



**ITEM CE 607**

VENDORS FRONT SHEET  
FOR A4 DOCUMENTS

PURCHASE ORDER NO.: -  
PO FF 22 26 1006  
PROCUREMENT PACKAGE NO.: -  
MA 006

PAGE 1 OF 10

VENDOR INFORMATION

COMPANY NAME: DE LAUNAY & FILS

ADDRESS: 6 RUE VALMY BP 429

76057 LE HAVRE FRANCE

TELEX/FAX: 35254327

TELEPHONE: 35253136

VENDOR DATA CONTROL CONTACT:

EXT:

VENDOR DOCUMENT NUMBER: 93260 TDS 2 -

DOCUMENT TITLE: EQUIP DATA SHEETS - CE 607  
- EQUITHERM -  
(3 feuilles)  
+ (6 feuilles)

PROJECT DOCUMENT N° DS-FF-22-26-8482

FRØY INTEGRATION WORK ON TCP2

EQUIPMENT DESCRIPTION:

- FRØY OIL INLET HEATER -

PKGE TAG NO: MA006 LOCATION: M35.

VDRL CODES: C07

ITEM TAG Nos: CE 607

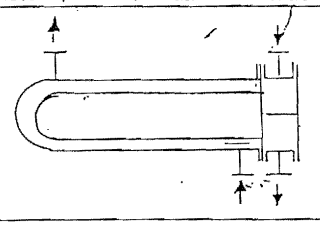
P O NUMBER	SEQUENCE No.	REV.	VDRL CAT.
PO.FF.22.26.1006		02	C



VERITEC

HEAT EXCHANGER SPECIFICATION SHEET

1					Job No.
2	Customer	FLF PETROLEUM NORGE A/S			Reference No. 506 038
3	Address	PROJECT: FROY INTEGRATION ON TCP2			Proposal No.
4	Plant Location	TCP2 - MODULE 35			Date ZG-02.93 Rev. 2
5	Service of Unit	FROY OIL INLET HEATER			Item No. CE 607
6	Size	740 x 4600	Type	AEU (Hor/Vert)	Connected In - Parallel - Series
7	Surf/Unit	122. m <sup>2</sup>	Shells/Unit	1	Surf/Shell 122. m <sup>2</sup> (0)
8	PERFORMANCE OF ONE UNIT DESIGN CASE YEAR 1997				
9	Fluid Allocation		Shell Side		Tube Side
10	Fluid Name		PARTIALLY STABILIZED CRUDE OIL		30% TEG
11	Fluid Quantity, Total		309248.8 (3)		78387
12	Vapor (In/Out)		6202.6 / 9015.6		
13	Liquid		253061 / 250248		78387 / 78387
14	Steam		49 / 176		
15	Water		49858 / 49731		
16	Noncondensable		78 / 78		
17	Temperature (In/Out)		41.4 / 65.8		180 / 120
18	Specific Gravity L/V		830.6 / 14.822 / 815. / 15.0138		906.4 / 962.7
19	Viscosity, Liquid		3.622 / 0.0119 / 2.638 / 0.0124		0.2569 / 0.5654
20	Molecular Weight, Vapor		23.55 / 26.54		
21	Molecular Weight, Noncondensable				
22	Specific Heat L/V		2.3924 / 2.0561 / 2.4788 / 2.079		4.2113 / 3.8934
23	Thermal Conductivity L/V		0.1522 / 0.0314 / 0.1474 / 0.0325		0.5131 / 0.5095
24	Latent Heat				
25	Inlet Pressure		15.5		17
26	Velocity				2.20
27	Pressure Drop, Allow./Calc.		0.5 / 0.46		2.0 / 1.41
28	Fouling Resistance (Min.)		0.000528		0.000352
29	Heat Exchanged		5413 kW		92.4 °C
30	Transfer Rate, Service		479 w/m <sup>2</sup> °C		882 w/m <sup>2</sup> °C
31	CONSTRUCTION OF ONE SHELL				
32			Shell Side		Tube Side
33	Design/Test Pressure		18.5 / 27.75		28 / 48
34	Design Temperature		-20 / 205		-20 / 205
35	No. Passes per Shell		1		8
36	Corrosion Allowance		3		0
37	Connections		In - 12" 300# RF		6" 300# RF
38	Size & Rating		Out - 12" 300# RF		6" 300# RF
39	Rating		Intermediate		
40	Tube No.		216 U <sup>o</sup> OD 19.05 mm Thk		1.65 mm; Length 4600 mm Pitch 25.4 mm
41	Tube Type		SEAMLESS		Material
42	Shell C.S.		ID 740 mm OD		Shell Cover CS (Integ.) (Remov.)
43	Channel or Bonnet		316L		Channel Cover 316L
44	Tubesheet-Stationary		316L		Tubesheet-Floating
45	Floating Head Cover		-		Impingement Protection 316L
46	Baffles-Cross		316L Type DOUBLE SEGM. VERT. % Cut (Diam/Shell) 26.6		Spacing: c/c 370 Inlet 700
47	Baffles-Long				Seal Type
48	Supports-Tube		316L U-Bend (2)		Type
49	Bypass Seal Arrangement		2 PAIRS MINI.		Tube-Tubesheet Joint WELDED
50	Expansion Joint				Type
51	Inlet Nozzle		4334 kg/m <sup>2</sup> Bundle Entrance		Bundle Exit
52	Gaskets-Shell Side				Tube Side
53	-Floating Head				
54	Code Requirements		BS 5500 CAT. 1		TEMA Class R
55	Weight/Shell		6250 Filled with Water		7585 Bundle 2700 (Vgs)
56	Remarks (1) U BENDS ARE INCLUDED IN HEAT TRANSFER SURFACE. 10% OVERSURFACE REQUIRED				
57	(2) BENDS ARE IN HORIZONTAL PLANE. PROVIDE STIFFENERS ON OUTER U BENDS.				
58	(3) MAXI. CO <sub>2</sub> CONTENT IS 1.5% MOLE.				
59	Mod. N <sub>2</sub> TUBES		3-05-93		JCP
60	Mod. MATERIALS		20-04-93		JCP
61	ISSUED AS A		10-03-93		JCP
62	REV. 3 OF CLIENT SPEC.		18-02-93		JCP
REV	DESCRIPTION		DATE		BY
6	MOD. LIQUES 12,36, 40.		17-5-93		JCP
<b>EQUITHERM</b>					
CE 607 (DESIGN CASE YEAR 1997)					
N° SPEC. P92061-CE607					



