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WHITE PAPER / **INTELLIGENT ENGINEERING DESIGN PRACTICES**

ELIMINATING DATA SILOS DRIVES QUALITY AND EFFICIENCY

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Accurate data is essential to the success of any engineering project, but manual data entry and quality assurance is time-consuming. By incorporating automatic data acquisition capabilities into industry standard software, innovative engineer-procure-construct companies are helping their clients bring high-quality products to market faster.

Large engineering projects involve millions of individual components, each of which must be identified precisely and consistently in all documents produced for a construction package. Construction package quality requires accurate data in everything from the piping and instrumentation diagram (P&ID) to the piping isometrics.

Historically, the associated data entry and quality assurance process has been manual, which is time-consuming and labor-intensive. Engineer-procure-construct (EPC) companies have been forced to seek a balance between investing large amounts of time in manual data entry and quality assurance and delivering on their clients' need to bring a high-quality product to market as quickly as possible.

Today, innovative uses of engineering design software make it possible for EPC companies to offer their clients the best of both worlds. By entering data once and then automating the sharing of the data to all construction deliverables, design teams are streamlining the data entry process, eliminating errors and freeing up more time for engineers to do what they do best: design, construct and commission highly effective projects, on time and on budget.

This paper will consider the current state of data entry and design management software in the engineering industry, explore some of the most innovative approaches to data acquisition for engineering projects, and outline the connective benefits these innovations offer to the many types of companies that hire EPC firms.

LIMITATIONS OF INDUSTRY STANDARD DESIGN SOFTWARE

On most engineering projects the same data is reported across numerous project deliverables. The engineering and design teams responsible for producing these documents enter the data manually, duplicate it in a variety of formats and spend hours reviewing all instances for accuracy. Figure 1 shows the default separation of data within industry software.

Industry standard software suites, such as AutoCAD Plant 3D or SmartPlant 3D, have many basic data connections in place to streamline this process and support production quality within similar deliverables. On P&IDs, annotations connect data fields and display them as text. If a data field is changed, all impacted annotations update automatically. Similarly, off-page connectors link line number data, so connected lines maintain the same information. When there is a discrepancy, the designer is flagged.

However, off-the-shelf software settings do not have the ability to connect a line service to a valve service. Therefore, an engineer has to check and verify the valve list against the line list and the P&IDs manually.

EXISTING SOFTWARE DOESN'T POPULATE MANY DELIVERABLES:

The built-in data connections available in industry standard software improve accuracy across P&IDs and models, but do not provide the data connections needed to populate many other deliverables, including:

1. **Piping and instrumentation diagrams (P&IDs)**
2. **Plans and sections**
3. **Isometrics**
4. **Multiple lists**
   - **Bill of materials**
   - **Drawing**
   - **Equipment**
   - **Line**
   - **Tie-point**
   - **Valve**

When it comes to developing the 3D model, components in a line number on a P&ID are displayed so the modeler can see all pieces that must be included. However, connections between the P&ID and model are limited, and the information contained within P&IDs is not enough to populate effective, constructable deliverables. Once again, the engineer has to manually verify that all the

necessary data is included and accurate. In the valve example, this would require double-checking to make sure the proper valve tag, body type, actuator type, size, rating and specification are used.

Though existing industry software simplifies data management, it doesn't deliver the comprehensive data acquisition capabilities EPC companies require. This is particularly true on megaprojects — those that cost billions of dollars — where entering, maintaining and verifying the vast quantity of data involved can significantly limit the time engineers have to focus on design.

MAKING DATA INTELLIGENT

Perhaps 20% of the data intelligence design teams require is already incorporated within existing engineering tools. Innovative EPC firms are developing the remaining 80% by building advanced capabilities into industry standard software.

BUILDING ADDITIONAL DATA FIELDS INTO THE SOFTWARE

EPC teams that specialize in data intelligence begin each project by creating an appropriate data structure during the engineering design process. Although the data itself may not be available until much later, teams can work through the details of procurement and construction to identify all necessary data fields. Then those fields are built into the design software suite.

For instance, to create an effective and constructable tie point list, EPC teams need to list the P&ID, plan and line number (isometric), as well as comment on the work to be performed. These fields are added during project setup to be filled as design continues and populate the construction tie-in list automatically.

