Department of Energy

Bonneville Power Administration
P.O. Box 3621
Portland, Oregon 97208-3621

FREEDOM OF INFORMATION ACT/PRIVACY PROGRAM

July 17, 2024

In reply refer to: FOIA BPA-2024-02445-F

SENT VIA EMAIL ONLY TO: burton@obwb.com

Carlyn Burton
Osha Bergman Watanabe & Burton LLP
1100 Louisiana St, Suite 4900
Houston, Texas 77002

Dear Ms. Burton,

The Bonneville Power Administration (BPA) received your request for agency records made under the Freedom of Information Act, 5 U.S.C. § 552 (FOIA). The agency received your request on July 5, 2024, and assigned tracking number BPA-2024-02445-F for your request. Please use that tracking number in any correspondence with the agency regarding your FOIA request. This communication is the agency's formal acknowledgment and response to your information request.

Original Request
You seek, "[i]nformation related to a Solvay Interox plant in Longview, WA, including any energy consumption or savings achieved through installation of new equipment used in the manufacture of hydrogen peroxide. Please provide 1) information for any time period and 2) any documents with a date prior to September 13, 2021."

Clarification
On July 12, 2024, you communicated with the agency via email and narrowed the scope of your FOIA request to the public release of two specific aged records. Those two records are:

1. Turboexpander Energy Savings Approval from BPA – 1996 – 1 page
2. Turboexpander Energy Savings Verification Report – 1996 – 29 pages

Acknowledgement
BPA reviewed your request and clarification and determined that they fulfill all criteria of a proper request under the FOIA and the U.S. Department of Energy's (DOE) FOIA regulations at Title 10, Code of Federal Regulations, Part 1004.

Response

BPA searched for and gathered the agency records you seek. Subject matter experts in the agency's FOIA office gathered 30 pages of records responsive to your request. Those 30 pages accompany this communication with no redactions applied. Those 30 pages are also available publicly, at the BPA FOIA Library, as you've requested.

Fees
There are no fees associated with processing your FOIA request.

Certification
Pursuant to 10 C.F.R. § 1004.7, I am the individual responsible for the records search and release described above. Your FOIA request BPA-2024-02445-F is now closed with all available responsive records provided.

Appeal
Note that the records release certified above is final. Pursuant to 10 C.F.R. § 1004.8, you may appeal the adequacy of the records search, and the completeness of this final records release, within 90 calendar days from the date of this communication. Appeals should be addressed to:

Director, Office of Hearings and Appeals
HG-1, L'Enfant Plaza
U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585-1615

The written appeal, including the envelope, must clearly indicate that a FOIA appeal is being made. You may also submit your appeal by e-mail to OHA.filings@hq.doe.gov, including the phrase "Freedom of Information Appeal" in the subject line. (The Office of Hearings and Appeals prefers to receive appeals by email.) The appeal must contain all the elements required by 10 C.F.R. § 1004.8, including a copy of the determination letter. Thereafter, judicial review will be available to you in the Federal District Court either (1) in the district where you reside, (2) where you have your principal place of business, (3) where DOE's records are situated, or (4) in the District of Columbia.

Additionally, you may contact the Office of Government Information Services (OGIS) at the National Archives and Records Administration to inquire about the FOIA mediation services they offer. The contact information for OGIS is as follows:

Office of Government Information Services
National Archives and Records Administration
8601 Adelphi Road-OGIS
College Park, Maryland 20740-6001
E-mail: ogis@nara.gov

Phone: 202-741-5770
Toll-free: 1-877-684-6448
Fax: 202-741-5769

Questions about this communication may be directed to James King, FOIA Public Liaison, at jjking@bpa.gov or 503-230-7621.

Sincerely,

Candice D. Palen
Freedom of Information/Privacy Act Officer

Department of Energy
The Bonneville Power Administration
Southwest District, Vancouver Sales and
Customer Service Center
Conservation and Energy Services Account Support
703 Broadway, Suite 510
Vancouver, WA 98660-3276

August 13, 1996

Mr. Mike Banigan
Solvay Interox
3500 Industrial Way
Longview, WA 98632

Subject: Energy $avings Plan Contract No. DE-MS79-94BP94546
Turboexpander Project - Completion Report Approval

Dear Mr. Banigan:

The Completion Report for the Turboexpander Project has been approved.

Please forward an invoice (Exhibit E of the contract) in the amount of $677,133.00 for final payment on this project.

If you have any questions about the invoicing process, please call me at (360) 418-8650. Thanks for your participation in the Energy $avings Plan Program.

Sincerely,

Barbara J. Thime

Barbara J. Thime
Contracting Officer's Technical Representative

cc:
J. Wellcome - Cowlitz PUD
A. Wykoff - SVV

SOLVAY INTEROX

June 27, 1996

Mr. Christopher Milan
Bonneville Power Administration
703 Broadway
Suite 510 - MEV - Chris Milan
Vancouver, WA. 98660-3276

Subject: Turboexpander Project - Energy Savings Verification Report Draft
Contract No. DE-MS79-94BP94546

Chris:

Per our recent conversation, attached is a draft copy of the subject report for your review. If necessary, a meeting between the appropriate BPA and Solvay Interox personnel can be convened to discuss any revisions to the report as required by BPA. A final verification report will be issued following resolution of any open issues.

Also, as we discussed, in addition to the balance of the acquisition payment, Solvay Interox is requesting reimbursement for the additional project costs identified in the report. If you require, I will submit detailed cost information in support of this request.. Solvay Interox would appreciate BPA's consideration of this matter.

I would like to express my sincere thanks to you for your help during this project. As expected, the turboexpander is proving to be a very effective means to reduce energy consumption at the Solvay Interox Longview facility.

Sincerely,

Mike Banigan
Engineering and Maintenance Manager

cc: G. Hall
M. Degelia
D. Roberts
T. Wilson
LW3 File

96-MB031.LW3

Solvay Interox
3500 Industrial Way, Longview, Washington 98632-9482
360/425-1114 Fax: 360/425-0291

SOLVAY

DRAFT

SOLVAY INTEROX

Longview, WA

Turboexpander

Energy Savings Verification

Report

June 14, 1996

96-MB030.LW3

Solvay Interox - Longview
Turboexpander Energy Savings Verification Report

1.0 Purpose

This report is submitted to The Bonneville Power Administration (BPA) as required in Energy Savings Plan Contract No. DE-MS79-94BP94546. The purpose of this report is to document the method and results of the energy savings verification testing conducted by Solvay Interox (SI) following the installation and commissioning of the new turboexpnder. This report also provides final project cost data for review by BPA.

2.0 Summary

Per the original project proposal, a turboexpander (X2405) was installed on one of the new process air compressors (C2405/1) in conjunction with the LW3 Modernization Project. The compressor was commissioned in April, 1995 and the turboexpander was subsequently brought on line in May, 1995.

Various control problems were experienced in the months following commissioning which prevented consistent operation of the process equipment. As a result of insufficient performance data, energy savings verification testing was repeatedly delayed.

The turboexpander then suffered a catastrophic failure on August 1, 1995. Analysis indicated that the root cause of the failure was a design oversight which allowed the introduction of water in the expander inlet during a startup of C2405/1 (see attached memo 95-EM240.DRR for detailed analysis). Upon inspection, it was also discovered that liquid entrainment in the off-gas stream was fouling the expander internals. The fouling was severe enough to require installation of additional process equipment (e.g. off-gas demister, etc.) to mitigate the problem.

In March, 1996, the turboexpander was repaired, the demister installation was completed, and the turboexpander was returned to service. Results of the verification testing conducted since April 1, 1996 indicate that the anticipated energy savings of 1,044 kW at design production rates is achievable.

3.0 Project Scope

The project scope was initially defined in the BPA Project Proposal document. However, the scope was expanded following the project hazard analysis and also to resolve the commissioning problems discussed above. In summary, the respective project scopes include:

A. Original scope:

- Install the turboexpander (X2405).
- Install a new air-to-air heat exchanger (E2408).
- Install new piping and miscellaneous instrumentation.

B. Additional scope following process hazard analysis:

- Install new process air cooler (E2409).
- Install new piping and instrumentation to accommodate E2409.
- Install additional heat tracing associated with E2409.

C. Additional scope to correct post-startup design deficiencies:

- Replace turboexpander rotor assembly.
- Repair nozzle block.
- Modify the drain/trap configuration on E2409.
- Re-configure miscellaneous piping to eliminate lowpoints.
- Install additional heat tracing and insulation.

D. Off-gas demister project scope:

- Install a demister vessel (V2419) to eliminate entrained working solution from the turboexpander off-gas stream.
- Install new piping and instrumentation to accommodate V2419.
- Install additional heat tracing and insulation.

4.0 Savings Verification

A. General:

- Two identical 3-stage, 2500 hp process air compressors (C2405/1 & C2405/2) were installed during the LW3 Modernization project. The compressors operate in parallel and supply process air to a common header. Flow to the process is regulated by throttling inlet guide vanes on the compressors. Since both guide vanes are controlled by the same control signal, the compressors equally supply the process load.
- The turboexpander, mounted on the high speed pinion of C2405/1, utilizes extracted energy from the process off-gas to help drive the compressor thus reducing the load on the electric motor.
- Verification testing began on April 1, 1996 following repair of the turboexpander and continued through June 11, 1996. Plant

production rates, which had been reduced during the first quarter of 1996, were also gradually increased beginning in April as shown in the attached "Crude Production" chart.

