\*\* 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 214.46 BTU/HR-FT2-F HEAT TRANSFER COEFF. AT RE = 10000 IS 1230.11 BTU/HR-FT2-F

Washington University ChE433 heat exchanger experiment E0002 P116

washington only	ergich curaco u	eat excilail	der exberiu	enc	E0002 F11
Young model F302D	Y4P				9/23/ 3
					CASE 58
SIZE 4- 18 TYPE B	EM, MULTI-PASS	FLOW, SEGME	ENTAL BAFFL	ES, RATING	
		JT TOH	JBE SIDE	COLD S	HELL SIDE
		Tube		Shel	1
		SENSI	BLE LIO	SENS	IBLE LIO
TOTAL FLOW RATE	KT.B/HR		800		300
TOTAL TEOM THIE	ILLD/ IIIC	TN	OIIT	TN	OIIT
TOTAL FLOW RATE  TEMPERATURE  DENSITY  VISCOSITY  SPECIFIC HEAT	חבכב	140 0	120 5*	70 0	122 0*
DENCITY	T D / Em 3	61 2012	61 6013	62 2515	61 5701
VICCOCIEV	TD/ FIJ	4726	61.0013	02.2313	01.5791
VISCOSIII	CP	.4/20	.5634	.9/03	.5556
SPECIFIC HEAT	BTU/LB-F	.99/3	.9976	1.0015	.9975
THERMAL COND.	B'I'U/HR-F'I'-F'	.3723	.3681	.3554	.3685
VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS TEMP, AVG & SKIN	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN VISCOSITY, AVG & S PRESSURE, IN & DES	DEGF	130.2	115.9	96.0	115.1
VISCOSITY, AVG & S	SKIN CP	.5149	.5890	.7222	.5932
PRESSURE. IN & DES	STGN PSTA	50 00	165 00	50 00	165 00
INDOONE, IN a DE	310W 101N	30.00	100.00	30.00	100.00
PRESSURE DROP, TO	r & ALLOWED PS	I .11	10.00	.00	10.00
PRESSURE DROP, TO VELOCITY, CALC & 1	MAX ALLOWED FT	/s .78	10.00	.05	10.00
,		,			
FOULING RESISTANCE	E HR-FT2-F/	BTU .(	00010		00010
FOULING RESISTANCE FILM COEFFICIENT	BTU/HR-FT	2-F 27	73.53	1	71.85
TOTAL HEAT DUTY RI					.015570
EFF TEMP DIF, DEG	F (LMTD= 31.5,	F= .78, BYPA	ASS= .91,BA	FF=1.00)	22.5
OVERALL COEFF REOU	JIRED BTU/HR-	FT2-F			96.69
CLEAN & FOULED CO	EFF BTU/HR-	FT2-F	99.0	4	97.03
SHELLS IN SERIES	1 PARALLEL 1	TOTAL EFF	F AREA	FT2	7.1
PASSES, SHELL	1 TUBE 4	EFFECTIVE	E AREA	FT2/SHELL	7.1
SHELLS IN SERIES PASSES, SHELL SHELL DIAMETER IN	3.820	TEMA SHEI	LL TYPE E	; REAR H	EAD FXTS
BAFFLE TYPE I	JOD7 CECMENTI	CDOCC DAG	cee beb en	ETT DACC	1
SPACING, CENTRAL	TM 4 200	CRUSS PAS	IN DON CUE	TI I D	20 00
SPACING, CENTRAL SPACING, INLET	IN. 4.309	BAFFLE CO	NOT TOOM O	LL I.V.	30.00
		CUT DISTA	ANCE FROM C.	ENTER, IN.	. / 64
SPACING, OUTLET		TMDTMCT			370
BAFFLE THICKNESS			ENT BAFFLE		NO
PAIRS OF SEALING 1	DEVICES 1	TUBESHEET	r blank are.	A, %	.0
TUBE TYPE	PLAIN	MATERIAL	E	LECTROLYTI	C COPPER
NO. OF TUBES/SHELD		EST MAX 1			36
TUBE LGTH, OVERAL				IN.	.3125
TODE TOTH, OVERMEN		1022 1110			. 5125

	cne433b(70).00T	
TUBE LGTH, EFF FT 1.43		.250
TUBE LAYOUT DEG 6	0 TUBE INSIDE DIAM IN.	.214
	O TUBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT 1.0 1.	O TUBE NOZZ ID, IN&OUT IN.	.8 .8
,	,	
* CALCULATED ITEMHEAT BALA	NCE CODE = 8	
		E0002 D117
	neat exchanger experiment	E0002 P117
Young model F302DY4P		9/23/ 3
		CASE 58
SUPPLEMENT	ARY RESULTS	
HT PARAMETERS SHELL TU	BE SHELLSIDE PERFORMANCE	
WALL CORRECTION 1.028 .9	78 NOMINAL VEL, X-FLOW FT/S	.04
PRANDTL NUMBER 4.8 3	.4 NOMINAL VEL, WINDOW FT/S	.08
RYNLD NO, AVG 156. 244	9. CROSSFLOW COEF BTU/HR-FT2-	F 172.5
RYNLD NO, IN BUN 115. 266	7. WINDOW COEF BTU/HR-FT2-	
RYNLD NO, OUT BUN 203. 223	8.	
FOULUG LAYER IN 0014 00	14 SHELLSIDE FLOW, % OF TOTAL	
TOOLING EITER TIVE	HEAT TRANSFER X-FLOW	81 30
TUPDMAI DECICTANCE & OF TOTAL	TUBE TO BAFFLE LEAKAGE A	- 2 03
SHELL TUBE FOULING METAL		
		= 68.08
	BUNDLE TO SHELL BYPASS C	= 12.63
	35 BAFFLE TO SHELL LEAKAGE E	= 16.35
	TUBE PASSLANE BYPASS F	= .00
DIFF RESIST .0000		
DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5	SHELLSIDE HEAT TRANSFER FA	CTORS
DIAMETRAL CLEARANCES	TOTAL = (BETA) (GAMMA) (FIN)	
BUNDLE TO SHELL IN5	000 BETA (BAFF CUT FACTOR)	= .920
TUBE TO BAFFLE HOLE INC	284 GAMMA (TUBE ROW ENTRY EFCT)	= .672
BAFFLE TO SHELL IN1	000 END (HT LOSS IN END ZONE)	= .994
SHELL NOZZLE DATA IN	OUT SHELL PRESSURE DROP, % OF	TOTAL
HT UNDR NOZ IN25		= 9.1
HT OPP NOZ IN 25	END ZONE	= 5.2
VELOCITY FT/S .25	25 CROSS FLOW	= 4.3
VELOCITY FT/S .25 DENSITY LB/FT3 62.252 61.	570 INTER NOTTE	= 42.0
NOZZ RHO*VSQ LB/FT-S2 3	3 OUTLET NOZZLE	= 39.5
		- 39.3
BUND RHO*VSQ LB/FT-S2 2	2	
TUDE WORLD TO THE	011	
	OUT WEIGHT PER SHELL, LB	4 = 0
	.18 DRY =	150.
DENSITY LB/FT3 61.291 61.		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 216.35 BTU/HR-FT2-F HEAT TRANSFER COEFF. AT RE = 10000 IS 1236.27 BTU/HR-FT2-F

Washington University ChE433 heat exchanger experiment E0002 P118

						0110	1000 (70) .0	0 1			
Young	g mo	del	F302	2DY4P						9/23/	/ 3
										CASE	59
SIZE	4 –	18	TYPE	BEM.	MULTI-PASS	FIOW.	SEGMENTAL	BAFFLES.	RATING		

SIZE 4- 18 TYPE BE	M, MULTI-PASS	FLOW, SEGME	ENTAL BAFFLI	ES, RATING	
		HOT TU	JBE SIDE	COLD SH	HELL SIDE
		Tube		Shell	-
		SENSI	IBLE LIQ	SENSI	BLE LIQ
TOTAL FLOW RATE	KLB/HR		.800		.400
TOTAL FLOW RATE		IN	OUT	IN	OUT
TEMPERATURE					
DENSITY					
VISCOSITY			.5852		
SPECIFIC HEAT					
THERMAL COND.					
MOLAR MASS		.5725	18.02	.3334	18.02
MOLAN MASS	TP/ TPMOT		10.02		10.02
TEMP, AVG & SKIN	DECE				
VISCOSITY, AVG & S					
PRESSURE, IN & DES	IGN PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT	c viiomed bo	т 11	10 00	0.0	10 00
VELOCITY, CALC & M					
VELOCITY, CALC & M	AX ALLOWED FI	/5 ./0	10.00	.00	10.00
FOULING RESISTANCE	HD_Em3_E/:	סיינו (	0010	C	00010
FILM COEFFICIENT					04.57
	B1U/ HR-F1			20	14.57
					010740
TOTAL HEAT DUTY RE				DD 1 00)	.018742
EFF TEMP DIF, DEGF			ASS= .93,BA	FF=1.00)	
OVERALL COEFF REQU			100 0	4	105.99
CLEAN & FOULED COE	FF BTU/HR-	F''I'2-F'	108.3	4	105.81
	1 03031101 1				7 1
SHELLS IN SERIES					
PASSES, SHELL					
SHELL DIAMETER IN.	3.820	TEMA SHEI	LL TYPE E	; REAR HE	CAD FXTS
BAFFLE TYPE H					
SPACING, CENTRAL					
SPACING, INLET			ANCE FROM C	ENTER, IN.	.764
SPACING, OUTLET					
BAFFLE THICKNESS			ENT BAFFLE		
PAIRS OF SEALING D	EVICES 1	TUBESHEET	r blank arez	A, %	. 0
TUBE TYPE	PLAIN				COPPER
NO. OF TUBES/SHELL					36
TUBE LGTH, OVERALL	FT 1.500	TUBE PITO	CH	IN.	.3125
TUBE LGTH, EFF	FT 1.436	TUBE OUTS	SIDE DIAM	IN.	.250
TUBE LAYOUT	DEG 60	TUBE INSI	IDE DIAM	IN.	.214
PITCH RATIO	1.250	TUBE SURI	FACE RATIO,	OUT/IN	1.184
SHL NOZZ ID, IN&OU					

\* CALCULATED ITEM--HEAT BALANCE CODE = 8

Washington University ChE433 heat exchanger experiment E0002 P119 Young model F302DY4P 9/23/ 3

CASE 59

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

			SHELLSIDE PERFORMANCE		
WALL CORRECTION	1.026	.975	NOMINAL VEL, X-FLOW FT/S		
PRANDTL NUMBER	5.0	3.4	NOMINAL VEL, WINDOW FT/S		.10
RYNLD NO, AVG	203.	2405.	CROSSFLOW COEF BTU/HR-FT	2-F	205.3
RYNLD NO, IN BUN	154.	2667.	WINDOW COEF BTU/HR-FT	2-F	206.8
RYNLD NO, OUT BUN	258.	2154.			
FOULNG LAYER IN.	.0014	.0014	SHELLSIDE FLOW, % OF TOT	AL	
1002110 2111211 111.	• 0 0 1 1		HEAT TRANSFER X-FLOW		81 45
THERMAI RESISTANCE	% OF TO		TUBE TO BAFFLE LEAKAGE		
	•		MAIN CROSSFLOW		
E1 1E 46 40 0	2.0	0.0	DIMDLE MO CHELL DADACC	C -	12 00
DOM OVER DESTON	• 29	_ 16	DARRIE TO SHELL DIFASS	C –	16.00
PCI OVER DESIGN	(	7.10	DAFFLE TO SHELL LEARAGE	E -	10.00
TOT FOUL RESIST	. (	000217	BUNDLE TO SHELL BIPASS BAFFLE TO SHELL LEAKAGE TUBE PASSLANE BYPASS	ተ =	.00
DIFF RESISI	(	000013			
DIAMETRAL CLEARA			SHELLSIDE HEAT TRANSFER		
DIAMETRAL CLEARA	NCES	= 0 0 0	TOTAL = (BETA) (GAMMA) (FIN)		
			BETA (BAFF CUT FACTOR)		
			GAMMA (TUBE ROW ENTRY EFCT		
BAFFLE TO SHELL	IN.	.1000	END (HT LOSS IN END ZONE	) =	.994
			SHELL PRESSURE DROP, % O		
HT UNDR NOZ IN.	.25		WINDOW	=	8.9
HT OPP NOZ IN.	.25		END ZONE	=	4.6
VELOCITY FT/S	.33	.33	CROSS FLOW	=	3.9
DENSITY LB/FT3	62.252	61.655	INLET NOZZLE	=	42.4
NOZZ RHO*VSQ LB/FT	-S2 6	6	WINDOW END ZONE CROSS FLOW INLET NOZZLE OUTLET NOZZLE	=	40.3
BUND RHO*VSQ LB/FT	-S2 4	4			
TUBE NOZZLE DATA	IN	OUT	WEIGHT PER SHELL, LB		
VELOCITY FT/S	1.18	1.17	DRY =		
DENSITY LB/FT3	61.291	61.660	WET =		165.
PRESS. DROP %					
<del>-</del>					

## \*\*\* 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 217.71 BTU/HR-FT2-F

HEAT TRANSFER COEFF. AT RE = 10000 IS 1240.84 BTU/HR-FT2-F

Washington University ChE433 heat exchanger experiment E0002 P120 Young model F302DY4P 9/23/3

		HOT TUBE	E SIDE	COLD SHEI	L SIDE
		Tube		Shell	
		SENSIBI	E LIQ	SENSIBI	E LIQ
TOTAL FLOW RATE	KLB/HR	.800		.500	
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	113.4*	70.0	112.5*

DENSITY VISCOSITY SPECIFIC HEAT THERMAL COND. MOLAR MASS  TEMP, AVG & SKIN VISCOSITY, AVG & SI PRESSURE, IN & DESS	LB/FT3 CP BTU/LB-F BTU/HR-FT-F LB/LBMOL  DEGF  XIN CP	.4726 .9973 .3723 	61.7061 .6034 .9979 .3665 18.02  108.9 .6308	.9783 1.0015 .3554  91.3 .7606	.6085 .9979 .3663 18.02  108.0 .6365
PRESSURE DROP, TOT VELOCITY, CALC & MA	& ALLOWED PSI	.12	10.00	.01	
FOULING RESISTANCE FILM COEFFICIENT		2-F 26	6.27	23	00010
TOTAL HEAT DUTY REGET TEMP DIF, DEGFOVERALL COEFF REQUIRED COEFF SHELLS IN SERIES	QUIRED MEGBTU/F (LMTD= 34.8,F IRED BTU/HR-F FF BTU/HR-F	IR  C= .82,BYPA  CT2-F  CT2-F  TOTAL EFF	SS= .93,BA 115.7 AREA	FF=1.00) 1 FT2	112.27 112.73 7.1
PASSES, SHELL SHELL DIAMETER IN.  BAFFLE TYPE HO	3.820	TEMA SHEL	L TYPE E		EAD FXTS
SPACING, CENTRAL SPACING, INLET SPACING, OUTLET BAFFLE THICKNESS PAIRS OF SEALING DI	IN. 4.309 IN. 4.309 IN. 4.309 IN. 125 EVICES 1	BAFFLE CU' CUT DISTA	T, PCT SHE NCE FROM C NT BAFFLE	LL I.D. ENTER, IN. INCLUDED	30.00 .764 NO
TUBE TYPE NO. OF TUBES/SHELL TUBE LGTH, OVERALL TUBE LGTH, EFF TUBE LAYOUT PITCH RATIO SHL NOZZ ID, IN&OU	76 FT 1.500 FT 1.436 DEG 60 1.250	EST MAX TO TUBE PITCO TUBE OUTS TUBE INSIDER SURFA	UBE COUNT H IDE DIAM DE DIAM ACE RATIO,	IN. IN. IN. OUT/IN	36 .3125 .250 .214 1.184
* CALCULATED ITEM Washington Univer Young model F302DY	rsity ChE433 he 4P	eat exchang	-		E0002 P121 9/23/ 3 CASE 60
SUPPLEI	M E N T A	R Y R	E S U	L T S	
HT PARAMETERS WALL CORRECTION PRANDTL NUMBER RYNLD NO, AVG RYNLD NO, IN BUN RYNLD NO,OUT BUN FOULNG LAYER IN.	192. 2667. 309. 2089.	NOMINAL NOMINAL CROSSFL WINDOW	COEF	W FT/S	-F 237.9

	HEAT TRANSFER X-FLOW	
THERMAL RESISTANCE, % OF TOTAL		
SHELL TUBE FOULING METAL		
47.35 50.12 2.44 .08	BUNDLE TO SHELL BYPASS C =	14.94
PCT OVER DESIGN .42 TOT FOUL RESIST .000217	BAFFLE TO SHELL LEAKAGE E =	15.78
TOT FOUL RESIST .000217	TUBE PASSLANE BYPASS F =	.00
DIFF RESIST .000037		
	SHELLSIDE HEAT TRANSFER FAC	
DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000	TOTAL = (BETA) (GAMMA) (FIN) =	.666
BUNDLE TO SHELL IN5000	BETA (BAFF CUT FACTOR) =	.920
TUBE TO BAFFLE HOLE IN0284	GAMMA (TUBE ROW ENTRY EFCT) =	.724
BAFFLE TO SHELL IN1000		
CHELL MODELE DAMA TY		
SHELL NOZZLE DATA IN OUT	SHELL PRESSURE DROP, % OF TO	OTAL
HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .41 .41	WINDOW = END ZONE = CROSS FLOW =	8.9 4.1 3.6
HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .41 .41 DENSITY LB/FT3 62.252 61.718	WINDOW = END ZONE = CROSS FLOW = INLET NOZZLE =	8.9 4.1 3.6 42.7
HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .41 .41	WINDOW = END ZONE = CROSS FLOW = INLET NOZZLE =	8.9 4.1 3.6 42.7
HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .41 .41 DENSITY LB/FT3 62.252 61.718	WINDOW = END ZONE = CROSS FLOW = INLET NOZZLE =	8.9 4.1 3.6 42.7
HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .41 .41 DENSITY LB/FT3 62.252 61.718 NOZZ RHO*VSQ LB/FT-S2 10 10	WINDOW = END ZONE = CROSS FLOW = INLET NOZZLE =	8.9 4.1 3.6 42.7
HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .41 .41 DENSITY LB/FT3 62.252 61.718 NOZZ RHO*VSQ LB/FT-S2 10 10	WINDOW = END ZONE = CROSS FLOW = INLET NOZZLE = OUTLET NOZZLE =	8.9 4.1 3.6 42.7
HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .41 .41 DENSITY LB/FT3 62.252 61.718 NOZZ RHO*VSQ LB/FT-S2 10 10 BUND RHO*VSQ LB/FT-S2 7 7	WINDOW = END ZONE = CROSS FLOW = INLET NOZZLE = OUTLET NOZZLE = WEIGHT PER SHELL, LB	8.9 4.1 3.6 42.7 40.8
HT UNDR NOZ IN25  HT OPP NOZ IN25  VELOCITY FT/S .41 .41  DENSITY LB/FT3 62.252 61.718  NOZZ RHO*VSQ LB/FT-S2 10 10  BUND RHO*VSQ LB/FT-S2 7 7  TUBE NOZZLE DATA IN OUT  VELOCITY FT/S 1.18 1.17	WINDOW = END ZONE = CROSS FLOW = INLET NOZZLE = OUTLET NOZZLE = WEIGHT PER SHELL, LB DRY =	8.9 4.1 3.6 42.7 40.8
HT UNDR NOZ IN25  HT OPP NOZ IN25  VELOCITY FT/S .41 .41  DENSITY LB/FT3 62.252 61.718  NOZZ RHO*VSQ LB/FT-S2 10 10  BUND RHO*VSQ LB/FT-S2 7 7  TUBE NOZZLE DATA IN OUT	WINDOW = END ZONE = CROSS FLOW = INLET NOZZLE = OUTLET NOZZLE =  WEIGHT PER SHELL, LB DRY = WET =	8.9 4.1 3.6 42.7 40.8

