Automating Trace Heating Designs from Plant 3-D Models

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Abstract - As capital projects grow in size and complexity, the necessity for compressing engineering and design schedules is becoming an important aspect of project execution. The design of trace heating, because it occurs near the end of the design phase and because of the need to coordinate across several disciplines, has not always been in step with construction schedules of projects. However, the technology now exists to complete electrical trace heating design from data extracted directly from the plant 3-D model database. Advanced trace heating design software systems can now provide high quality deliverables and maintain accuracy through project completion. This paper will look at the advancements of trace heating design software, which allows the designer to create the trace heating deliverables directly from the 3-D model database. It will also demonstrate the usefulness of the software as both a document control and material management tool and the additional value in verifying accuracy on an on-going basis.

I. Introduction

Trace heating is historically one of the last considerations on a project because of its location on the project timeline and relatively low cost. However, its importance to the success of a project is unquestioned. Traditionally, the manufacturer or supplier of the trace heating system would be responsible for the system design. As part of the project design package, such deliverables as Trace Heating Line List, Loading Calculations, Material Take-offs and Trace Heating Isometric Drawings required extensive manpower. The trace heating designer typically created isometric drawings from paper copies of the piping spool piece isometrics. Depending on the complexity of the circuit design, developing these custom drawings and adding the trace heating information and installation details could require substantial man-hours per trace heating circuit to complete. Document control and management of revisions also substantially increased the man-hour requirement.

II. Design Deliverables

Prior to the utilization of electronic file formats, generation of trace heating deliverables was executed primarily as a manual process. Project design deliverables typically consisted of the following documents:

- Trace Heating Isometric Drawings
- Trace Heating Line List
- Loading Calculations
- Material Take-offs
- Trace Heating Circuit Power Connection Locations

Historically, the work performed by the trace heating designer started with the organization of the available information provided by the Project Engineering Design Team. The information package typically consisted of the following documents:

- P&ID Drawings (paper copy)
- Piping Spool Piece Drawings (paper copy)
- Area Classification Drawings (paper copy)
- Equipment Drawings (paper copy)
- Plot Plans (paper copy)
- Piping/Instrument Line Lists (paper copy)

This organizational process included the manual sorting of the piping isometric spool piece drawings to determine the traced versus non-traced lines. It also included grouping and sorting the information into anticipated designs based on area zoning and/or work package releases. The trace heating designer would arrange these groups, taking into account each circuit's maximum circuit length. He would also consider the control point/circuit breaker rating, the maintenance temperature, minimum ambient and insulation thickness detailed in the Piping/Instrument Line Lists. The designer would manually sketch the routing of the trace heating circuit onto the piping spool isometric drawings and tabulate the required trace heater length by manually adding up the pipe length, number of valves, in-line equipment, pipe supports, etc. Once the total trace heating circuit length was acquired, the designer would use the trace heating manufacturer's software, combined with the

supplied information contained in the Piping/Instrument Line Lists, Area Classification Drawings and Trace Heating Specification, to determine the correct heat loss, product selection and loading information. The designer would then perform the tedious task of manually entering all the design information from the trace heating manufacturer's software into a spreadsheet format. The sketch of the trace heating circuit routing along with the circuit design data would be submitted to the CAD department. The CAD operator would take the routing detail and create a trace heating isometric drawing. The drawing would incorporate the circuit design data and installation details. The new drawing would then be returned to the designer for a drafting check and either re-submitted back to the CAD group for modifications or issued for a secondary design check and sign-off.

Additional manpower was required in Document Control to administer the flow of all necessary documents. With each issue of documents from the Project Engineering Design Team, a manual tracking process was utilized to determine the status of drawings and documents, whether existing, new, or revised. The new drawings or revisions to existing drawings were passed on to the designer to create, add to, or revise a design. In the cases where the designer has to deal with a revised drawing, the process of locating the existing revision can be very time-consuming. If the drawing has already been used in a design, the location is generally simpler because there is some form of tracking (manual input) available. If the drawing has not been sorted into a design, finding it can be very tedious.

Executing projects under the traditional workflow process could require substantial manpower from both the Project Engineering Design Team and the Trace Heating Supplier (Figure 1).

