# Steel Pipeline Construction – from Pipeline Management Tool to Electronic Pipe Book

By Rainer Bach, Stephan Maier and Hans-Jürgen Kocks

*The article looks into options for streamlining documentation on pipeline construction sites by means of an electronic pipe book. The basis for this is the PMT app for mobile phone or I-Pad, which, in combination with an Internet browser, allows data to be processed on the computer without installing any additional software. Geodata-based recording of the component identity provides for a high degree of transparency in the processes on and around the construction site. Targeted utilization of the many and varied data networking options opens up the potential to link further processes to this application.*

## Introduction

The Ordinance on High-pressure Gas Pipelines (GasHDrLtgV) requires that high-pressure gas pipelines be constructed and operated according to the state of the art so that the safety of the environment is not impaired and harmful effects on humans and the environment are avoided [1]. The operator must therefore ensure appropriate maintenance and monitoring. Methods employed to this end include flying over and driving or walking on the pipelines. In addition, targeted component inspections secure safe operation until the next planned maintenance inspection.

For such interim inspections, the regulations specify pigging runs and, above all, the evaluation of the coating condition by measuring methods of cathodic corrosion protection [2]. In this way, damage can be localised and, if necessary, changes to the component can be examined. For the assessment of a component's integrity, its mechanical properties must be known. This is where the pipe book required according to the regulations comes into play. Only via the pipe book and with the aid of the pipe numbers recorded there can a pipe or component be related to the relevant reports and certificates at any time without the need for excavations. This documentation is mandatory not only for gas pipelines within the meaning of the Ordinance on High-pressure Gas Pipelines (GasHDrLtgV), i. e. with operating pressures of 16 bar and higher [3], but also with operating pressures of 5 bar and above [4].

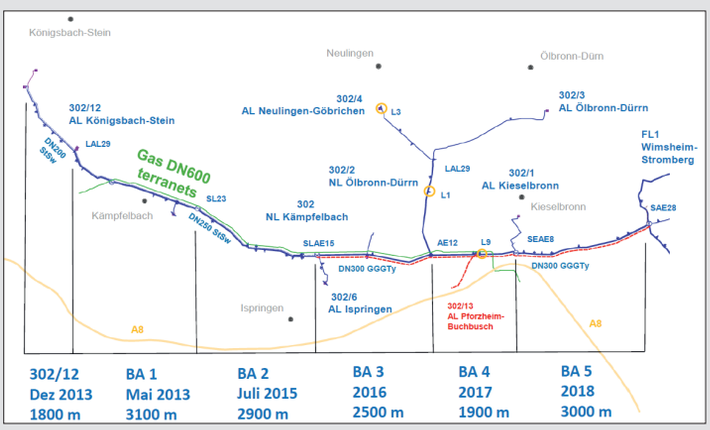


***Figure 1**: Profile of the Kämpfelbach project with the individual construction phases [6]*

Based on the procedure described for high-pressure gas pipelines, this possibility of a later assessment of the components is often also transferred to other applications. Such pipe books are also stipulated in the specifications for pipe-laying projects concerning gas distribution pipes in the low-pressure range and for water pipes. In order to simplify the compilation of pipe book, electronic recording of the pipe numbers at the construction sites was considered at a very early stage.

The term "Industry 4.0" is used to describe, among other things, the possibility of networking data from the production of input materials and products through to their use or even disposal. For the assessment of a pipeline, this means that, if necessary, not only the minimum values of a component's technical delivery condition are available, but also the real material data. For many years now, pipe manufacturers have collected pipe numbers and component-related data as part of their production data acquisition. Each pipe is provided with a barcode for electronic recording. Other possibilities from today's point of view would of course be the use of QR codes, RFIDs, etc.

Against this background, the (P)ipeline-(M)anagement-(T)ool PMT was developed [5]. With the aid of this tool, in conjunction with Android or IOS-based mobile phones, pipes can be localized by their number and barcode. Browser-supported processing of this data on the computer makes it possible to take account of:

- shortened pipes,
- external components
- welds, and
- position corrections (if necessary).

***Figure 2**: Pipes for the field test section, with barcode labels at their ends*

In addition to the electronic creation of the pipe book, users have other possibilities at their disposal:

- Coordination and logistics of storage sites - e. g. an assessment of the environmental conditions is possible by geodata-based recording of the pipe numbers.
- Monitoring of the construction progress - by situation-related data acquisition.
- Retrieval of pipe information - through the internet connection, the retrieval of certificates or real pipe data is possible, e. g. for the planning of stress pressure tests or during subsequent operation.