#### \*\*\* 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 218.75 BTU/HR-FT2-F HEAT TRANSFER COEFF. AT RE = 10000 IS 1244.09 BTU/HR-FT2-F

Washington University ChE433 heat exchanger experiment E0002 P122 Young model F302DY4P 9/23/3 CASE 61

	•	HOT TU	JBE SIDE	COLD SI	HELL SIDE
		Tube		Shell	L
		SENSI	BLE LIQ	SENSI	BLE LIQ
TOTAL FLOW RATE	KLB/HR		.800		.600
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	110.7*	70.0	109.0*
DENSITY	LB/FT3	61.2913	61.7442	62.2515	61.7689
VISCOSITY	CP	.4726	.6195	.9783	.6305
SPECIFIC HEAT	BTU/LB-F	.9973	.9980	1.0015	.9981
THERMAL COND.	BTU/HR-FT-F	.3723	.3659	.3554	.3654
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	125.4	106.3	89.5	105.3
VISCOSITY, AVG & S	KIN CP	.5383	.6481	.7759	.6545
PRESSURE, IN & DES	IGN PSIA	50.00	165.00	50.00	165.00

PRESSURE DROP, TOT & ALLOWED PSI VELOCITY, CALC & MAX ALLOWED FT/S	.12 10.00 .01 10.00 .78 10.00 .09 10.00
FOULING RESISTANCE HR-FT2-F/BTU FILM COEFFICIENT BTU/HR-FT2-F	
TOTAL HEAT DUTY REQUIRED MEGBTU/HR EFF TEMP DIF, DEGF (LMTD= 35.7,F= OVERALL COEFF REQUIRED BTU/HR-FT2 CLEAN & FOULED COEFF BTU/HR-FT2	-F 118 /8
SHELLS IN SERIES 1 PARALLEL 1 TPASSES, SHELL 1 TUBE 4 E	
SPACING, CENTRAL IN. 4.309 B SPACING, INLET IN. 4.309 C SPACING, OUTLET IN. 4.309 BAFFLE THICKNESS IN125 I	ROSS PASSES PER SHELL PASS 4 AFFLE CUT, PCT SHELL I.D. 30.00 UT DISTANCE FROM CENTER, IN764  MPINGEMENT BAFFLE INCLUDED NO UBESHEET BLANK AREA, % .0
NO. OF TUBES/SHELL 76 E TUBE LGTH, OVERALL FT 1.500 T TUBE LGTH, EFF FT 1.436 T TUBE LAYOUT DEG 60 T PITCH RATIO 1.250 T	
* CALCULATED ITEMHEAT BALANCE C Washington University ChE433 heat Young model F302DY4P	ODE = 8 exchanger experiment E0002 P123 9/23/ 3 CASE 61
S U P P L E M E N T A R	
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.024 .969 PRANDTL NUMBER 5.2 3.5 RYNLD NO, AVG 291. 2342. RYNLD NO, IN BUN 231. 2667. RYNLD NO,OUT BUN 358. 2035. FOULNG LAYER IN0014 .0014	SHELLSIDE PERFORMANCE  NOMINAL VEL, X-FLOW FT/S .08  NOMINAL VEL, WINDOW FT/S .15  CROSSFLOW COEF BTU/HR-FT2-F 266.6  WINDOW COEF BTU/HR-FT2-F 268.3  SHELLSIDE FLOW, % OF TOTAL
THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 44.11 53.24 2.57 .09	TUBE TO BAFFLE LEAKAGE A = 3.64  MAIN CROSSFLOW B = 65.18  BUNDLE TO SHELL BYPASS C = 15.56  BAFFLE TO SHELL LEAKAGE E = 15.61  TUBE PASSLANE BYPASS F = .00
DIAMETRAL CLEARANCES	SHELLSIDE HEAT TRANSFER FACTORS TOTAL = (BETA) (GAMMA) (FIN) = .690

BUNDLE TO SHELL	IN.	.5000	BETA (BAFF CUT FACTOR)	=	.920
TUBE TO BAFFLE HOLE	IN.	.0284	GAMMA (TUBE ROW ENTRY EFCT)	=	.750
BAFFLE TO SHELL	IN.	.1000	END (HT LOSS IN END ZONE)	=	.994
SHELL NOZZLE DATA	IN	OUT	SHELL PRESSURE DROP, % OF	TOT	AL
HT UNDR NOZ IN.	.25		WINDOW	=	8.9
HT OPP NOZ IN.	.25		END ZONE	=	3.8
			CROSS FLOW		3.3
DENSITY LB/FT3	62.252	61.769	INLET NOZZLE	=	42.8
NOZZ RHO*VSQ LB/FT-S	2 14	15	OUTLET NOZZLE	=	41.2
BUND RHO*VSQ LB/FT-S	2 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	61.744	WET =		165.
PRESS. DROP %	8.8	5.5			

## \*\*\* 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 219.53 BTU/HR-FT2-F HEAT TRANSFER COEFF. AT RE = 10000 IS 1246.83 BTU/HR-FT2-F

Washington University ChE433 heat exchanger experiment E0002 P124 Young model F302DY4P 9/23/3 CASE 62

SIZE 4- 18 T	TYPE BEM,	MULTI-PASS	FLOW,	SEGMENTAL	BAFFLES,	RATING
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-	, -	- ,		- ,	
		HOT TU	UBE SIDE	COLD SH	HELL SIDE
		Tube		Shell	L
		SENS	IBLE LIQ	SENSI	BLE LIQ
TOTAL FLOW RATE	KLB/HR		.800		.700
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	108.5*	70.0	106.0*
DENSITY	LB/FT3	61.2913	61.7759	62.2515	61.8108
VISCOSITY	CP	.4726	.6337	.9783	.6501
SPECIFIC HEAT	BTU/LB-F	.9973	.9981	1.0015	.9983
THERMAL COND.	BTU/HR-FT-F	.3723	.3653	.3554	.3647
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	124.2	103.9	88.0	102.9
VISCOSITY, AVG & S	KIN CP	.5439	.6638	.7892	.6707
PRESSURE, IN & DES	IGN PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT	& ALLOWED PSI	.12	10.00	.01	10.00
VELOCITY, CALC & MA	AX ALLOWED FT/	s .78	10.00	.11	10.00
FOULING RESISTANCE	HR-FT2-F/B	ru . (	00010	. (	00010
FILM COEFFICIENT	BTU/HR-FT2	-F 2	61.01	29	95.63
TOTAL HEAT DUTY REC	OUTRED MEGRAUI/HI	⊋			025160

TOTAL HEAT DUTY REQUIRED MEGBTU/HR .025160
EFF TEMP DIF, DEGF (LMTD= 36.2,F= .83,BYPASS= .94,BAFF=1.00) 28.4

	che433b(70).OUT	
OVERALL COEFF REQUIRED BTU/HR-FT2	2-F 123	3.89
CLEAN & FOULED COEFF BTU/HR-FT2	2-F 127.14 123	3.39
SHELLS IN SERIES 1 PARALLEL 1	TOTAL EFF AREA FT2	7 1
	EFFECTIVE AREA FT2/SHELL	
	FEMA SHELL TYPE E ; REAR HEAD F	
SHELL DIAMETER IN. 5.020 I	IEMA SHELL IIPE E , KEAK HEAD E	VIP
	2000 010000 000 00011 0100	4
	CROSS PASSES PER SHELL PASS	
	BAFFLE CUT, PCT SHELL I.D. 30	
	CUT DISTANCE FROM CENTER, IN	764
SPACING, OUTLET IN. 4.309		
BAFFLE THICKNESS IN125	IMPINGEMENT BAFFLE INCLUDED	NO
PAIRS OF SEALING DEVICES 1	TUBESHEET BLANK AREA, %	.0
TUBE TYPE PLAIN N	MATERIAL ELECTROLYTIC COPE	PER
	EST MAX TUBE COUNT	36
	TUBE PITCH IN3	
	TUBE OUTSIDE DIAM IN	
		214
	TUBE SURFACE RATIO, OUT/IN 1.	
SHL NOZZ ID, IN&OUT 1.0 1.0	TUBE NOZZ ID, IN&OUT IN8	. 8
* CALCULATED ITEMHEAT BALANCE Of Washington University ChE433 heat Young model F302DY4P	t exchanger experiment E0002 9/23 CASE	
S U P P L E M E N T A R	Y RESULTS	
HT PARAMETERS SHELL TUBE	SHELLSIDE PERFORMANCE	
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.023 .967	SHELLSIDE PERFORMANCE NOMINAL VEL, X-FLOW FT/S	
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.023 .967 PRANDTL NUMBER 5.3 3.6	SHELLSIDE PERFORMANCE NOMINAL VEL, X-FLOW FT/S NOMINAL VEL, WINDOW FT/S	.18
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.023 .967 PRANDTL NUMBER 5.3 3.6 RYNLD NO, AVG 334. 2318.	SHELLSIDE PERFORMANCE NOMINAL VEL,X-FLOW FT/S NOMINAL VEL,WINDOW FT/S CROSSFLOW COEF BTU/HR-FT2-F 29	.18
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.023 .967 PRANDTL NUMBER 5.3 3.6	SHELLSIDE PERFORMANCE NOMINAL VEL,X-FLOW FT/S NOMINAL VEL,WINDOW FT/S CROSSFLOW COEF BTU/HR-FT2-F 29	.18
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.023 .967 PRANDTL NUMBER 5.3 3.6 RYNLD NO, AVG 334. 2318.	SHELLSIDE PERFORMANCE NOMINAL VEL,X-FLOW FT/S NOMINAL VEL,WINDOW FT/S CROSSFLOW COEF BTU/HR-FT2-F 29	.18
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.023 .967 PRANDTL NUMBER 5.3 3.6 RYNLD NO, AVG 334. 2318. RYNLD NO, IN BUN 269. 2667.	SHELLSIDE PERFORMANCE  NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F 29  WINDOW COEF BTU/HR-FT2-F 29	.18
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.023 .967 PRANDTL NUMBER 5.3 3.6 RYNLD NO, AVG 334. 2318. RYNLD NO, IN BUN 269. 2667. RYNLD NO,OUT BUN 405. 1989.	SHELLSIDE PERFORMANCE  NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F 29  WINDOW COEF BTU/HR-FT2-F 29	.18 96.8 98.6
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.023 .967 PRANDTL NUMBER 5.3 3.6 RYNLD NO, AVG 334. 2318. RYNLD NO, IN BUN 269. 2667. RYNLD NO,OUT BUN 405. 1989. FOULNG LAYER IN0014 .0014	SHELLSIDE PERFORMANCE NOMINAL VEL, X-FLOW FT/S NOMINAL VEL, WINDOW FT/S CROSSFLOW COEF BTU/HR-FT2-F 29 WINDOW COEF BTU/HR-FT2-F 29 SHELLSIDE FLOW, % OF TOTAL HEAT TRANSFER X-FLOW 81	.18 96.8 98.6
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.023 .967 PRANDTL NUMBER 5.3 3.6 RYNLD NO, AVG 334. 2318. RYNLD NO, IN BUN 269. 2667. RYNLD NO,OUT BUN 405. 1989. FOULNG LAYER IN0014 .0014 THERMAL RESISTANCE, % OF TOTAL	SHELLSIDE PERFORMANCE  NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F 29  WINDOW COEF BTU/HR-FT2-F 29  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81  TUBE TO BAFFLE LEAKAGE A = 3	.18 96.8 98.6
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.023 .967 PRANDTL NUMBER 5.3 3.6 RYNLD NO, AVG 334. 2318. RYNLD NO, IN BUN 269. 2667. RYNLD NO,OUT BUN 405. 1989. FOULNG LAYER IN0014 .0014 THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL	SHELLSIDE PERFORMANCE  NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F 29  WINDOW COEF BTU/HR-FT2-F 29  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81  TUBE TO BAFFLE LEAKAGE A = 3  MAIN CROSSFLOW B = 64	.18 96.8 98.6 .46 8.82
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.023 .967 PRANDTL NUMBER 5.3 3.6 RYNLD NO, AVG 334. 2318. RYNLD NO, IN BUN 269. 2667. RYNLD NO,OUT BUN 405. 1989. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 41.27 55.97 2.68 .09	SHELLSIDE PERFORMANCE  NOMINAL VEL,X-FLOW FT/S  NOMINAL VEL,WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F 29  WINDOW COEF BTU/HR-FT2-F 29  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81  TUBE TO BAFFLE LEAKAGE A = 3  MAIN CROSSFLOW B = 64  BUNDLE TO SHELL BYPASS C = 15	.18 96.8 98.6 .46 8.82 4.84 5.85
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.023 .967 PRANDTL NUMBER 5.3 3.6 RYNLD NO, AVG 334. 2318. RYNLD NO, IN BUN 269. 2667. RYNLD NO,OUT BUN 405. 1989. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 41.27 55.97 2.68 .09	SHELLSIDE PERFORMANCE  NOMINAL VEL,X-FLOW FT/S  NOMINAL VEL,WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F 29  WINDOW COEF BTU/HR-FT2-F 29  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81  TUBE TO BAFFLE LEAKAGE A = 3  MAIN CROSSFLOW B = 64  BUNDLE TO SHELL BYPASS C = 15	.18 96.8 98.6 .46 8.82 4.84 5.85
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.023 .967 PRANDTL NUMBER 5.3 3.6 RYNLD NO, AVG 334. 2318. RYNLD NO, IN BUN 269. 2667. RYNLD NO,OUT BUN 405. 1989. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 41.27 55.97 2.68 .09 PCT OVER DESIGN40 TOT FOUL RESIST .000217	SHELLSIDE PERFORMANCE  NOMINAL VEL,X-FLOW FT/S  NOMINAL VEL,WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F 29  WINDOW COEF BTU/HR-FT2-F 29  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81  TUBE TO BAFFLE LEAKAGE A = 3  MAIN CROSSFLOW B = 64  BUNDLE TO SHELL BYPASS C = 15	.18 96.8 98.6 .46 8.82 4.84 5.85
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.023 .967 PRANDTL NUMBER 5.3 3.6 RYNLD NO, AVG 334. 2318. RYNLD NO, IN BUN 269. 2667. RYNLD NO,OUT BUN 405. 1989. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 41.27 55.97 2.68 .09	SHELLSIDE PERFORMANCE  NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F 29  WINDOW COEF BTU/HR-FT2-F 29  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81  TUBE TO BAFFLE LEAKAGE A = 3  MAIN CROSSFLOW B = 64  BUNDLE TO SHELL BYPASS C = 15  BAFFLE TO SHELL LEAKAGE E = 15  TUBE PASSLANE BYPASS F =	.18 96.8 98.6 .46 3.82 4.84 5.85 5.49
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.023 .967 PRANDTL NUMBER 5.3 3.6 RYNLD NO, AVG 334. 2318. RYNLD NO, IN BUN 269. 2667. RYNLD NO,OUT BUN 405. 1989. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 41.27 55.97 2.68 .09 PCT OVER DESIGN40 TOT FOUL RESIST .000217 DIFF RESIST000033	SHELLSIDE PERFORMANCE  NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F 29  WINDOW COEF BTU/HR-FT2-F 29  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81  TUBE TO BAFFLE LEAKAGE A = 3  MAIN CROSSFLOW B = 64  BUNDLE TO SHELL BYPASS C = 15  BAFFLE TO SHELL LEAKAGE E = 15  TUBE PASSLANE BYPASS F =	.18 96.8 98.6 .46 3.82 4.84 5.85 5.49
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.023 .967 PRANDTL NUMBER 5.3 3.6 RYNLD NO, AVG 334. 2318. RYNLD NO, IN BUN 269. 2667. RYNLD NO,OUT BUN 405. 1989. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 41.27 55.97 2.68 .09 PCT OVER DESIGN40 TOT FOUL RESIST .000217 DIFF RESIST .000033	SHELLSIDE PERFORMANCE  NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F 29  WINDOW COEF BTU/HR-FT2-F 29  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81  TUBE TO BAFFLE LEAKAGE A = 3  MAIN CROSSFLOW B = 64  BUNDLE TO SHELL BYPASS C = 15  BAFFLE TO SHELL LEAKAGE E = 15  TUBE PASSLANE BYPASS F =  SHELLSIDE HEAT TRANSFER FACTORS  TOTAL = (BETA) (GAMMA) (FIN) =	.18 96.8 98.6 .46 3.82 4.84 5.85 5.49 .00
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.023 .967 PRANDTL NUMBER 5.3 3.6 RYNLD NO, AVG 334. 2318. RYNLD NO, IN BUN 269. 2667. RYNLD NO,OUT BUN 405. 1989. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 41.27 55.97 2.68 .09 PCT OVER DESIGN40 TOT FOUL RESIST .000217 DIFF RESIST .000033  DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000	SHELLSIDE PERFORMANCE  NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F 29  WINDOW COEF BTU/HR-FT2-F 29  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81  TUBE TO BAFFLE LEAKAGE A = 3  MAIN CROSSFLOW B = 64  BUNDLE TO SHELL BYPASS C = 15  BAFFLE TO SHELL LEAKAGE E = 15  TUBE PASSLANE BYPASS F =  SHELLSIDE HEAT TRANSFER FACTORS  TOTAL = (BETA) (GAMMA) (FIN) = .  BETA (BAFF CUT FACTOR) = .	.18 96.8 98.6 .46 3.82 4.84 5.85 5.49 .00
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.023 .967 PRANDTL NUMBER 5.3 3.6 RYNLD NO, AVG 334. 2318. RYNLD NO, IN BUN 269. 2667. RYNLD NO,OUT BUN 405. 1989. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 41.27 55.97 2.68 .09 PCT OVER DESIGN40 TOT FOUL RESIST .000217 DIFF RESIST .000217 DIFF RESIST000033  DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000 TUBE TO BAFFLE HOLE IN0284	SHELLSIDE PERFORMANCE  NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F 29  WINDOW COEF BTU/HR-FT2-F 29  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81  TUBE TO BAFFLE LEAKAGE A = 3  MAIN CROSSFLOW B = 64  BUNDLE TO SHELL BYPASS C = 15  BAFFLE TO SHELL LEAKAGE E = 15  TUBE PASSLANE BYPASS F =  SHELLSIDE HEAT TRANSFER FACTORS  TOTAL = (BETA) (GAMMA) (FIN) = .  BETA (BAFF CUT FACTOR) = .  GAMMA (TUBE ROW ENTRY EFCT) = .	.18 96.8 98.6 .46 3.82 1.84 5.85 5.49 .00
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HT PARAMETERS SHELL TUBE WALL CORRECTION 1.023 .967 PRANDTL NUMBER 5.3 3.6 RYNLD NO, AVG 334. 2318. RYNLD NO, IN BUN 269. 2667. RYNLD NO,OUT BUN 405. 1989. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 41.27 55.97 2.68 .09 PCT OVER DESIGN40 TOT FOUL RESIST .000217 DIFF RESIST .000217 DIFF RESIST000033  DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000 TUBE TO BAFFLE HOLE IN0284 BAFFLE TO SHELL IN1000	SHELLSIDE PERFORMANCE  NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F 29  WINDOW COEF BTU/HR-FT2-F 29  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81  TUBE TO BAFFLE LEAKAGE A = 3  MAIN CROSSFLOW B = 64  BUNDLE TO SHELL BYPASS C = 15  BAFFLE TO SHELL LEAKAGE E = 15  TUBE PASSLANE BYPASS F =  SHELLSIDE HEAT TRANSFER FACTORS  TOTAL = (BETA) (GAMMA) (FIN) =  BETA (BAFF CUT FACTOR) =  GAMMA (TUBE ROW ENTRY EFCT) =  END (HT LOSS IN END ZONE) =  SHELL PRESSURE DROP, % OF TOTAL	.18 96.8 98.6 .46 3.82 4.84 5.85 5.49 .00
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.023 .967 PRANDTL NUMBER 5.3 3.6 RYNLD NO, AVG 334. 2318. RYNLD NO, IN BUN 269. 2667. RYNLD NO,OUT BUN 405. 1989. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 41.27 55.97 2.68 .09 PCT OVER DESIGN40 TOT FOUL RESIST .000217 DIFF RESIST .000217 DIFF RESIST000033  DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000 TUBE TO BAFFLE HOLE IN0284 BAFFLE TO SHELL IN1000  SHELL NOZZLE DATA IN OUT HT UNDR NOZ IN25	SHELLSIDE PERFORMANCE  NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F 29  WINDOW COEF BTU/HR-FT2-F 29  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81  TUBE TO BAFFLE LEAKAGE A = 3  MAIN CROSSFLOW B = 64  BUNDLE TO SHELL BYPASS C = 15  BAFFLE TO SHELL LEAKAGE E = 15  TUBE PASSLANE BYPASS F =  SHELLSIDE HEAT TRANSFER FACTORS  TOTAL = (BETA) (GAMMA) (FIN) =  BETA (BAFF CUT FACTOR) =  GAMMA (TUBE ROW ENTRY EFCT) =  END (HT LOSS IN END ZONE) =  SHELL PRESSURE DROP, % OF TOTAL  WINDOW =	.18 .18 .18 .18 .18 .18 .18 .18
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.023 .967 PRANDTL NUMBER 5.3 3.6 RYNLD NO, AVG 334. 2318. RYNLD NO, IN BUN 269. 2667. RYNLD NO,OUT BUN 405. 1989. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 41.27 55.97 2.68 .09 PCT OVER DESIGN40 TOT FOUL RESIST .000217 DIFF RESIST .000217 DIFF RESIST000033  DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000 TUBE TO BAFFLE HOLE IN0284 BAFFLE TO SHELL IN1000	SHELLSIDE PERFORMANCE  NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F 29  WINDOW COEF BTU/HR-FT2-F 29  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81  TUBE TO BAFFLE LEAKAGE A = 3  MAIN CROSSFLOW B = 64  BUNDLE TO SHELL BYPASS C = 15  BAFFLE TO SHELL LEAKAGE E = 15  TUBE PASSLANE BYPASS F =  SHELLSIDE HEAT TRANSFER FACTORS  TOTAL = (BETA) (GAMMA) (FIN) =  BETA (BAFF CUT FACTOR) =  GAMMA (TUBE ROW ENTRY EFCT) =  END (HT LOSS IN END ZONE) =  SHELL PRESSURE DROP, % OF TOTAL  WINDOW = END ZONE	.18 .18 .18 .18 .18 .18 .18 .18
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.023 .967 PRANDTL NUMBER 5.3 3.6 RYNLD NO, AVG 334. 2318. RYNLD NO, IN BUN 269. 2667. RYNLD NO,OUT BUN 405. 1989. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 41.27 55.97 2.68 .09 PCT OVER DESIGN40 TOT FOUL RESIST .000217 DIFF RESIST .000217 DIFF RESIST000033  DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000 TUBE TO BAFFLE HOLE IN0284 BAFFLE TO SHELL IN1000  SHELL NOZZLE DATA IN OUT HT UNDR NOZ IN25	SHELLSIDE PERFORMANCE  NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F 29  WINDOW COEF BTU/HR-FT2-F 29  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81  TUBE TO BAFFLE LEAKAGE A = 3  MAIN CROSSFLOW B = 64  BUNDLE TO SHELL BYPASS C = 15  BAFFLE TO SHELL LEAKAGE E = 15  TUBE PASSLANE BYPASS F =  SHELLSIDE HEAT TRANSFER FACTORS  TOTAL = (BETA) (GAMMA) (FIN) = .  BETA (BAFF CUT FACTOR) = .  GAMMA (TUBE ROW ENTRY EFCT) = .  END (HT LOSS IN END ZONE) = .  SHELL PRESSURE DROP, % OF TOTAL  WINDOW = END ZONE = .	.18 .18 .18 .18 .18 .18 .18 .18
HT PARAMETERS SHELL TUBE WALL CORRECTION 1.023 .967 PRANDTL NUMBER 5.3 3.6 RYNLD NO, AVG 334. 2318. RYNLD NO, IN BUN 269. 2667. RYNLD NO,OUT BUN 405. 1989. FOULNG LAYER IN0014 .0014  THERMAL RESISTANCE, % OF TOTAL SHELL TUBE FOULING METAL 41.27 55.97 2.68 .09 PCT OVER DESIGN40 TOT FOUL RESIST .000217 DIFF RESIST .000217 DIFF RESIST000033  DIAMETRAL CLEARANCES BUNDLE TO SHELL IN5000 TUBE TO BAFFLE HOLE IN0284 BAFFLE TO SHELL IN1000  SHELL NOZZLE DATA IN OUT HT UNDR NOZ IN25 HT OPP NOZ IN25	SHELLSIDE PERFORMANCE  NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F 29  WINDOW COEF BTU/HR-FT2-F 29  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW 81  TUBE TO BAFFLE LEAKAGE A = 3  MAIN CROSSFLOW B = 64  BUNDLE TO SHELL BYPASS C = 15  BAFFLE TO SHELL LEAKAGE E = 15  TUBE PASSLANE BYPASS F =  SHELLSIDE HEAT TRANSFER FACTORS  TOTAL = (BETA) (GAMMA) (FIN) = .  BETA (BAFF CUT FACTOR) = .  GAMMA (TUBE ROW ENTRY EFCT) = .  END (HT LOSS IN END ZONE) = .  SHELL PRESSURE DROP, % OF TOTAL  WINDOW = .  END ZONE = .  CROSS FLOW = .	.18 .18 .18 .18 .18 .18 .18 .18

