

APPENDIX A

This table lists the variables contained the database *data_base.mat* together with a description of each variable.

Matlab Variable	Variable Description
i	Wavelet level number
j	Variable number
x	Dataset number
bipl_index_lev_i	Biplot level index
demap_b1_lev_i	First layer bias values for the demapping neural network
demap_b2_lev_i	Second layer bias values for the demapping neural network
demap_f1_lev_i	First layer transfer function for the demapping neural network
demap_f2_lev_i	Second layer transfer function for the demapping neural network
demap_w1_lev_i	First layer weights for the demapping neural network
demap_w2_lev_i	Second layer weights for the demapping neural network
ddeg_var_j	Daubechies degree applied to each variable during wavelet analysis
filt_var_j	Reconstructed, thresholded signal
FSr_level_i	Reduced linear principal component scores
lpca_l_lev_i	Eigenvalues of covariance matrix
lpca_lr_lev_i	Reduced eigenvalues of covariance matrix
level_thwc_i	Thresholded wavelet coefficients
lpca_scr_lev_i	Linear principal component scores
lpca_sumry_lev_i	1 st column: Proportion of total variability accounted for by each pc 2 nd column: Cumulative variability
lpca_u_lev_i	Linear principal loading (eigenvectors of the covariance matrix)
lpca_ur_lev_i	Reduced principal loadings
map_b1_lev_i	First layer bias values for the mapping neural network
map_b2_lev_i	Second layer bias values for the mapping neural network
map_f1_lev_i	First layer transfer function for the mapping neural network
map_f2_lev_i	Second layer transfer function for the mapping neural network
map_w1_lev_i	First layer weights for the mapping neural network
map_w2_lev_i	Second layer weights for the mapping neural network
mra_var_j	Multilevel reconstructed signal based on wavelet coefficients
mwsiz_var_j	Maximum window size for wavelet analysis
newdata	New data on which to test the final NLMSPCA model
newdatan	Normalized new data
newdatas	Standardized new data
nlpca_b1_lev_i	First layer bias values for the input training neural network
nlpca_b2_lev_i	Second layer bias values for the input training neural network
nlpca_f1_lev_i	First layer transfer function for the input training neural network
nlpca_f2_lev_i	Second layer transfer function for the input training neural network
nlpca_scr_lev_i	Nonlinear principal components generated from the input training neural network
nlpca_w1_lev_i	First layer weights for the input training neural network
nlpca_w2_lev_i	Second layer weights for the input training neural network
num_var	Total number of variables
Num_pcs_x	Number of principal components to retain
orig_var_j	Original variables before normalization or standardization

APPENDIX A

testdata	Validation data
testdatan	Normalized validation data
testdatas	Standardized validation data
th_level_i	Thresholded wavelet coefficients for each level
thmra_var_j	Multilevel reconstructed signal based on thresholded wavelet coefficients
thtype_var_j	Threshold type applied to each variable
traindata	Training data used to train the NLMSPCA model
traindatan	Normalized training data
traindatas	Standardized training data
Ur_level_i	Reduced linear principal component loadings
wlevels	Total number of wavelet decomposition levels
wlevs_var_1	Number of wavelet decomposition levels applied to each variable



APPENDIX B

This appendix gives a short description of how the interfaces were created if someone is interested in creating similar interfaces.

The following procedure creates the basic interface template on which to add buttons, text boxes, etc.:

1. Create the background using Microsoft PowerPoint.
2. After creating the background, run the background as a PowerPoint presentation, filling the whole screen.
3. Capture the screen by pressing the *Alt* and *Print Screen* keys on the keyboard simultaneously.
4. Past the image in a picture editor, in this case Microsoft Picture Editor.
5. Cut out the part of the image that is needed and past it as a new image.
6. Save the image as a bitmap file.
7. From the Matlab prompt change to the directory containing your bitmap image.

```
>> cd c:\asm\interfaces\images
```

8. Type the following command at the Matlab prompt

```
>> [a, b] = imread('my_image.bmp');
```

```
>> image(a);
```




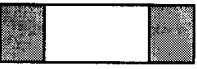
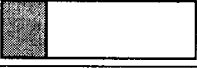

```
>> guide
```

This will display the image as a new figure and activate Guide Control Panel which is the graphical user interface editor. The figure can be sized and scaled to preference and is ready to be used as a background. Buttons, edit boxes, etc. can be added on top of the image.

9. The best way to create such an interface is to open an existing interface from the Matlab command window and to type

```
>> guide
```


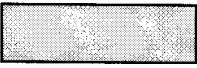

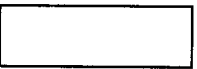
which will launch the Guide Control Panel. Use the Property Editor and Callback Editor to view the different properties and their values.

Colour Code	Description
	Background (bitmap)
	Push button
	Edit box
	Slider
	Popup menu
	Axis

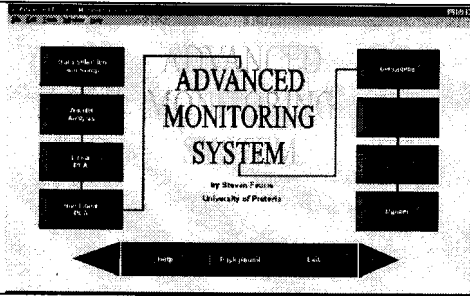

APPENDIX B

A few examples are provided to illustrate the most important parameters and their values.



