

## Measuring Cheng Cycle trends at FS Karton GmbH Neuss

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**THERMIE**

**MEASURING CHENG CYCLE TRENDS  
AT FS KARTON GmbH NEUSS**

**Ricky Doelman  
WFW Report 94.015**

# MEASURING CHENG CYCLE TRENDS AT FS KARTON GmbH NEUSS

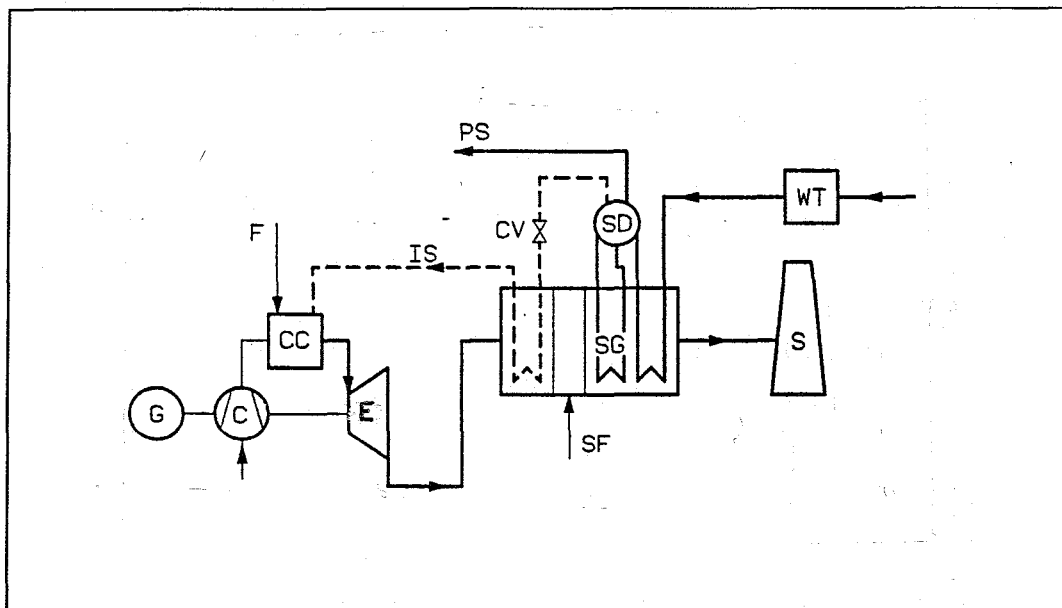
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## Introduction

FS Karton GmbH in Neuss is a producer and seller of high quality folding boxboard for packaging purposes. The continuous boxboard production process extensively consumes steam and electricity. Steam is needed for drying purposes; electricity is needed to fullfil the power demand of the machinery. In case of a malfunction in the production process the steam demand declines, while extra electrical energy is required to restart the process.

Recently, together with a more advanced production line, a new power/steam generating system has been brought into use. The heart of the power plant consists of an Allison 501 KH gasturbine which has been adapted in such a way that it is possible to inject steam into the combustion chamber of the gasturbine. Whenever there are situations characterised by more need for electric power and less need for steam, via an extra injection of steam, the mass flow through the expander is increased, and so a higher electricity output is created.

A cogeneration plant (Dutch: warmte/krachtinstallatie) based on a Steam Injected Gas Turbine (STIG) is also called a Cheng Cycle. The following picture schematically depicts the principle of the Cheng process and shows how the exhaust heat from the gasturbine is used for steam production in a heat recovery steam generator.



figuur 1: Cheng Cycle Cogeneration Plant

|    |                    |      |                               |     |                     |
|----|--------------------|------|-------------------------------|-----|---------------------|
| f  | fuel               | s    | stack                         | sf  | supplemental firing |
| cc | combustion chamber | ps   | process steam                 | is  | injection steam     |
| sg | steam generator    | wt   | water treatment               | cv  | control valve       |
| g  | generator          | sd   | steam drum                    | sh  | super heater        |
| e  | expander           | c    | compressor                    | eco | economiser          |
| gt | gasturbine         | hrsg | heat recovery steam generator |     |                     |

**process description:**

first the feedwater is treated (wt), then it is preheated in the economiser (eko) from where it flows to a steam drum (sd). From there the water leads to the evaporator (sg) where steam is generated. The steam is lead back to the drum (sd) from where it can either be directed towards the process (ps), or it can be further heated in the superheater (sh) and injected into the combustion chamber of the gasturbine (cc), where it expands (e), thus producing additional work. With the supplemental firing (sf) the total steam producing capability of the system can be increased.

A process computer controls and supervises the Cheng Cycle and acquires data from it. Data is saved at intervals of every 60 seconds and stored in files which contain 1 hour of data. 26 files are saved for each trend point, providing for 26 hours of data. To store data for longer periods of time, the trend files are saved to an archive on floppy. FS Karton supplied us with their Trend Archive Reader and floppies which contain measurement data over 2 days.

**Aim of the report:**

- to indicate which trend points are available for dynamic measurement
- to convert the trend files to such a format that they are ready for use in MATLAB and/or PRIMAL and system identification can be performed
- to supply measurement data on behalf of the project on 'Steady State Modeling and Economical Optimisation' (Frans Penning)

## 1. Measurable Trendpoints

In this section we present a scheme in which we indicate which trendpoints are accessible for measurement. This scheme is a major simplification of the original Process and Instrumentation Diagram. Simplification has been performed by omitting

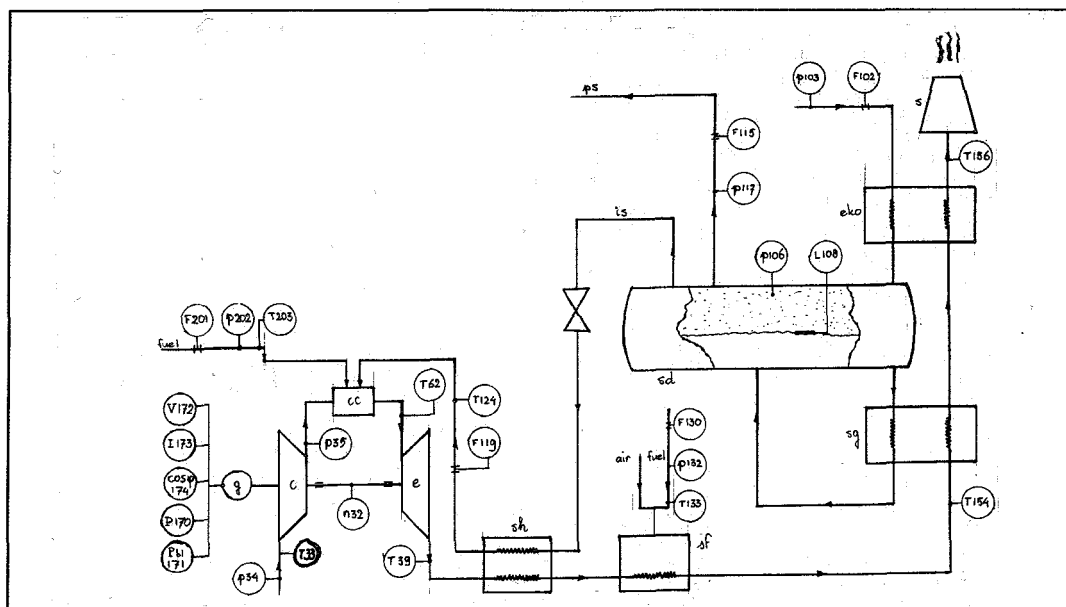
- drawing numbers
- line diameters and specifications
- normally closed valves, safety relief valves and reducers
- supplier limits

Furthermore, the symbols used here are not according to DIN or ISO-standards. This slight abuse of representation should not create any misinterpretation.

The following letter codes are used:

|   |             |   |                  |
|---|-------------|---|------------------|
| p | pressure    | n | rotational speed |
| f | flow        | V | voltage          |
| T | temperature | I | current          |
| l | level       | P | power            |

The letter code is followed by a number. This number equals the index number FS Karton uses to indicate a trend point, e.g. '103' means 'eko speisewasser eintrittsdruck' (see Appendix).



figur 2: Cheng Cycle Cogeneration Plant

## 2. Graphical Representation of Signal Variables

Measurement data is available in digital form and in such a format that it can be processed in MATLAB or PRIMAL for system identification purposes.

On behalf of the project on 'Steady State Modeling and Economical Optimisation' (see: Report 3 - Collecting Information at FS Karton Neuss - Chapter. 5 - Frans Penning) and to allow for visual inspection of the measured data, we present in this section the signal variables as a function of time in graphical form. The signal variables are grouped together as follows:

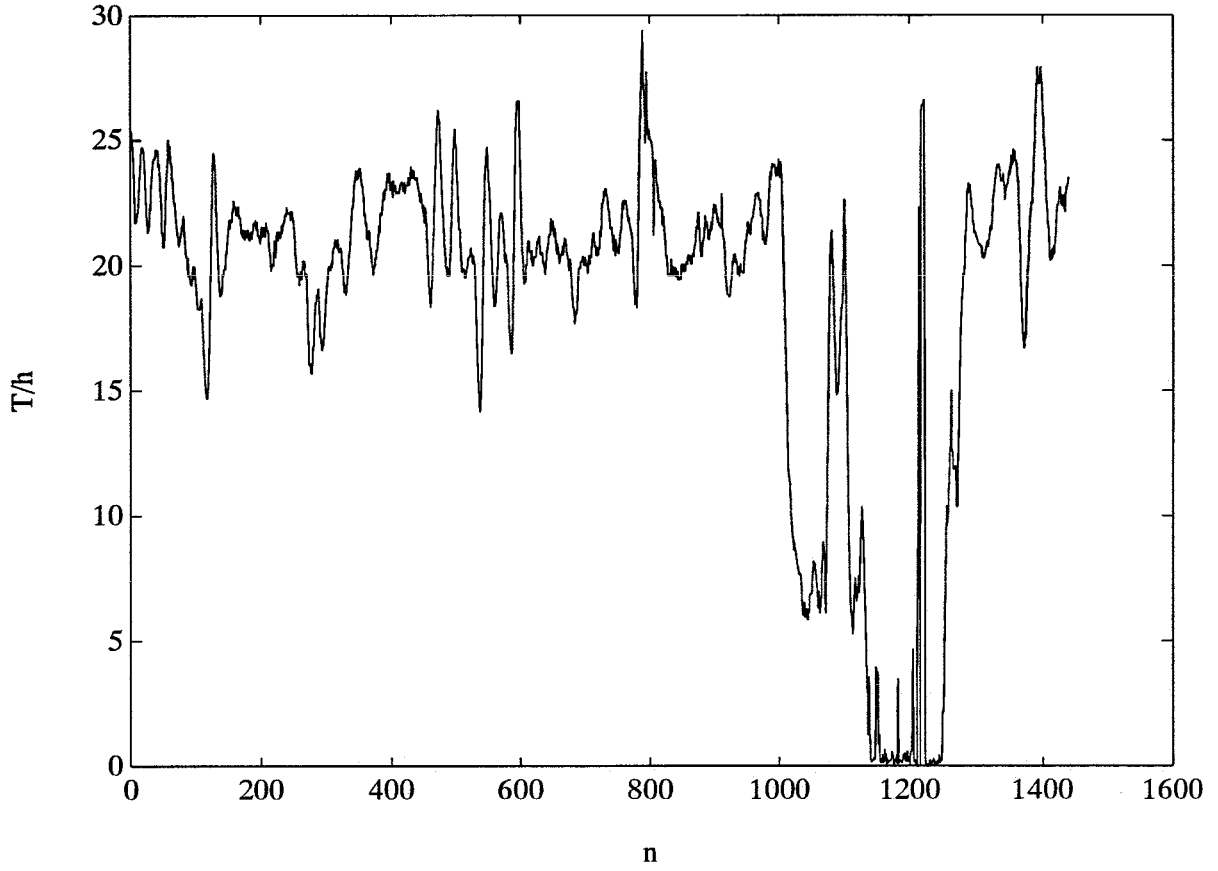
- economiser:
  - eko eintritt speisewassermenge (102)
  - eko speisewasser eintrittsdruck (103)
  - abgastemperatur eko austritt (156)
  
- steam generator:
  - abgastemperatur verdampfer eintritt (154)
  
- steam drum:
  - kesseltrommel druck (106)
  - kesseltrommel niveau (108)
  - prozessdampfmenge (115)
  - prozessdampfdruck (117)
  
- super heater:
  - injektionsdampfmenge (119)
  - ueberhitzer austrittstemperatur (124)
  
- supplemental firing:
  - kanalbrenner erdgasmenge (130)
  - kanalbrenner erdgasdruck (132)
  - kanalbrenner erdgastemperatur (133)
  
- gasturbine:
  - turbine erdgasmenge (201)
  - turbine erdgasdruck (202)
  - turbine erdgastemperatur (203)
  - verbrennungsluft eintrittstemperatur (33)
  - kompressor eintrittsdruck (34)
  - kompressor austrittsdruck (35)
  - drehzahlaufnehmer turbine (32)
  - turbine austrittstemperatur (39)
  - TIT sollwert (62)
  