B. Test Method and Results

- Electrical data for C2405/1 and C2405/2 was monitored and recorded daily. The resulting kilowatt consumption of the respective motors was compared and trends were plotted as shown in the attached "Compressor Power Consumption" chart. Since the compressors are identical and each is subjected to the same process conditions, the difference between the two is due to the power contribution of the turboexpander. Based on the latest June data, average daily energy savings was approaching 1,000 kW per hour at production rates less than maximum. The original proposal target is 1,044 kW at maximum production.
- Process data was also recorded daily via the existing plant DCS. Turboexpander inlet and outlet temperatures along with turboexpander off-gas flow data were used to compare actual turboexpander performance to the theoretical performance. Results indicate that actual turboexpander performance is within reasonable limits compared to the theoretical design as shown in the attached "Temperature Drop", "Power Output", and "Process Data" charts.

5.0 Project Cost

A summary of the final project cost is provided below and itemized by project scope as defined in Section 3 above. Expanded summary cost sheets are attached for additional information.

Scope Description	Original Budget	Actual Cost
Original Scope	753,803	
Original Scope + Hazard Analysis		801,522
Turboexpander Repairs		65,542
Off-gas Demister Installation		261,807
Total	$753,803	$1,128,871

Project cost reports will be made available if BPA requires additional detail.

In August, 1995, Solvay Interox received a partial reimbursement from BPA in the amount of $376,902. Per the Energy Savings Plan contract, the balance of the acquisition payment is due upon BPA's acceptance of the energy savings verification test results.

P2405/1-2
AUXILARY PUMPS
5 HP

C2405/1-2
PROCESS AIR COMPRESSORS
11180 SCFM 13.7 PSIA INLET
2500 HP 110 PSIA OUTLET

X2405
TURBOEXPANDER

MS2405/1-2
BLOW-OFF SILENCERS

F2404/1-2
PROCESS AIR COMPR. FILTERS

E2404/1-2
OIL COOLERS
25 GPM COOLING WATER

E2408
TURBOEXPANDER PREHEATER
GO OUTLET: 210° F
GO ΔP: < 1.5 PSI

E2409
PROCESS AIR COOLER

	DP(PSIG)	DT(° F)
SHELL	100	200
TUBES	85	300

E2407
PROCESS AIR COOLER

	DP(PSIG)	DT(° F)
SHELL	150	200
TUBES	150	300

NOTES

1. INSULATE FOR NOISE REDUCTION.
2. DIRECTLY TO STORM WATER POND

VENDOR
INTEROX

3. INSTRUMENTS ON SEAL SYSTEM NOT SHOWN:
PSL-C2405/1L /2L
PI-C2405/1M, /2M
4. SPEC. EXCEPT. VALVES

CONTROL PANEL
MS2405/1
F2404/1
(EXIST. REUSE)
X2405
C2405/1
STAGE 1
STAGE 2
STAGE 3
E2405/1
E2406/1
E2404/1
F2405/11
OIL FILTERS
F2405/12
MAIN PUMP
P2405/1
(AUX. PUMP)
OIL RESERVOIR
VENDOR
SOLVAY INTEROX
NOTE 9:
ET 180°F & INSULATION TO BE INSTALLED ON EXPANDER SEAL VENT PIPING AND CASING DRAIN.
SEAL SYSTEM
E2409/1
E2409
E2407/1
E2407
E2408
MS2405/2
F2404/2
C2405/2
E2405/2
E2406/2
E2404/2
P2405/2
(AUX. PUMP)
TO T2416
L216406/2
TO T416
B116406/1
FROM WC 0606
TO WR 0613
WR B169502/25
WC B169502/22
FROM AI-0216
AI B169502/1
FROM PIC-T2416/A
L216406/3
FROM WC-4616
TO V422
B116406/3
TO V222
L216406/3
FROM WC-4616
L216406/3

C2405/1-2
E2404/1-2
E2407
F2404/1-2
MS2405/1-2
P2405/1-2
X2405
E2408
E2409

REV	DATE	BY	DESCRIPTION
9	30OCT95	ARC	MODIF. TANP, ADDED CSO TO VALVES
8	10AUG95	ELM	AS-BUILT LW3 FOR RECORD
7	10MAY95	ARC	REVISED TURBOEXPANDER SYSTEM
7	30JAN95	ARC	ISSUED FOR CONSTRUCTION

INDUSTRA
Engineers & Consultants
SEATTLE WA. PORTLAND OR. GREENVILLE S.C.

DOC. NO. SUBJECT
REFERENCES

REV NO.	DESCRIPTION	DATE	BY	DFFT	MAINT	APR	CHG
9	POST LW3, ESR 457	30OCT95	ARC	ELM			
8	AS-BUILT LW3 FOR RECORD	10AUG95	ELM				
7	LW3	30JAN95	ARC	CHR			
6	RFQ	5JAN93	BWD				

DWG. TITLE
P&ID SECTOR H4
OXIDATION
COMPRESSOR

DWG. SCALE	ESR NO.	CNS NO.
NONE		2164081

SOLVAY INTEROX
LONGVIEW, WASHINGTON

DWG NO. L216408/1 REV. 9

E 2418
OXIDIZER OFF GAS COOLER
BTU/HR
AREA:

	DP PSIG	DTF	MAT'L
SHELL:	85	300	SS
TUBES:	90	150	SS

V2422
OXIDIZER OFF GAS DEMISTER
4'10" ID x 11'8"
DP: 85 PSIG – DT: 250°F
CAPACITY: 1500 GALS
MAT'L: SS

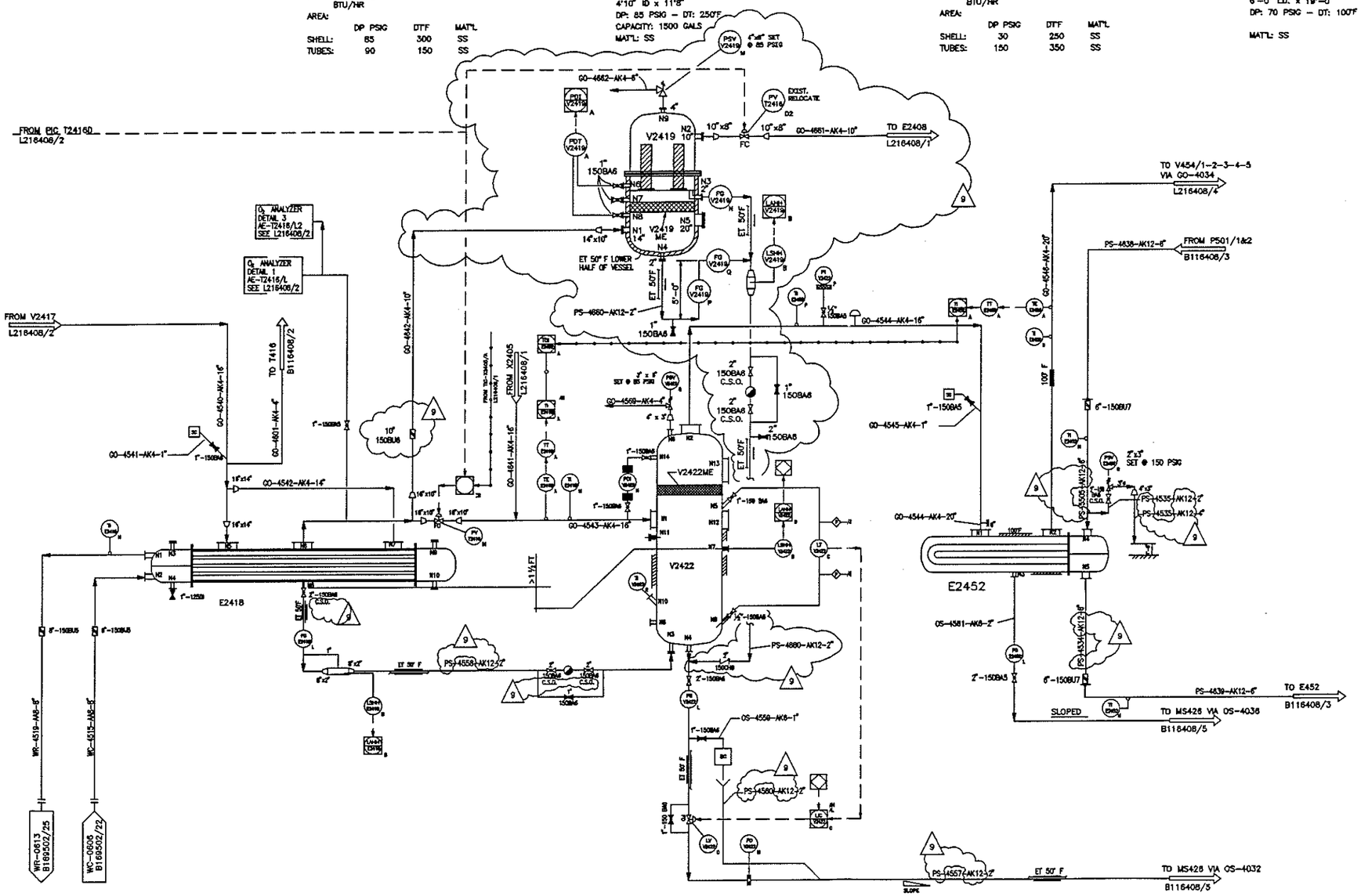
V2422 ME
DEMISTER

E2452
OFF GAS HEATER
BTU/HR
AREA:

	DP PSIG	DTF	MAT'L
SHELL:	30	250	SS
TUBES:	150	350	SS

V2419 ME
DEMISTER

V2419
MIST ELIMINATOR
6'-0" I.D. x 19'-0"
DP: 70 PSIG – DT: 100°F
MAT'L: SS



NOTES

⚠ SOME AK4 SPEC LINES HAVE OUT-OF-SPEC VALVES. 150 BA6 VALVES REQUIRED.

