

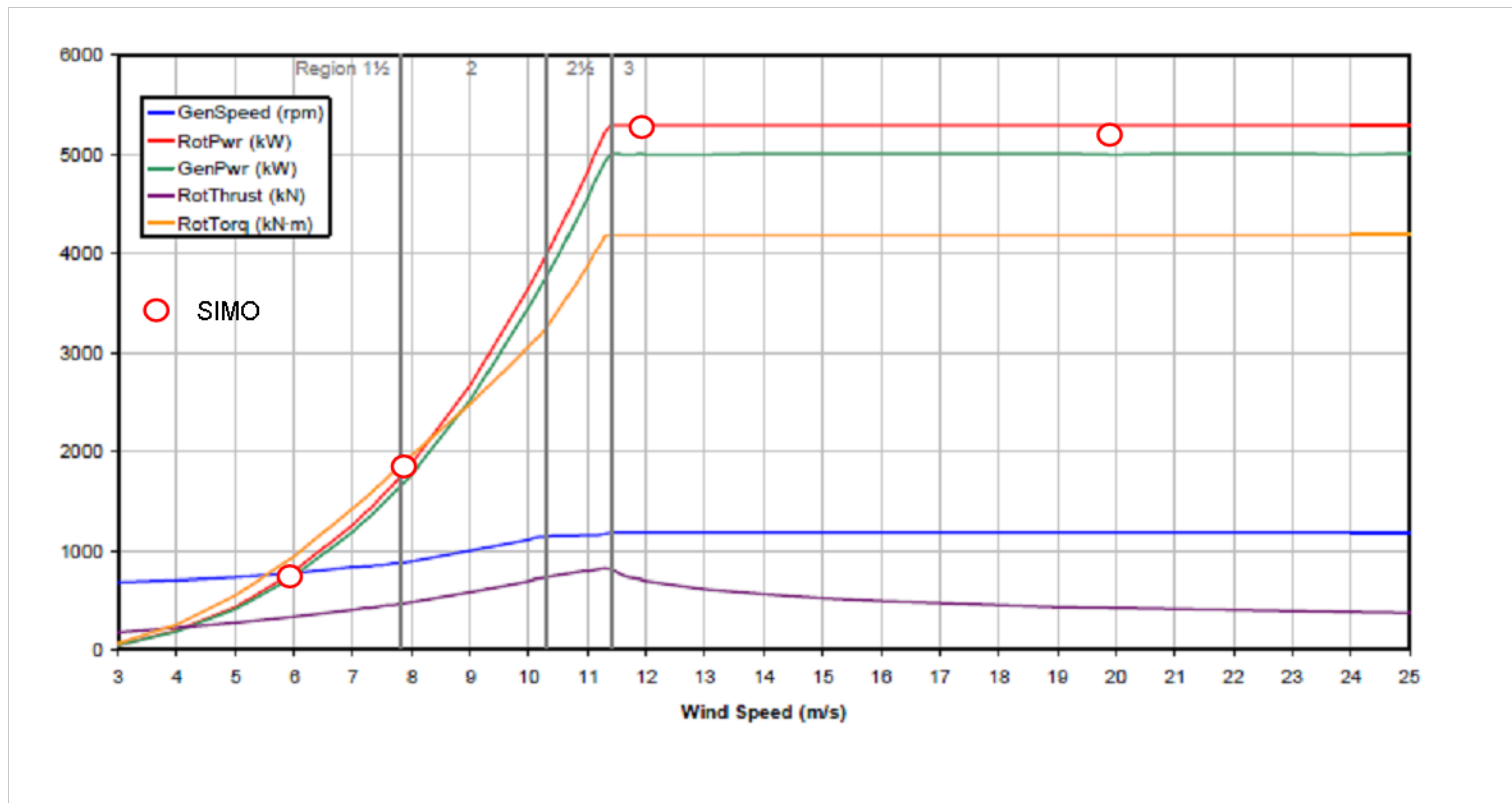
# Designtools for floating wind turbines - NREL test case

Risø 13.03.2009  
Ivar Fylling, MARINTEK

- Frequency domain modelling – MIMOSA; Motion transfer functions, results for passive rotor (files F\_domain\_transferfunctions.pdf, MIMOSAREPOR-SURVIVAL.pdf)
- Time domain modelling – rigid body model (this file + fwt1.avi, fwt2.avi, w08\_wi12\_cu07.pdf)

# BEM model for wind force

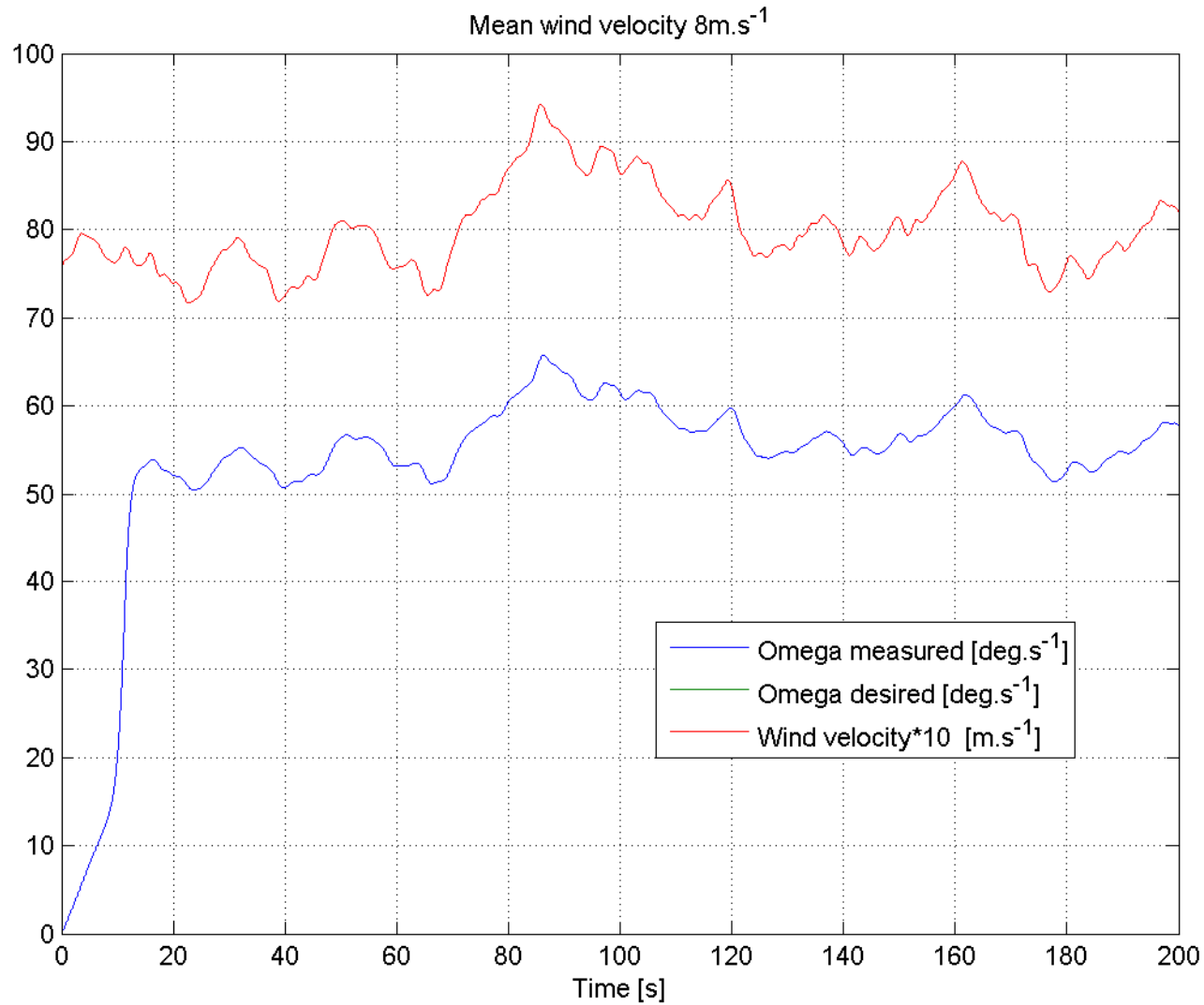
- Developed by Karl Merz summer 08
- Implemented into SIMO and tested by Knut Mo, autumn 08
- Verification against results from NREL results
- Good correspondence, rotation speed, torque and power.



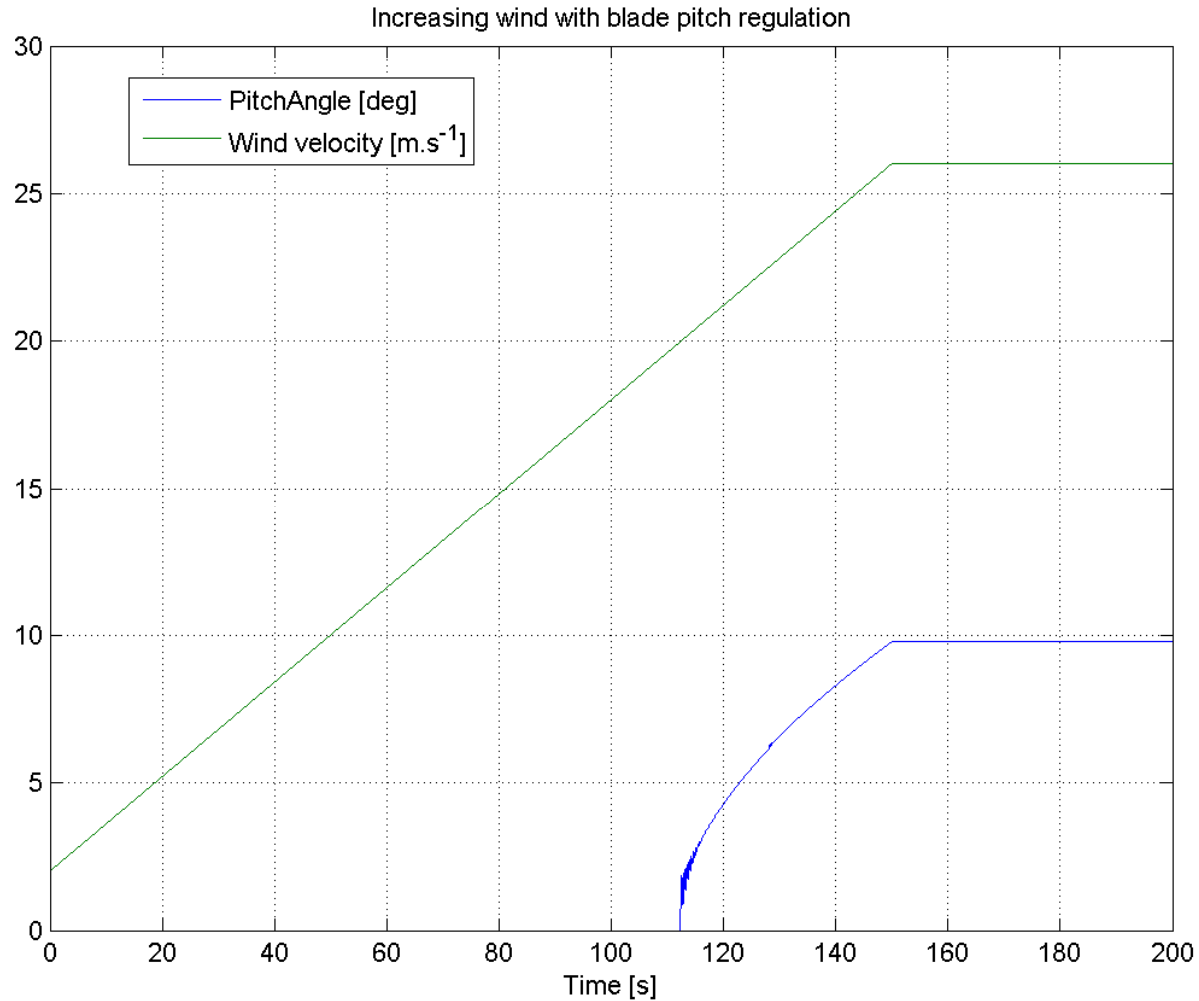
# BEM implementation test

Case		NREL FAST			SIMO				Diff		
Wind (m/s)	Pitch (deg)	Rotor power (kW)	Thrust (kN)	Ang. vel. (rpm)	Quad. damp.	Power (kW)	Thrust (kN)	Ang. vel. (rpm)	Power %	Thrust %	RPM %
6.00	0				1400	777.0	233.0	7.85			
8.00	0	1883	389	9.00	2000	1872.0	389.0	9.34	-0.59	0.00	3.78
12.00	3.83				2100	5379.0	600.0	12.33			
20.00	17.47				2500	5268.0	319.0	12.24			