225/6/93

# HEAT EXCHANGER SPECIFICATION SHEET

1 Customer <b>ELF PETROLEUM NORGE AS</b>	Job No.
2 Address <b>PROTECT FROY INTEGRATION ON TCP2</b>	Reference No. <b>SAE 038</b>
3 Plant Location <b>TCP2 - MODULE 35</b>	Proposal No.
4 Service of Unit <b>FROY OIL INLET HEATER</b>	Date <b>26.02.93</b> Rev. <b>2</b>
5 Size <b>740 x 4600</b> Type <b>AEU (Hor/Vert)</b>	Item No. <b>CE 607</b>
6 Surf/Unit <b>122 m<sup>2</sup></b> Shells/Unit	Connected In - Parallel - Series
7 Surf/Shell <b>122 m<sup>2</sup></b>	

## PERFORMANCE OF ONE UNIT DESIGN CASE YEAR 2000

9 Fluid Allocation	Shell Side	Tube Side
10 Fluid Name	<b>PARTIALLY STABILIZED CRAUDE OIL</b>	<b>30% TEG</b>
11 Fluid Quantity, Total	<b>321 968,4</b>	<b>43 172,1</b>
12 Vapor (In/Out)	<b>-</b>	<b>23,3</b>
13 Liquid HC	<b>122 376,1</b>	<b>122 352,4</b>
14 Steam	<b>-</b>	<b>5,1</b>
15 Water	<b>199 592,3</b>	<b>199 587,6</b>
16 Noncondensable		
17 Temperature (In/Out)	<b>49,6</b>	<b>59</b>
18 Specific Gravity L/V	<b>912 / -</b>	<b>904,6 / 13,2372</b>
19 Viscosity, Liquid /V	<b>18,51 / -</b>	<b>15,79 / 0,0125</b>
20 Molecular Weight, Vapor	<b>-</b>	<b>23,23</b>
21 Molecular Weight, Noncondensable		
22 Specific Heat L/V	<b>3,4503 / -</b>	<b>3,4698 / 2,1162</b>
23 Thermal Conductivity L/V	<b>0,3371 / -</b>	<b>0,3282 / 0,0341</b>
24 Latent Heat		
25 Inlet Pressure	<b>BARA</b>	<b>15,5</b>
26 Velocity		<b>1,21</b>
27 Pressure Drop, Allow./Calc.	<b>0,5</b>	<b>1</b> <del>0,195</del> <b>2,0</b> <b>0,48</b>
28 Fouling Resistance (Min.)	<b>0,000 528</b>	<b>0,000 352</b>
29 Heat Exchanged	<b>2 982 Kw</b>	<b>92,2 °C</b>
30 Transfer Rate, Service	<b>256 w/m<sup>2</sup>°C</b> Clean	<b>339 w/m<sup>2</sup>°C</b>

SEE FOLIO 1

## CONSTRUCTION OF ONE SHELL

32 Design/Test Pressure	Shell Side	Tube Side	Sketch (Bundle/Nozzle Orientation)
33 Design Temperature	<b>/</b>	<b>/</b>	SEE FOLIO 1
34 No. Passes per Shell			
35 Corrosion Allowance			
36 Connections			
37 Size & Rating			
38 Tube No.	<b>OD</b>	<b>Thk (Min/Avg)</b>	<b>Length</b>
39 Tube Type			<b>Pitch</b>
40 Shell	<b>ID</b>	<b>OD</b>	<b>Material</b>
41 Channel or Bonnet			<b>Shell Cover</b>
42 Tubesheet-Stationary			<b>Channel Cover</b>
43 Floating Head Cover			<b>Tubesheet-Floating</b>
44 Baffles-Cross	<b>Type</b>		<b>Impingement Protection</b>
45 Baffles-Long			<b>% Cut (Diam/Area)</b>
46 Supports-Tube		<b>U-Bend</b>	<b>Spacing: c/c</b>
47 Bypass Seal Arrangement			<b>Inlet</b>
48 Expansion Joint			<b>Seal Type</b>
49 Inlet Nozzle	<b>2112 kg/m<sup>2</sup></b>	<b>Bundle Entrance</b>	<b>Type</b>
50 Gaskets-Shell Side		<b>Tube Side</b>	<b>Tube-Tubesheet Joint</b>
51 -Floating Head			<b>Type</b>
52 Code Requirements			<b>Bundle Exit</b>
53 Weight/Shell		<b>Filled with Water</b>	<b>TEMA Class</b>
54 Remarks	<b>CALCULATED OVERDESIGN 8,8 %</b>		<b>Bundle</b>

SEE FOLIO 1

58	6 MOD. LIGNE 29	27-05-93	JCP	[Signature]	[Signature]	[Signature]
59	5 MOD. NB. TUBES	03-05-93	JCP	[Signature]	[Signature]	[Signature]
60	4 Rev. Folio 1	20-04-93	JCP	[Signature]	[Signature]	[Signature]
61	3 REV. FOLIO 1	10-03-93	JCP	[Signature]	[Signature]	[Signature]
	2 REV. 3 OF CLIENT SPEC.	26-02-93	JCP	[Signature]	[Signature]	[Signature]
	REV DESCRIPTION	DATE	BY	CHK	APP.	

