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Demonstration of Telecalibration capabilities as a new tool for metrology at the German Primary High Pressure Natural Gas Test Facility "*pigsar*"

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Abstract
The paper demonstrates the telecalibration capabilities of *pigsar*, the national standard for natural gases at high pressure of Germany. The telecalibration tool was developed in order to give PTB an efficient access to the on-going calibrations at *pigsar*. It can be considered as a new tool for metrology to maintain and supervise the dissemination of the units volume and mass of natural gases under high pressures. Furthermore, telecalibration is a necessary tool and issue to provide for PTB-certificates based on the harmonized reference value for high-press natural gases as agreed between between NMI-VSL and PTB.

After a short introduction explaining the metrological situation, an overview is given about the technology and features of the software. The telecalibration software used by PTB is identical to the software used at the national lab *pigsar* for the daily calibrations. Due to security and safety reasons, not all options and functions are available at PTB. The handling of the software is based on different software screens necessary to visualize the process of calibration and to supervise a gas meter under test respectively. The screens shown in the paper are test results of a "watch dog test" carried out to supervise the harmonization procedure of the natural gas cubic meter between PTB and NMi.

Introduction
During the last years the amount of gas transported and used in Germany increased continuously. Furthermore, the number of companies involved in transportation business increased as well. In order to guarantee a fair trade the correct measurement of gas became increasingly important. The efforts necessary to build an appropriate high pressure test facility are enormous and an economic use of such a test facility needs a commercial exploitation. That's the main background for the agreement between Ruhrgas Company and PTB was established to recognize *pigsar* as a national standard for natural gas at high pressure of Germany. In order to realise the traceability to national standards PTB is responsible for the calibration and regular recalibrations as well as to fulfill some legal aspects. As shown in Fig. 1 *pigsar* is located roughly 300 km away from PTB main quarter. This circumstance leads to a considerably travel activity. At the other hand many tasks, like watchdog tests do not need always the personal presence of PTB staff at *pigsar* if a supervision tool and remote control is available. This new tool which covers all aspects like fast data availability and data security/safety, is *pigsar*'s telecalibration software developed as an additional part of the test facility software.