REV	DATE	BY	DESCRIPTION
9	30OCT95	ARC	ADDED V2419 DEMISTER
8	10NOV95	ELM	AS-BUILT LW3 FOR RECORD
7	10MAY95	ARC	REV. TP-488 & TP-489
7	30JAN95	ARC	ISSUED FOR CONSTRUCTION

INDUSTRA Engineers & Consultants
SEATTLE, WA. PORTLAND, OR. GREENVILLE, S.C.

DOC. NO.	SUBMIT

REFERENCES

7	LW3	4.5.95	CMR				
6	REDLINE	4.5.95	DWG				
5	POST LW2	4.5.95					
9	DWG TYPE CLASSIFICATION ADDED V2419	10.30.95	ELM				
8	AS-BUILT LW3 FOR RECORD	8/95	ELM				

REV. NO.	DESCRIPTION	DATE	BY	DFTY	MAINT	MFG	ENG

REVISIONS

DWG. TITLE
P&ID SECTOR H4
OXIDATION
OFF GAS SYSTEM

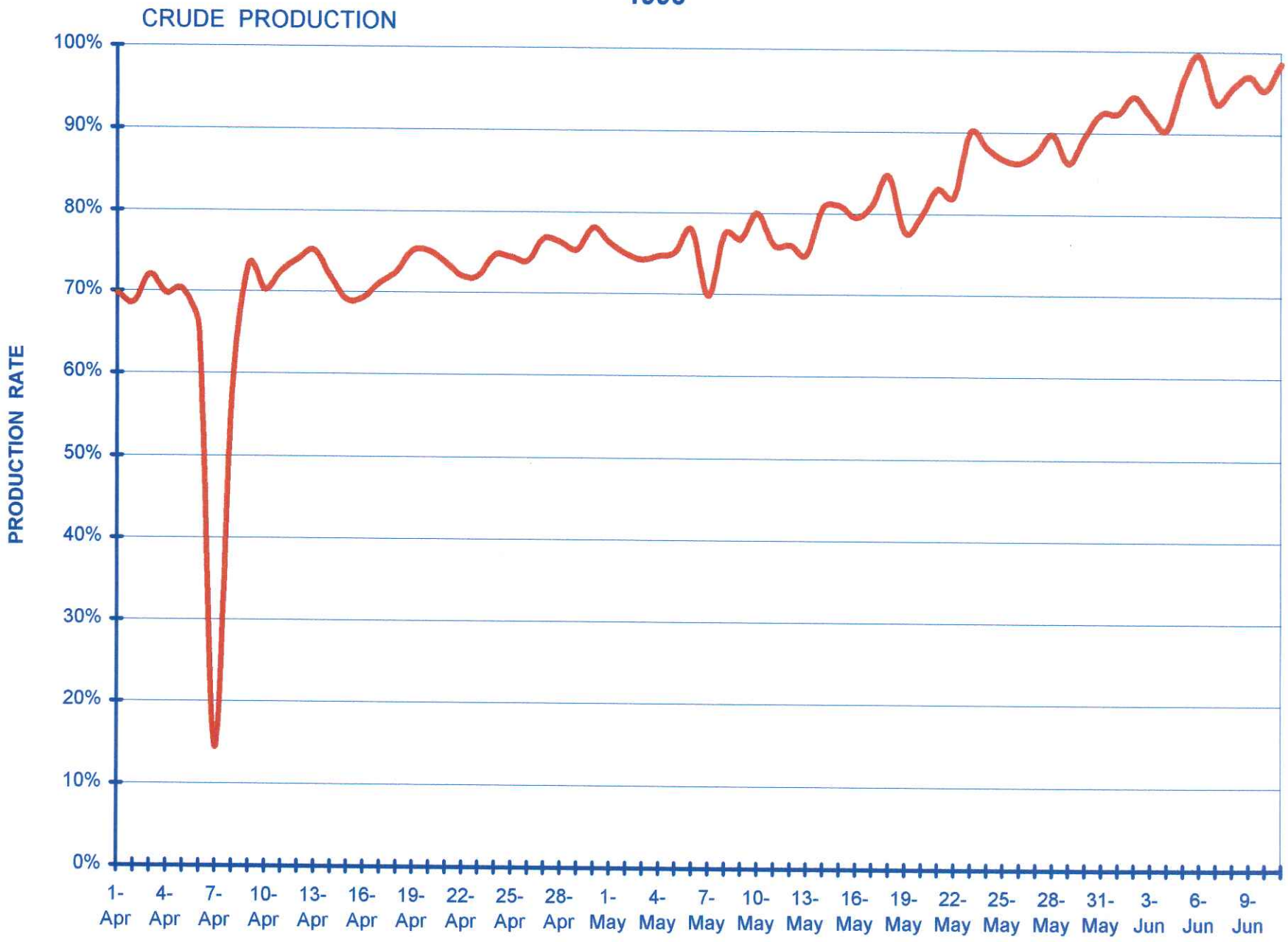
DWG. SCALE	ESM NO.	CAD NO.
NONE		K-C-0006