# EQUITHERM

CE.607  
(DESIGN CASE YEAR 2000)

P92061  
N° SPEC. P92061-CE607

3

FOLIO

2/5

25/6/93

# HEAT EXCHANGER SPECIFICATION SHEET

Customer <b>ELF PETROLEUM NORGE A/S</b>	Job No.
Address	Reference No. <b>50E038</b>
Plant Location <b>TCP2: M35 FROY TIE IN</b>	Proposal No.
Service of Unit <b>FWY OIL INLET HEATER</b>	Date <b>26.02.93</b> Rev. 2
Size <b>740 x 4600</b> Type <b>AEU</b> (Hor/Vert)	Item No. <b>CE-607</b>
Surf/Unit <b>122 m<sup>2</sup></b> Shells/Unit <b>1</b> Surf/Shell <b>122 m<sup>2</sup></b>	Connected In - Parallel - Series

PERFORMANCE OF ONE UNIT CASE START UP YEAR 2000				
Fluid Allocation	Shell Side		Tube Side	
Fluid Name	STABILIZED CRUDE OIL		30% TEG	
Fluid Quantlty, Total <b>kg/h</b>	96041 (1)		82914	
Vapor (In/Out)	-	82,8		
Liquid	36207	36124.2	82914	82914
Steam	-	11,2		
Water	59834	59822,8		
Noncondensable				
Temperature (In/Out) <b>°C</b>	5,14	66,1	180	120
Specific Gravity L/V <b>kg/m<sup>3</sup></b>	946,4 /	899,2 /		
Viscosity, Liquid L/V <b>cp</b>	47,062 /	14,068 /	↑	
Molecular Weight, Vapor	23,2059	24,1401		
Molecular Weight, Noncondensable				(SEE FOLIO 1/1)
Specific Heat L/V <b>KJ/kg°C</b>	3,3803 /	3,486 /		
Thermal Conductivity L/V <b>W/m°C</b>	0,3263 /	0,3388 /		
Latent Heat			↓	
Inlet Pressure <b>BAR A.</b>	15,5		17	
Velocity <b>m/s</b>	0,16		2,35	
Pressure Drop, Allow./Calc. <b>BAR</b>	0,5	0,03	2	1,56
Fouling Resistance (Min.) <b>m<sup>2</sup>°C/W</b>	0,000528		0,000352	
Heat Exchanged <b>5600 KW</b>	: MTD (Corrected)		107,7 °C	
Transfer Rate, Service <b>425</b>	Clean	715	<b>W/m<sup>2</sup>°C</b>	

CONSTRUCTION OF ONE SHELL				Sketch (Bundle/Nozzle Orientation)
		Shell Side	Tube Side	
Design/Test Pressure		/	/	
Design Temperature				
No. Passes per Shell				
Corrosion Allowance				
Connections	In			
Size & Rating	Out			
	Intermediate			
Tube No.	OD	Thk (Min/Avg)	Length	
Tube Type			Pitch	
Shell	ID	OD	Material	
Channel or Bonnet			Sheet Cover (Integ.) (Remov.)	
Tubesheet-Stationary			Channel Cover	
Floating Head Cover			Tubesheet-Floating	
Baffles-Cross	Type		Impingement Protection	
Baffles-Long			% Cut (Diam/Area) Spacing: c/c Inlet	
Supports-Tube		U-Bend	Seal Type	
Bypass Seal Arrangement			Type	
Expansion Joint			Tube-Tubesheet Joint	
μv-Inlet Nozzle		Bundle Entrance	Type	
Gaskets-Shell Side			Bundle Exit	
-Floating Head				
Code Requirements			TEMA Class	
Weight/Shell		Filled with Water	Bundle	

Remarks (1) FLOW RATES DETERMINED BY PERFORMANCES OF EXCHANGER, THE TEMPERATURES BEING IMPOSED.				
6	MOD. FOLIOS 1 & 2	27.05.93	JCP	[Signature]
5	MOD. NB TUBES	03.05.93	JIP	[Signature]
4	RW. FOLIO 1	26.04.93	JCP	[Signature]
3	REV. FOLIO 1	10.03.93	JCP	[Signature]
2	REV. 3 OF CLIENT SPEC.	26.02.93	JCP	[Signature]
REV	DESCRIPTION	DATE	BY	CHK APP.
<b>EQUITHERM</b>				CE 607 (START-UP YEAR 2000)
				P 92061
				N° SPEC. P92061-CE607
				FOLIO 3/3

A 25/6/93

PROBLEM DESCRIPTION-P92061 ELF NORGE TCP2 YEAR 1997 -

CASE-CE607.3

\*\*\*FLOW INDUCED VIBRATION ANALYSIS (LEVEL 1.00)\*\*\* 2-PHASE MIX. SHELLSIDE

01	LOG DECREMENT 0.1000 AXIAL STRESS LOADING	0.0 (MPA)		
02	BETA 2.711 ADDED MASS FACTOR 2.4733	-----POSITION IN BUNDLE-----		
		INLET	CENTER	U-BEND
03	LENGTH FOR NATURAL FREQUENCY (M)	1.060	0.740	2.052
04	LENGTH/TEMA MAXIMUM SPAN (--)	0.694	0.485	1.092*
05	NUMBER OF SPANS (--)	6	7	1
06	TUBE NATURAL FREQUENCY (HZ)	56.69+	71.15	6.55
07	SHELL ACOUSTIC FREQUENCY (HZ)	---	---	---
	- FLOW VELOCITIES - - - - -			
08	WINDOW PARALLEL VELOCITY (M/S)	1.72	1.92	2.13
09	BUNDLE CROSSFLOW VELOCITY (M/S)	0.97	2.02	1.60
10	BUNDLE/SHELL VELOCITY (M/S)	0.40	0.83	0.66
	- FLUIDELASTIC INSTABILITY CHECK - -			
11	BAFFLE TIP CROSS VELOCITY (M/S)	0.81	1.68	1.33
12	AVERAGE CROSSFLOW VELOCITY (M/S)	0.97	2.02	1.60
13	CRITICAL VELOCITY (M/S)	2.68	2.80	2.91
	- ACOUSTIC VIBRATION CHECK - - - - -			
14	VORTEX SHEDDING RATIO (--)	---	---	---
15	TURBULENT BUFFETING RATIO (--)	---	---	---
	- TUBE VIBRATION CHECK - - - - -			
16	VORTEX SHEDDING RATIO (--)	0.318	0.663*	0.526*
17	TURBULENT BUFFETING RATIO (--)	---	---	---
18	PARALLEL FLOW AMPLITUDE (MM)	0.004	0.006	0.116
19	CROSSFLOW AMPLITUDE (MM)	0.100	0.149	3.873*
20	TUBE GAP (MM)	6.300	6.300	6.300
21	CROSSFLOW RHO-V-SQ (KG/M-S2)	361.	1405.	799.
	- DAMAGE NUMBER CHECK - - - - -			
22	BAFFLE DAMAGE NUMBER (--)	0.0477	0.0905	0.3957*
23	COLLISION DAMAGE NUMBER (--)	0.0352	0.0325	1.0930*
24	CRITICAL DAMAGE NUMBER LIMIT (--)	0.2871	0.2831	0.2799
25	RHO/SQRT(MU) (LB**5FT**-2.5HR**5)	8.2455	8.0135	7.8331
	BUNDLE PARAMETERS AT NOZZLES	ENTRANCE	EXIT	
26	IMPINGEMENT PLATE	YES	--	
27	FLOW AREA (AESC) (M2)	0.0720	0.0883	
28	VELOCITY (VESC) (M/S)	3.09	3.12	
29	RHO-V-SQ (RV2E) (KG/M-S2)	3683.	3032.	
30	TEMA E SHELL WITH	VERT DBL. SEG. RAFFLES AND	U-T BUNDLE	
31				
32	PLAIN 316 S. STL TUBES 19.1000 DIAMETER (MM)		90 DEGREE LAYOUT	
33	PITCH RATIO 1.330			