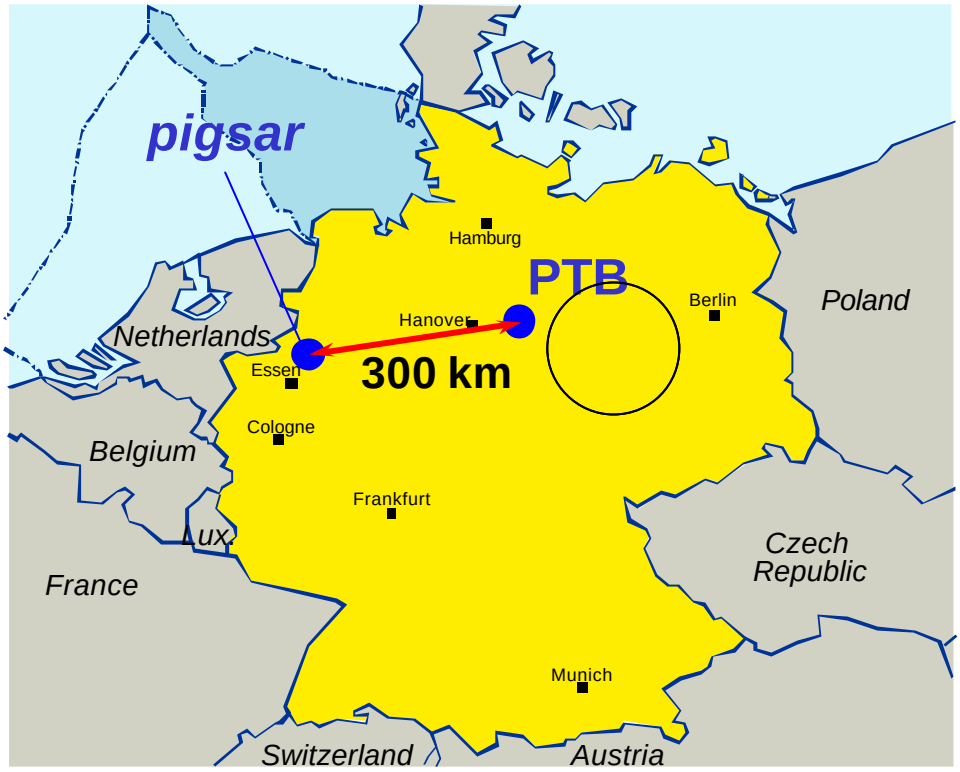


Figure 1: Location of national lab *pigsar* and PTB.

Features of hard- and software

In order to run *pigsar* a hardware solution was installed consisting of VXI-data acquisition hardware, a programmable logic controller (PLC) and a computer network of different standard PC. The software of *pigsar* is a UNIX -based system split in different modules:

- controlling (e.g. flow rate, pressure, temperature),
- data acquisition,
- database,
- visualisation and telecalibration.

The connection between the modules is organised by software layer, known as CORBA middle ware. The software tasks are able to run on different computers in parallel. The advantage of such solution is that the single modules are smaller and easier to handle and, in the case of failure, a single task can be moved from one computer to another.

It is possible to operate the visualisation module at different computers in order to allow the customers of *pigsar* to witness the calibration procedure.

The telecalibration task is a copy of the visualisation module, hence the implementation and the support of the software at PTB is economical. Because of security reasons, the telecalibration task is connected via ISDN telephone line.

By implementation of the following additional measures a high security standard was reached:

- The ISDN-access is normally deactivated and will be activated manually by *pigsar* operator after personal request of PTB staff (via telephone).
- The server of *pigsar*'s local network accepts only calls from known participants (checking the phone number communicated by the ISDN connection itself).
- The caller needs a password to enter the local network.
- The list of commands for access from outside is limited.

Software description

The software is divided into 2 main parts, the control task and the display task. Further, connection software is used to connect the PC network at *pigsar* with a PC at PTB via ISDN telephone line.
As the connection is switched on, the control task has to be started and *pigsar*'s control screen appears (Fig. 2).
This screen shows a list of all calibrations carried out by *pigsar* since the installation of the software in January 2002.
The different columns of the list in Fig. 2 display the calibration number, the date, the nominal pressure and temperature, the name of the manufacturer, the serial number and the name of the customer. Further the status of the calibration and some commercial data are listed.

