Many process plants contain both brand new equipment and pipes, as well as components that may be several decades old. It is now widely recognised that up to date documentation is essential for safe and efficient plant operations, as well as regulatory compliance. Outdated documentation makes it difficult to identify parts of the plant that are more likely to fail, leading to accidents or production interruption and unscheduled maintenance, and/or design and manage plant revamps. Older documentation is often less accessible because it is only available in hard copy format, or data formats that are no longer supported. The obvious solution is to execute a 3D scanning survey of the plant and develop an accurate as-built 3D model of the facility. Later on, this model can be used both by the plant management, and by its

Mario Arnić, Numikon Ltd, Croatia, and Peter van der Weijde, Intergraph CADWorx & Analysis Solutions, the Netherlands, present an integrated laser surveying solution that can increase efficiency during brownfield project execution.
specialise in the design and analysis of mechanical and process equipment, with Numikon also specialising in laser surveying.

The project
Like many process plants, the Sisak refinery possessed extensive documentation about its assets, but the operator was unsure how complete this was. There was insufficient information about the specifications of the piping and the exact pipe runs through the plant. This lack of information was highly undesirable for safety, operational and regulatory reasons.

Therefore, INA decided to have all of the piping in the refinery surveyed to create an accurate and up to date 3D model, complete with information about the piping material grades, wall thicknesses, topology, etc., of the pipes, and document all of this on new isometric drawings. Once the basic information was gathered, the stresses on some of the components had to be analysed. The survey had to be undertaken while the refinery was operating, and some of the piping was difficult to access because of its location above ground, or because it was insulated. Furthermore, the work had to be carried out to a tight deadline.

The tools
Numikon proposed to survey the refinery using a combination of the following hardware and software:
- Leica Total Station for measuring the plant.
- Intergraph CADWorx fieldPipe™ for laser surveying and measurement of the plant.
- Intergraph CADWorx Plant Professional for isometrics and data integration.
- Intergraph CAESAR II® for stress analysis of the piping system.

The Intergraph CADWorx Plant Design Suite is a set of software that integrates with AutoCAD. It offers intelligent drawing tools, database connectivity and advanced automation. For piping surveys, the fieldPipe module is used onsite, running on a laptop computer connected to a Leica Total Station. The three points surveyed on the circumference of a pipe enables fieldPipe to calculate the pipe’s outside diameter; two points measured at the pipe extremity or pipe ends, just

Figure 1. Laser surveying in action at the Sisak refinery using a Leica Total Station.

Figure 2. A 3D model of the plant created in CADWorx fieldPipe Professional (part of the Sisak refinery).
before a change of direction, compute the orientation and length of the pipe. Straight lengths of pipe are connected together using branch and elbow components selected automatically from the referenced piping specification. Inline items, such as flange pairs and valves, are positioned using just a single measured point on the back face of the flange or centre of the valve. The process is repeated until all pipelines of interest are captured in the 3D model.

The 3D model created by fieldPipe can be used by other CADWorx tools, such as Plant Professional, P&ID, and others. All piping in the entire plant can be surveyed by setting the Total Station up at a select number of locations, enabling many pipelines to be captured easily from the ground. The fieldPipe software can also be used for surveying equipment, steelwork, cable trays, and so on. The combination of Leica Total Stations and fieldPipe provides an unrivalled solution to quickly document brownfield plant piping, providing highly accurate results and man hour savings compared to traditional manual measurement methods.

**The execution**

Following the award of the contract, Numikon surveyed the relevant areas of the Sisak refinery over a period of 49 days. Using the laser scan data, it created the deliverables required by the client, including:

- 3D models.
- Piping isometrics.
- Details of piping components (valves, pressure regulators, flanges, supports, etc).
- Tag and nameplate details.
- Details of the equipment the piping is connected to.
- Pipe stress analyses (including required test pressure) and pipe data (wall thickness, material properties, etc).

At the start of the project, Numikon analysed INA’s drawing specifications and configured the Isogen® component of CADWorx to ensure that all of the deliverables fulfilled the customer’s requirements. The company also entered details into a database of the equipment used at the refinery to support day to day plant operations and maintenance activities.

Numikon used the combination of Leica hardware and Intergraph software on earlier projects with successful results. Laser surveying is less time consuming than manual measurement, and personnel do not have to work at height or close to live equipment containing hazardous materials. Additionally, it makes it much easier to survey piping covered by insulation. At the Sisak refinery, a number of insulated pipes were surveyed and included in a 3D model. Next, isometric drawings of each line were produced automatically, linked to relevant data, using Isogen. Integrating the stress analysis calculations in the process was simple using the bi-directional interface between CADWorx Plant Professional and CAESAR II. Links to Excel spreadsheets were also created to retrieve component details, such as the test and operating pressures.

When Numikon first started using the Leica Total Station and Intergraph software, the two companies trained its staff. It took approximately 10 days to get them up to speed and start on their first project.

**The benefits**

On an earlier project, it took Numikon 17 days to survey, measure and model six lines using manual pipe surveying. When laser surveying was introduced on the same project, it only took eight days to deal with a further 18 lines. At the Sisak refinery, the company dealt with 173 lines in 49 days. Additionally, there is the advantage that personnel can now work on the ground rather than at height, meaning that they can work more safely. On the whole, Numikon estimates that productivity has increased by as much as 640%. This productivity gain means that onsite project time can be minimised, and efficiency can be maximised.

**Conclusion**

Combining laser surveying and 3D models makes plant maintenance, modification and operations easier and safer. This offers major benefits to the industry, particularly now that margins are under severe pressure and regulatory demands are increasing. Essentially, it means that clients benefit from cost effective piping surveys and can use the 3D models and integrated information management to operate their plants more efficiently and safely, with less effort and uncertainty.