+ FREQUENCY RATIOS ARE BASED UPON LOWEST NATURAL OR ACOUSTIC FREQUENCY OMITTING THE U-BEND. CALCULATIONS ASSUME NO INTERMEDIATE SUPPORTS

NOTE -- U-BEND EXCEEDS THE TE MA MAXIMUM SPAN. CONSIDER ADDING STIFFNESS TO THE U-BEND REGION.

5

10/3/93  
 10/3/93  
 JCP 10/3/93

R 4/5/93

1/8

FINAL RESULTS\* PROBLEM DESCRIPTION-P92061 ELF NORGE TCP2 YEAR 1997 -  
 RATING CASE MULTIPASS FLOW IN A T.E.M.A. AEU SHELL WITH DOUBLE-SEG. BAFFLES

CASE-CE607.3  
 ALT. SOLN.-\*\*

**** PROCESS DATA ****			COLD SHELLSIDE	HOT TUBESIDE	**** SHELLSIDE PERFORMANCE ****	
01 FLUID NAME			CRUDE	TEG30%	01 NOM. VEL, X-FLOW/WINDOW	0.73/ 0.81
02 FLUID CONDITION			2-PHASE MIX.	SENS. LIQUID	02 FILM COEF, X-FLOW/WINDOW	2542.7/ 2033.9
03 TOTAL FLOW RATE	(KG/S)	85.903		21.774	03 FLOW FRACTIONS FOR HEAT TRANSFER=	0.765
					04 A=0.004 B=0.638 C=0.031 E=0.038 F=0.290	
04 TEMPERATURE, IN/OUT	(DEG C)	41.4 / 65.8	180.0 / 120.0		**** SHELLSIDE HEAT TRANSFER CORRECTIONS ****	
05 TEMPERATURE, AVERAGE/SKIN	(DEG C)	53.6/ 89.4	150.0/ 143.8		05 TOTAL BETA GAMMA END FIN	
06 PRESSURE, INLET/AVERAGE	(KPA)	1550.0/ 1525.0	0.0/ 0.0		06 0.952 0.895 1.064 0.954 1.000	
07 PRESSURE DROP, TOTAL/ALLOW	(KPA)	45.92/ 50.00	140.67/ 130.00		**** PRESSURE DROPS **** (PERCENT TOTAL DP)	
08 VELOCITY, CALC./MAX.ALLOW	(M/S)	0.85/ 0.00	2.20/ 0.00		07 WIND 47.62 NOZZLE SHELL 10.07/ 9.28	
09 FILM COEF (SAF.FACT)	(W/M2-C)	1441.77 (0.75)	10089.28 (1.00)		08 END 11.41 (IN/OUT) TUBE 0.62/ 0.37	
10 FOULING RESISTANCE	(M2-C/W)	0.00053	0.00035		**** H.T. PARAMETERS **** SHELL TUBE	
11 DENSITY	(KG/M3)	822.8380	934.4736		09 WALL CORRECTION	1.058 0.986
12 THERMAL CONDUCTIVITY	(W/M-C)	0.1495	0.5113		10 PRANDTL NO.	20.5 2.9
13 SPECIFIC HEAT CAPACITY	(KJ/KG-C)	2.4373	4.0521		11 AVERAGE REYNOLDS NO.	6977 87774
14 VISCOSITY AT AVERAGE TEMP	(MPA-S)	3.05343	0.37056		12 BUNDLE INLET REYNOLDS NO.	10958 126561
15 VISCOSITY AT SKIN TEMP	(MPA-S)	2.00782	0.40217		13 BUNDLE OUTLET REYNOLDS NO.	15151 57588
					14 FOULING LAYER (MM)	0.00000 0.00000

**** OVERALL PERFORMANCE DATA ****			**** THERMAL RESISTANCES **** (PCT. OVERALL)	
16 TOTAL HEAT DUTY REQUIRED	(MEGAWATTS)	5.413051	15 SHELL TUBE FOULING METAL OVER DES	
17 EFFECTIVE MTD, (LMTD) (F) (DELTA) = (DEG C)	95.28(0.97)(1.00) = 92.4		16 37.08 6.41 50.98 5.533 11.891	
18 F FACTOR=(TUBE) (BAFFLES) (F/G) (HOT/COLD)=(0.972)(1.000)(1.000)(0.977)			17 TOTAL FOULING RESISTANCE	0.000954
19 OVERALL COEF, REQD/CLEAN/ACTUAL	(W/M2-C) 477.82/1090.63/ 534.64		18 DIFFERENTIAL RESISTANCE	0.000222