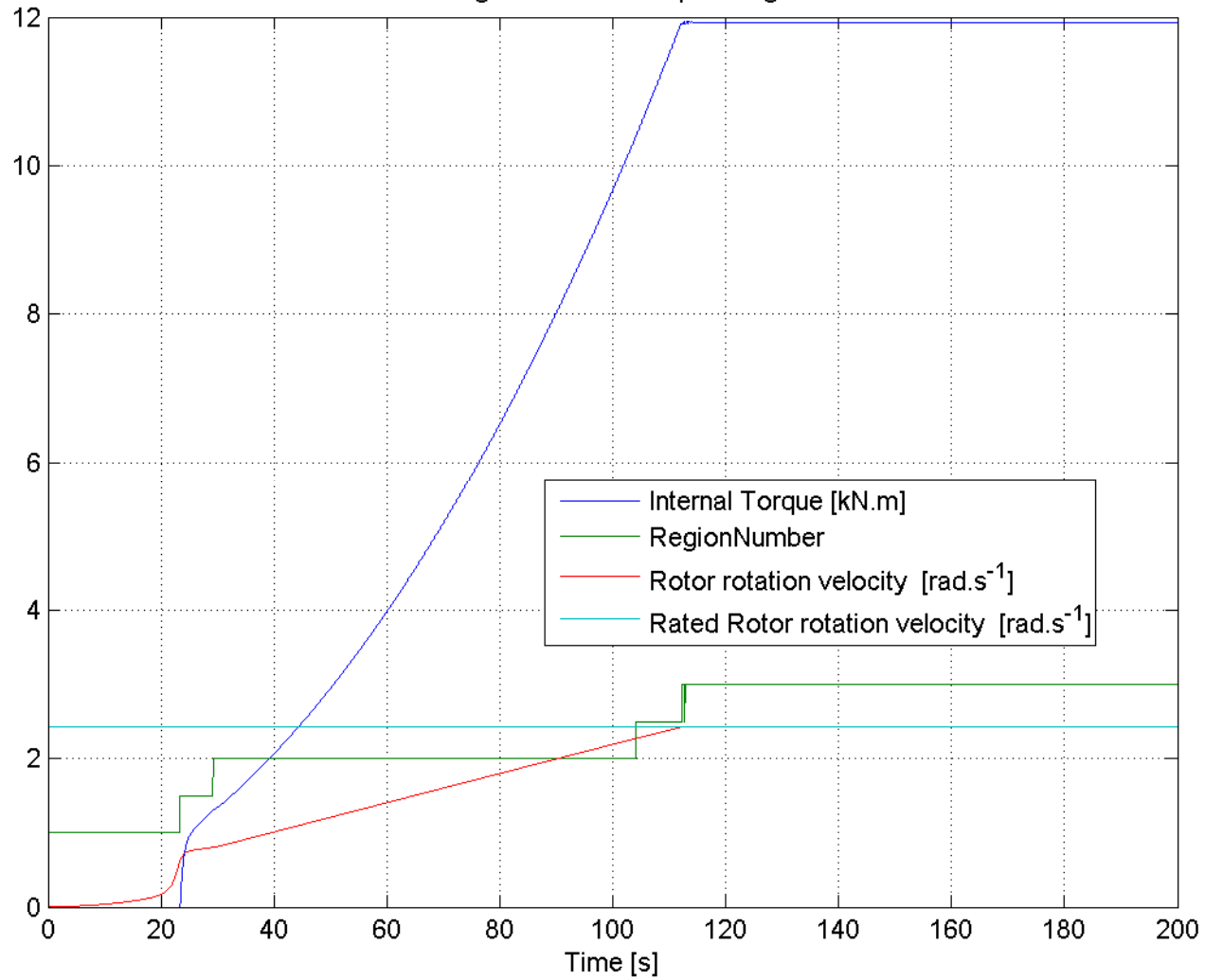
# Test with irregular wind - passive

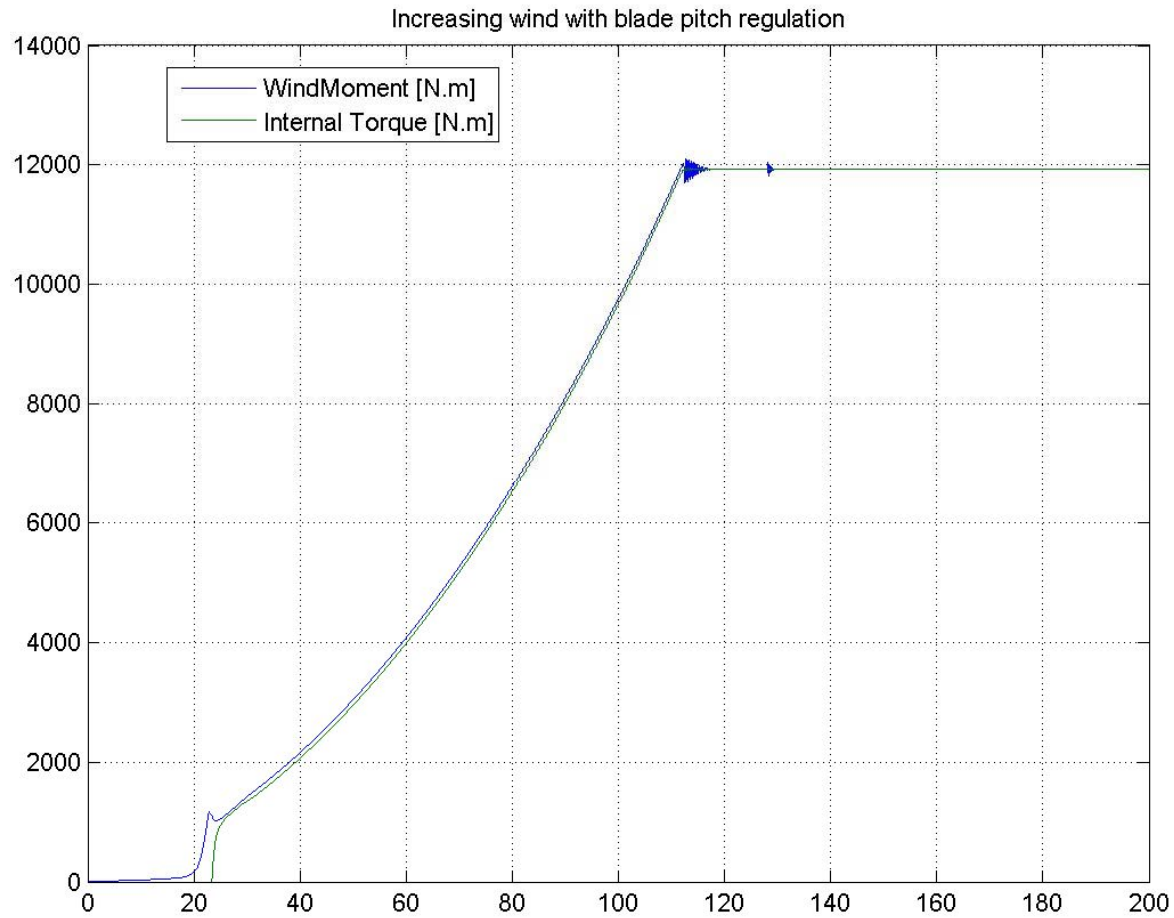


# Test case for power takeoff controller



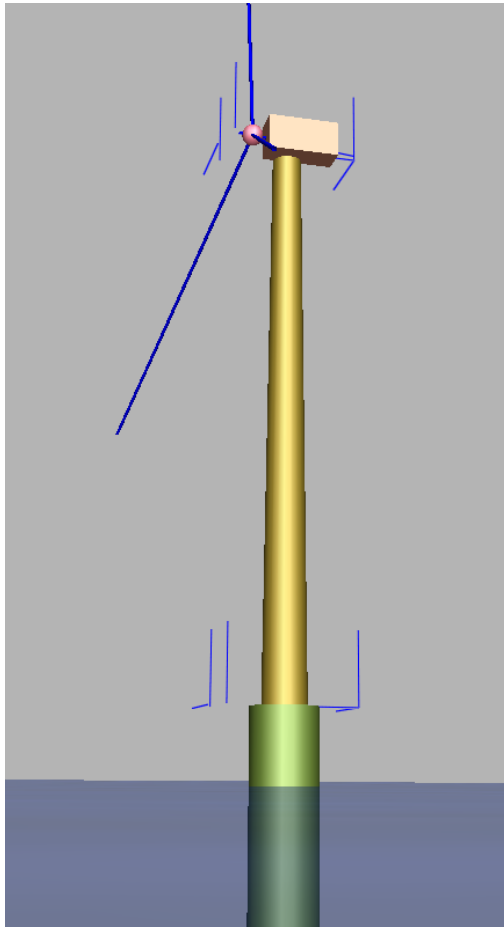
Increasing wind with blade pitch regulation





# FWT in SIMO - 4-body model

## Motions and forces



Rotor with  
shaft & blades

5-dof stiff coupling

Nacelle

6-dof stiff coupling

Tower

6-dof stiff coupling

Spar buoy with  
mooring lines

Mooring lines, elastic

# Step loads for transient response

1. 0 – 100 s: No load
2. 100 s: Vertical force  $F_Z = 1520$  kN
3. 600 s: Horizontal force,  $F_x = 1000$  kN applied at fairlead level (-97 m)
4. 1100 s: Remove  $F_x$
5. 1600 s: Horizontal force  $F_x = 1000$  kN applied at nacelle level (90 m)
6. 2100 s: Remove  $F_x$