			che433b(70).OUT		
NOZZ RHO*VSQ LB/FT-	S2 20	20	OUTLET NOZZLE	=	41.5
BUND RHO*VSQ LB/FT-	S2 13	14			
TUBE NOZZLE DATA	IN	OUT	WEIGHT PER SHELL, LB		
VELOCITY FT/S	1.18	1.17	DRY	=	150.
DENSITY LB/FT3	61.291	61.776	WET	=	165.
PRESS. DROP %	8.7	5.5			

# \*\*\* 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 220.15 BTU/HR-FT2-F HEAT TRANSFER COEFF. AT RE = 10000 IS 1248.99 BTU/HR-FT2-F

Washington University ChE433 heat exchanger experiment E0002 P126 Young model F302DY4P 9/23/3

Young model F302DY	_	<u>-</u>		9/23/ 3	
					CASE 63
SIZE 4- 18 TYPE BE	M, MULTI-PASS E				
		HOT TU	BE SIDE		
				Shell	
		SENSI	BLE LIQ	SENSI	BLE LIQ
TOTAL FLOW RATE	KLB/HR		.800		.800
		IN	.800 TUO	IN	OUT
TEMPERATURE	DEGF	140.0	106.6*	70.0	103.3*
DENSITY	LB/FT3	61.2913	61.8014	62.2515	61.8473
VISCOSITY	CP	.4726	.6456	.9783	.6683
SPECIFIC HEAT	BTU/LB-F	.9973	.6456 .9982	1.0015	.9984
THERMAL COND.	BTU/HR-FT-F	.3723	.3649	.3554	.3641
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN					
VISCOSITY, AVG & S					
PRESSURE, IN & DES	IGN PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT	& ALLOWED PSI	12	10.00	. 01	10.00
VELOCITY, CALC & M.					
FOULING RESISTANCE					
FILM COEFFICIENT					25.73
					006606
					.026626
EFF TEMP DIF, DEGF (LMTD= 36.7,F= .84,BYPASS= .94,BAFF=1.00) 29.2 OVERALL COEFF REQUIRED BTU/HR-FT2-F 127.67					
					127.67
CLEAN & FOULED COE	F'F' B'I'U/HR-F	!"I'Z-F'	131.81	L	127.72
SHELLS IN SERIES	1 PARALLEL 1	TOTAL EFF	' AREA	FT2	7.1
PASSES, SHELL					
SHELL DIAMETER IN.					
BAFFLE TYPE H					
SPACING, CENTRAL	IN. 4.309	BAFFLE CU	T, PCT SHEI	LL I.D.	30.00

	che433b(70).OUT
SPACING, INLET IN. 4.309	CUT DISTANCE FROM CENTER, IN764
SPACING, OUTLET IN. 4.309	
BAFFLE THICKNESS IN125	IMPINGEMENT BAFFLE INCLUDED NO
PAIRS OF SEALING DEVICES 1	
PAIRS OF SEALING DEVICES I	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 OUTSIDE DIAM IN250
TUBE LAYOUT DEG 60	TUBE INSIDE DIAM IN214
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 IN8 .8
,	,
* CALCULATED ITEMHEAT BALANC	TE CODE = 8
	neat exchanger experiment E0002 P127
Young model F302DY4P	9/23/ 3
	CASE 63
SUPPLEMENTA	R Y R E S U L T S
HT PARAMETERS SHELL TUBE	SHELLSIDE PERFORMANCE
WALL CORRECTION 1.022 .965	NOMINAL VEL, X-FLOW FT/S .10
PRANDTL NUMBER 5.4 3.6	NOMINAL VEL, WINDOW FT/S .20
RYNLD NO, AVG 376. 2298.	
RYNLD NO, IN BUN 308. 2667.	
RYNLD NO, OUT BUN 451. 1953.	
FOULNG LAYER IN0014 .0014	
FOULING LAYER IN0014 .0014	
	HEAT TRANSFER X-FLOW 81.46
THERMAL RESISTANCE, % OF TOTAL	
SHELL TUBE FOULING METAL	
38.77 58.37 2.77 .09	
PCT OVER DESIGN .03	BAFFLE TO SHELL LEAKAGE E = 15.38
TOT FOUL RESIST .000217	TUBE PASSLANE BYPASS $F = .00$
DIFF RESIST .000003	
	SHELLSIDE HEAT TRANSFER FACTORS
DIAMETRAL CLEARANCES	TOTAL = (BETA) (GAMMA) (FIN) = .740
BUNDLE TO SHELL IN500	
	GAMMA (TUBE ROW ENTRY EFCT) = .804
DARRIE TO CURIT IN 100	OO END (HT LOSS IN END ZONE) = .994
BAFFLE TO SHELL IN100	TO END (HI LOSS IN END ZONE)994
	T SHELL PRESSURE DROP, % OF TOTAL
HT UNDR NOZ IN25	
HT OPP NOZ IN25	
VELOCITY FT/S .65 .6	
DENSITY LB/FT3 62.252 61.84	7 INLET NOZZLE = 43.0
NOZZ RHO*VSQ LB/FT-S2 26 2	6 OUTLET NOZZLE = 41.7
BUND RHO*VSQ LB/FT-S2 18 1	
~ ,	
TUBE NOZZLE DATA IN OU	IT WEIGHT PER SHELL LR
VELOCITY FT/S 1.18 1.1	
DENSITY LB/FT3 61.291 61.80	
PRESS. DROP % 8.7 5.	5

# \*\*\* 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 1250.44 BTU/HR-FT2-F

Washington University ChE433 heat exchanger experiment E0002 P128

Young model F302D	=	ireae exemany	ger experim	.0110	9/23/ 3
					CASE 64
SIZE 4- 18 TYPE BE	EM, MULTI-PASS				
		HOT TU	JBE SIDE	COLD SH	HELL SIDE
		Tube		Shell	L
		SENSI	IBLE LIQ	Shell SENSI	BLE LIQ
TOTAL FLOW RATE	KLB/HR		.800		.900
		IN	OUT	IN	OUT
TEMPERATURE DENSITY	DEGF	140.0	104.9*	70.0	101.2*
DENSITY	LB/FT3	61.2913	61.8260	62.2515	61.8758
VISCOSITY	CP	.4726	.6576	.9783	.6833
SPECIFIC HEAT	BTU/LB-F	.9973	.9983	1.0015	.9986
THERMAL COND. MOLAR MASS	BTU/HR-FT-F	.3723	.3644	.3554	.3635
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN					
VISCOSITY, AVG & S	SKIN CP	.5532	.6910	.8111	.6991
PRESSURE, IN & DES	GIGN PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TO	n callowed b	CT 12	10 00	0.2	10 00
VELOCITY, CALC & N					
VELOCITY, CALC & I	MAX ALLOWED F	1/5 ./0	10.00	• 1 4	10.00
FOULING RESISTANCE	E HR-FT2-F	/BTU .(	00010	. (	00010
FILM COEFFICIENT					56.53
TOTAL HEAT DUTY RE	EQUIRED MEGBTU	/HR			.028050
EFF TEMP DIF, DEG	F (LMTD= 36.8	F= .85,BYPA	ASS= .96,BA	FF=1.00)	29.9
OVERALL COEFF REQU					131.49
CLEAN & FOULED COR	EFF BTU/HR	-FT2-F	135.9	2	131.52
SHELLS IN SERIES	1 DADALIDI 1			TIM O	7 1
PASSES, SHELL					
SHELL DIAMETER IN					
SHELL DIAMETER IN	, 3.020	IEMA SHEI	LL LIPE E	; KLAK HI	TAD FXIS
BAFFLE TYPE	HORZ SEGMENTL	CROSS PAS	SSES PER SH	ELL PASS	4
SPACING, CENTRAL	IN. 4.309	BAFFLE CU	JT, PCT SHE	LL I.D.	30.00
SPACING, INLET			ANCE FROM C	ENTER, IN.	.764
SPACING, OUTLET	IN. 4.309				
BAFFLE THICKNESS	IN125	IMPINGEME	ENT BAFFLE	INCLUDED	NO
PAIRS OF SEALING I	DEVICES 1	TUBESHEET	r blank are	A, %	.0
TUBE TYPE	PLAIN	МАТЕВТАТ.	F	LECTROLYTIC	COPPER
NO. OF TUBES/SHELI			TUBE COUNT		36
TUBE LGTH, OVERALI				IN.	.3125
TUBE LGTH, EFF			SIDE DIAM	IN.	.250
, =	=			-	

TUBE LAYOUT DEG	60 T	UBE INSIDE DIAM IN.		.214
PITCH RATIO	1.250 T	UBE SURFACE RATIO, OUT/IN		1.184
SHL NOZZ ID, IN&OUT 1.0	1.0 T	UBE NOZZ ID, IN&OUT IN.	.8	.8
* CALCULATED ITEMHEAT	BALANCE C	ODE = 8		
		exchanger experiment	E0(	)02 P129
Young model F302DY4P	112 100 11000	ononanger emperament		<sup>'</sup> 23/ 3
Toding model 1002D111				ASE 64
S U P P L E M E N	T A R	Y RESULTS	CI	101 04
HT DARAMETERS SHELL	TIBE	SHELLSIDE PERFORMANCE		
		NOMINAL VEL, X-FLOW FT/S		1.2
		NOMINAL VEL, WINDOW FT/S		
		CROSSFLOW COEF BTU/HR-FT2		
		WINDOW COEF BTU/HR-FT2		
RYNLD NO, IN BUN 346.  RYNLD NO, OUT BUN 496.		WINDOW COEF BIU/HR-FT2	. – r	200.1
RINLD NO, OUT BUN 496.	1917.			
FOULNG LAYER INUU14	.0014	SHELLSIDE FLOW, % OF TOTA HEAT TRANSFER X-FLOW	<del>1</del> ⊥	01 45
		HEAT TRANSFER X-FLOW		81.45
THERMAL RESISTANCE, % OF	TOTAL	TUBE TO BAFFLE LEAKAGE	7 =	4.10
SHELL TUBE FOULING M	E'I'AL	MAIN CROSSFLOW	3 =	64.48
36.47 60.58 2.85	.09	BUNDLE TO SHELL BYPASS	] =	16.14
PCT OVER DESIGN	.02	BAFFLE TO SHELL LEAKAGE	<u> </u>	15.28
TOT FOUL RESIST	.000217	TUBE PASSLANE BYPASS	? =	.00
DIFF RESIST	.000001	BUNDLE TO SHELL BYPASS  BAFFLE TO SHELL LEAKAGE  TUBE PASSLANE BYPASS		
		SHELLSIDE HEAT TRANSFER I TOTAL = (BETA) (GAMMA) (FIN)	FACTO	DRS
DIAMETRAL CLEARANCES		TOTAL = (BETA) (GAMMA) (FIN)	=	.766
		BETA (BAFF CUT FACTOR)		
		GAMMA (TUBE ROW ENTRY EFCT)		
BAFFLE TO SHELL IN.	.1000	END (HT LOSS IN END ZONE)	=	.994
SHELL NOZZLE DATA I	N OUT	SHELL PRESSURE DROP, % OF	TOI	TAL
HT UNDR NOZ IN2	5	WINDOW	=	8.9
HT OPP NOZ IN2	5	END ZONE	=	3.2
VELOCITY FT/S .7	4 .74	CROSS FLOW	=	2.9
DENSITY LB/FT3 62.25	2 61.876	WINDOW END ZONE CROSS FLOW INLET NOZZLE OUTLET NOZZLE	=	43.1
NOZZ RHO*VSQ LB/FT-S2 3	3 33	OUTLET NOZZLE	=	41.9
BUND RHO*VSQ LB/FT-S2 2	2 23			
TUBE NOZZLE DATA I	N OUT	WEIGHT PER SHELL, LB		
VELOCITY FT/S 1.1	8 1.17	DRY =		150.
		WET =		165.
DENSITY LB/FT3 61.29				