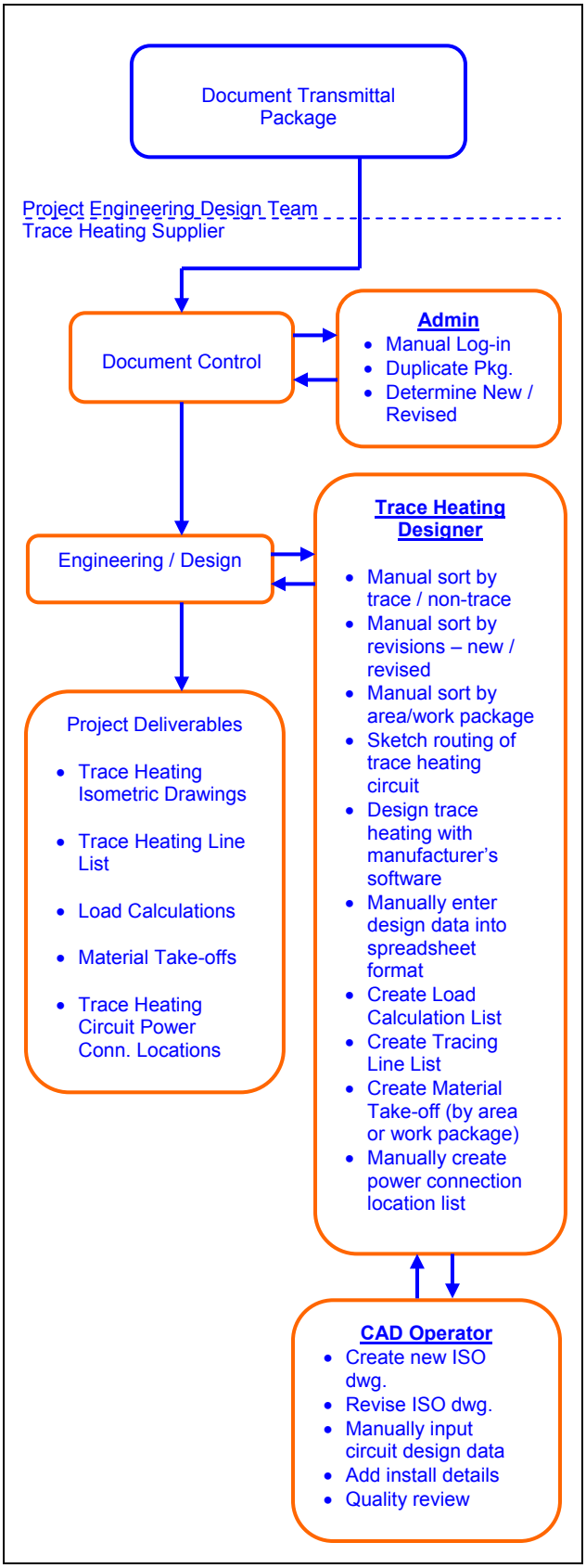

Figure 1: Traditional Trace Heating Design Execution

III. Automated Trace Heating Design Software System

The specific advanced design software system is not a single program but rather a set of different utility programs. Through program links, the trace heating designer is able to establish a workflow process that is virtually automated from initial design to the final deliverable documents. The basic component structure of the design system consists of the following elements:

- Trace Heating 3-D Design Software
- Trace Heating Manufacturers Design Software
- Trace Heating Spreadsheet Software
- Trace Heating CAD (Computer Aided Drafting) Software

The trace heating 3-D design software utilizes data that is directly extracted from the project 3-D model. The design information from these 3-D model systems can be exported to a neutral exchange format, such as IDF or PCF. This neutral file format contains the design information for pipelines in the 3-D model. From the neutral files, isometric drawings can be created automatically by extracting the information using the trace heating 3-D design software. Each piping component contained in the neutral file is positioned within the 3-D model with an assigned X, Y, Z plant coordinate. By using these coordinates, the trace heating 3-D design software combines the neutral files to create the trace heating isometric drawing.

The Project 3-D Model Administrator performs the exporting of the design information from the 3-D model database to the neutral exchange format. This data exporting and neutral file formatting create the piping spool isometrics, for use by the piping contractor for fabrication. The trace heating 3-D design software utilizes the same exported data; therefore, there are no special setup or sorting procedures required by the 3-D model administrator. The trace heating 3-D design software will automatically identify and sort heat traced piping from non-heat traced piping. The non-traced piping can be quickly separated and filed, saving substantial man-hours in the document control process (Figure 2).