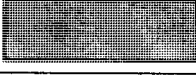
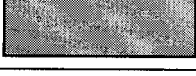
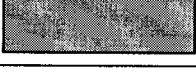
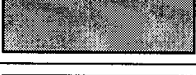

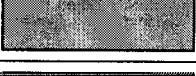


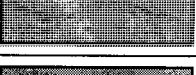

Database_fig

		Callback	Other	Function
FileName : 'C:\ASM\monitor\Interfaces\setup\database_fig.m' Tag : dbfig Name : Database Setup			NumberTitle: 'Off' Resize: 'Off'	
	psuccess.bmp			Interface background
Axes			'Ytick','[]', 'Xtick','[]', 'Layer','Bottom'	
	Db_push_01	dbsetup	'String','OK'	Accept and advance to next interface
	Db_edit_01		'String','data_base'	Specify name of database

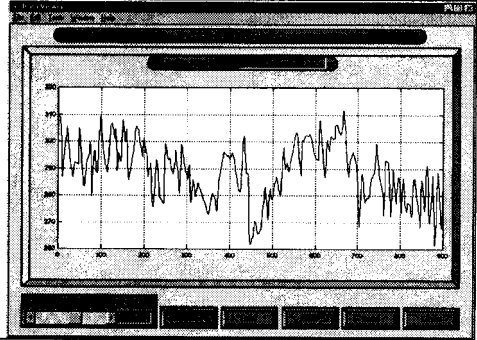


Int_main

		Callback	Other	Function
FileName : 'C:\ASM\monitor\Interfaces\int_main.m' Tag : int_01 Name : Advanced Monitoring System				
	Int_main.bmp			Interface background
Axes			'Ytick','[]', 'Xtick','[]', 'Layer','Bottom'	
Figure			'Name','Advanced Process Monitoring System' 'NumberTitle','Off', 'Resize','Off'	








APPENDIX B

	int_01_start_01	int_data	CData : a [a,b]=imread('button 01.bmp');	Data selection and Setup
	int_01_start_02	Int_wave	CData : a [a,b]=imread('button 02.bmp');	Wavelet Analysis
	int_01_start_03	Int_lpca_main	CData : a [a,b]=imread('button 03.bmp');	LPCA
	int_01_start_04	Fig_05_main	CData : a [a,b]=imread('button 04.bmp');	NLPCA
	int_01_start_05		CData : a [a,b]=imread('button 05.bmp');	Demapping
	int_01_start_06		CData : a [a,b]=imread(bck_m arb.bmp');	
	int_01_start_07		CData : a [a,b]=imread(bck_m arb.bmp');	
	int_01_start_08		CData : a [a,b]=imread('button 08.bmp');	Monitoring
	Int_01_help_01		CData : a [a,b]=imread(bck_m arb.bmp');	
	int_01_bckg_01	Bckgr_01_01	CData : a [a,b]=imread(bck_m arb.bmp');	Background
	int_01_exit_01	Int_exit	CData : a [a,b]=imread(bck_m arb.bmp');	Exit
	int_01_next_01	int_data	CData : bck_marb.bmp	Next

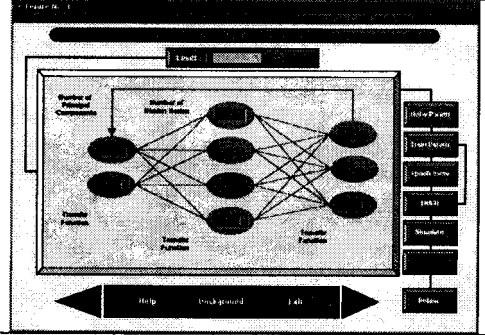





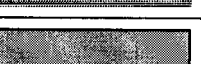
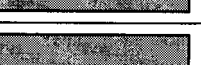
View_01a

	Callback	Other	Function
Name : Data Viewer Filename : c:\asm\monitor\programs\data\view_01a.m Tag : viewer_01a			
	View_01a.bmp		Background image
	view_01a_edit_02		Matlab variable containing data



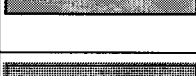
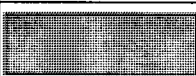
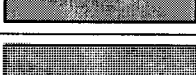

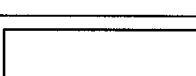


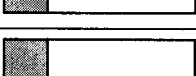

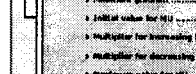


APPENDIX B

	view_01a_plot_01		Layer : top	
	view_01a_slid_01	plot_01a	Max Min SliderStep Value	
	view_01a_edit_01	int_main	String	
	view_01a_grid_01	grid_on_off	String	Grid on/off
	view_01a_hold_01	hold_on_off	String	Hold On/off
	view_01a_hold_01			Help
	view_01a_close_01			Close

Fig_05_main

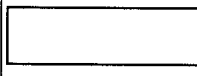
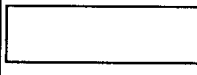
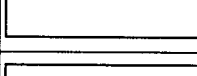
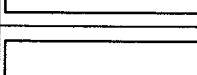
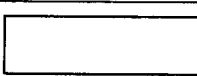
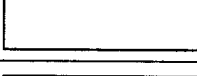




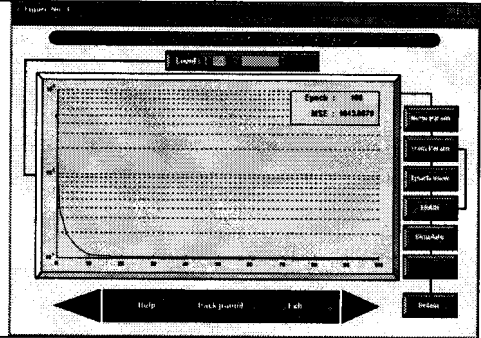



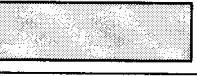

		Callback	Other	Function
MAIN				
				Interface background
	fig_05m_pop_01			Specify wavelet level to analyze
	fig_05m_edit_01			Display slider value
	fig_05m_push_01	Fig_05_push('net w')		Network parameters Display layer 1
	fig_05m_push_02	Fig_05_push('train')		Training parameters
	fig_05m_push_03	Fig_05_push('epoch')		Epoch view
	fig_05m_push_04			Train network

