# PROBERA–KÖS – Program for Process- and Heat-balance Calculations and Model Based Condition Monitoring

Partial translation to English from OKG Report 2004-12417
Some additional notes are added.
Information for OSART 2009 / Bertil Persson TM

# 1        Summary

Program-package PROBERA-KÖS is developed and implemented at OKG as a standard application for process- and heat-balance calculations. It is mainly used for two purposes:

-            As a Model based Condition Monitoring System (KÖS) for trending of performance for turbine systems and cooling chains.

-            As a tool for process analysis, system dimensioning and simulations at OKG Technical Department.

In this report is given a general description of the program package and how the system and models are built and used.

# 2        General description

PROBERA include models of the most important physical components in a power plant. Objects of these components can be connected to build models of entire systems and also generate whole plant heat-balance models.

To the system are coupled program-modules for steam-water condition functions, functions for ideal gases, thermo-hydraulic code for pressure drop, heat exchange, condensation etc.  It also includes numeric routines for iterative equation solving (Newton-Raphson) and dynamic simulations with a numeric integrator (Runge-Kutta). Other routines are for one- and two-dimensional

interpolation. Most of the functions in the library is placed in a COM function server that can be used also by Excel or other modern computer codes.

The program package is used to solve mass- and heat balances for steady-state models. For the KÖS-applications the models automatically read data delivered from the plant computer via a process data-base where on-line historic data for several years are available.

The measured data normally give an over-determined system. It is therefore possible to use a minimization routine on the normalized square-sum of all deviations on measured values between the plant and the model. This is done automatically by adjustments of a subset of model parameters. The redundance in information also makes it possible to detect "outliers" in the measured data.

Based on input of individual signal uncertainties the Probera models calculate reconciled uncertainties for all signal values and for the model results, for example cooling capacities, plant efficiencies and so on.

Measured data can be brought from the DRUS database (InfoPlus21) or Excel-files. Calculated conditions can be saved in data-files, written back to the DRUS database (InfoPlus21) or any type of relation database.

It can also be used for successive calculations and generation of result tables on variation of a parameter. The parameter can be changed in step and also control a numeric integration.Generated tables can be illustrated graphically in diagrams or exported to Excel for further treatment. Diagrams as well as the all process couplings can be written to printers or to graphic files.

# 3       Graphic Interactive User Interface

All models are built by using the graphic interface where the component symbols are placed out to a process-diagram. The models are configured concerning coupling and function calls. For iterative solutions the components are placed under control of an equation solver. Component data can be read from a component database where specified component objects can be stored.

All user access to the models data is done via the component data-window. Data can also be brought in via data-files or databases where former calculations are stored.

Special data-windows are used to present a calculated process condition. This make the process diagram to excellent calculation documentation for reports etc.

# 4       Model Based Condition Monitoring

Condition monitoring is performed on all 3 OKG units. It is based on data scanned minute-wise from the plant computers and transferred in a "one-way"
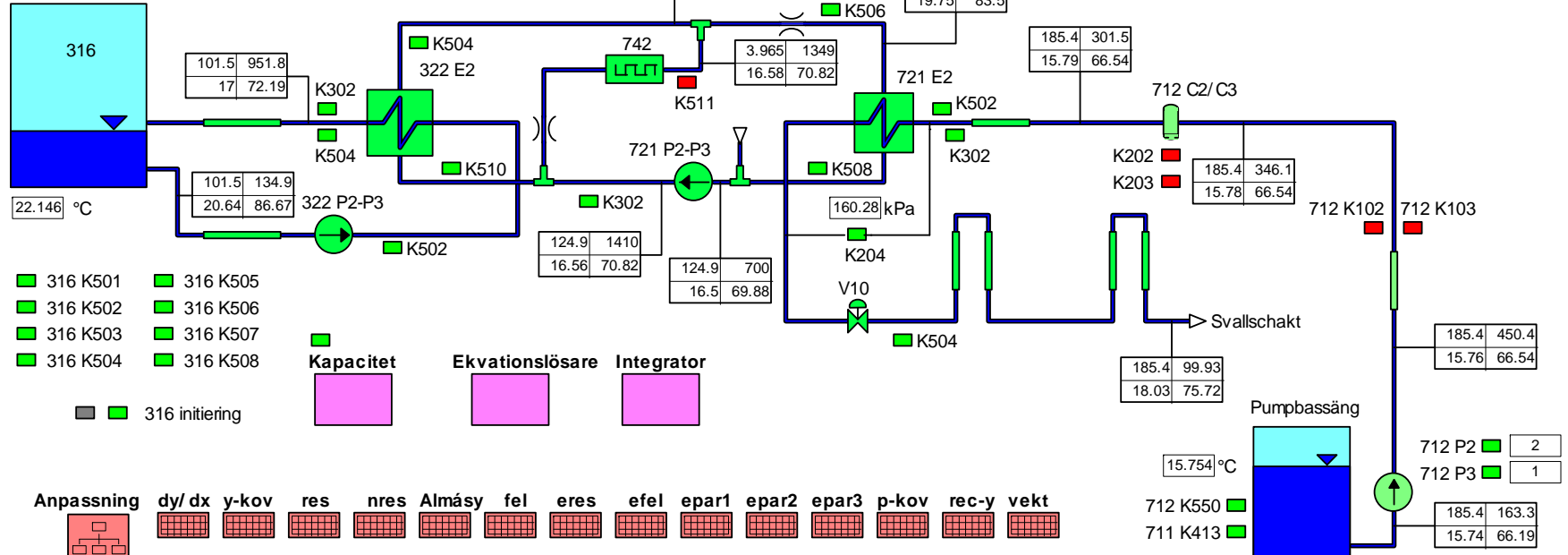
connection over to the PC-network. In the PC-network data are stored in a database – InfoPlus21. The database can store plant history for several years back. The trends in data can be followed with the trending tool "Process Explorer". This tool is available for most operation and maintenance staff.