Important, nonlinear coupling: surge - pitch

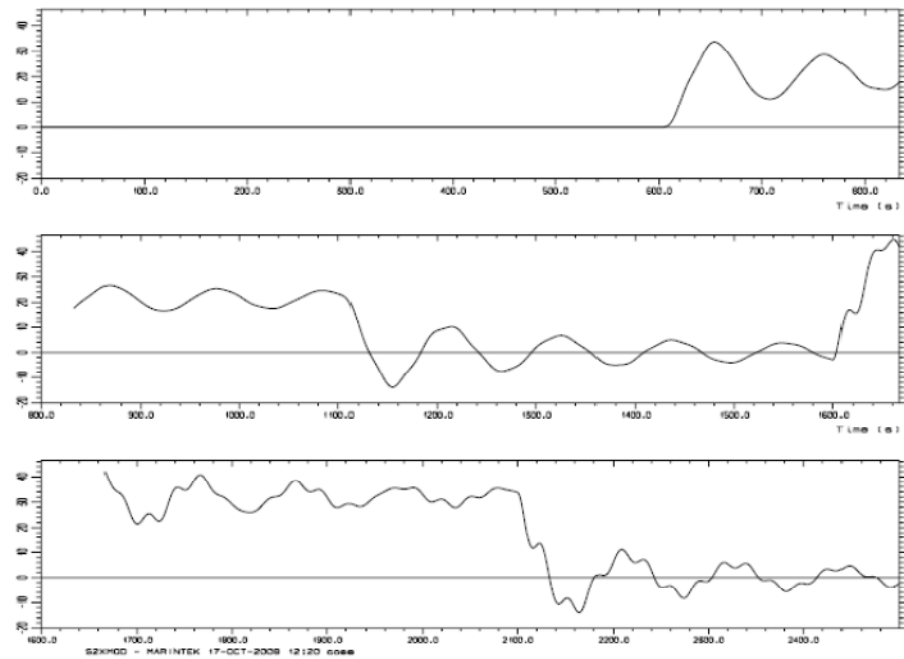


Figure 2.1 Surge, quadratic damping

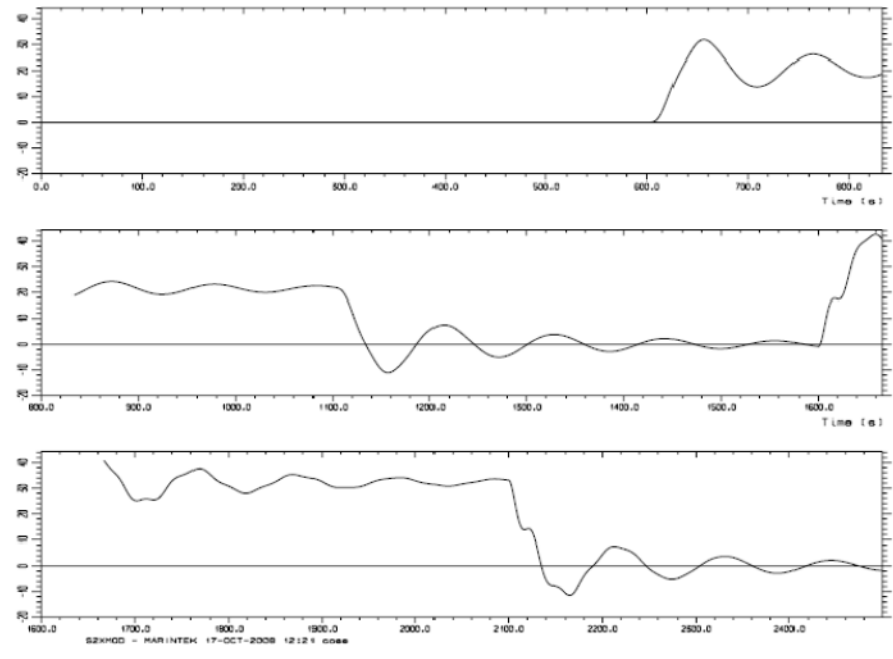


Figure 2.2 Surge, quadratic + linear damping

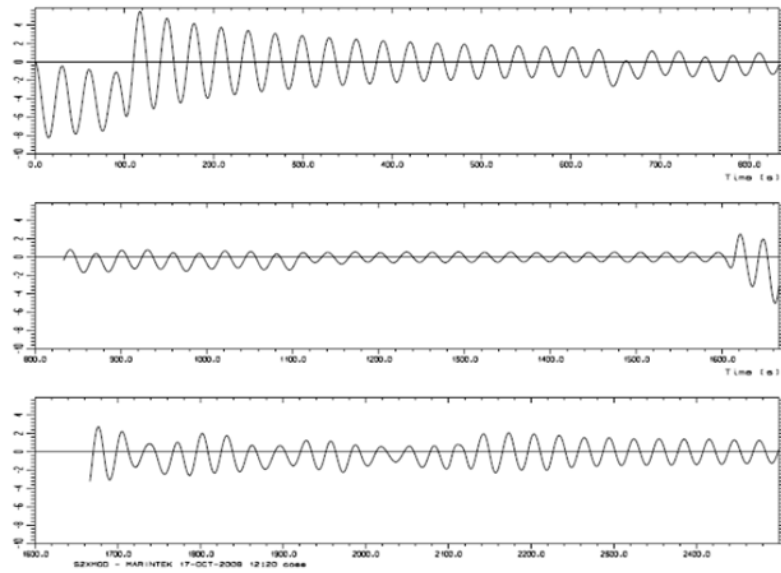


Figure 2.3 Heave, quadratic damping

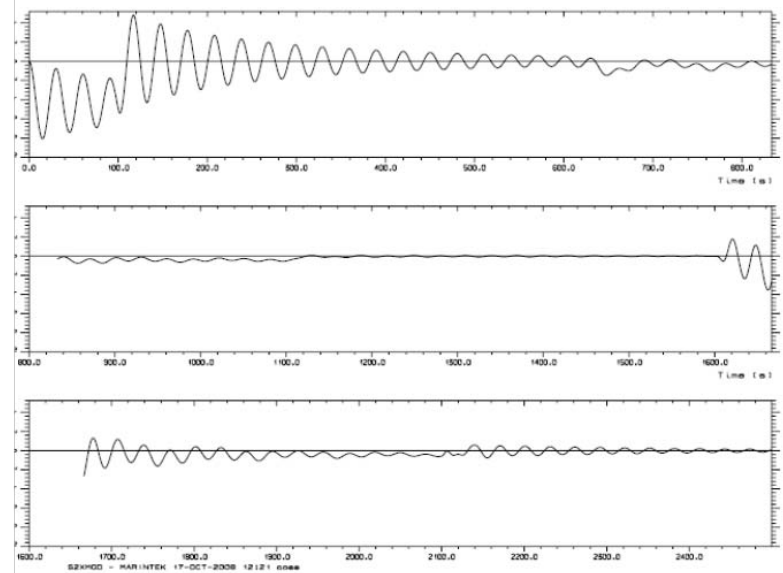


Figure 2.4 Heave, quadratic + linear damping

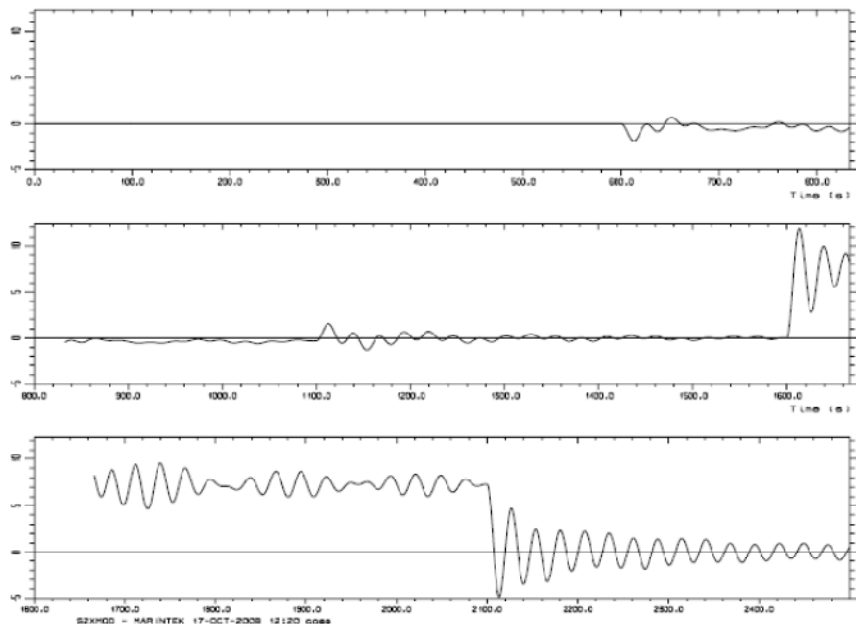