APPENDIX B

	fig_05m_push_05			Simulate network and plot comparison and error
	fig_05m_push_06			
	fig_05m_push_07			Retain network parameters if results are satisfactory
				Previous step (lpca)
				Help
				Background
				Exit
				Next step (demapping)
LAYER 1				
	Fig_05m_edit_03			Number of PC's
	Fig_05m_edit_02			Number of hidden nodes
	Fig_05m_text_01			Number of variables
	Fig_05m_pop_01			Input layer transfer function
	Fig_05m_pop_02			Hidden layer transfer function
	Fig_05m_pop_03			Output layer transfer function
LAYER 2	Fig_05_a			



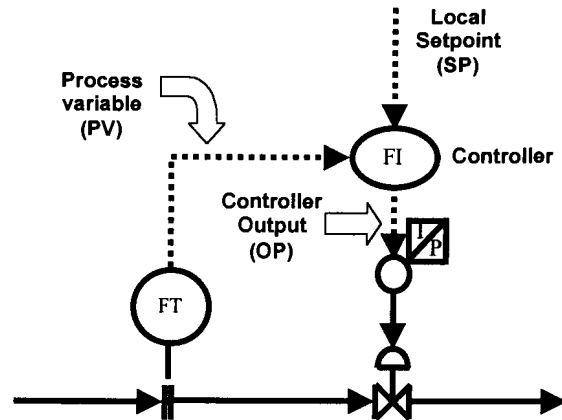
APPENDIX B

	Fig_05a_edit_01		'Visible','Off'	Epochs between updating display
	Fig_05a_edit_02		'Visible','Off'	Maximum number of epochs to train
	Fig_05a_edit_03		'Visible','Off'	Sum-squared error goal
	Fig_05a_edit_04		'Visible','Off'	Minimum gradient
	Fig_05a_edit_05		'Visible','Off'	Initial value for mu
	Fig_05a_edit_06		'Visible','Off'	Multiplier of increasing mu
	Fig_05a_edit_07		'Visible','Off'	Multiplier of decreasing mu
	Fig_05a_edit_08		'Visible','Off'	Maximum value for mu
	Fig_05a_edit_09		'Visible','Off'	Learning rate for input training
	Fig_05a_image_01		'Visible','Off'	
				
LAYER 3	Fig_05_b		'Visible','Off'	
	Fig_05b_line_01		'Visible','Off'	
	Fig_05b_text_04		'Visible','Off'	Epoch string
	Fig_05b_text_02		'Visible','Off'	Display epoch number
	Fig_05b_text_03		'Visible','Off'	Error string
	Fig_05b_text_01		'Visible','Off'	Display SSE

APPENDIX C

The purpose of the taglist is as follows:

- It gives a summary of all the variables (total number and type) that had to be considered when selecting the most important variables for modeling purposes.
- It gives an indication of the signal source which can be one of the following:
 - OP = controller output signal
 - SP = set point
 - PV = process variable
 - CR, CK, CS = calculated



- The tag number gives an indication of the type of signal, i.e. 36P1001D.OP is a pressure signal.
- The tag number also gives the process unit where the signal is generated, 36P1001D.OP indicates that the signal is generated in unit 36. If all the tags are viewed it can be gathered that variables from many process units had to be considered which made it even more difficult since each unit is operated independently.
- The shaded cells contain the variables that were used in the modeling and indicate how they were calculated.

TAGLIST			
NO	TAG	DESCRIPTION	INFO
1	63P1001D.OP	43-8BAR LETDOWN VLV 1	
2	63P1001E.OP	43-8BAR LETDOWN VLV 2	
3	63P1001F.OP	43-8BAR LETDOWN VLV 3	
4	63P1001G.OP	43-8BAR LETDOWN VLV 4	
5	63P1005A.OP	43-4BAR LETDOWN VLV 1	
6	50FIC140.PV	43 BAR STEAM FLOW	Gasification exp
7	50FIC142.PV	43 BAR STEAM FLOW FASE 2	Gasification exp
8	10F0164.PV	HP STEAM HEADER FLOW	
9	10F2564.PV	HP STEAM HEADER FLOW	
10	20F1127.PV	SATURATD HPSTM EXPORT	
11	20F1239.PV	HP SAT STEAM EXPORT	
12	16F1036.PV	ES115 REB STM FL	Phenosolvan exp
13	23F2077.PV	H.P.STM TO REB	Benfield/Cold Sep exp
14	32F1034.PV	HPSU STM TRAIN 1	Cat Cond/LPG Recovery exp
15	32F2034.PV	HPSU STM TRAIN 2	Cat Cond/LPG Recovery exp
16	29F1006.PV	HP STEAM TO ES-101B	Light Oil Fractionation exp

