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MEASURING THE PRESSURE INSIDE A SEALED BURNER  
A closer look into the LabVIEW-environment and spectrometry



# MEASURING THE PRESSURE INSIDE A SEALED BURNER

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A process in Philips Lighting Turnhout uses a LabVIEW based application to measure and calculate the pressure inside a sealed projector burner. The mentioned application had become outdated, so a new application, based on a newer environment and standardized Philips' LabVIEW-template, was desired. Some additional features were also needed.

The project was divided into two sections due to the limited time dedicated for the bachelor's thesis, and this thesis describes one half of the project. To track the progression of the project, the usage of time was carefully planned and updated daily. Meetings with the stakeholders of the project were held weekly. In practice most of the work revolved around coding in LabVIEW and trying to manage the resources to provide for tests, hardware etc.

The deadlines were met and the project was finished on time, although additional tests were needed to find the correlations and deviations between the measurements in the old and new software. As of writing this abstract, the new application is running non-stop on all three different production lines.

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## **ABBREVIATIONS USED IN THE THESIS**

DFM Data Flow Manager

DPL Digital Projection Lighting

FS Functional Specification

GTD Global Technology Development

GUI Graphical User Interface

Hg Mercury, a chemical element, atomic number 80

IOS Input/Output Server

LabVIEW Laboratory Virtual Instrument Engineering Workbench

lm Lumen (SI derived unit)

PHg Pressure of the Mercury Vapor

PLC Programmable Logic Controller

RS-232 Recommended Standard 232, serial data communications

TFS Transformation Server

UHP Ultra High Pressure/Performance

US User Specification

W Watt (SI derived unit,  $W = V \cdot A$ )

VI Virtual Instrument

# 1 INTRODUCTION

The DPL (Digital Projection Lighting) department of Philips Lighting Turnhout is concentrated on working with UHP (Ultra High Pressure/Performance) burners, which are widely used in common digital projectors and rear-projection television sets. As the name suggests, the working pressure of the said burners is at a high level, usually at around 200...250 bars (1).

As the pressure rises, the luminosity of a burner increases exponentially. Thus, it is an important factor to measure when dealing with the projector burners, which depend much on the luminosity to project a clear image on a surface. Philips has researched this area of measuring extensively and now, with this kind of burners, relies on spectrophotometry. It is rather an affordable method and provides Philips with reasonably reliable, accurate and fast results (2). The spectra are analyzed with specific algorithms, the results are monitored and then the defect lamps are discarded.

The current application Philips DPL uses for measuring the pressure has been under development for around 10 years (3). It is based on an old software environment and has become, due to the extent of the application, near impossible to debug or to improve and it also reports a few specific cases of lamps being defect while they in reality are perfectly good. The production cost of the burners is high, and unnecessarily discarded burners are apparently something that is not desired.

The difference between an application built on a template and a freely developed application is overwhelming. Getting to understand the flow of the template takes a little time and might seem quite complex at the beginning. Still, it is nothing compared to the mind numbing size and structure of an application which has been under development, without a logical template, for a decade. Furthermore, it still contains methods from the first results of the research done for accomplishing a certain kind of measurement.

These are some of the main reasons for Philips to justify this assignment. The improvement of the original application became very time consuming due to the size and flow of it, and improvements were required to correct some cases of unnecessarily failed measurements.

Due to the nature of the old application it had become expensive for Philips to alter it. While the application itself ran reliably, the features this project had as a goal would have been much too time consuming to implement. Also, since the LabVIEW template built by Philips is familiar to the software department, fixing bugs is much easier.

An improved measuring algorithm was needed to measure certain types of spectra correctly. The algorithm used in the old application would give erroneous results, or no results at all, for spectra, which had too large an extra peak at 546,1 nanometers (4). Erroneous or absent results are considered to mean defect burners.

Researching the reasons causing the defect burners was not very easy either. The old application had very little support for logging or bug diagnosis. This problem was bypassed by taking screenshots of the results measured by the application and then trying to study those. A proper logging was one of the main requirements for the application made in this project. It was already implemented in a default way in the Philips' LabVIEW template, but had to be modified to satisfy the needs of the customer.

The old application had a password dialog for editing the settings file and the editing was done in a basic text editor within the application. This did not prevent the end users from modifying the settings outside the application. Such editing had to be restricted leaving the modifying of the settings files to quality engineers. By using checksum-controlled settings files the application could be prevented from launching.

The objective of this project was to develop a non-stop, robust, improvable and reliable application for measuring the pressure inside a sealed burner

using spectrophotometry and the LabVIEW template built by Philips as a basis. Designing the actual algorithm for measuring the pressure was not in the scope of the project, but the additional features, documentation and the training of the quality engineers and operators were.

Philips estimated the project to be large enough to employ two automation engineering students, without much prior experience in the programming environment used, for from three to four months, full time. To comply with the rules of the School of Engineering regarding the theses, the project had to be split into two distinct parts so that two individual theses could be made. Still, the premises and the ultimate objectives of the projects were equal. Much of the work was done in direct communication with the other student, whose main areas of work were implementing the PLC (Programmable Logic Controller) communication (serial port and digital I/O) and voltage measuring with a new multimeter.

The other part of the project, which this thesis covers, was concentrated more on implementing the actual algorithm for measuring the spectra and to develop some wanted features, for example the protection of critical files with checksums and easy-to-read log files with the needed variables. Many of the features the customer at Philips requested were already developed, in some way, in the new Philips' template, which was used as a basis. They still needed major revising, or even full redeveloping, to make the resulting application as simple and efficient as possible and with the details the customer wanted.

The interface of the application came along while developing the code. The main divisions of the display are defined in the template, but care was taken to try to maintain the simplicity of the interface. Operators should not be required to read a manual to start the automatic measuring or to review the results while the application is running in an automatic mode.

## **2 THEORETICAL BACKGROUND**

The reasons for using the mercury-based Ultra High Pressure burners are reviewed in this section. The quickly advancing LED technology might be a competitor somewhere in the future, but currently there still are a few points to be considered.

### **2.1 UHP-lamps**

Projectors used in home theaters are usually operated in comparatively dim lighting, at least compared to usual usage in conference or class rooms, but both cases desire an even, small and bright source of light with a long lifetime and relatively low consumption of power. Today the UHP and LED lamps are the only ones to meet these requirements in projectors. (5.)

Projectors rely on the characteristics of an ellipse. Putting a light source in one focus of an ellipse reflects the beams that hit it to the other focus of the ellipse. This is important since more light to the second focus point, or the lens, means more light to the screen. In addition, the smaller the light source is, the smaller amount of light is radiated away from the focus, keeping the casing of the projector cooler and causing less distracting light leaks on top of other unpreferred properties. (6.)

This is where the UHP burners come in. They have a small arc gap, from 1,0 mm to 1,3 mm (7), compared to over 2 mm in the metal halide burners used earlier. The lighting efficiency can be greater in a 100 W UHP burner than in a 250 W metal halide burner. (6.)

### **2.2 Luminous efficacy**

Living the ecological times that we are, it is crucial to get as much results as possible for every kilowatt-hour used. Lumen is a measure of the power of light perceived by the human eye (8) and thus the luminous efficacy, or lumens per watt (lm/W), is a good measure for comparing lamps. Philips UHP 120 W lamp has a luminous efficacy of 58 lm/W (9), which, by the

value, compares to lower efficacies of LEDs (10), but has the small light source, defined by the short arc length of 1,0 mm (9), on its advantage.

LED projectors are slowly becoming more and more popular for their portability, extremely long lifetime and low consumption of power. However their output of 1000 lumens (11) is not adequate for every situation (12). Modern UHP projectors can output up to 9 000 lm (with a 150 W lamp) (13), while 3000 lm should be enough for all usual home and business usage even in daylight (12).

## **3 METHODS OF MEASURING**

Spectrum analysis is the Philips' current way of measuring the pressure inside a burner in a continuous process. The analysis relies on information gathered using other methods, of which the X-ray-diagnostics is a reliable way and as such it is also discussed here.

### **3.1 Spectrum analysis**

During many years of research Philips found a correlation between the Hg (mercury, a chemical element) peak shape of the spectrum of a burner, voltage, power, pressure and arc gap (2). The spectrum can be acquired with a spectrometer, voltage and power with a multimeter, but the pressure is somewhat more difficult one to measure inside a sealed burner. The arc gap could be measured using machine vision or x-ray, but nevertheless it is also a result of this method explained here.

The correlating attribute of the mercury peak is called, at least at Philips, the effective half width or, as simplified, the peak width. The first term is more precise, since the width is measured on the half height of the peak. (Figure 1.) The actual algorithm needed to calculate the width is more complicated since the spectrum varies between different kinds of products, variables, settings of the spectrometer and with the smallest changes in the housing of a burner. The data acquired from the camera is discrete, but it must be handled like a continuous function. The algorithm is explained in detail in the implementation section of the thesis.

The power is dependent on the product type being produced, the voltage is measured by a multimeter, and the spectrum analysis results in the effective half width of the Hg peak. Using these variables the pressure and arc gap can be calculated.

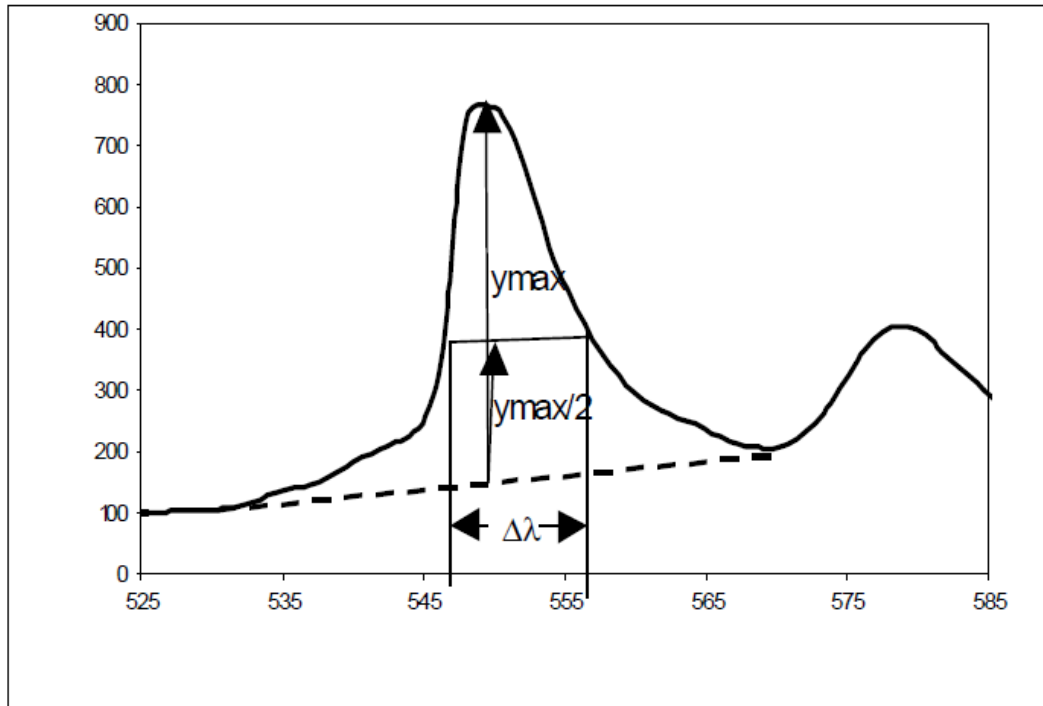


FIGURE 1. Schematic representation of the definition of the “effective half width” (2)

### 3.2 X-ray diagnostics

While researching the ways of calculating the pressure inside a burner X-ray was used to confirm the results from the spectrum analysis and voltage measuring. The arc gap is usually measured in cold lamps. Spectrum analysis has to be done on a burning lamp, thus affecting the arc gap through thermal expansion. The lamps heat up to an average of 2000 K while burning, and knowing the free length of electrodes, the thermal expansion can be calculated. (2.)

This allows the correction of the arc gap values calculated with the spectrum analysis, and the results vary much less than the scatter in the arc gap length itself. Because of these properties the spectrum analysis can be considered a faster, more reliable and far less expensive method than X-ray diagnostics. (2.)

## **4 INSTRUMENTS & TOOLS**

Philips provided the tools for the project, of which the most important ones were the LabVIEW license, the meters and the LabVIEW template Philips uses. The offline and simulated online testing facilities were also used extensively.

### **4.1 LabVIEW, the visual programming language**

LabVIEW (Laboratory Virtual Instrument Engineering Workbench) is a graphical programming language that uses icons instead of lines of text to create applications. In contrast to the text-based programming languages, where instructions determine the order of program execution, LabVIEW uses dataflow programming. The flow of data through the nodes on the block diagram determines the execution order of the Virtual Instruments (VIs) and functions. VIs are LabVIEW programs that imitate physical instruments. (14.)

GTD (Global Technology Development) Mechanization within Philips Lighting chose LabVIEW because of its support for rapid prototyping and development, presence of operational GUI template and ease of software maintenance. GTD's former experience with a certain machine vision software compatible with LabVIEW was an argument, but it is no longer supported by Philips Applied Technologies. For measurement applications National Instruments provides various data acquisition modules. (15.)

In LabVIEW, one builds a user interface by using a set of tools and objects. The user interface is known as the front panel. After building the front panel, code is added by using graphical representations of functions to control the front panel objects. One adds this graphical code, also known as G-code or block diagram code, to the block diagram. In some ways, the block diagram resembles a flowchart. (14.)

In contrast to the aforementioned ways of developing the application, the approach taken in this project was to concentrate on the block diagram

(Figure 2). The front panel (Figure 3), that is the user interface, was built “on the side” and when required to test the application. This seemed like a more intuitive way, even though it actually is closer to the theory and the very fundamentals of any LabVIEW application.