- generator:
  - generator leistung (170)
  - generator blindleistung (171)
  - generator spannung (172)
  - generator strom (173)
  - cos fi (174)

total: 27 trendpoints

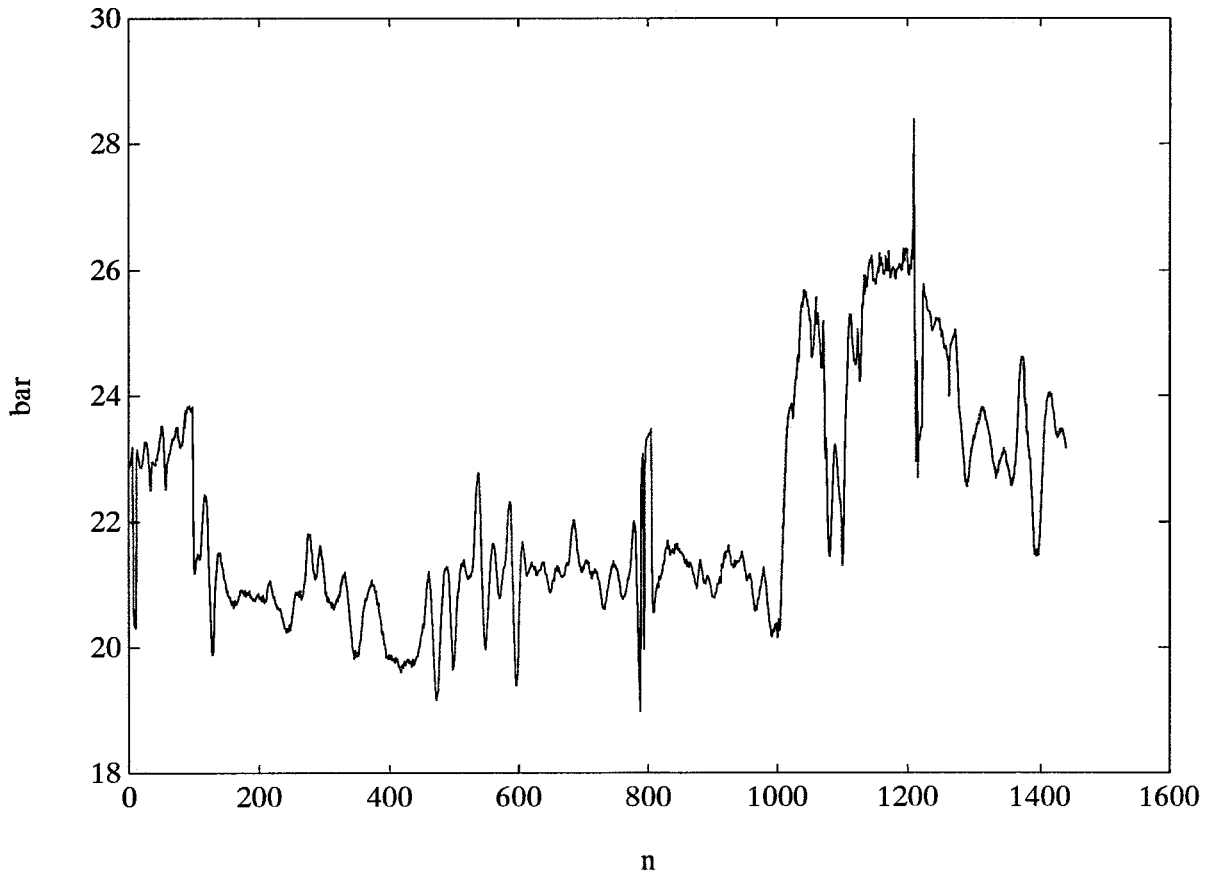
**24th NOV 1993**



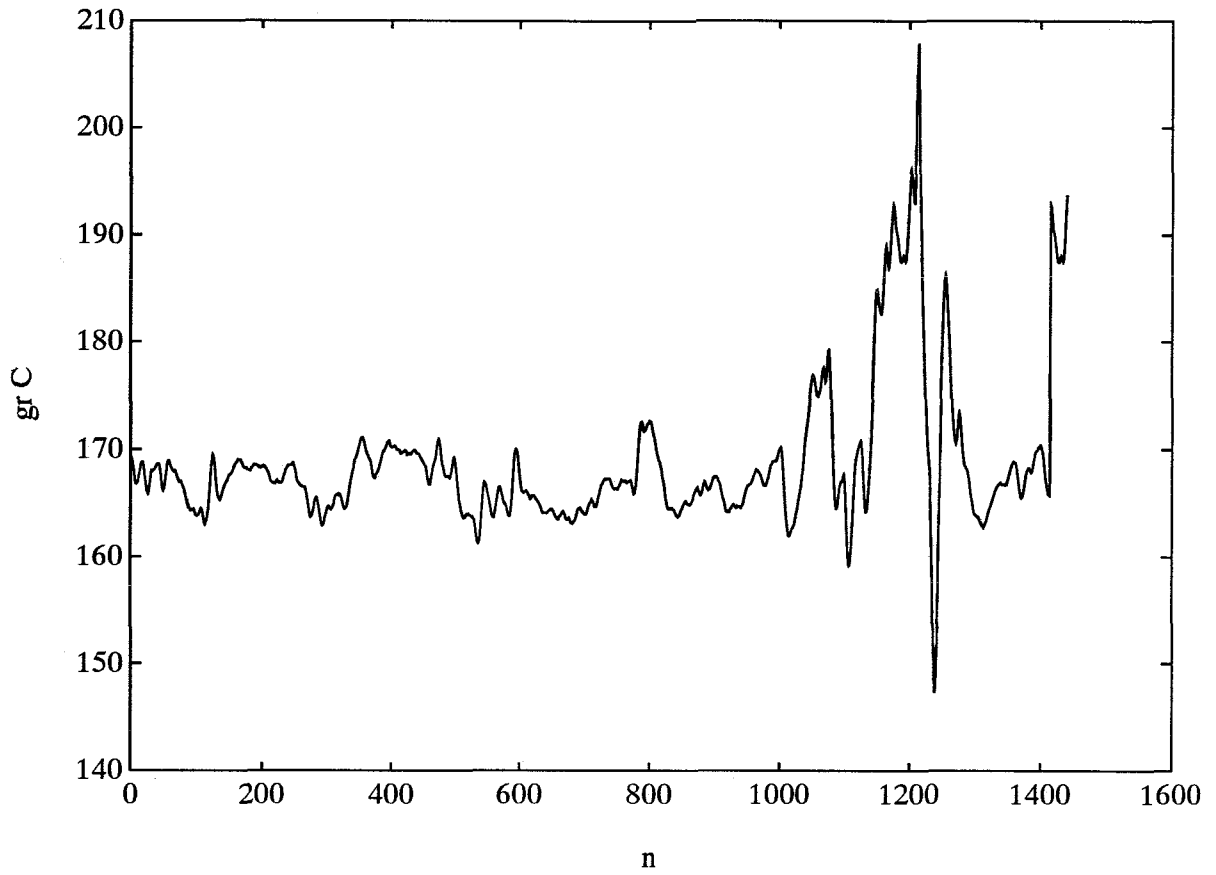
24 NOV 1993 - EKO EINTRITT SPEISEWASSERMENGE



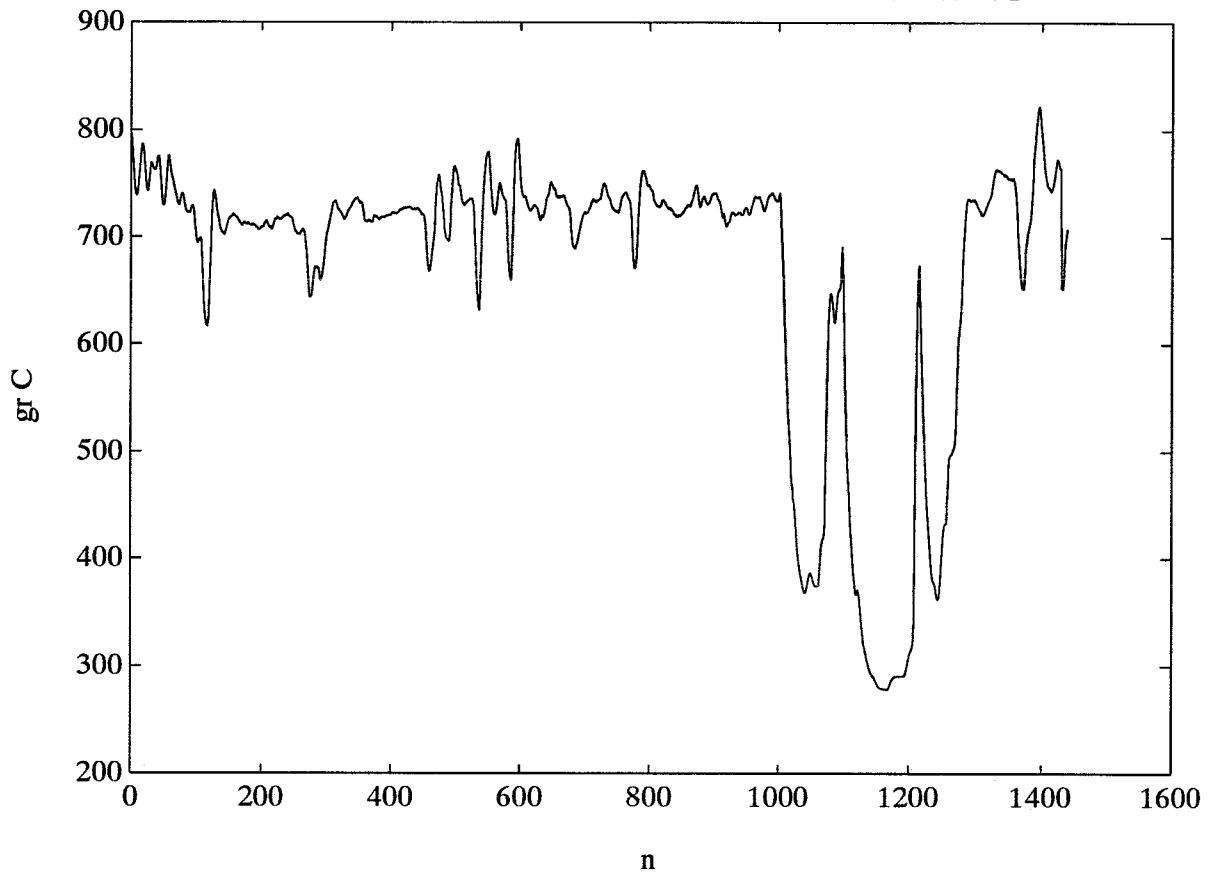
24 NOV 1993 - EKO SPEISEWASSER EINTRITTSDRUCK



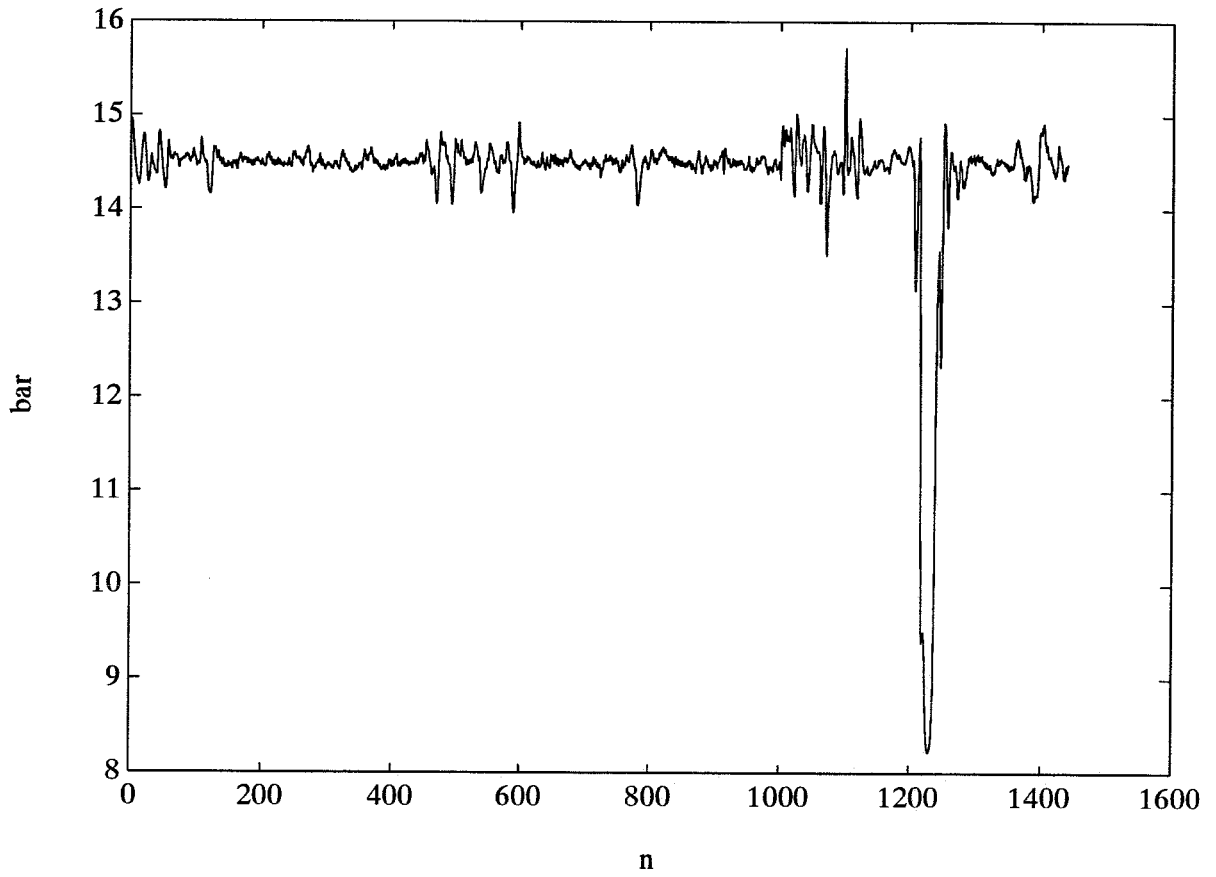
24 NOV 1993 - ABGASTEMP EKO AUSTRITT



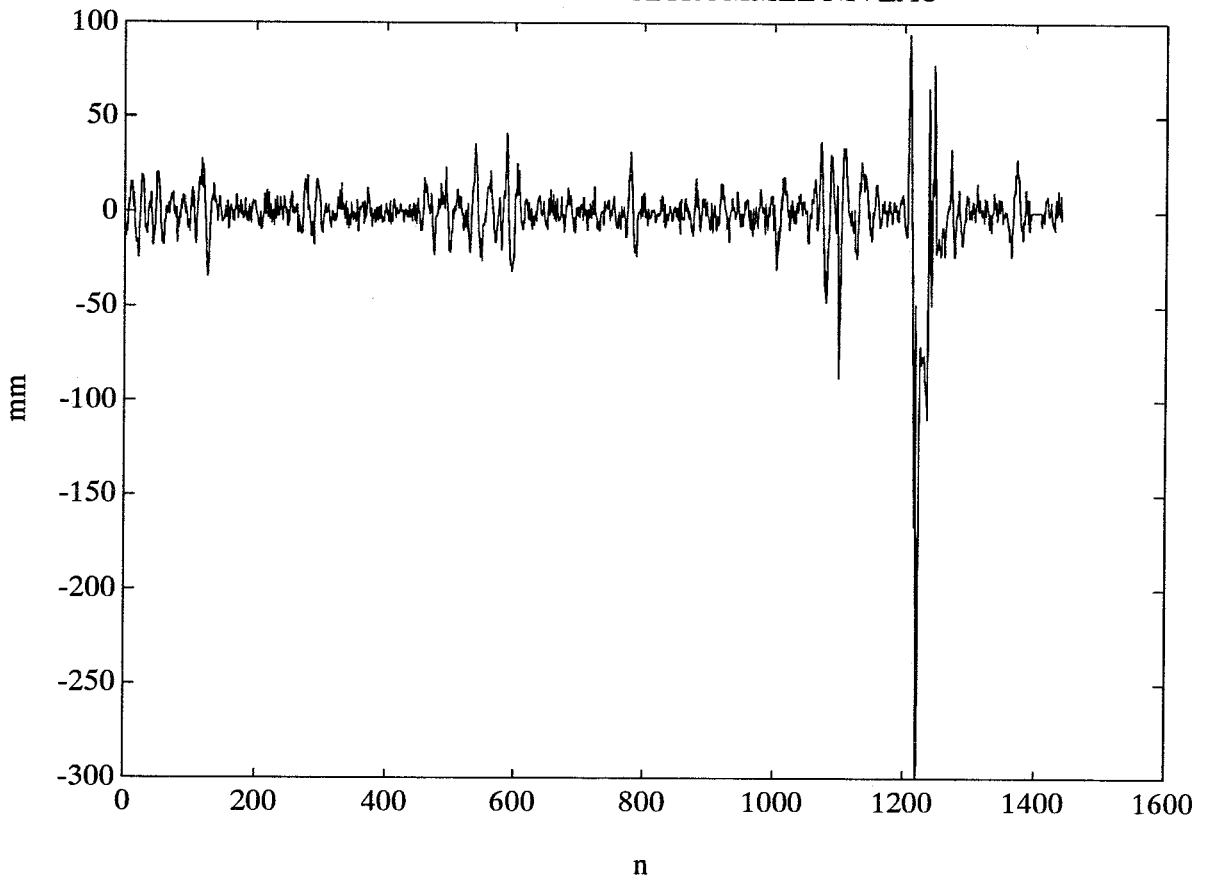
24 NOV 1993 - ABGASTEMP VERDAMPFER EINTRITT