APPENDIX C

17	29F1005.PV	HP STEAM TO ES-101A	Light Oil Fractionation exp
18	37F1023.PV	FIC MEK DEH TWR ST	CWU exp
19	37F1022.PV	FIC ACETONE RECYC	CWU exp
20	15F1028.PV	HPSA STM	Naphta exp
21	35F1108.PV	HPSA STM TO UNIT 35	Distillate HTU exp
22	27F1077.PV	HP STM ES-109	Isomerisation exp
23	14F1003.PV	HPSA STM TO REB	Tar exp
24	14F2003.PV	HPSA STM TO REB	Tar exp
25	14F3003.PV	HPSA STM TO REB	Tar exp
26	14F4003.PV	HPSA STM TO REB	Tar exp
27	71F0126.PV	2500 kPa steam to VL104	Acid Recovery exp
28	71F0202.PV	2500 kPa steam to VL201	Acid Recovery exp
29	71F0209.PV	2500 kPa steam to VL202	Acid Recovery exp
30	71F0218.PV	2500 kPa steam to 71VL203	Acid Recovery exp
31	20F084.CS	REACTION WATER	
32	20F1111.CS	T.T REACT H2O	
33	20F1001A.PV	PURE GAS FEED TRAIN 1	
34	20F2001A.PV	PURE GAS FEED TRAIN 2	
35	20F3001.PV	PURE GAS FEED TRAIN 3	
36	20F4001.PV	PURE GAS FEED TRAIN 4	
37	20F5001.PV	PURE GAS FEED TRAIN 5	
38	20F6001A.PV	PURE GAS FEED TRAIN 6	
39	20F7001A.PV	PURE GAS FEED TRAIN 7	
40	20F8001.PV	PURE GAS FEED TRAIN 8	
41	20F1002A.PV	EXT RECYCLE FEED TRN 1	
42	20F2002.PV	H2 RICH REF.GAS TRAIN 2	
43	20F3002.PV	H2 RICH REF.GAS TR 3	
44	20F4002A.PV	EXT RECYCLE FEED TRN 4	
45	20F5002.PV	H2 RICH REF GAS TRAIN 5	
46	20F6002A.PV	EXT RECYCLE FEED TRN 6	
47	20F7002A.PV	EXT RECYCLE FEED TRN 7	
48	20F8002.PV	H2 RICH REF GAS TRAIN 8	
49	20F0102.PV	REF GAS FLOW TO PLANT	
50	20F1080.PV	TAILGAS PRODUCT TRAIN 1	
51	20F2080.PV	TAILGAS PRODUCT TRAIN 2	
52	20F3080.PV	TAILGAS PRODUCT TRAIN 3	
53	20F4080.PV	TAILGAS PRODUCT TRAIN 4	
54	20F5080.PV	TAILGAS PRODUCT TRAIN 5	
55	20F6080.PV	TAILGAS PRODUCT TRAIN 6	
56	20F7080.PV	TAILGAS PRODUCT TRAIN 7	
57	20F8080.PV	TAILGAS PRODUCT TRAIN 8	
58	12F1003.PV	PURE GAS FLOW TR1	
59	12F2003.PV	PURE GAS FLOW TR2	
60	12F4003.PV	PURE GAS FLOW TR4	
61	12F5003.PV	PURE GAS FLOW TR5	
62	F0F1013A.PV	S3 TO S2 PURE GAS	
63	F0F1013B.PV	S2 TO S3 PURE GAS	