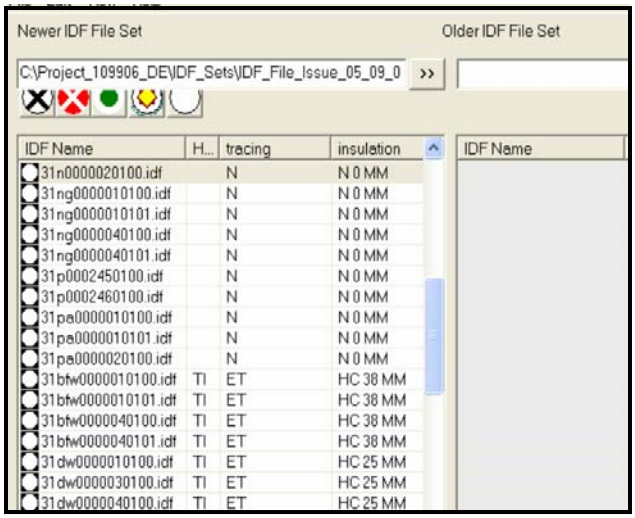

Figure 2: Sort to identify traced and non-traced piping.

Managing Revisions is another key aspect on major projects. The trace heating 3-D design software will automatically compare the latest issue of the neutral files to previous issues and will identify and record changes (Figure 3). These changes can be in the form of new, changed or deleted files. A revision history log is automatically generated.

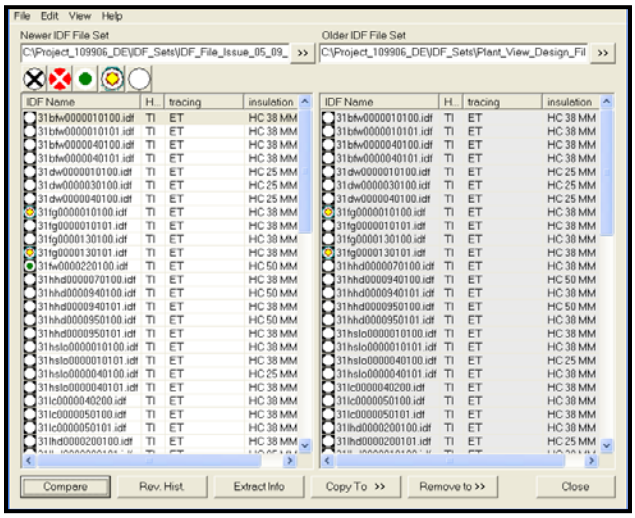

Figure 3: Compare latest issue of neutral files to originals and record changes.

Using the data from the individual neutral files, the trace heating 3-D design software creates a single line 3-D model consisting of only the piping that requires trace heating. This plant view environment is used by the trace heating designer to define each trace heating circuit and automatically tabulate pipe length, number of valves, in-line equipment, pipe supports, etc. (Figure 4).

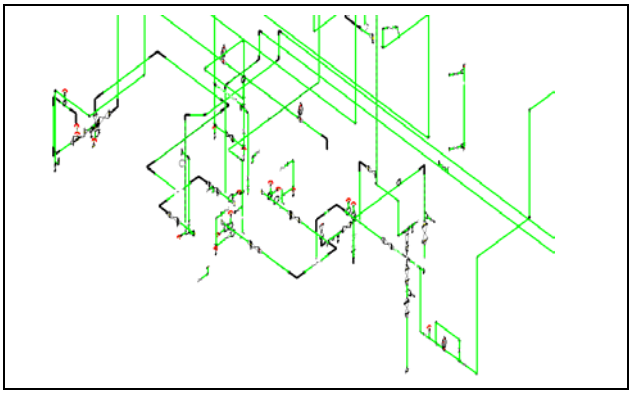

Figure 4: Plant view consisting of only traced piping.

Using the trace heating 3-D design software, the trace heating designer locates all trace heating power junction boxes, end terminations, and temperature sensors in the plant view environment. This information can be used by the project electrical design team to optimize the size and location of power distribution cable and cable tray. Through software program links, the final trace heating isometric deliverable is automatically generated by the trace heating CAD Software and data imported from the Spreadsheet. This process provides a high degree of design accuracy and an efficient means for handling model revisions.