# \*\*\* 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 221.07 BTU/HR-FT2-F HEAT TRANSFER COEFF. AT RE = 10000 IS 1252.21 BTU/HR-FT2-F

Washington University ChE433 heat exchanger experiment E0002 P130 Young model F302DY4P 9/23/3

SIZE 4- 18 TYPE BEM, MULTI-PASS FLOW, SEGMENTAL BAFFLES, RATING TUBE SIDE   COLD SHELL SIDE   Tube   Shell   Shell   Shell   Sensible Liq						CASE 65
Tube SENSIBLE LIQ SENSIBLE LIQ CONTROL FLOW RATE   KLB/HR   SENSIBLE LIQ   Sensib	SIZE 4- 18 TYPE BEM, MUL	TI-PASS F	LOW, SEGME	NTAL BAFFLI	ES, RATING	
Tube SENSIBLE LIQ SENSIBLE LIQ CONTROL FLOW RATE   KLB/HR   SENSIBLE LIQ   Sensib			HOT TU	BE SIDE	COLD SI	HELL SIDE
TOTAL FLOW RATE   KLB/HR					Shell	L
TOTAL FLOW RATE   KLB/HR			SENSI	BLE LIQ	SENS	IBLE LIQ
TIM	TOTAL FLOW RATE KLB/H	R		.900		.200
DENSITY LB/FT3 61.2913 61.5030 62.2515 61.4723 VISCOSITY CP .4726 .5307 .9783 .5213 SPECIFIC HEAT BTU/LB-F .9973 .9974 1.0015 .9974 THERMAL COND. BTU/HF-FT-F .3723 .3696 .3554 .3700 MOLAR MASS LB/LBMOL 18.02  TEMP, AVG & SKIN DEGF 133.5 122.1 99.4 121.4 VISCOSITY, AVG & SKIN CP .5003 .5548 .6960 .5584 PRESSURE, IN & DESIGN PSIA 50.00 165.00 50.00 165.00  PRESSURE DROP, TOT & ALLOWED FSI .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 .0010 FILM COEFFICIENT BTU/HR-FT2-F 319.31 137.36  TOTAL HEAT DUTY REQUIRED MEGBTU/HR .011756 EFF TEMP DIF, DEGF (LMTD= 28.1, F= .77, BYPASS= .85, BAFF=1.00) 18.4  OVERALL COEFF REQUIRED BTU/HR-FT2-F 91.36 89.65  CLEAN & FOULED COEFF BTU/HR-FT2-F 91.36 89.85  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 BAFFLE CUT, PCT SHELL I.D. 30.00 SPACING, INLET IN. 4.309 BAFFLE CUT, PCT SHELL I.D. 30.00 SPACING, CENTRAL IN. 4.309 BAFFLE CUT, PCT SHELL I.D. 30.00 SPACING, CENTRAL IN. 4.309 BAFFLE CUT, PCT SHELL I.D. 30.00 SPACING, CENTRAL IN. 4.309 BAFFLE CUT, PCT SHELL I.D. 30.00 SPACING, CENTRAL IN. 4.309 BAFFLE CUT, PCT SHELL I.D. 30.00 SPACING, CENTRAL IN. 4.309 BAFFLE DIAM AREA, % .0  TUBE TYPE PLAIN MATERIAL ELECTROLYTIC COPPER NO. OF TUBES/SHELL 76 EST MAX TUBE COUNT IN. 36 SPACING, CENTRAL FT 1.436 TUBE OUTSIDE DIAM IN250 TUBE LAYOUT DEG 60 TUBE NISIDE DIAM IN250 TUBE LAYOUT DEG 60 TUBE NISIDE DIAM IN214 PITCH RATIO 1.250 TUBE SURFACE RATIO, OUT/IN 1.88  * CALCULATED ITEM-HEAT BALANCE CODE = 8 WASHINGTON UNIVERSITY CRE433 heat exchanger experiment ED002 P131 YOUNG model F302DY4P			IN	OUT	IN	OUT
DENSITY LB/FT3 61.2913 61.5030 62.2515 61.4723 VISCOSITY CP .4726 .5307 .9783 .5213 SPECIFIC HEAT BTU/LB-F .9973 .9974 1.0015 .9974 THERMAL COND. BTU/HF-FT-F .3723 .3696 .3554 .3700 MOLAR MASS LB/LBMOL 18.02  TEMP, AVG & SKIN DEGF 133.5 122.1 99.4 121.4 VISCOSITY, AVG & SKIN CP .5003 .5548 .6960 .5584 PRESSURE, IN & DESIGN PSIA 50.00 165.00 50.00 165.00  PRESSURE DROP, TOT & ALLOWED FSI .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 .0010 FILM COEFFICIENT BTU/HR-FT2-F 319.31 137.36  TOTAL HEAT DUTY REQUIRED MEGBTU/HR .011756 EFF TEMP DIF, DEGF (LMTD= 28.1,F= .77,BYPASS= .85,BAFF=1.00) 18.4  OVERALL COEFF REQUIRED BTU/HR-FT2-F 91.36 89.65  CLEAN & FOULED COEFF BTU/HR-FT2-F 91.36 89.85  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 BAFFLE CUT, PCT SHELL I.D. 30.00 SPACING, INLET IN. 4.309 BAFFLE THE INCLUDED NO PAIRS OF SEALING DEVICES 1 TUBESHEET BLANK AREA, % .0  TUBE TYPE PLAIN MATERIAL ELECTROLYTIC COPPER NO. OF TUBES/SHELL 7.6 EST MAX TUBE COUNT 1N. 36 TUBE LAYOUT DEG 60 TUBE NISIDE DIAM IN250 TUBE LAYOUT DEG 60 TUBE NISIDE DIAM IN250 TUBE LAYOUT DEG 60 TUBE SINDE DIAM IN250 TUBE LAYOUT DEG 60 TUBE SINDE DIAM IN214 PITCH RATIO 1.250 TUBE SUFFACE RATIO, OUT/IN 1.88  * CALCULATED ITEM—HEAT BALANCE CODE = 8 WASHINGTO UNIVERSITY CRE433 heat exchanger experiment ED002 P131 YOUNG model F302DY4P	TEMPERATURE DEGF		140.0	126.9*	70.0	128.9*
SPECIFIC HEAT BUTU/LD-F .9973 .9974 1.0015 .9974 THERMAL COND. BUTU/HR-FT-F .3723 .3696 .3554 .3700 MOLAR MASS LB/LBMOL 18.02 18.02  TEMP, AVG & SKIN DEGF 133.5 122.1 99.4 121.4 VISCOSITY, AVG & SKIN CP .5003 .5548 .6960 .5584 PRESSURE, IN & DESIGN PSIA 50.00 165.00 50.00 165.00  PRESSURE DROP, TOT & ALLOWED FSI .14 10.00 .00 10.00 VELOCITY, CALC & MAX ALLOWED FSI .88 10.00 .03 10.00  FOULING RESISTANCE HR-FT2-F/BTU .00010 .0010 FILM COEFFICIENT BTU/HR-FT2-F 319.31 137.36  TOTAL HEAT DUTY REQUIRED MEGBTU/HR .011756 EFF TEMP DIF, DEGF (LMTD= 28.1,F= .77,BYPASS= .85,BAFF=1.00) 18.4 OVERALL COEFF REQUIRED BTU/HR-FT2-F 91.36 89.65 CLEAN & FOULED COEFF BTU/HR-FT2-F 91.36 89.85  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, IN764 SPACING, CUTLET IN. 4.309 BAFFLE THICKNESS IN125 IMPINGEMENT BAFFLE INCLUDED NO PAIRS OF SEALING DEVICES 1 TUBESHEET BLANK AREA, % .0  TUBE TYPE PLAIN MATERIAL ELECTROLYTIC COPPER NO. OF TUBES/SHELL 75 1.436 TUBE COUNT IN3125 TUBE LGTH, OVERALL FT 1.436 TUBE OUTS DIAM IN250 TUBE LATOUT DEG 60 TUBE NISIDE DIAM IN250 TUBE LATOUT DEG 60 TUBE SURFACE RATIO, OUT/IN 1.184 SHL NOZZ ID, IN&OUT 1.0 1.0 TUBE NOZZ ID, IN&OUT IN8 .8  * CALCULATED ITEM-HEAT BALANCE CODE = 8 WASHINGTON UNIVERSITY CREASE ABLANCE	DENSITY LB/FT	3	61.2913	61.5030	62.2515	61.4723
### SPECIFIC HEAT BTU/LE-F	VISCOSITY CP		.4726	.5307	.9783	.5213
THERMAL COND. BTU/HR-FT-F	SPECIFIC HEAT BTU/LI	B-F	.9973	.9974	1.0015	.9974
MOLAR MASS	THERMAL COND. BTU/HI	R-FT-F				
TEMP, AVG & SKIN DEGF 133.5 122.1 99.4 121.4 VISCOSITY, AVG & SKIN CP .5003 .5548 .6960 .5584 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 PRESSURE DROP, TOT & ALLOWED FT/S .88 10.00 .03 10.00 PRESSURE DROP, TOT & ALLOWED FT/S .88 10.00 .03 10.00 PRESSURE DROP, TOT & ALLOWED FT/S .88 10.00 .03 10.00 PRESSURE DROP, TOT & ALLOWED FT/S .88 10.00 .03 10.00 PRESSURE DROP, TOT & ALLOWED FT/S .88 10.00 .03 10.00 PRESSURE DROP, TOT & ALLOWED FT/S .88 10.00 .03 10.00 PRESSURE DROP, TOT & ALLOWED FT/S .88 10.00 .03 10.00 PRESSURE DROP, TOT & ALLOWED FT/S .88 10.00 .03 10.00 PRESSURE DROP, TOT & ALLOWED FT/S .88 10.00 .03 10.00 PRESSURE DROP, TOT & ALLOWED FT/S .88 10.00 .03 10.00 PRESSURE DROP, TOT & ALLOWED FT/S .88 10.00 .03 10.00 PRESSURE DROP, TOT & ALLOWED FT/S .88 10.00 .03 10.00 PRESSURE DROP, TOT & ALLOWED FT/S .89.65 PRESSURE PRE		MOL		18.02		18.02
VISCOSITY, AVG & SKIN CP .5003 .5548 .6960 .5584  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 319.31 137.36  TOTAL HEAT DUTY REQUIRED MEGBTU/HR .011756  EFF TEMP DIF, DEGF (LMTD= 28.1,F= .77, BYPASS= .85, BAFF=1.00) 18.4  OVERALL COEFF REQUIRED BTU/HR-FT2-F 91.36 89.65  CLEAN & FOULED COEFF BTU/HR-FT2-F 91.36 89.85  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, IN764  SPACING, OUTLET IN. 4.309  BAFFLE THICKNESS IN125 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 IN3125  TUBE LGTH, OVERALL FT 1.500 TUBE PITCH IN3125  TUBE LGTH, EFF FT 1.436 TUBE OUTSIDE DIAM IN250  TUBE LGTH, EFF FT 1.436 TUBE OUTSIDE DIAM IN214  PITCH RAPIO 1.250 TUBE SURFACE RAPIO, OUT/IN 1.184  SH NOZZ ID, INWOUT 1.0 1.0 TUBE NOZZ ID, INWOUT IN8 .8  * CALCULATED ITEM-HEAT BALANCE CODE = 8  Washington University Che433 heat exchanger experiment E0002 P131  Young model F302DY4P 5000						
VISCOSITY, AVG & SKIN CP .5003 .5548 .6960 .5584  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 319.31 137.36  TOTAL HEAT DUTY REQUIRED MEGBTU/HR .011756  EFF TEMP DIF, DEGF (LMTD= 28.1,F= .77, BYPASS= .85, BAFF=1.00) 18.4  OVERALL COEFF REQUIRED BTU/HR-FT2-F 91.36 89.65  CLEAN & FOULED COEFF BTU/HR-FT2-F 91.36 89.85  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, IN764  SPACING, OUTLET IN. 4.309  BAFFLE THICKNESS IN125 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 IN3125  TUBE LGTH, OVERALL FT 1.500 TUBE PITCH IN3125  TUBE LGTH, EFF FT 1.436 TUBE OUTSIDE DIAM IN250  TUBE LGTH, EFF FT 1.436 TUBE OUTSIDE DIAM IN214  PITCH RAPIO 1.250 TUBE SURFACE RAPIO, OUT/IN 1.184  SH NOZZ ID, INWOUT 1.0 1.0 TUBE NOZZ ID, INWOUT IN8 .8  * CALCULATED ITEM-HEAT BALANCE CODE = 8  Washington University Che433 heat exchanger experiment E0002 P131  Young model F302DY4P 5000	TEMP, AVG & SKIN DI	EGF	133.5	122.1	99.4	121.4
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 319.31 137.36  TOTAL HEAT DUTY REQUIRED MEGBTU/HR  EFF TEMP DIF, DEGF (LMTD= 28.1,F= .77,BYPASS= .85,BAFF=1.00) 18.4  OVERALL COEFF REQUIRED BTU/HR-FT2-F 91.36 89.65  CLEAN & FOULED COEFF BTU/HR-FT2-F 91.36 89.85  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 BAFFLE CUT, PCT SHELL I.D. 30.00  SPACING, OUTLET IN. 4.309 CUT DISTANCE FROM CENTER, IN764  SPACING, OUTLET IN. 4.309  BAFFLE THICKNESS IN125 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 IN3125  TUBE LGTH, OFF FT 1.436 TUBE OUTSIDE DIAM IN250  TUBE LGTH, OFF FT 1.436 TUBE OUTSIDE DIAM IN250  TUBE LGTH, OFF FT 1.436 TUBE OUTSIDE DIAM IN250  TUBE LGTH, OFF FT 1.436 TUBE OUTSIDE DIAM IN250  TUBE LGTH, OFF FT 1.436 TUBE OUTSIDE DIAM IN250  TUBE LGTH, OFF FT 1.436 TUBE OUTSIDE DIAM IN250  TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN250  TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN214  PITCH RATIO 1.250 TUBE SURFACE RATIO, OUT/IN 1.184  SHANDARD TO TUBE NOZZ ID, IN&OUT IN8 .8  * CALCULATED ITEM-HEAT BALANCE CODE = 8  WASHINGTON UNIVERSITY CHE433 heat exchanger experiment E0002 P131  YOUNG model F302DY4P 9/23/3  CASE 65			.5003	.5548	.6960	.5584
PRESSURE DROP, TOT & ALLOWED PSI	PRESSURE, IN & DESIGN PS	SIA	50.00	165.00	50.00	165.00
FOULING RESISTANCE						
FOULING RESISTANCE	PRESSURE DROP, TOT & ALLO	OWED PSI	.14	10.00	.00	10.00
FOULING RESISTANCE   HR-FT2-F/BTU   .00010   .00010   FILM COEFFICIENT   BTU/HR-FT2-F   319.31   137.36    TOTAL HEAT DUTY REQUIRED MEGBTU/HR   .011756   EFF TEMP DIF, DEGF (LMTD= 28.1, F= .77, BYPASS= .85, BAFF=1.00)   18.4   OVERALL COEFF REQUIRED BTU/HR-FT2-F   91.36   89.65   CLEAN & FOULED COEFF   BTU/HR-FT2-F   91.36   89.85    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   F   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   T.   5.500   TUBE PITCH   IN.   .3125   TUBE LGTH, OVERALL   FT   1.500   TUBE PITCH   IN.   .3125   TUBE LGTH, OVERALL   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 P131   Young model F302DY4P   500000000000000000000000000000000000	VELOCITY, CALC & MAX ALLO	OWED FT/	s .88	10.00	.03	10.00
TOTAL HEAT DUTY REQUIRED MEGBTU/HR  TOTAL HEAT DUTY REQUIRED MEGBTU/HR  EFF TEMP DIF, DEGF (LMTD= 28.1, F= .77, BYPASS= .85, BAFF=1.00) 18.4  OVERALL COEFF REQUIRED BTU/HR-FT2-F 89.65  CLEAN & FOULED COEFF BTU/HR-FT2-F 91.36 89.85  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, IN764  SPACING, OUTLET IN. 4.309  BAFFLE THICKNESS IN125 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 IN3125  TUBE LGTH, EFF FT 1.436 TUBE OUTSIDE DIAM IN250  TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN250  TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN250  TUBE LAYOUT DEG 60 TUBE SURFACE RATIO, OUT/IN 1.184  SHL NOZZ ID, IN&OUT 1.0 1.0 TUBE NOZZ ID, IN&OUT IN8 .8  * CALCULATED ITEM-HEAT BALANCE CODE = 8  Washington University ChE433 heat exchanger experiment E0002 P131  Young model F302DY4P 9/23/ 3  CASE 65						
TOTAL HEAT DUTY REQUIRED MEGBTU/HR  TOTAL HEAT DUTY REQUIRED MEGBTU/HR  EFF TEMP DIF, DEGF (LMTD= 28.1, F= .77, BYPASS= .85, BAFF=1.00) 18.4  OVERALL COEFF REQUIRED BTU/HR-FT2-F 89.65  CLEAN & FOULED COEFF BTU/HR-FT2-F 91.36 89.85  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, IN764  SPACING, OUTLET IN. 4.309  BAFFLE THICKNESS IN125 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 IN3125  TUBE LGTH, EFF FT 1.436 TUBE OUTSIDE DIAM IN250  TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN214  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 IN8 .8  * CALCULATED ITEM—HEAT BALANCE CODE = 8  Washington University ChE433 heat exchanger experiment E0002 P131  Young model F302DY4P 9/23/ 3  CASE 65	FOULING RESISTANCE H	R-FT2-F/B	TU .0	0010	. (	00010
TOTAL HEAT DUTY REQUIRED MEGBTU/HR  EFF TEMP DIF, DEGF (LMTD= 28.1,F= .77,BYPASS= .85,BAFF=1.00) 18.4  OVERALL COEFF REQUIRED BTU/HR-FT2-F 89.65  CLEAN & FOULED COEFF BTU/HR-FT2-F 91.36 89.85  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, IN764  SPACING, OUTLET IN. 4.309  BAFFLE THICKNESS IN125 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 IN3125  TUBE LGTH, EFF FT 1.436 TUBE OUTSIDE DIAM IN250  TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN250  TUBE LAYOUT DEG 60 TUBE SURFACE RATIO, OUT/IN 1.184  SHL NOZZ ID, IN&OUT 1.0 1.0 TUBE NOZZ ID, IN&OUT IN8 .8  * CALCULATED ITEMHEAT BALANCE CODE = 8  Washington University ChE433 heat exchanger experiment E0002 P131  Young model F302DY4P 9/23/ 3  CASE 65	FILM COEFFICIENT BY	TU/HR-FT2	-F 31	9.31		
### TEMP DIF, DEGF (LMTD= 28.1, F= .77, BYPASS= .85, BAFF=1.00)						
### TEMP DIF, DEGF (LMTD= 28.1, F= .77, BYPASS= .85, BAFF=1.00)	TOTAL HEAT DUTY REQUIRED	MEGBTU/H	R			.011756
OVERALL COEFF REQUIRED BTU/HR-FT2-F 91.36 89.65 CLEAN & FOULED COEFF BTU/HR-FT2-F 91.36 89.85  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, IN764 SPACING, OUTLET IN. 4.309 BAFFLE THICKNESS IN125 IMPINGEMENT BAFFLE INCLUDED NO PAIRS OF SEALING DEVICES 1 TUBESHEET BLANK AREA, % .0  TUBE TYPE PLAIN MATERIAL ELECTROLYTIC COPPER NO. OF TUBES/SHELL FT 1.500 TUBE PITCH IN3125 TUBE LGTH, EFF FT 1.436 TUBE OUTSIDE DIAM IN250 TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN250 TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN214 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 IN8 .8  * CALCULATED ITEMHEAT BALANCE CODE = 8 Washington University Che433 heat exchanger experiment E0002 P131 Young model F302DY4P 9/23/ 3 CASE 65				SS= .85,BA		18.4
CLEAN & FOULED COEFF BTU/HR-FT2-F 91.36 89.85  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, IN764  SPACING, OUTLET IN. 4.309  BAFFLE THICKNESS IN125 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 IN3125  TUBE LGTH, EFF FT 1.436 TUBE OUTSIDE DIAM IN250  TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN250  TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN214  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 IN8 .8  * CALCULATED ITEMHEAT BALANCE CODE = 8  Washington University ChE433 heat exchanger experiment E0002 P131  Young model F302DY4P 9/23/3  CASE 65						
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, IN764 SPACING, OUTLET IN. 4.309 BAFFLE THICKNESS IN125 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 IN3125 TUBE LGTH, EFF FT 1.436 TUBE OUTSIDE DIAM IN250 TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN214 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 IN8 .8  * CALCULATED ITEMHEAT BALANCE CODE = 8 Washington University ChE433 heat exchanger experiment E0002 P131 Young model F302DY4P 9/23/3 CASE 65				91.3	5	
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, IN764 SPACING, OUTLET IN. 4.309 BAFFLE THICKNESS IN125 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 IN3125 TUBE LGTH, EFF FT 1.436 TUBE OUTSIDE DIAM IN250 TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN250 TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN214 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 IN8 .8  * CALCULATED ITEMHEAT BALANCE CODE = 8 Washington University ChE433 heat exchanger experiment E0002 P131 Young model F302DY4P 9/23/3 CASE 65						
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, IN764 SPACING, OUTLET IN. 4.309 BAFFLE THICKNESS IN125 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 IN3125 TUBE LGTH, EFF FT 1.436 TUBE OUTSIDE DIAM IN250 TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN250 TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN214 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 IN8 .8  * CALCULATED ITEMHEAT BALANCE CODE = 8 Washington University ChE433 heat exchanger experiment E0002 P131 Young model F302DY4P 9/23/3 CASE 65	SHELLS IN SERIES 1 PARA	LLEL 1	TOTAL EFF	' AREA	FT2	7.1
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, IN764 SPACING, OUTLET IN. 4.309 BAFFLE THICKNESS IN125 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 IN3125 TUBE LGTH, EFF FT 1.436 TUBE OUTSIDE DIAM IN250 TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN214 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 IN8 .8  * CALCULATED ITEM—HEAT BALANCE CODE = 8 Washington University ChE433 heat exchanger experiment E0002 P131 Young model F302DY4P  9/23/3 CASE 65						
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, IN764 SPACING, OUTLET IN. 4.309 BAFFLE THICKNESS IN125 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 IN3125 TUBE LGTH, EFF FT 1.436 TUBE OUTSIDE DIAM IN250 TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN214 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 IN8 .8  * CALCULATED ITEMHEAT BALANCE CODE = 8 Washington University ChE433 heat exchanger experiment E0002 P131 Young model F302DY4P 9/23/ 3 CASE 65						
SPACING, CENTRAL IN. 4.309 BAFFLE CUT, PCT SHELL I.D. 30.00 SPACING, INLET IN. 4.309 CUT DISTANCE FROM CENTER, IN764 SPACING, OUTLET IN. 4.309 BAFFLE THICKNESS IN125 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 IN3125 TUBE LGTH, EFF FT 1.436 TUBE OUTSIDE DIAM IN250 TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN214 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 IN8 .8  * CALCULATED ITEMHEAT BALANCE CODE = 8 Washington University ChE433 heat exchanger experiment E0002 P131 Young model F302DY4P 9/23/ 3 CASE 65						
SPACING, CENTRAL IN. 4.309 BAFFLE CUT, PCT SHELL I.D. 30.00 SPACING, INLET IN. 4.309 CUT DISTANCE FROM CENTER, IN764 SPACING, OUTLET IN. 4.309 BAFFLE THICKNESS IN125 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 IN3125 TUBE LGTH, EFF FT 1.436 TUBE OUTSIDE DIAM IN250 TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN214 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 IN8 .8  * CALCULATED ITEMHEAT BALANCE CODE = 8 Washington University ChE433 heat exchanger experiment E0002 P131 Young model F302DY4P 9/23/ 3 CASE 65	BAFFLE TYPE HORZ SI	EGMENTL	CROSS PAS	SES PER SHI	ELL PASS	4
SPACING, INLET IN. 4.309 CUT DISTANCE FROM CENTER, IN764 SPACING, OUTLET IN. 4.309 BAFFLE THICKNESS IN125 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 IN3125 TUBE LGTH, EFF FT 1.436 TUBE OUTSIDE DIAM IN250 TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN214 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 IN8 .8  * CALCULATED ITEMHEAT BALANCE CODE = 8 Washington University ChE433 heat exchanger experiment E0002 P131 Young model F302DY4P  9/23/3 CASE 65						
SPACING, OUTLET IN. 4.309 BAFFLE THICKNESS IN125 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 IN3125 TUBE LGTH, EFF FT 1.436 TUBE OUTSIDE DIAM IN250 TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN214 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 IN8 .8  * CALCULATED ITEM-HEAT BALANCE CODE = 8 Washington University ChE433 heat exchanger experiment E0002 P131 Young model F302DY4P 9/23/3 CASE 65	SPACING, INLET IN.	4.309	CUT DISTA	NCE FROM CI	ENTER, IN.	.764
BAFFLE THICKNESS IN125 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 IN3125 TUBE LGTH, EFF FT 1.436 TUBE OUTSIDE DIAM IN250 TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN214 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 IN8 .8  * CALCULATED ITEMHEAT BALANCE CODE = 8 Washington University ChE433 heat exchanger experiment E0002 P131 Young model F302DY4P  9/23/3 CASE 65	SPACING, OUTLET IN.	4.309				
TUBE TYPE PLAIN MATERIAL ELECTROLYTIC COPPER NO. OF TUBES/SHELL 76 EST MAX TUBE COUNT 36 TUBE LGTH, OVERALL FT 1.500 TUBE PITCH IN3125 TUBE LGTH, EFF FT 1.436 TUBE OUTSIDE DIAM IN250 TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN214 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 IN8 .8  * CALCULATED ITEMHEAT BALANCE CODE = 8 Washington University ChE433 heat exchanger experiment E0002 P131 Young model F302DY4P  9/23/3 CASE 65			IMPINGEME	NT BAFFLE	INCLUDED	NO
TUBE TYPE PLAIN MATERIAL ELECTROLYTIC COPPER NO. OF TUBES/SHELL 76 EST MAX TUBE COUNT 36  TUBE LGTH, OVERALL FT 1.500 TUBE PITCH IN3125  TUBE LGTH, EFF FT 1.436 TUBE OUTSIDE DIAM IN250  TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN214  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 IN8 .8  * CALCULATED ITEMHEAT BALANCE CODE = 8  Washington University ChE433 heat exchanger experiment E0002 P131  Young model F302DY4P 9/23/ 3  CASE 65						
NO. OF TUBES/SHELL 76 EST MAX TUBE COUNT 36  TUBE LGTH, OVERALL FT 1.500 TUBE PITCH IN3125  TUBE LGTH, EFF FT 1.436 TUBE OUTSIDE DIAM IN250  TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN214  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 IN8 .8  * CALCULATED ITEMHEAT BALANCE CODE = 8  Washington University ChE433 heat exchanger experiment E0002 P131  Young model F302DY4P 9/23/ 3  CASE 65						
TUBE LGTH, OVERALL FT 1.500 TUBE PITCH IN3125  TUBE LGTH, EFF FT 1.436 TUBE OUTSIDE DIAM IN250  TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN214  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 IN8 .8  * CALCULATED ITEMHEAT BALANCE CODE = 8  Washington University ChE433 heat exchanger experiment E0002 P131  Young model F302DY4P 9/23/ 3  CASE 65	TUBE TYPE	PLAIN	MATERIAL	El	LECTROLYTI(	C COPPER
TUBE LGTH, OVERALL FT 1.500 TUBE PITCH IN3125  TUBE LGTH, EFF FT 1.436 TUBE OUTSIDE DIAM IN250  TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN214  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 IN8 .8  * CALCULATED ITEMHEAT BALANCE CODE = 8  Washington University ChE433 heat exchanger experiment E0002 P131  Young model F302DY4P 9/23/ 3  CASE 65	NO. OF TUBES/SHELL	76	EST MAX T	UBE COUNT		36
TUBE LGTH, EFF FT 1.436 TUBE OUTSIDE DIAM IN250  TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN214  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 IN8 .8  * CALCULATED ITEMHEAT BALANCE CODE = 8  Washington University ChE433 heat exchanger experiment E0002 P131  Young model F302DY4P 9/23/ 3  CASE 65	TUBE LGTH, OVERALL FT	1.500	TUBE PITC	Н	IN.	.3125
TUBE LAYOUT DEG 60 TUBE INSIDE DIAM IN214 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 IN8 .8  * CALCULATED ITEMHEAT BALANCE CODE = 8 Washington University ChE433 heat exchanger experiment E0002 P131 Young model F302DY4P 9/23/ 3 CASE 65	TUBE LGTH, EFF FT	1.436	TUBE OUTS	IDE DIAM	IN.	
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 IN8 .8  * CALCULATED ITEMHEAT BALANCE CODE = 8 Washington University ChE433 heat exchanger experiment E0002 P131 Young model F302DY4P 9/23/ 3 CASE 65	TUBE LAYOUT DEG	60	TUBE INSI	DE DIAM		
* CALCULATED ITEMHEAT BALANCE CODE = 8 Washington University ChE433 heat exchanger experiment E0002 P131 Young model F302DY4P 9/23/3 CASE 65						
* CALCULATED ITEMHEAT BALANCE CODE = 8 Washington University ChE433 heat exchanger experiment E0002 P131 Young model F302DY4P 9/23/3 CASE 65		0 1.0	TUBE NOZZ	ID, IN&OU'	Γ IN.	.8 .8
Washington University ChE433 heat exchanger experiment E0002 P131 Young model F302DY4P 9/23/3 CASE 65	, =====================================			, =======	-	
Washington University ChE433 heat exchanger experiment E0002 P131 Young model F302DY4P 9/23/3 CASE 65	* CALCULATED ITEMHEAD	T BALANCE	CODE = 8			
Young model F302DY4P 9/23/ 3 CASE 65				er experime	ent	E0002 P131
CASE 65	<del>-</del>		9	1		
	J					
	SUPPLEME	N T A	R Y R	E S U	L T S	