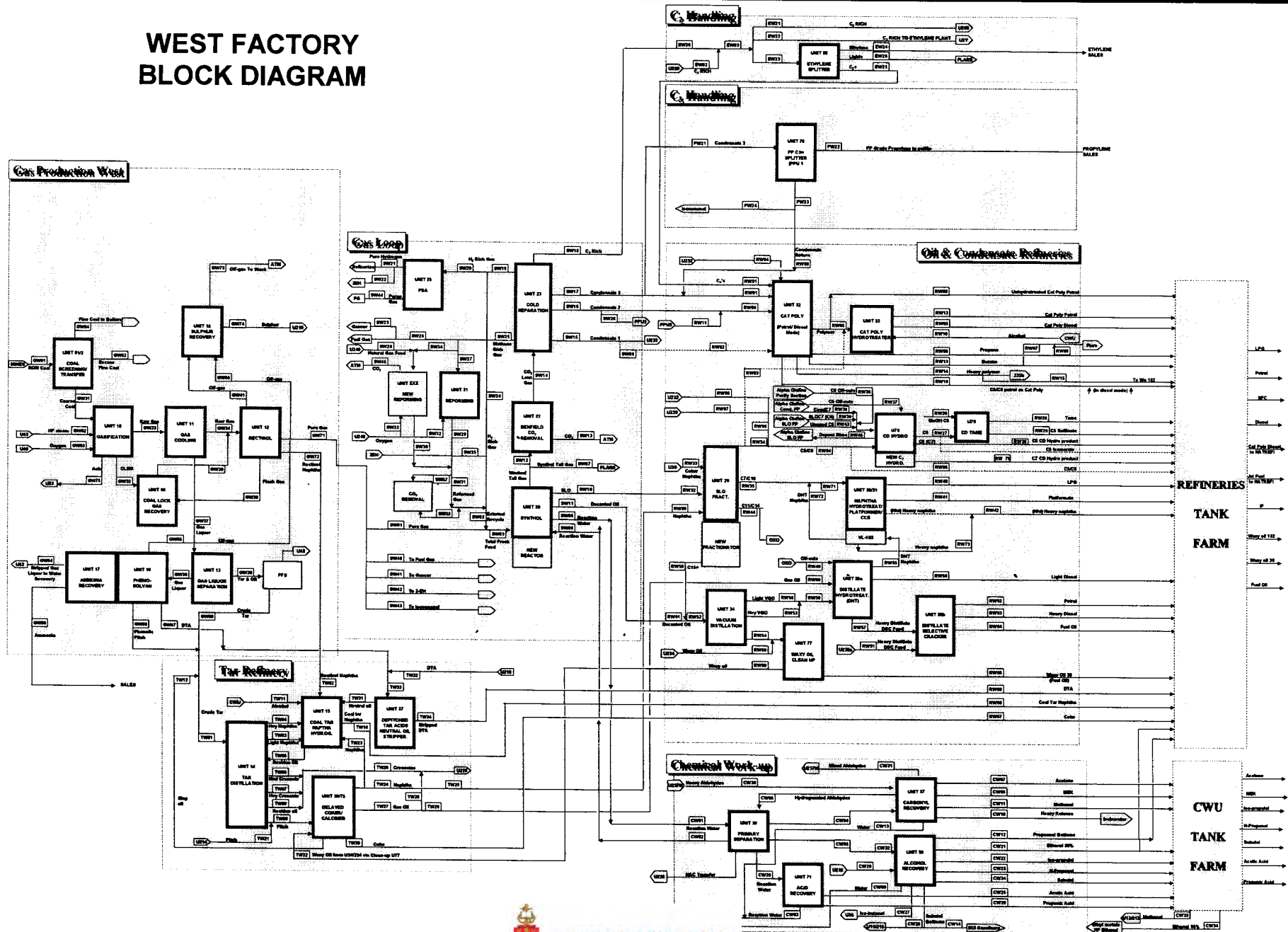


APPENDIX C

64	20F1092.PV	TAIL GAS WASH TWR OVHD A	
65	20F1096.PV	TAIL GAS WASH TWR OVHD B	
66	10K0146.CS	TOT LPTYD.VERGSRS	Total gassifiers on line
67	21K0168.CR	TOTAAL	Total reformers on line
68	20K1001.CR	use for 20K1001A.CR	
69	20K2001.CR	use for 20K1001A.CR	
70	20K3001.CR	RUN STATUS TR3	
71	20K4001.CR	RUN STATUS TR4	
72	20K5001.CR	RUN STATUS TR5	
73	20K6001.CR	RUN STATUS TR6	
74	20K7001.CR	RUN STATUS TR7	
75	20K8001.CR	RS901 on Line	
76	20F0101.CK	TOT SUIWERGAS TO SYNTHOL	
77	20F0102.CK	TOTAL REF GAS +H2	
CALCULATED			
78		Total Rectisol Feed	58+59+60+61+62-63
79		Total PG feed	33+34+35+36+37+38+39+40
80		Total RG Feed	41+42+43+44+45+46+47+48
81		Total FF	79+80
82		Total Tailgas	64+65
83		CFB's on Line	70+72
84		SAS (10.7m) on Line	(68+69+73+74)/[2]
85		SAS (8.0m) on Line	71+75
86		43-8BAR LETDN FLOW VLV1	1*[2.3379]
87		43-8BAR LETDN FLOW VLV2	2*[2.3379]
88		43-8BAR LETDN FLOW VLV3	3*[1.96695]
89		43-8BAR LETDN FLOW VLV4	4*[1.96695]
90		43-4BAR LETDN FLOW	5*[1.96248]
91		Total Steam Consumers	
92		Total Steam Letdn	86+87+88+89+90
93		Total Steam Export (Calc)	91+92
94		Total Steam Export (Meas)	10+11