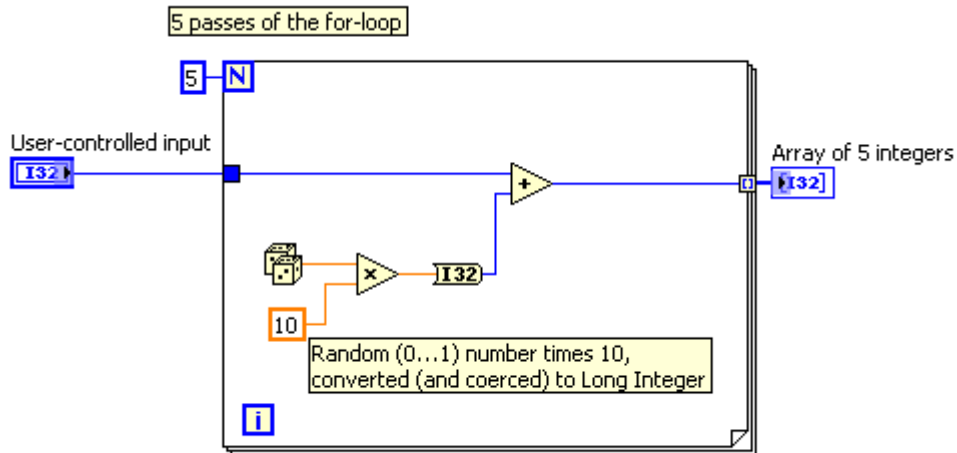


FIGURE 2. A simple example of a block diagram in LabVIEW

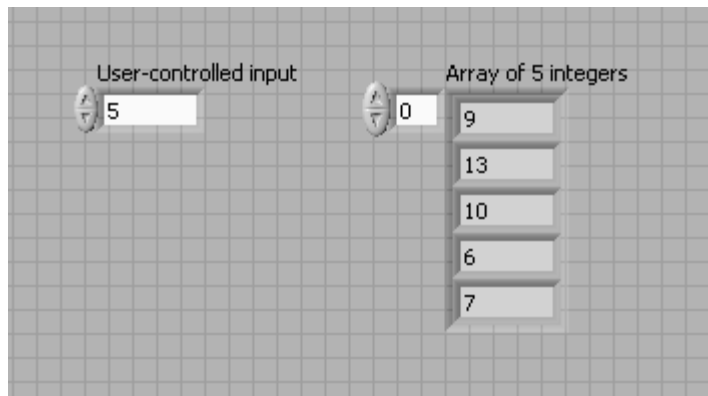


FIGURE 3. The front panel of the block diagram (Figure 2) in LabVIEW

## 4.2 Spectro- and multimeter

The Acton Standard Series spectrometers were used in both offline and online testing. During the development of the application, the algorithm for finding the effective half width was tested with an Acton SpectraPro-300i

spectrometer and some basic UHP burners. Acton SpectraPro-2300i is used on the production line. They both have a scan range of 0...1400 nm and a resolution of ~0,1 nm. (16; 17.)

For measuring the voltage of the burner, a new Fluke 8080A was installed. It supports communication through RS-232 and has a range of 0,200...750 VAC and 0,020...10 AAC. (18.)

### **4.3 Philips' LabVIEW-template**

The reasons why Philips started to use a standard template instead of building every application individually lie on cost reductions. While the development of such a template requires quite an effort, it also offers many advantages, such as re-use of structural architecture elements (for example GUI [Graphical User Interface], logging, interfacing and error handling) and faster development and deployment of applications. The knowledge transfer becomes less troublesome since the structure of different applications is similar. The template even enables the easy promotion of new developments to standard modules. (15.)

A quick summary of the template might be in place. Data flow managers (DFM) are in the center of everything. They pass information to and from the Input/Output servers (IOSs) and transformation servers (TFSs). I/O servers handle the inputs and outputs (for example displays, human interface devices, meters, communication). Transformation servers are called when some information needs processing.

## **5 DESIGNING PROCESS**

Usually the designing processes of this kinds of projects start with the user specifications and lead to the functional specifications. The latter are used as references for the whole duration of the projects. This was the case in this project as well.

### **5.1 User specification**

The user specification (US) was made by Calibration Specialist Chris Dries, the client at Philips. Original specification was written in Dutch (see Appendix 1).

Many topics for discussing arose while getting familiarized with the specification. Ordinarily, US's describe the needs and wishes of the client without going too deep in the technical details. This is one of the major obstacles in scheduling and designing a project if the software used is new for the developer and if the theory behind the measuring becomes complex.

### **5.2 Functional specification**

The purpose of the functional specification (FS) is to get to a written agreement between the client and the provider. Some parts of the US might not be affordable due to a large amount of hours needed for developing and some parts need some more defining to be detailed enough. Details are important in the FS, since one of the goals is to get a signed document, which describes all the deliverables so that both the provider and the client can unanimously agree when a certain part of the project has been completed. (19.)

Based on the user specification, a short experience with the Philips' LabVIEW-template and studying the old PHg-measuring application the functional specification was produced. Writing the FS took a considerable amount of time, and against the usually advisable ways of project planning, the implementation was already started while designing the FS. In this case it

was necessary for accomplishing a functional specification which would be even near to what could be the end result. During the development the FS was – in cooperation with the client – modified to accommodate new and cleverer ways of achieving certain results, for example the algorithm and the checksum protection. The latest modified FS is seen in Appendix 2.

## 6 IMPLEMENTATION

In this section the method of calculating the pressure inside the burners is explained. As discussed earlier in the thesis, it is based on the "effective half width of the PHg peak". In addition, the ways of implementing the additional features desired by Philips are examined.

### 6.1 Algorithm for calculating the pressure and arc gap

The width of the Hg-peak of the spectrum at half height of the peak is calculated by the LabVIEW function *TFS\_PeakWidth.vi*. Using the width of the peak it is possible to calculate the resulting mercury pressure and arc gap, using the function *TFS\_Calc\_pHg\_and\_electr\_dist.vi*. The algorithm uses a variety of user-defined settings to accomplish this in the needed accuracy:

- boundary wavelengths for the Hg-peak
- a wavelength to the right (longer wavelengths) of the 546,1 nm side-peak, from where the application starts looking for the actual maximum of the peak
- number of samples for calculating the average intensities at the top of the peak
- number of samples for fitting the polynomials at
  - base of the peak
  - sides of the peak to find the width

The algorithm used is roughly based on the old LabVIEW 7.1 –application. The actual calculations, which result in the value of pressure and arc gap, have been researched earlier by Philips (2).

The algorithm for finding the width of the peak at half height is presented on the oncoming pages. Figure 4 is the overview of the front panel of the *TFS\_PeakWidth.vi*.

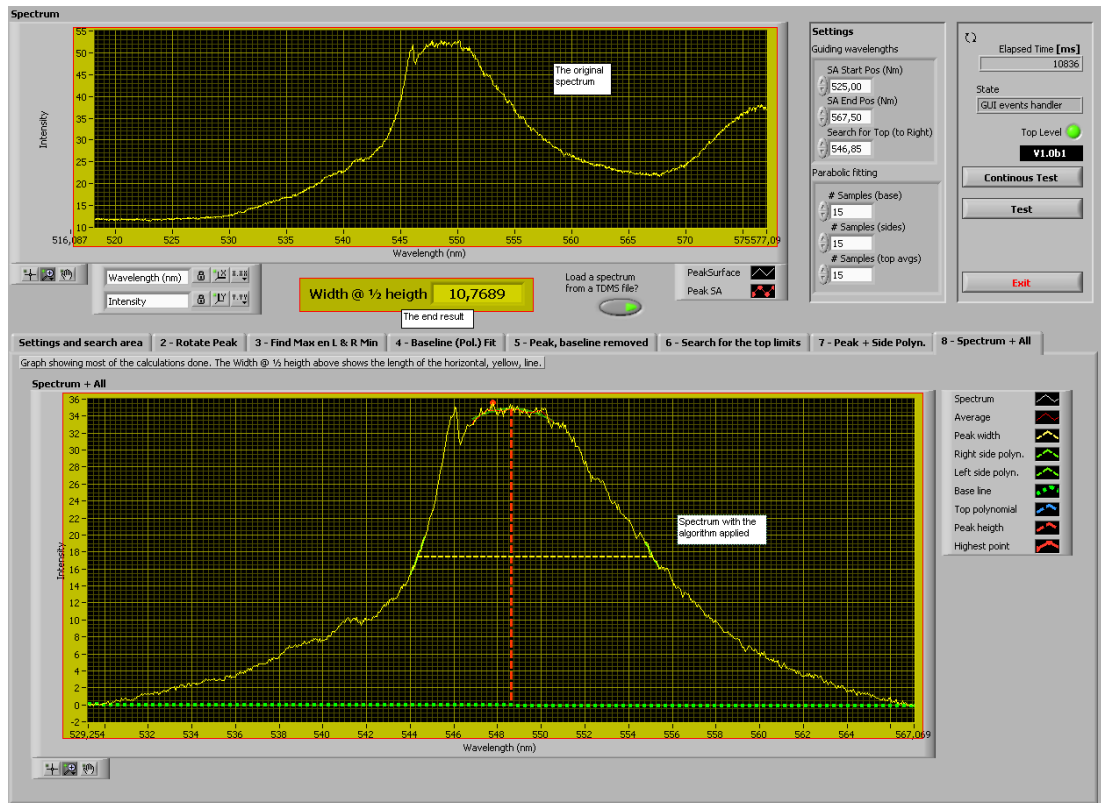
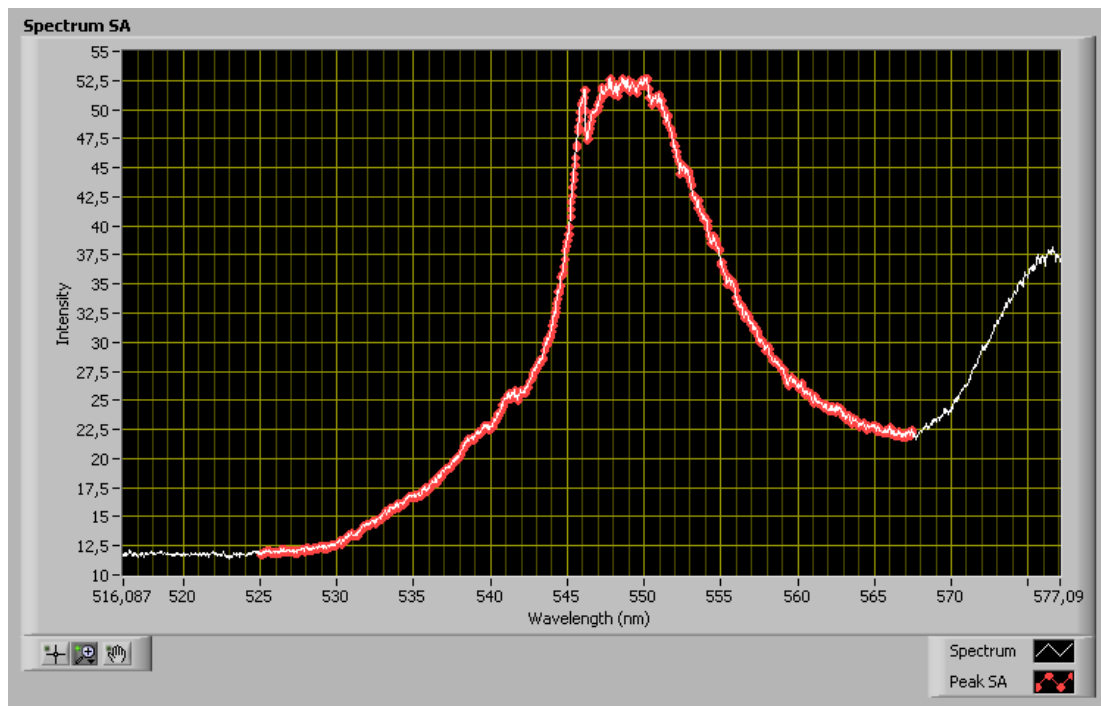


FIGURE 4. Overview. The front panel of the TFS Peak Width.vi

The first step of the algorithm is to discard the excess spectrum, since only the mercury peak is of interest in this case. The user-defined and product type specific settings [SA Start Pos (nm) and SA End Pos (nm)] are used to accomplish this. In Figure 5 the defined area is highlighted.



*FIGURE 5. Finding the boundaries of the Hg peak*

Next, the spectrum is leveled so that the first and the last points of the highlighted area are located at  $y = 0$ . Figure 6 presents the spectrum before rotating (white), a line from the first to the last point and the resulting, rotated, spectrum, which is in green.

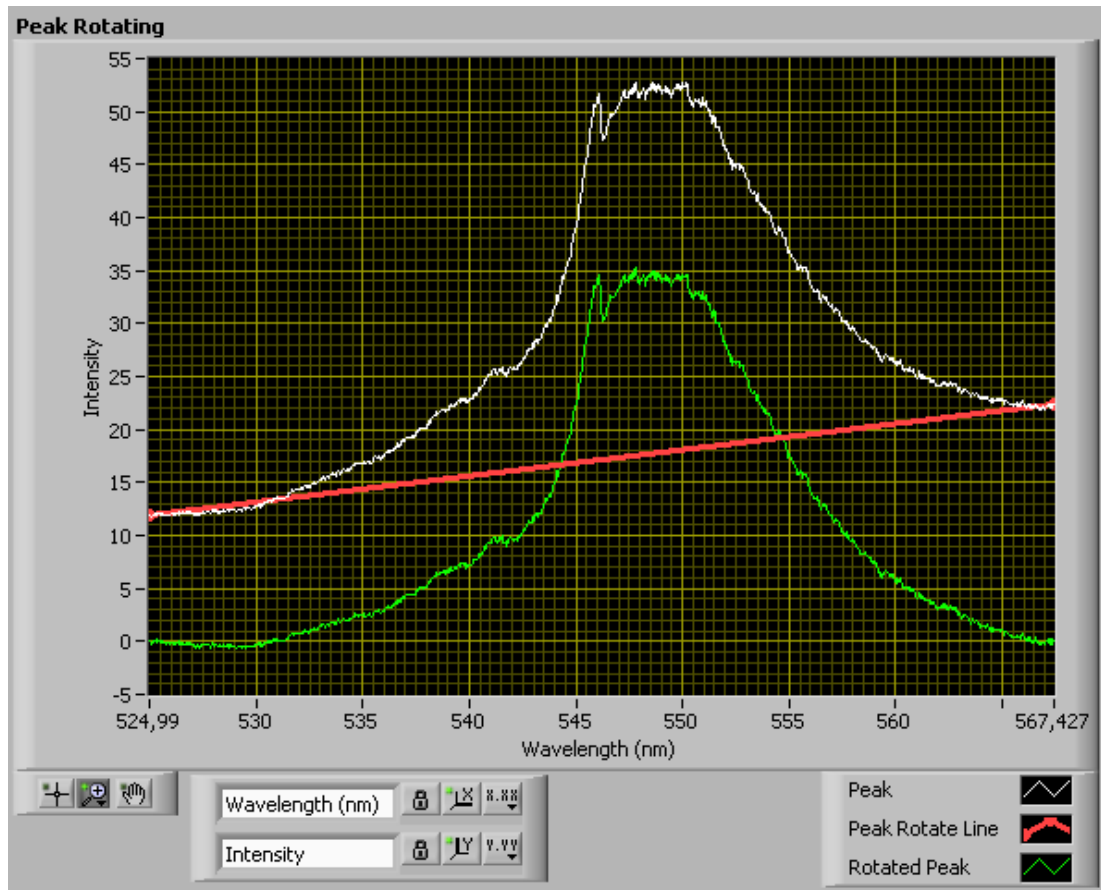


FIGURE 6. Rotating the peak so that both boundaries are at the same level

The next step is to find the maximum of the peak to divide the spectrum into two parts. The global minimum is then calculated for both of the parts. (Figure 7.)