SOLVAY INTEROX
LONGVIEW, WASHINGTON

DWG NO.	REV.
L216408/3	9

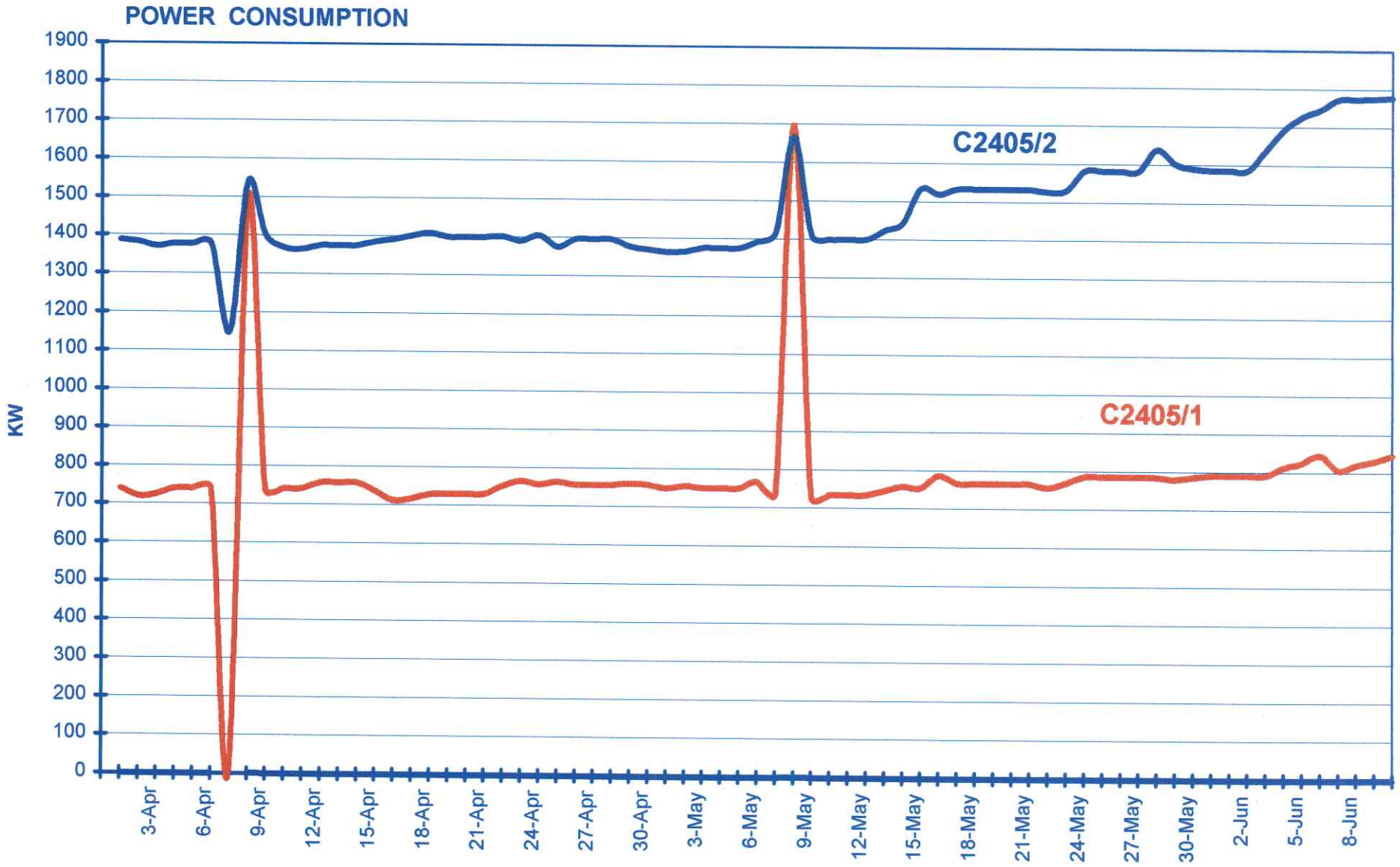
E2418
E2452
V2422
V2419

Solvay Interox - Longview
1996



PRODUCTN.XLS
6/14/96

Solvay Interox - Longview
Turboexpander Performance



TURBO.XLS
6/14/96

Solvay Interox - Longview
Compressor Electrical Data
April, 1996

		C2405/1			C2405/2			Delta
	Date	KW	% Load	Amps	KW	% Load	Amps	KW
Mon	1-Apr	739	33%	99	1388	64%	190	649
Tues	2-Apr	719	32%	97	1383	64%	190	664
Wed	3-Apr	724	32%	97	1372	63%	188	648
Thurs	4-Apr	739	34%	102	1378	64%	190	639
Fri	5-Apr	739	34%	100	1378	64%	190	639
Sat	6-Apr	739	34%	100	1378	64%	185	639
Sun	7-Apr	0		0	1150		160	1150
Mon	8-Apr	1496	70%	213	1538	72%	213	42
Tues	9-Apr	737	32%	99	1402	64%	190	665
Wed	10-Apr	741	33%	99	1369	63%	184	628
Thurs	11-Apr	740	33%	99	1366	63%	186	626
Fri	12-Apr	757	34%	102	1375	63%	186	618
Sat	13-Apr	757	34%	102	1375	63%	186	618
Sun	14-Apr	757	34%	102	1375	63%	186	618
Mon	15-Apr	736	33%	100	1386	64%	190	650
Tues	16-Apr	711	32%	97	1392	64%	190	681
Wed	17-Apr	716	32%	97	1402	64%	190	686
Thurs	18-Apr	728	32%	97	1409	64%	190	681
Fri	19-Apr	729	32%	97	1399	64%	190	670
Sat	20-Apr	729	32%	97	1399	64%	190	670
Sun	21-Apr	729	32%	97	1399	64%	190	670
Mon	22-Apr	750	34%	102	1402	64%	190	652
Tues	23-Apr	764	34%	104	1391	64%	190	627
Wed	24-Apr	755	34%	102	1405	64%	190	650
Thurs	25-Apr	763	34%	104	1376	63%	188	613
Fri	26-Apr	755	34%	104	1397	64%	190	642
Sat	27-Apr	755	34%	104	1397	64%	190	642
Sun	28-Apr	755	34%	104	1397	64%	190	642
Mon	29-Apr	759	34%	102	1378	64%	190	619
Tues	30-Apr	757	34%	104	1370	63%	184	613

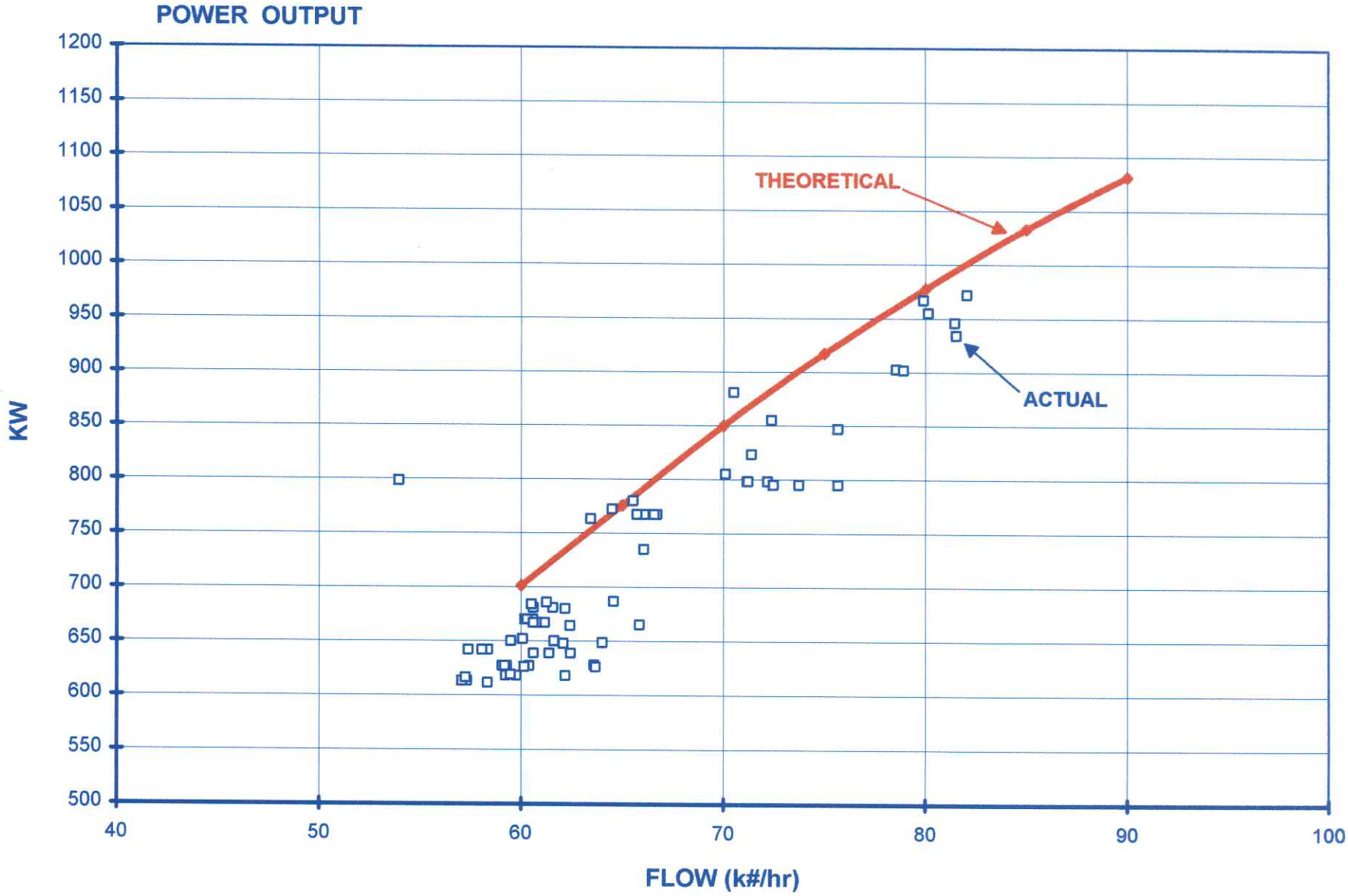
Solvay Interox - Longview
Compressor Electrical Data
May, 1996

	Date	C2405/1 KW	C2405/1 % Load	C2405/1 Amps	C2405/2 KW	C2405/2 % Load	C2405/2 Amps	Delta KW
Wed	1-May	748	34%	104	1364	62%	184	616
Thurs	2-May	754	34%	102	1365	62%	184	611
Fri	3-May	749	34%	102	1376	63%	186	627
Sat	4-May	749	34%	102	1376	63%	186	627
Sun	5-May	749	34%	102	1376	63%	186	627
Mon	6-May	767	34%	104	1393	64%	190	626
Tues	7-May	736	33%	100	1417	65%	193	681
Wed	8-May	1697	81%	244	1666	77%	228	-31
Thurs	9-May	726	32%	97	1410	64%	190	684
Fri	10-May	734	32%	97	1401	64%	190	667
Sat	11-May	734	32%	97	1401	64%	190	667
Sun	12-May	734	32%	97	1401	64%	190	667
Mon	13-May	745	34%	100	1425	65%	193	680
Tues	14-May	757	34%	104	1444	66%	197	687
Wed	15-May	753	34%	104	1533	71%	210	780
Thurs	16-May	785	34%	104	1520	70%	206	735
Fri	17-May	766	34%	104	1533	71%	210	767
Sat	18-May	766	34%	104	1533	71%	210	767
Sun	19-May	766	34%	104	1533	71%	210	767
Mon	20-May	766	34%	104	1533	71%	210	767
Tues	21-May	766	34%	104	1533	71%	210	767
Wed	22-May	755	34%	104	1527	71%	210	772
Thurs	23-May	768	34%	104	1531	71%	210	763
Fri	24-May	785	34%	104	1583	73%	217	798
Sat	25-May	785	34%	104	1583	73%	217	798
Sun	26-May	785	34%	104	1583	73%	217	798
Mon	27-May	785	34%	104	1583	73%	217	798
Tues	28-May	784	34%	104	1639	75%	224	855
Wed	29-May	779	34%	104	1602	75%	222	823
Thurs	30-May	785	34%	104	1590	73%	217	805
Fri	31-May	791	36%	106	1586	73%	217	795