Figure 2.5 Pitch, quadratic damping

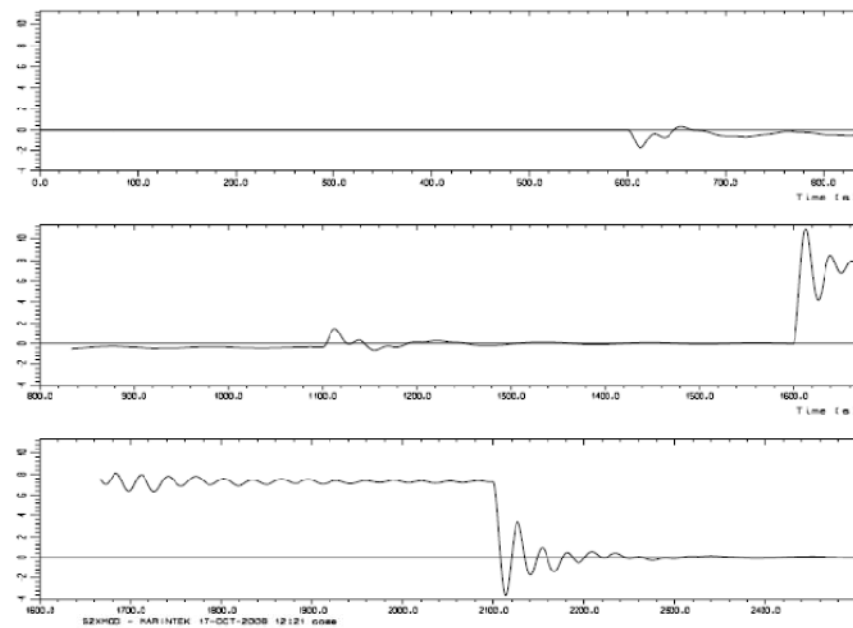
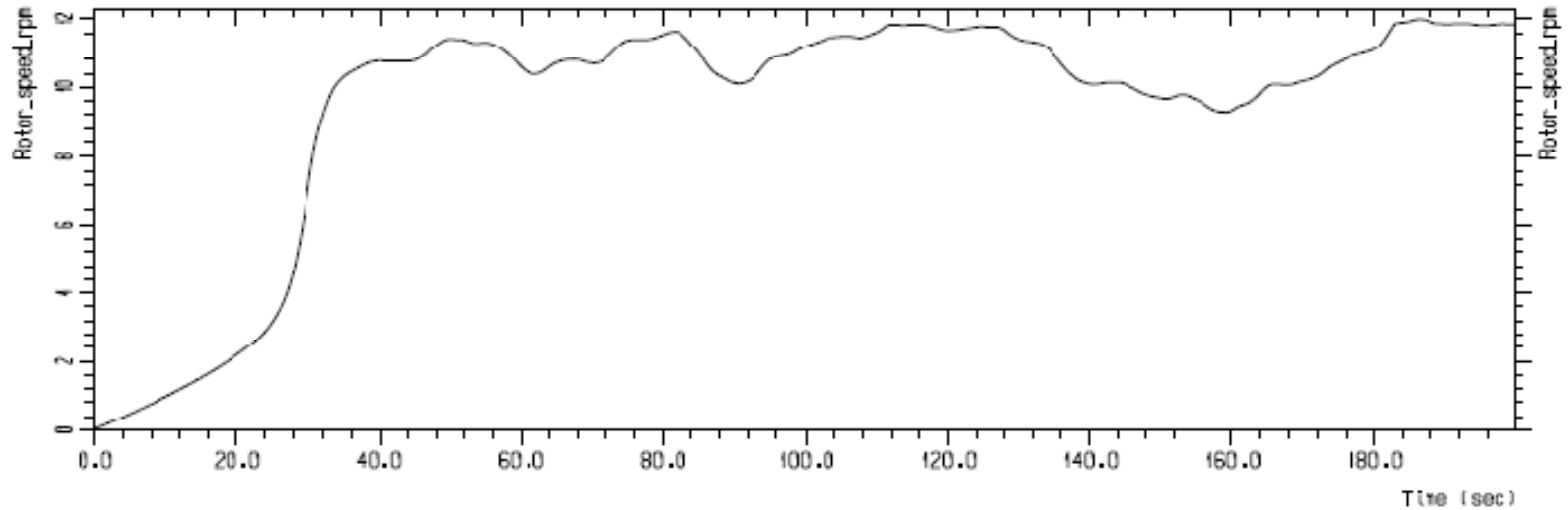
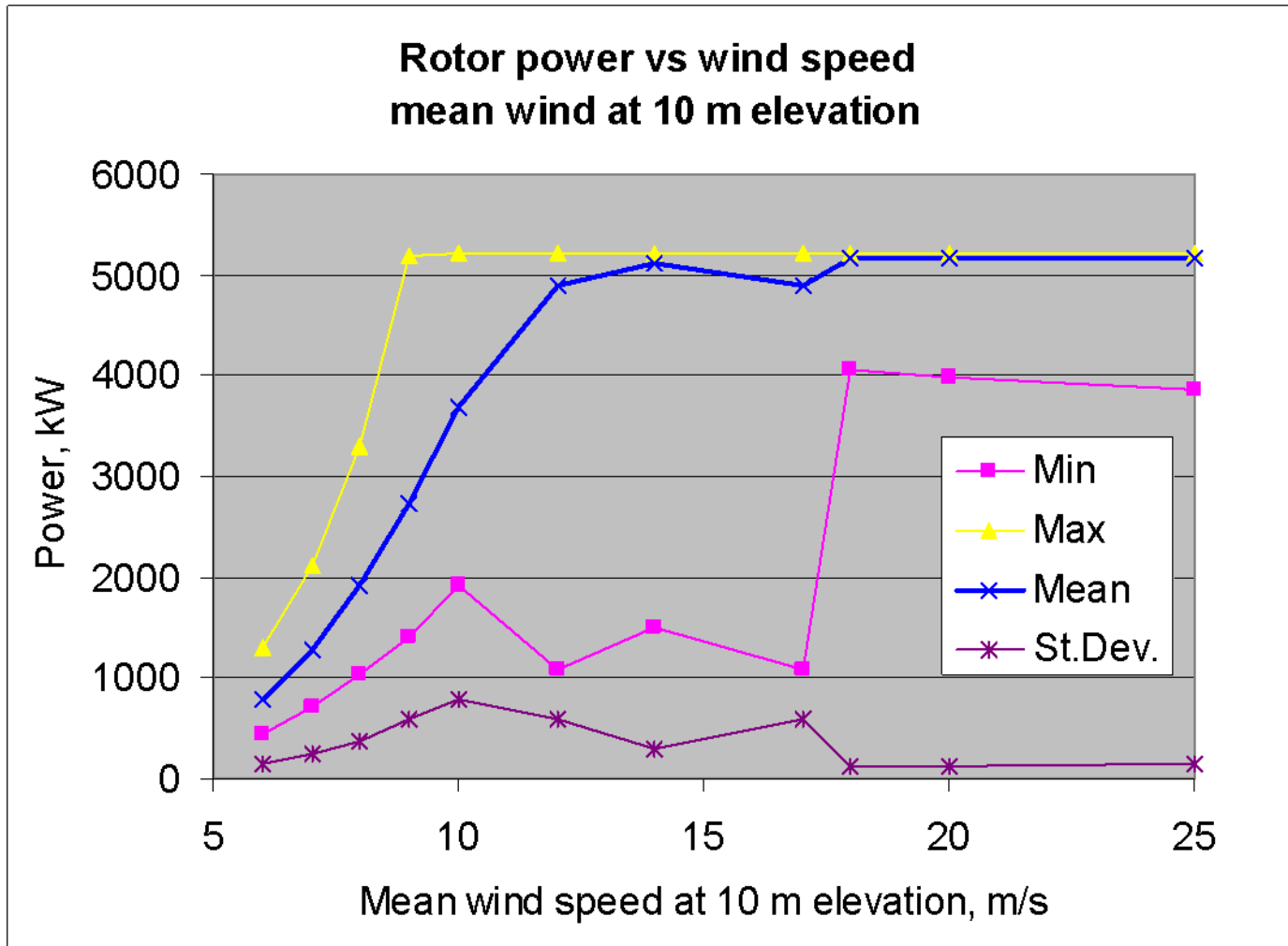


Figure 2.6 Pitch, quadratic + linear damping.

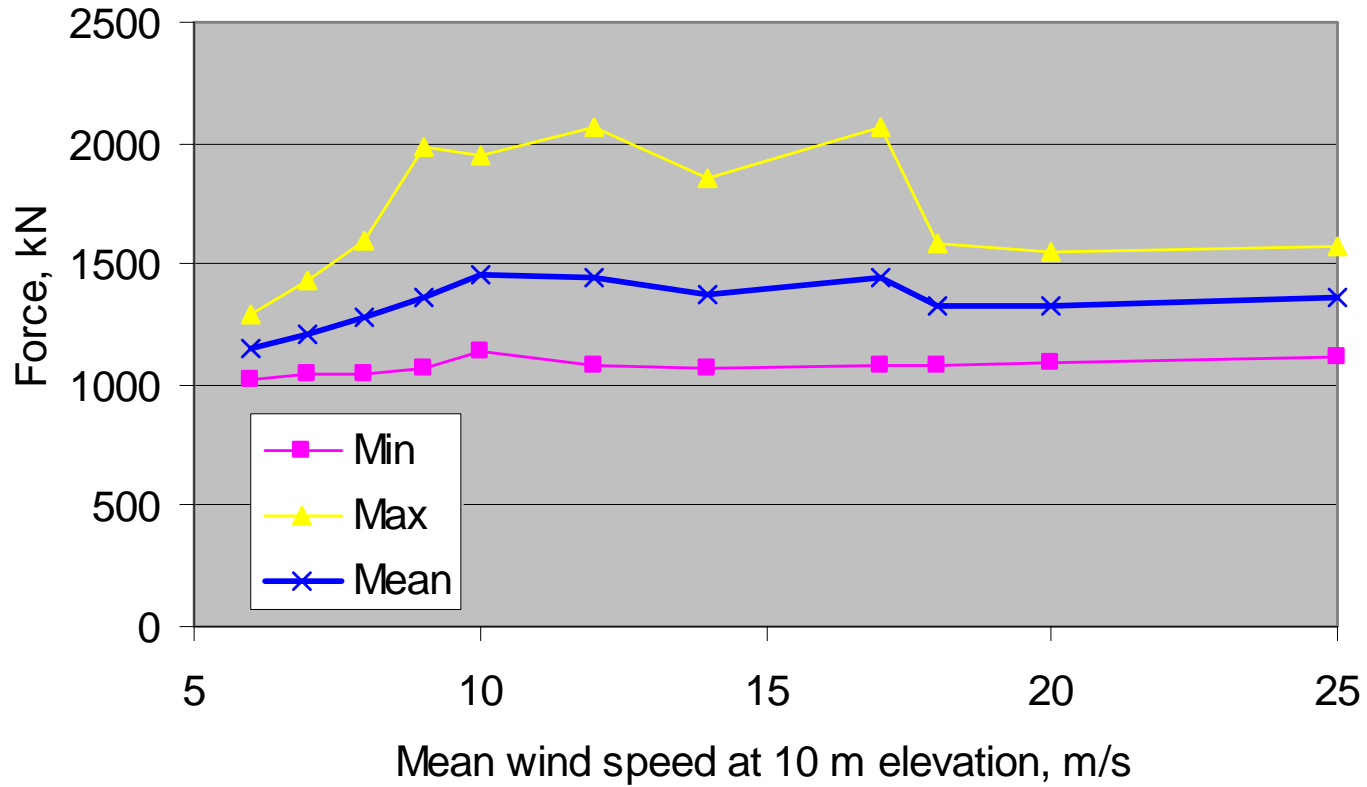
## Rotor rpm and power after start-up, 10 m/s wind



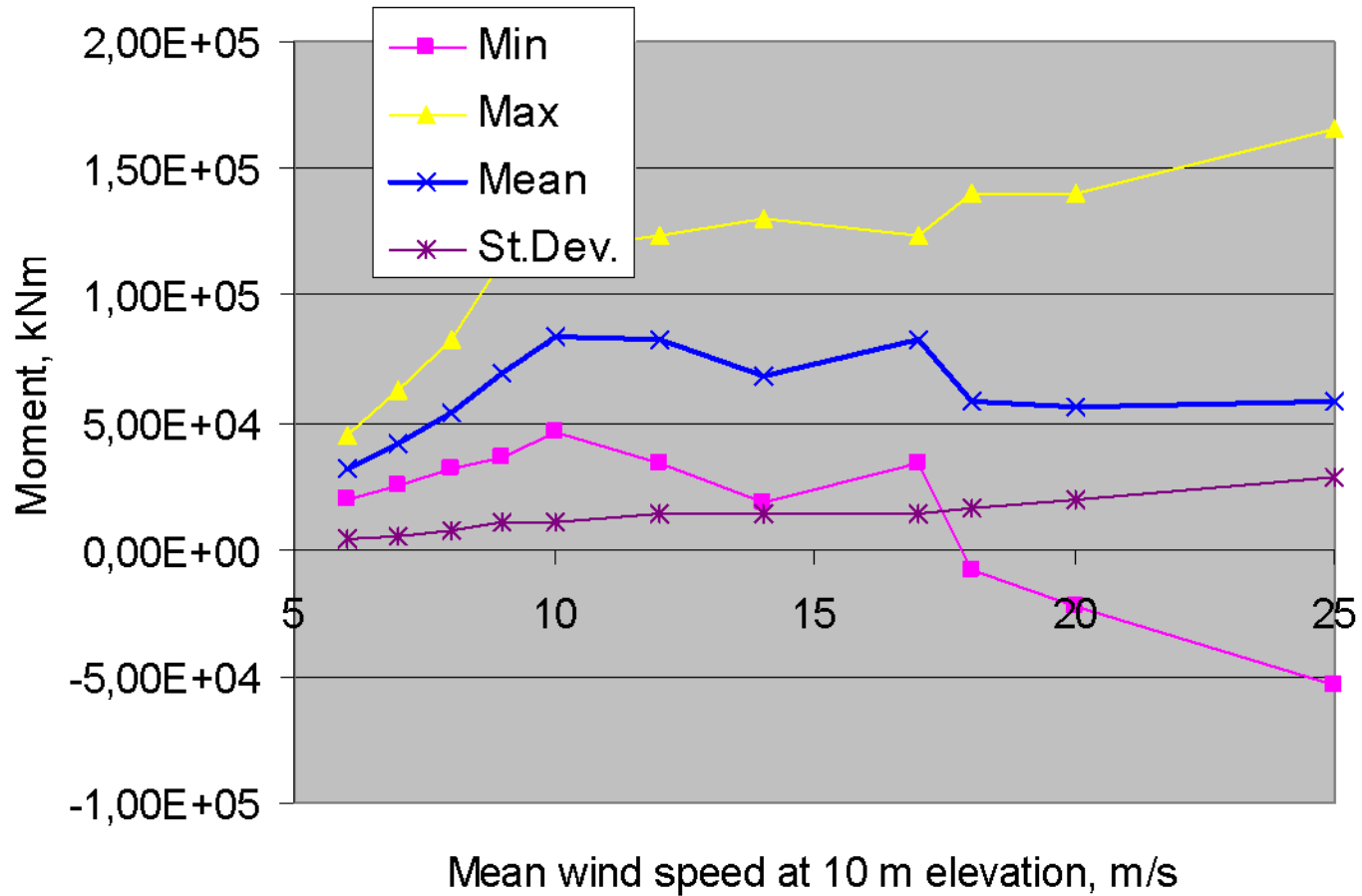
Express - MARINTEK 14:41 11-05-2008 /c:/drive/s/MarIntek/MSE/Examples/4b-ops File : GenReg.txt