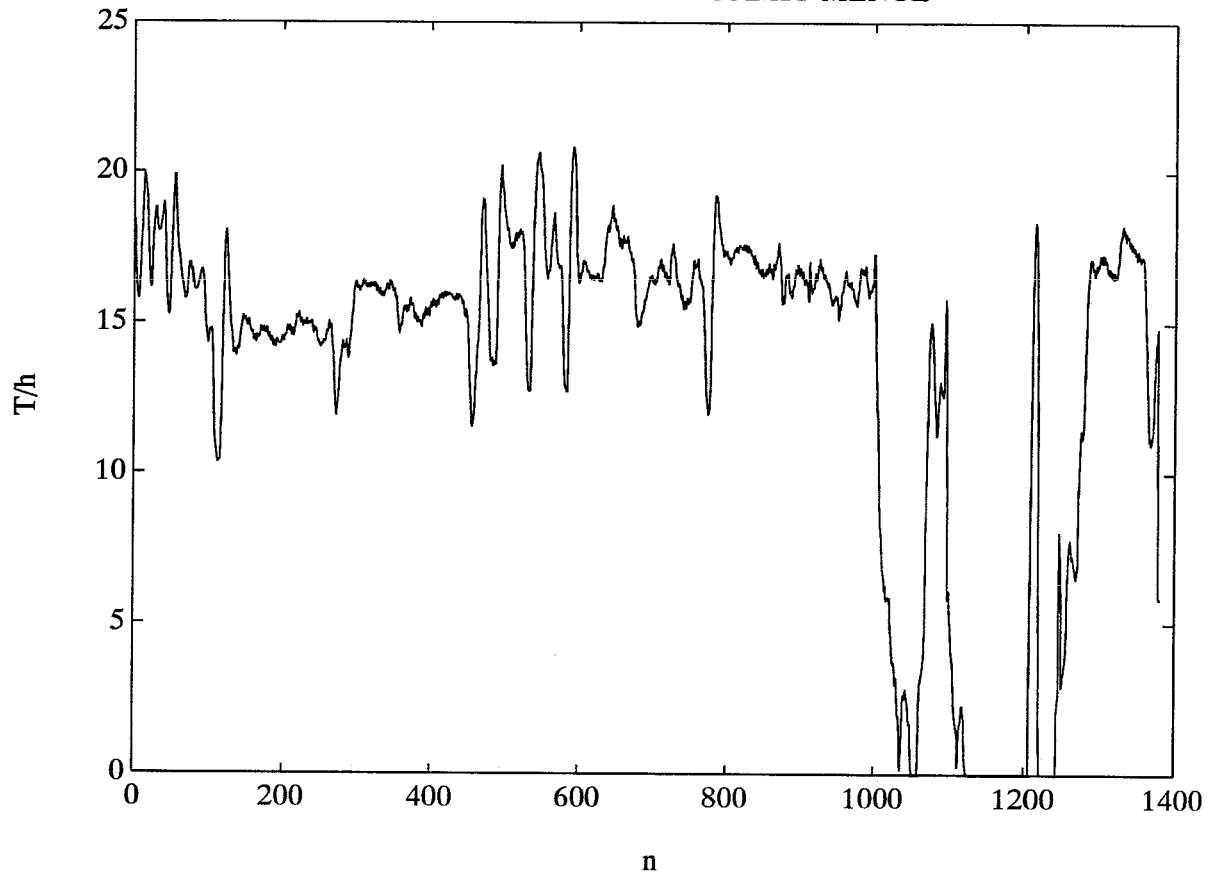
24 NOV 1993 - KESSELTROMMEL DRUCK



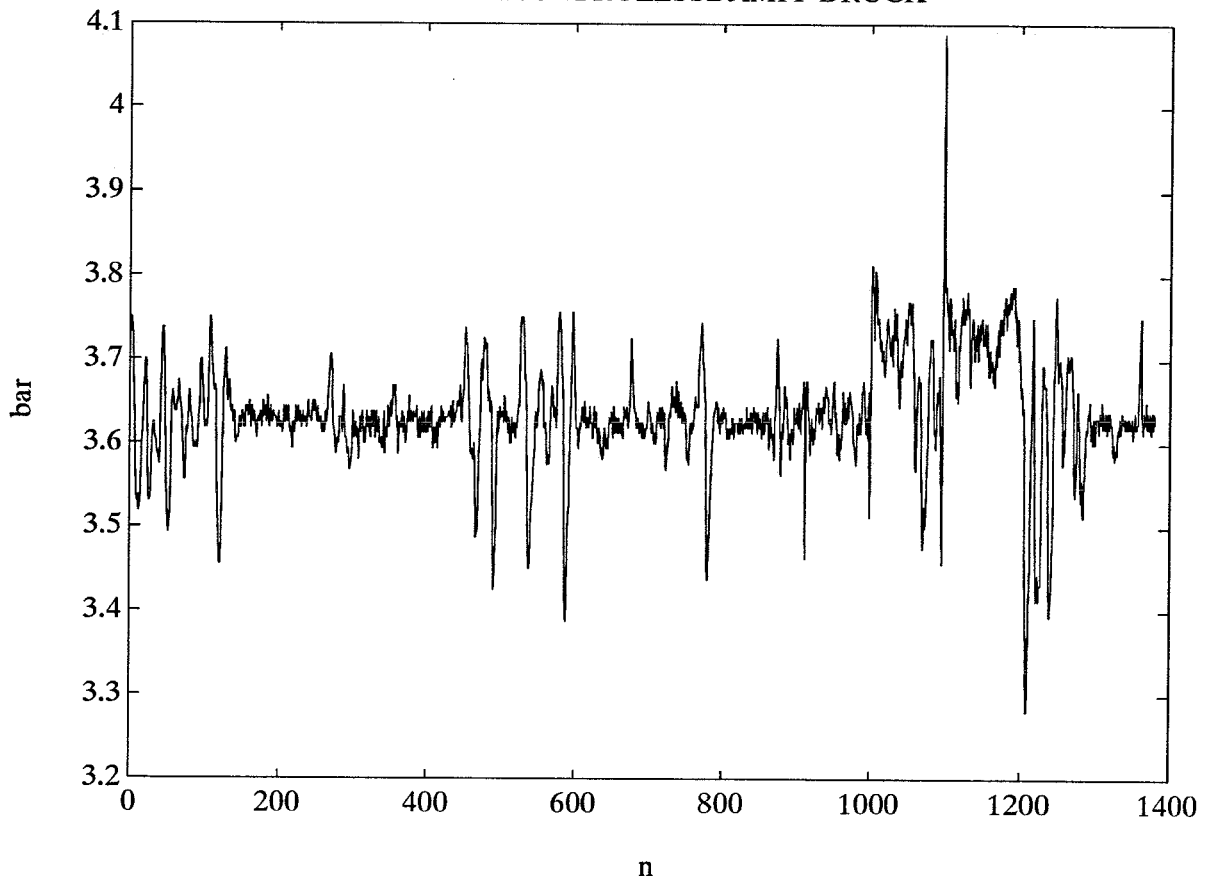
24 NOV 1993 - KESSELTROMMEL NIVEAU



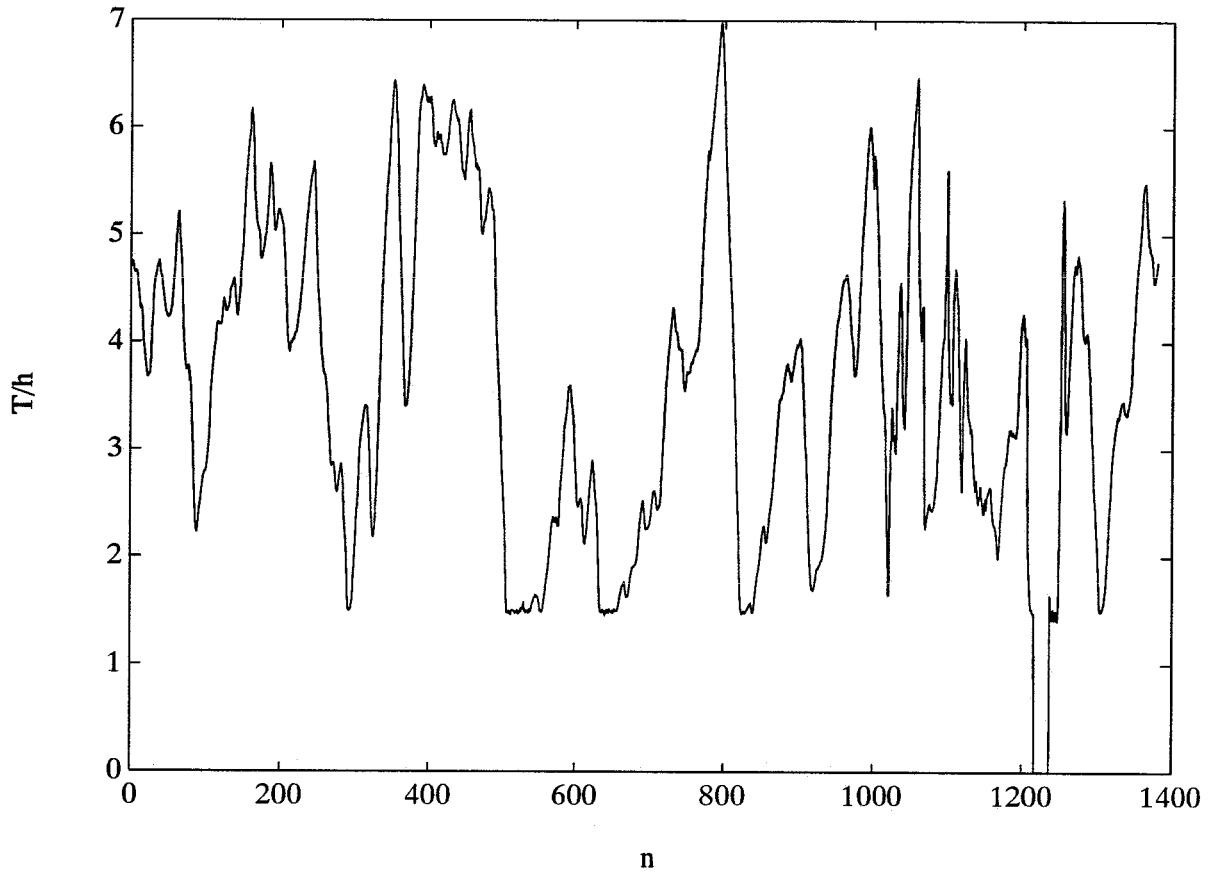
24 NOV 1993 - PROZESSDAMPF MENGE



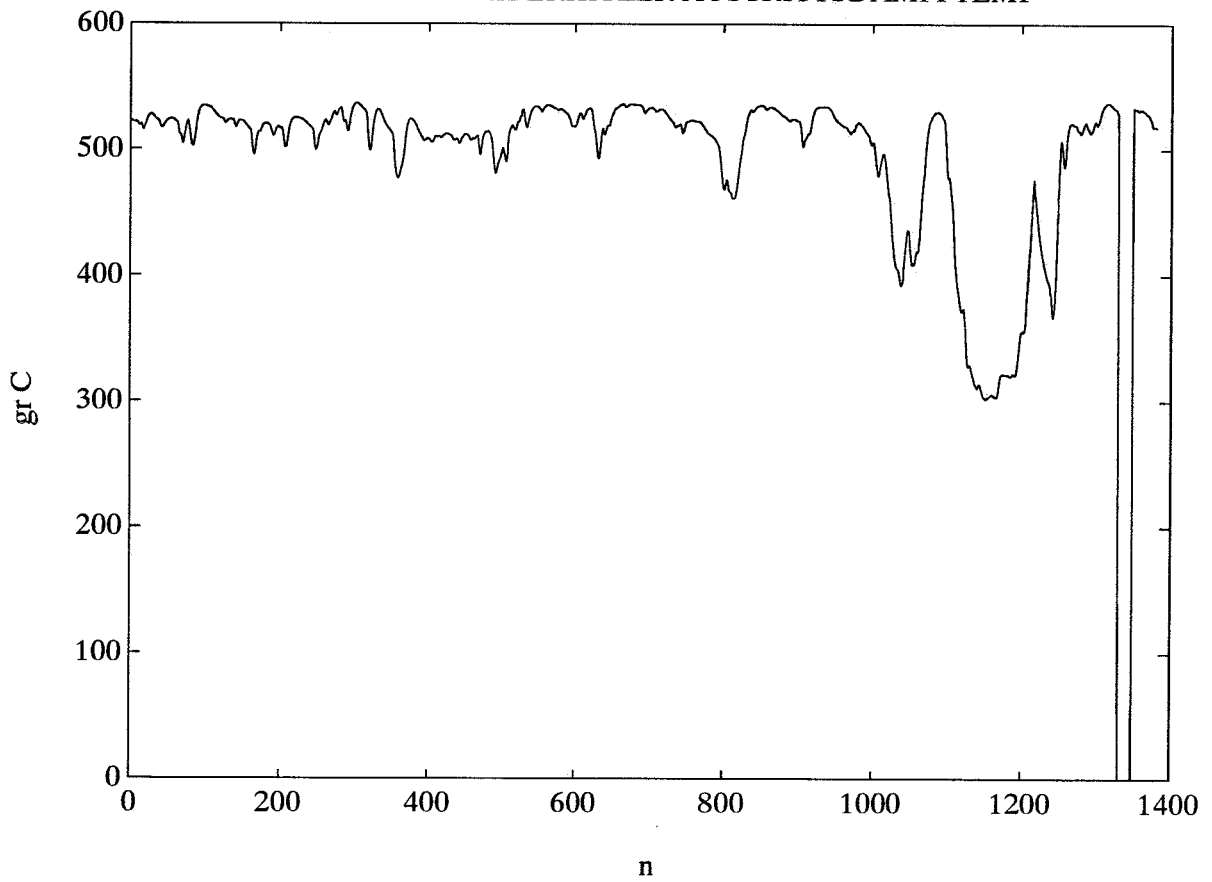
24 NOV 1993 - PROZESSDAMPF DRUCK



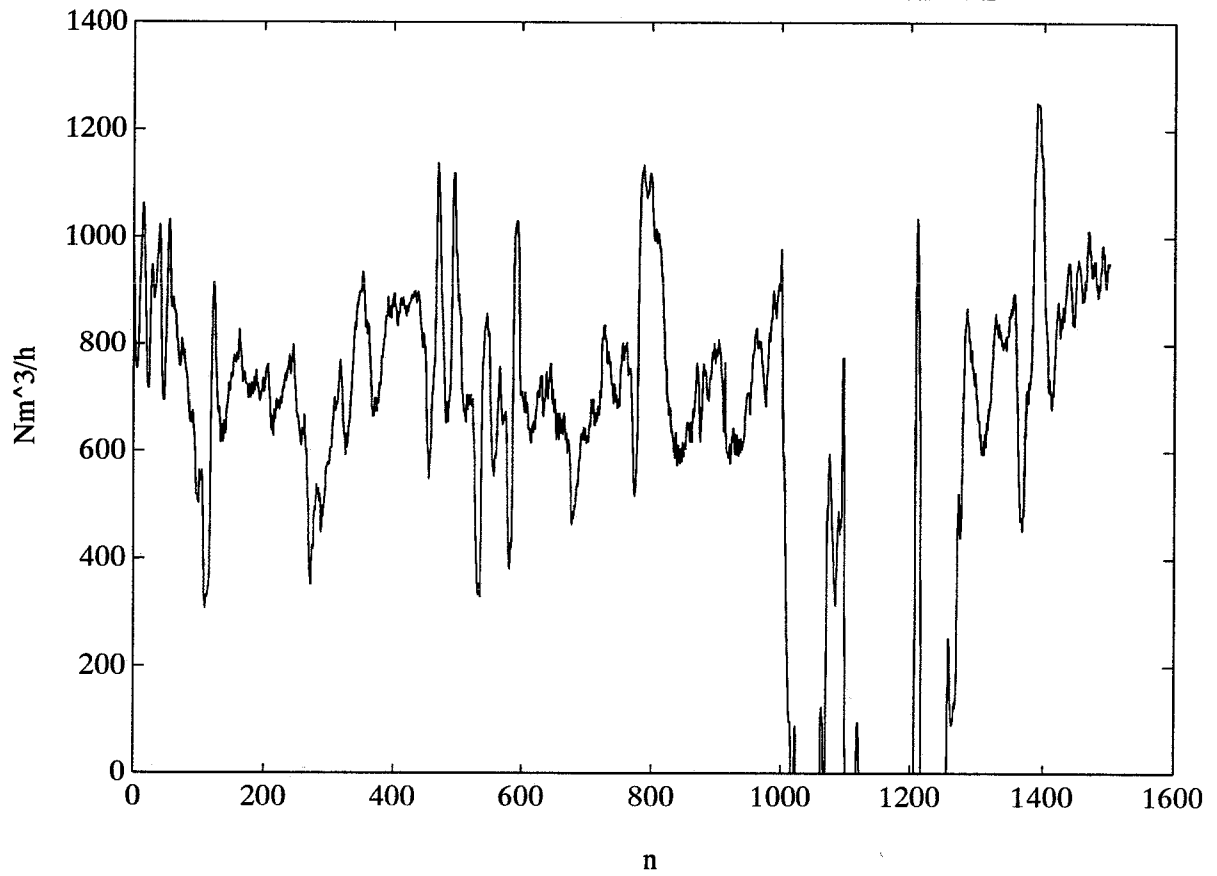
24 NOV 1993 - INJEKTIONS-DAMPFMENGE



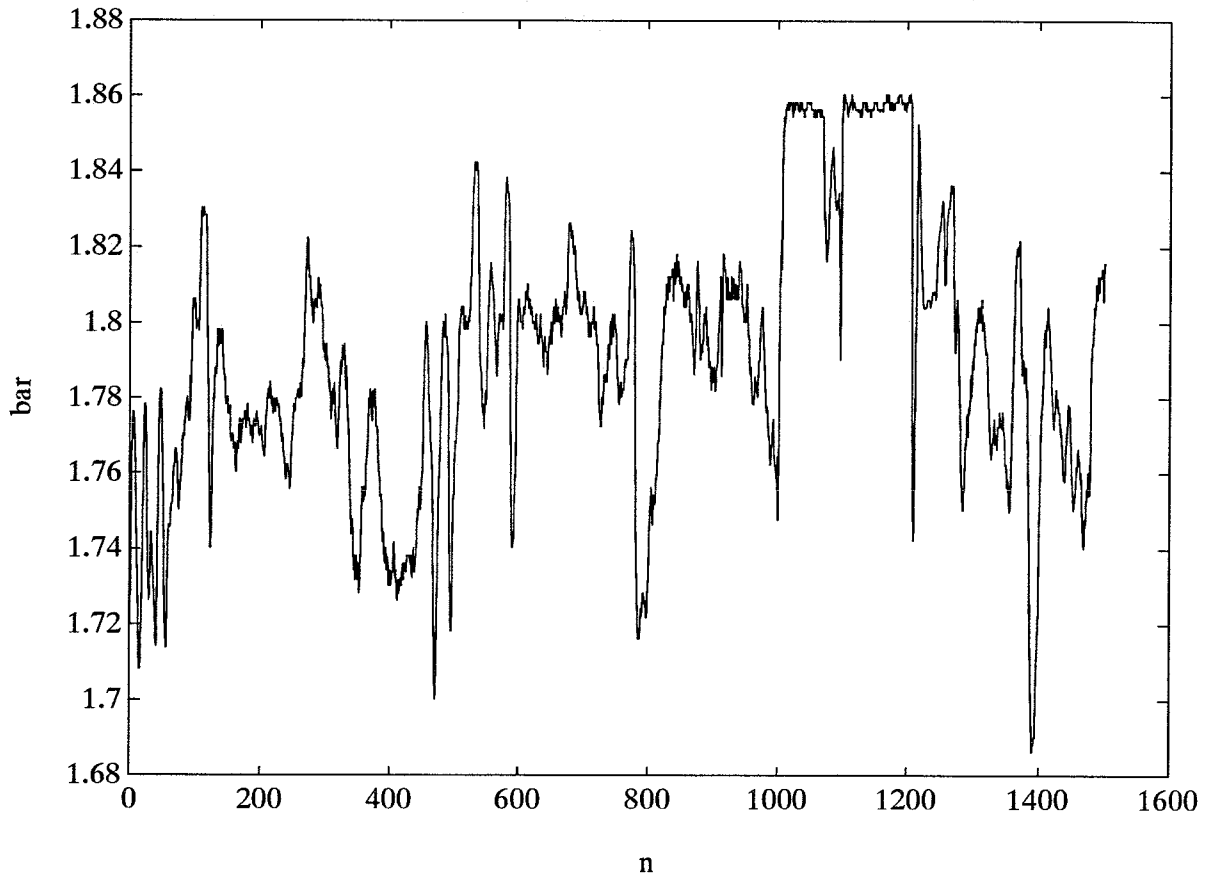
24 NOV 1993 - UEBERHITZER AUSTRITTS-DAMPFTEMP