Solvay Interox - Longview
Compressor Electrical Data
June, 1996

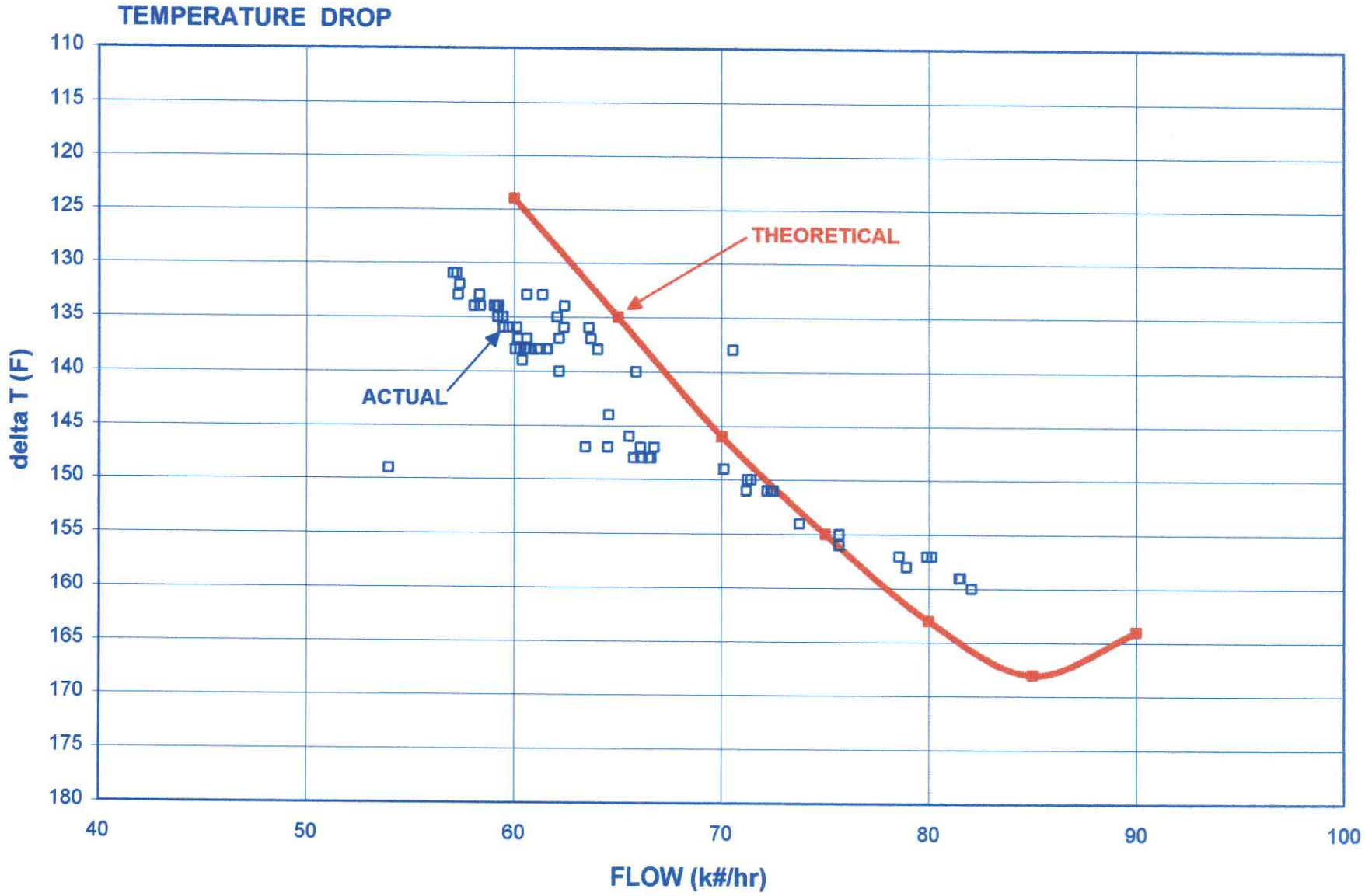
		C2405/1			C2405/2			Delta
	Date	KW	% Load	Amps	KW	% Load	Amps	KW
Sat	1-Jun	791	36%	106	1586	73%	217	795
Sun	2-Jun	791	36%	106	1586	73%	217	795
Mon	3-Jun	791	36%	110	1638	75%	224	847
Tues	4-Jun	812	36%	110	1693	80%	237	881
Wed	5-Jun	824	36%	110	1727	80%	237	903
Thurs	6-Jun	844	36%	110	1746	82%	244	902
Fri	7-Jun	806	36%	108	1773	82%	244	967
Sat	8-Jun	820	36%	110	1775	82%	245	955
Sun	9-Jun	830	36%	112	1776	83%	246	946
Mon	10-Jun	844	37%	113	1778	84%	248	934
Tues	11-Jun	839	37%	113	1811	84%	250	972
Wed	12-Jun							
Thurs	13-Jun							
Fri	14-Jun							
Sat	15-Jun							
Sun	16-Jun							
Mon	17-Jun							
Tues	18-Jun							
Wed	19-Jun							
Thurs	20-Jun							
Fri	21-Jun							
Sat	22-Jun							
Sun	23-Jun							
Mon	24-Jun							
Tues	25-Jun							
Wed	26-Jun							
Thurs	27-Jun							
Fri	28-Jun							
Sat	29-Jun							
Sun	30-Jun							

Solvay Interox - Longview
Turboexpander Performance



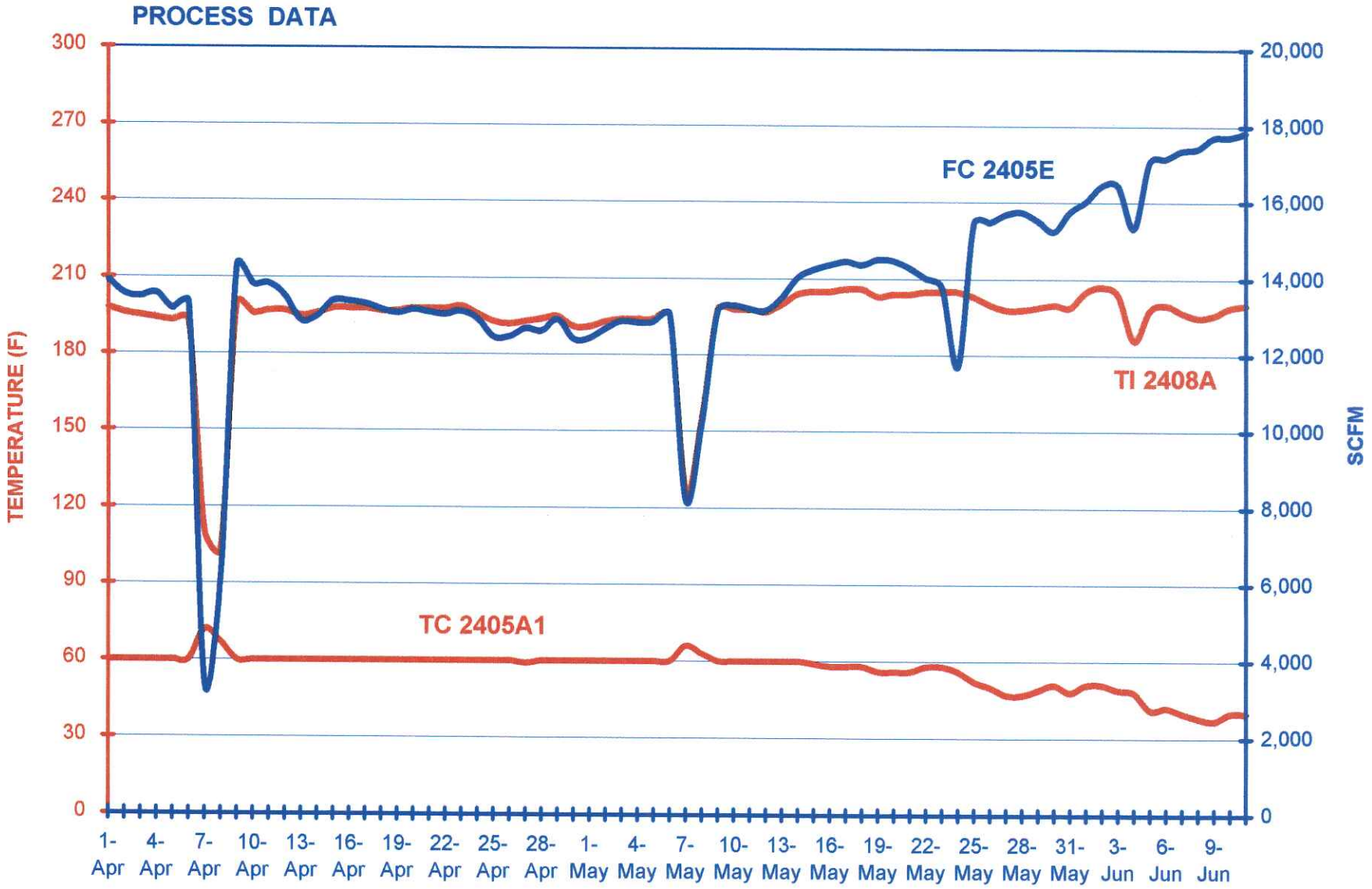
04TURBO.XLS
6/14/96

Solvay Interox - Longview
Turboexpander Performance



04TURBO.XLS
6/14/96

Solvay Interox - Longview
Turboexpander Performance



04TURBO.XLS
6/14/96

Solvay Interox - Longview
Turboexpander Project Cost Summary

Period Ending: 31 DEC 1995
($000)

G70X-0071-2377	TIC-1 Budget	Indicated Final	Variance Under (Over)
Direct Area Costs	710.7	686.8	23.9
Construction Indirects	0.0	0.0	0.0
Execution Contingency	50.0	0.0	50.0
Taxes	54.0	0.0	54.0
Total Construction Costs	814.7	686.8	127.9
Outside Engineering	55.0	87.2	(32.2)
SI-LW Engineering	0.0	21.7	(21.7)
Owner's Cost	20.0	5.8	14.2
Total Planning & Engr. Costs	75.0	114.7	(39.7)
Total Installed Cost	889.7	801.5	88.2
BPA (Note 1)	753.8	801.5	(47.7)

Notes:

1. The BPA budget is the contract budget established during the feasability phase of the project. The BPA budget differs from the TIC-1 budget as a result of anticipated cost savings to be realized if the turboexpander was installed in conjunction with LW3.