In the context of a project of ZV Bodenseewasserversorgung (Lake Constance Water Supply Authority), the current status of this (P)ipeline-(M)anagement-(T)ool was tested under construction site conditions.

## The pilot project

The pipeline selected for the field test (NL Kämpfelbach) is part of a drinking water pipeline near Pforzheim that has been renewed in several construction phases [6]. Due to corrosion damage, the existing 50-year-old pipe made of ductile cast iron has been replaced with a new steel pipe in five construction phases. The last section, which runs from Kieselbronn towards Enzberg over a length of about 3,000 m, was finished in 2018 using DN 400 pipes, completing the renewal of the 15 km long drinking water pipeline from Enzberg to Königsbach-Stein (***Figure 1***).
Like all line pipes, cement-mortar-lined and PE- and FCM-coated steel pipes are provided with labels at their ends as standard (***Figure 2***). On these labels, the unique pipe number is hidden behind a 10-digit barcode. As the current version of the PMT will be tested for the first time in this pilot project, a double documentation is planned so that the effort that went into the creation of the pipe books can be compared at the end.

## The Pipeline Management Tool (PMT)

### *General*

Given the task in hand, the provision of the Pipeline Management Tool is a great challenge for the programmer. For example, the framework conditions of a construction site must be captured in the software. The application should work with as many operating systems as possible (Android, IOS) and different browser versions (IE, Firefox, Chrome...). An interface had to be created to enable communication between the production data acquisition system and the SAP in place at the manufacturing plant. In addition, the application should also be available in different languages - another aspect that must be taken into account in the program structure.
With this concept, an application can be provided that does not require any software installation and can be used by everyone in principle. Another very important aspect is the personalized use of the application. For this purpose, the data is protected by personal registration via email and password.

### *Description of the app*

The application is accessible for mobile phones in the usual way via the App Store for the IOS or via Google Play for the Android operating system. After calling up the app, users can log in via email and password. User registration is triggered by email, whereupon the user receives the link for processing the data via the browser, also in an email.
The project name and the name or designation of the pipeline section to be captured must be entered on the mobile phone. This will take the user to the main

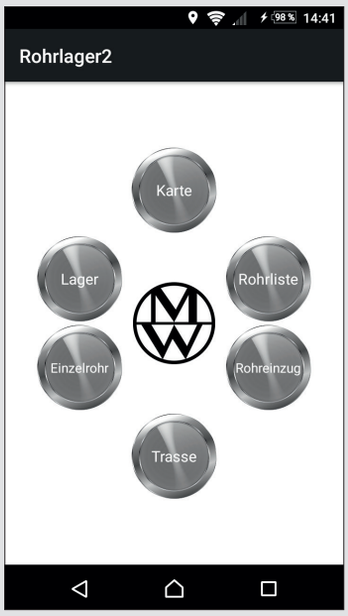


***Figure 3**: Main menu of the mobile application*

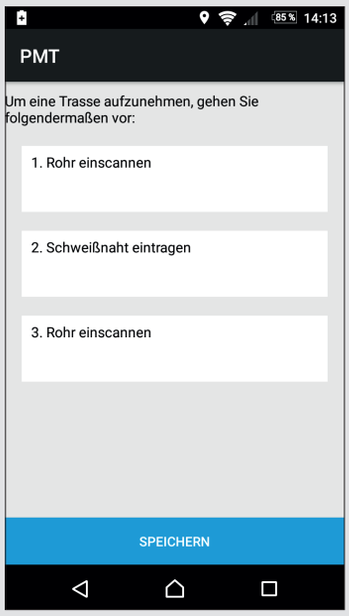


***Figure 4**: Menu for recording pipes along the pipeline route*

application menu.
From the main menu, pipes can then be captured as (***Figure 3***):

- stored pipes (stock)
- single pipes (single)
- pipes aligned for welding (line)

In addition, trenchless pipeline sections can be recorded using the camera function. Under the "Map" and "Pipe list" menus, the already recorded components and pipe data can be viewed. In the map, the different types of pipes recorded are represented by markings in different colors.
The functions for recording stored or single pipes allow individual pipes to be captured on site. The distinction between these two pipe types serves the user, since stored pipes are often shown one above the other on the screen. So the user knows that, in the case of stored pipes, several pipe markings can lie behind one another.
The camera function records and locates pipes by means of geodata-based reading of the pipe number in a single step. The pipe number is captured via the barcode on the pipe and stored in a database together with the GPS coordinates. If there is no Internet connection during the recording, the data will be stored and transmitted when a connection is available.