**** CONSTRUCTION INFORMATION ****			**** SHELL NOZZLE INFO. **** INLET OUTLET	
20 NO. SHELLS SERIES 1 PARALLEL 1 TOTAL SURFACE AREA	(M2)	126	19 INSIDE DIAMETER	(MM) 289.1 289.1
21 NO. PASSES SHELL 1 TUBE 8 EFF. SURF. AREA (M2/SHELL)		122.6	20 VELOCITY	(M/S) 3.32 4.17
22 SHELL I.D. (MM) 740.000 TEMA SHELL TYPE E REAR HEAD U-T			21 DENSITY	(KG/M3) 393.201 313.802
23 BAFFLE TYPE VERT DBL. SEG. NO. CROSSPASSES/SHELL PASS		12	22 NOZZLE R-V-SQ	(KG/M-S2) 4334 5458
24 CENTRAL SPACING (MM) 370.000 BAFFLE CUT (PCT. DIA)		26.60	23 SHELL ENT. R-V-SQ	(KG/M-S2) 3483 3031
25 INLET SPACING (MM) 690.000 CUT AREA(PCT)1) 41.8 2) 42.3 3) 0.0			24 HEIGHT UNDER NOZZLE	(MM) 94.0 94.0
26 OUTLET SPACING (MM) 516.000 CUT HEIGHT FROM CENTER LINE (MM)			** TUBE NOZZLES (RADIAL) ** INLET OUTLET	
27 BAFFLE THICKNESS (MM) 7.937 POS-1) 173.2 2) 122.4 3) 0.0			25 INSIDE DIAMETER	(MM) 152.0 152.0
28 PAIRS SEAL STRIPS 2 TOT.TUBESHEET(MM) 110.0 IMPINGEMENT PLATE YES			26 VELOCITY	(M/S) 1.32 1.25
29 F-STREAM SEAL RODS (MM) 19.100 NO. 6 PCT.TUBES REM.(BOTH) 15.38			27 DENSITY	(KG/M3) 905.974 962.973
30 TUBE TYPE PLAIN TUBECOUNT PER SHELL		432	**** DIAMETRAL CLEARANCES ****	
31 OVERALL LENGTH (M) 4.841 TUBE PITCH (MM) 25.3999			28 BAFFLE-TO-SHELL	(MM) 4.0090
32 EFFECTIVE LENGTH (M) 4.731 OUTSIDE DIAMETER (MM) 19.100			29 BUNDLE-TO-SHELL	(MM) 12.7000
33 LAYOUT ANGLE (DEG) 90 INSIDE DIAMETER (MM) 15.800			30 TUBE-TO-BAFFLEHOLE	(MM) 0.4000
34 PITCH RATIO 1.330 SURFACE AREA RATIO (OUT/IN) 1.209			31 MULTI.SEG. BAFFLE OVERLAP	(MM) 50.800
35			32	
36 WEIGHT ESTIMATION (KG/SHELL) DRY 4608 WET 6901				

\*\*\* WARNING MESSAGES \*\*\*

NOTE - THE PHYSICAL PROPERTIES FOR THE COLD FLUID SHOWN ON LINES 11 THROUGH 15 ON THE LEFT SIDE OF THE FINAL RESULTS PRINTOUT ARE FOR THE LIQUID PHASE ONLY.

⑥

JCP 12/3/93  
 JCP 12/3/93 R4/5/9  
 JCP 12/3/93 2/8

START-UP YEAR 2000

\*FINAL RESULTS\* PROBLEM DESCRIPTION-P92061 ELF NORGE TCP2 START-UP YAR 2000 CE 607  
 RATING CASE MULTIPASS FLOW IN A T.E.M.A. AEU SHELL WITH DOUBLE-SEG. BAFFLES ALT. SOLN.-\*\*