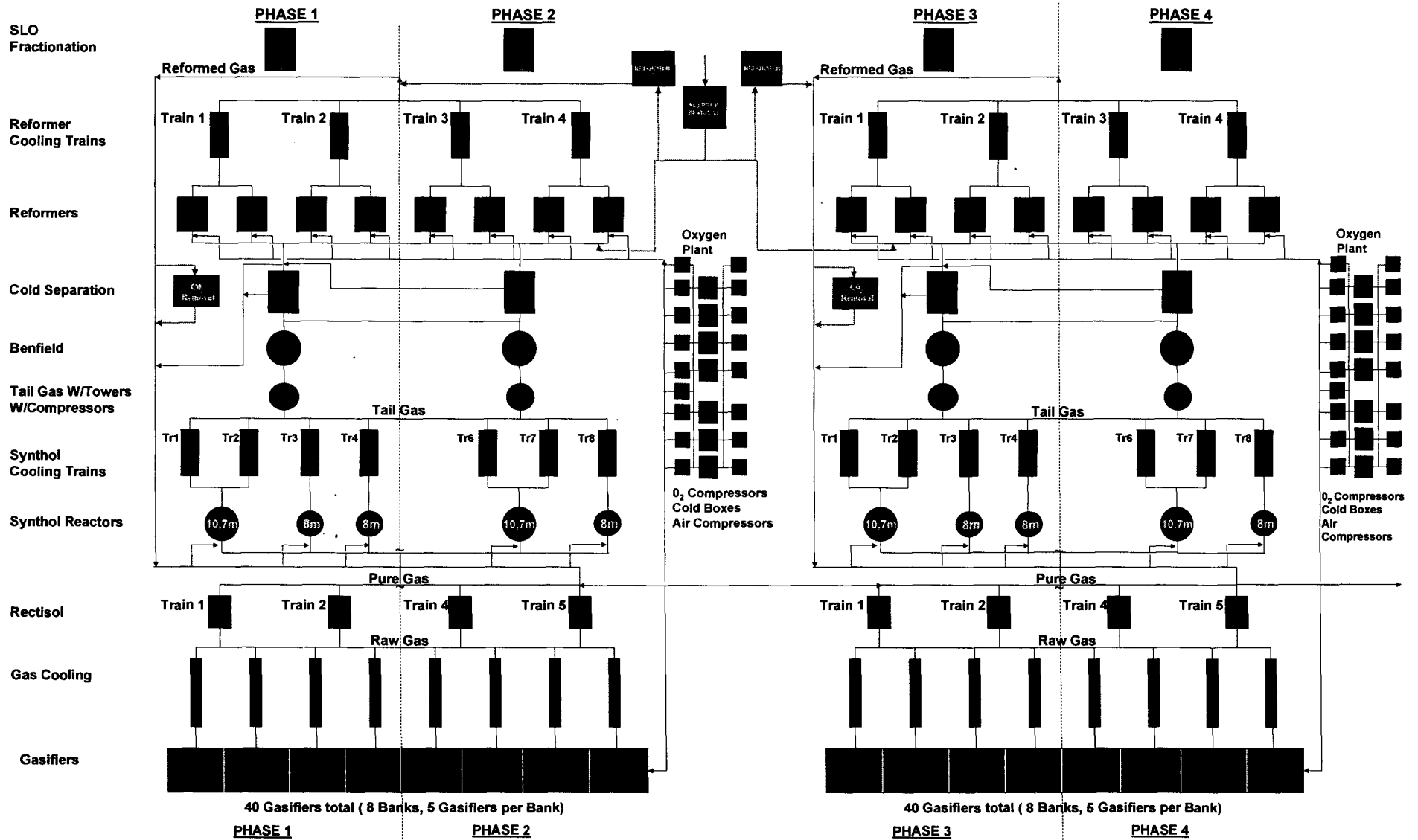


WEST FACTORY BLOCK DIAGRAM



WEST FACTORY PHASES AND TRAINS

EAST FACTORY PHASES AND TRAINS



REFERENCES

- Abbas, H. M., and M. M. Fahmy, "Neural Model for Karhunen Loeve Transformation with Application to Adaptive Image Compression," *Proc. Inst. Elec. Eng., I. Commun. Speech Vision*, **2**, 135 (1993).
- Abnormal Situation Management Consortium Website: www.iac.honeywell.com/Pub/AbSitMang/.
- Ackley, D. H., G. E. Hinton, and T. J. Sejnowski, "A Learning Algorithm for Boltzmann Machines," *Cognitive Sci.*, **9**, 147 (1985).
- Anderson, N.R. and P. Vamsikrishna, "Best Practices for Information Presentation to Operators," *Proceedings of the AIChE 1996 Process Plant Safety Symposium*, Houston, Texas, 224 (1996).
- Bakshi, B. R. and G. Stephanopoulos, G., "Representation of Process Trends – 3: Multiscale Extraction of Trends from Process Data," *Computers and Chemical Engineering*, **18**, 267 (1994).
- Bakshi, B. R. and G. Stephanopoulos, "Reasoning in Time: Modelling, Analysis and Pattern Recognition of Temporal Process Trends," In G. Stephanopoulos, & Han, *Intelligent Systems in Process Engineering – Paradigms from design to Operations*, 487 (1996).
- Bakshi, B. R., "Multiscale PCA with Application to Multivariate Statistical Process Monitoring," *AIChE J.*, **44**(7), 1596 (1998).
- Berman, Z., and J. S. Baras; "Properties of the Multi-Scale Maxima and Zerocrossing Representations," *IEEE Transactions on Signal Processing*, **41**, 3216 (1993).
- Bowman, A. W., " An Alternative Method of Cross-Validation for the Smoothing of Density Estimates," *Biometika*, **71**, 353 (1984).
- Bullemer, P. and I. Nimmo, "Tackle Abnormal Situation Management with Better Training," *Chemical Engineering Progress*, **94**(1), 43 (1998).
- Chen, B. H., X. Z. Wang, S. H. Yang and C. McGreavy, "Application of Wavelets and Neural Networks to Diagnostic System Development, 1, Feature Extraction," *Comput. Chem. Eng.*, **23**, 899 (1999).
- Cheung, J. T. Y. and G. Stephanopoulos, "Representation of Process Trends – 1: a Formal Representation Framework," *Comput. Chem. Eng.*, **14**, 495 (1990).
- Chui, C. K., *An Introduction to Wavelets*, Academic Press: New York, 1-18 (1992).
-

References

- Cochran, E., and P. Bullemer, "Abnormal Situation Management: Not By New Technology Alone," *Proceedings of the AIChE 1996 Process Plant Safety Symposium*, Houston, Texas, 218 (1996).
- Cohen, A., I. Daubechies, and P. Vial, "Wavelets on the Interval and Fast Wavelet Transform," *Appl. Comput. Harmonic Anal.*, **1**, 54 (1993).
- Cottrel, G. W., P. Munro, and D. Zipser, "Learning Internal Representations from Gray-Scale Images: An Example of Extensional Programming," *Proc. Conf. Cognitive Sci. Soc.*, 461 (1987).
- Cvetkovic, Z., and M. Vetterli, "Discrete-Time Wavelet Extrema Representation: Design and Consistent Reconstruction," *IEEE Transactions on Signal Processing*, **43**, 681 (1995).
- Cybenco, G., "Approximation by Superpositions of a Sigmoidal Function," *Math. Control, Signals, Syst.*, **2**, 303 (1989).
- Dai, X., B. Joseph, and R. L. Motard, "Introduction to Wavelet Transformation and Time Frequency Analysis," In R. L. Motard, and B. Joseph, *Wavelet Applications in Chemical Engineering*, 1-32, Dordrecht: Kluwer (1994).
- Daiguji M.; O. Kudo, and T. Wada, "Application of Wavelet Analysis to Fault Detection in Oil Refinery," *Comput. Chem. Eng.*, **21**, Suppl., S1117 (1997).
- Daubechies, I., "Orthonormal Bases of Compactly Supported Wavelets," *Comm. Pure Appl. Math.*, **XLI**, 909 (1988).
- Daubechies, I., *Ten Lectures on Wavelets*. Philadelphia, PA: Society of Industrial and Applied mathematics (1992).
- Dijkerman, R. W., and R. R. Majmdar, "Wavelet Representations of Stochastic Processes and Multiresolution Stochastic Models," *IEEE Trans. Signal Process.*, **42**, 1640 (1994).
- Dong, D., and T. J. McAvoy, "Nonlinear Principal Component Analysis-Based on Principal Curves and Neural Networks," *Comput. Chem. Eng.*, **20**(1), 65 (1996).
- Donoho, D. L., "De-Noising by Soft-Thresholding," *IEEE Trans. Inform. Theory*, **41**(3), 613 (1995).
- Donoho, D. L., and I. M. Johnstone, "Ideal Spatial Adaptation by Wavelet Shrinkage," *Biometrika*, **81**(3), 425 (1994).
- Donoho, D. L., and I. M. Johnstone, "Adapting to Unknown Smoothness via Wavelet Shrinkage," *J. Amer. Stat. Assoc.*, **90**(432), 1200 (1995).