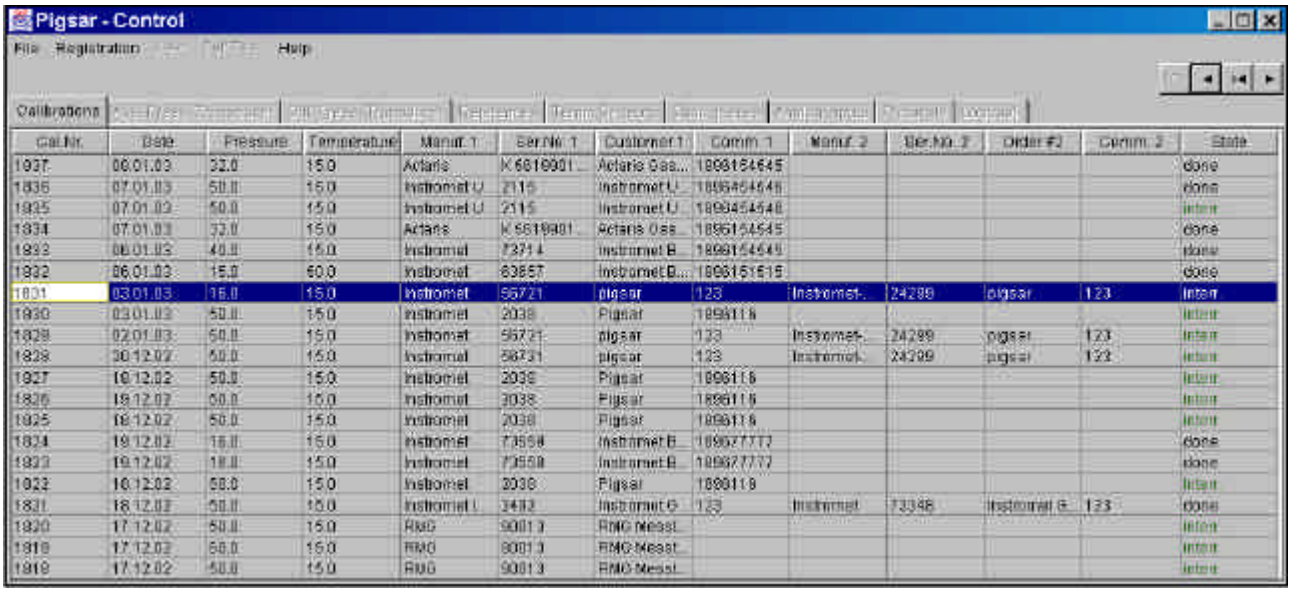
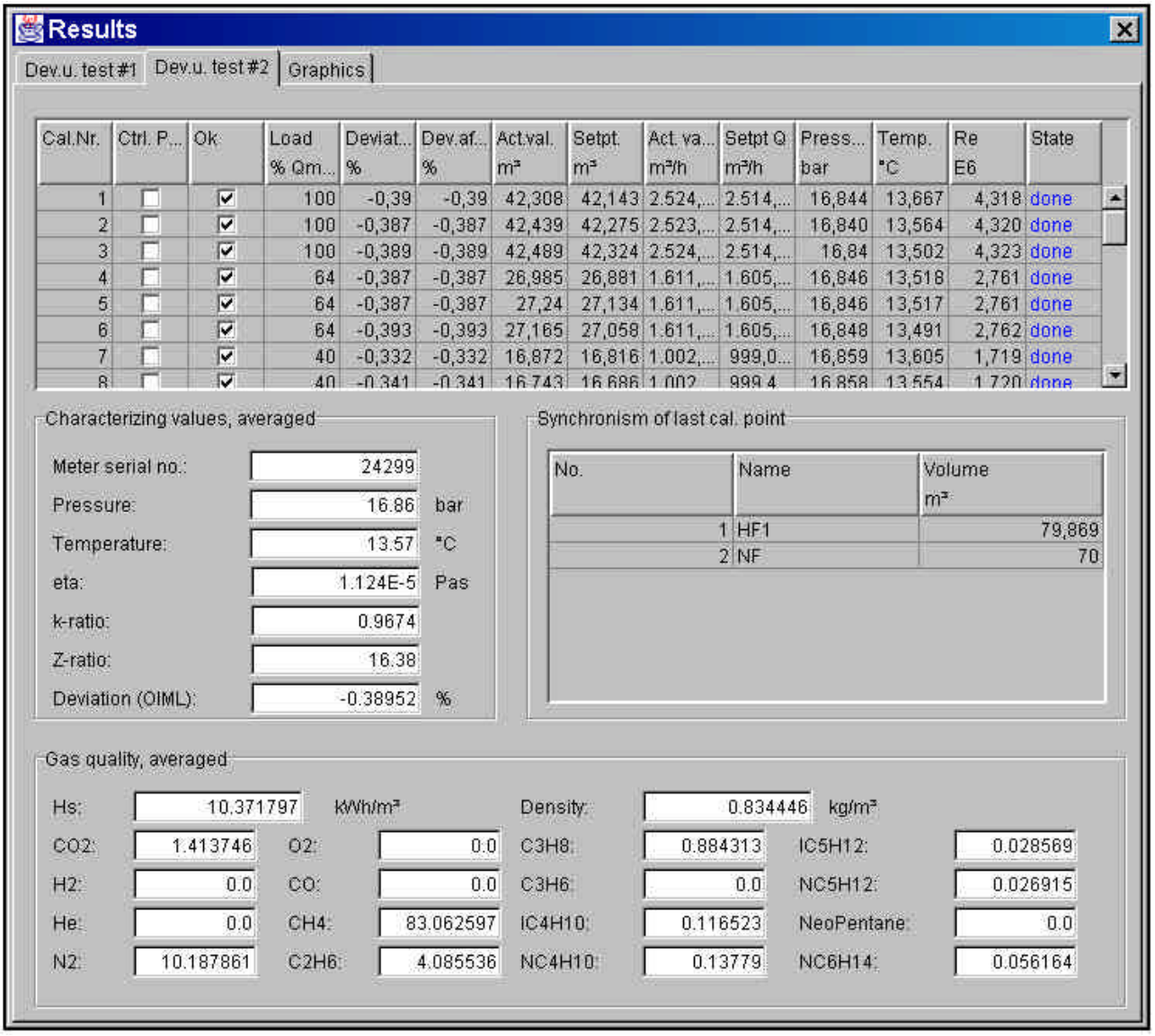