**** PROCESS DATA ****		COLD SHELLSIDE		HOT TUBESIDE		**** SHELLSIDE PERFORMANCE ****	
01 FLUID NAME		CRUDE		TEG30Z		01 NOM. VEL, X-FLOW/WINDOW	0.21/ 0.23
02 FLUID CONDITION		SENS. LIQUID		SENS. LIQUID		02 FILM COEF, X-FLOW/WINDOW	1004.0/ 1008.9
03 TOTAL FLOW RATE	(KG/S)	26.678		23.032		03 FLOW FRACTIONS FOR HEAT TRANSFER=	0.577
						04 A=0.003 B=0.443 C=0.009 E=0.033 F=0.511	
04 TEMPERATURE, IN/OUT	(DEG C)	5.1 / 66.1		180.0 / 120.0		**** SHELLSIDE HEAT TRANSFER CORRECTIONS ****	
05 TEMPERATURE, AVERAGE/SKIN	(DEG C)	35.6/ 93.6		150.0/ 144.5		05 TOTAL BETA GAMMA END FIN	
06 PRESSURE, INLET/AVERAGE	(KPA)	1550.0/ 1532.5		0.0/ 0.0		06 0.905 0.905 1.000 0.951 1.000	
07 PRESSURE DROP, TOTAL/ALLOW	(KPA)	2.67/ 35.00		156.28/ 130.00		**** PRESSURE DROPS **** (PERCENT TOTAL DP)	
08 VELOCITY, CALC./MAX.ALLOW	(M/S)	0.16/ 0.00		2.34/ 0.00		07 WIND 39.56 NOZZLE SHELL 12.05/ 7.00	
						08 END 21.77 (IN/OUT) TUBE 0.63/ 0.38	
09 FILM COEF (SMF.FACT)	(W/M2-C)	824.40 (0.95)		10563.81 (1.00)		**** H.T. PARAMETERS **** SHELL TUBE	
10 FOULING RESISTANCE	(M2-C/W)	0.00054		0.00035		09 WALL CORRECTION	1.135 0.988
11 DENSITY	(KG/M3)	894.8578		931.4737		10 PRANDTL NO.	258.9 2.9
12 THERMAL CONDUCTIVITY	(W/M-C)	0.3325		0.5113		11 AVERAGE REYNOLDS NO.	145 92946
13 SPECIFIC HEAT CAPACITY	(KJ/KG-C)	3.4327		4.0521		12 BUNDLE INLET REYNOLDS NO.	77 133873
14 VISCOSITY AT AVERAGE TEMP	(MPA-S)	25.06566		0.37056		13 BUNDLE OUTLET REYNOLDS NO.	242 60894
15 VISCOSITY AT SKIN TEMP	(MPA-S)	10.14072		0.39837		14 FOULING LAYER (MM)	0.00000 0.00000
**** OVERALL PERFORMANCE DATA ****							
16 TOTAL HEAT DUTY REQUIRED	(MEGAWATTS)			5.600053		**** THERMAL RESISTANCES **** (PCT. OVERALL)	
17 EFFECTIVE HTD, (LMTD) (F) (DELTA) =	(DEG C)	114.39(0.95)(0.99)		= 107.7		15 SHELL TUBE FOULING METAL OVER DES	
18 F FACTOR=(TUBE) (BAFFLES) (F/G) (HOT/COLD)=	(1.000)(1.000)(1.000)(0.999)					16 50.66 4.78 40.24 4.322 -0.543	
19 OVERALL COEF, RECD/CLEAN/ACTUAL	(W/M2-C)	419.18/ 698.84/ 417.63				17 TOTAL FOULING RESISTANCE	0.000964
						18 DIFFERENTIAL RESISTANCE	-0.000011
**** CONSTRUCTION INFORMATION ****							
20 NO. SHELLS SERIES	1 PARALLEL	1	TOTAL SURFACE AREA (M2)	126		**** SHELL NOZZLE INFO. **** INLET OUTLET	
21 NO. PASSES SHELL	1 TUBE	8	EFF. SURF. AREA (M2/SHELL)	122.6		19 INSIDE DIAMETER (MM)	289.1 289.1
22 SHELL I.D. (MM)	740.000		TEMA SHELL TYPE	E REAR HEAD U-T		20 VELOCITY (M/S)	0.43 0.43
23 BAFFLE TYPE	VERT DBL. SEG.		NO. CROSSPASSES/SHELL PASS	12		21 DENSITY (KG/M3)	945.740 843.976
24 CENTRAL SPACING (MM)	370.000	BAFFLE CUT (PCT. DIA)	26.60			22 NOZZLE R-V-SQ (KG/M-S2)	174 196
25 INLET SPACING (MM)	700.000	CUT AREA(PCT) 1) 42.0 2) 44.4 3) 0.0				23 SHELL ENT. R-V-SQ (KG/M-S2)	174 125
26 OUTLET SPACING (MM)	506.205	CUT HEIGHT FROM CENTER LINE (MM)				24 HEIGHT UNDER NOZZLE (MM)	87.0 87.0
27 BAFFLE THICKNESS (MM)	7.937	POS-1) 173.2 2) 129.2 3) 0.0				** TUBE NOZZLES (RADIAL) ** INLET OUTLET	
28 PAIRS SEAL STRIPS	2	TOT.TUBESHEET(MM) 110.0	IMPINGEMENT PLATE YES			25 INSIDE DIAMETER (MM)	152.0 152.0
29 F-STREAM SEAL RODS (MM)	19.100	NO. 6	PCT.TUBES REM.(HALF) 7.41			26 VELOCITY (M/S)	1.40 1.33
						27 DENSITY (KG/M3)	905.974 956.973
30 TUBE TYPE	PLAIN	TUBECOUNT PER SHELL	432			**** DIAMETRAL CLEARANCES ****	
31 OVERALL LENGTH (M)	4.841	TUBE PITCH (MM)	25.3999			28 BAFFLE-TO-SHELL (MM)	4.0090
32 EFFECTIVE LENGTH (M)	4.731	OUTSIDE DIAMETER (MM)	19.100			29 BUNDLE-TO-SHELL (MM)	12.7000
33 LAYOUT ANGLE (DEG)	30	INSIDE DIAMETER (MM)	15.800			30 TUBE-TO-BAFFLEHOLE (MM)	0.7937
34 PITCH RATIO	1.330	SURFACE AREA RATIO (OUT/IN)	1.209			31 MULTI.SEG. BAFFLE OVERLAP (MM)	43.998
35						32	
36 WEIGHT ESTIMATION (KG/SHELL)	DRY	4600	WET	6893			

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START-UP YEAR 2000

PROBLEM DESCRIPTION-F72061 ELF NORGE TCP2 START-UP 2000-

CE-607

\*\*FLOW INDUCED VIBRATION ANALYSIS (LEVEL 1.00)\*\* SENS. LIQUID SHELLSIDE

		INLET	CENTER	U-BEND
01	LOG DECREMENT 0.1000 AXIAL STRESS LOADING		0.0 (MPA)	
02	BETA 4.958 ADDED MASS FACTOR 2.5233	-----POSITION IN BUNDLE-----		
		INLET	CENTER	U-BEND
03	LENGTH FOR NATURAL FREQUENCY (M)	1.070	0.740	2.032
04	LENGTH/TEMA MAXIMUM SPAN (--)	0.701	0.485	1.079*
05	NUMBER OF SPANS (--)	6	7	1
06	TUBE NATURAL FREQUENCY (HZ)	47.98+	61.23	5.74
07	SHELL ACOUSTIC FREQUENCY (HZ)	---	---	---
	- FLOW VELOCITIES - - - - -			
08	WINDOW PARALLEL VELOCITY (M/S)	0.21	0.22	0.24
09	BUNDLE CROSSFLOW VELOCITY (M/S)	0.08	0.16	0.13
10	BUNDLE/SHELL VELOCITY (M/S)	0.02	0.03	0.02
	- FLUIDELASTIC INSTABILITY CHECK - -			
11	BAFFLE TIP CROSS VELOCITY (M/S)	0.07	0.14	0.11
12	AVERAGE CROSSFLOW VELOCITY (M/S)	0.08	0.16	0.13
13	CRITICAL VELOCITY (M/S)	3.08	3.13	3.18
	- ACOUSTIC VIBRATION CHECK - - - - -			
14	VORTEX SHEDDING RATIO (--)	---	---	---
15	TURBULENT BUFFETING RATIO (--)	---	---	---
	- TUBE VIBRATION CHECK - - - - -			
16	VORTEX SHEDDING RATIO (--)	0.020	0.040	0.031
17	TURBULENT BUFFETING RATIO (--)	---	---	---
18	PARALLEL FLOW AMPLITUDE (MM)	0.000	0.000	0.003
19	CROSSFLOW AMPLITUDE (MM)	0.002	0.001	0.045
20	TUBE GAP (MM)	6.300	6.300	6.300
21	CROSSFLOW RHO-V-SQ (KG/M-S2)	6.	24.	13.
	- DAMAGE NUMBER CHECK - - - - -			
22	BAFFLE DAMAGE NUMBER (--)	0.0011	0.0019	0.0082
23	COLLISION DAMAGE NUMBER (--)	0.0015	0.0013	0.0431
24	CRITICAL DAMAGE NUMBER LIMIT (--)	0.2354	0.2678	0.2958
25	RHO/SQRT(MU) (LB**0.5FT**2.5HR**0.5)	5.5415	7.1730	8.7481

BUNDLE PARAMETERS AT NOZZLES		ENTRANCE	EXIT
26	IMPINGEMENT PLATE	YES	--
27	FLOW AREA (AESC) (M2)	0.0656	0.0819
28	VELOCITY (VESC) (M/S)	0.43	0.39
29	RHO-V-SQ (RV2E) (KG/M-S2)	175.	126.