SHELLSIDE PERFORMANCE

HT PARAMETERS SHELL TUBE

HT PARAMETERS SHELL TUBE		
WALL CORRECTION 1.031 .983	NOMINAL VEL, X-FLOW FT/S	.03
PRANDTL NUMBER 4.6 3.3		
RYNLD NO, AVG 107. 2835.		
RYNLD NO, IN BUN 76. 3001.	WINDOW COEF BTU/HR-FT2-F	138./
RYNLD NO, OUT BUN 143. 2672.		
FOULNG LAYER IN0014 .0014	SHELLSIDE FLOW, % OF TOTAL	
	HEAT TRANSFER X-FLOW	80.84
THERMAL RESISTANCE, % OF TOTAL		
SHELL TUBE FOULING METAL		
64.68 33.31 1.95 .06		
PCT OVER DESIGN .22	BAFFLE TO SHELL LEAKAGE E =	17.06
TOT FOUL RESIST .000217	TUBE PASSLANE BYPASS F =	.00
DIFF RESIST .000025		
	SHELLSIDE HEAT TRANSFER FACT	rors
DIAMETRAL CLEARANCES	TOTAL = (BETA) (GAMMA) (FIN) =	. 598
BUNDLE TO SHELL IN5000	BETA (BAFF CUT FACTOR) =	920
TUBE TO BAFFLE HOLE IN0284		
BAFFLE TO SHELL IN1000	END (HT LOSS IN END ZONE) =	.994
SHELL NOZZLE DATA IN OUT		
HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .16 .17	WINDOW =	9.4
HT OPP NOZ IN25	END ZONE =	6.4
VELOCITY FT/S .16 .17	CROSS FLOW =	5.0
DENSITY LB/FT3 62.252 61.472	INLET NOZZLE =	41.0
NOZZ RHO*VSQ LB/FT-S2 1 1	OUTLET NOZZLE =	38 1
BUND RHO*VSQ LB/FT-S2 1 1	OUTET NOZZEE –	30.1
BOND KHO"VSQ LB/F1-32 I I		
TUBE NOZZLE DATA IN OUT		
VELOCITY FT/S 1.33 1.32	DRY =	150.
VELOCITY FT/S 1.33 1.32 DENSITY LB/FT3 61.291 61.503	WET =	165.
PRESS. DROP % 9.0 5.7		
+++ ODECTAL MEGGACHO AND MADALANCO +	т т	
*** SPECIAL MESSAGES AND WARNINGS *	^ ^	
WARNINGTUBESIDE FLUID HAS PASSED	THROUGH TRANSITION ZONE. CONS	IDER
RERUNNING WITH ITEM 132 IN	EFFECT.	
HEAT TRANSFER COEFF. AT RE	= 2000 IS 213.35 BTU/HR-FT2	-F
HEAT TRANSFER COEFF. AT RE	= 10000 IS 1229.18 BTU/HR-FT2	-F
Washington University ChE433 heat		0002 P132
		9/23/ 3
Young model F302DY4P		
		CASE 66
SIZE 4- 18 TYPE BEM, MULTI-PASS FLO		
	HOT TUBE SIDE COLD SHE	LL SIDE
	Tube Shell	
	SENSIBLE LIQ SENSIB	LE LIO
TOTAL FLOW RATE KLB/HR	_	300
101111 11011 111111 111111	IN OUT IN	OUT
	TIN OOT IN	OOI

TEMPERATURE DEGF 140.0 122.1\* 70.0 123.6\* DENSITY LB/FT3 61.2913 61.5768 62.2515 61.5541

VISCOSITY CP SPECIFIC HEAT BT		che433b(70	.5548	.9783	.5472
THERMAL COND. BT MOLAR MASS LB	U/HR-FT-F	.3723		.3554	.3688 18.02
TEMP, AVG & SKIN VISCOSITY, AVG & SKIN PRESSURE, IN & DESIGN	CP	131.1 .5111	117.8	96.8 .7159	117.0 .5826
PRESSURE DROP, TOT & VELOCITY, CALC & MAX					
FOULING RESISTANCE FILM COEFFICIENT		-F 314	.06		
TOTAL HEAT DUTY REQUI EFF TEMP DIF, DEGF ( OVERALL COEFF REQUIRE CLEAN & FOULED COEFF	RED MEGBTU/HI LMTD= 30.9,F= D BTU/HR-F	R = .78,BYPAS Г2-F	S= .91,BAF		102.33
SHELLS IN SERIES 1 P PASSES, SHELL 1 T SHELL DIAMETER IN.	UBE 4	EFFECTIVE	AREA	FT2/SHELL	7.1
BAFFLE TYPE HORZ SPACING, CENTRAL IN. SPACING, INLET IN. SPACING, OUTLET IN. BAFFLE THICKNESS IN.	4.309 4.309 4.309	CROSS PASS BAFFLE CUT CUT DISTAN IMPINGEMEN	, PCT SHEL CE FROM CE	L I.D. NTER, IN.	30.00
PAIRS OF SEALING DEVI	CES 1	TUBESHEET	BLANK AREA	, %	.0
TUBE TYPE  NO. OF TUBES/SHELL  TUBE LGTH, OVERALL F  TUBE LGTH, EFF F  TUBE LAYOUT D  PITCH RATIO  SHL NOZZ ID, IN&OUT	76 T 1.500 T 1.436 EG 60 1.250		BE COUNT  DE DIAM  E DIAM  CE RATIO,	IN. IN. IN. OUT/IN	36 .3125 .250 .214 1.184
* CALCULATED ITEM Washington Universi Young model F302DY4P			r experime	nt	E0002 P133 9/23/ 3 CASE 66
S U P P L E M	E N T A I	R Y R	E S U	L T S	CASE 00
HT PARAMETERS SH WALL CORRECTION 1. PRANDTL NUMBER RYNLD NO, AVG 1 RYNLD NO, IN BUN 1 RYNLD NO, OUT BUN 2	029 .980 4.8 3.3 57. 2775. 15. 3001. 06. 2556.	NOMINAL NOMINAL CROSSFLO WINDOW C	IDE PERFOR VEL, X-FLOW VEL, WINDOW W COEF B OEF B	FT/S FT/S TU/HR-FT2- TU/HR-FT2-	.08 F 173.3 F 174.4
FOULNG LAYER IN0	014 .0014		IDE FLOW, NSFER X-FL		81.32