Figure 2: Telecalibration control task screen, menu point *Pigsar* Control (calibration list)

The chosen calibration No.1831 in Fig. 2 was a watch dog test carried out 2003-March-01. That's why the customer was *pigsar* itself. After an interactive dialog verifying the access by a password the result screen is available.

Figure 3 shows the result screen with a serial list of all single results measured. The list contains three 100%, three 65% and two 40% points (loads in percentage of maximal flow rate). In order to see all results it is necessary to scroll the screen by the right hand scroll bar.
For every calibration point the number, the status, the measuring deviation, the read out of the meter under test (Setpt.) and the actual values measured by the reference standards (concerning flow rate and volume passed through the meters during the measuring time) are displayed. Further, the temperature, the pressure and the Re-number are listed.

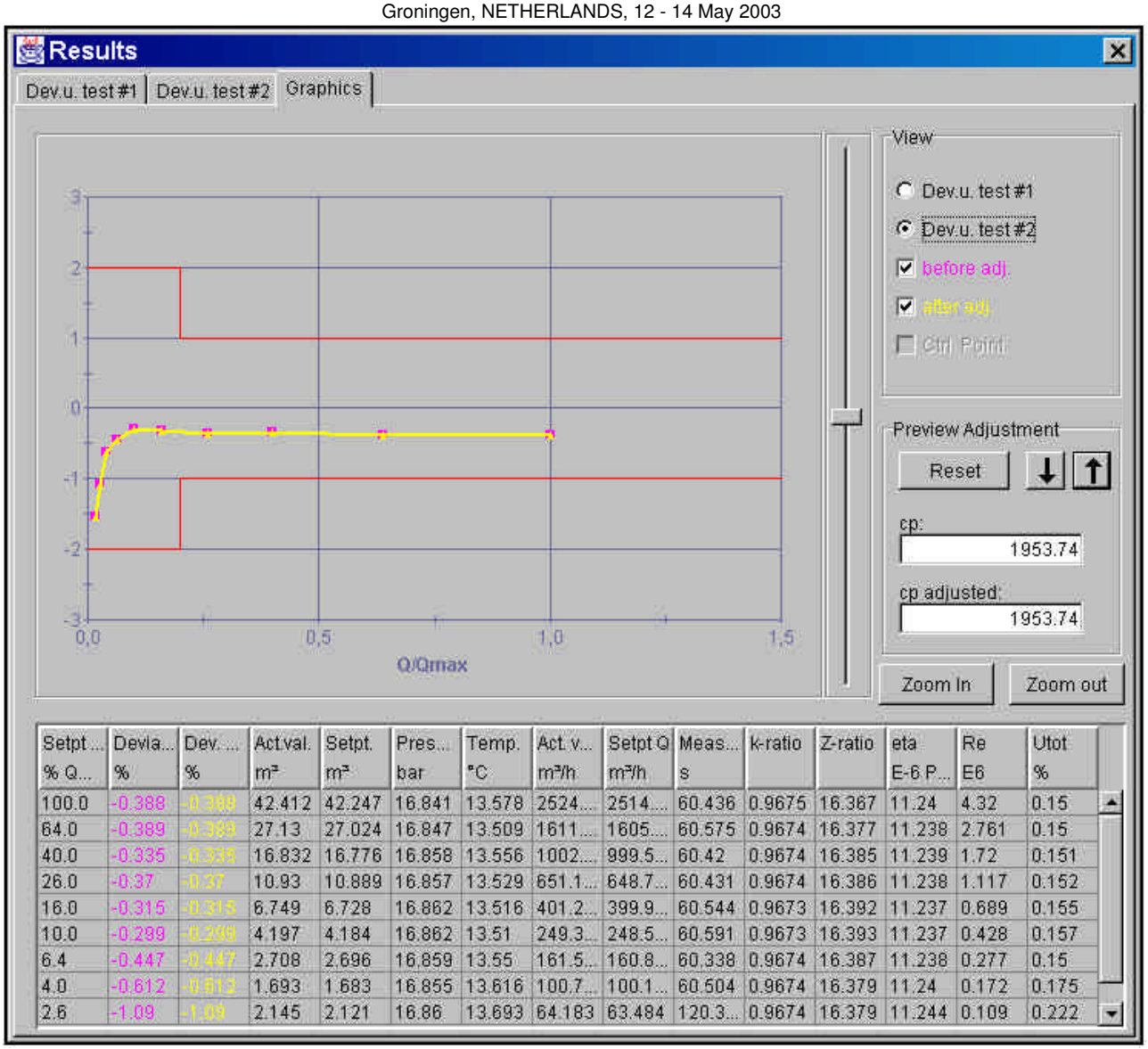


Cal.Nr.	Ctrl. P...	Ok	Load % Qm...	Deviat... %	Dev.af... %	Act.val. m³	Setpt. m³	Act. va... m³/h	Setpt Q m³/h	Press... bar	Temp. °C	Re E6	State
1	☐	☑	100	-0,39	-0,39	42,308	42,143	2.524,...	2.514,...	16,844	13,667	4,318	done
2	☐	☑	100	-0,387	-0,387	42,439	42,275	2.523,...	2.514,...	16,840	13,564	4,320	done
3	☐	☑	100	-0,389	-0,389	42,489	42,324	2.524,...	2.514,...	16,84	13,502	4,323	done
4	☐	☑	64	-0,387	-0,387	26,985	26,881	1.611,...	1.605,...	16,846	13,518	2,761	done