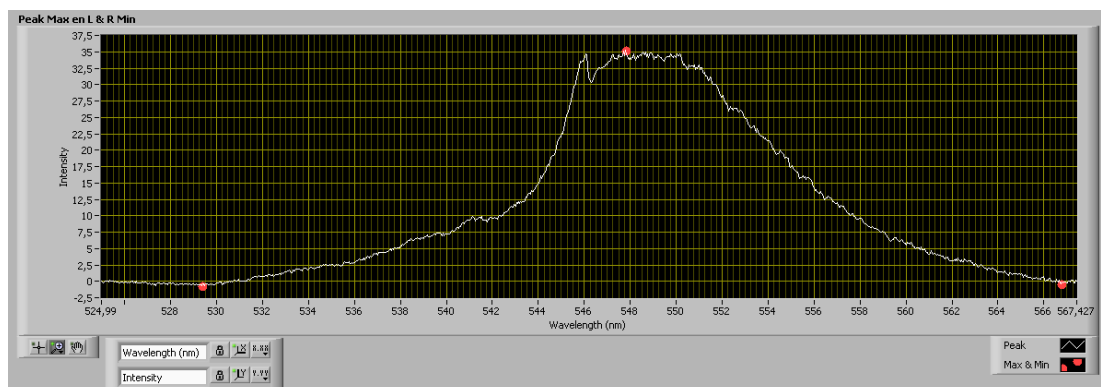


FIGURE 7. Finding the global minima

After the minima are found, the least square method of data fitting is used to fit the polynomials through the minima. For this the application uses the amount of samples set in the product type specific settings. The base line is then calculated through the global minima of these two polynomials (Figure 8).

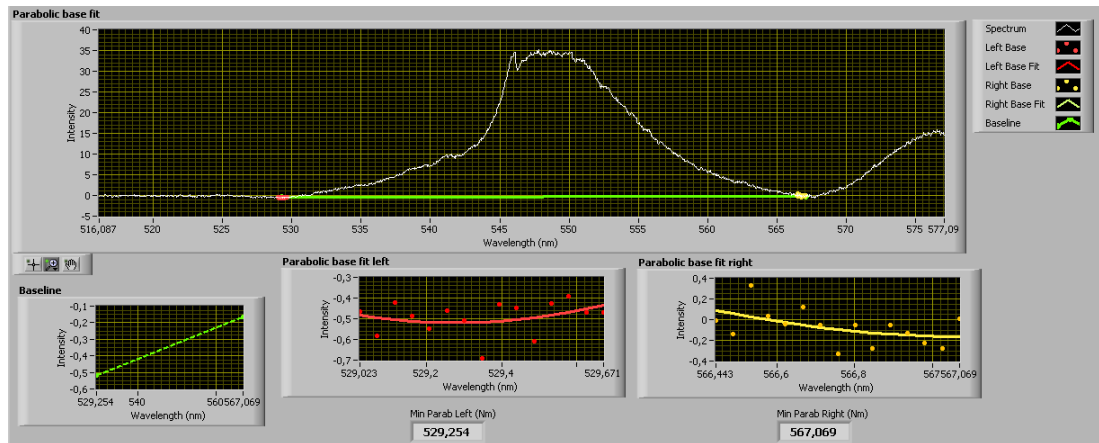


FIGURE 8. Fitting polynomials at the boundaries and calculate the base line

The spectrum is, once again, leveled using the base line calculated above. Excess data is removed from the spectra resulting in a peak usable for further handling (Figure 9).

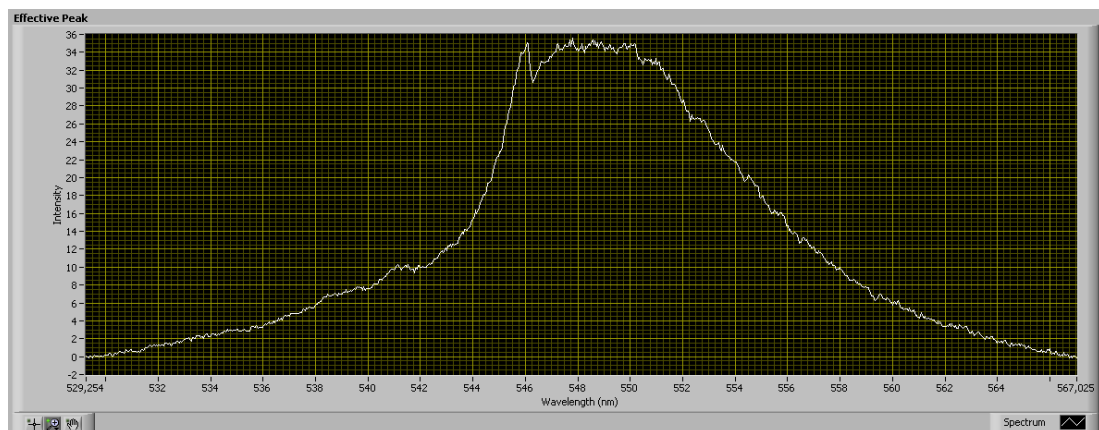


FIGURE 9. Removing the portion of the spectrum below the base line

Bypassing the 546 nm side-peak and defining the top area is done by averaging the spectrum and finding on the right side of the peak a wavelength, where the intensity value correlates with the intensity on the left

side. Starting at the user defined wavelength, which was to be set between the 546 nm side-peak and the actual top area of the spectrum, the average for every point is calculated, point by point, using equation 1. The calculation is continued until the slope is declining and the calculated average is equal to or smaller than the first average. The block diagram for this paragraph is shown in Figure 10.

$$y(i_0) = \frac{\sum_{i=i_0-\frac{n}{2}}^{i_0+\frac{n}{2}} y(i)}{n} \quad \text{EQUATION 1}$$

where  $y$  = intensity,  $n$  = the amount of samples,  $i$  = the index number and  $i_0$  = the index number of the average being calculated.

In arrays  $i$  is the index number for a certain wavelength so that  $n$  is the real amount of samples. The index numbers have to be interpolated within the array to return the wavelengths and intensities. An example of the average calculations, which define the beginning and ending points of the area for the next step, is shown in Figure 11.

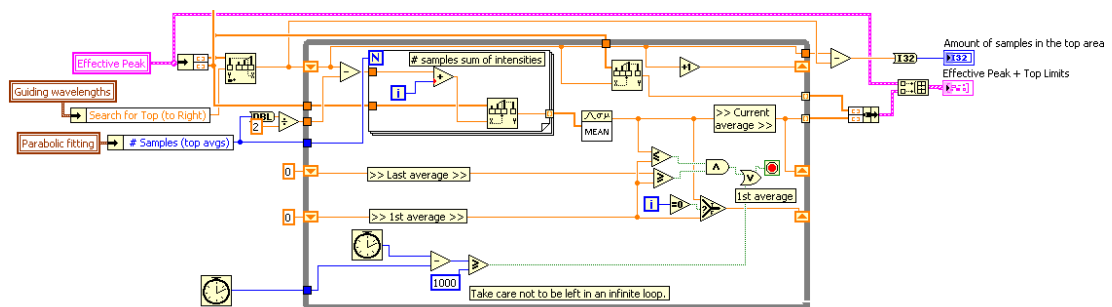


FIGURE 10. The block diagram of the average calculation

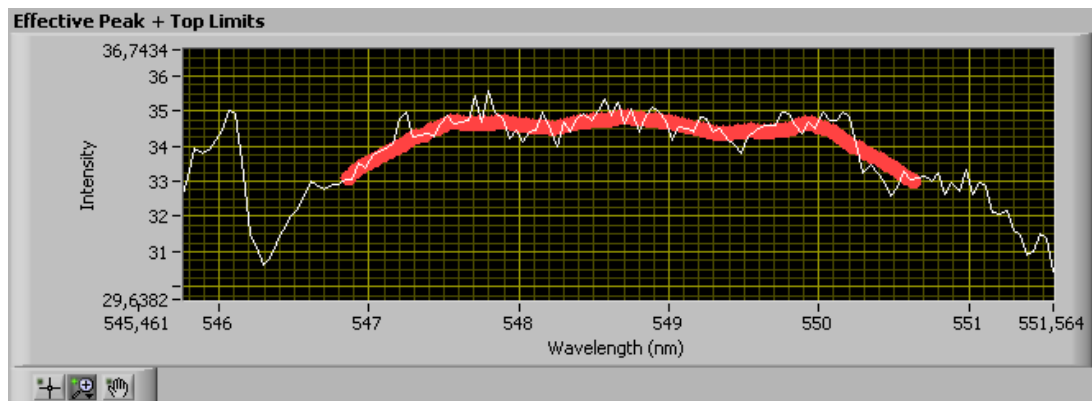


FIGURE 11. Calculating the average

After determining the limits for the actual top area of the peak, the least square method can be used to approximate the spectrum (Figure 12). The maximum of this polynomial is used to determine the height, half height and thus the locations for the side polynomials (Figure 13).

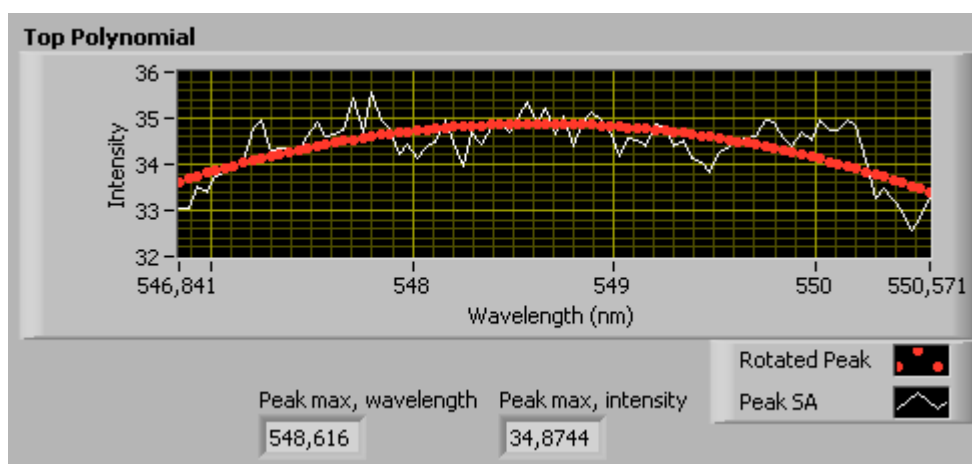


FIGURE 12. Fitting a polynomial between those two points found before and seeking the maximum

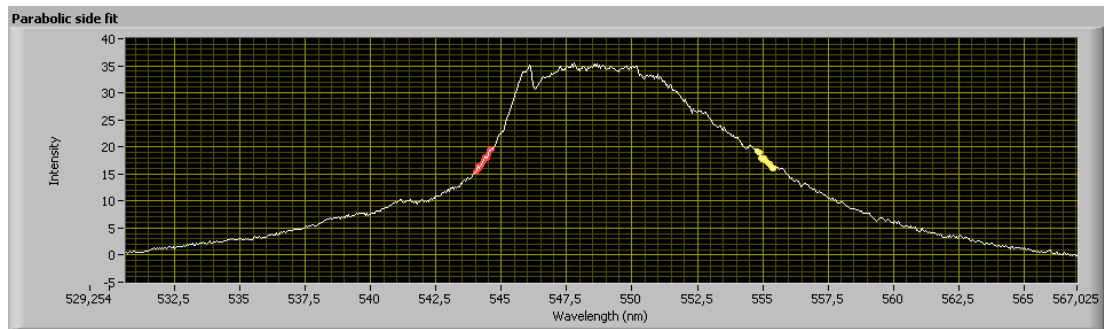


FIGURE 13. Dividing the height by two, and fitting polynomials on the sides of the peak at the half height

In Figure 14 most of the process is drawn on a single graph providing an easy way to determine if there are harsh miscalculations or problems with the algorithm. Figure 15 is the wanted end result of this VI, and is passed on to another VI for calculating the pressure and arc gap. This algorithm itself needs milliseconds only from start to end.