Today more than 10 PROBERA-KÖS models are automatically working in the PC-network for monitoring cooling-chains and turbine systems. The models are scheduled to read data from the database on a regularly basis. The condition evaluation is made after some basic control of the quality of the data. One common criterion is that the process must be in a steady state. Some results from the automatic evaluations are directly put back to the process database and will show long term trends in cooling capacities, heat-exchanger fouling and MW-losses.

The information from the system is intended for use by the operation support and maintenance on a daily or weekly basis, but shall not be used for direct action from the control room staff.

Deviations in the monitored conditions are reported by the operation support in daily or weekly meetings.

# Probera    O2_322    stråk 2

**316**

22.146 °C

| 101.5 | 951.8 |
|-------|-------|
| 17 | 72.19 |

K302

322 E2
K504

K504

K510

| 101.5 | 134.9 |
|-------|-------|
| 20.64 | 86.67 |

322 P2-P3

K502

| 120.9 | 1349 |
|-------|------|
| 19.71 | 83.92 |

K506

742

| 3.965 | 1349 |
|-------|------|
| 16.58 | 70.82 |

K511

721 P2-P3

K302

| 124.9 | 1410 |
|-------|------|
| 16.56 | 70.82 |

| 124.9 | 700 |
|-------|-----|
| 16.5 | 69.88 |

V10

| 124.9 | 749.5 |
|-------|-------|
| 19.75 | 83.5 |

721 E2

K502

K508

K302

160.28 kPa

K204

K504

| 185.4 | 301.5 |
|-------|-------|
| 15.79 | 66.54 |

712 C2/ C3

K202

K203

| 185.4 | 346.1 |
|-------|-------|
| 15.78 | 66.54 |

712 K102    712 K103

▷ Svallschakt

| 185.4 | 99.93 |
|-------|-------|
| 18.03 | 75.72 |

Pumpbassäng

15.754 °C

712 K550

711 K413

| 185.4 | 450.4 |
|-------|-------|
| 15.76 | 66.54 |

712 P2    2

712 P3    1

| 185.4 | 163.3 |
|-------|-------|
| 15.74 | 66.19 |

316 K501    316 K505
316 K502    316 K506
316 K503    316 K507
316 K504    316 K508

316 initiering

**Kapacitet**    **Ekvationslösare**    **Integrator**

**Anpassning**  **dy/ dx**  **y-kov**  **res**  **nres**  **Almásy**  **fel**  **eres**  **efel**  **epar1**  **epar2**  **epar3**  **p-kov**  **rec-y**  **vekt**

| | | | | |
|---|---|---|---|---|
| Mätdatum | 2008-09-06 | | frihetsgrader | 6 |
| Mättidpunkt | 20:02:00 | | konfidensnivå | 95 % |
| avvikelse | 0.1436 | | model X2 | 0.3093 |
| kapacitet | 326.82 kW/ K | | linear X2 | 0.3093 |
| osäkerhet | 40.455 kW/ K | | konvergens | 2.5677e-9 |
| rel.osäkerhet | 12.378 % | | linear GOF | 0.99945 |