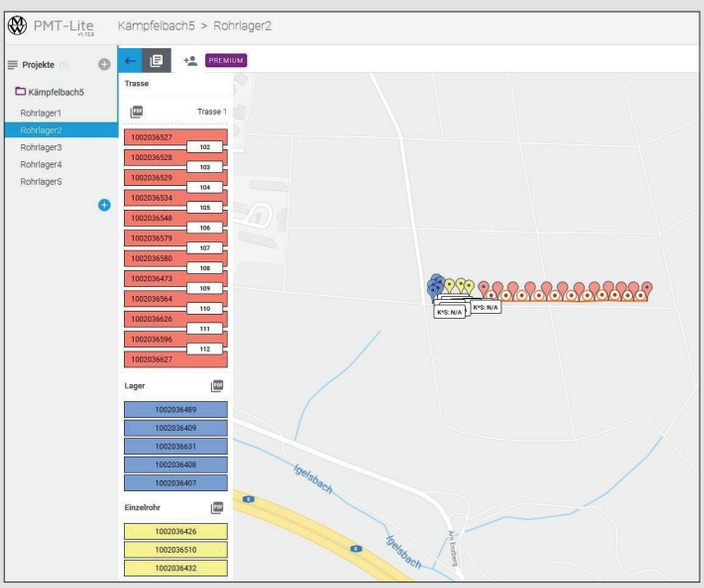


***Figure 5**: Map view in the browser application with a section of the satellite view of the pipeline*

### *Routing*

In the same way, the PMT lite can identify individual pipes in a welded string along the pipeline route (***Figure 4***). It determines the pipe's GPS position and number and records this information in a database; it also records which pipes are welded together as well as the relevant weld numbers. By combining the numbers of joined pipes and the weld numbers, the pipeline section to which they belong can be identified.

### *Trenchless pipe-laying*

Another query option is the distinction between open-trench and trenchless pipe-laying. In the latter case, the beginning and the end of the hole are recorded first. Then the pipes planned for this pipeline section are scanned. This data can later be saved in the computer in the appropriate sequence and with the relevant weld numbers as a complete pipeline section.

### *Description of the browser application*

Data processing is possible via the browser. The main advantage is that no software has to be installed for this purpose. The map display can be converted into a satellite view on the computer to allow the position of the route in the terrain to be checked (***Figure 5***). This makes it possible to correct any inaccuracies in the site recording by shifting the markings accordingly.
At the left edge of the screen there is an overview bar with the recorded components. A click on a component will move it to the center of the screen, so it can be located on the map. The computer can also be used to generate additional components such as arcs, T-pieces, etc. in the map, and thus complete the structure for documentation purposes.
Each of the blocks shown on the left is assigned a small logo for the creation of a pdf file with these components. In the case of line pipes with weld numbers, the pipe book could be generated from them (***Figure 6***). The fields can be edited so that, for example, welding results can

PMT Lite

Kämpfelbach5 -Rohrlager2 -Trasse 1

| Rohrfolge | Bauteil | | | | | | | | Schweißnaht-Nr. |
|---|---|---|---|---|---|---|---|---|---|
| | Rohrnummer | Länge (mm) | Abmessung | | Bezeichnung | Werkstoff | Hersteller | Umhüllung | |
| | | | ø(mm) | Wd.(mm) | | | | | |
| 1 | 1002036527 | 14036 | 406,4 | 6,30 | Rohr | P235TR2 (1.0255) | Mannesmann Line Pipe Siegen | | |
| | | | | | | | | | 102 |
| 2 | 1002036528 | 14035 | 406,4 | 6,30 | Rohr | P235TR2 (1.0255) | Mannesmann Line Pipe Siegen | | |
| | | | | | | | | | 103 |
| 3 | 1002036529 | 14037 | 406,4 | 6,30 | Rohr | P235TR2 (1.0255) | Mannesmann Line Pipe Siegen | | |
| | | | | | | | | | 104 |
| 4 | 1002036534 | 13979 | 406,4 | 6,30 | Rohr | P235TR2 (1.0255) | Mannesmann Line Pipe Siegen | | |
| | | | | | | | | | 105 |
| 5 | 1002036548 | 14032 | 406,4 | 6,30 | Rohr | P235TR2 (1.0255) | Mannesmann Line Pipe Siegen | | |
| | | | | | | | | | 106 |