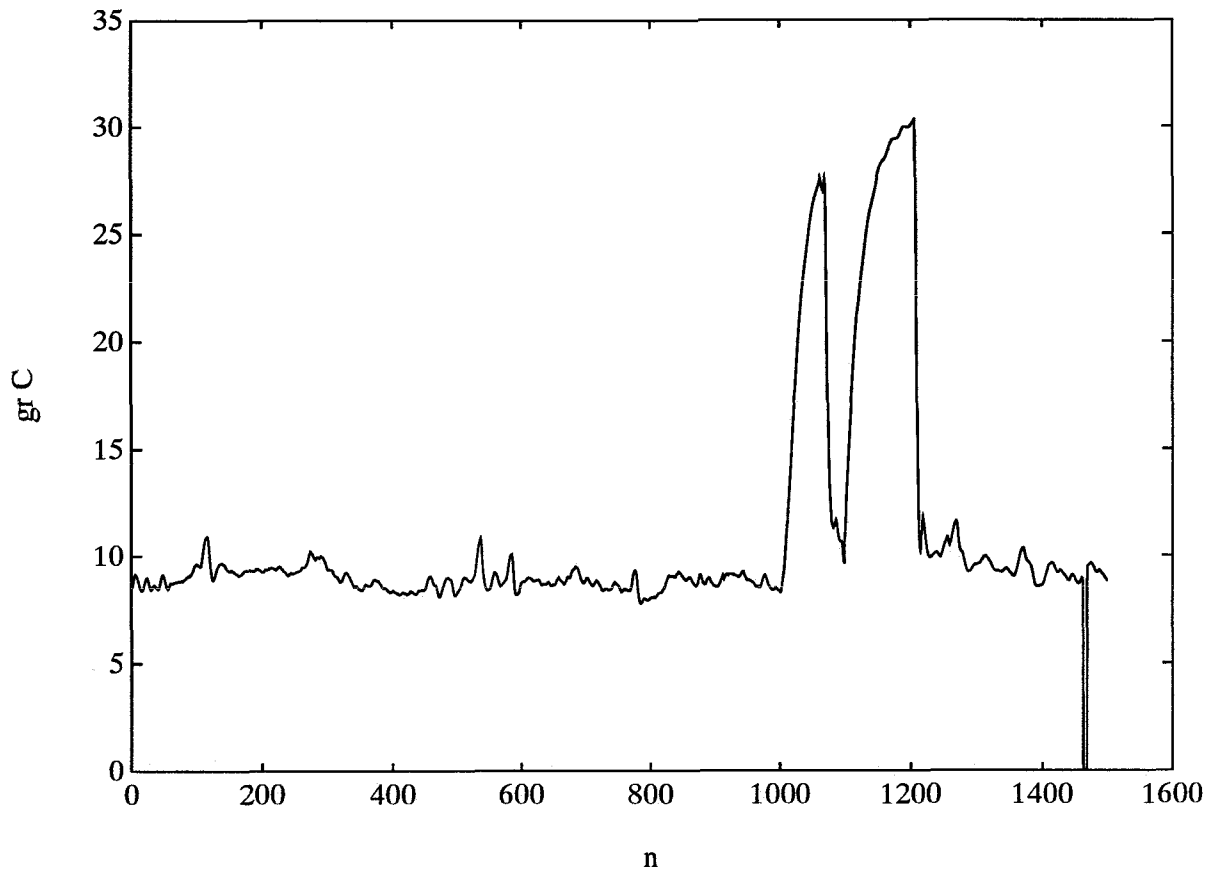
24 NOV 1993 - KANALBRENNER ERDGASMENGE



24 NOV 1993 - KANALBRENNER ERDGASDRUCK

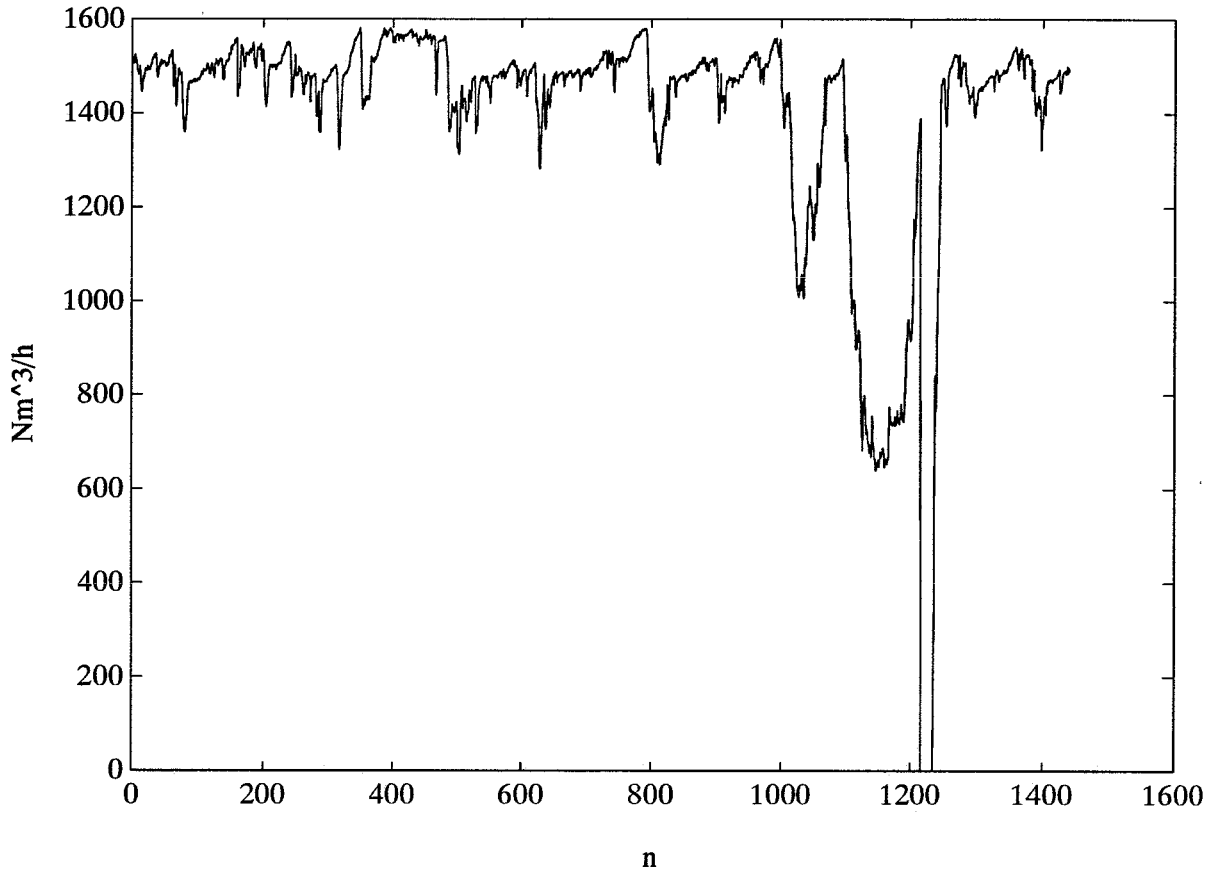


24 NOV 1993 - KANALBRENNER ERDGASTEMPERATUR

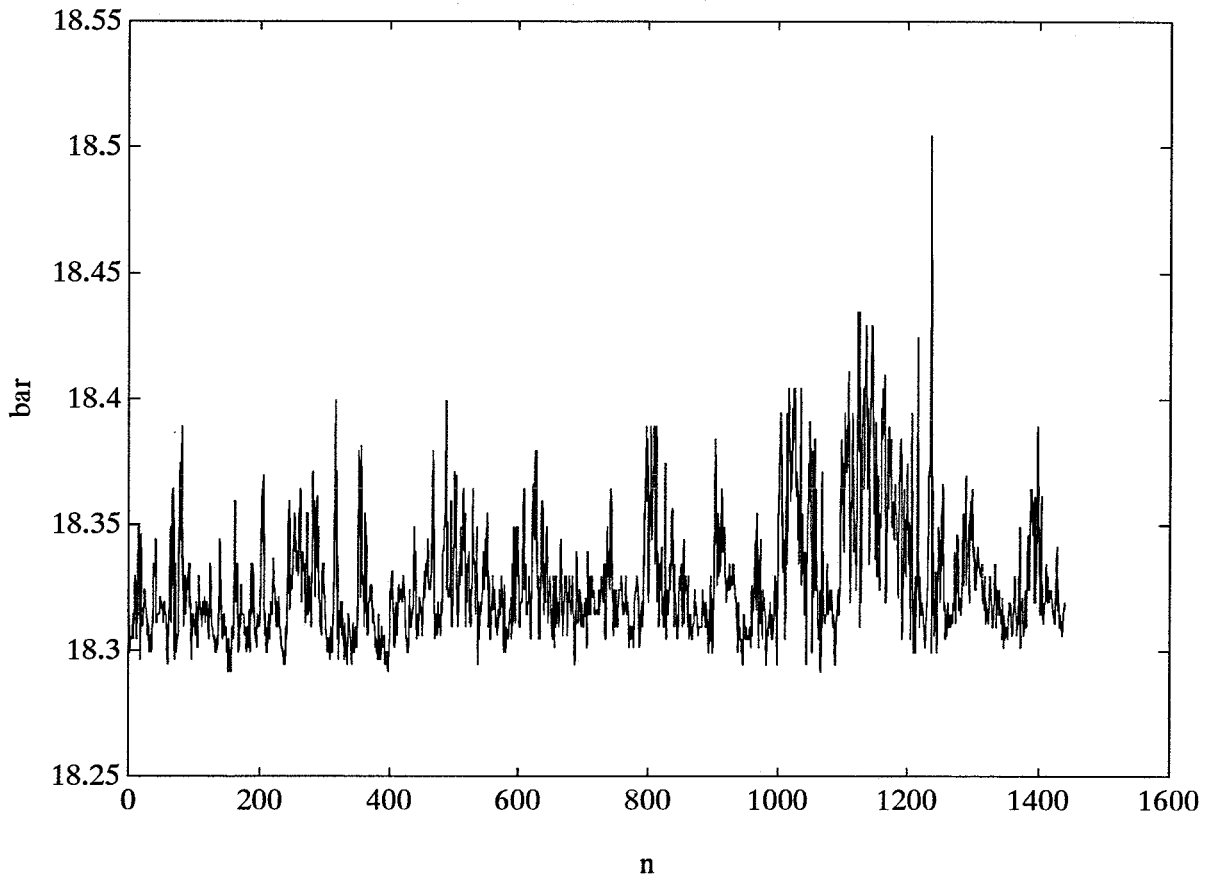




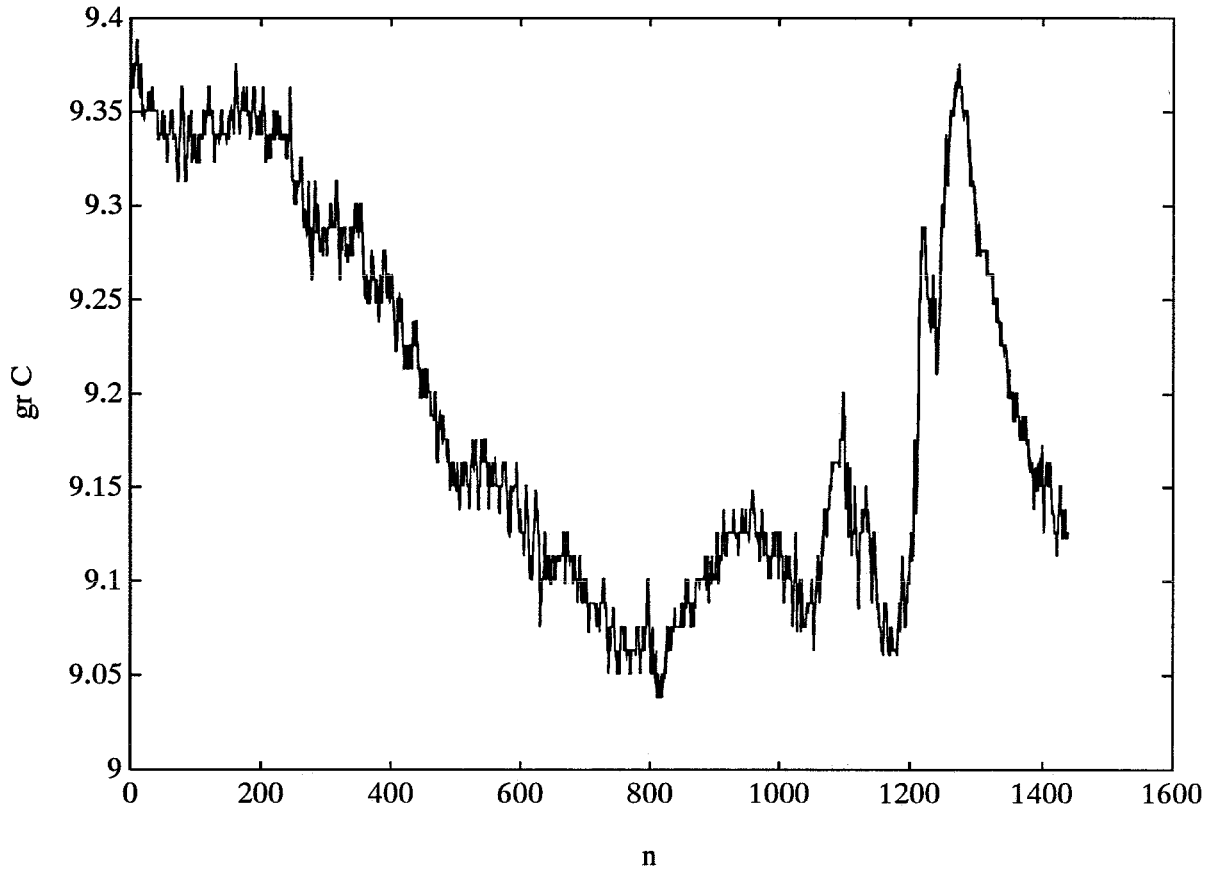