5	☐	☑	64	-0,387	-0,387	27,24	27,134	1.611,...	1.605,...	16,846	13,517	2,761	done
6	☐	☑	64	-0,393	-0,393	27,165	27,058	1.611,...	1.605,...	16,848	13,491	2,762	done
7	☐	☑	40	-0,332	-0,332	16,872	16,816	1.002,...	999,0...	16,859	13,605	1,719	done
8	☐	☑	40	-0,341	-0,341	16,743	16,686	1.002	999,4	16,858	13,554	1,720	done

Figure 3: Telecalibration control task screen, menu point Results

The table of test points can be recognised for loads between 100 % and 40 % and in the lower part of *Figure 3* the screen also lists some average values like the z- ratio, the averaged pressure and temperature. The OIML deviation is calculated from all results using the weighted average formula published in the OIML Recommendation R 32. In addition, the screen displays the gas composition during the test, which is mostly very stable at the test facility *pigsar*.

The Graphical Results screen of the calibrated meter is shown in *Figure 4*. The screen is used to display the error curve of the meter under test. It is possible to zoom the (vertical) deviation scale in order to optimise the view for details. The turbine calibrated presents a very flat error curve with measuring deviations less than 0.2 % in the upper flow range. The screen contains also a list of the averaged results for every load. The different columns of the list display all required information to check the quality of the measurement.