References

- Donoho, D. L., I. M. Johnstone, and G. Kerkyacharian, "Density-Estimation by Wavelet Thresholding," *Annals of Statistics*, **24**(2), 508 (1996).
- Donoho, D. L., I. M. Johnstone, G. Kerkyacharian, and D. Picard, "Wavelet Shrinkage: Asymptopia?" *J. R. Stat. Soc. B*, **57**, 301 (1995).
- Dunia, R., S. J. Quin, T. F. Edgar, and T. J. McAvoy, "Identification of Faulty Sensors Using Principal Component Analysis," *AIChE J.*, **42**(10), 2797 (1996).
- Dunia, R., S. J. Quin, "Subspace Approach to Multidimensional Fault Identification and Reconstruction," *AIChE J.*, **44**(8), 1813 (1998).
- Eastment, H. T. and W. J. Krzanowski, "Cross-Validatory Choice of the Number of Components from a Principal Component Analysis," *Technometrics*, **24**, 73 (1982).
- Embrey, D. E., "Approaches to Aiding and Training Operators' Diagnosis in Abnormal Situations," *Chemistry and Industry*, **7**, 454 (1986).
- Hagan, M. T. and M. B. Menhaj, "Training feedforward Networks with the Marquardt Algorithm," *IEE Transactions on Neural Networks*, **5**(6), 989, (1994).
- Hall, P., I. McKay, and B. A. Turlach, "Performance of Wavelet Methods for Functions with Many Discontinuities," *Annals of Statistics*, **24**(6), 2462 (1996).
- Harrold, D., "How to Avoid Abnormal Situations," *Control Engineering International*, **5**(3), 23 (1998).
- Harrold, D., "No single Method can Satisfy all the Complexities of ASM", *Control Engineering*, **5**(9), 75 (1998).
- Hastie, T. J., and W. Stuetzle, "Principal Curves," *J. Amer. Stat. Assoc.*, **84**, 505 (1989).
- Heinonen, P., and Y. Neuvo, "FIR-Median Hybrid Filters," *IEEE Trans. on Acoustics, Speech, and Signal Process.*, **ASSP-35**, 832 (1987).
- Hertz, J., A. Krogh, and R. G. Palmer, *Introduction to the theory of Neural Computation*, Addison-Wesley, Redwood City, CA, p. 198 (1991).
- Jackson, J. E., "Principal Components and Factor Analysis: I. Principal Components," *J. Qual. Technology*, **12**(4), 201 (1980).
- Jackson, J. E. and G. S. Mudholkar, "Control Procedures for Residuals Associated with Principal Components Analysis," *Technometrics*, **21**, 341 (1979).
- Janusz, M. E. and V. Venkatasubramanian, "Automatic Generation of Qualitative Descriptions of Process Trends for Fault Detection and Diagnosis," *Engineering Applications of Artificial Intelligence*, **4**, 329 (1991).
-



References

- Jia, F., E. B. Martin, and A. J. Morris, "Non-linear Principal Components Analysis for Process Fault Detection," *Comput. Chem. Eng.*, **22**(SS), S851 (1998).
- Johnson, R. A., and D. W. Wichern; *Applied Multivariate Statistical Analysis*, Englewood Cliffs, NJ: Prentice-Hall (1992).
- Kosanovich, K. A., and M. J. Piovoso, "PCA of Wavelet Transformed Process Data for Monitoring," *Intell. Data Anal.*, <http://www.elsevier.com/locate/ida>, **1**, 2 (1997).
- Kramer, M.A., "Nonlinear Principal Component Analysis Using Autoassociative Neural Networks," *AIChE J.*, **37**(2), 233 (1991).
- Kramer, M. A., "Autoassociative Neural Networks," *Comput. Chem. Eng.*, **16**, 313 (1992).
- Kramer, M. A. and R. S. H. Mah, "Model-Based Monitoring," *Proc. Int. Conf. On Foundations of Computer Aided Process Operations*, D. Rippin, J. Hale, J. Davis, eds. CACHE, Austin, TX (1994).
- Kresta, J., J. F. MacGregor, and T. E. Marlin, "Multivariate Statistical Monitoring of Process Operating Performance," *Can. J. Chem. Eng.*, **69**, 35 (1991).
- Krzanowski, W. J., "Cross-validation in Principal Component Analysis," *Biometrics*, **43**, 515 (1987).
- Ku, W., R. H. Storer, and C. Georgakis, "Disturbance Detection and Isolation by Dynamic Principal Component Analysis," *Chem. Intell. Lab. Syst.*, **30**, 179 (1995).
- Lorenzo, D., *A Manager's Guide to Reducing Human Errors Improving Human Performance in the Chemical Industry* (1991).
- MacGregor, J. F., C. Jaeckle, C. Kiparissides, and M. Koutoudi, "Process Monitoring and Diagnosis by Multiblock PLS Methods," *AIChE J.*, **40**, 827 (1994).
- Malinowski, E. R., *Factor Analysis in Chemistry*, Wiley, New York (1991).
- Mallat, S. G., "A Theory for Multiresolution Signal Decomposition: The Wavelet Representation," *IEE Trans. Pattern Anal. Mach. Intell.*, **PMAI-11**, 674 (1989).
- Mallat, S. G., "Zero-Crossings of a Wavelet Transform," *IEEE Trans. Inform. Theory*, **IT-37**(4), 1019 (1991).
- Mallat, S., and W. L. Hwang,, "Singularity Detection and Processing with Wavelets," *IEEE Transactions on information theory*, **38**, 617 (1992).
- Mallat, S., and S. Zhong, "Characterisation of Signals from Multi-Scale Edges," *IEEE Transaction Pattern Analysis and Machine Intelligence*, **14**(7), 710 (1992).