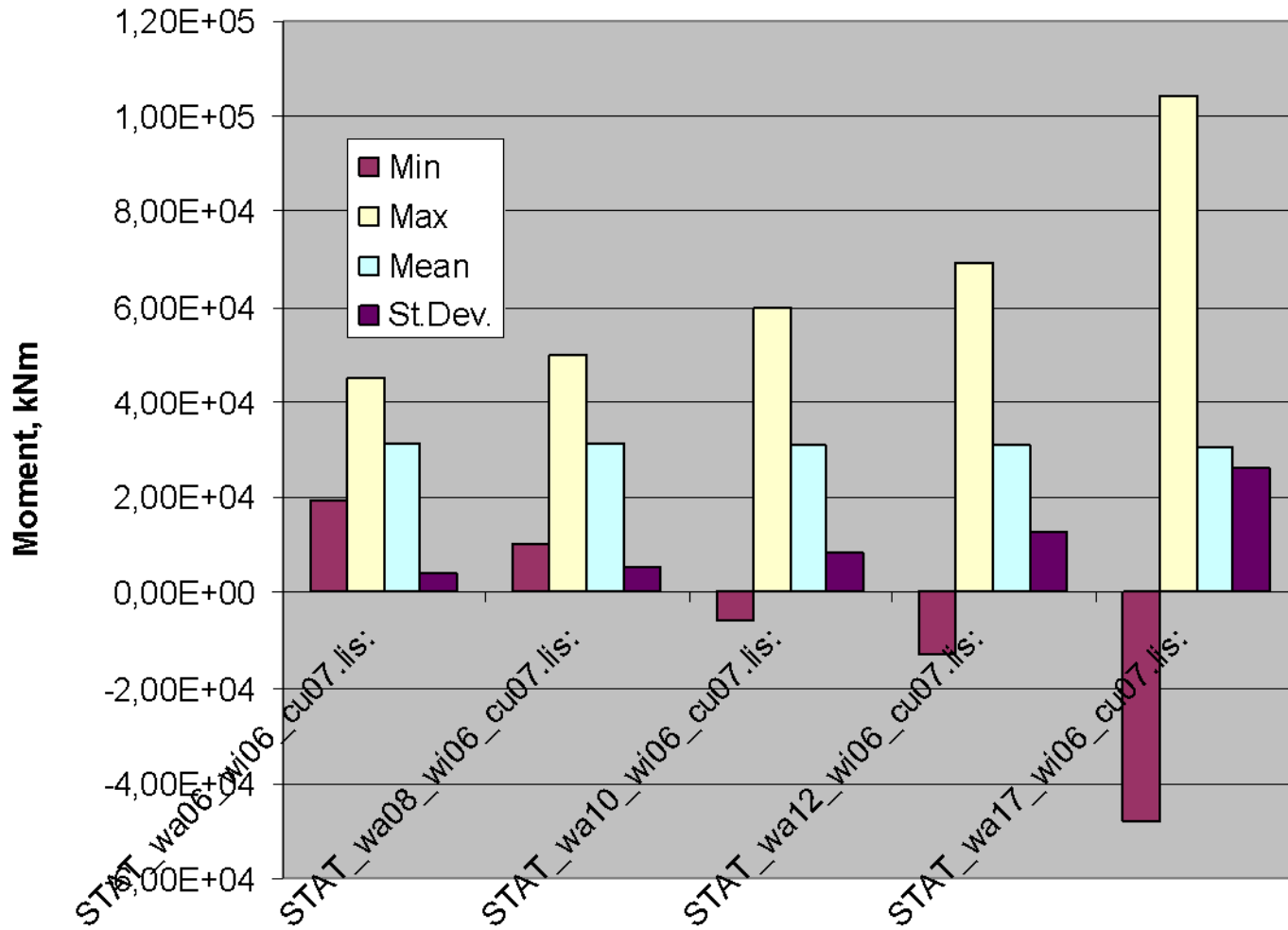
### Mooring line tension vs wind speed



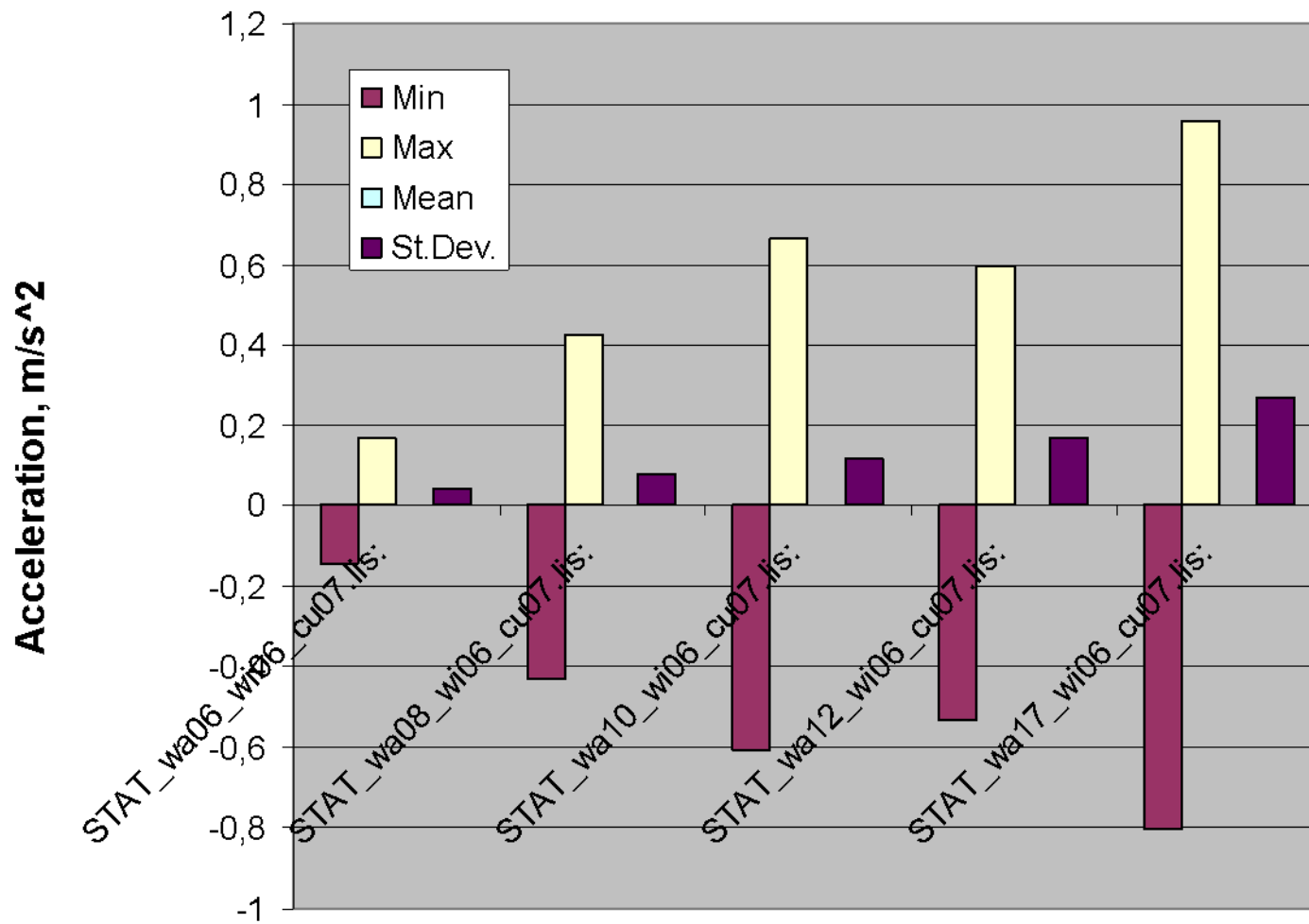
### Tower base moment vs wind speed



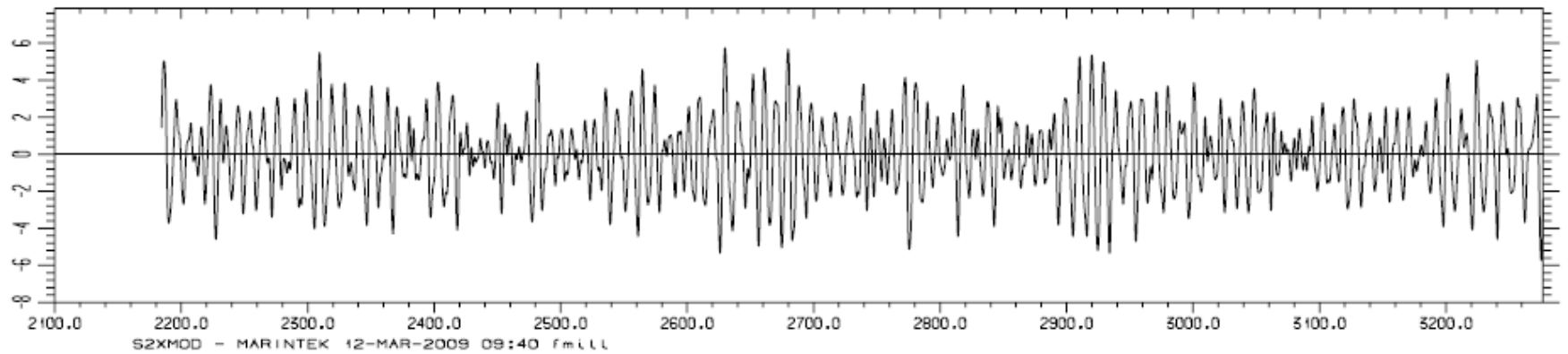
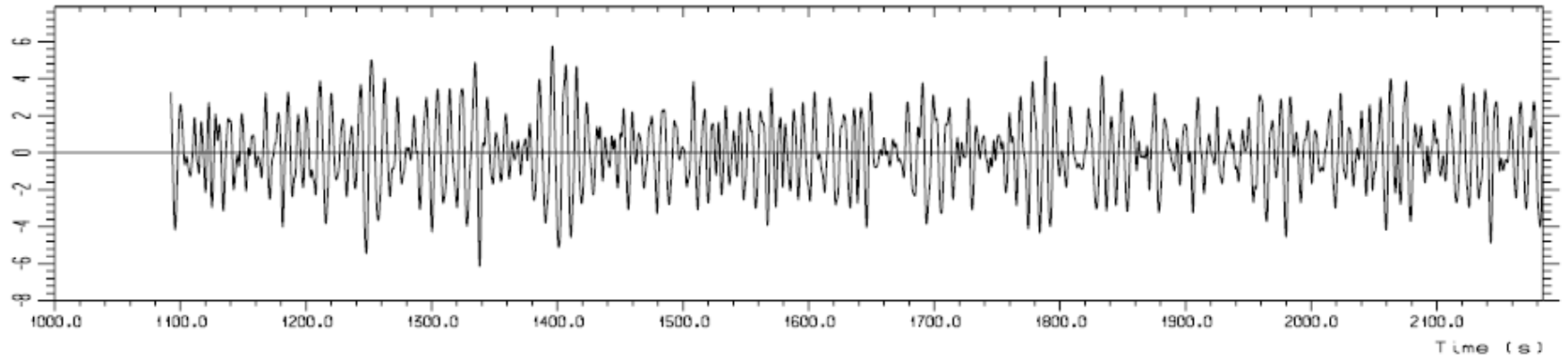
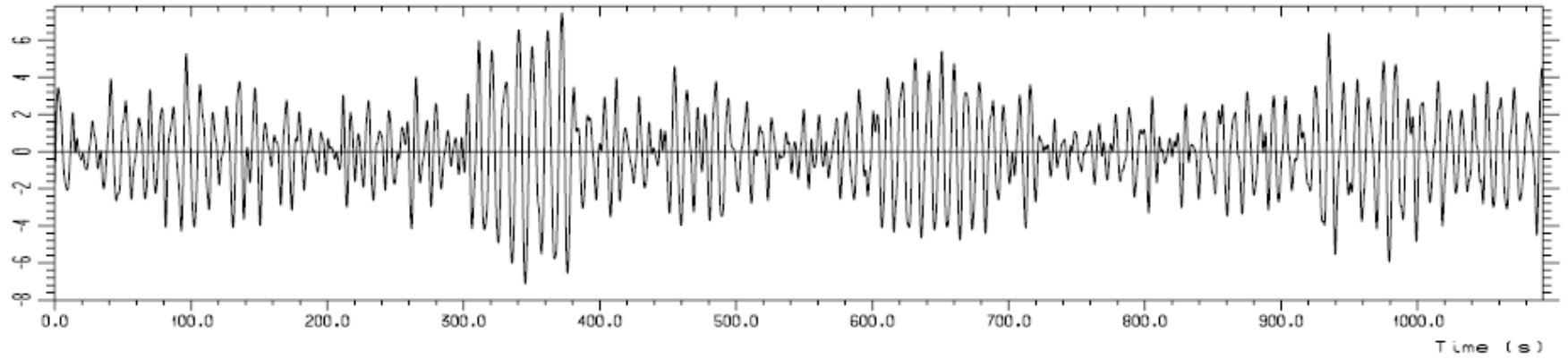
## Tower base moment vs seastate