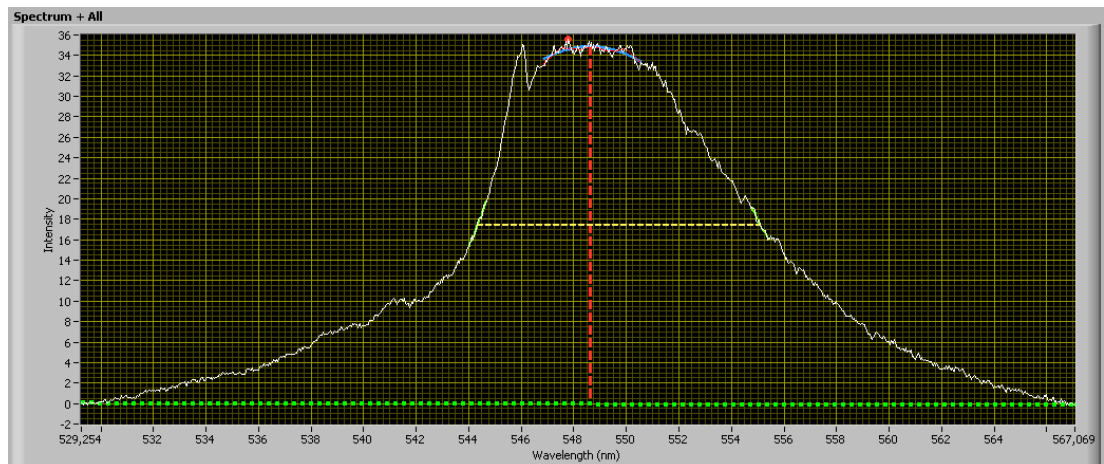


FIGURE 14. Algorithm applied: peak width at half height

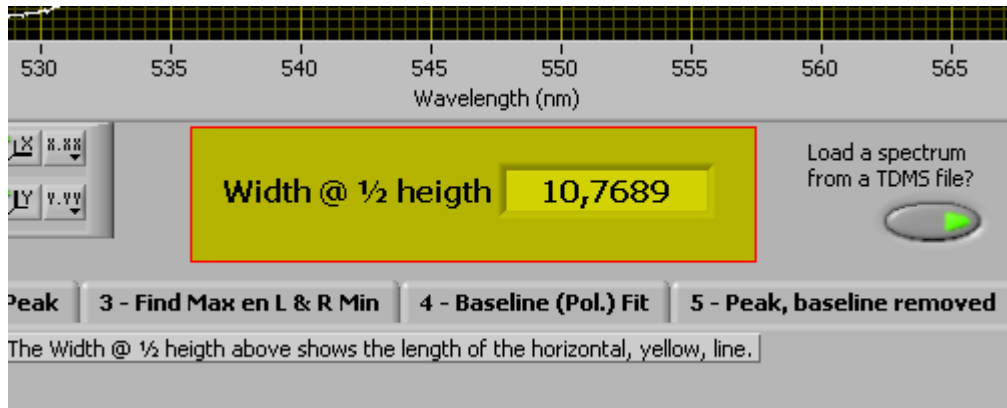
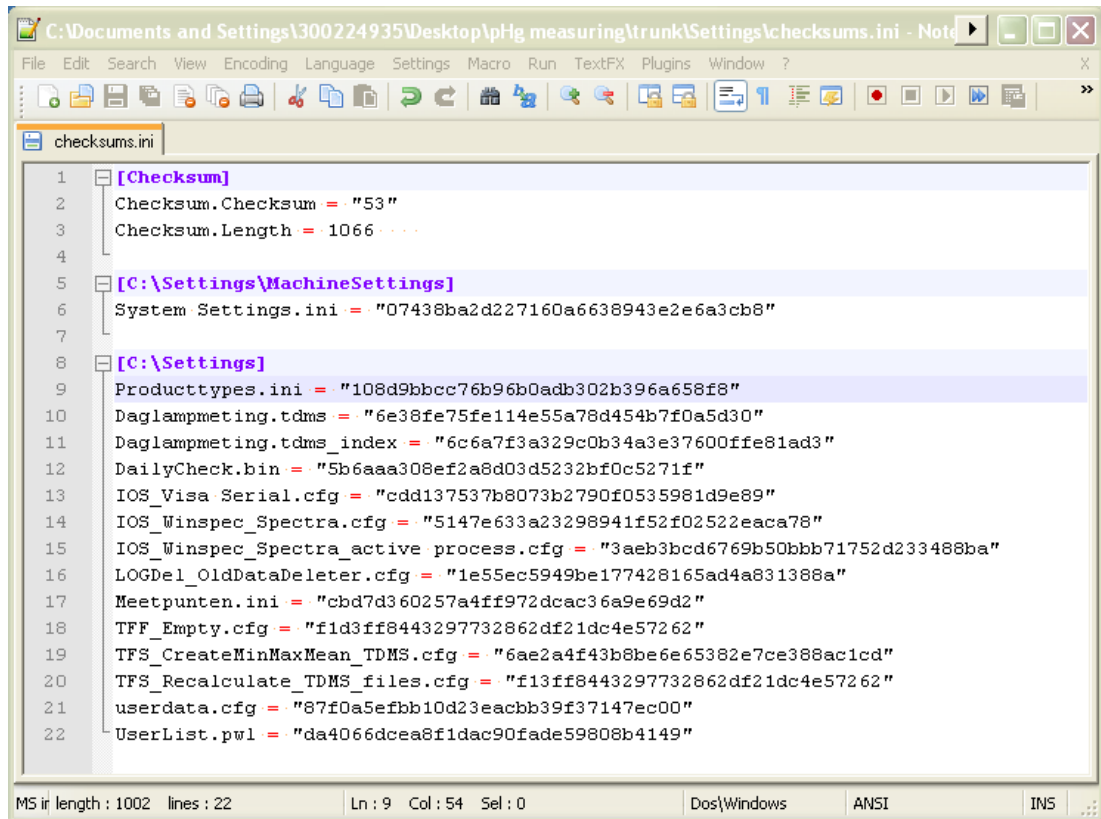


FIGURE 15. The numeric result of the algorithm

## 6.2 Checksum-controlled critical files

The checksums are calculated using the MD5-algorithm. Then the checksum is saved in a file called "Settings\checksums.ini" (Figure 16), which is hard coded in the application. The directory of the file for which the checksum has been calculated for serves as an ini-file "section", and the filename itself as the key. The checksum is the value for that key, and it is expressed as a 32-digit hexadecimal string. To prevent the checksums.ini itself from being altered, it is protected with hash and length –information, under the section "Checksum".



```
1 [Checksum]
2 Checksum.Checksum = "53"
3 Checksum.Length = 1066
4
5 [C:\Settings\MachineSettings]
6 System Settings.ini = "07438ba2d227160a6638943e2e6a3cb8"
7
8 [C:\Settings]
9 Producttypes.ini = "108d9bbcc76b96b0adb302b396a658f8"
10 Daglampmeting.tdms = "6e38fe75fe114e55a78d454b7f0a5d30"
11 Daglampmeting.tdms_index = "6c6a7f3a329c0b34a3e37600ffe81ad3"
12 DailyCheck.bin = "5b6aaa308ef2a8d03d5232bf0c5271f"
13 IOS_Visa Serial.cfg = "cdd137537b8073b2790f0535981d9e89"
14 IOS_Winspec_Spectra.cfg = "5147e633a23298941f52f02522eaca78"
15 IOS_Winspec_Spectra_active process.cfg = "3aeb3bcd6769b50bbb71752d233488ba"
16 LOGDel_OldDataDeleter.cfg = "1e55ec5949be177428165ad4a831388a"
17 Meetpunten.ini = "cbd7d360257a4ff972dcac36a9e69d2"
18 TFF_Empty.cfg = "f1d3ff8443297732862df21dc4e57262"
19 TFS_CreateMinMaxMean_TDMS.cfg = "6ae2a4f43b8be6e65382e7ce388ac1cd"
20 TFS_Recalculate_TDMS_files.cfg = "f13ff8443297732862df21dc4e57262"
21 userdata.cfg = "87f0a5efbb10d23eacbb39f37147ec00"
22 UserList.pwl = "da4066dcea8f1dac90fade59808b4149"
```

FIGURE 16. An example of the contents of the checksums.ini

The "checksum.ini" is processed thoroughly at the startup of the application. All the checksums for section+"\)+key (which corresponds to file path + filename) are calculated and compared to the stored checksum. If any difference is found or if the .ini itself has been modified, the user is presented with an error popup (with a list of the files which failed the check, Figure 17) and the startup of the program is prevented. The user has the option to exit or to let the application calculate new checksums after inputting a Quality Engineer or an Administrator –level password (Figures 18-20). If all of the files pass the test, no output is given to the user.

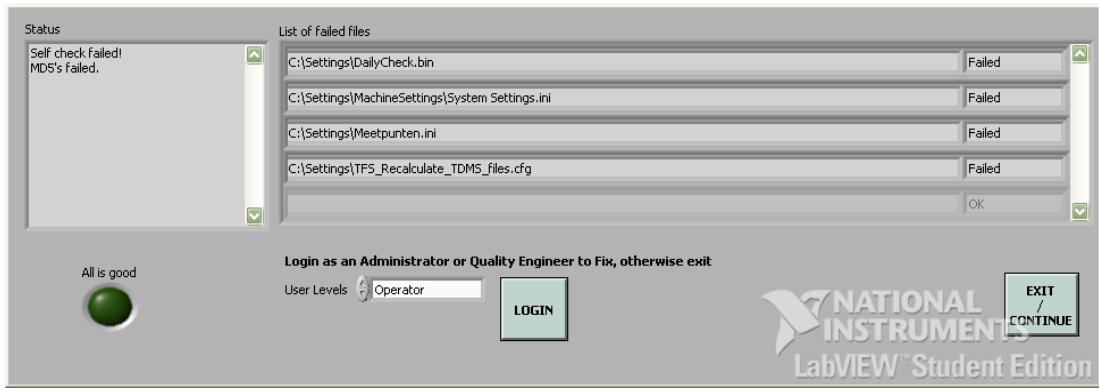


FIGURE 17. Error pop-up preventing the startup of the application

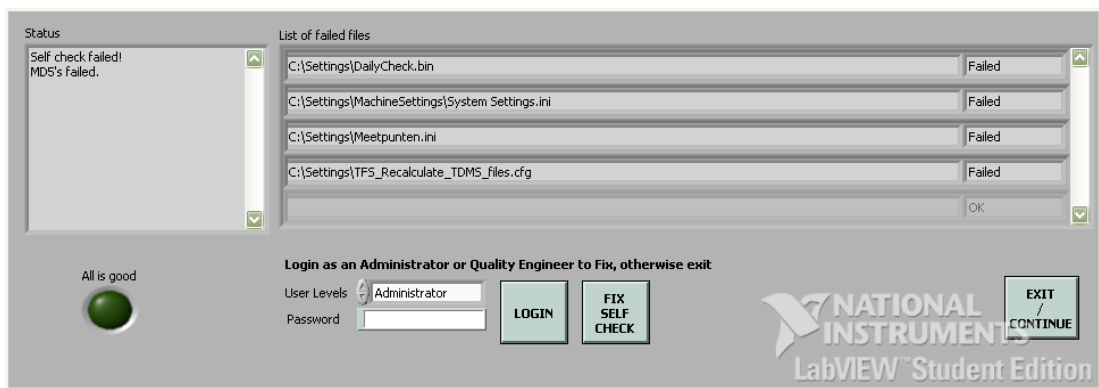


FIGURE 18. Logged in as an administrator

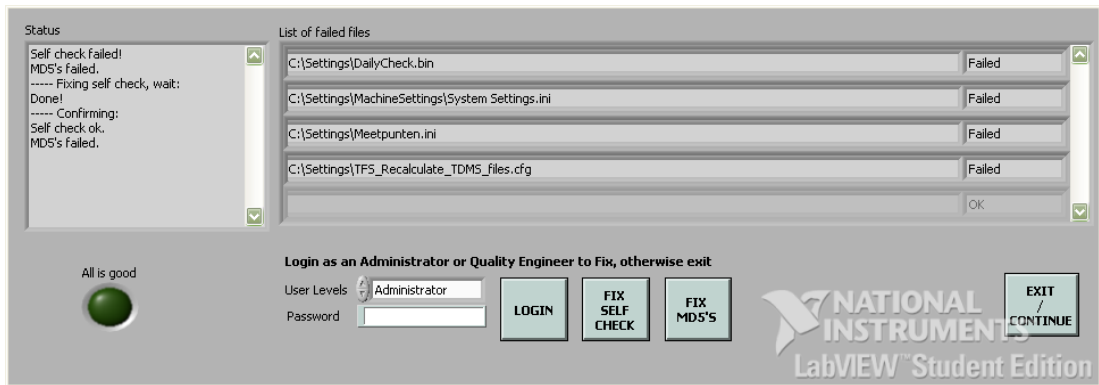


FIGURE 19. Fixed checksums.ini self check

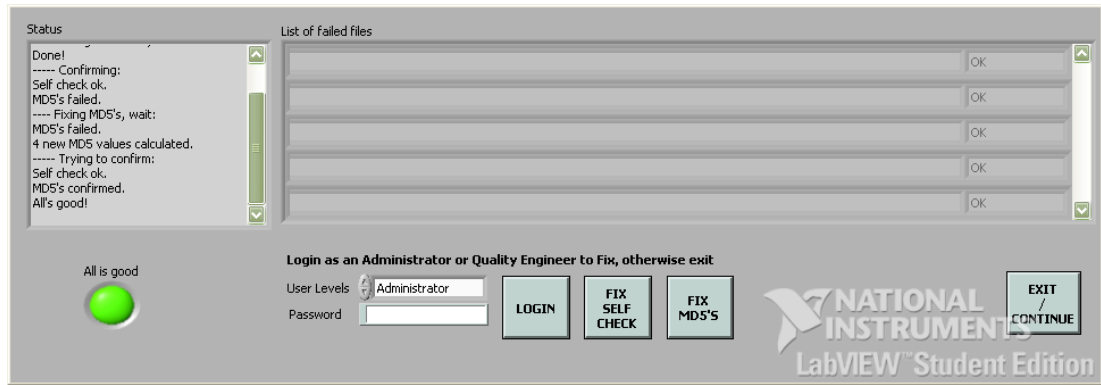


FIGURE 20. Also MD5's checked, everything is fine and ready to continue

If not specially configured, the application keeps track of the human-readable "Settings\MachineSettings\System Settings.ini", UserList.pwl and the product types, which are .txt. Their checksums are calculated always when saving the modified settings (for which you need special privileges).

If desired, the user is presented a panel in where he/she can choose the files on the computer to protect with the checksum (Figures 21-23). The recommendable files to protect would be some of which WinSpec uses.