References

- Martin, E. B. and A. J. Morris, "Non-Parametric Confidence Bounds for Process Performance Monitoring Charts," *Journal of Process Control*, **6**(6), 349 (1996).
- Miller, P., R. E. Swanson, and C. F. Heckler, "Contribution Plots: The Missing Link in Multivariate Quality Control," *37th Annual Fall Conference*, ASQC, Rochester, NY (1993).
- Motard, R. L. and B. Joseph, *Wavelet Applications in Chemical Engineering*, Kluwer Academic Publishers: Boston, 1-26 (1994).
- Musliner, D. J., and K. D. Krebsbach, "Applying a Procedural and Reactive Approach to Abnormal Situations in Refinery Control," *Chemical Technology*, **5**(9), 3 (1998).
- Nason, G. P., "Wavelet Shrinkage Using Cross-Validation," *J. R. Stat. Soc. B*, **58**(2), 463 (1996).
- Nason, G. P. and B. W. Silverman, "The Discrete Wavelet Transform in S," *J. Comput. Graph. Statist.*, **3**, 163 (1994).
- Nason, G. P. and B. W. Silverman, "The Stationary Wavelet Transform and Some Statistical Applications," *Lect. Notes Statist.*, **103**, 281 (1995).
- Nimmo, I., "Abnormal Situation Management," *Process & Control Engineering*, **49**(5), 8 (1996).
- Nimmo, I., "Abnormal Situation Management: Giving Your Control System Ability to Cope," *The Journal for Industrial Automation and Control*, **32**(9), 23 (1998a).
- Nimmo, I., "Adequately Address Abnormal Operations," *Chemical Engineering Progress*, **91**(9), 36 (1995).
- Nimmo, I., "Industry Initiative Addresses Abnormal Events," *Hydrocarbon Processing*, October, 71 (1998b).
- Nomikos, P., and J. F. MacGregor, "Monitoring Batch Processes Using Multiway Principal Component Analysis," *AIChE J.*, **40**(8), 1361 (1994).
- Nounou, M. N., and B. R. Bakshi, "On-Line Multiscale Rectification of Random and Gross Errors without Process Models," Technical Report, Dept. of Chemical Engineering, Ohio State Univ. (1998).
- Ogden, R. T., *Essential Wavelets for Statistical Applications and Data Analysis*, Boston: Birkhauser (1997).
- Piovosio, M. J., K. A. Kosanovich, and R. K. Pearson, "Monitoring Process Performance in Real-Time," *Proc. of the Amer. Contr. Conf.*, Chicago, IL, **3**, 2359 (1992).

References

- Ramesh, T.S., and B.V. Kral, "Plant Monitor: An On-line Advisory System for Monitoring Polyethylene Plants," *Intelligent Systems for Process Engineering (IPSE) Conference*, Snowmass, Colorado, (1995).
- Ramesh, T., B. Kral, and J. Freeman, "A Generic Real-Time Monitor for Detecting Abnormal Events in Continuous Processes," *Proceedings of the AIChE 1996 Process Plant Safety Symposium*, Houston, Texas, 209 (1996).
- Rioul, O. and M. Vetterli, "Wavelets and Signal Processing," *IEEE Sig. Proc. Mag.*, **8**, 14 (1991).
- Rothenberg, D., and I. Nimmo, "The Concept of Abnormal Situation Management and Mechanical Reliability," *Proceedings of the AIChE 1996 Process Plant Safety Symposium*, Houston, Texas, 193 (1996).
- Scott, D. W., *Multivariate Density Estimation: Theory, Practice and Visualisation*, New York: Wiley (1992).
- Shao, R., F. Jia, E. B. Martin and A. J. Morris, "Wavelets and Non-Linear Principal Components Analysis for Process Monitoring," *Control Engineering Practice*, **7**, 865 (1999).
- Shimizu, H., K. Uchiyama, and S. Shioya, "On-Line Fault Diagnosis for Optimal Rice Alpha-Amylase Production Process of a Temperature-Sensitive Mutant of *Saccharomyces Cerevisiae* by an Autoassociative Neural Network," *Journal of Fermentation and Bioengineering*, **83**(5), 435 (1997).
- Sticles, R. P. and G. A. Melhem, "How much Safety is Enough?" *Hydrocarbon Processing*, October, 50 (1998).
- Strang, G. and R. Nguyen, *Wavelets and Filter Banks*, John Wiley & Sons: New York (1995).
- Tan, S., and M. L. Mavrovouniotis, "Reducing Data Dimensionality Through Optimizing Neural Network Inputs," *AIChE J.*, **41**, 1471 (1995).
- Tong, H., and C. M. Crowe, "Detection of Gross Errors in Data Reconciliation by Principal Component Analysis," *AIChE J.*, **41**, 1712 (1995).
- Wang, X. Z., B. H. Chen, S. H. Yang and C. McGreavy, "Application of Wavelets and Neural Networks to Diagnostic System Development, 2, an Integrated Framework and its Application," *Comput. Chem. Eng.*, **23**, 945 (1999).
- Whitely, J. R., J. F. Davis, "Knowledge-Based Interpretation of Sensor Patterns." *Computers and Chemical Engineering*, **16**, 329 (1992).



References

- William, B. C., "Doing Time: Putting Qualitative Reasoning on Firmer Ground," *National Conference on Artificial Intelligence*, Philadelphia, (1986).
- Wise, B. M., N. L. Ricker, D. F. Veltkamp, and B. R. Kowalski, "A Theoretical Basis for the Use of Principal Component Models for Monitoring Multivariate Processes," *Process Control and Quality*, **1**, 41 (1990).
- Wise, B. M. and Gallagher, N. B., "Process Chemometrics Approach to Process Monitoring and Fault Detection," *J. Process Control*, **6**, 329 (1996).
- Wold, S., "Cross-Validatory Estimation of the Number of Principal Components in Factor and Principal Component Analysis," *Technometrics*, **20**, 397 (1978).
- Wold, S., K. Esbensen, and P. Geladi, "Principal Component Analysis," *Chem. Intell. Lab. Syst.*, **2**, 37 (1987).
- Wornell, G. W., "A Karhunen-Loeve-Like Expansion for $1/f$ Processes via Wavelets," *IEEE Trans. Inform. Theory*, **IT-36**(4), 859 (1990).
- Wold, S., N. Kettaneh, and K. Tjessem, "Hierarchical Multiblock PLS and PC Models for Easier Model Interpretation and as an Alternative to Variable Selection," *J. Chemometrics*, **10**, 463 (1996).
- Wold, S., "Exponentially Weighted Moving Principal Component Analysis and Projection to Latent Structures," *Chem. Intell. Lab. Syst.*, **23**, 149 (1994).