24 NOV 1993 - TURBINE ERDGASMENGE



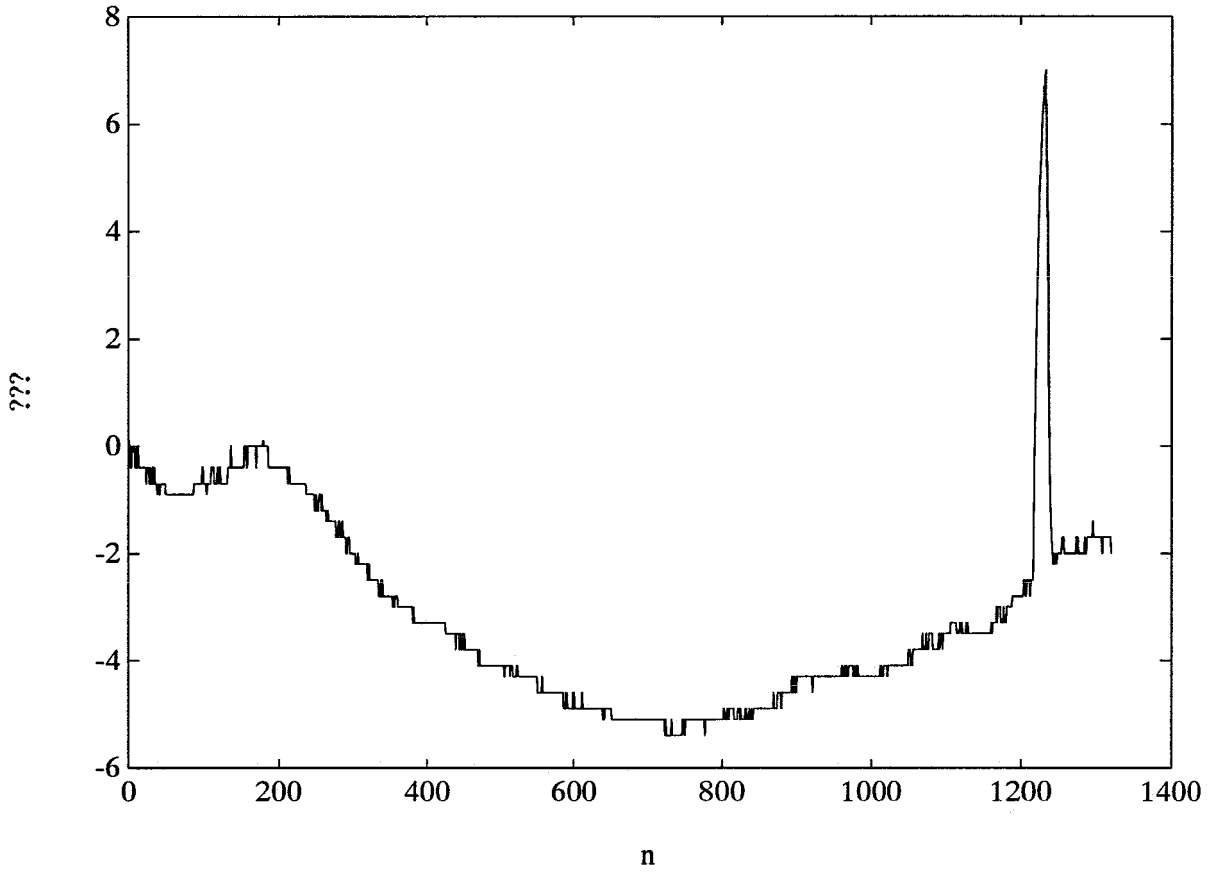
24 NOV 1993 - TURBINE ERDGASDRUCK



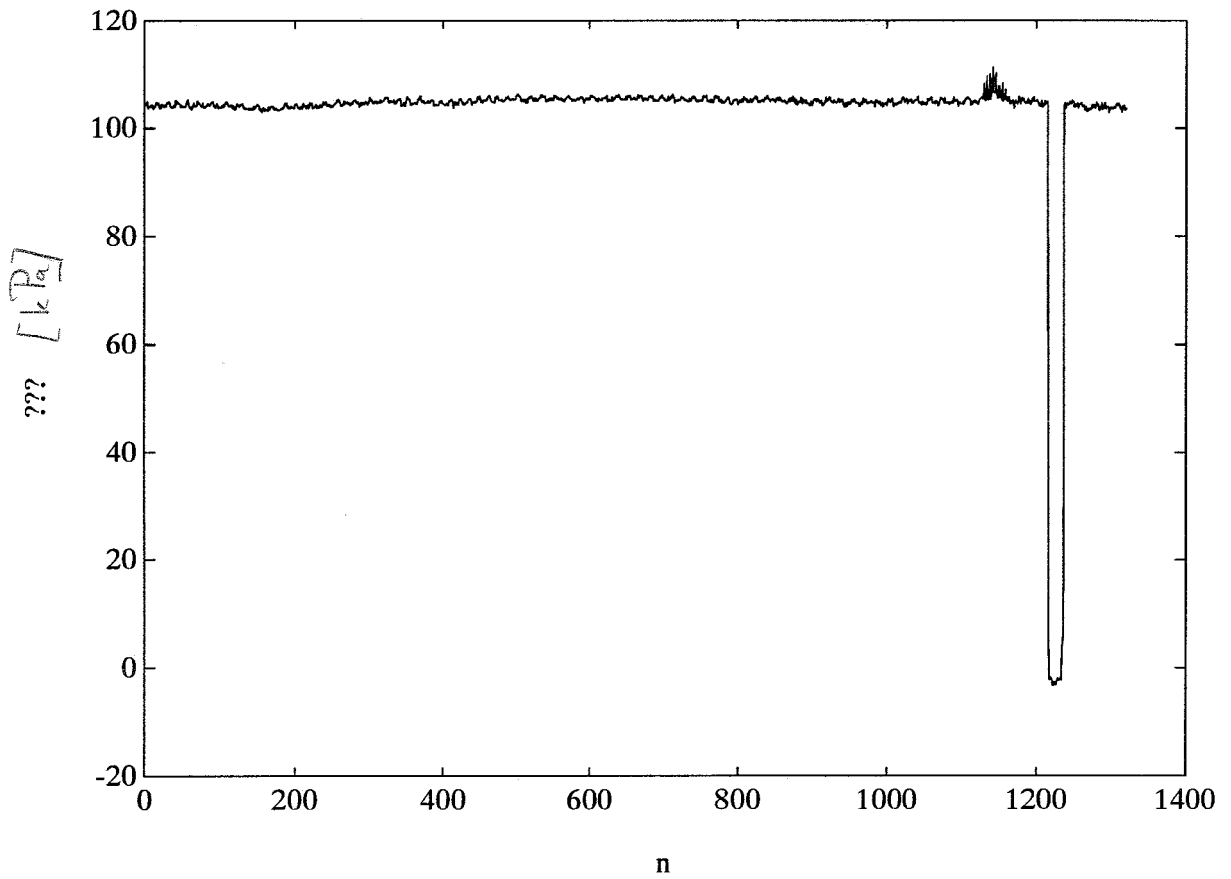
24 NOV 1993 - TURBINE ERDGASTEMPERATUR



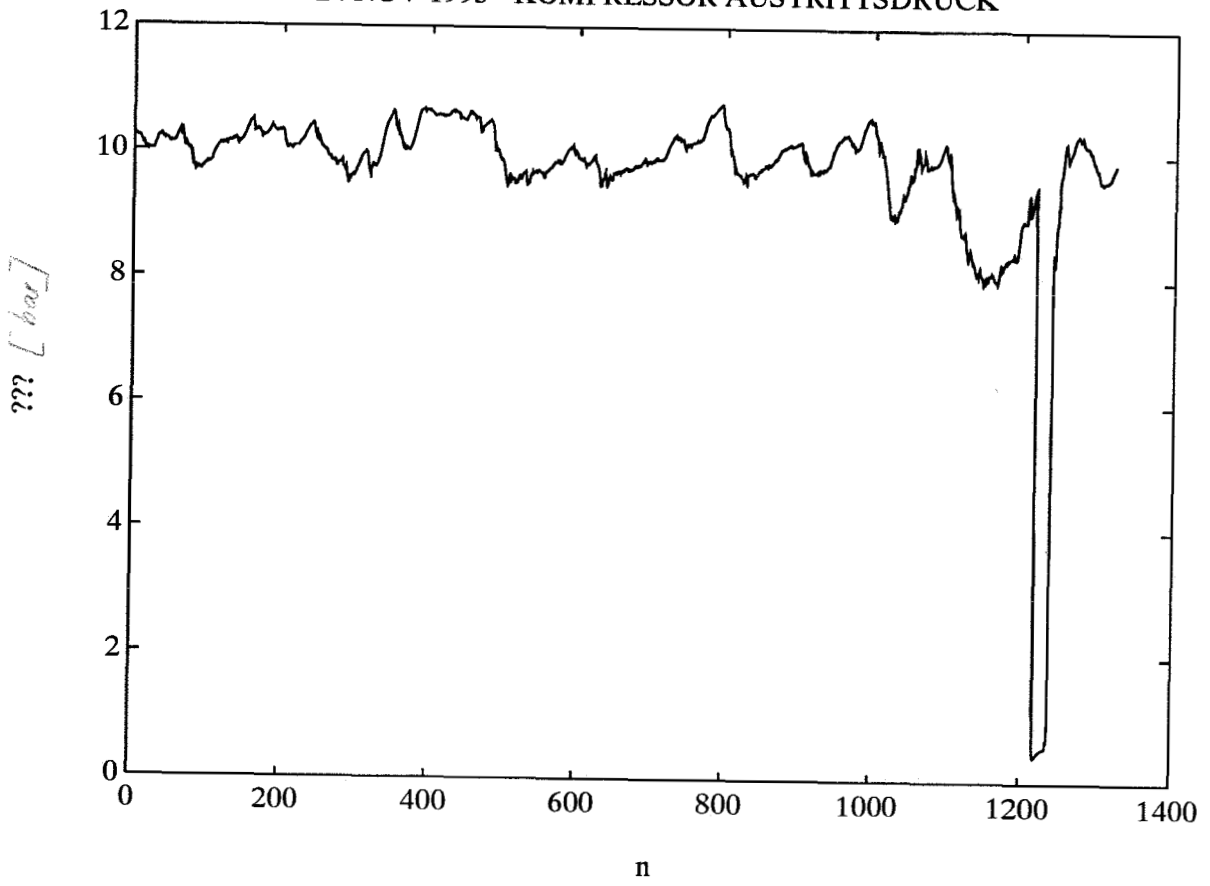
24 NOV 1993 - VERBRENNUNGSLUFT-EINTRITTSTEMP