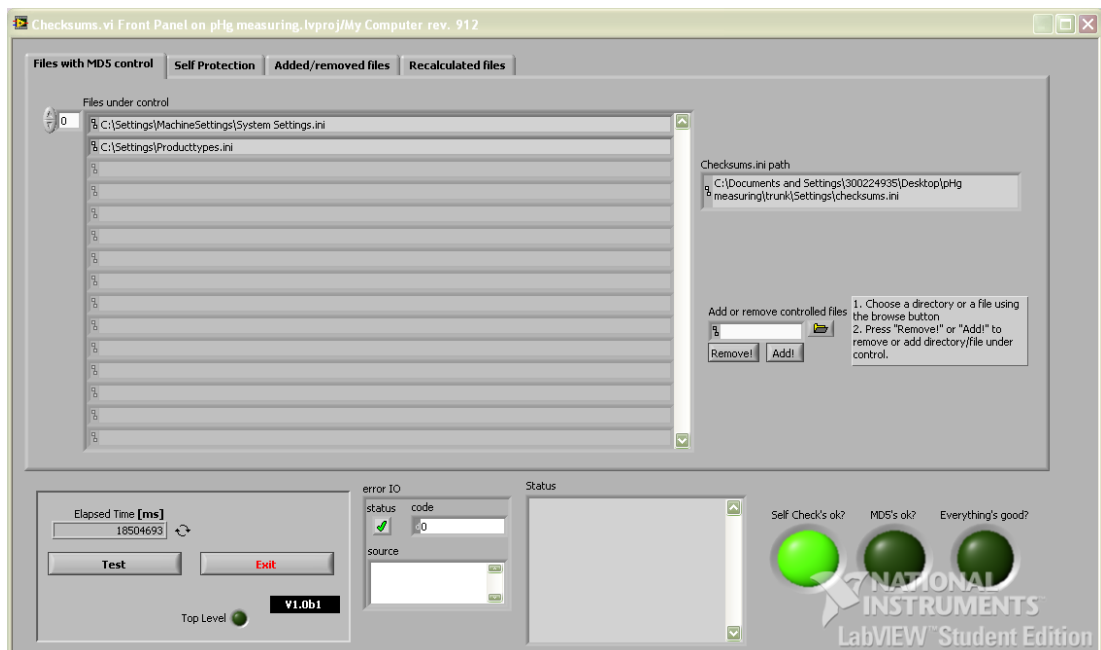


FIGURE 21. The front panel of the checksums.vi

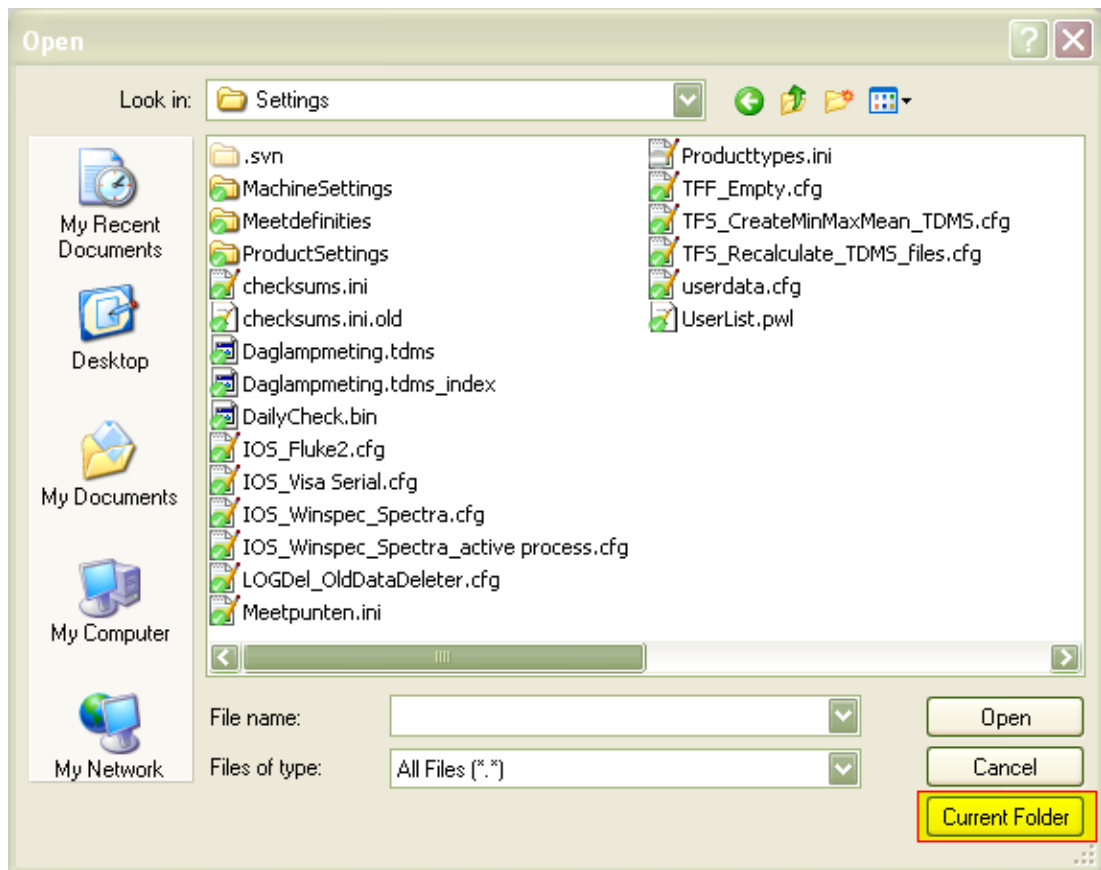


FIGURE 22. Choosing the files to add under control

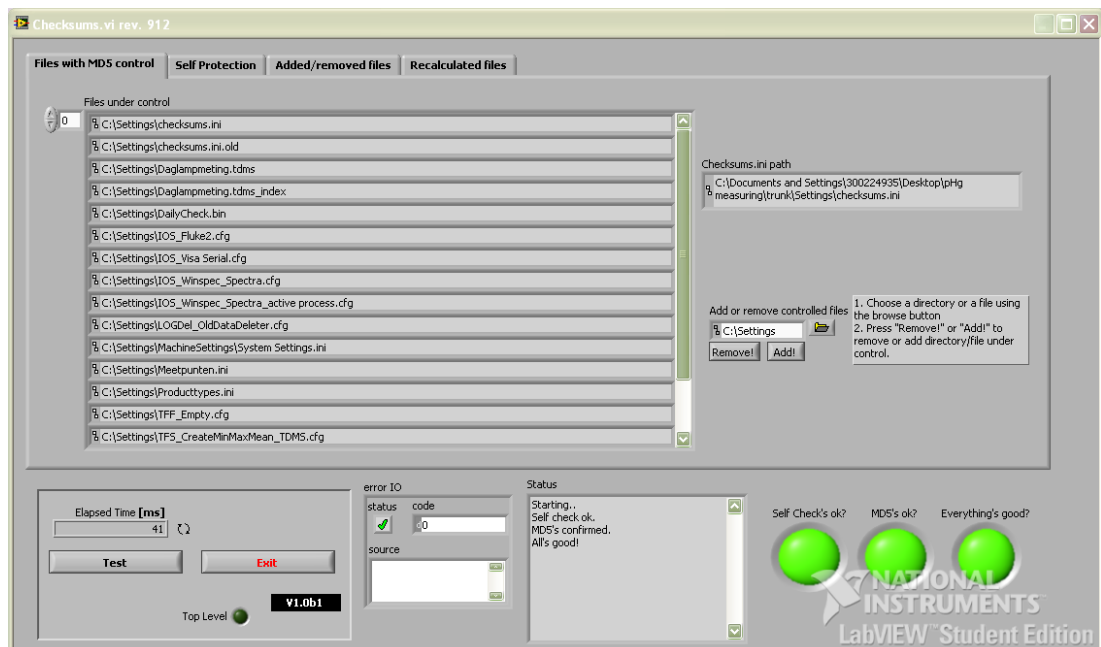


FIGURE 23. Front panel after adding the files

Also, mostly for debugging, the user is presented the tab "Self Protection", which explains the reason why a file has not passed the check. This can be checked without altering the checksums.ini by fixing its own checksum protection. (Figure 24.)

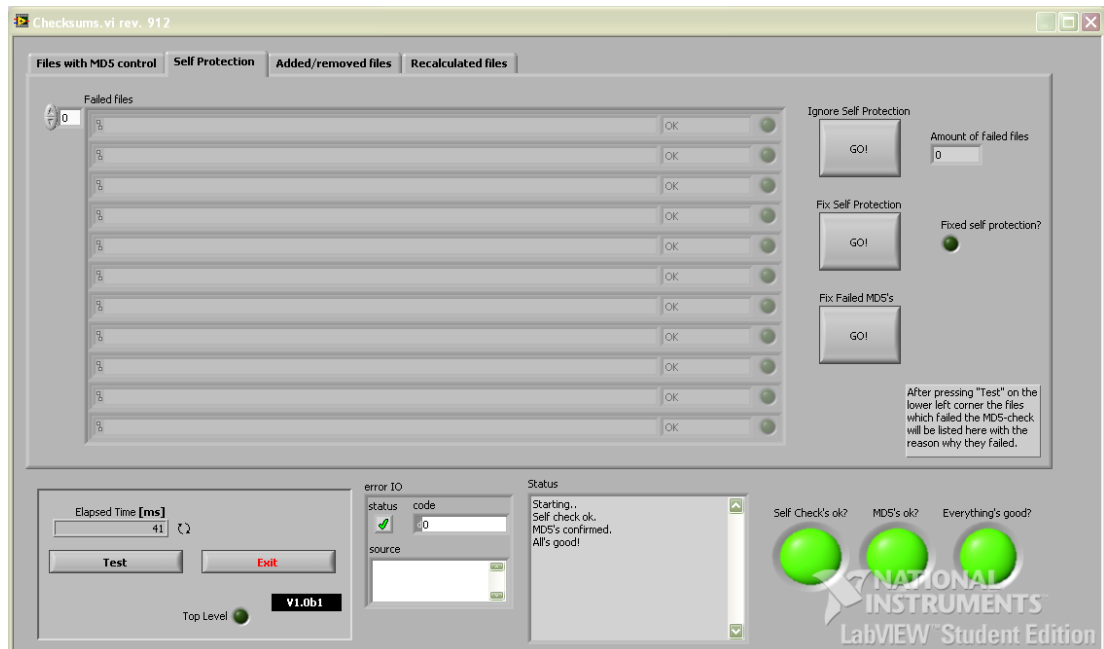


FIGURE 24. Checksums front panel, Self Protection tab

The format of checksums.ini is:

```
[File path]
Filename = "MD5-string"
Filename_2 = "MD5-string_2"
[Some other path]
File_in_another_path = "MD5-string_3"
[Checksum]
Checksum.Checksum = "hex"
Checksum.Length = integer
```

The template was used in non-standard ways to accomplish this method of checksum protection. The *InitApplication.vi*, which initializes all the directory variables and loads the settings, is called from *Main.vi* before the other VIs

start. It was modified to hold the case "Checksums" (Figure 25), which is situated between the cases "Init" and "Load settings".

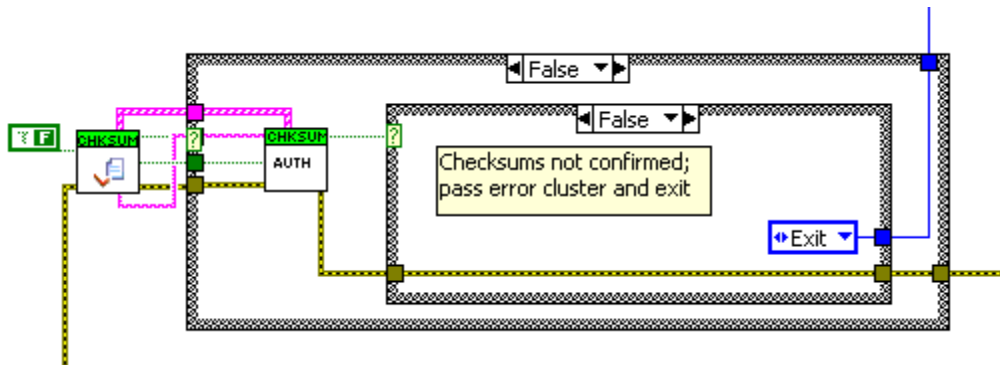


FIGURE 25. The contents of the "Checksums" case in *InitApplication.vi*

The popup, which the case produces if there is a trouble with the checksums (Figure 17), does not correlate either with the usual ways of working with the framework. To prevent the application from starting while erroneous, it was quite necessary to implement it this way, and it was approved by the supervisor of the project at GTD.

### 6.3 Logging

US specified the logging to be done in the D: -partition, which is a small exception to the template. By default the template logs to the same partition where the application is situated, under the directory *Application name Application description - Log*, and there forms directories based on the current date (e.g. 20110501). In this application the logging is done in *D:\pHg measuring Online stand - Log\* and divided into directories based on the ongoing year and week number (e.g. 2011, week 17). The spectrum for every measurement is logged as TDMS, resulting in two files for a measurement, which could mean thousands of files in an hour. Therefore, every week is divided to weekdays to prevent the directories for spectra to become too clogged up.

Human readability without extra software was required for the log files which included the conditions for every measurement and the results of the

measurements taken. To accomplish this, the text file is tab delimited and may use multiple consecutive delimiters to keep the columns aligned. This was however implemented so that the log file format could follow the standard, which in practice means that no consecutive delimiters are used by default. If those are wanted, the project owner is able to change the Boolean parameter of “Consecutive delimiters allowed?” input to TRUE in DFM\_Measurement.vi.

If consecutive delimiters are used, it should be taken into account that Microsoft Notepad uses a tab size of eight characters, so if reading the log file in another text editor or viewer the tab size should be set to be the same. If using the log file in a spreadsheet, it should be imported with the parameter “Treat consecutive delimiters as one” to get the formatting right.

According to the user specification, automatic deletion of log files older than 28 days was required. The panel for logging has the option to define the amount of days after which the log files are deleted (Figure 26). Deleting can be done manually from the panel or automatically while the application is idling, but not while there are ongoing measurements.

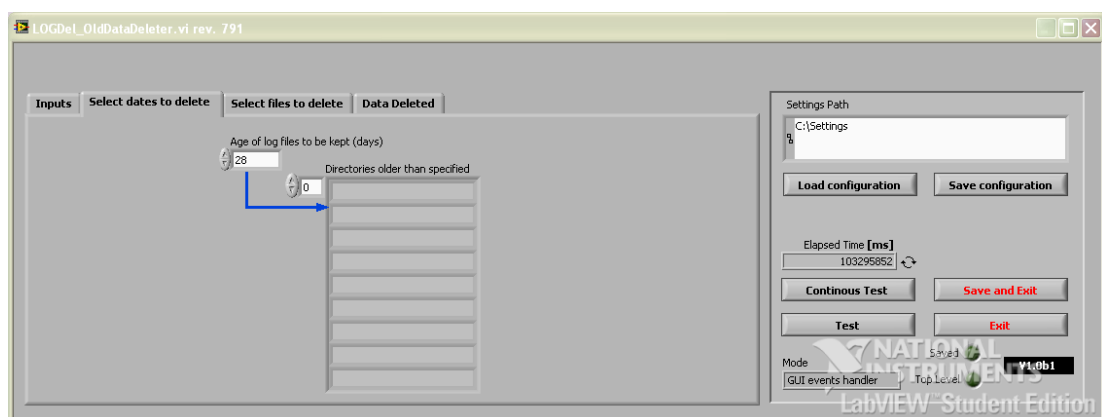


FIGURE 26. The front panel for log file deletion

## 6.4 Daily calibration of the halogen burner

The daily calibration was, for most of the parts required by this project, already done in the bromine measuring application. The stabilization time as

well as the limits for differences in the spectrum compared to the reference spectrum can be set in the system settings by an administrator or a quality engineer. By pressing the “Use as ref”-button the measured spectrum are saved as a reference and used as one in the later calibrations, too.