THERMAL RESISTANCE, % OF TOTAL	TUBE TO BAFFLE LEAKAGE A = 2.9
SHELL TUBE FOULING METAL	MAIN CROSSFLOW $B = 68.0$
58.92 38.77 2.23 .07	BUNDLE TO SHELL BYPASS C = 12.6
PCT OVER DESIGN .5	BAFFLE TO SHELL LEAKAGE E = 16.3 TUBE PASSLANE BYPASS F = .00
TOT FOUL RESIST .00021	TUBE PASSLANE BYPASS $F = .00$
DIFF RESIST .00005	50
	SHELLSIDE HEAT TRANSFER FACTORS
DIAMETRAL CLEARANCES	TOTAL = (BETA) (GAMMA) (FIN) = .61
BUNDLE TO SHELL IN50	TOTAL = (BETA) (GAMMA) (FIN) = .611
	284 GAMMA (TUBE ROW ENTRY EFCT) = .673
	000 END (HT LOSS IN END ZONE) = .99
SHELL NOZZLE DATA IN O	OUT SHELL PRESSURE DROP, % OF TOTAL
HT UNDR NOZ IN25	WINDOW = 9.
HT OPP NOZ IN25	WINDOW = 9. END ZONE = 5.
VELOCITY FT/S .25 .	.25 CROSS FLOW = 4.5 554 INLET NOZZLE = 42.0
DENSITY LB/FT3 62.252 61.5	554 INLET NOZZLE = 42.
NOZZ RHO*VSQ LB/FT-S2 3	3 OUTLET NOZZLE = 39.
BUND RHO*VSQ LB/FT-S2 2	2
TUBE NOZZLE DATA IN O	DUT WEIGHT PER SHELL, LB
VELOCITY FT/S 1.33 1.	
DENSITY LB/FT3 61.291 61.5	577 WET = 165
PRESS. DROP % 9.0 5	

## \*\*\* 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 215.30 BTU/HR-FT2-F HEAT TRANSFER COEFF. AT RE = 10000 IS 1235.14 BTU/HR-FT2-F

Washington University ChE433 heat exchanger experiment E0002 P134 Young model F302DY4P 9/23/3 CASE 67

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

		HOT TU	JBE SIDE	COLD SH	HELL SIDE
		Tube		Shell	L
		SENSI	BLE LIQ	SENSI	BLE LIQ
TOTAL FLOW RATE	KLB/HR		.900		.400
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	118.3*	70.0	118.8*
DENSITY	LB/FT3	61.2913	61.6344	62.2515	61.6264
VISCOSITY	CP	.4726	.5754	.9783	.5724
SPECIFIC HEAT	BTU/LB-F	.9973	.9977	1.0015	.9977
THERMAL COND.	BTU/HR-FT-F	.3723	.3676	.3554	.3677
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN	DEGF	129.1	114.1	94.4	113.3
VISCOSITY, AVG & SI	KIN CP	.5200	.5989	.7347	.6041
PRESSURE, IN & DES	IGN PSIA	50.00	165.00	50.00	165.00

		che433b(70)	.OUT	
PRESSURE DROP, TOT & AS VELOCITY, CALC & MAX AS	LLOWED PSI LLOWED FT/	.14 S .88	10.00	.00 10.00 .06 10.00
FOULING RESISTANCE FILM COEFFICIENT	BTU/HR-FT2	-F 309.	73	.00010 205.68
TOTAL HEAT DUTY REQUIRE EFF TEMP DIF, DEGF (LI OVERALL COEFF REQUIRED CLEAN & FOULED COEFF	ED MEGBTU/HI MTD= 32.9,F= BTU/HR-F	= .80,BYPASS	= .92,BAFF=1.0	.019505 24.2 112.78 112.95
SHELLS IN SERIES 1 PAR PASSES, SHELL 1 TUR SHELL DIAMETER IN.	3E 4	EFFECTIVE A	REA FT2/S	SHELL 7.1
BAFFLE TYPE HORZ SPACING, CENTRAL IN. SPACING, INLET IN. SPACING, OUTLET IN. BAFFLE THICKNESS IN. PAIRS OF SEALING DEVICE	4.309 4.309 4.309 .125	BAFFLE CUT, CUT DISTANC:	S PER SHELL PAPER PORT SHELL I.DE FROM CENTER,  BAFFLE INCLUDE LANK AREA, %	in. 30.00 in764
TUBE TYPE  NO. OF TUBES/SHELL  TUBE LGTH, OVERALL FT  TUBE LGTH, EFF FT  TUBE LAYOUT DEC  PITCH RATIO  SHL NOZZ ID, IN&OUT	76 1.500 1.436 60 1.250	EST MAX TUBE TUBE PITCH TUBE OUTSIDE TUBE INSIDE TUBE SURFACE	IN. E DIAM IN. DIAM IN. E RATIO, OUT/I	36 .3125 .250 .214 IN 1.184
* CALCULATED ITEMHI Washington University Young model F302DY4P			experiment	E0002 P135 9/23/ 3 CASE 67
S U P P L E M E	N T A	R Y R	E S U L T	
HT PARAMETERS SHEET WALL CORRECTION 1.02 PRANDTL NUMBER 4 RYNLD NO, AVG 203 RYNLD NO, IN BUN 156 RYNLD NO,OUT BUN 263 FOULNG LAYER IN003	TUBE .977 .9 3.4 .5. 2727.4. 3001.	SHELLSI NOMINAL VI NOMINAL VI CROSSFLOW WINDOW CO	DE PERFORMANCE EL,X-FLOW FT/ EL,WINDOW FT/ COEF BTU/HF EF BTU/HF	S .05 S .10 R-FT2-F 206.5 R-FT2-F 207.9
FOULNG LAYER IN003	. 2403. L4 .0014	SHELLSI	DE FLOW, % OF	TOTAL
THERMAL RESISTANCE, % ( SHELL TUBE FOULING 54.30 43.17 2.45 PCT OVER DESIGN TOT FOUL RESIST DIFF RESIST	) Ψ. '''' ( ) ''' ( )	MAIN CROSS BUNDLE TO BAFFLE TO TUBE PASS	AFFLE LEAKAGE SFLOW SHELL BYPASS SHELL LEAKAGE LANE BYPASS	A = 3.22 $B = 66.90$ $C = 13.92$ $E = 15.97$ $E = 0.00$
DIAMETRAL CLEARANCES BUNDLE TO SHELL II	N5000	SHELLSI: TOTAL = (B: BETA (BA:	DE HEAT TRANSF ETA) (GAMMA) (FI FF CUT FACTOR)	ER FACTORS (N) = .643 = .920

		GAMMA (TUBE ROW ENTRY EFCT) END (HT LOSS IN END ZONE)	
HT UNDR NOZ IN25	5	SHELL PRESSURE DROP, % OF WINDOW	TOTAL = 8.9
HT OPP NOZ IN25	5	END ZONE	= 4.5
VELOCITY FT/S .33	.33	CROSS FLOW	= 3.9
DENSITY LB/FT3 62.252	61.626	INLET NOZZLE	= 42.5
NOZZ RHO*VSQ LB/FT-S2	6	OUTLET NOZZLE	= 40.3
BUND RHO*VSQ LB/FT-S2	4		
TUBE NOZZLE DATA IN	TUO	WEIGHT PER SHELL, LB	
VELOCITY FT/S 1.33	1.32	DRY =	150.
DENSITY LB/FT3 61.291	61.634	WET =	165.
PRESS. DROP % 9.0	5.7		

#### \*\*\* 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 216.75 BTU/HR-FT2-F HEAT TRANSFER COEFF. AT RE = 10000 IS 1239.62 BTU/HR-FT2-F

Washington University ChE433 heat exchanger experiment E0002 P136 Young model F302DY4P 9/23/ 3

Young model F302DY	74P				9/23/ 3
					CASE 68
SIZE 4- 18 TYPE BE	CM, MULTI-PASS	FLOW, SEGME	ENTAL BAFFLI	ES, RATING	
		HOT TU	JBE SIDE	COLD SH	HELL SIDE
		Tube		Shell	L
		SENSI	BLE LIQ	SENSI	BLE LIQ
TOTAL FLOW RATE	KLB/HR				
		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	115.1*	70.0	114.7*
DENSITY	, -				
VISCOSITY	CP	.4726	.5932	.9783	.5956
SPECIFIC HEAT	BTU/LB-F	.9973	.9978	1.0015	.9978
THERMAL COND.					
MOLAR MASS	LB/LBMOL		18.02		18.02
TEMP, AVG & SKIN					
VISCOSITY, AVG & S					
PRESSURE, IN & DES	SIGN PSIA	50.00	165.00	50.00	165.00
PRESSURE DROP, TOT					
VELOCITY, CALC & N	MAX ALLOWED F	T/S .88	10.00	.08	10.00
FOULING RESISTANCE	: HR-FT2-F	/BTII (	00010	(	00010
FILM COEFFICIENT					
TOTAL HEAT DUTY RE	QUIRED MEGBTU	/HR			.022337
EFF TEMP DIF, DEGE	~		ASS= .93,BA	FF=1.00)	
OVERALL COEFF REQU			•	•	121.13
~	,				