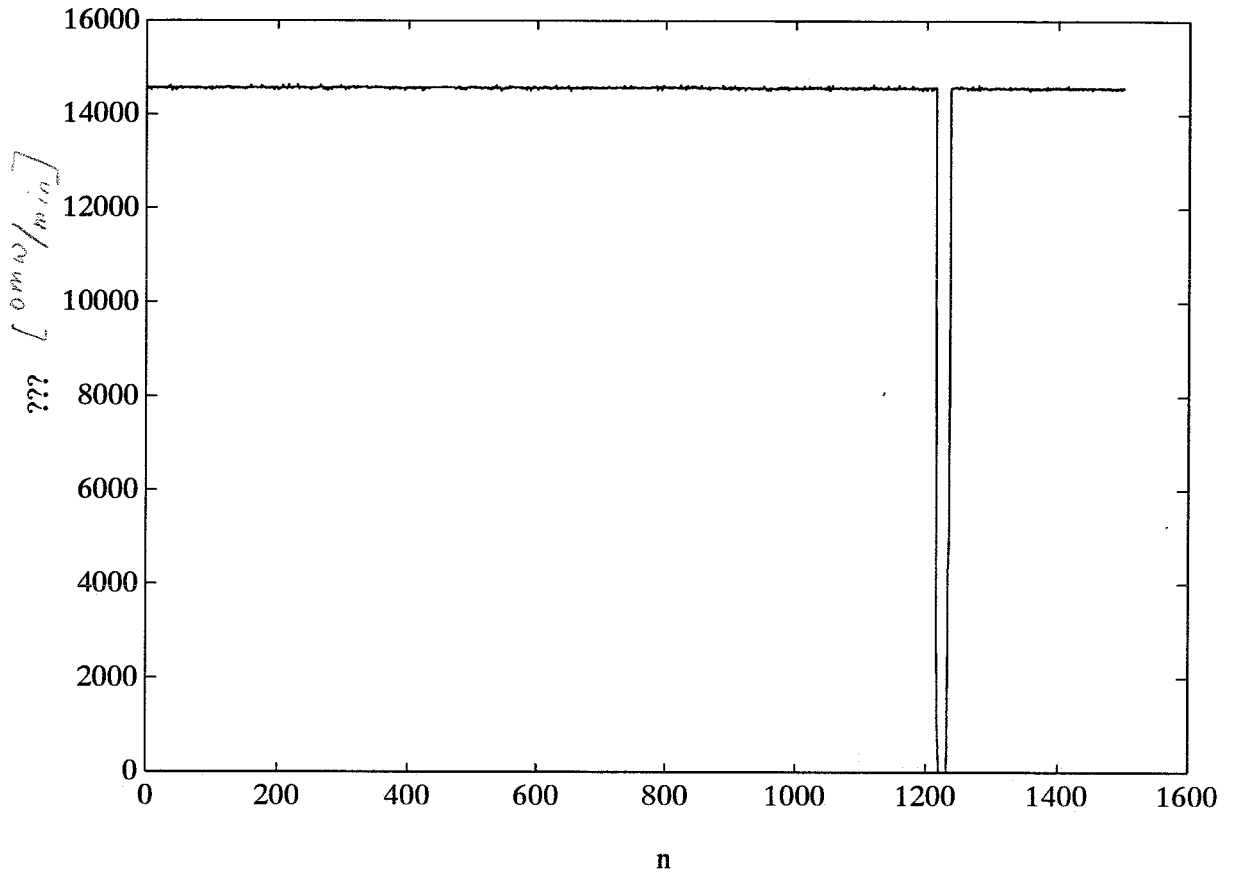
24 NOV 1993 - KOMPRESSOR EINTRITTSDRUCK



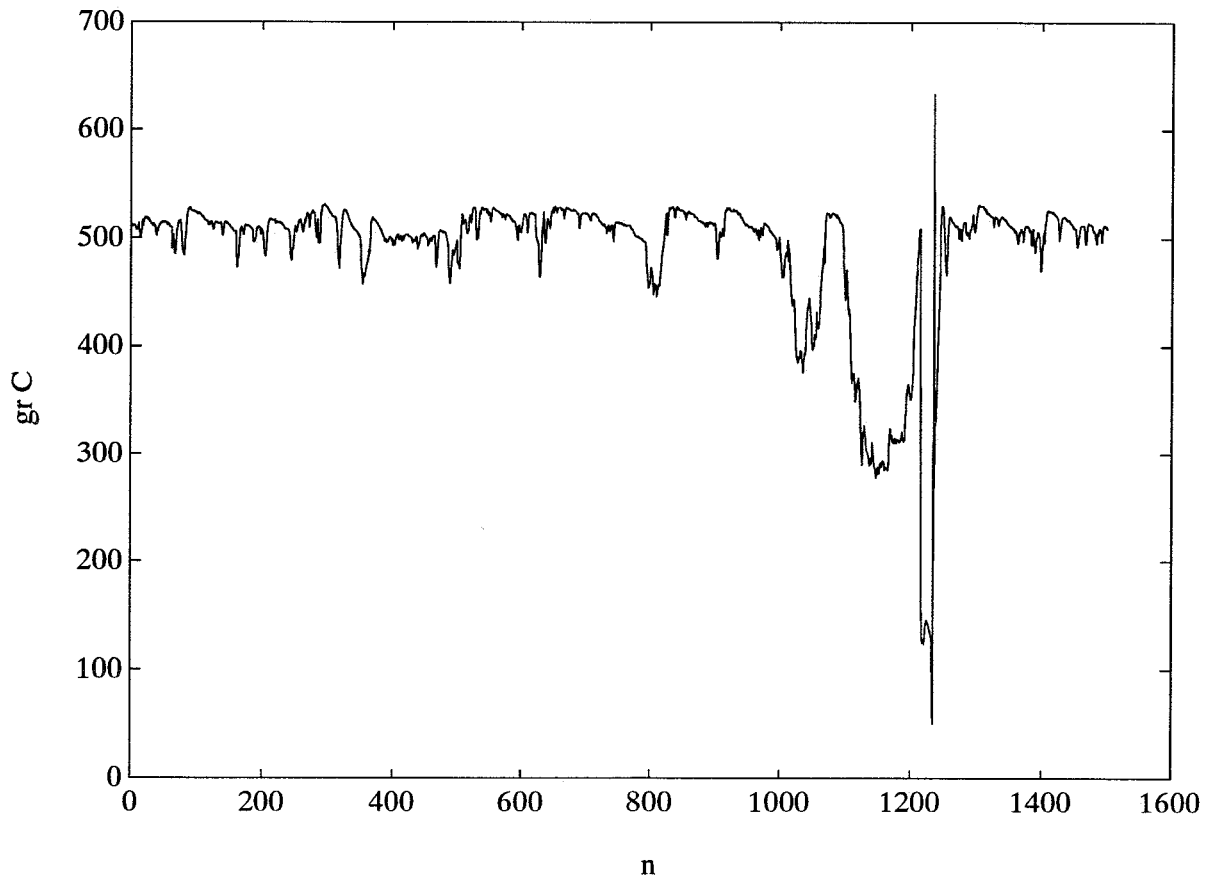
24 NOV 1993 - KOMPRESSOR AUSTRITTSDRUCK



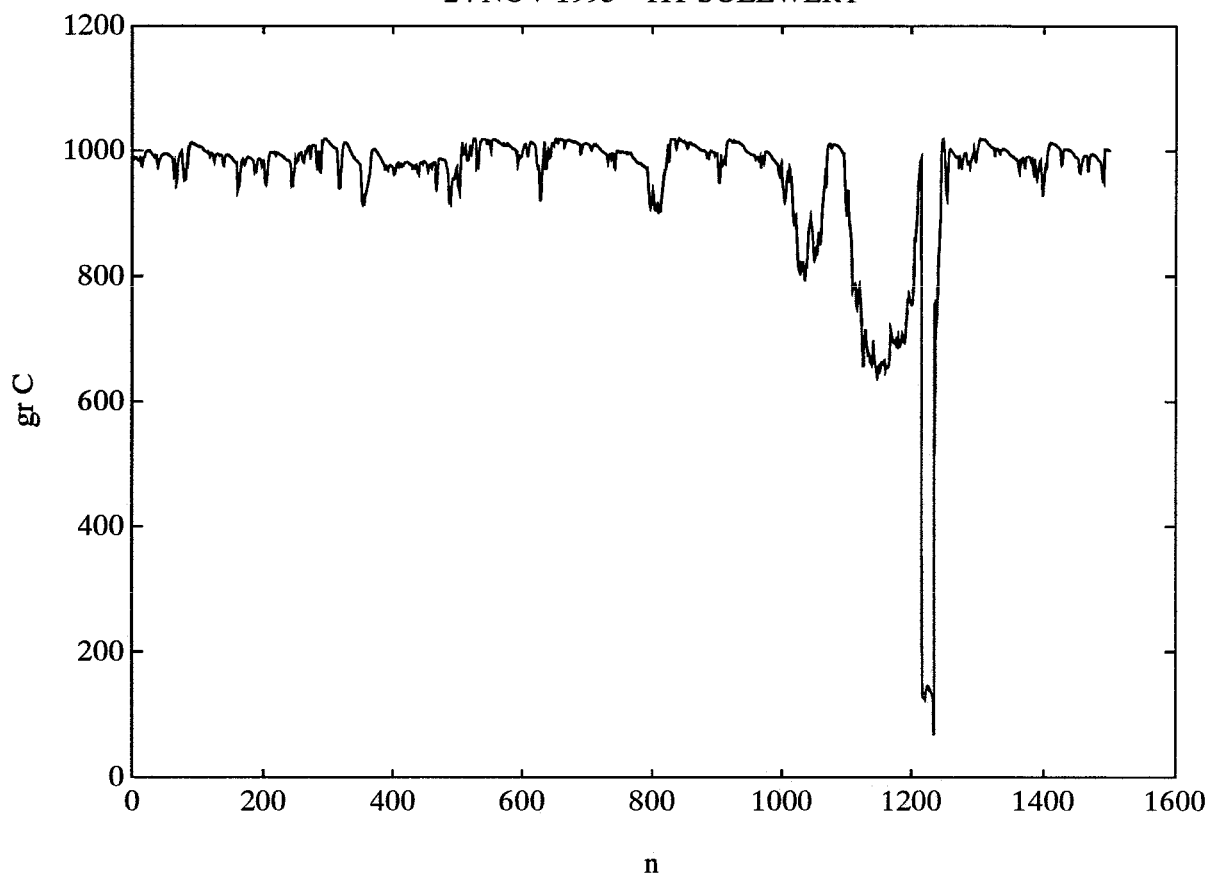
24 NOV 1993 - DREHZAHLAUFNEHMER TURBINE



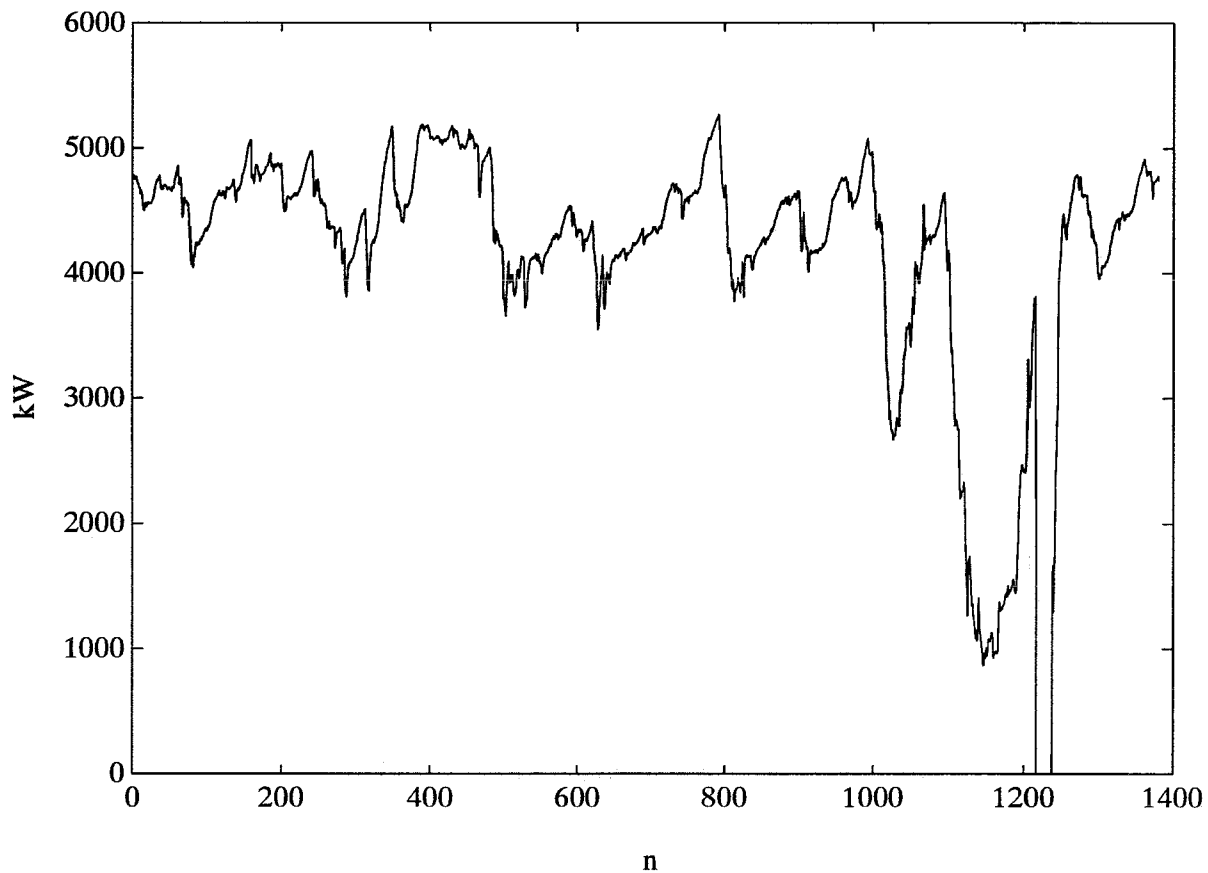
24 NOV 1993 - TURBINE AUSTRITTSTEMP



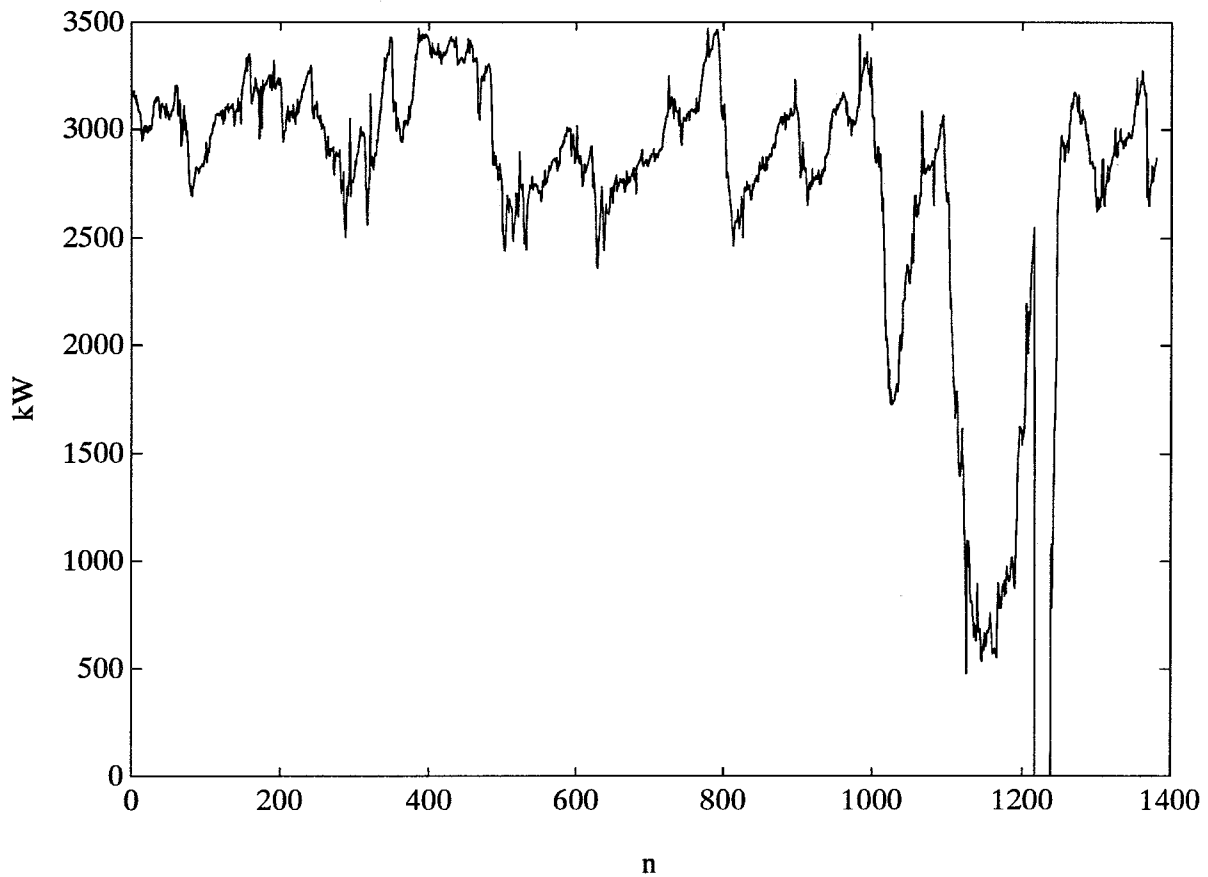
24 NOV 1993 - TIT SOLLWERT



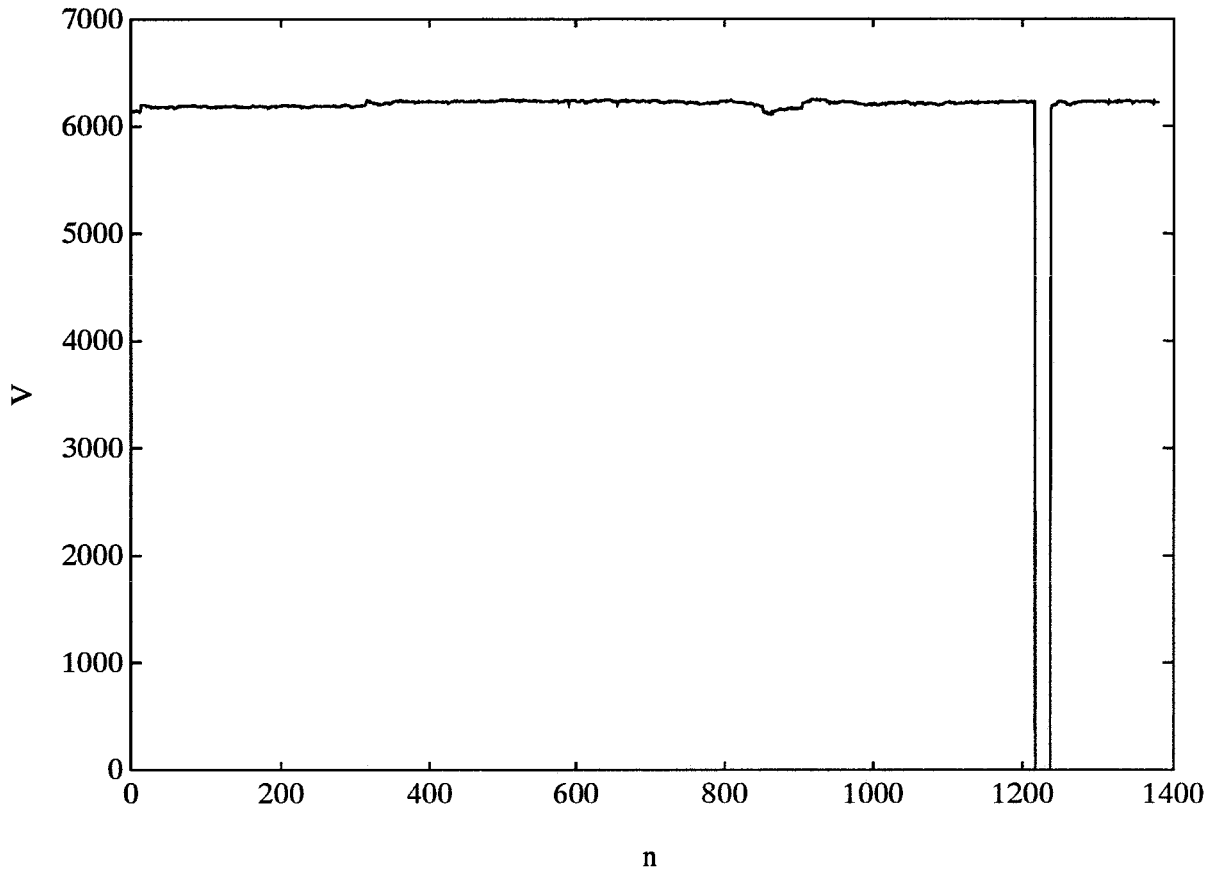
24 NOV 1993 - GENERATOR LEISTUNG



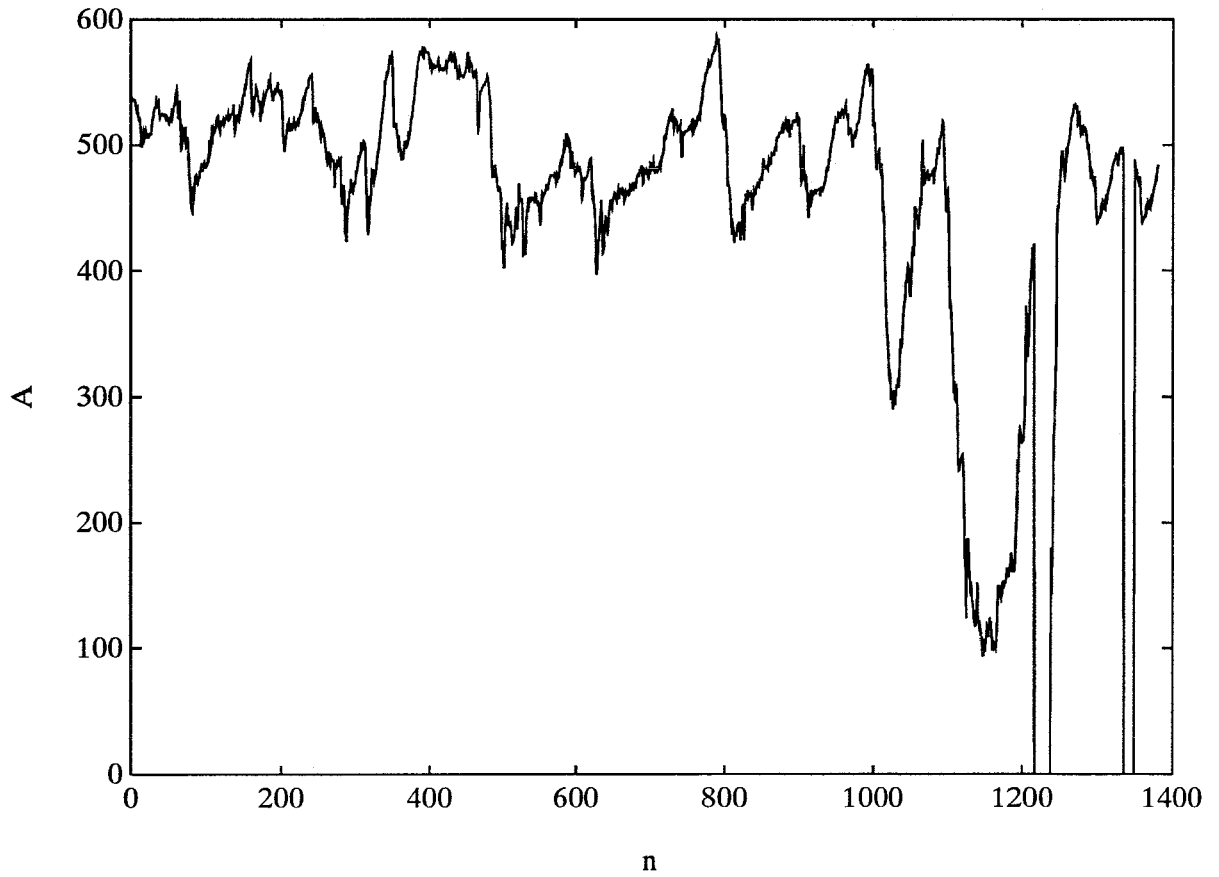
24 NOV 1993 - GENERATOR BLINDLEISTUNG



24 NOV 1993 - GENERATORSPANNUNG

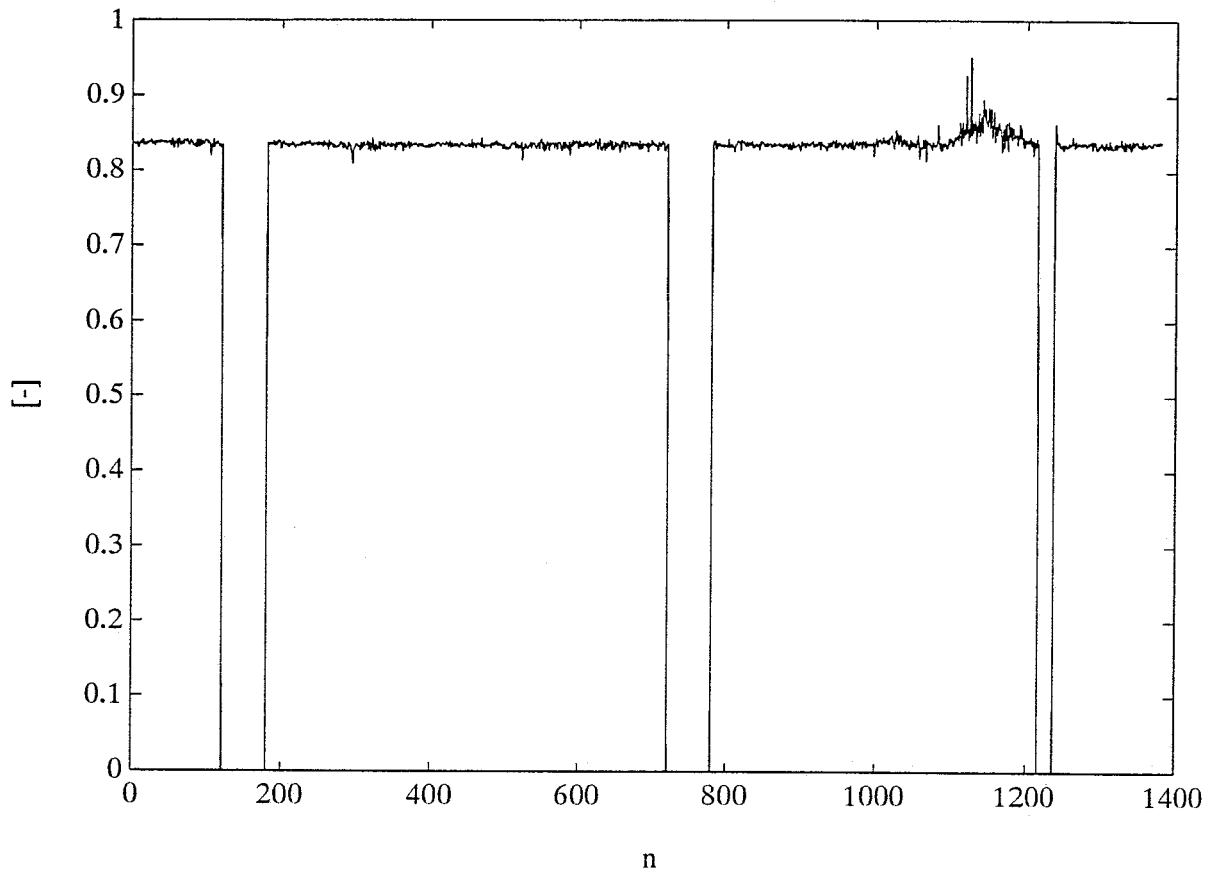


24 NOV 1993 - GENERATORSTROM





24 NOV 1993 - COS FI



# **APPENDIX**

## PCV Tag List

| Index | Tag        | Description                      | Type    | Block |
|-------|------------|----------------------------------|---------|-------|
| 1     | 1-PAH-102  | DIFF DRUCK VERBRENN LUFT-FILTER  | DIGITAL | 102   |
| 2     | 1-ZI-110   | TURB ERDGAS-VENTIL               | ANALOG  | 110   |
| 3     | 1-PAH-110  | TURB ERDGASFILTER DIFF DRUCK     | DIGITAL | 115   |
| 4     | 1-PDAH-110 | TURB ERDGASFILTER DIFF DRUCK     | DIGITAL | 109   |
| 5     | 1-ZAB-110A | T. ERDGAS-ABSPERRVENT 1 N-GESCHL | DIGITAL | 111   |
| 6     | 1-ZAB-110B | T. ERDGAS-ABSPERRVENT 2 N-GESCHL | DIGITAL | 112   |
| 7     | 1-PAL-113  | TURBINE ERDGASDRUCK              | DIGITAL | 113   |
| 8     | 1-LAH-122  | TURB ENTWAESSER TANK NIVEAU      | DIGITAL | 122   |
| 10    | 1-GB-127   | SCHMIEROEL ENTWAESSER PUMPE      | RCM     | 401   |
| 12    | 1-GB-128   | SCHMIEROEL HILFSPUMPE MOTOR      | RCM     | 402   |
| 14    | 1-GB-129   | SCHMIEROEL DUNSTABSCH PUMPE      | RCM     | 403   |
| 15    | 1-TI-130   | SCHMIEROELTANK TEMPERATUR        | ANALOG  | 131   |
| 17    | 1-GB-130   | SCHMIEROELTANK HEIZUNG           | RCM     | 404   |
| 18    | 1-LAL-130  | SCHMIEROELTANK NIVEAU            | DIGITAL | 130   |
| 19    | 1-TAB-130  | SCHMIEROELTANK RTD FEHLER        | DIGITAL | 129   |
| 20    | 1-TAH-133  | SCHMIEROELVERTEILER TEMPERATUR   | DIGITAL | 132   |
| 21    | 1-PAL-133  | SCHMIEROELVERTEILER DRUCK        | DIGITAL | 133   |
| 22    | 1-TI-136   | SCHMIEROELTEMP GEN LAGER ANTRIEB | ANALOG  | 136   |
| 23    | 1-TAB-136  | GEN LAGER RTD FEHLER             | DIGITAL | 139   |
| 24    | 1-TAH-136  | GEN LAGER ANTRIEB TEMPERATUR     | DIGITAL | 134   |
| 25    | 1-TI-137   | GEN LAGER ERREGERS TEMPERATUR    | ANALOG  | 137   |