Setpt ... % Q...	Devia... %	Dev. ... %	Act.val. m³	Setpt. m³	Pres... bar	Temp. °C	Act. v... m³/h	Setpt Q m³/h	Meas... s	k-ratio	Z-ratio	eta E-6 P...	Re E6	Utot %
100.0	-0.388	-0.388	42.412	42.247	16.841	13.578	2524....	2514....	60.436	0.9675	16.367	11.24	4.32	0.15
64.0	-0.389	-0.389	27.13	27.024	16.847	13.509	1611....	1605....	60.575	0.9674	16.377	11.238	2.761	0.15
40.0	-0.335	-0.335	16.832	16.776	16.858	13.556	1002....	999.5...	60.42	0.9674	16.385	11.239	1.72	0.151
26.0	-0.37	-0.37	10.93	10.889	16.857	13.529	651.1...	648.7...	60.431	0.9674	16.386	11.238	1.117	0.152
16.0	-0.315	-0.315	6.749	6.728	16.862	13.516	401.2...	399.9...	60.544	0.9673	16.392	11.237	0.689	0.155
10.0	-0.299	-0.299	4.197	4.184	16.862	13.51	249.3...	248.5...	60.591	0.9673	16.393	11.237	0.428	0.157
6.4	-0.447	-0.447	2.708	2.696	16.859	13.55	161.5...	160.8...	60.338	0.9674	16.387	11.238	0.277	0.15
4.0	-0.612	-0.612	1.693	1.683	16.855	13.616	100.7...	100.1...	60.504	0.9674	16.379	11.24	0.172	0.175
2.6	-1.09	-1.09	2.145	2.121	16.86	13.693	64.183	63.484	120.3...	0.9674	16.379	11.244	0.109	0.222

Figure 4: Telecalibration control task screen, menu point Graphical Results

The different columns of the list displays:

- the load in percent,
- the averaged deviation (before and after a possible adjustment),
- the actual value measured by the standards and the read out of the meter under test (Setpt *Q*.) concerning the volume passed through the meters during the measuring time,
- the average values of pressure and temperature for to each load,
- the results concerning the flow rate,
- the average measuring time,
- k- and z- ratio,
- the viscosity,
- the average Re- number and
- the total uncertainty.

The total uncertainty is calculated as geometrical sum of the best measurement capability of the test facility *pigsar* (U = 0.15 % ; k = 2) and the standard uncertainty calculated from the results of each load expanded by k = 2.

Because of the small spread of the measuring deviations of the turbine, the total uncertainty is less than $U < 0.16$ % for all loads in the upper range. It is to mention that the 2.6 % point is not inside the flow range claimed by the manufacturer. In order to get information about the mechanical status of the meter this point was measured. The total uncertainty at this point is still very good.

In order to show the current situation of the facility the display task is used. Different screens are available, showing information about the pipe sections and reference standards just used, the status of the valves, the temperatures and pressures and the stability of different quantities respectively. A flow chart is applied to visualise the flow situation of *pigsar* as an overview comprising information about temperatures and pressures at the input and output lines connecting *pigsar* with the pipe network of the Ruhr area. This chart shows also the status of all important valves. A second screen displays the working standards actual used and the actual flow rate through each of those. (*Fig. 5)*. In order to decide whether the influence values are stable enough to start a measurement or not, the stability screen is available (*Fig. 6)*. The stability screen displays the current values of pressure (bar), density under standard conditions (kg/m^3), temperature (°C) and flow rate (m^3/h) during the last 5 minutes as a graph.