		che433b(70).OUT	
CLEAN & FOULED COEFF BT	TU/HR-FT2	-F 124.29	120.97
SHELLS IN SERIES 1 PARALLE	EL 1 T	OTAL EFF AREA FT2	7.1
PASSES, SHELL 1 TUBE	4 E	FFECTIVE AREA FT2/SHELL	7.1
SHELL DIAMETER IN. 3	3.820 T	EMA SHELL TYPE E ; REAR HEAI	D FXTS
BAFFLE TYPE HORZ SEGM	MENTL C	ROSS PASSES PER SHELL PASS	4
SPACING, CENTRAL IN. 4	1.309 В	AFFLE CUT, PCT SHELL I.D.	30.00
SPACING, INLET IN. 4	1.309 C	UT DISTANCE FROM CENTER, IN.	.764
SPACING, OUTLET IN. 4	1.309		
BAFFLE THICKNESS IN.	.125 I	MPINGEMENT BAFFLE INCLUDED	NO
		UBESHEET BLANK AREA, %	
TUBE TYPE P	PLAIN M	ATERIAL ELECTROLYTIC ( ST MAX TUBE COUNT  UBE PITCH IN.	COPPER
NO. OF TUBES/SHELL	76 E	ST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT 1	L.500 T	UBE PITCH IN.	.3125
TODE BOTH, BIT IT I	. 100	ODD COIDIDD DIMI IN.	• 2 0 0
TUBE LAYOUT DEG	60 T	UBE INSIDE DIAM IN. UBE SURFACE RATIO, OUT/IN	.214
PITCH RATIO 1	L.250 T	UBE SURFACE RATIO, OUT/IN	1.184
SHL NOZZ ID, IN&OUT 1.0	1.0 T	UBE NOZZ ID, IN&OUT IN8	8 .8
* CALCULATED ITEMHEAT B			0000 5127
Young model F302DY4P	1433 neat	exchanger experiment E	9/23/ 3
foung model F302D14P			9/23/ 3 CASE 68
S II P P T. F M F. N	T A R	Y RESULTS	CASE 00
	I A K		
HT PARAMETERS SHELL	TUBE	SHELLSIDE PERFORMANCE	
HT PARAMETERS SHELL WALL CORRECTION 1.027	TUBE	SHELLSIDE PERFORMANCE NOMINAL VEL.X-FLOW FT/S	.07
WALL CORRECTION 1.027	.974	NOMINAL VEL, X-FLOW FT/S	.07
WALL CORRECTION 1.027 PRANDTL NUMBER 5.0	.974 3.4	NOMINAL VEL, X-FLOW FT/S NOMINAL VEL, WINDOW FT/S	.13
WALL CORRECTION 1.027 PRANDTL NUMBER 5.0 RYNLD NO, AVG 251.	.974 3.4 2688.	NOMINAL VEL, X-FLOW FT/S NOMINAL VEL, WINDOW FT/S CROSSFLOW COEF BTU/HR-FT2-F	.13 237.8
WALL CORRECTION 1.027 PRANDTL NUMBER 5.0 RYNLD NO, AVG 251. RYNLD NO, IN BUN 192. RYNLD NO, OUT BUN 316.	.974 3.4 2688. 3001. 2391.	NOMINAL VEL, X-FLOW FT/S NOMINAL VEL, WINDOW FT/S CROSSFLOW COEF BTU/HR-FT2-F WINDOW COEF BTU/HR-FT2-F	237.8 239.4
WALL CORRECTION 1.027 PRANDTL NUMBER 5.0 RYNLD NO, AVG 251. RYNLD NO, IN BUN 192. RYNLD NO, OUT BUN 316.	.974 3.4 2688. 3001. 2391.	NOMINAL VEL, X-FLOW FT/S NOMINAL VEL, WINDOW FT/S CROSSFLOW COEF BTU/HR-FT2-F WINDOW COEF BTU/HR-FT2-F SHELLSIDE FLOW, % OF TOTAL	.13 237.8 239.4
WALL CORRECTION 1.027 PRANDTL NUMBER 5.0 RYNLD NO, AVG 251. RYNLD NO, IN BUN 192. RYNLD NO,OUT BUN 316. FOULNG LAYER IN0014	.974 3.4 2688. 3001. 2391.	NOMINAL VEL, X-FLOW FT/S NOMINAL VEL, WINDOW FT/S CROSSFLOW COEF BTU/HR-FT2-F WINDOW COEF BTU/HR-FT2-F SHELLSIDE FLOW, % OF TOTAL HEAT TRANSFER X-FLOW	.13 237.8 239.4
WALL CORRECTION 1.027 PRANDTL NUMBER 5.0 RYNLD NO, AVG 251. RYNLD NO, IN BUN 192. RYNLD NO,OUT BUN 316. FOULNG LAYER IN0014 THERMAL RESISTANCE, % OF TO	.974 3.4 2688. 3001. 2391. .0014	NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F  WINDOW COEF BTU/HR-FT2-F  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW  TUBE TO BAFFLE LEAKAGE A =	237.8 239.4 81.49 3.45
WALL CORRECTION 1.027 PRANDTL NUMBER 5.0 RYNLD NO, AVG 251. RYNLD NO, IN BUN 192. RYNLD NO,OUT BUN 316. FOULNG LAYER IN0014  THERMAL RESISTANCE, % OF TO SHELL TUBE FOULING MET	.974 3.4 2688. 3001. 2391. .0014	NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F  WINDOW COEF BTU/HR-FT2-F  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW  TUBE TO BAFFLE LEAKAGE A =  MAIN CROSSFLOW B =	.13 237.8 239.4 81.49 3.45 65.82
WALL CORRECTION 1.027 PRANDTL NUMBER 5.0 RYNLD NO, AVG 251. RYNLD NO, IN BUN 192. RYNLD NO,OUT BUN 316. FOULNG LAYER IN0014  THERMAL RESISTANCE, % OF TO SHELL TUBE FOULING MET 50.50 46.79 2.62	.974 3.4 2688. 3001. 2391. .0014 DTAL	NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F  WINDOW COEF BTU/HR-FT2-F  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW  TUBE TO BAFFLE LEAKAGE A =  MAIN CROSSFLOW B =  BUNDLE TO SHELL BYPASS C =	.13 237.8 239.4 81.49 3.45 65.82 14.97
WALL CORRECTION 1.027 PRANDTL NUMBER 5.0 RYNLD NO, AVG 251. RYNLD NO, IN BUN 192. RYNLD NO,OUT BUN 316. FOULNG LAYER IN0014  THERMAL RESISTANCE, % OF TO SHELL TUBE FOULING MET 50.50 46.79 2.62	.974 3.4 2688. 3001. 2391. .0014 DTAL	NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F  WINDOW COEF BTU/HR-FT2-F  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW  TUBE TO BAFFLE LEAKAGE A =  MAIN CROSSFLOW B =  BUNDLE TO SHELL BYPASS C =	.13 237.8 239.4 81.49 3.45 65.82 14.97
WALL CORRECTION 1.027 PRANDTL NUMBER 5.0 RYNLD NO, AVG 251. RYNLD NO, IN BUN 192. RYNLD NO,OUT BUN 316. FOULNG LAYER IN0014  THERMAL RESISTANCE, % OF TO SHELL TUBE FOULING MET 50.50 46.79 2.62 . PCT OVER DESIGN TOT FOUL RESIST .0	.974 3.4 2688. 3001. 2391. .0014 DTAL FAL .09 13	NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F  WINDOW COEF BTU/HR-FT2-F  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW  TUBE TO BAFFLE LEAKAGE A =  MAIN CROSSFLOW B =	.13 237.8 239.4 81.49 3.45 65.82 14.97
WALL CORRECTION 1.027 PRANDTL NUMBER 5.0 RYNLD NO, AVG 251. RYNLD NO, IN BUN 192. RYNLD NO,OUT BUN 316. FOULNG LAYER IN0014  THERMAL RESISTANCE, % OF TO SHELL TUBE FOULING MET 50.50 46.79 2.62	.974 3.4 2688. 3001. 2391. .0014 DTAL FAL .09 13	NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F  WINDOW COEF BTU/HR-FT2-F  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW  TUBE TO BAFFLE LEAKAGE A =  MAIN CROSSFLOW B =  BUNDLE TO SHELL BYPASS C =  BAFFLE TO SHELL LEAKAGE E =  TUBE PASSLANE BYPASS F =	81.49 3.45 65.82 14.97 15.75
WALL CORRECTION 1.027 PRANDTL NUMBER 5.0 RYNLD NO, AVG 251. RYNLD NO, IN BUN 192. RYNLD NO,OUT BUN 316. FOULNG LAYER IN0014  THERMAL RESISTANCE, % OF TO SHELL TUBE FOULING MET 50.50 46.79 2.62 PCT OVER DESIGN TOT FOUL RESIST .0 DIFF RESIST .0	.974 3.4 2688. 3001. 2391. .0014 DTAL TAL .09 13 000217	NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F  WINDOW COEF BTU/HR-FT2-F  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW  TUBE TO BAFFLE LEAKAGE A =  MAIN CROSSFLOW B =  BUNDLE TO SHELL BYPASS C =  BAFFLE TO SHELL LEAKAGE E =  TUBE PASSLANE BYPASS F =	81.49 3.45 65.82 14.97 15.75 .00
WALL CORRECTION 1.027 PRANDTL NUMBER 5.0 RYNLD NO, AVG 251. RYNLD NO, IN BUN 192. RYNLD NO,OUT BUN 316. FOULNG LAYER IN0014  THERMAL RESISTANCE, % OF TO SHELL TUBE FOULING MET 50.50 46.79 2.62 PCT OVER DESIGN TOT FOUL RESIST .0 DIFF RESIST .0	.974 3.4 2688. 3001. 2391. .0014 DTAL TAL .09 13 000217	NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F  WINDOW COEF BTU/HR-FT2-F  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW  TUBE TO BAFFLE LEAKAGE A =  MAIN CROSSFLOW B =  BUNDLE TO SHELL BYPASS C =  BAFFLE TO SHELL LEAKAGE E =  TUBE PASSLANE BYPASS F =	81.49 3.45 65.82 14.97 15.75 .00
WALL CORRECTION 1.027 PRANDTL NUMBER 5.0 RYNLD NO, AVG 251. RYNLD NO, IN BUN 192. RYNLD NO,OUT BUN 316. FOULNG LAYER IN0014  THERMAL RESISTANCE, % OF TO SHELL TUBE FOULING MET 50.50 46.79 2.62 . PCT OVER DESIGN TOT FOUL RESIST .0 DIFF RESIST .0 DIAMETRAL CLEARANCES BUNDLE TO SHELL IN.	.974 3.4 2688. 3001. 2391. .0014 DTAL TAL .09 13 000217 000010	NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F  WINDOW COEF BTU/HR-FT2-F  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW  TUBE TO BAFFLE LEAKAGE A =  MAIN CROSSFLOW B =  BUNDLE TO SHELL BYPASS C =  BAFFLE TO SHELL LEAKAGE E =  TUBE PASSLANE BYPASS F =  SHELLSIDE HEAT TRANSFER FACTOR  TOTAL = (BETA) (GAMMA) (FIN) =  BETA (BAFF CUT FACTOR) =	.13 237.8 239.4 81.49 3.45 65.82 14.97 15.75 .00
WALL CORRECTION 1.027 PRANDTL NUMBER 5.0 RYNLD NO, AVG 251. RYNLD NO, IN BUN 192. RYNLD NO,OUT BUN 316. FOULNG LAYER IN0014  THERMAL RESISTANCE, % OF TO SHELL TUBE FOULING MET 50.50 46.79 2.62 . PCT OVER DESIGN TOT FOUL RESIST .0 DIFF RESIST .0 DIAMETRAL CLEARANCES BUNDLE TO SHELL IN. TUBE TO BAFFLE HOLE IN.	.974 3.4 2688. 3001. 2391. .0014 DTAL TAL .09 13 000217 000010	NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F  WINDOW COEF BTU/HR-FT2-F  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW  TUBE TO BAFFLE LEAKAGE A =  MAIN CROSSFLOW B =  BUNDLE TO SHELL BYPASS C =  BAFFLE TO SHELL LEAKAGE E =  TUBE PASSLANE BYPASS F =  SHELLSIDE HEAT TRANSFER FACT  TOTAL = (BETA) (GAMMA) (FIN) =  BETA (BAFF CUT FACTOR) =  GAMMA (TUBE ROW ENTRY EFCT) =	.13 237.8 239.4 81.49 3.45 65.82 14.97 15.75 .00 FORS .667 .920 .726
WALL CORRECTION 1.027 PRANDTL NUMBER 5.0 RYNLD NO, AVG 251. RYNLD NO, IN BUN 192. RYNLD NO,OUT BUN 316. FOULNG LAYER IN0014  THERMAL RESISTANCE, % OF TO SHELL TUBE FOULING MET 50.50 46.79 2.62 . PCT OVER DESIGN TOT FOUL RESIST .0 DIFF RESIST .0 DIAMETRAL CLEARANCES BUNDLE TO SHELL IN. TUBE TO BAFFLE HOLE IN. BAFFLE TO SHELL IN.	.974 3.4 2688. 3001. 2391. .0014 DTAL FAL .09 13 000217 000010	NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F  WINDOW COEF BTU/HR-FT2-F  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW  TUBE TO BAFFLE LEAKAGE A =  MAIN CROSSFLOW B =  BUNDLE TO SHELL BYPASS C =  BAFFLE TO SHELL LEAKAGE E =  TUBE PASSLANE BYPASS F =  SHELLSIDE HEAT TRANSFER FACT  TOTAL = (BETA) (GAMMA) (FIN) =  BETA (BAFF CUT FACTOR) =  GAMMA (TUBE ROW ENTRY EFCT) =  END (HT LOSS IN END ZONE) =	81.49 3.45 65.82 14.97 15.75 .00 TORS .667 .920 .726
WALL CORRECTION 1.027 PRANDTL NUMBER 5.0 RYNLD NO, AVG 251. RYNLD NO, IN BUN 192. RYNLD NO,OUT BUN 316. FOULNG LAYER IN0014  THERMAL RESISTANCE, % OF TO SHELL TUBE FOULING MET 50.50 46.79 2.62 . PCT OVER DESIGN TOT FOUL RESIST .0 DIFF RESIST .0 DIAMETRAL CLEARANCES BUNDLE TO SHELL IN. TUBE TO BAFFLE HOLE IN. BAFFLE TO SHELL IN. SHELL NOZZLE DATA IN	.974 3.4 2688. 3001. 2391. .0014 DTAL TAL .09 13 000217 000010	NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F  WINDOW COEF BTU/HR-FT2-F  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW  TUBE TO BAFFLE LEAKAGE A =  MAIN CROSSFLOW B =  BUNDLE TO SHELL BYPASS C =  BAFFLE TO SHELL LEAKAGE E =  TUBE PASSLANE BYPASS F =  SHELLSIDE HEAT TRANSFER FACT  TOTAL = (BETA) (GAMMA) (FIN) =  BETA (BAFF CUT FACTOR) =  GAMMA (TUBE ROW ENTRY EFCT) =  END (HT LOSS IN END ZONE) =	.13 237.8 239.4 81.49 3.45 65.82 14.97 15.75 .00 TORS .667 .920 .726 .994
WALL CORRECTION 1.027 PRANDTL NUMBER 5.0 RYNLD NO, AVG 251. RYNLD NO, IN BUN 192. RYNLD NO,OUT BUN 316. FOULNG LAYER IN0014  THERMAL RESISTANCE, % OF TO SHELL TUBE FOULING MET 50.50 46.79 2.62 . PCT OVER DESIGN TOT FOUL RESIST .0 DIFF RESIST .0 DIAMETRAL CLEARANCES BUNDLE TO SHELL IN. TUBE TO BAFFLE HOLE IN. BAFFLE TO SHELL IN. SHELL NOZZLE DATA IN HT UNDR NOZ IN25	.974 3.4 2688. 3001. 2391. .0014 DTAL TAL .09 13 000217 000010	NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F  WINDOW COEF BTU/HR-FT2-F  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW  TUBE TO BAFFLE LEAKAGE A =  MAIN CROSSFLOW B =  BUNDLE TO SHELL BYPASS C =  BAFFLE TO SHELL LEAKAGE E =  TUBE PASSLANE BYPASS F =  SHELLSIDE HEAT TRANSFER FACT  TOTAL = (BETA) (GAMMA) (FIN) =  BETA (BAFF CUT FACTOR) =  GAMMA (TUBE ROW ENTRY EFCT) =  END (HT LOSS IN END ZONE) =  SHELL PRESSURE DROP, % OF TOWINDOW =	.13 237.8 239.4 81.49 3.45 65.82 14.97 15.75 .00 TORS .667 .920 .726 .994
WALL CORRECTION 1.027 PRANDTL NUMBER 5.0 RYNLD NO, AVG 251. RYNLD NO, IN BUN 192. RYNLD NO,OUT BUN 316. FOULNG LAYER IN0014  THERMAL RESISTANCE, % OF TO SHELL TUBE FOULING MET 50.50 46.79 2.62 . PCT OVER DESIGN TOT FOUL RESIST .0 DIFF RESIST .0 DIAMETRAL CLEARANCES BUNDLE TO SHELL IN. TUBE TO BAFFLE HOLE IN. BAFFLE TO SHELL IN. SHELL NOZZLE DATA IN HT UNDR NOZ IN25 HT OPP NOZ IN25	.974 3.4 2688. 3001. 23910014  DTAL TAL TAL 0913 000217 000010  .5000 .0284 .1000  OUT	NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F  WINDOW COEF BTU/HR-FT2-F  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW  TUBE TO BAFFLE LEAKAGE A =  MAIN CROSSFLOW B =  BUNDLE TO SHELL BYPASS C =  BAFFLE TO SHELL LEAKAGE E =  TUBE PASSLANE BYPASS F =  SHELLSIDE HEAT TRANSFER FACT  TOTAL = (BETA) (GAMMA) (FIN) =  BETA (BAFF CUT FACTOR) =  GAMMA (TUBE ROW ENTRY EFCT) =  END (HT LOSS IN END ZONE) =  SHELL PRESSURE DROP, % OF TOWINDOW =  END ZONE =	.13 237.8 239.4 81.49 3.45 65.82 14.97 15.75 .00 TORS .667 .920 .726 .994
WALL CORRECTION 1.027 PRANDTL NUMBER 5.0 RYNLD NO, AVG 251. RYNLD NO, IN BUN 192. RYNLD NO, OUT BUN 316. FOULNG LAYER IN0014  THERMAL RESISTANCE, % OF TO SHELL TUBE FOULING MET 50.50 46.79 2.62 PCT OVER DESIGN TOT FOUL RESIST .0 DIFF RESIST .0 DIAMETRAL CLEARANCES BUNDLE TO SHELL IN. TUBE TO BAFFLE HOLE IN. BAFFLE TO SHELL IN. SHELL NOZZLE DATA IN HT UNDR NOZ IN25 HT OPP NOZ IN25 VELOCITY FT/S .41	.974 3.4 2688. 3001. 23910014  DTAL TAL TAL .0913 .000217 .000010  .5000 .0284 .1000  OUT	NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F  WINDOW COEF BTU/HR-FT2-F  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW  TUBE TO BAFFLE LEAKAGE A =  MAIN CROSSFLOW B =  BUNDLE TO SHELL BYPASS C =  BAFFLE TO SHELL LEAKAGE E =  TUBE PASSLANE BYPASS F =  SHELLSIDE HEAT TRANSFER FACT  TOTAL = (BETA) (GAMMA) (FIN) =  BETA (BAFF CUT FACTOR) =  GAMMA (TUBE ROW ENTRY EFCT) =  END (HT LOSS IN END ZONE) =  SHELL PRESSURE DROP, % OF TOWNOW  END ZONE =  CROSS FLOW =	37.8 237.8 239.4 81.49 3.45 65.82 14.97 15.75 .00 FORS .667 .920 .726 .994
WALL CORRECTION 1.027 PRANDTL NUMBER 5.0 RYNLD NO, AVG 251. RYNLD NO, IN BUN 192. RYNLD NO,OUT BUN 316. FOULNG LAYER IN0014  THERMAL RESISTANCE, % OF TO SHELL TUBE FOULING MET 50.50 46.79 2.62 . PCT OVER DESIGN TOT FOUL RESIST .0 DIFF RESIST .0 DIAMETRAL CLEARANCES BUNDLE TO SHELL IN. TUBE TO BAFFLE HOLE IN. BAFFLE TO SHELL IN. SHELL NOZZLE DATA IN HT UNDR NOZ IN25 HT OPP NOZ IN25	.974 3.4 2688. 3001. 23910014  DTAL TAL TAL .0913 .000217 .000010  .5000 .0284 .1000  OUT  .41 61.687	NOMINAL VEL, X-FLOW FT/S  NOMINAL VEL, WINDOW FT/S  CROSSFLOW COEF BTU/HR-FT2-F  WINDOW COEF BTU/HR-FT2-F  SHELLSIDE FLOW, % OF TOTAL  HEAT TRANSFER X-FLOW  TUBE TO BAFFLE LEAKAGE A =  MAIN CROSSFLOW B =  BUNDLE TO SHELL BYPASS C =  BAFFLE TO SHELL LEAKAGE E =  TUBE PASSLANE BYPASS F =  SHELLSIDE HEAT TRANSFER FACT  TOTAL = (BETA) (GAMMA) (FIN) =  BETA (BAFF CUT FACTOR) =  GAMMA (TUBE ROW ENTRY EFCT) =  END (HT LOSS IN END ZONE) =  SHELL PRESSURE DROP, % OF TOWINDOW =  END ZONE =  CROSS FLOW =  INLET NOZZLE =	.13 237.8 239.4 81.49 3.45 65.82 14.97 15.75 .00 TORS .667 .920 .726 .994

BUND RHO\*VSQ LB/FT-S2 7 7

TUBE NOZ	ZLE DATA	IN	OUT	WEIGHT PER SHELL,	LB		
VELOCITY	FT/S	1.33	1.32	DRY		=	150.
DENSITY	LB/FT3	61.291	61.681	WET		=	165.
PRESS. DRO	P %	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 217.84 BTU/HR-FT2-F HEAT TRANSFER COEFF. AT RE = 10000 IS 1243.13 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
---------	----	------	------	------------	-------	-----------	----------	--------

SIZE 4- 18 TYPE BE	M, MULTI-PASS F	LOW, SEGME	NIAL BALLLI	15, RATING	
			JBE SIDE		
		Tube		Shell	-
		SENSI	BLE LIQ	SENSI	BLE LIQ
TOTAL FLOW RATE	KLB/HR		.900		.600
TOTAL FLOW RATE TEMPERATURE		IN	OUT	IN	OUT
TEMPERATURE	DEGF	140.0	112.5*	70.0	111.2*
DENSITY	LB/FT3	61.2913	61.7185	62.2515	61.7380
VISCOSITY	CP	.4726	.6086	.9783	.6169
SPECIFIC HEAT	BTU/LB-F	.9973	.9979	1.0015	.9980
THERMAL COND.	BTU/HR-FT-F	.3723	.3663	.3554	.3660
THERMAL COND. MOLAR MASS	LB/LBMOL		18.02		18.02
	, -				
TEMP, AVG & SKIN	DEGF	126.3	108.4	90.6	107.4
VISCOSITY, AVG & S					
PRESSURE, IN & DES					
•					
PRESSURE DROP, TOT	& ALLOWED PSI	.14	10.00	.01	10.00
VELOCITY, CALC & M.	AX ALLOWED FT/	S .88	10.00	.09	10.00
•	·				
FOULING RESISTANCE	HR-FT2-F/B	STU .C	00010	.0	00010
FILM COEFFICIENT					
TOTAL HEAT DUTY RE	OUIRED MEGBTU/H	IR			.024676
EFF TEMP DIF, DEGF			ASS= .94,BA		
OVERALL COEFF REQU			,	,	127.58
CLEAN & FOULED COE			131.5	4	
				_	
SHELLS IN SERIES	1 PARALLEL 1	TOTAL EFF	AREA	FT2	7.1
PASSES, SHELL					
SHELL DIAMETER IN.					
~ DIMILION IN.	3.020	11111 011111	1	,	
BAFFLE TYPE H	ORZ SEGMENTI	CROSS PAS	SSES PER SHI	ELL PASS	4
SPACING, CENTRAL					
SPACING, INLET					
211121110, 1111111	1.005	001 01011			• / 5 1

		che433b(70).OUT	
SPACING, OUTLET IN.	4.309		
BAFFLE THICKNESS IN.	.125	IMPINGEMENT BAFFLE INCLUDED	NO
PAIRS OF SEALING DEVICES		TUBESHEET BLANK AREA, %	
TUBE TYPE	PLAIN 1	MATERIAL ELECTROLYT	IC COPPER
		EST MAX TUBE COUNT	36
TUBE LGTH, OVERALL FT			
TUBE LGTH, OVERALL FT		TUBE PITCH IN.	.3125
	1.436	TUBE OUTSIDE DIAM IN.	
TUBE LAYOUT DEG		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 ITEMHEAT	BALANCE (	CODE = 8	
Washington University Cl	nE433 hea	t exchanger experiment	E0002 P139
Young model F302DY4P			9/23/ 3
roung moder rouzern			CASE 69
	m 7 D	Y RESULTS	CASE 05
	IAK		
		SHELLSIDE PERFORMANCE	
WALL CORRECTION 1.025	.972	NOMINAL VEL, X-FLOW FT/S	.08
PRANDTL NUMBER 5.1	3.5	NOMINAL VEL, WINDOW FT/S	.15
RYNLD NO, AVG 295.	2657.	CROSSFLOW COEF BTU/HR-FT2	
RYNLD NO, IN BUN 231. RYNLD NO, OUT BUN 366.	3001.	WINDOW COEF BTU/HR-FT2	2-F 270.1
RYNLD NO, OUT BUN 366.	2330.		
FOULNG LAYER IN0014	.0014	SHELLSIDE FLOW, % OF TOTA	AL
		HEAT TRANSFER X-FLOW	
THERMAL RESISTANCE, % OF	готат.		
SHELL TUBE FOULING MI	T T N T	MAIN CROSSFLOW	3.00
47.23 49.91 2.77	7177	BUNDLE TO SHELL BYPASS (	
47.23 49.91 2.77	.12	BAFFLE TO SHELL LEAKAGE	
PCT OVER DESIGN	.12	BAFFLE TO SHELL LEAKAGE	<u> </u>
TOT FOUL RESIST DIFF RESIST	.000217	TUBE PASSLANE BYPASS	· = .00
DIFF RESIST	.000009		
		SHELLSIDE HEAT TRANSFER H	
DIAMETRAL CLEARANCES		TOTAL = (BETA) (GAMMA) (FIN)	= .692
BUNDLE TO SHELL IN.	.5000	BETA (BAFF CUT FACTOR)	
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	TUO V	SHELL PRESSURE DROP, % OF	TOTAL
HT UNDR NOZ IN25		WINDOW	= 8.8
HT OPP NOZ IN25	5	END ZONE	= 3.8
VELOCITY FT/S .49	10		
VELOCITY FT/S .49	.49	CROSS FLOW	= 3.3
DENSITY LB/FT3 62.252			= 42.9
NOZZ RHO*VSQ LB/FT-S2 14	4 15	OUTLET NOZZLE	= 41.2
BUND RHO*VSQ LB/FT-S2 10	10		
TUBE NOZZLE DATA IN	TUO N	WEIGHT PER SHELL, LB	
TUBE NOZZLE DATA IN VELOCITY FT/S 1.33	3 1.32	DRY =	150.
DENSITY LB/FT3 61.293	1 61.719	WET =	
	9 5.6		
	. 0.0		

\*\*\* 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 218.71 BTU/HR-FT2-F HEAT TRANSFER COEFF. AT RE = 10000 IS 1245.80 BTU/HR-FT2-F