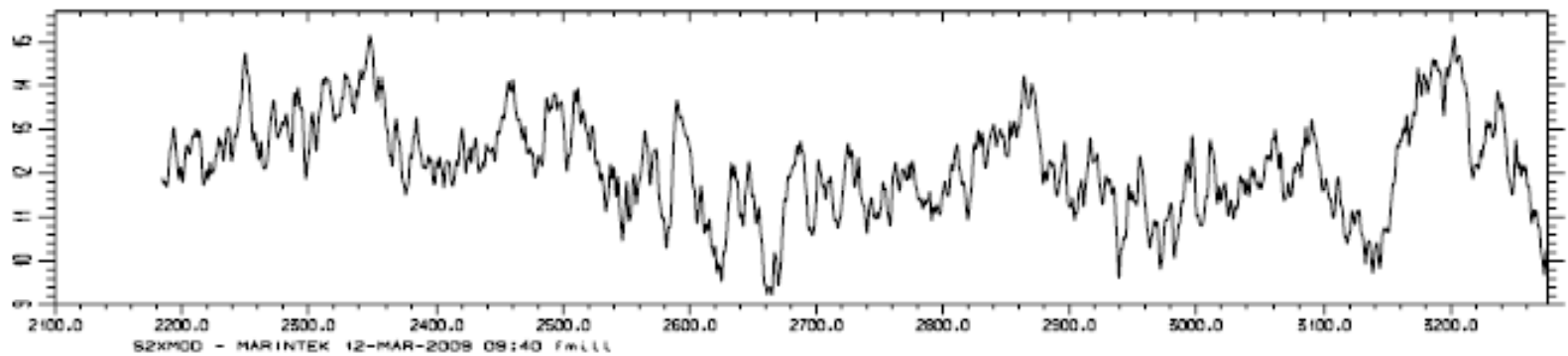
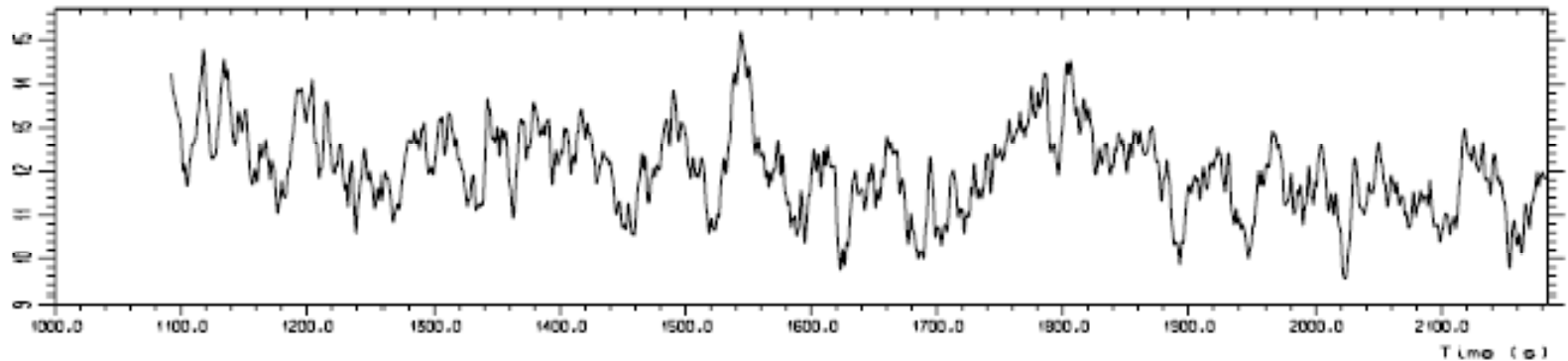
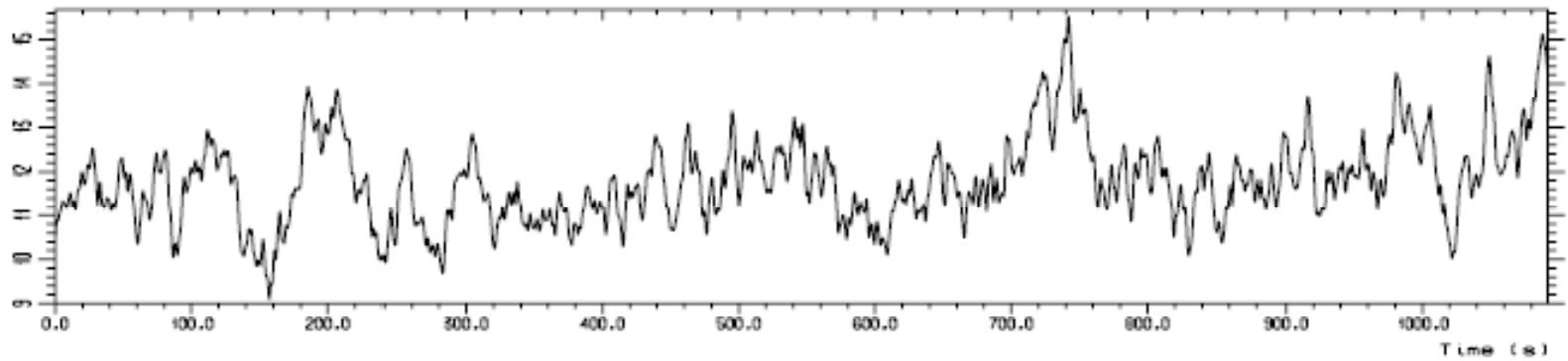
## Rotor x-acceleration vs seastate



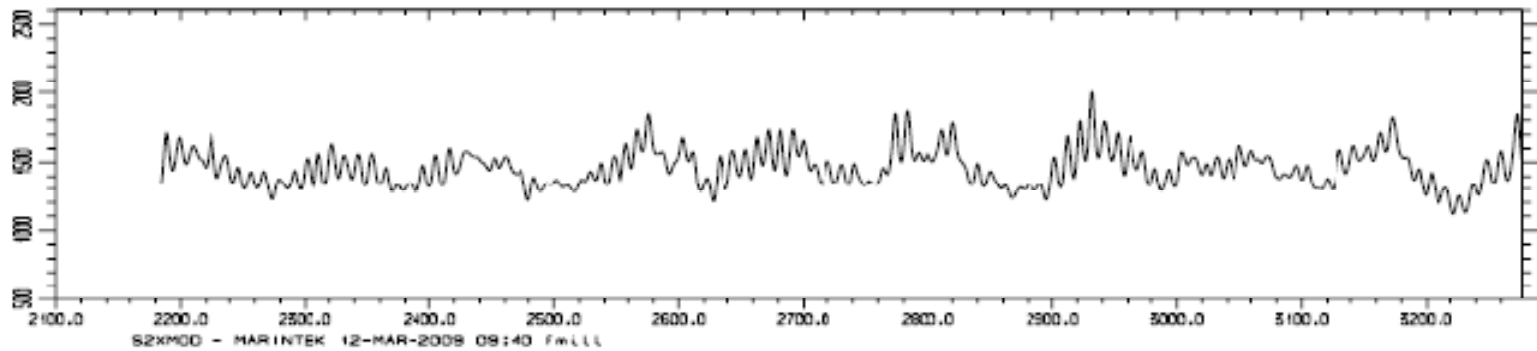
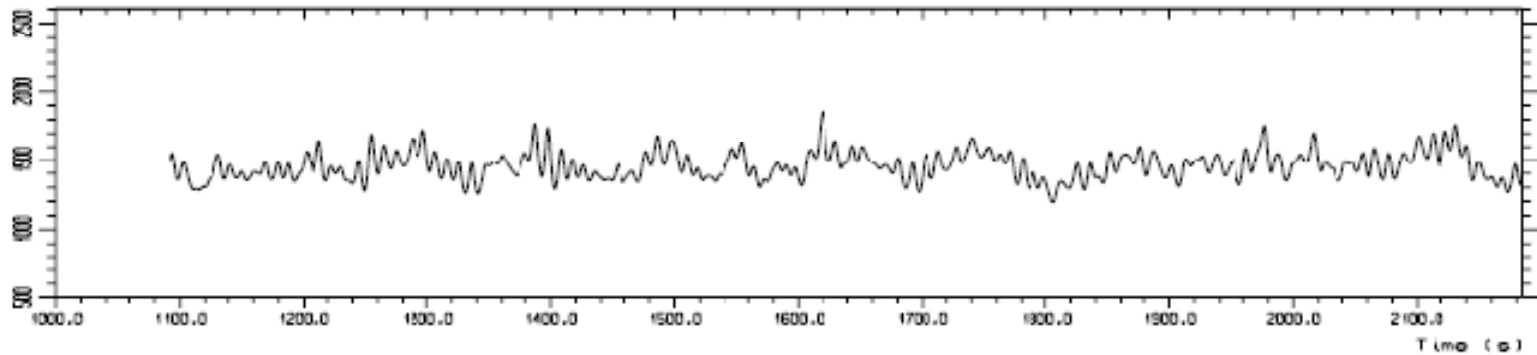
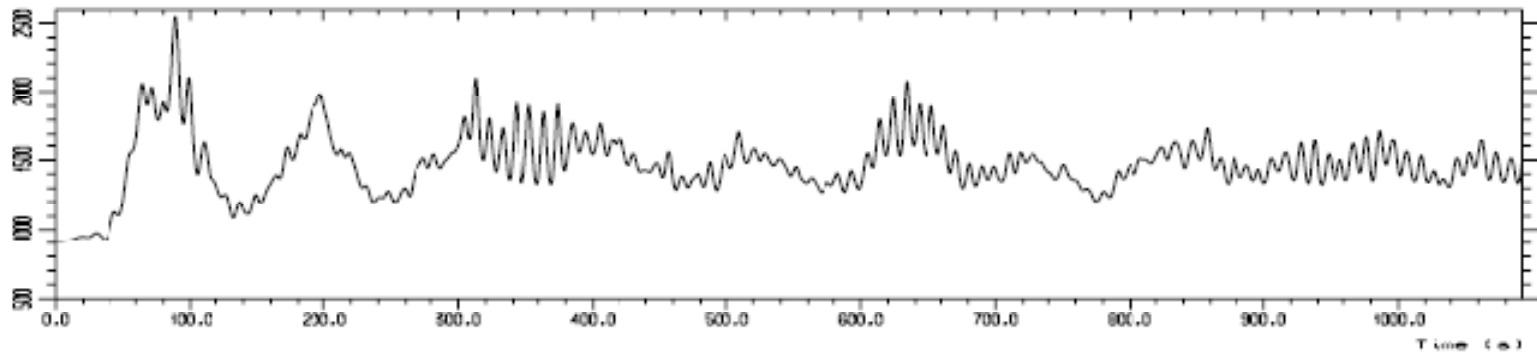
Arr 1 Body 1 Resp 2 Chann 1 : Totalwaveelevation  
Min=-7.1061 Max= 7.4443 Std= 1.9984 Av=-.34828E-09