***Figure 6**: Excerpt from the pipe book*

be entered on the computer. After entering the place and date in the header, the document can be printed out.
Shortened pipes are also generated in the browser application and connected to the route on the screen. The length of the original pipe is shortened accordingly. Depending on the number of cuts made, the shortened pipe is appended with -1, -2, etc. In addition, it is possible to add terrain height markings. In a future version of the app, it will be possible to call up certificates by entering the relevant pipe number.
Another important element is the organization of the users authorized for a project or line section. Further employees can be "invited", e. g. to record components. These employees are assigned various functions, which may be associated with only limited authorizations for processing the data.

## Conclusion and outlook

After successful completion of the "learning by doing" phase of the PMT software during construction phases 2 and 5 of the Kämpfelbach pipeline, a positive conclusion was drawn from the users' point of view. The acquisition of pipe data is already running in a manner adapted to construction site conditions, the recorded pipes are located with sufficient accuracy. The assignment to the options storage site, single pipe and pipes aligned for welding facilitates the overview of the project.
The possibility of entering fittings or shaft installations subsequently enhances the pipe book preparation, since it allows optimal data acquisition and data linking "in real time" on the construction site. As a result, users can gain a quick and relatively up-to-date overview of the project progress. In addition, the pipe data is georeferenced and allows perfect traceability of the affected material in the case of damage. In the context of documentation obligations, the client can use this tool to record, process and archive all the necessary data. Further tests are currently being conducted with various customers in order to identify any potential for improvement in the handling and application of the PMT.
With the PMT further possibilities of data acquisition and networking can be generated. One example is automated on-site welding (***Figure 7***). In this development, ultrasonic testing is performed immediately after welding [7], [8]. The resulting test documentation could be assigned to the weld number specified in the PMT. In addition to the pipe certificates, the test results would then also be available at any time.

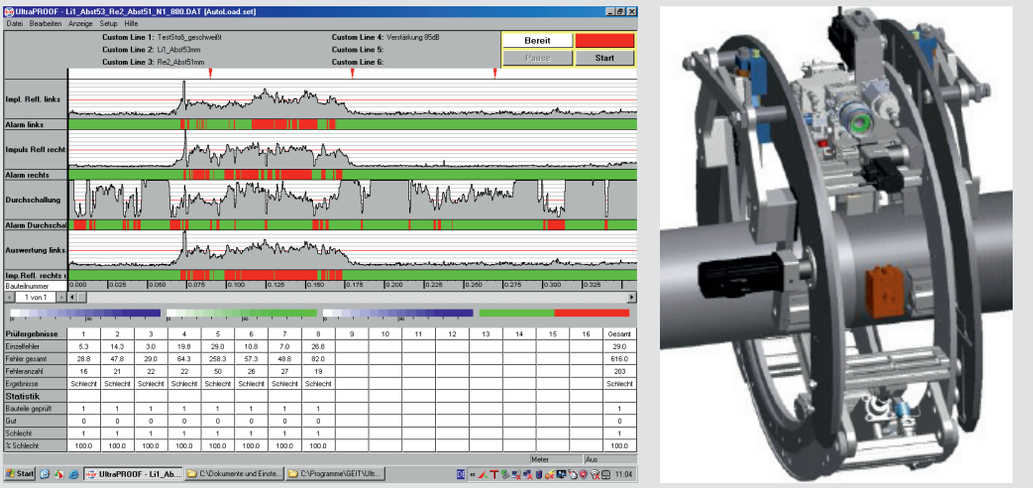




***Figure 7**: Automated laser beam welding with documentation of the weld test*

## Literature


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## AUTOREN


Dipl. Ing. **RAINER BACH**
Zweckverband Bodensee-Wasserversorgung,
Stuttgart, Germany
Phone: +49 711 9732302
Rainer.Bach@bodensee-wasserversorgung.de
www.bodensee-wasserversorgung.de



**STEPHAN MAIER**
Mannesmann Line Pipe GmbH, Siegen,
Germany
Phone: +49 271 691 243
Stephan.Maier@mannesmann.com
www.mannesmann-linepipe.com



Dr. **HANS-JÜRGEN KOCKS**
Mannesmann Line Pipe GmbH, Siegen,
Germany
Phone: +49 271 691 170
Hans-Juergen.Kocks@mannesmann.com
www.mannesmann-linepipe.com