Commitments

Solvay Interox - Longiew
Turboexpander Total Actual Expenditures
Period Ending: 31 DEC 1995

G70X-0071-2377
Turboexpander

		Budget (TIC-1)	Actual To Date	Open Commits	Indicated Final
	DIRECTS (Note 1)				
D	Major Equipment	358,595.00	333,299.50	0.00	333,299.50
D	Piping	231,500.00	223,750.23	0.00	223,750.23
D	Electrical	0.00	10,230.00	0.00	10,230.00
D	Structural	0.00	11,644.00	0.00	11,644.00
D	Instrumentation	120,587.00	65,078.15	0.00	65,078.15
D	Corrosion Protection	0.00	0.00	0.00	0.00
D	Foundations / Piling (Note 2)	0.00	36,390.00	0.00	36,390.00
D	Insulation	Note 3	1,500.00	0.00	1,500.00
D	Fire Protection / Safety Equip	0.00	0.00	0.00	0.00
	Directs Subtotal	710,682.00	681,891.88	0.00	681,891.88
	INDIRECTS				
E	Primary Engineering (Industra)	55,000.00	87,228.57	0.00	87,228.57
O	Misc Engineering Contractors	0.00	0.00	0.00	0.00
O	Temp Clerical	0.00	0.00	0.00	0.00
O	Eng Supplies/Miscellaneous	0.00	2,167.36	0.00	2,167.36
S	SI Direct Salaries	0.00	0.00	0.00	0.00
I	Field Construction Mgmt (CRS Sirrene)	0.00	0.00	0.00	0.00
I	Field Const Mgmt Support - Temp Clerical	0.00	0.00	0.00	0.00
D	Contractor Overhead - Major Contracts	0.00	4,895.00	0.00	4,895.00
I	Site Improvements	0.00	0.00	0.00	0.00
O	SI & BRIS Indirect Labor	0.00	1,512.03	0.00	1,512.03
I	Field Consumables & Rentals	0.00	0.00	0.00	0.00
I	Temporary Facilities	0.00	0.00	0.00	0.00
O	Security	0.00	0.00	0.00	0.00
O	Furniture & Computers	0.00	2,148.77	0.00	2,148.77
O	Miscellaneous Owner's Cost	20,000.00	0.00	0.00	0.00
	Execution Contingency (7%)	50,000.00	0.00	0.00	0.00
	Escalation	0.00	0.00	0.00	0.00
	Taxes	54,000.00	0.00	0.00	0.00
	Indirects Subtotal	179,000.00	97,951.73	0.00	97,951.73
	Capitalized Engr Expense - SI	0.00	21,678.04	0.00	21,678.04
	TOTAL S-005 Budget for DCT	$889,682.00	$801,521.65	$0.00	$801,521.65
	Capitalized Interest	0.00	0.00	0.00	0.00
	TOTAL S-005 Budget for Accounting	$889,682.00	$801,521.65	$0.00	$801,521.65

Notes:
1. Direct Construction Costs budget includes 6% unlisted contingency.
2. E2409 was added.
3. "Insulation" estimate was included in the "Piping" budget.

FINAL_2.EXP
ppb: MMH, 6/24/96

Solvay Interox - Longview
Additional LW3 Scope Item Cost Summary
Period Ending: 31 MAY 1996

G70X-0221-3553 - Demister

		Budget	Revised TIC	Committed To Date	Indicated Final	Variance Under (Over)
	DIRECTS					
D	Major Equipment (Monsanto)	100,000.00	106,850.00	106,550.00	106,550.00	(6,550.00)
D	Misc. Equipment Mods (Wayron)		1,400.00	1,400.00	1,400.00	(1,400.00)
D	Piping (JHK - note 1)	42,310.00	44,136.00	49,695.06	49,695.06	(7,385.06)
D	Electrical (LKC)	24,000.00	30,203.00	30,203.00	30,203.00	(6,203.00)
D	Structural (JHK)		9,585.00	10,975.35	10,975.35	(10,975.35)
D	Instr Mat'l (See SI/BRIS below for Labor)		6,100.00	9,296.86	9,296.86	(9,296.86)
O	Corrosion Protection					0.00
D	Foundations / Piling (JHK)		1,390.00	(incl. in piping)	(incl. in piping)	1,390.00
D	Insulation (JHK)		9,870.00	9,870.00	9,870.00	(9,870.00)
D	Fire Protection (Grinnell)		8,125.00	8,125.00	8,125.00	(8,125.00)
D	Demolition					
	Directs Subtotal	166,310.00	217,659.00	226,115.27	226,115.27	(59,805.27)
	INDIRECTS					
E	Primary Engineering (Industra) Note 2	20,106.00	20,883.50	28,124.36	28,124.36	(8,018.36)
O	Misc Engineering Contractors					
O	Temp Clerical					
O	Eng Supplies/Miscellaneous	0.00	0.00	653.18	653.18	(653.18)
O	Permits					
S	SI Direct Salaries					
I	Field Construction Mgmt					
I	Field Const Mgmt Support - Other Mgmt					
D	Contractor Overhead - Major Contracts					
I	Site Improvements					
O	SI Indirect Labor	0.00	4,000.00	4,087.78	4,087.78	(4,087.78)
O	BRIS Indirect Labor	0.00	2,500.00	3,730.30	3,730.30	(3,730.30)
I	Field Consumables & Rentals	0.00	0.00	449.22	449.22	(449.22)
O	Security					
O	Miscellaneous Owner's Cost					
	Spare Parts					
	Execution Contingency	26,000.00	0.00	0.00	0.00	26,000.00
	Escalation					
	Taxes					
	Indirects Subtotal	46,106.00	27,383.50	37,044.84	37,044.84	9,061.16
	Total Directs and Indirects	212,416.00	245,042.50	263,160.11	263,160.11	(50,744.11)
	Total for BPA (Note 2)	**204,740.00**		**261,807.11**	**261,807.11**	
	TOTAL S-005 Budget for DCT	212,416.00	245,042.50	263,160.11	263,160.11	(50,744.11)

		Budget	Revised TIC	Committed To Date	Indicated Final	Variance Under (Over)
	BELOW THE LINE					
	Capitalized Engr Expense					
	Capitalized Interest					
	TOTAL S-005 Budget for Accounting					

Notes:
1. The original installation budget included piping and foundations. Following the HAZOP, additional equipment required installation (e.g. heat tracing, instrumentation, fire protection, structural, etc.).
2. Engineering figures include Budget & Final ($7,676 & $1,353 respectively) from WEYCO hydrogen supply job that was canceled (G70X-0221-3559).

ppb: MPB 6/24/96
FINAL_2.LW3

Solvay Interox - Longview
Additional LW3 Scope Item Cost Summary
Period Ending: 31 MAY 1996

G70X-0221-3554
Turbo Rotor Assembly

		Budget	Revised TIC	Committed To Date	Indicated Final	Variance Under (Over)
	DIRECTS					
D	Major Equipment (Atlas Copco)	52,200.00	56,100.00	56,097.27	56,097.27	(3,897.27)
D	Misc. Equipment Mods (Rotoflow)	0.00	2,500.00	2,510.68	2,510.68	(2,510.68)
D	Misc. C2405/1 Material & Allignment	0.00	1,000.00	522.38	522.38	(522.38)
D	Piping					
D	Electrical					
D	Structural					
D	Instrumentation					
O	Corrosion Protection					
D	Foundations / Piling					
D	Insulation					
D	Fire Protection					
	Directs Subtotal	52,200.00	59,600.00	59,130.33	59,130.33	(6,930.33)
	INDIRECTS					
E	Primary Engineering					
O	Misc Engineering Contractors					
O	Eng Supplies/Miscellaneous					
O	Permits					
S	SI Direct Salaries					
I	Field Construction Mgmt					
I	Field Support (Atlas Copco technician)		1,600.00	1,600.00	1,600.00	(1,600.00)
D	Contractor Overhead (Atlas Copco travel)		2,500.00	2,246.00	2,246.00	(2,246.00)
I	Site Improvements					
O	SI Indirect Labor					
O	BRIS Indirect Labor	1,000.00	1,240.00	2,570.00	2,565.43	(1,565.43)
I	Field Consumables & Rentals		1,000.00	0.00	0.00	0.00
O	Security					
O	Miscellaneous Owner's Cost					
	Spare Parts					
	Execution Contingency	17,585.00	0.00	0.00	0.00	17,585.00
	Escalation					
	Taxes					
	Indirects Subtotal	18,585.00	6,340.00	6,416.00	6,411.43	12,173.57
	Total Directs and Indirects	70,785.00	65,940.00	65,546.33	65,541.76	5,243.24
	TOTAL S-005 Budget for DCT	70,785.00	65,940.00	65,546.33	65,541.76	5,243.24

	Budget	Revised TIC	Committed To Date	Indicated Final	Variance Under (Over)
BELOW THE LINE					
Capitalized Engr Expense					
Capitalized Interest					
TOTAL S-005 Budget for Accounting					

ppb: MPB 6/24/96
FINAL_2.LW3

SOLVAY INTEROX
LONGVIEW

To: Mike Banigan
Todd Wilson

Date: August 10, 1995

From: Dan Roberts DRR

Ref. No: 95-EM240.DRR

Re: X2405 August 1,1995 Failure Analysis

---

cc: G. Hall
H. Erdelbrock
T. McLellan
D. Spencer
J. Zearfoss
E/M File

A failure analysis was conducted on the 8/1/95 incident in which the X2405 turboexpander impeller was destroyed. Root cause of the failure was a design error which allowed the introduction of water in the expander inlet during a startup of C2405/1. The water was present due to inadequate facilities for draining condensate from the minimum air flow cooler, E2409. Following are details concerning the failure and recommendations on how to prevent future occurrences.

Events preceding and during failure

Prior to 8/1/95, X2405 had been on-line (i.e. running with process gas flow through the expander) without interruption for ten days. This was the longest continuous run up to that time. On the morning of 8/1/95, work was being conducted to modify the controls associated with the minimum air flow valve, FV X2405/E. During this work the machine was inadvertently tripped. The failure occurred during the restart from this shutdown.