## 6.5 Shutter offset

WinSpec handles the settings of the camera and thus has the parameter to control the shutter offset as well. The parameter for the shutter offset from the system settings is passed to the WinSpec among other parameters.

## 6.6 Product definitions

Adding and modifying the product definitions was also developed for the bromine measuring application, but for measuring the mercury vapor pressure major alterations had to be made. Many of the parameters were obsolete in this system.

In the *Info and variables* section one has the option to write a comment to describe the product and alter the results which are sent to the Circle software. There are slight variations in the results between the three production lines, and the *Gain* and *Offset* can be used to correct the pressure measurement. Both the original and manipulated pressure result are still be logged. (Figure 27.)

*Power* is the amount of watts the burner uses. *Voltage TEMP* is used only for simulations. Simulating the voltage input uses the parameter given here as an average and alters it randomly by a few volts in both directions.

*Meting* has the settings for WinSpec. They are sent as a configuration to the WinSpec when measuring automatically.

*Piek detectie* –settings are for the peak width measuring algorithm. *Seek area start* and *Seek area end* define the boundary wavelengths where the actual mercury peak of interest is within. *Search for top* is a single wavelength between the 546 nm side-peak and the top of the peak. It should

be situated on an inclining part of the spectrum (Figure 28). *Amount of samples base* is the amount of samples used when calculating the polynomials for the endings of the baseline. *Amount of samples side* is for the polynomials in the sides of the peak. *Amount of samples for top avg* is the amount of samples taken into account when calculating an average intensity for every point in the top area of the peak (the red thick curve represents the averaged spectrum in Figure 28).

**Info and variables**

Commentaar

Testing definition

Manipulation

Gain  
1,00200

Offset  
0,01000

Power  
211

Voltage TEMP  
65

**Meting**

Centrale Golfengte  
547,0

Exposure  
1,00 (s)

Accumulaties  
1

Winspec Setup naam  
setup1200cw549Br

Flatfield naam  
ff1200cw549Br.SPE

**Piek detectie**

Seek area start  
525,0 (nm)

Seek area end  
568,0 (nm)

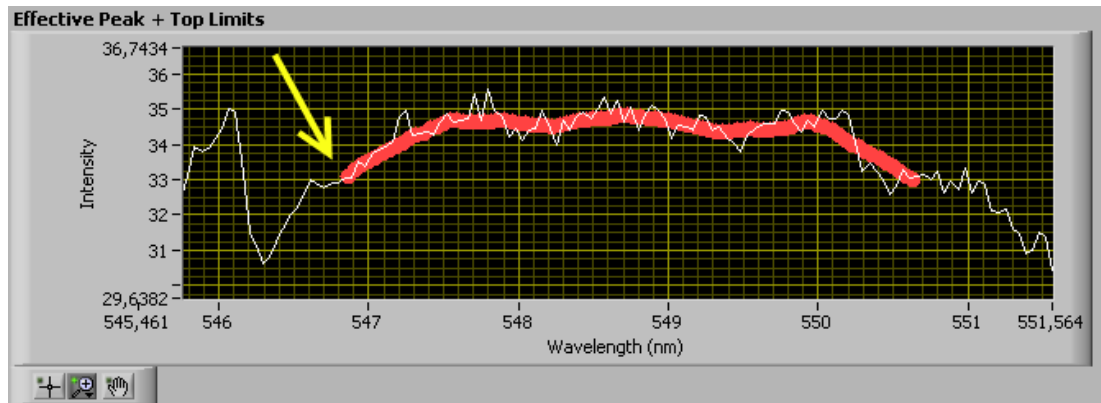
Search for top  
546,9 (nm to right)

Amount of samples base  
12

Amount of samples side  
15

Amount of samples for top avg  
13

FIGURE 27. Product definition (parameters for a product)



*FIGURE 28. The point to start looking for the top area of the peak, marked by a yellow arrow*

A last minute addition to the application was considered important since the PLC reports the product types to the application before the measurements are done. The corresponding product definition settings were made to load automatically. This enables for easier testing of different settings for different product types and makes it more effortless to add new product types.

## **6.7 System settings**

The system settings window is based on the bromine measuring application, and consists mostly of WinSpec related settings. There are Boolean switches if, for example, voltage or PLC simulation is desired, or for switching PLC communication off. In addition, there are the limits for the daily lamp check.

## **6.8 Measuring buffer**

For calculating the pressure inside a burner, two measurements have to be taken. The measuring unit is a rotating device with 32 holders, each containing one burner. Unit rotates one position at a time to provide the burners a warming up time and to accomplish the needed measurements – unit first acquires the spectrum of a burner and on the next position it measures the voltage of the burner with the Fluke multimeter. The voltage is needed for calculating the pressure inside a burner, and since both of these measurements are done simultaneously, but for successive burners, a buffer to store the spectrum and the needed values for a burner are necessary.

This is accomplished by a functional global variable DATA\_AllTheResults\_gli.vi. It comprises of two uninitialized (except for the case Init, which is called only when going to the Auto-mode) shift registers and the methods to in- and output needed variables. One of the registers (let us call it X) holds the spectrum and other data from the previous run, and in the ongoing run that data is completed with voltage, pressure and arc gap info. Then it is sent to the PLC (and through PLC to Circle), and the data from the other register, Y, (with the spectrum etc from the ongoing run, from another burner) is moved to X, clearing the old, already sent, data.

## 7 RESULTS AND SUMMARY

The goal of the project was to replace an old measuring software with a new one based on a standard template, with an improved algorithm and a few other features. This was achieved as wished.

Because of the size of the project and the requirement of individual theses, the actual development of the project was divided into two distinct parts. This in itself requires much effort in communicating and constant discussions since even the methods of transferring information from one VI to another should be agreed upon on the beginning of the development to avoid wasted working hours.

Weekly meetings with the client were arranged to keep track of the progress, to overcome possible problems and to analyze all the potential risks on the project. In addition, occasional meetings were organized with the stake holders, for example with Toon Raes, the coach at software development, Geert van Baelen and Yves Casteels, the supervisors in the DPL and the machine owner etc.

In spite of the meetings and necessary communication the development itself was mainly about pondering the smartest ways to achieve the wanted goal, using the available resources, which usually came to skills on thinking in the LabVIEW-way. In addition, scheduling the development, testing and documenting was also, at the beginning, quite a time-consuming task.

Long hours were required towards the deadline to accommodate all the test runs and modifications in the code. Additional tests were needed to find the correlations and deviations between the measurements in the old and new software. As of writing this thesis, the new application is running on all three production lines non-stop.

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## **APPENDICES**

Appendix 1. User Specification by Chris Dries (Philips)

Appendix 2. Functional Specification

<p><b>IT : QDL-DPL</b></p>	<p>Gebruikersspecificatie (GS) UHP_PHg V1.0</p>	<p>Kode : Datum : 02/02/11</p>
<p><b>Gebruikersspecificatie</b></p> <p>Gebruikersspecificatie ..... 1</p> <p><b>1. Projectomschrijving</b> ..... <b>2</b></p> <p>1.1. Algemene doelstelling en argumentatie..... 2</p> <p>1.2. Projectresultaat ..... 2</p> <p>1.3. Afbakening van het project..... 2</p> <p>1.4. Niet tot het project behoren ..... 2</p> <p>1.5. Randvoorwaarden ..... 2</p> <p>1.6. Dwingende eisen..... 2</p> <p>1.7. Wensen..... 3</p> <p><b>2. Productgegevens</b> ..... <b>3</b></p> <p>2.1. Te verwerken producttypes ..... 3</p> <p><b>3. Proces</b> ..... <b>3</b></p> <p>3.1. Proceskeuze ..... 3</p> <p>3.2. Processpecificaties ..... 3</p> <p>3.3. Procescontroles ..... 3</p> <p><b>4. Machineconcept</b> ..... <b>4</b></p> <p>4.1. Algemene beschrijving ..... 4</p> <p>4.2. gedetailleerde beschrijvingen: ..... 4</p> <p>4.2.1. Burner types ..... 4</p> <p>4.2.2. logging ..... 4</p> <p>4.2.3. error trapping ..... 4</p> <p>4.2.4. daglamp..... 4</p> <p>4.2.5. settings ..... 5</p> <p>4.2.6. installatie..... 5</p> <p>4.2.7. GUI (Graphical User Interface) ..... 5</p> <p>4.2.8. Diagnostiek ..... 5</p> <p>4.2.9. meten..... 5</p> <p>4.3. Snelheid ..... 6</p> <p>4.4. Bediening ..... 6</p> <p>4.4.1. Operator taken..... 6</p> <p>4.4.2. Specifieke start-stop procedures..... 6</p> <p>4.4.3. Veiligheid en ergonomie ..... 6</p> <p>4.4.4. Handleiding / bedieningsvoorschrift ..... 6</p> <p>4.5. Opleiding (operators en V&amp;O technici) ..... 6</p> <p><b>5. Normen</b> ..... <b>7</b></p> <p>5.1. Veiligheid ..... 7</p> <p>5.2. Bijkomende eisen..... 7</p> <p>5.3. Ergonomie..... 7</p> <p>5.4. Milieu..... 7</p>		
<p>N.V. Philips Lighting Fabrieken Turnhout</p>	<p>Auteur : C. Dries</p>	<p>1/7</p>

IT : QDL-DPL	Gebruikersspecificatie (GS) UHP_PHg V1.0	Kode : Datum : 02/02/11
<p><b>1. Projectomschrijving</b></p> <p><b>1.1. Algemene doelstelling en argumentatie</b> De doelstelling van dit project is de ontwikkeling van gebruiks- en onderhoudsvriendelijke software voor de Kwikdrukmeting.</p> <p><b>1.2. Projectresultaat</b> Het resultaat bestaat uit een aantal functies:</p> <ul style="list-style-type: none"> <li>• Installatie</li> <li>• Kalibratie</li> <li>• Meten</li> <li>• Logging</li> <li>• Error trapping</li> <li>• Bijkomende metingen</li> </ul> <p><b>1.3. Afbakening van het project</b> De software, installatie procedures, testplan, handleidingen en eventueel nodige hardware behoren tot dit project.</p> <p><b>1.4. Niet tot het project behoren</b> Onderzoeken naar de meetmethode. Aanpassingen aan de meetmolen.</p> <p><b>1.5. Randvoorwaarden</b> De software wordt ontwikkeld en bedrijfsklaar gemaakt op 1 operationele opstelling. Er wordt in samenspraak met productie een maximum van 2 dagen (48 uur) op de productie machines voorzien voor test en ontwikkeling van de software. Er moet steeds een back-up procedure voorzien zijn zodat productie binnen 2 uur terug kan draaien. Vervolgens worden de overige opstellingen aangepast. De software en procedures worden gedocumenteerd en gearchiveerd volgens de BM voorschriften.</p> <p><b>1.6. Dwingende eisen</b> De installatie, diagnose van problemen en het opzetten van bijkomende meetpunten moet kunnen zonder ingrijpen van een programmeur door een "gewone" gebruiker.</p>		
N.V. Philips Lighting Fabrieken Turnhout	Auteur : C. Dries	2/7

<b>IT : QDL-DPL</b>	Gebruikersspecificatie (GS) UHP_PHg V1.0	Kode : Datum : 02/02/11
<p>Settings mogen enkel op 1 plaats staan, er zijn zo weinig mogelijk settings bestanden. De settings worden centraal beheerd van uit 1 plaats in het programma.</p> <p>De software moet overzichtelijk en volgens de Turnhout standaarden opgebouwd en gearchiveerd worden, inclusief een Image van C:\.</p> <p>Enkel na overleg met de projectleider en de projecteigenaar mag er een verandering in de personeelbezetting en of in de planning doorgevoerd worden.</p> <p>De implementatie van algoritmes word in team gerevied door de programmeur, de projecttrekker en de nodige specialisten.</p> <p>Opgegeven prijzen gelden voor het gehele project (alle mijlpalen) inclusief documentatie, image, archivering,.... Een gedeeltelijke prijs tot mijlpaal 3 kan indicatief mee opgegeven worden.</p> <p><b>1.7. Wensen</b> Administrator rechten zijn niet nodig om de software te gebruiken.</p> <p><b>2. Productgegevens</b></p> <p><b>2.1. Te verwerken producttypes</b> Losse burners van 50 w tot 400 W conform huidige werkwijze (PLC communicatie)</p> <p><b>3. Proces</b></p> <p><b>3.1. Proceskeuze</b> De keuze van het meetprincipe berust deels op de bestaande software (versie na de aanpassingen voor de Fluke Vla meter) deels op nog uit te voeren testen. De software moet de kwikdruk betrouwbaar berekenen zonder invloed van de sporadisch optredende extra piek. Voor de ontwikkeling wordt gestart van af het frame work van de vernieuwde broomsoftware.</p> <p><b>3.2. Processpecificaties</b> Elke meting wordt minstens gedefinieerd door middel van een centrale golflengte, belichtingstijd en zoek gebieden, indien nodig kan dit uitgebreid worden.</p> <p><b>3.3. Procescontroles</b> Dagelijkse controle moet optioneel (vinkje) mogelijk zijn voor de lichttechnische kalibratie</p>		
N.V. Philips Lighting Fabrieken Turnhout	Auteur : C. Dries	3/7

