

Intelligent P&IDs for the Digital Future

Challenges and Solutions for the Process and Chemical Industry

The piping & instrumentation diagram (P&ID for short) is one of the central documents in plant design – however, its role is fundamentally evolving in the era of digitalization.

Where static drawings have long been sufficient, data driven models are now being developed to better integrate process engineering data with operations and maintenance workflows. Brownfield plant operators in particular are often faced with the challenge of how to digitize existing process diagrams and add engineering data to them.

The piping and instrumentation process diagram serves as a central master document for all disciplines involved in plant design. It provides a clear overview of the entire process – from process equipment and piping to instrumentation and safety systems. This creates a common foundation for detailed planning, approval processes, and safety assessments.

In its digital form, the P&ID becomes a critical source of engineering data. Changes can be tracked through traceable version control, while associated data can be linked to 3D models and engineering lists.



Automated validation tools help detect and prevent errors early in the design process.

“A digital P&ID provides real-time access to current engineering data for operations

and maintenance, forming a critical foundation for digital twins, simulations, and other Industry 4.0 initiatives,” explains Ajit Joshi, Managing Director, ITandFactory.

Existing Plants and Brownfield: Theory vs. Reality

Despite the clear benefits of digital P&IDs, PDF-based as-built documents still dominate in many facilities, particularly in brownfield projects where systems have often been in operation for decades. These documents often originate from disparate engineering systems, contain limited usable data, and do not support automated workflows or effective change management.

A digital P&ID enables quick access to up-to-date information, especially for operations and maintenance. It therefore forms an essential basis for digital twins, simulations and further Industry 4.0 applications.

Ajit Joshi, Managing Director, ITandFactory

„Information often has to be manually recreated to support system migrations or documentation requirements. At the same time, there is increasing pressure to modernize these documents as part of digitalization initiatives and convert them into a structured, data-ready format,“ says Joshi. In most cases, complete manual re-crea-

tion is extremely time-consuming and difficult to justify economically. This is why intelligent solutions that adopt existing geometries, recognize relevant attributes and clearly assign equipment without having to redesign the process diagram manually are becoming increasingly important.

Digitization of P&I Data

This requirement results in the need for a clearly defined set of specifications. The geometries of the PDF process diagrams must be reliably transferred to a CAE or engineering system. Pipes including tag numbers, nominal sizes and pressure ratings should be identified automatically, as should all components contained in the pipes. Process equipment such as tanks, pumps, and heat exchangers must be digitally represented with their corresponding type and operating parameters.

At the same time, it is essential that subsequent adjustments in the engineering system remain possible without the need for a complete redraw. The primary goal is therefore not a completely native P&ID, but an efficiently created, machine-readable model that serves as the foundation for further use and analysis.

„As a provider of engineering services, we see an increasing need to digitize as-built process diagrams worldwide, especially in the chemical industry. The aim is to keep engineering data available and up-to-date throughout the entire plant life cycle,“ says Heiko Hosse, Managing Director, Neilsoft. „This not only increases efficiency in the long term, but also ensures the transfer of knowledge and experience – a particularly important aspect in view of demographic change and the shortage of skilled employees. Solutions for the automated conversion of P&IDs from PDFs therefore make a decisive contribution to

the successful digitization process and represent a future-proof measure.“

Automated Solutions

As the developer of the Cadison engineering platform, ITandFactory meets this challenge with an automated process.

PDF-based P&IDs are imported, vector geometries are transferred and texts are read out using OCR. Machine learning algorithms recognize components, convert them into intelligent objects and store them in the Cadison database. Pipes are linked to their tag numbers. In addition, colour-coded representations facilitate step-by-step digitization and verification of the results.

Data-driven information management in engineering creates clear advantages.

Wilhelm Otten, Data Exchange in the Process Industry (DEXPI) Association

This creates a consistent, verifiable data model that can be integrated into existing workflows without media discontinuity. This approach minimizes manual rework and significantly reduces errors. As-built data can be checked using the functions within Cadison. With this solution approach, the existing data can be converted into structured, reliable engineering information with little effort – a pragmatic approach that facilitates the digital transformation of brownfield plants.

Basis for Data-driven Engineering

A digital process diagram is much more than just a drawing. It forms the foundation of data-driven engineering, in which decisions are no longer based on isolated files, but on linked, consistent plant data. Once a change has been made, it is automatically adopted in all relevant flowcharts, parts lists and systems, so that all departments involved are always working

with up-to-date information. As a result, analyses, simulations and plausibility checks are based on a uniform data status. The model also remains active during the operating phase: it supports maintenance, optimization and predictive maintenance and forms a key element of the digital twin.

Wilhelm Otten, from the Data Exchange in the Process Industry (DEXPI) association, explains: „Data-driven information management in engineering creates clear advantages: It enables interoperability instead of isolated solutions, as uniform standards ensure smooth collaboration across tools, disciplines and company boundaries. At the same time, it forms the basis for the digital twin. And last but not least, intelligent information management significantly increases efficiency – with cost savings of 20% to 40% in engineering and better quality in operations at the same time.“

Prerequisite for the Connection of AI

These added values alone make the conversion of stock flow diagrams into intelligent P&IDs and the implementation of data-driven information management

a top priority. In fact the benefits go far beyond this. As Otten emphasizes: „Standardized process and plant models are the prerequisite for the successful use of AI in the process industry. Without consistent, harmonized data structures, AI applications can neither work reliably nor deliver real added value.“

In short: intelligent P&IDs make plant information usable, reliable and future-proof – and thus become the heart of modern, data-driven engineering.

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