**DRUS-objekt**
- Kylkedjekapacitet
- 322 E2 beläggning
- 721 E2 beläggning
- 721 E2 flödesmotstånd

**Datafönster**

| kg/s | kPa |
|------|-----|
| °C | kJ/kg |

**O3-721-ED1  Beläggningsmotstånd**
Havsvattenkyld plattvärmeväxlare
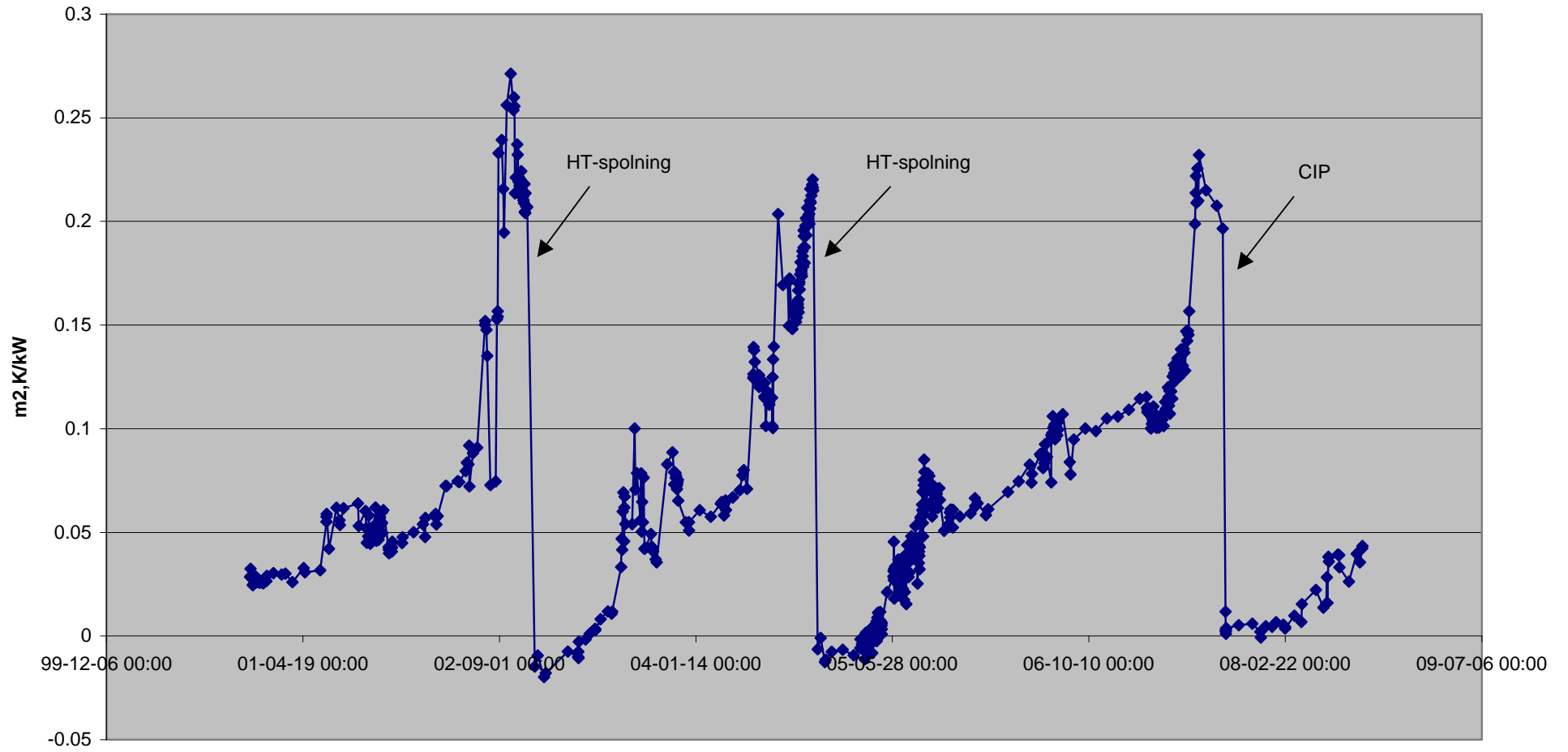
# Oskarshamn 2 – Cooling chain 322-721-712 train 2 capacity monitoring