| 26    | 1-TAH-137  | SCHMIEROELTEMP GEN LAGER ERREGER | DIGITAL | 135   |
| 27    | 1-PAL-138  | TURB SCHMIEROEL DRUCK            | DIGITAL | 138   |
| 28    | 1-HS-141   | TURBINE CRANK                    | RCM     | 141   |
| 30    | 1-GB-141   | HYDR STARTER MOTOR               | RCM     | 405   |
| 31    | 1-TI-143   | SCHMIEROEL ABLAUFTEMP v GETRIEB  | ANALOG  | 143   |
| 32    | 1-SI-150   | DREHZAHLAUFNEHMER TURBINE        | ANALOG  | 150   |
| 33    | 1-TI-152   | VERBRENNUNGSLUFT-EINTRITTSTEMP.  | ANALOG  | 152   |
| 34    | 1-PDI-152  | KOMPRESSOR EINTRITTSDRUCK        | ANALOG  | 153   |
| 35    | 1-PI-154   | KOMPRESSOR AUSTRITTSDRUCK        | ANALOG  | 154   |
| 36    | 1-PYA-154  | KOMPRESSOR AUSTRITTSDRUCK HOCH   | DIGITAL | 160   |
| 37    | 1-PYZ-154  | KOMPRESSOR AUSTRITTSDRUCK        | RCM     | 162   |
| 38    | 1-PZL-154  | KOMPRESSOR AUSTRITTSDRUCK NIEDR  | RCM     | 161   |
| 39    | 1-TI-155   | TURBINEN AUSTRITTSTEMPERATUR     | ANALOG  | 155   |
| 40    | 1-HS-157   | MAXIMAL TIT                      | RCM     | 151   |
| 41    | 1-TYI-157  | MAXIMAL TIT SOLLWERT             | ANALOG  | 157   |
| 42    | 1-YI-158   | SCHWINGUNGSaufN. TURBINE         | ANALOG  | 158   |
| 43    | 1-YAB-158  | SCHWINGUNGSaufN. TURBINE FEHLER  | DIGITAL | 142   |
| 44    | 1-YAH-158  | SCHWINGUNGSaufN. TURBINE         | DIGITAL | 148   |
| 45    | 1-YI-159   | SCHWINGUNGSaufN TURB ABTRIEBSWEL | ANALOG  | 159   |
| 46    | 1-YAH-159  | SCHWINGUNGSaufN TURB ABTRIEBSWEL | DIGITAL | 149   |
| 47    | 1-YI-167   | SCHWINGUNGSaufN GEN LAGER ANTR   | ANALOG  | 167   |
| 48    | 1-YAH-167  | SCHWINGUNGSaufN GEN LAGER ANTR   | DIGITAL | 146   |
| 49    | 1-TI-168   | GEN LUFT AUSTRITTSTEMPERATUR     | ANALOG  | 169   |
| 50    | 1-YI-168   | SCHWINGUNGSaufN GEN LAGER ERREG  | ANALOG  | 168   |
| 51    | 1-TAH-168  | GEN LUFT AUSTRITTSTEMP ALARM     | DIGITAL | 144   |
| 52    | 1-YAH-168  | SCHWINGUNGSaufN GEN LAGER ERREG  | DIGITAL | 147   |
| 53    | 1-TAB-169  | GENERATOR RTD FEHLER             | DIGITAL | 163   |
| 54    | 1-TAH-169  | GENERATOR STATOR TEMPERATUR      | DIGITAL | 145   |
| 55    | 1-TI-169A  | GEN ROT STATOR TEMPERATUR        | ANALOG  | 164   |

PCV Tag List

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|-------|------------|-----------------------------------|---------|-------|
| 56    | 1-TI-169B  | GEN GELB STATOR TEMPERATUR        | ANALOG  | 165   |
| 57    | 1-TI-169C  | BEN BLAU STATOR TEMPERATUR        | ANALOG  | 166   |