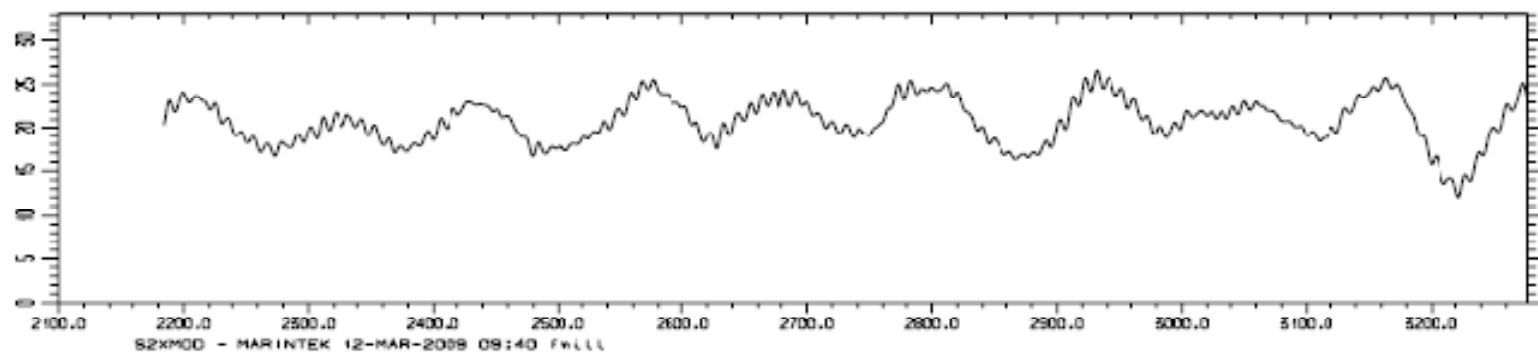
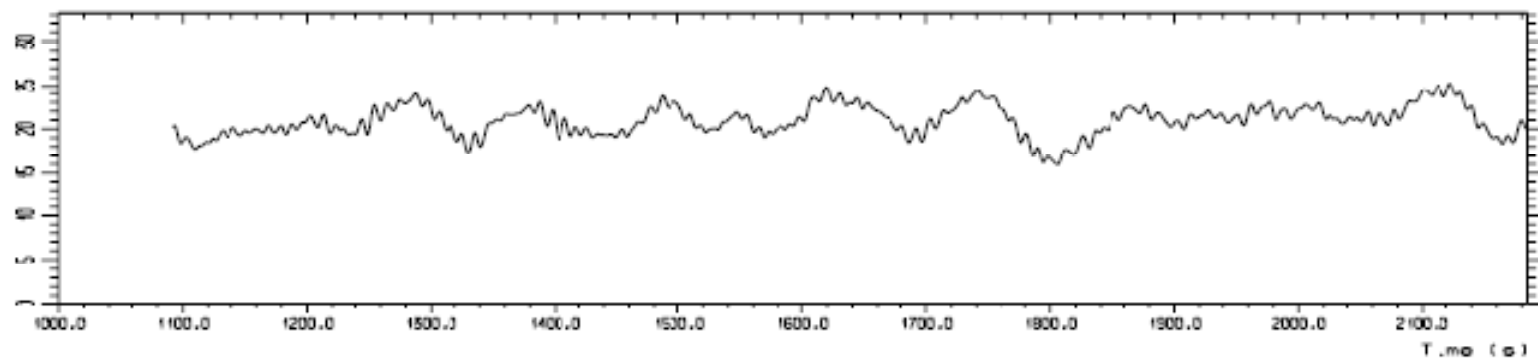
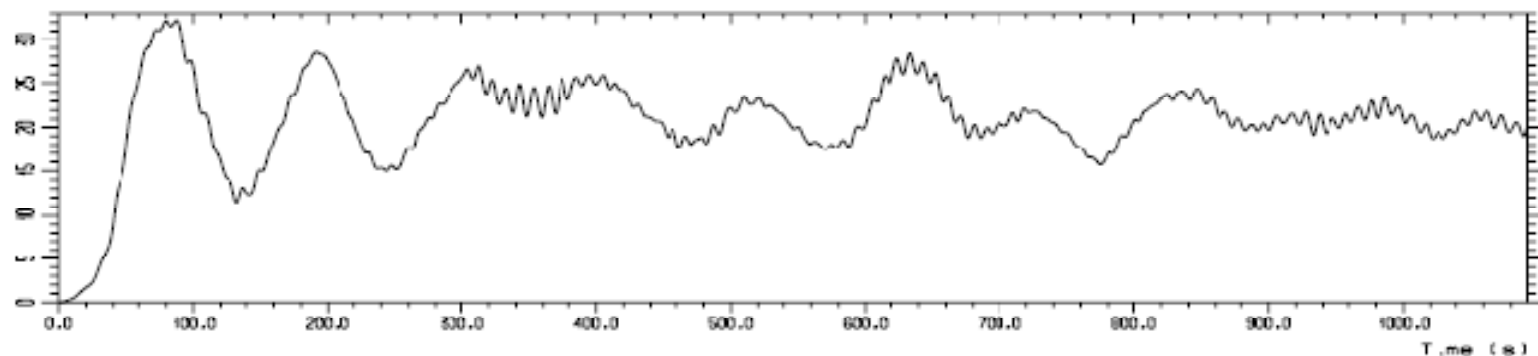
Ann 163 Body 4 Resp 1 Chann 1 : Velocity in main direction  
Min= 9.1099 Max= 15.520 Std= 1.0177 Av= 12.000



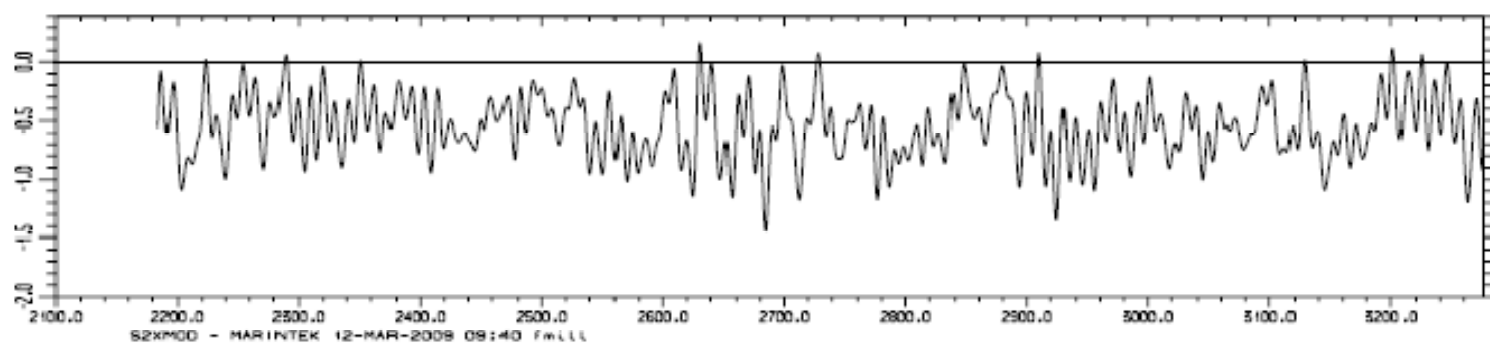
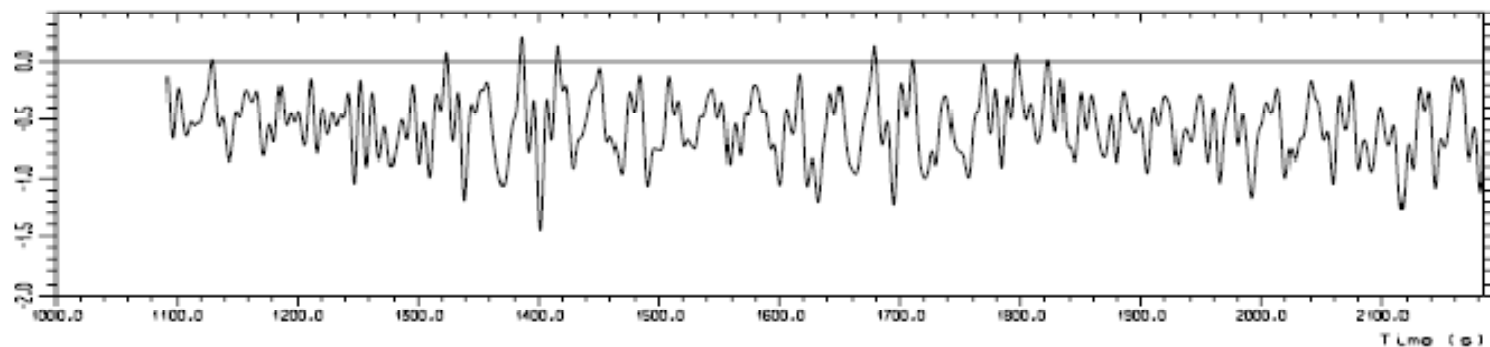
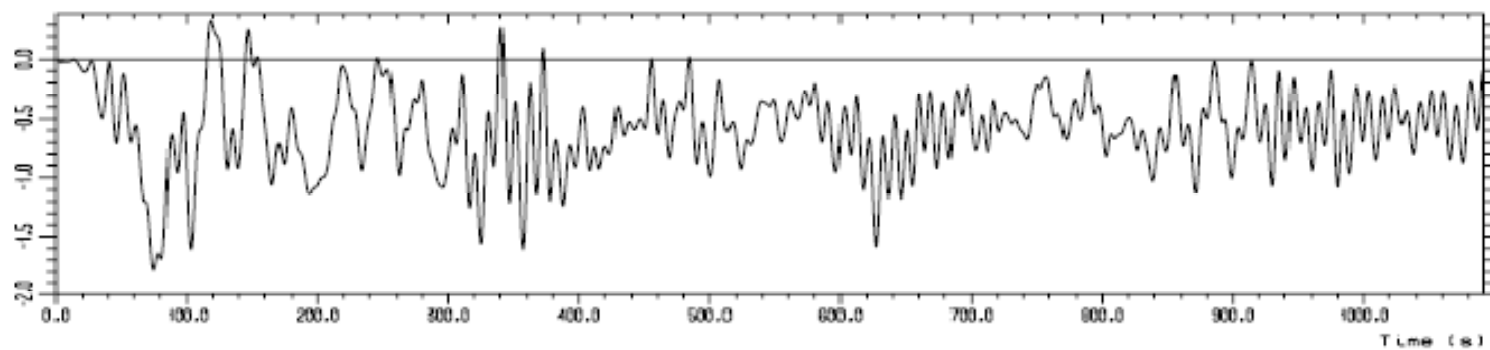
Arr 112 Body 1 Resp 20 Chann 2 : TotalforceElement2  
Min= 911.29 Max= 2545.0 Std= 156.64 Av= 1463.2