When the compressor was restarted, it completed its programmed 30 second unloaded start and tripped on high vibration within ten seconds of loading. It is important to note that until the compressor loads, there is nearly no flow moving through the turboexpander minimum air flow loop. When the compressor loads, this flow almost instantly increases to over 5000 scfm.

At this time field personnel identified water leaking from a flange immediately downstream of X2405. Further investigation revealed water in a low point upstream of the machine, in the expander housing itself, and in the downstream piping. No water was found in the liquid trap on the outlet of E2409 nor in the

exchanger itself. No measurements were made of the volume of water drained from the various locations.

Subsequent to draining all lines and verifying that the system was free of liquid, a restart of the machine was attempted. Although the compressor was successfully restarted, attempts to put the turboexpander back on-line failed. Damage to the machine was suspected and a decision was made to disassemble it.

Results of failure

Inspection quickly revealed that the turboexpander had suffered a catastrophic failure and that the expander wheel was loose in the housing. Complete disassembly revealed that the tie-bolt, outboard washer and nut had unthreaded from the shaft. Having traveled downstream in the process piping to an inaccessible location they were not recovered. Following is a summary of the damage to the equipment :

- The expander wheel contacted the housing and damage is irreparable.
- The nozzle block suffered minor damage but no significant loss of base metal. The nozzle tips were slightly bent and aluminum from the wheel was laid down on the follower.
- The tie-bolt, outboard washer and nut traveled downstream in the process piping and were not recovered.
- The compressor pinion suffered only minor damage and will require machining prior to reassembly of the turboexpander. The compressor is currently running with this pinion and vibration levels are normal.
- The gas seals were not damaged and showed no signs of contact.

The compressor was carefully inspected and subsequently put back on-line with the turboexpander wheel and nozzle assembly removed. The compressor is operating within normal parameters.

Necessary repairs to X2405 are estimated at roughly $65k with a four day outage of C2405/1 required. This cost is based on materials, on-site vendor support, and in-house labor to replace the rotor assembly with minimal downtime on the machine.

Technical analysis

As an integral part of a motor driven compressor the turboexpander spins whenever the compressor is running and, at various times during operation, is either a driving or a driven machine. When it is not producing horsepower (i.e. is off-line) the expander consumes energy and, therefore, generates heat and requires cooling. Cooled air flow on the order of 3500 scfm must be routed

through the expander. This cooling flow is provided via a flow control valve, FV X2405/E, a cooler, E2409, and the associated piping. Attachment 1 is a simplified P&I diagram and a brief description of the system.

The impeller in the turboexpander is driven by friction induced by a compression load at the attachment point between shaft and wheel. The compression is supplied by a bolted joint. A compression load capable of supporting 2x the maximum calculated torque is applied by pre-stretching the tie-bolt. The direction of the threads in this joint are based on the direction of the torsional load during normal operation (i.e. expander on-line).

In the 8/1/95 failure of X2405 several gallons of condensate were ingested with the cooling air flow. This liquid contacting the impeller vanes, with tip speeds of 900 fps, induced enough reverse torque (i.e. opposite to the direction of the bolt threads) to exceed the capacity of the bolted joint and the impeller released itself from the shaft. With the wheel turning at a speed of nearly 20,000 rpm this occurred so rapidly that the tie bolt virtually shot out of the joint, and the impeller wheel separated from the shaft without causing any serious damage to the compressor.

Up to this point in the investigation, the physical cause and effect of the failure were straightforward. The major item still unresolved was the source of the water. It seemed obvious that the water in question was trapped in the minimum air flow loop which had been inactive for the ten day period that X2405 was on-line. When the compressor was restarted and loaded, then, the liquid carried over into the expander inlet.

E2409 is equipped with a liquid separator on its outlet which is designed to remove condensate (see Attachment 2, figure 2a). The separator is fitted with a trap and bypass. According to reports by personnel on-site during the failure, the trap bypass was not blown down per SOP prior to starting the machine. Subsequent testing, however, indicated that the trap was functioning properly prior to the incident. The fact that the operator failed to check the drains did not contribute to the failure.

The ultimate problem identified is a design error in the liquid removal system for E2409. Assuming design flow through the exchanger, the existing drain/trap was properly located in the low point of the liquid separator. When the system has low/no flow, however, condensate can accumulate in the exchanger heads and lower tubes (refer to figure 2a). When flow was suddenly established (as was previously explained) the carryover of trapped liquid was more than the separator and associated trap could remove. This resulted in the "slug" of liquid which destroyed the machine.

A contributing factor to the volume of liquid which had accumulated during the ten days prior to the failure was that FV X2405/E was leaking through. This provided a constant source of hot, saturated air from which the liquid condensed.

This theory on the source of the liquid has been verified. Conditions similar to those which existed in E2409 during the ten day period in question were simulated. After four days the existing low point blow-down was opened and no liquid was present. The exchanger low point, however, yielded approximately seven gallons of water.

Conclusions/Recommendations

The technical explanation of the impeller-to-shaft attachment in the subject machine and how it failed is in no way intended as an indictment of this particular rotor design. In cooperation with the vendor (and before they had knowledge of the liquid ingestion) an in-depth design review was conducted and no flaws or oversights were identified. From both a theoretical standpoint and through operating experience, it is a proven design. With the available data, there is no accurate way to calculate the torsional load caused by this incident. There is, therefore, no way to definitively show whether the rotor failed prematurely. The writer is, however, confident in stating that no manufacturer of high speed, gas handling, rotating machinery will suggest that their equipment will survive substantial liquid ingestion. The solution to this problem is elimination of the liquid, not redesign of the machinery.

That having been said, the root-cause of this failure was a system design error. An oversight in the location of lowpoint drains/traps allowed condensate to accumulate in the system until it was ingested by the turboexpander in one "slug". To prevent recurrence of this event the following recommendations are made:

1. Modify the liquid drain/trap configuration on E2409 per Attachment 2, figure 2b.
   - Heat trace and insulate all associated piping

2. Heat trace and insulate (removable) the outlet head and separator for E2409
   - Condensate may accumulate and freeze in cold weather regardless of adequacy of drains/traps

3. Reconfigure the piping associated with FV X2405/E to eliminate a lowpoint between the valve and E2409

4. Institute a periodic activation of the minimum flow system when X2405 is on-line for extended periods of time.

- This may be done via Manufacturing SOP's or could be configured in the DCS to automatically take place.

5. Include routine blow-downs of all traps associated with the process air compressors and turboexpander into operator rounds.
   - Minimum once per day, once per shift recommended
   - Reference to this failure should be used to emphasize necessity for this action with Manufacturing personnel

Attachment 3 summarizes estimated costs for required repairs and for implementation of the recommended hardware upgrades.

Attachment 1
X2405/1 TURBOEXPANDER CONTROLS

Normal Operation

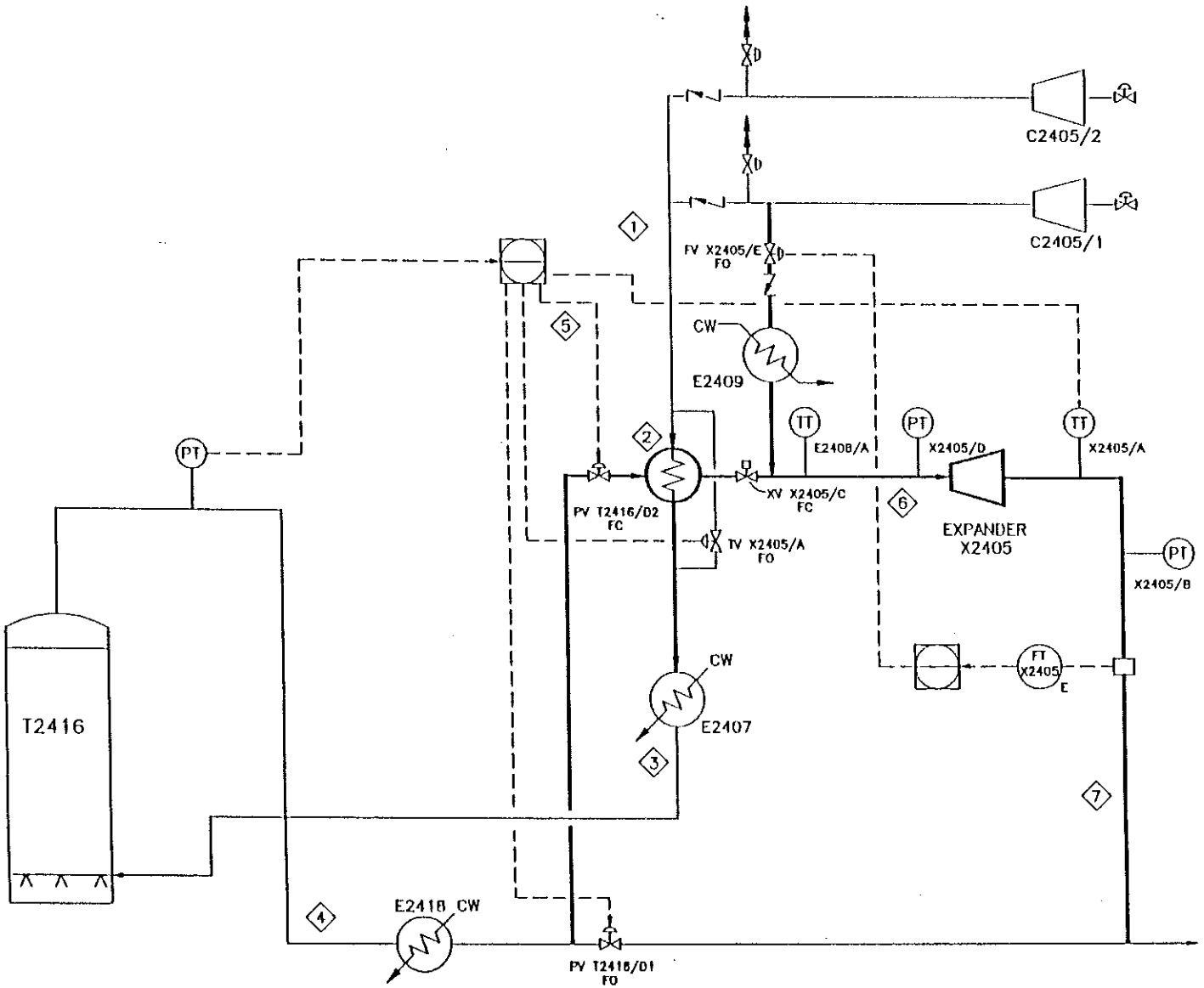
1. Compressor loaded
2. XV X2405/C open (PLC)
3. FV X2405/E active on flow control but closed due to minimal setpoint (DCS)
4. TV X2405/A active on temperature control (DCS); this valve is 100% closed during normal, steady-state conditions
5. PV T2416/D2 active (DCS)
   - primary control is pressure setpoint on T2416
   - override control is process temperature downstream of X2405 (i.e. bypasses expander to maintain downstream temperature above 3°C.)
   - Note: If temperature downstream of X2405 exceeds 48°C the DCS shall shut down the compressor. This is a process safety interlock.