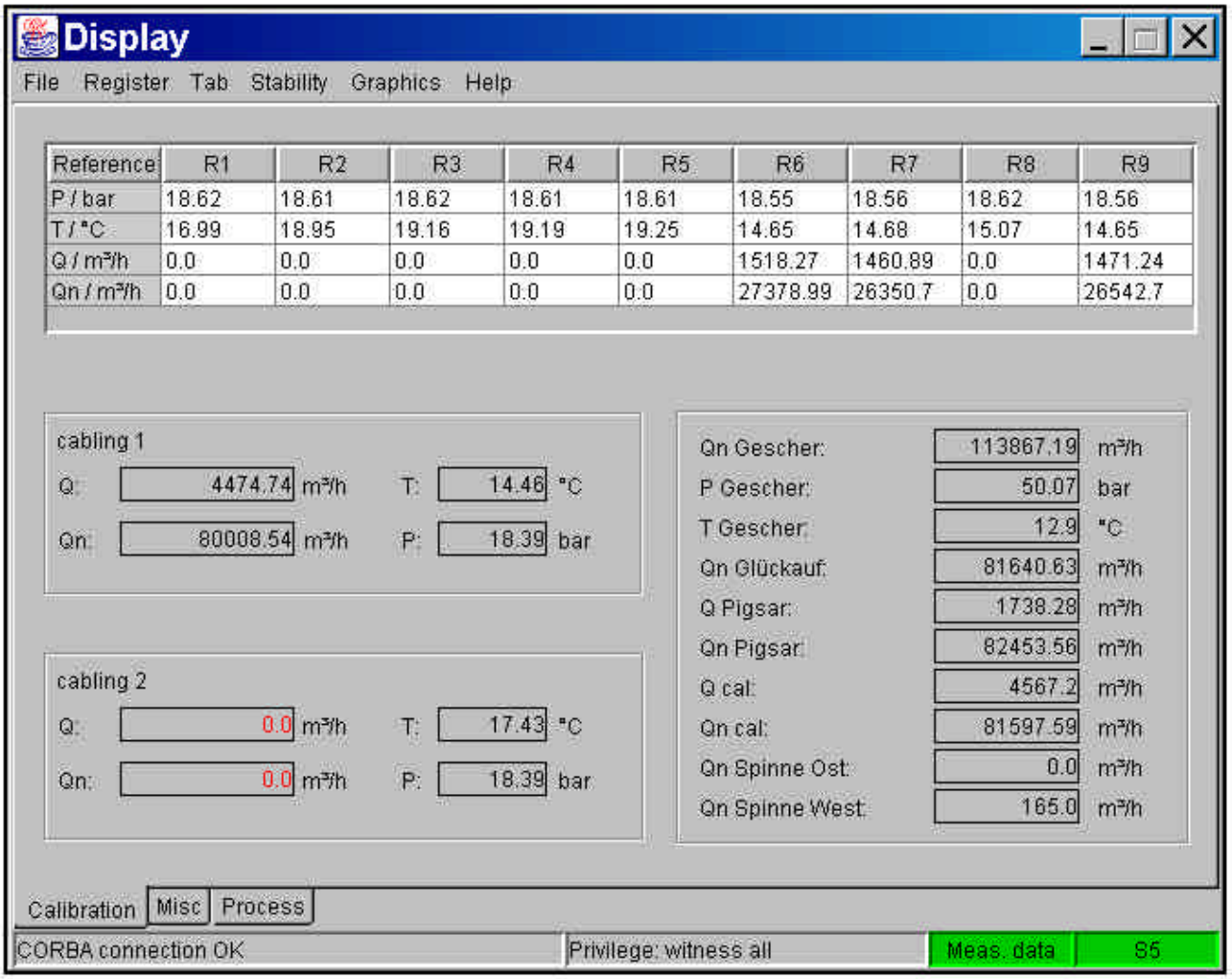


Figure 5: Telecalibration display task screen

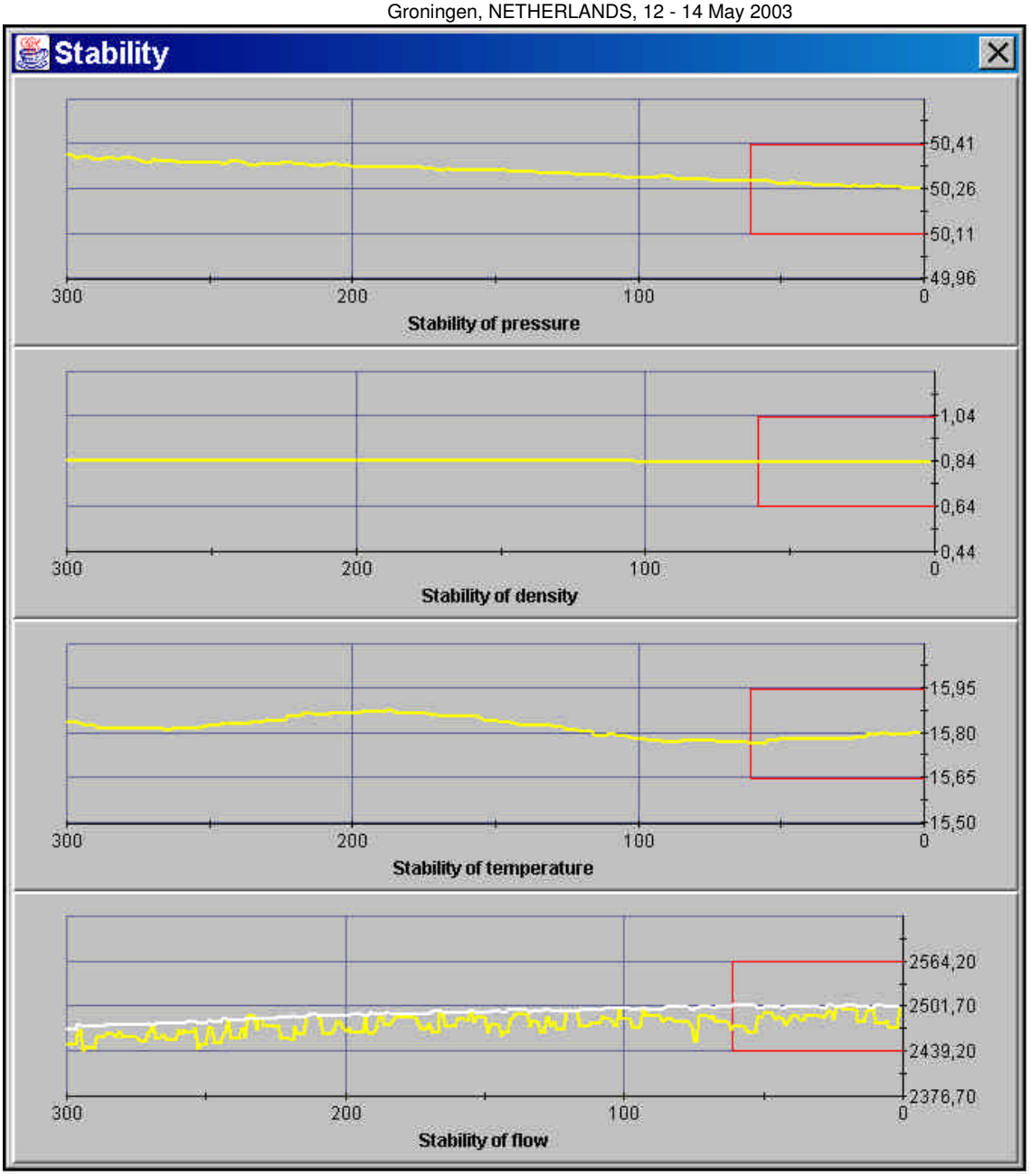


Figure 6: Telecalibration display task, menu point Stability

Conclusion

Telecalibration between *pigsar* and PTB is now in use since more than one year and we can conclude that the tool has shown to be very helpful for *pigsar* and PTB as well. Especially if difficult calibrations or tasks have to be solved, a fast reaction is possible. In addition, this tool allows PTB to disseminate PTB test certificates (PTB-Prüfschein) for international use in a very comfortable way.