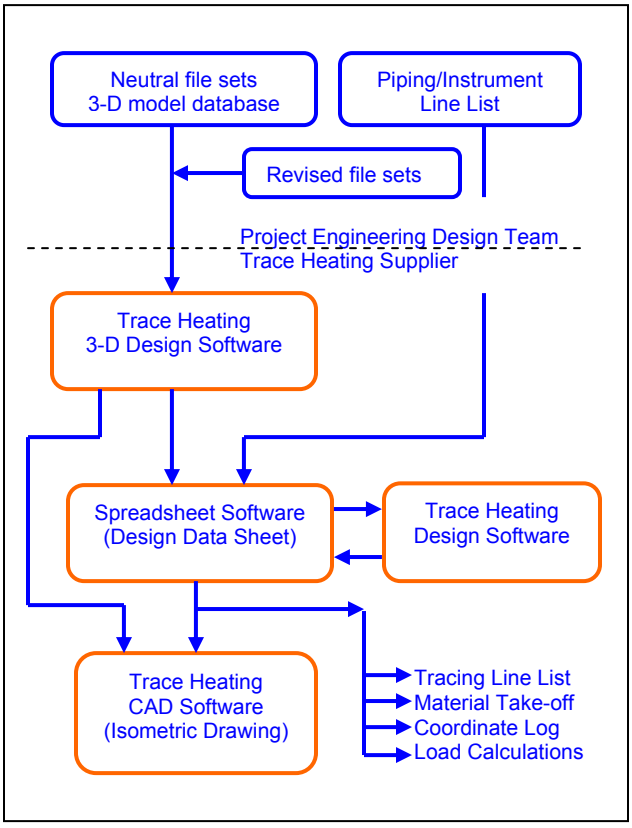

Figure 5: Trace Heating Design Execution with 3-D Software

IV. Design Workflow Process

The trace heating designer will start with the base information provided by the Project Engineering Design Team and the 3-D model administrator. This information is project specific and typically includes:

- Trace Heating Specification
- Area Classification Drawings
- Insulation Specification
- P&IDs
- Equipment Drawings
- Plot Plans
- Piping/Instrument Line Lists
- Neutral exchange files (piping spool isometric drawings extracted from 3-D model database)

Having already identified and separated the traced and non-traced lines, the trace heating designer will use the overall plant view (Figure 4) along with software links to the manufacturer's trace heating design software, spreadsheet software, and the trace heating CAD software as the platform for executing the trace heating designs. The design process begins with the selection of piping in the plant view environment to define a trace heating circuit (Figure 6). By selecting the individual components of the piping spool pieces, the trace heating 3-D software will re-group these components to create the trace heating circuit.

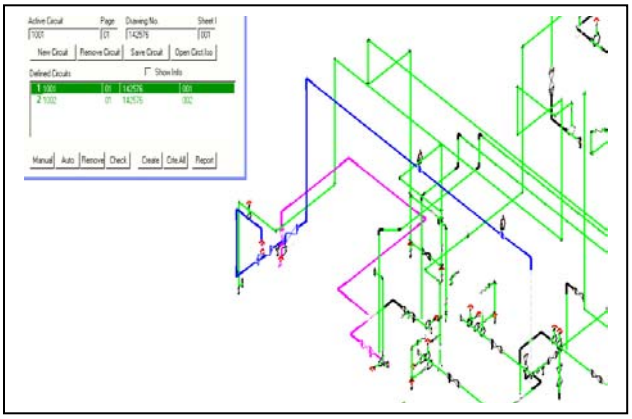

Figure 6: Trace heating circuit selection process.

Once a trace heating circuit has been defined, the piping information, in-line equipment, pipe supports, etc., are totaled and exported to the spreadsheet. The spreadsheet combines this information with the project specific data imported from the Piping/Instrument Line List. With the required circuit design data defined within the spreadsheet, the trace heating design software (provided by the trace heating manufacturer) can then be utilized to select and validate the trace heating components and design. The trace heating design software then exports the relevant design information back to the spreadsheet.