Expander "Off-line" Condition - Defined as any condition during which the normal process flow is not flowing through the expander but the compressor is running

1. XV X2405/C closed
2. TV X2405/A open
3. FV X2405/E active on flow control; maintains minimum cooling air flow(DCS)
4. PV T2416/D2 closed (DCS)

Notes:

- The same downstream temperature process safety interlock applied as during normal conditions.



NOTES

	Nm^3/hr	Barg	°C
1	36,000	>6.5	115
2	36,000	>6.5	50
3	36,000	6.5	30
4	30,400	5.0	50
5	30,400	4.9	25
6	30,400	4.8	100
7	30,400	0.2	2

1. BOLD LINE REPRESENTS EXPANDER PROJECT.

DOC. NO.	SUBJECT

REFERENCES

REV. NO.	DESCRIPTION	DATE	I.I.E. BY	SFTY	MAINT	MFG	ENG

REVISIONS

DWG. TITLE

TURBO EXPANDER CONTROL SYSTEMS

DWG. SCALE	ESR NO.	DRAFTING NO.	AREA
NONE	-	DRR-1	

SOLVAY INTEROX
LONGVIEW, WASHINGTON

DWG NO.	REV.
DRR-1	0

Attachment 2
E2409

Figure 2.a
E2409 (existing)

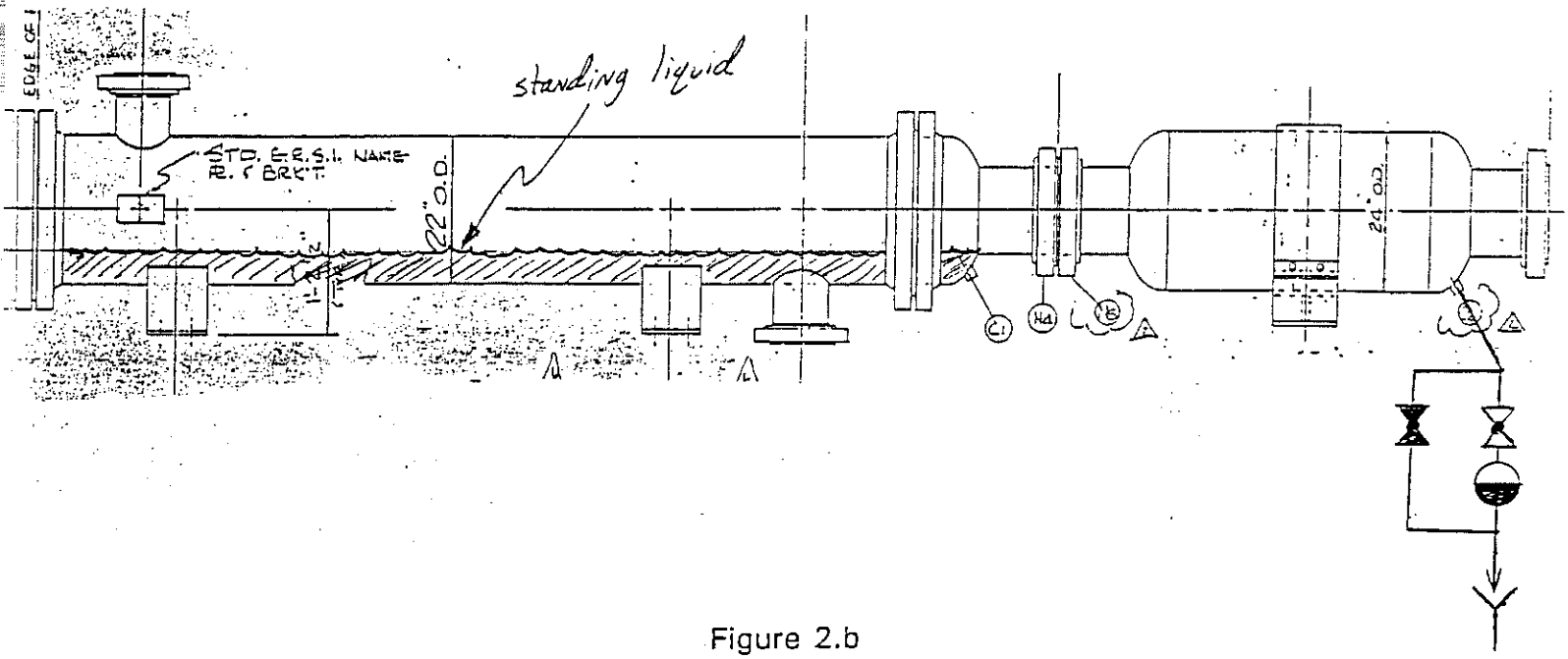
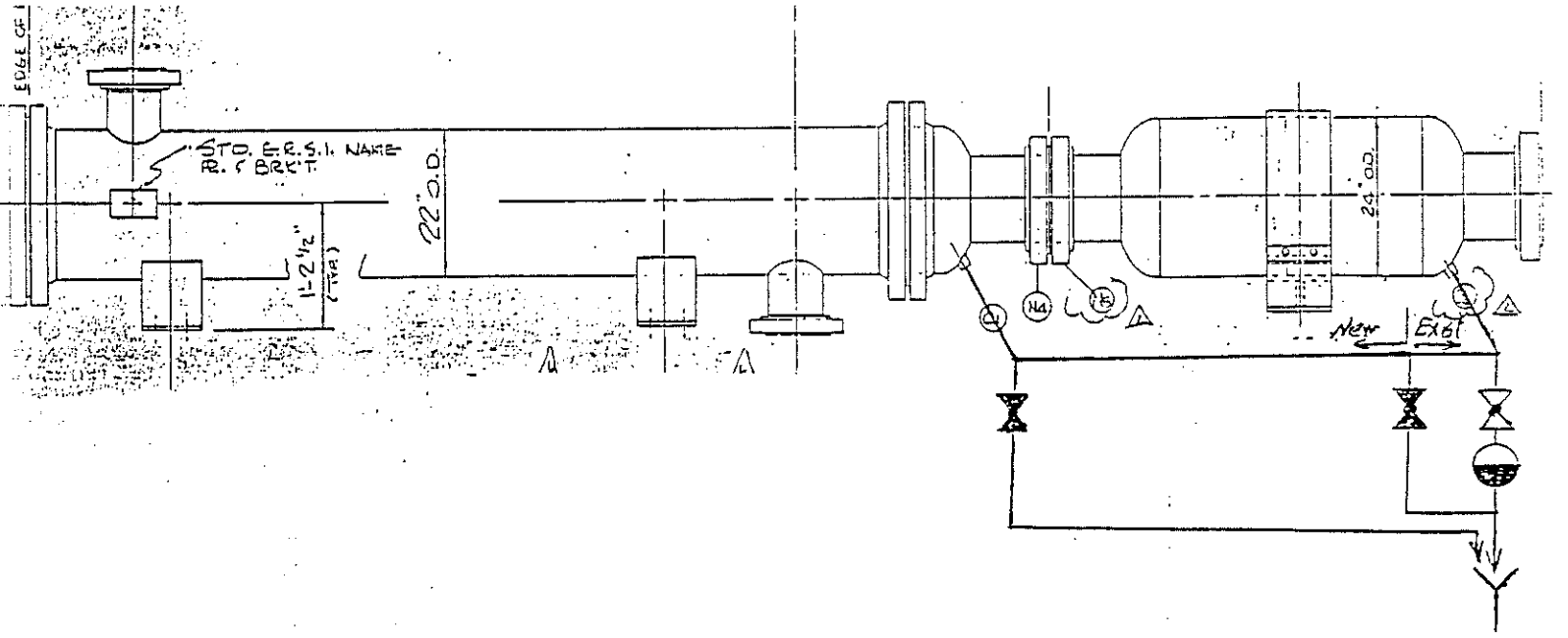


Figure 2.b
E2409 (proposed)



Attachment 3
Estimated costs for Repairs and Recommended Upgrades

• Replacement of damaged rotor assembly	$65,000
• Upgrades to drains/traps on E2409	$1,000
• Modifications to piping around FV X2405/E	$800
• Heat tracing/insulation	$4,000
Total estimated cost :	$70,800