30 TEMA E SHELL WITH VERT DBL. SEG. BAFFLES AND U-T BUNDLE  
 31  
 32 PLAIN 316 S. STL TUBES 19.1000 DIAMETER (MM) 30 DEGREE LAYOUT  
 33 PITCH RATIO 1.330

\* FREQUENCY RATIOS ARE BASED UPON LOWEST NATURAL OR ACOUSTIC FREQUENCY OMITTING THE U-BEND. CALCULATIONS ASSUME NO INTERMEDIATE SUPPORTS FOR THE U-BEND.

\*\*FLOW-INDUCED VIBRATION WARNING MESSAGES\*\*

NOTE -- U-BEND EXCEEDS THE TEMA MAXIMUM SPAN. CONSIDER ADDING STIFFNESS TO THE U-BEND REGION.

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DESIGN CASE YEAR 2000

\*FINAL RESULTS\* PROBLEM DESCRIPTION-P92061 ELF NORGE TCP2 YEAR 2000 -  
 RATING CASE MULTIPASS FLOW IN A T.E.M.A. AEU SHELL WITH DOUBLE-SEG. BAFFLES

CASE-CE607  
 ALT. SOLN.-\*\*

*** PROCESS DATA ***		COLD SHELLSIDE	HOT TUBESIDE	*** SHELLSIDE PERFORMANCE ***	
01 FLUID NAME		CRUDE	TEG30%	01 NOM. VEL, X-FLOW/WINDOW	0.70/ 0.78
02 FLUID CONDITION		SENS. LIQUID	SENS. LIQUID	02 FILM COEF, X-FLOW/WINDOW	1793.5/ 1568.3
03 TOTAL FLOW RATE	(KG/S)	89496 <del>89496</del>	11.992	03 FLOW FRACTIONS FOR HEAT TRANSFER=	0.769
				04 A=0.007 B=0.652 C=0.020 E=0.031 F=0.290	
04 TEMPERATURE, IN/OUT	(DEG C)	49.6 / <del>59.3</del>	180.0 / 120.0	*** SHELLSIDE HEAT TRANSFER CORRECTIONS ***	
05 TEMPERATURE, AVERAGE/SKIN	(DEG C)	54.3/ 95.3	150.0/ 141.6	05 TOTAL BETA GAMMA END FIN	
06 PRESSURE, INLET/AVERAGE	(KPA)	1550.0/ 1525.0	0.0/ 0.0	06 0.690 0.690 1.000 0.963 1.000	
07 PRESSURE DROP, TOTAL/ALLOW	(KPA)	19.49/ 50.00	47.51/ 130.00	*** PRESSURE DROPS *** (PERCENT TOTAL DP)	
08 VELOCITY, CALC./MAX.ALLOW	(M/S)	0.81/ 0.00	1.21/ 0.00	07 WIND 37.65 NOZZLE SHELL 14.44/ 9.68	
09 FILM COEF (SAF.FACT)	(W/M2-C)	1067.27 (1.00)	6265.97 (1.00)	08 END 11.08 (IN/OUT) TUBE 0.56/ 0.33	
10 FOULING RESISTANCE	(M2-C/W)	0.00053	0.00035	*** H.T. PARAMETERS *** SHELL TUBE	
11 DENSITY	(KG/M3)	905.4744	934.4735	09 WALL CORRECTION	1.090 0.981
12 THERMAL CONDUCTIVITY	(W/M-C)	0.3375	0.5113	10 PRANDTL NO.	175.2 2.9
13 SPECIFIC HEAT CAPACITY	(KJ/KG-C)	3.4601	4.0521	11 AVERAGE REYNOLDS NO.	968 48342
14 VISCOSITY AT AVERAGE TEMP	(MPA-S)	17.08200	0.37056	12 BUNDLE INLET REYNOLDS NO.	892 69703
15 VISCOSITY AT SKIN TEMP	(MPA-S)	9.24889	0.41470	13 BUNDLE OUTLET REYNOLDS NO.	1045 31706
				14 FOULING LAYER (MM)	0.00000 0.00000
*** OVERALL PERFORMANCE DATA ***					
16 TOTAL HEAT DUTY REQUIRED	(MEGAWATTS)		2.892027	*** THERMAL RESISTANCES *** (PCT. OVERALL)	
17 EFFECTIVE MTD, (LMTD) (F) (DELTA) = (DEG C)		93.43(0.99)(1.00)=	92.2	15 SHELL TUBE FOULING METAL OVER DES	
18 F FACTOR=(TUBE) (BAFFLES) (F/S) (HOT/COLD)=(0.989)(1.000)(1.000)(0.998)				16 42.84 8.82 43.60 4.732 78.779	
19 OVERALL COEF, REQD/CLEAN/ACTUAL	(W/M2-C)	255.77/ 810.78/ 457.27		17 TOTAL FOULING RESISTANCE	0.000954
				18 DIFFERENTIAL RESISTANCE	0.001723
*** CONSTRUCTION INFORMATION ***					
20 NO. SHELLS SERIES 1 PARALLEL 1	TOTAL SURFACE AREA (M2)		126	*** SHELL NOZZLE INFO. *** INLET OUTLET	
21 NO. PASSES SHELL 1 TUBE 8	EFF. SURF. AREA (M2/SHELL)		122.6	19 INSIDE DIAMETER (MM)	289.1 289.1
22 SHELL I.D. (MM)	740.000	TEMA SHELL TYPE E REAR HEAD U-T		20 VELOCITY (M/S)	1.52 1.54
23 BAFFLE TYPE VERT DBL. SEG.	NO. CROSSPASSES/SHELL PASS		12	21 DENSITY (KG/M3)	911.974 898.974
24 CENTRAL SPACING (MM)	370.000	BAFFLE CUT (PCT. DIA)	26.60	22 NOZZLE R-V-SQ (KG/M-S2)	2112 2143
25 INLET SPACING (MM)	700.000	CUT AREA(PCT) 1) 42.0 2) 42.2 3) 0.0		23 SHELL ENT. R-V-SQ (KG/M-S2)	2115 1377
26 OUTLET SPACING (MM)	506.205	CUT HEIGHT FROM CENTER LINE (MM)		24 HEIGHT UNDER NOZZLE (MM)	87.0 87.0
27 BAFFLE THICKNESS (MM)	7.937	POS-1) 173.2 2) 122.4 3) 0.0		** TUBE NOZZLES (RADIAL) ** INLET OUTLET	
28 PAIRS SEAL STRIPS 2	TOT. TUBESHEET (MM)	110.0	IMPINGEMENT PLATE YES	25 INSIDE DIAMETER (MM)	152.0 152.0
29 F-STREAM SEAL RODS (MM)	19.100	NO. 6	PCT. TUBES REM. (HALF) 7.41	26 VELOCITY (M/S)	0.73 0.69
				27 DENSITY (KG/M3)	905.974 962.973
30 TUBE TYPE PLAIN	TUBECOUNT PER SHELL		432	*** DIAMETRAL CLEARANCES ***	
31 OVERALL LENGTH (M)	4.841	TUBE PITCH (MM)	25.3997	28 BAFFLE-TO-SHELL (MM)	4.0090
32 EFFECTIVE LENGTH (M)	4.731	OUTSIDE DIAMETER (MM)	19.100	29 BUNDLE-TO-SHELL (MM)	12.7000
33 LAYOUT ANGLE (DEG)	90	INSIDE DIAMETER (MM)	15.800	30 TUBE-TO-BAFFLEHOLE (MM)	0.7937
34 PITCH RATIO 1.330	SURFACE AREA RATIO (OUT/IN)		1.209	31 MULTI.SEG. BAFFLE OVERLAP (MM)	50.800
35				32	
36 WEIGHT ESTIMATION (KG/SHELL)	DRY	4600	WET	6873	