IT : QDL-DPL	Gebruikersspecificatie (GS) UHP_PHg V1.0	Kode :  Datum : 02/02/11
<p><b>4. Machineconcept</b></p> <p><b>4.1. Algemene beschrijving</b></p> <p>De software bestuurt een Roper Scientific spectrometer (OMA). Doormiddel van deze spectrometer wordt het spectrum gemeten. Aan de hand van de analyse van dit spectrum wordt de kwikdruk in de burner bepaald. Alle metingen worden gestandaardiseerd naar een belichtingstijd van 1 sec. De lampspanning word gemeten door een Fluke 8808A.</p> <p><b>4.2. gedetailleerde beschrijvingen:</b></p> <p><b>4.2.1. Burner types</b></p> <p>Voor elke burner type kan zo nodig de meet parameters aangepast worden. De de aanpassingen en toevoegingen van types moet mogelijk zijn zijn zonder tussenkomst van een programmeur.</p> <p>De parameters zijn tenminste:</p> <ul style="list-style-type: none"> <li>• Centrale golflengte</li> <li>• Verwachte piek breedte</li> <li>• Base line type</li> <li>• Grenzen van de meetwaarde</li> </ul> <p><b>4.2.2. logging</b></p> <p>Zowel fout meldingen als meet resultaten worden gelogd op D:\.</p> <p>De software moet op dezelfde manier comuncieren met Cirkel als nu.</p> <p>De gelogde meetresultaten zijn minstens:</p> <ul style="list-style-type: none"> <li>• Het numeriek resultaat van elke meetwaarde <ul style="list-style-type: none"> <li>○ Voor elke producttype een aparte folder</li> <li>○ Per week een nieuw bestand, oude bestanden worden na 4 weken verwijderd.</li> <li>○ De eerste regel bevat telkens de kolom koppen</li> <li>○ Tab of komma gescheiden</li> </ul> </li> <li>• Eventueel gebruikte kalibratie factoren</li> <li>• De lamp spanning</li> <li>• Het complete gemeten spectrum in ASCII en of Excel formaat.</li> </ul> <p><b>4.2.3. error trapping</b></p> <p>De fout afhandeling en fout detectie is zo opgebouwd dat er maximale ondersteuning is bij het diagnosticeren van problemen.</p> <p><b>4.2.4. daglamp</b></p> <p>Dagelijks word de daglamp in de opstelling geplaatst. Het spectrum van de dag lamp wordt vergeleken met de certificaatwaarde. Als de daglamp meer dan de gestelde grenzen afwijkt, krijgt de operator een foutmelding.</p>		
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IT : QDL-DPL	Gebruikersspecificatie (GS) UHP_PHg V1.0	Kode :  Datum : 02/02/11
<p><b>4.2.5. settings</b> Alle settings worden op een overzichtelijke wijze op 1 plaats gegroepeerd en geediteerd. Het editeren van de settings gebeurt in de GUI niet in de "ini" bestanden. Ongeoorloofd editeren van de settings (ook offline in de ini bestanden) wordt onmogelijk gemaakt en of bewaakt (bvb door checksums). Alle settings in de ini bestanden moeten gedocumenteerd zijn.</p> <p>Er zijn een aantal gemeenschappelijke settings voor het programma:</p> <ul style="list-style-type: none"> <li>• Pat settings voor log bestanden , FF,...</li> <li>• Daglamp grenzen</li> <li>• Roi</li> <li>• Shutteroffset</li> <li>• Slit breedte</li> <li>• grating</li> <li>• A/D converter keuze</li> <li>• Mogelijk productielijnen</li> <li>• Product types <ul style="list-style-type: none"> <li>○ Belichtingstijd</li> <li>○ Hardware of software binning</li> <li>○ Product specifieke kalibratie waarden</li> </ul> </li> </ul> <p><b>4.2.6. installatie</b> De installatie procedure van af een clean geïnstalleerde Windows PC tot het werkend meetsysteem moet uitgevoerd kunnen worden door een gebruiker zonder tussenkomst van de programmeur. De installatie procedure mag volgende stappen omvatten:</p> <ul style="list-style-type: none"> <li>• Installatie run time Labiew</li> <li>• Installatie of copieren van het programma naar een voorgeschreven map.</li> <li>• Installatie van de OMA</li> <li>• Installatie van Winspec en Spectra Pro</li> <li>• Copieren of aanmaken "ini" bestanden</li> <li>• Manueel aanmaken van een snelkoppeling op het bureel blad</li> <li>• De installatie gebeurt op een type 2 pc met firewall</li> </ul> <p><b>4.2.7. GUI (Graphical User Interface)</b> De GUI wordt opgebouwd op basis van de CIT/BM template. De toepassing heeft minstens dezelfde vensters als de broom software.</p> <p><b>4.2.8. Diagnostiek</b> De bedoeling van de diagnostiek module is de gebruiker de mogelijkheid geven om halfautomatisch diagnostische metingen te doen. V&amp;O technici krijgen zo de mogelijkheid om eventueel telefonisch bijgestaan door TTM, BM of Imspec bij problemen de juiste acties te ondernemen.</p> <p><b>4.2.9. meten</b></p> <ul style="list-style-type: none"> <li>• De meeting moet dezelfde parameters naar Cickel sturen als nu.</li> </ul>		
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<p><b>4.3. Snelheid</b> De snelheid wordt bepaald door de meetmolen, de toepassing moet de meting binnen 75% van de takt tijd kunnen afronden.</p> <p><b>4.4. Bediening</b></p> <p><b>4.4.1. Operator taken</b> Zoals in de bestaande situatie</p> <p><b>4.4.2. Specifieke start-stop procedures</b> Zoals in de bestaande situatie</p> <p><b>4.4.3. Veiligheid en ergonomie</b> De opstelling moet aan alle geldende voorschriften voldoen.</p> <p><b>4.4.4. Handleiding / bedieningsvoorschrift</b> Een gedetailleerde handleiding is onderdeel van het project. De handleiding bevat minstens:</p> <ul style="list-style-type: none"> <li>• Gebruikers handleiding voor het meten</li> <li>• Installatie handleiding</li> <li>• Gebruikers handleiding voor het instellen van de opstelling</li> <li>• Kalibratie voorschriften</li> <li>• Een fouten lijst met mogelijke fout oorzaken</li> </ul> <p><b>4.5. Opleiding (operators en V&amp;O technici)</b> Er wordt minstens een opleiding voorzien voor een (TOP) operator, V&amp;O en de leden van de TTM groep. Deze mensen verzorgen opleiding voor iedere verder gebruiker en of technicus.</p>		
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<p><b>5. Normen</b></p> <p><b>5.1. Veiligheid</b></p> <ul style="list-style-type: none"><li>- De software moet eventueel onveilige toestanden voor de gebruiker of de instrumenten bewaken en afvangen. De huidige situatie levert geen problemen en moet bijgevolg gehandhaafd blijven.</li></ul> <p><b>5.2. Bijkomende eisen</b></p> <p><b>5.3. Ergonomie</b></p> <ul style="list-style-type: none"><li>- De software moet met zo weinig mogelijk handelingen bediend kunnen worden, minder handelingen als de huidige software is beter meer handelingen mag niet.</li></ul> <p><b>5.4. Milieu</b></p> <ul style="list-style-type: none"><li>- Kwik afzuiging is voorzien op de opstelling</li></ul>		
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# Functional Specification

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## 1. Introduction

The software of the mercury pressure measurement on the measuring production mills of DPL burner is not (anymore) up to all expectations. To ensure the continuity of the production process a software upgrade is more and more needed. The goal of this project is to determine the technical and economic feasibility of an upgrade and if the upgrade is necessary execute it in a secured way. (C. Dries)

The task of this project was to develop a user-friendly software and thus provide maintenance for the mercury pressure measurement. This application will be written with LabVIEW 2009 (9.0 SP1) -software. Following applications will be used as a basis for the new application:

- GTD Meervoudige W-meting
- GTD Broommeting
- Inline Kwikdruk meting

From these applications only parts needed are used.

## 2. Features

### 2.1 Algorithm for measuring the mercury vapor pressure

“TFS Width at half height.vi” will calculate the width of the Hg-peak at half height of the peak. Using the width of the peak it is possible to calculate the resulting mercury pressure and electrode distance. The algorithm will use a variety of user-defined settings to accomplish this in the needed accuracy:

- # of samples for fitting the polynomials at
  - base of the peak
  - sides of the peak to find the width
- boundary wavelengths for the Hg-peak
- a wavelength to the right (longer wavelengths) of the 546 nm side-peak, from where the application will start looking for the actual maximum of the peak

Algorithm used will be based in the old LabVIEW 7.1 -application, mostly done by H.J. v. Alderen. The actual calculations, which will result in the value of pressure and electrode distance, are from “PFL - Aachen report 1594/2002: Spectroscopic determination of operating pressure, arc length and radiation properties of UHP lamps. E. Fischer”.

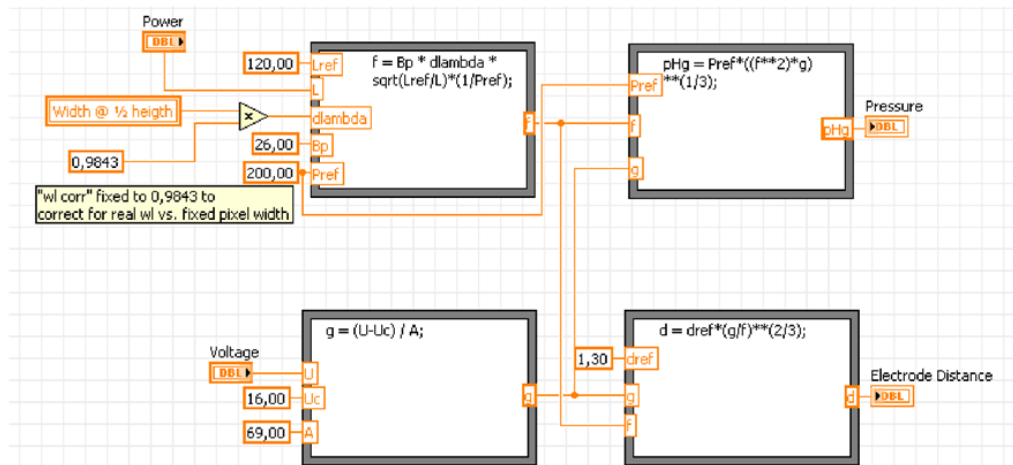


FIGURE 1. Calculation of the p<sub>Hg</sub> and electrode distance

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Algorithm for finding the width at half height:

1. Find the boundaries of the Hg peak
2. Rotate the peak so that both boundaries are at the same level
3. Fit polynomials at the boundaries
4. Calculate a tangential line for the two polynomials to form a base line
5. Remove the portion of the spectrum below the base line
6. Locate the intensity of the spectrum at the user-defined wavelength, which has to be set to be in between of the 546 nm side-peak and the actual maximum of the peak
7. *Using that intensity as a central point start calculating averages (for the user-defined amount of samples), move to right one sample at a time and continue calculating averages until coming to a point where the first average is equal to or larger than the last calculated value*
8. *Use that point as a right-side limit for the searching of the maximum*
9. Fit a polynomial between those two points
10. Search for a maximum at the polynomial resulting on the intensity (and so the height) of the peak max
11. Divide the height by two, and fit polynomials on the sides of the peak at the half height
12. Search for the half height on the side polynomials and calculate the difference of the found wavelengths, resulting in the width of the peak at half height

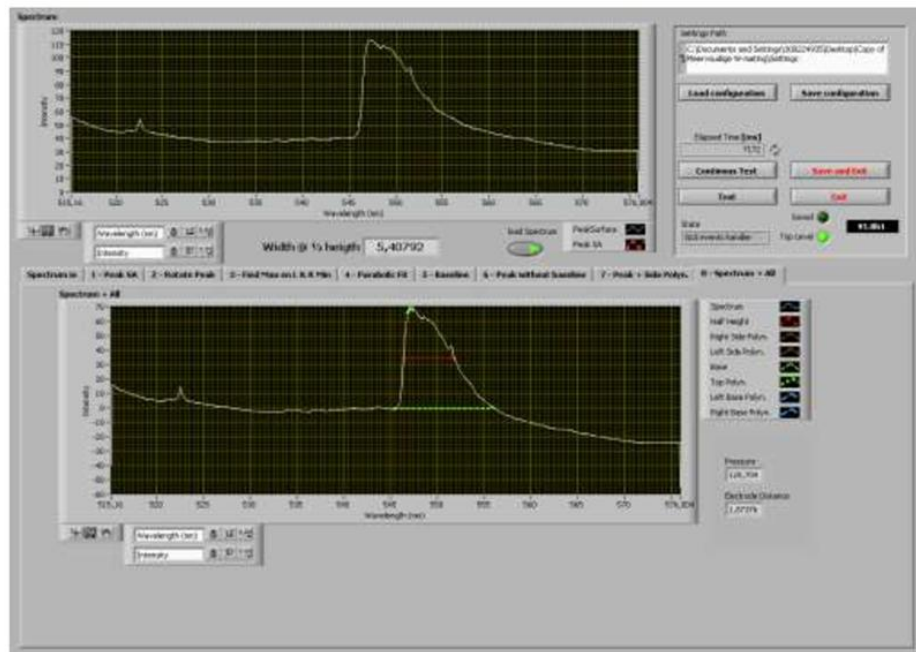


FIGURE 2. Illustrative screenshot of the spectrum measurement and calculation

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<p><b>2.2 Logging</b></p> <p>After measuring the properties of a burner the collected data is stored on the computer used, in the D: -drive, following the standards of the framework. Logging is done in TDMS- and delimiter-separated values -formats. Following data will, at least, be logged in a human-readable form:</p> <ul style="list-style-type: none"><li>• Peak width at half height</li><li>• Numerical result (mercury pressure)</li><li>• Gain and offset used to manipulate the end result (pHg)</li><li>• Lamp voltage</li></ul> <p>Original spectra will be logged as TDMS, a binary-based file format.</p> <p>Also each product type will be logged in their own folder and in there arranged into subfolders (which are named after the current week number). Log files older than 28 days are removed automatically when the application is idling.</p> <p>National Instruments provides Add-In Tools to use TDMS with Microsoft Excel and OpenOffice.org Calc.</p>		
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### 2.3 Daily check

Spectrum of a halogen lamp is compared with the previously given certificate values. If the measured spectrum is not within the given limits, operator will be given an error message. Interface is based on the bromine measuring application.