LINKING DATA FOR RELATED COMPONENTS

After the necessary fields are established in the software, relationships are created between them. All data is linked back to its parent component, so data only needs to be entered once. Additionally, the data contained within each component is customized to create relationships between related data that wouldn't necessarily be linked otherwise. For example, the system might be designed to require that every instance of a particular valve acquires the related line information, including size, specification and the product going through the pipe. When a valve is placed, it is forced to have the same size as the line that it is placed on. This safeguards quality and provides a second annotation to identify any errors in the line work.

FIGURE 1: *P3D Automation Figures (Before).*

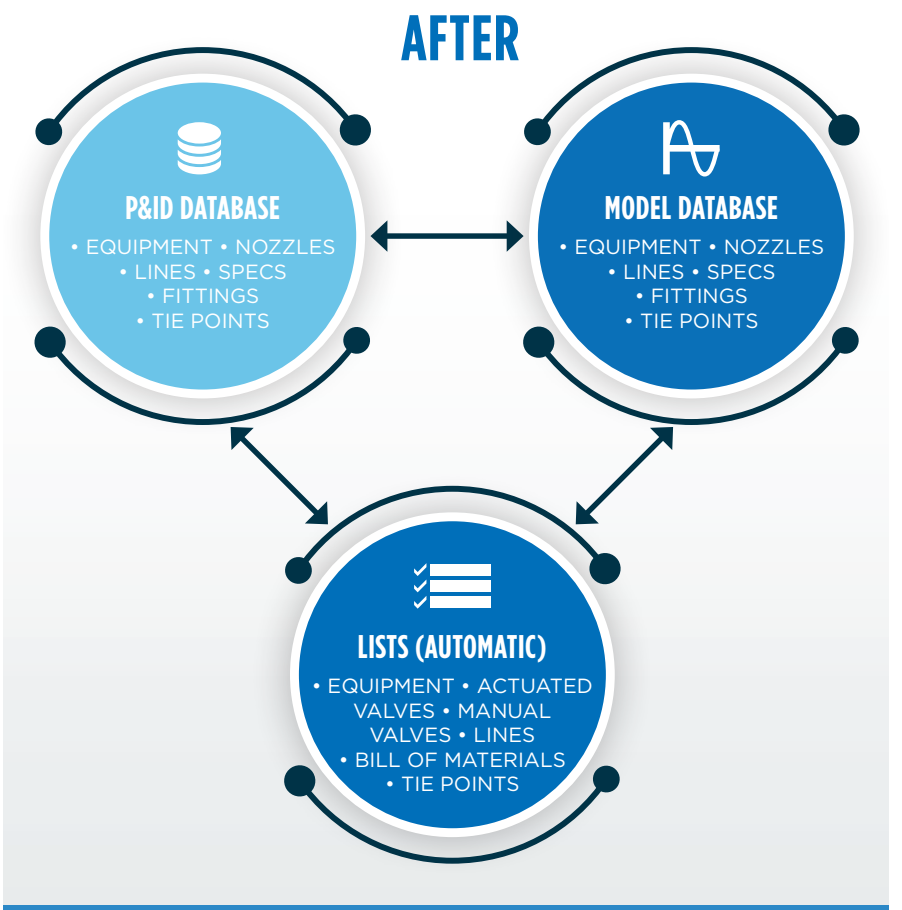

FIGURE 2: *P3D Automation Figures (After).*

This approach connects components within the P&ID and across deliverables, meaning data in the 3D model can be acquired automatically when the design team begins that stage.

AUTOMATING DATA UPDATES ACROSS DELIVERABLES

As data becomes available, it is entered into the prepared fields and verified. Then it is pushed automatically to all its child components. This drives the creation of line, equipment, tie-point and other lists. For example, if "P100" has been entered in the "provided by" and "installed by" data fields within the design software suite, it can automatically filter all equipment by "P100" and populate a list of components to be provided by that P100 contract. An equipment list for each contract on the project can then be issued with minimal effort and high accuracy.

When data is populated in the P&IDs, it is acquired into the 3Dmodel and the corresponding plan sheets are updated with the same information. Line annotations (including size, service, specification and line number) and valve annotations (such as tag, size and specification) are populated automatically. Isometrics, line and bill of material information also is generated automatically based on the data contained within the 3D model.