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DESIGN CASE YEAR 2000.

PROBLEM DESCRIPTION-P92061 ELF NORGE TCP2 YEAR 2000 -

CASE-CE607

\*\*FLOW INDUCED VIBRATION ANALYSIS (LEVEL 1.00)\*\* SENS. LIQUID SHELLSIDE

		-----POSITION IN BUNDLE-----		
		INLET	CENTER	U-BEND
01	LOG DECREMENT 0.1000 AXIAL STRESS LOADING	0.0 (MPA)		
02	BETA 2.711 ADDED MASS FACTOR 2.4733			
03	LENGTH FOR NATURAL FREQUENCY (M)	1.070	0.740	2.032
04	LENGTH/TEMA MAXIMUM SPAN (--)	0.701	0.485	1.079*
05	NUMBER OF SPANS (--)	6	7	1
06	TUBE NATURAL FREQUENCY (HZ)	48.55+	61.33	5.68
07	SHELL ACOUSTIC FREQUENCY (HZ)	---	---	---
- FLOW VELOCITIES - - - - -				
08	WINDOW PARALLEL VELOCITY (M/S)	0.77	0.78	0.78
09	BUNDLE CROSSFLOW VELOCITY (M/S)	0.42	0.81	0.60
10	BUNDLE/SHELL VELOCITY (M/S)	0.11	0.22	0.16
- FLUIDELASTIC INSTABILITY CHECK - -				
11	BAFFLE TIP CROSS VELOCITY (M/S)	0.37	0.70	0.51
12	AVERAGE CROSSFLOW VELOCITY (M/S)	0.42	0.81	0.60
13	CRITICAL VELOCITY (M/S)	1.71	1.72	1.72
- ACOUSTIC VIBRATION CHECK - - - - -				
14	VORTEX SHEDDING RATIO (--)	---	---	---
15	TURBULENT BUFFETING RATIO (--)	---	---	---
- TUBE VIBRATION CHECK - - - - -				
16	VORTEX SHEDDING RATIO (--)	0.163	0.310	0.229
17	TURBULENT BUFFETING RATIO (--)	---	---	---
18	PARALLEL FLOW AMPLITUDE (MM)	0.002	0.003	0.044
19	CROSSFLOW AMPLITUDE (MM)	0.044	0.039	1.136*
20	TUBE GAP (MM)	6.300	6.300	6.300
21	CROSSFLOW RHO-V-SQ (KG/M-S2)	164.	593.	319.
- DAMAGE NUMBER CHECK - - - - -				
22	BAFFLE DAMAGE NUMBER (--)	0.0277	0.0477	0.1937*
23	COLLISION DAMAGE NUMBER (--)	0.0406	0.0335	1.0253*
24	CRITICAL DAMAGE NUMBER LIMIT (--)	0.2917	0.2965	0.3013
25	RHO/SQRT(MU) (LB**5FT**-2.5HR**1.5)	8.5067	8.7921	9.0762

BUNDLE PARAMETERS AT NOZZLES		ENTRANCE	EXIT
26	IMPINGEMENT PLATE	YES	--
27	FLOW AREA (AESC) (M2)	0.0656	0.0819
28	VELOCITY (VESC) (M/S)	1.52	1.24
29	RHO-V-SQ (RV2E) (KG/M-S2)	2114.	1377.

30 TEMA E SHELL WITH VERT DBL. SEG. BAFFLES AND U-T BUNDLE  
 31  
 32 PLAIN 316 S. STL TUBES 19.1000 DIAMETER (MM) 90 DEGREE LAYOUT  
 33 PITCH RATIO 1.330

\* FREQUENCY RATIOS ARE BASED UPON LOWEST NATURAL OR ACOUSTIC FREQUENCY OMITTING THE U-BEND. CALCULATIONS ASSUME NO INTERMEDIATE SUPPORTS FOR THE U-BEND.

\*\*FLOW-INDUCED VIBRATION WARNING MESSAGES\*\*

NOTE -- U-BEND EXCEEDS THE TEMA MAXIMUM SPAN. CONSIDER ADDING STIFFNESS TO THE U-BEND REGION.

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