| 58    | 1-HS-170   | TURBINE LAEUFT/STOP               | RCM     | 180   |
| 59    | 1-UU-170   | TURBINE ABSCHALTUNG ZUAMMENFASS   | TEXT    | 70    |
| 60    | 1-UZ-170   | TURBINE SUMMENALARM               | DIGITAL | 71    |
| 61    | 1-XB-170   | TURBINE LAEUFT                    | DIGITAL | 176   |
| 62    | 1-TIK-170  | TIT SOLLWERT                      | STATION | 170   |
| 63    | 1-HS-172   | ABSCHALTUNG RUCKSTELLUNG          | RCM     | 182   |
| 64    | 1-UA-175A  | TURBINE DIGITAL LEITSYS FEHLER    | DIGITAL | 72    |
| 65    | 1-UA-175B  | KOMP EINTEMP ELEMENT FEHLER       | DIGITAL | 73    |
| 66    | 1-UA-175C  | KOMP EINTEMP ELEMENT UNTERSCHIED  | DIGITAL | 74    |
| 67    | 1-UA-175D  | THERMOELEMENT FEHLER              | DIGITAL | 75    |
| 68    | 1-UA-175E  | THERMOELEMENT UNTERSCHIED         | DIGITAL | 76    |
| 69    | 1-UA-175F  | MAXIMAL TIT                       | DIGITAL | 77    |
| 70    | 1-UA-175G  | FALSCH FLAMME                     | DIGITAL | 78    |
| 71    | 1-UA-175H  | TURBINE OBERTEMPERATUR ANFANG     | DIGITAL | 79    |
| 72    | 1-UA-175I  | TURBINE OBERTEMPERATUR LAEUFT     | DIGITAL | 80    |
| 73    | 1-UA-175J  | TUBINE OBERDREHZAHLLAUFNEHMER     | DIGITAL | 81    |
| 74    | 1-UU-176   | TURBINENSTATUS                    | TEXT    | 85    |
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| 76    | 1-UA-170   | TURBINE SUMMENALARM               | DIGITAL | 69    |
| 77    | 1-XA-179   | SERIAL LINK ALARM                 | DIGITAL | 1023  |
| 78    | 1-XI-179   | SERIAL LINK STATUS                | ANALOG  | 1022  |
| 79    | 1-HS-180   | HAND NOT AUS                      | RCM     | 50    |
| 80    | 1-GB-182   | KOMPR WASCHPUMPE                  | RCM     | 407   |
| 81    | 1-TI-191   | SCHALLHAUBE LUFT-AUSTRITTSTEMP.   | ANALOG  | 191   |
| 82    | 1-QAH-191  | SCHALLHAUBE ALARM GAS-DETEKTOR    | DIGITAL | 190   |
| 83    | 1-TAH-191  | SCHALLHAUBE LUFT-AUSTRITTSTEMP.   | DIGITAL | 192   |
| 84    | 1-PDAH-191 | SCHALLH BELUEFTUNG FILTER Delta p | DIGITAL | 193   |
| 85    | 1-FAL-192  | SHALLHAUBE LUFT ALARM             | DIGITAL | 194   |
| 87    | 1-GB-192   | SCHALLHAUBE LUEFTERMOTOR          | RCM     | 406   |
| 88    | 1-FB-192A  | SCHALLHAUBE LUFTMENGE EIN         | DIGITAL | 195   |
| 89    | 1-FB-192B  | SCHALLHAUBE LUFTMENGE AUFHEBEN    | DIGITAL | 196   |
| 90    | 1-XA-195   | SCHALLHAUBE FEUER                 | DIGITAL | 198   |
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