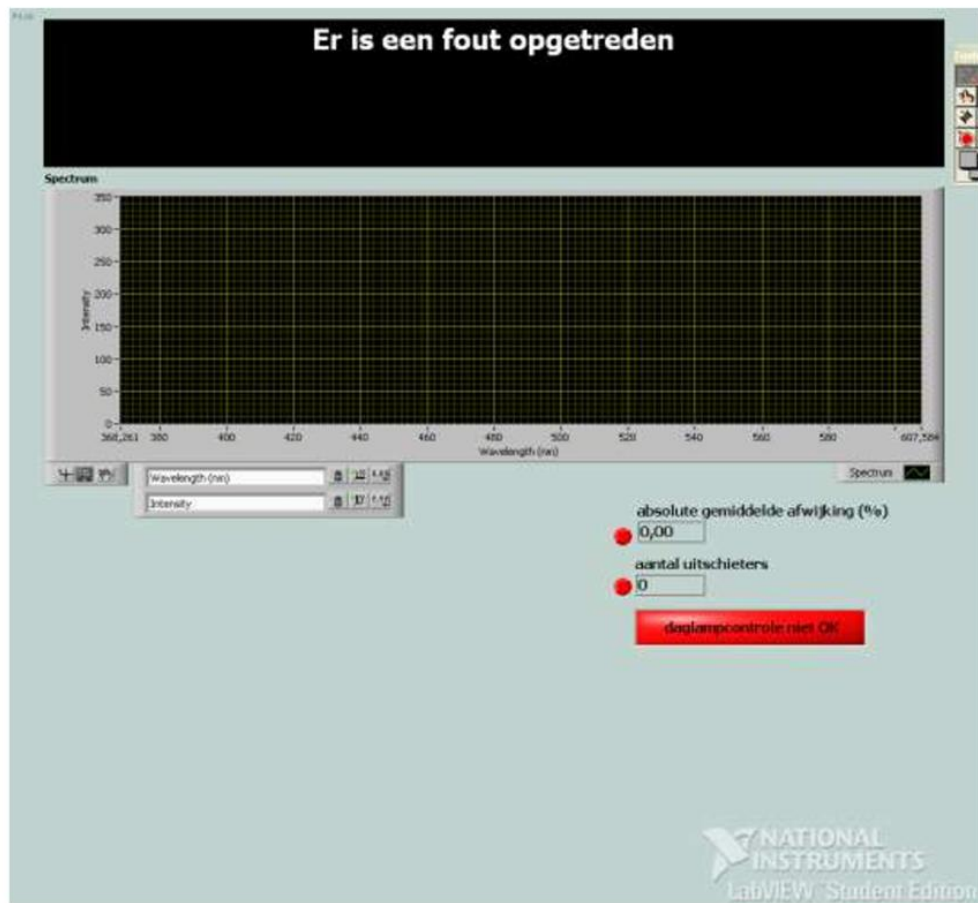


FIGURE 3. Illustrative screenshot of the daily lamp check interface

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## 2.4 Adding new products and their settings

User has the option to add new products and the settings for those products for operators to use. The interface and operation are based on the bromine measuring application. When the measuring is started, the burner type has to be selected and depending on this selection according burner settings are loaded automatically. Burner type specific parameters include:

- A wavelength right of the 546 nm side-peak
- Expected peak position (Boundaries for the baseline)
- Number of samples for polynomials at base and sides and for the peak's top area average calculations
- Gain and offset to manipulate the resulting mercury pressure value

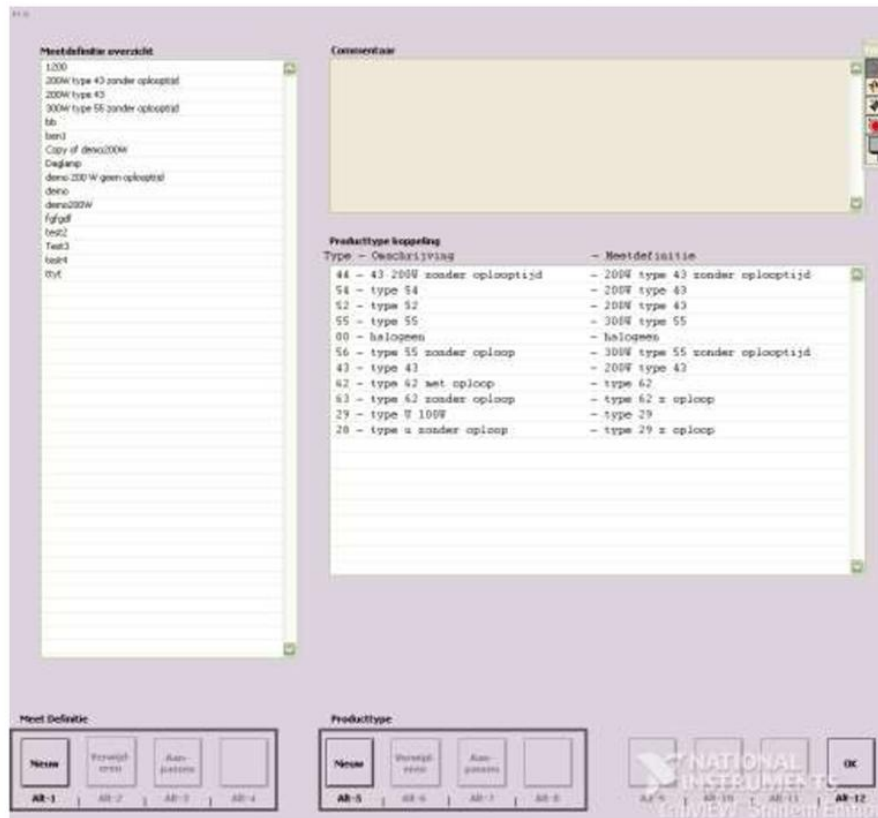


FIGURE 4. Illustrative screenshot of the product adding/modifying interface

This feature will be password protected, and in use for the Quality Engineers and Administrators.

### 2.5 Changing the parameters of the burners

User has the option to change the parameters mentioned at 2.4.

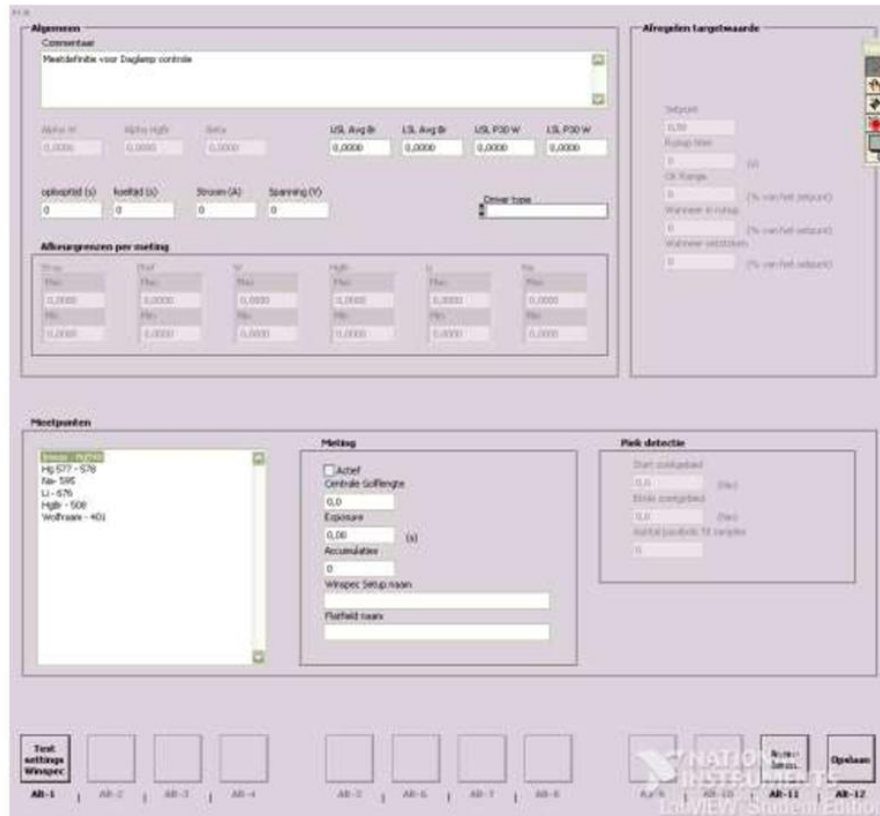


FIGURE 5. Illustrative screenshot of the parameter changing interface

This feature will be password protected, and in use for the Quality Engineers and Administrators. Guide for adding/changing these parameters is in user manual.

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<h2>2.6 Setting the shutter offset from within the application</h2>		
<p>User has the option to set the shutter offset (at the system settings), application will then take it into account when doing measurements.</p>		
<p>This feature will be password protected, and in use for the Quality Engineers and Administrators.</p>		
<h2>2.7 Settings-files</h2>		
<p>All necessary settings are edited on the application interface. Depending on the user level different settings can be modified. Operator will not have the possibility to edit any settings.</p>		
<p>Winspec-settings are partly human-readable and partly binary. Tampering with those is not in the scope of the project, except for protecting them with checksums (2.8).</p>		
<p>System settings are in ini-file format, measuring definitions (product type specific) in xml.</p>		
<h2>2.8 Checksums</h2>		
<p><i>User is presented a panel in where the user can choose the files on the computer to protect with the checksum. For the settings files used in the framework the checksum will be calculated automatically and updated when updating the settings within the application.</i></p>		
<p>The checksum is calculated using the MD5-algorithm. The hash (=checksum) is saved in a file called "checksums.ini". The directory of the file for which the hash was calculated for will serve as an ini-file "section", and the filename itself as the key for the hash. Hash is the value for that key, and it is expressed as a 32-digit hexadecimal number.</p>		
<p>The "checksum.ini" will be processed thoroughly at the startup of the application. All the checksums for section+"\\"+key (which corresponds to file path + filename) are calculated and compared to the stored checksum. If any difference is found, the user is presented with an error dialog (with a list of the files which failed the check) and the startup of the program is prevented. User has the option to exit or to let the application calculate new checksums after inputting a Quality Engineer or an Administrator –level password. If all files pass the test no output is given to user.</p>		
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### 3. Installation

When the application is ready to use it will be installed on the measuring machine (MM2) in the production line. The new application is installed on a new Type 2 PC and the old applications will remain on their current computers. In the case the new application crashes (or otherwise is not working properly) for some reason during the testing phase, the older application remaining on the older PC can be set up quickly and the production is able to run again in two (2) hours. Image of the C:\ -drive on a freshly installed new PC will be created after confirmed it will work as is.

Installation to measurement system contains following items:

- Installing Run Time LabVIEW
- Copying application to a specified folder
- Copying (default) settings files to a specified folder
- Installing OMA
- Installing Winspec and Spectra Pro
- Shortcut creation

Guide for installing these items is included in the user manual or in a separated installation guide.

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## 4. User Interface

The user interface is based on the *Broommeting and W-meting* applications. Screen appearance/features will depend on user level and the following user levels will be in use:

- Operator
- Quality Engineer (password protected)
- Administrator (password protected)

An option for manual measurement will be added in GUI (only available to Quality Engineer and Administration users).

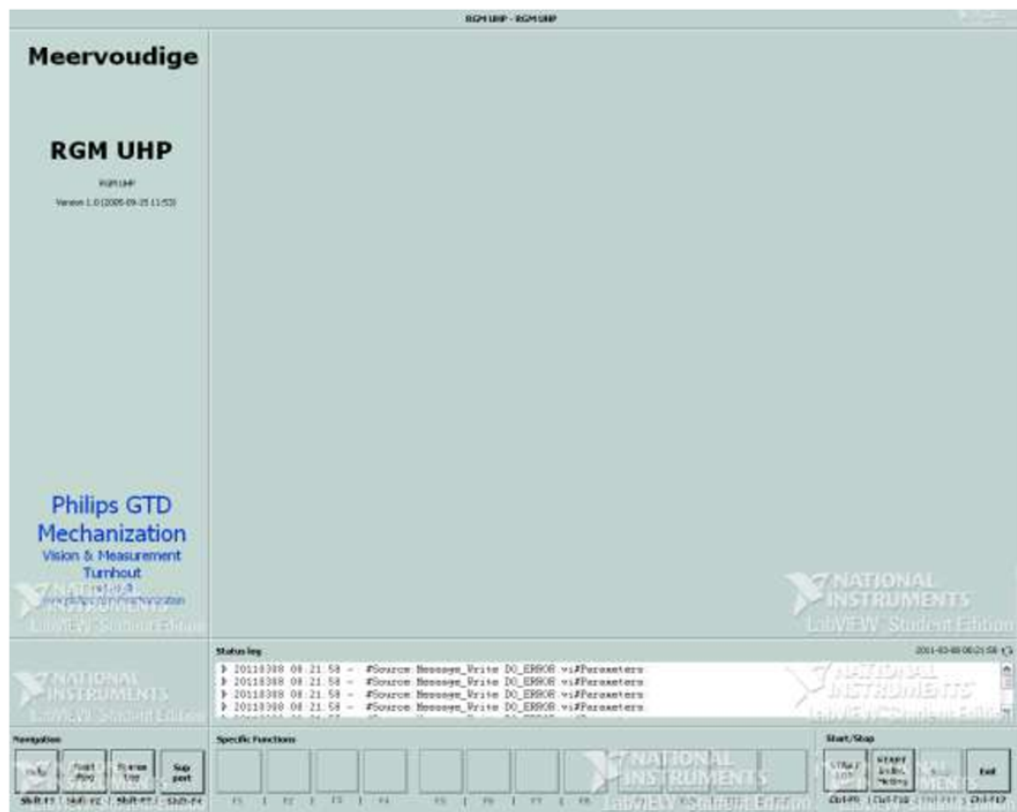


FIGURE 5. Illustrative screenshot of the start window of GUI

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<b>5. Error handling</b>		
<p>The error detection and error handling is constructed so that there is support in diagnosing problems. When an error occurs, the error message will be shown in the GUI. Depending on the type of error, user must react to this by pressing the OK-button or contact e.g. maintenance for solving the problem. Non-critical errors should not stop the process. Error codes will be listed and explained as necessary in the documentation/user manual.</p>		
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## 6. Documentation

- User manual
  - User manual for the measurement
    - Guide for setting up the measurement
  - Installation guide
  - Calibration requirements
  - A list of possible errors and causes
- Test plan.