Washington University ChE433 heat exchanger experiment E0002 P140 0

washington oniv	=	icac excitation	ger experim	CIIC	0/02/114
Young model F302D	Y 4 P				9/23/ 3
					CASE 70
SIZE 4- 18 TYPE B	EM, MULTI-PASS	FLOW, SEGME	ENTAL BAFFL	ES, RATING	
		HOT TO	UBE SIDE	COLD SI	HELL SIDE
		Tube		Shell	L
		SENS	IBLE LIQ	SENS	IBLE LIQ
TOTAL FLOW RATE	KLB/HR		.900		.700
		IN	OUT	IN	OUT
TEMPERATURE	DEGE	140 0	110 3*	70 0	108 1*
DENSITY	LB/FT3	61.2913	61.7505	62.2515	61.7804
VISCOSITY	CP	.4726	.6223	.9783	.6358
SPECIFIC HEAT	BTU/LB-F	.9973	.9980	1.0015	.9982
THERMAL COND. MOLAR MASS	BTU/HR-FT-F	. 3723	. 3657	. 3554	. 3652
MOLAR MASS	I.B / I.BMOT.	•0,20	18.02	• 0001	18.02
HODAK HASS			10.02		10.02
TEMP, AVG & SKIN	DECE				
VISCOSITY, AVG & SKIN	CKIN CD	123.1	.6489	7705	6561
PRESSURE, IN & DE	OLUM CL	.5594	105 00	. / / 9 J	105 00
PRESSURE, IN & DE	SIGN PSIA	50.00	165.00	50.00	165.00
		- 15	10.00	0.1	10.00
PRESSURE DROP, TO	T & ALLOWED PS	.15	10.00	.01	10.00
VELOCITY, CALC &	MAX ALLOWED F"I	'/S .88	10.00	.11	10.00
FOULING RESISTANC	E HR-FT2-F/	BTU .(	00010		
FILM COEFFICIENT					97.86
TOTAL HEAT DUTY R					.026689
EFF TEMP DIF, DEG			ASS= .94,BA	FF=1.00)	
OVERALL COEFF REQ					133.51
CLEAN & FOULED CO	EFF BTU/HR-	FT2-F	137.8	4	133.58
SHELLS IN SERIES	1 PARALLEL 1	TOTAL EF	F AREA	FT2	7.1
PASSES, SHELL	1 TUBE 4	EFFECTIVE	E AREA	FT2/SHELL	7.1
SHELL DIAMETER IN	. 3.820	TEMA SHE	LL TYPE E	; REAR HI	EAD FXTS
BAFFLE TYPE	HORZ SEGMENTL	CROSS PAS	SSES PER SH	ELL PASS	4
SPACING, CENTRAL	IN. 4.309	BAFFLE CU	UT, PCT SHE	LL I.D.	30.00
SPACING, INLET	TN 4 309	CUT DISTA	ANCE FROM C	ENTER. IN	764
SPACING, OUTLET		001 21011	11.02 11.011 0		• / 0 1
BAFFLE THICKNESS		TMDTNCFMI	ENT BAFFLE	TNCTIDED	NO
PAIRS OF SEALING			I BLANK ARE.		.0
PAIRS OF SEALING	DEVICES I	IUDESREE.	I DLANK AKE	A, 0	. 0
MIDE MADE	DIATN	машертат			CODDED
TUBE TYPE	PLAIN		E	LECTROLITI	
NO. OF TUBES/SHEL			TUBE COUNT	T.1.	36
TUBE LGTH, OVERAL				IN.	.3125
	FT 1.436		SIDE DIAM	IN.	.250
TUBE LAYOUT	DEG 60	TUBE INS	IDE DIAM	IN.	.214

PTTCH RATTO 1 250 T	UBE SURFACE RATIO, OUT/IN 1.184
	TUBE NOZZ ID, IN&OUT IN8 .8
5111 NO22 1D, INGOOT 1.0 1.0 1	ODE NOZZ ID, INWOOT IN
* CALCULATED ITEMHEAT BALANCE C	'ODF = 8
	c exchanger experiment E0002 P141
Young model F302DY4P	9/23/3
roung moder F302D14P	
	CASE 70
S U P P L E M E N T A R	YRESULTS
HT PARAMETERS SHELL TUBE	SHELLSIDE PERFORMANCE
	NOMINAL VEL, X-FLOW FT/S .09
PRANDTL NUMBER 5.2 3.5	NOMINAL VEL, X-FLOW F1/S .09  NOMINAL VEL, WINDOW FT/S .18
PRANDIL NUMBER 5.2 5.5	CROSSFLOW COEF BTU/HR-FT2-F 299.1
	WINDOW COEF BTU/HR-FT2-F 299.1 WINDOW COEF BTU/HR-FT2-F 300.9
	WINDOW COEF BTU/HR-FTZ-F 300.9
RYNLD NO, OUT BUN 414. 2279.	
FOULNG LAYER IN0014 .0014	SHELLSIDE FLOW, % OF TOTAL
	HEAT TRANSFER X-FLOW 81.47
THERMAL RESISTANCE, % OF TOTAL	TUBE TO BAFFLE LEAKAGE A = 3.84
SHELL TUBE FOULING METAL	MAIN CROSSFLOW $B = 64.85$
44.35 52.66 2.90 .10	BUNDLE TO SHELL BYPASS C = 15.85
PCT OVER DESIGN .05	BAFFLE TO SHELL LEAKAGE E = 15.47
TOT FOUL RESIST .000217	TUBE PASSLANE BYPASS F = .00
DIFF RESIST .000004	
	SHELLSIDE HEAT TRANSFER FACTORS
DIAMETRAL CLEARANCES	
	BETA (BAFF CUT FACTOR) = .920
TUBE TO BAFFLE HOLE IN0284	GAMMA (TUBE ROW ENTRY EFCT) = .780
BAFFLE TO SHELL IN1000	END (HT LOSS IN END ZONE) = .994
	SHELL PRESSURE DROP, % OF TOTAL
HT UNDR NOZ IN25	WINDOW = 8.8
HT OPP NOZ IN25	END ZONE = 3.5
VELOCITY FT/S .57 .58	CROSS FLOW $=$ 3.2
DENSITY LB/FT3 62.252 61.780	INLET NOZZLE = 43.0
NOZZ RHO*VSQ LB/FT-S2 20 20	WINDOW = 8.8 END ZONE = 3.5 CROSS FLOW = 3.2 INLET NOZZLE = 43.0 OUTLET NOZZLE = 41.5
BUND RHO*VSQ LB/FT-S2 13 14	
TUBE NOZZLE DATA IN OUT	WEIGHT PER SHELL, LB
VELOCITY FT/S 1.33 1.32	DRY = $150.$
DENSITY LB/FT3 61.291 61.750	WET = 165.
PRESS. DROP % 8.9 5.6	
*** SPECIAL MESSAGES AND WARNINGS *	**
MADNING HUDEGIDE ELLID HAG PAGGED	MUDOUGU MDANGIMION ZONE CONGIDED
WARNINGTUBESIDE FLUID HAS PASSED	INKOUGH IKANSIIION ZONE. CONSIDEK

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

HEAT TRANSFER COEFF. AT RE = 2000 IS 219.40 BTU/HR-FT2-F HEAT TRANSFER COEFF. AT RE = 10000 IS 1247.99 BTU/HR-FT2-F

Washington University ChE433 heat exchanger experiment E0002 P142 Young model F302DY4P 9/23/3

CASE 71

		che433b(	70).OUT		
SIZE 4- 18 TYPE BE	EM, MULTI-PASS F	LOW, SEGME	NTAL BAFFL	ES, RATING	
		HOT TU	BE SIDE	COLD SI	HELL SIDE
		Tube		Shell	1
		SENSI	BLE LIO	SENS	IBLE LIO
TOTAL FLOW RATE	KLB/HR		.900		.800
	,	IN	OUT	IN	OUT
TEMPERATURE	DEGE	140 0	108.3*	70 0	105 5*
DENSITY	LB/FT3	61 2913	61 7778	62 2515	61 8164
VISCOSITY	CP		.6346		
SPECIFIC HEAT		9973	.9981	1 0015	0023
THERMAL COND.	BTI / HD - FT - F	3723	3653	355/	3646
MOLAR MASS		.5725	19 02	.5554	18.02
MOLAK MASS	TP/ TPMOT		18.02		10.02
TEMP, AVG & SKIN	DEGE				
VISCOSITY AND S	SKIN CD	5//2	6627	7910	6705
VISCOSITY, AVG & S PRESSURE, IN & DES	ONIN CE	.5442	165 00	50 00	165 00
FRESSORE, IN & DE.	DIGN FSIA	30.00	103.00	30.00	103.00
PRESSURE DROP, TO	r & Allowed Pst	15	10 00	0.1	10 00
VELOCITY, CALC & N	MAX ALLOWED FT/	's 88	10.00	12	10.00
VIIIOCITI, CAIC & I	MX ADDOWED 11/	5 .00	10.00	• 12	10.00
FOULING RESISTANCE	HR-FT2-F/B	. O	0.010	_ (	00010
FILM COEFFICIENT				3:	28.41
					2011
TOTAL HEAT DUTY RE	COUTRED MEGRTU/H	IR			.028427
EFF TEMP DIF, DEGI			SS= 94 RA		
OVERALL COEFF REQU			.51,611	11 1.00)	138.74
CLEAN & FOULED CON			1/12 /	1	138.73
CLEAN & FOOLED COI	SFF BIO/HK-F	12-1	143.4	Τ.	130.73
SHELLS IN SERIES	1 PARALLET, 1	TOTAL EFF	' AREA	FT2	7.1
PASSES, SHELL					
SHELL DIAMETER IN	3.820	TEMA SHEL	L TYPE E	: REAR HI	EAD FXTS
				,	
BAFFLE TYPE	HORZ SEGMENTL	CROSS PAS	SES PER SH	ELL PASS	4
SPACING, CENTRAL					
SPACING, INLET	TN. 4.309	CUT DISTA	NCE FROM C	ENTER, IN.	. 764
SPACING, OUTLET	TN 4 309	001 21011	11.011 0.		• / 0 -
BAFFLE THICKNESS		TMPTNGEME	NT BAFFLE	TNCLUDED	NO
PAIRS OF SEALING I			' BLANK ARE.		.0
TAIRS OF SEALING I	DEVICED I	1000011001	DIANIC AICE.	, o	• 0
TUBE TYPE	PLAIN	MATERTAL	E	LECTROLYTI	C COPPER
NO. OF TUBES/SHELD			UBE COUNT		36
TUBE LGTH, OVERALI				IN.	.3125
TUBE LGTH, EFF		TUBE OUTS		IN.	.250
TUBE LAYOUT			DE DIAM		.214
PITCH RATIO					
			ACE RATIO, ID, IN&OU		
SHL NOZZ ID, IN&OU	)T T.O T.O	TODE NOZZ	TIN TIN & OU	T TIM.	.0 .0
* CALCULATED ITE	гмцглт ратамст	CODE - °			
Washington Unive			er evnorim	ent	E0002 P143
_	_	at exchang	ler exberiu	CIIC	
Young model F302D	145				9/23/ 3
	M D N D 3	D V 5		. m ^	CASE 71
SUPPLE	M E N T A	R Y R	E S U	L T S	

			che433b(70).OUT			
HT PARAMETERS	SHELL	TUBE	SHELLSIDE PERFC	RMANCE		
WALL CORRECTION	1.023	.968	NOMINAL VEL, X-FLC	W FT/S		.10
PRANDTL NUMBER	5.3	3.6	NOMINAL VEL, WINDO	W FT/S		.20
RYNLD NO, AVG	381.	2606.	CROSSFLOW COEF	BTU/HR-FT	Γ2-F	329.8
RYNLD NO, IN BUN	308.	3001.	WINDOW COEF	BTU/HR-FT	Γ2-F	331.7
RYNLD NO, OUT BUN	461.	2235.				
FOULNG LAYER IN.	.0014	.0014	SHELLSIDE FLOW,	% OF TOT	ΓAL	
			HEAT TRANSFER X-F	'LOW		81.47
THERMAL RESISTANCE,	% OF TO	OTAL	TUBE TO BAFFLE LE	AKAGE	A =	3.99
			MAIN CROSSFLOW			
41.77 55.12 3.	.01 .	.10	BUNDLE TO SHELL B	YPASS	C =	16.08
PCT OVER DESIGN		.00	BAFFLE TO SHELL I	EAKAGE	E =	15.35
TOT FOUL RESIST	. (	000217	BAFFLE TO SHELL I TUBE PASSLANE BYF	ASS	F =	.00
DIFF RESIST	. (	00000				
				TRANSFER	FACT	ORS
DIAMETRAL CLEARAN	ICES		TOTAL = (BETA) (GAM			
BUNDLE TO SHELL	IN.	.5000	BETA (BAFF CUT F	'ACTOR)	=	.920
TUBE TO BAFFLE HOLE	E IN.	.0284	GAMMA (TUBE ROW E	NTRY EFCI	Γ) =	.808
BAFFLE TO SHELL	IN.	.1000	END (HT LOSS IN	END ZONE	Ξ) =	.994
SHELL NOZZLE DATA	A IN	OUT	SHELL PRESSURE	DROP, % C	OF TO	TAL
HT UNDR NOZ IN.	.25		WINDOW		=	8.8
HT OPP NOZ IN.	.25		END ZONE		=	3.3
HT UNDR NOZ IN. HT OPP NOZ IN. VELOCITY FT/S DENSITY LB/FT3 NOZZ RHO*VSQ LB/FT-	.65	.66	CROSS FLOW		=	3.0
DENSITY LB/FT3	62.252	61.816	INLET NOZZLE		=	43.1
NOZZ RHO*VSQ LB/FT-	-S2 26	26	OUTLET NOZZLE		=	41.7
BUND RHO*VSQ LB/FT-	-S2 18	18				
TUBE NOZZLE DATA	IN	OUT	WEIGHT PER SHEI	L, LB		
VELOCITY FT/S	1.33	1.32	DRY	=	=	150.
DENSITY LB/FT3	61.291	61.778	WET	=	=	165.
PRESS. DROP %						

## \*\*\* 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 219.97 BTU/HR-FT2-F HEAT TRANSFER COEFF. AT RE = 10000 IS 1249.78 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 TU	BE SIDE	COLD SH	ELL SIDE	
		Tube		Shell		
		SENSI	BLE LIQ	SENSI	BLE LIQ	
TOTAL FLOW RATE	KLB/HR	.900		.900		
		IN	OUT	IN	OUT	
TEMPERATURE	DEGF	140.0	106.4*	70.0	103.5*	
DENSITY	LB/FT3	61.2913	61.8043	62.2515	61.8445	
VISCOSITY	CP	.4726	.6470	.9783	.6668	

SPECIFIC HEAT BTU/I THERMAL COND. BTU/E MOLAR MASS LB/LE	B-F R-FT-F	.9973	.3648 18.02	.3554	.3641 18.02
TEMP, AVG & SKIN DESIGN FRESSURE, IN & DESIGN F	P	123.2 .5491	102.3 .6754	.8003	101.1 .6837
PRESSURE DROP, TOT & ALI VELOCITY, CALC & MAX ALI					
FOULING RESISTANCE E	TU/HR-FT2-F	29	5.51		
TOTAL HEAT DUTY REQUIRED EFF TEMP DIF, DEGF (LMT OVERALL COEFF REQUIRED CLEAN & FOULED COEFF	D= 36.5,F= BTU/HR-FT2	.84,BYPA	SS= .96,BA		143.71
SHELLS IN SERIES 1 PARA PASSES, SHELL 1 TUBE SHELL DIAMETER IN.	4 E	EFFECTIVE	AREA	FT2/SHELL	7.1
BAFFLE TYPE HORZ S SPACING, CENTRAL IN. SPACING, INLET IN. SPACING, OUTLET IN. BAFFLE THICKNESS IN. PAIRS OF SEALING DEVICES	4.309 B 4.309 C 4.309 .125 I	AFFLE CU' CUT DISTA	I, PCT SHE NCE FROM ( NT BAFFLE	HELL PASS ELL I.D. EENTER, IN. INCLUDED EA, %	30.00 .764 NO
	PLAIN M 76 E 1.500 T 1.436 T 60 T 1.250 T	ATERIAL ST MAX TO UBE PITCO UBE OUTS UBE INSI	E UBE COUNT H IDE DIAM DE DIAM ACE RATIO,	IN. IN. IN. IN. OUT/IN	C COPPER 36 .3125 .250 .214 1.184
* CALCULATED ITEMHEA Washington University Young model F302DY4P	ChE433 heat	exchang	-		E0002 P14: 9/23/ 3 CASE 72
HT PARAMETERS SHELL WALL CORRECTION 1.022 PRANDTL NUMBER 5.4 RYNLD NO, AVG 423. RYNLD NO, IN BUN 346.	TUBE .966 3.6 2583. 3001.	SHELL NOMINAL NOMINAL CROSSFL	SIDE PERFO VEL,X-FLO VEL,WINDO		.23 -F 361.3
RYNLD NO, OUT BUN 508. FOULNG LAYER IN0014 THERMAL RESISTANCE, % OF	.0014	HEAT TR	ANSFER X-E	% OF TOTAI CLOW CAKAGE A	81.46

SHELL TUBE FOULING ME	ETAL	MAIN CROSSFLOW E	3 =	64.51
39.39 57.41 3.11	.10	BUNDLE TO SHELL BYPASS C	: =	16.11
PCT OVER DESIGN	30	BAFFLE TO SHELL LEAKAGE	: =	15.25
TOT FOUL RESIST .	000217	TUBE PASSLANE BYPASS F	' =	.00
DIFF RESIST	000021			
		SHELLSIDE HEAT TRANSFER F		
DIAMETRAL CLEARANCES		TOTAL = (BETA) (GAMMA) (FIN)	=	.770
BUNDLE TO SHELL IN.	.5000	BETA (BAFF CUT FACTOR)	=	.920
TUBE TO BAFFLE HOLE IN.	.0284	GAMMA (TUBE ROW ENTRY EFCT)	=	.837
BAFFLE TO SHELL IN.	.1000	END (HT LOSS IN END ZONE)	=	.994
SHELL NOZZLE DATA IN	TUO	SHELL PRESSURE DROP, % OF	TO	TAL
HT UNDR NOZ IN25			=	8.8
HT OPP NOZ IN25	5	END ZONE CROSS FLOW	=	3.2
VELOCITY FT/S .74	.74	CROSS FLOW	=	2.9
DENSITY LB/FT3 62.252	2 61.844	INLET NOZZLE	=	43.1
NOZZ RHO*VSQ LB/FT-S2 33	33	OUTLET NOZZLE	=	41.9
BUND RHO*VSQ LB/FT-S2 22	2 23			
TUBE NOZZLE DATA IN	TUO	WEIGHT PER SHELL, LB		
VELOCITY FT/S 1.33	3 1.32			
DENSITY LB/FT3 61.291	61.804	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 220.36 BTU/HR-FT2-F HEAT TRANSFER COEFF. AT RE = 10000 IS 1251.91 BTU/HR-FT2-F