If the design team updates a piece of data, that change is carried throughout all documents automatically. Validation checks can also be run to identify discrepancies between deliverables. When an error is detected, it can be corrected in one place, with updates pushed to all deliverables. This allows the production of highly accurate construction packages — including P&IDs, 3D models, isometric diagrams and lists — faster and with fewer engineering resources. Figure 2 shows improved acquisition and sharing of data to form a connected deliverable set.

MAKING UPGRADES STANDARD

For the greatest quality and efficiency, data intelligence innovations need to be incorporated into industry standard software like AutoDesk products. Yet many firms continue to enter data manually for every project deliverable.

With automated data acquisition, it's possible to see a 90% reduction in errors and 50% reduction in time spent on quality assurance.

By comparison, an EPC firm that has completed multiple megaprojects already knows what data is required and how to automate data acquisition. If that firm has a strong partnership with AutoDesk, Intergraph or other software manufacturers, it can work directly with the software developers to build additional capabilities into the application. Then the manufacturer can incorporate those new features into its next platform-wide release. Going forward, the client's design team can leverage these capabilities regardless of project size. It's also not uncommon for EPC firms to drive software enhancements that eventually become standard offerings within the industry.

ACHIEVING BETTER PROJECT RESULTS, FASTER

Because data acquisition allows engineers to enter information once and share it across multiple deliverables, it improves product quality while allowing clients to finish projects faster or complete more projects in the same time.

FEWER ERRORS WITH LESS QUALITY ASSURANCE

Data quality is essential to engineering projects, and quality assurance (QA) has to be included in every design process. However, projects built around automated data acquisition achieve greater accuracy in less time. On a given project, the same data appears on multiple deliverables. For instance, a valve number would appear on the P&ID, plans, sections, isometrics, valve lists, valve procurement package and valve data sheet. When data is pulled from a single source, there are fewer errors across these documents. Every piece of data is still reviewed, but the QA task shifts from searching for errors to spotting anomalies. If an error is identified, the correction is shared throughout all deliverables.

ENHANCED PROJECT QUALITY, LOWER CONSTRUCTION COSTS

Because data acquisition produces more accurate project deliverables, engineers can spend less time verifying the data and more time looking at the project as a system. This provides the opportunity to identify potential efficiencies and enhance the design to achieve them. Enhanced design results in better project quality.

When a client's engineers don't have to concentrate on the accuracy of project documents, an EPC team can focus on constructability and evaluate opportunities to save on equipment, piping, fittings and other materials. This reduces requests for information (RFIs) and engineering change notices during construction. Ultimately, construction is completed more smoothly, which translates to higher project quality and lower construction costs.

SHORTER TIME TO MARKET

When combined with an EPC approach, automatic data acquisition allows clients to get to market faster and start making money sooner. Unlike the design-bid-build approach — which proceeds sequentially from design to documentation to procurement and construction — the EPC approach allows procurement to begin when design is only 30% complete.

A client can quantify the bill of materials for each discipline, release the purchase order before construction documents have been produced and procure long-lead items in advance. Grading, rebar and concrete work are often completed before other crews arrive. When the construction drawings are ready, all necessary materials will be on-site and construction can begin right away.

CONCLUSION

Intelligent engineering design practices include building new data fields, linking data for related components, automating data updates across deliverables, and — perhaps most importantly — working with software manufacturers to incorporate these innovations into industry standard software applications. Together, these data initiatives combine to produce heightened intelligence your engineers and designers can use to design a quality product and deliver it to you faster. Or, you may choose to expand your scope and complete more projects within the same budget.

Data entry and quality review significantly impact both product quality and construction schedules. From small upgrades to megaprojects, automatic data acquisition reduces errors in project deliverables, which in turn improves engineering quality and accelerates project schedules.

BIOGRAPHY

KEVIN REENE, PE, is a senior mechanical engineer in the Oil, Gas & Chemical Group at Burns & McDonnell. He is passionate about using data efficiently, both to help his clients achieve success and to allow engineers to spend their time on engineering, procuring and constructing efficient projects, rather than on data entry and reviewing for consistency. Kevin has successfully led an international team of engineers, designers and drafters in designing megaprojects and has direct EPC-support experience on projects his teams have designed.

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