Ann 120 Body 1 Reep 29 Chann 1 : XGtranslationTotalAmotion  
Min= 0.0000 Mcx= 32.230 Std= 3.4100 Av= 20.809

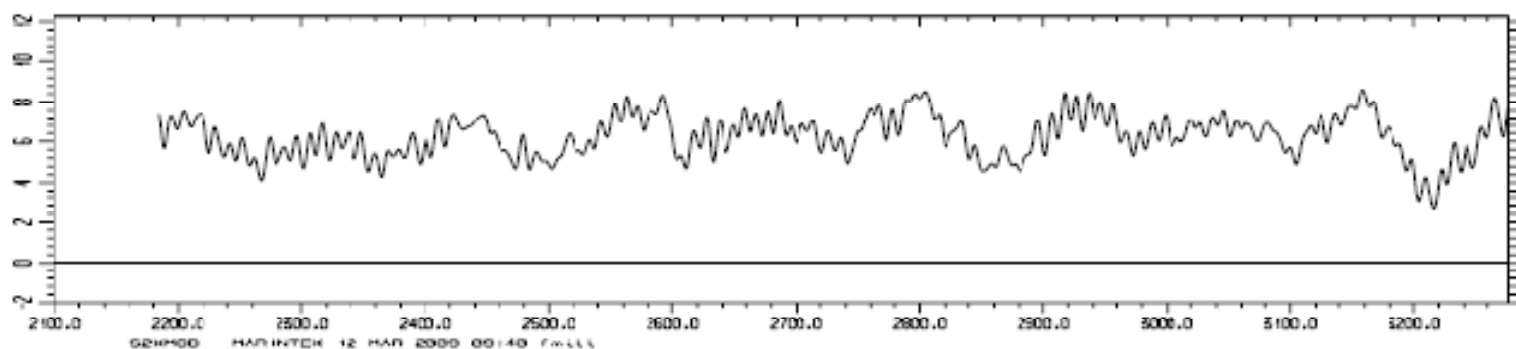
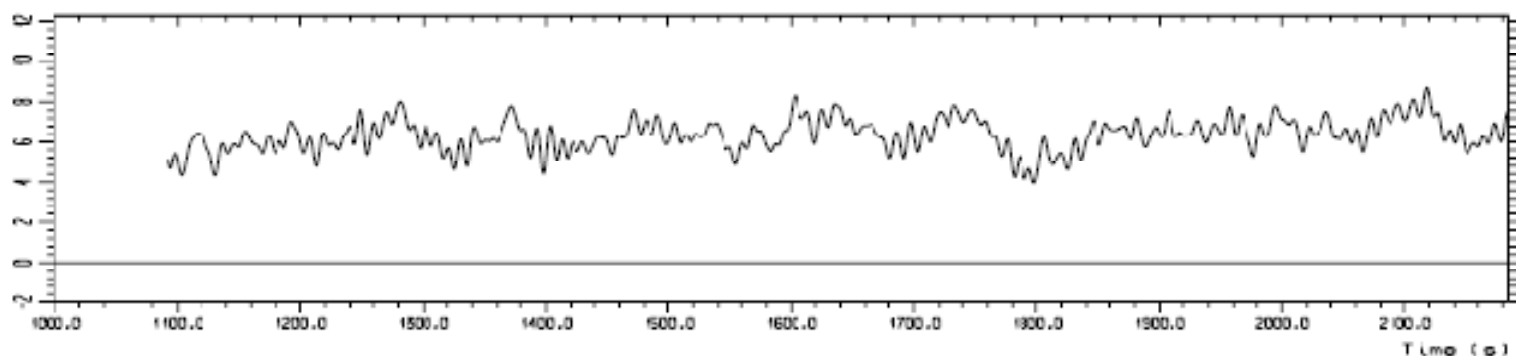
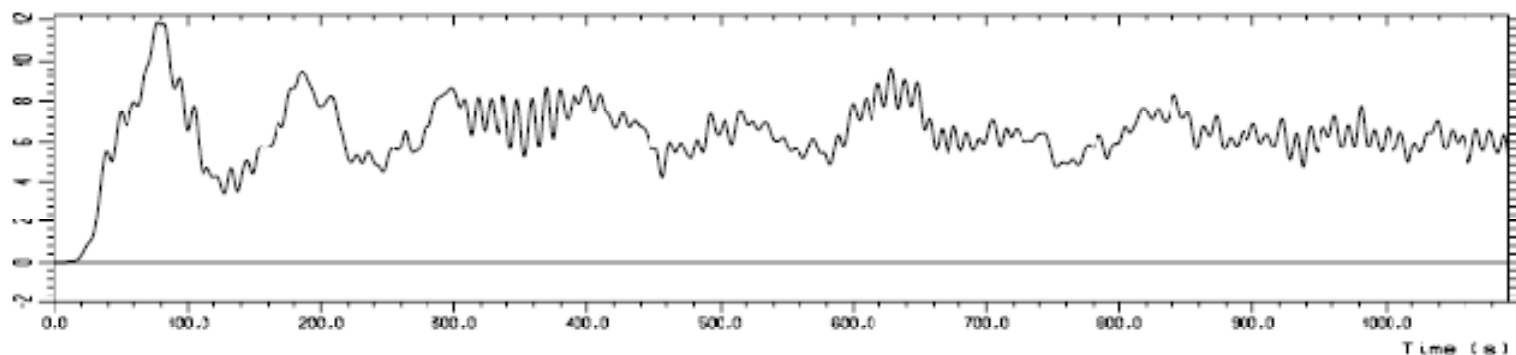


Arr 122 Body 1 Resp 29 Chann 3 : ZGtranslationTotalmotion  
Min=-1.7823 Max=0.33387 Std=0.28899 Av=-.56075

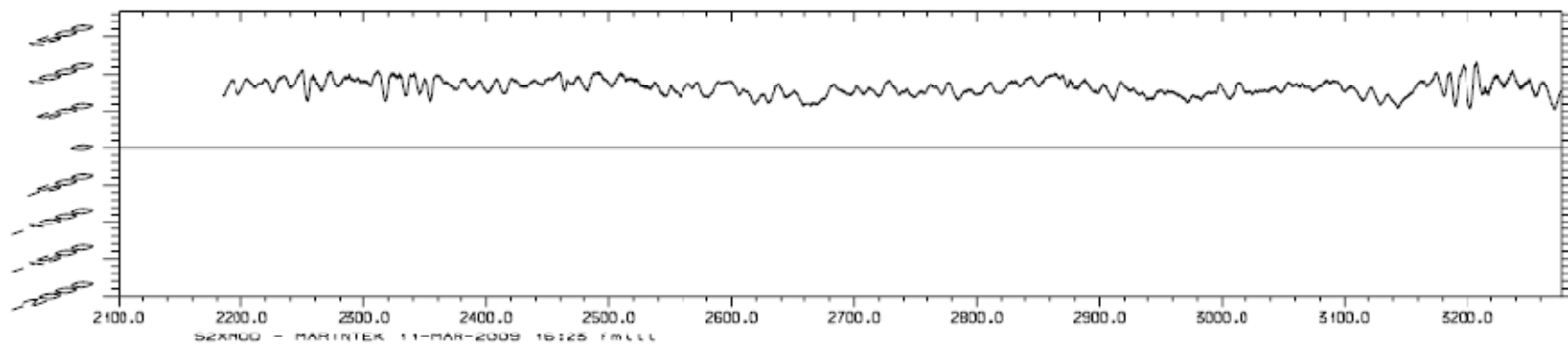
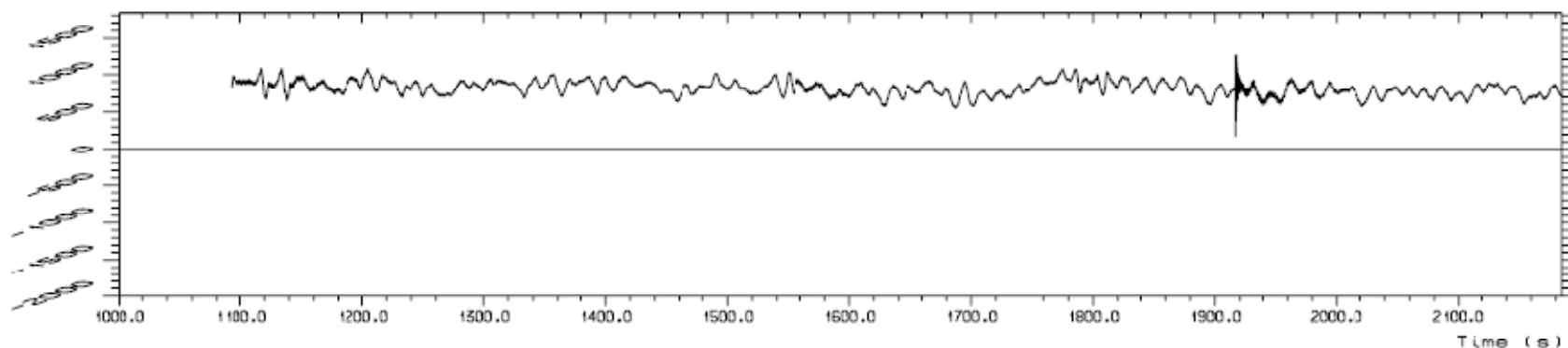
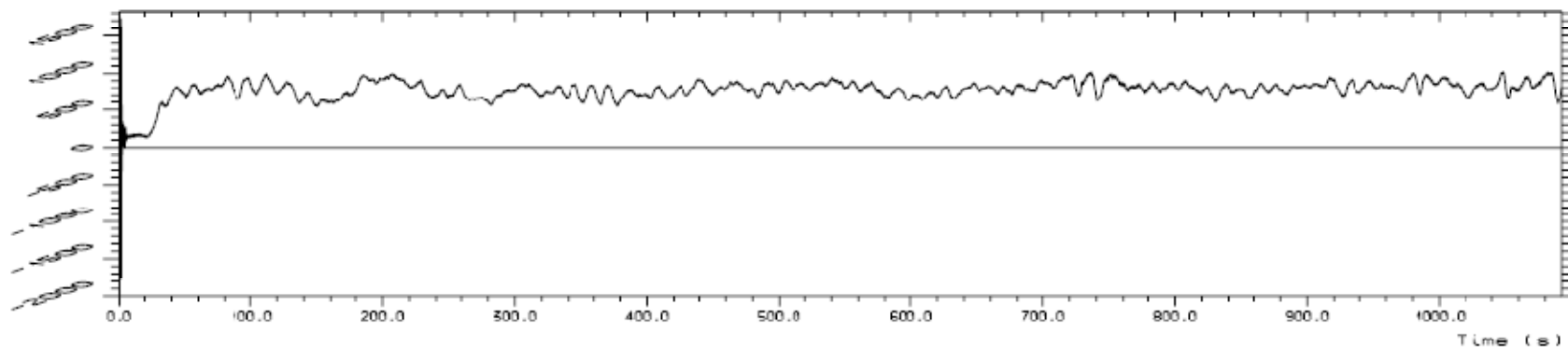


S2XMOD - MARINTEK 12-MAR-2008 09:40 Fwlll

App 124 Body 1 Resp 29 Chann 5 : YLrotationTotalmotion  
Min=-.18717E-01 Max= 11.867 Std= 1.2062 Av= 6.3283



Arr 156 Body 3 Resp 21 Chann 9 : TotalforceTHRUST  
Min=-1768.6 Max= 1731.7 Std= 118.09 Av= 804.65



SEARUD - MARINTEK 11-MAR-2009 16:25 FMULL