The final step in the design process is to create the trace heating isometric drawing. This is accomplished by exporting the piping information from the trace heating 3-D design software and the circuit design data from the spreadsheet to the trace heating isometric template drawing. Included with the data from the spreadsheet will be additional information, such as coordinates for the power connection, temperature sensor and end termination for each trace heating circuit. A material take-off will also be provided on a per circuit basis (Figure 7).

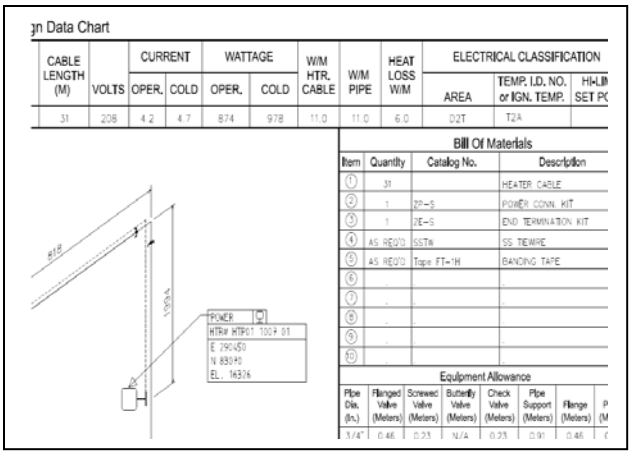

Figure 7: Trace heating isometric drawing complete with circuit design data and bill of materials.

With the implementation of a 3-D Design Software System, the overall reduction of required man-hours can be illustrated as shown below. This represents a recently completed petro-chemical project consisting of 425 trace heating circuits and approximately 16,000 meters of trace heating.

Man-hour Reductions:

- **Project Engineering Design Team**
  - 3-D Model Administrator extracts piping spool information (neutral files) from plant model. Trace heating 3-D design software utilizes the same data.
  - No paper copies of piping spool isometrics to be sorted/logged by Document Control for initial transmittal or revisions.
  - Electronic document transmittal.

  Reduction in required man-hours of approximately 60%.

- **Trace Heating Supplier**
  - No paper copies of piping spool isometrics to be sorted/logged by Document Control.
  - Automated process for identifying traced and non-traced piping.
  - Automated process for identifying and implementing revisions.
  - Automated trace heating design process.
  - Automated generation of trace heating deliverable documents.
  - Electronic document transmittal.

  Reduction in required man-hours of approximately 50%.

The complete process now requires less than half the original man-hours and includes many other benefits, including material management, power distribution coordination and management of design revisions.

In addition to providing the standard deliverable items and documents, the design software system is capable of creating a log file, which captures the plant coordinates for all trace heating circuit power points, temperature sensors and trace heating termination points. These coordinates can then be overlaid onto the plant plot plan drawings and used to optimize the location of power distribution panels and transformers, as well as cable tray, tray loading and routing (Figure 8). The coordinate log can also be provided to the plant 3-D model administrator and plotted back into the model.

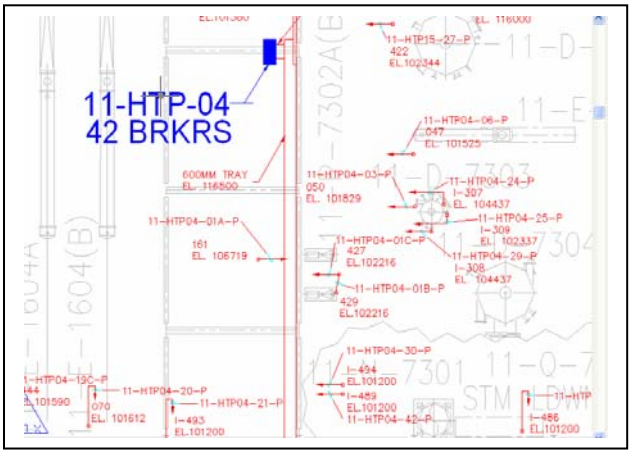

Figure 8: Plant plot plan drawing showing trace heating component locations.

The timely execution of the trace heating design package is an important aspect of the success of the project. However, just as important is proper material management. Using utilities within the trace heating 3-D

design software, the trace heating designer can select and isolate piping based on:

- Priority or critical piping
- Plant area or modules
- Piping service
- Work package
- Other criteria

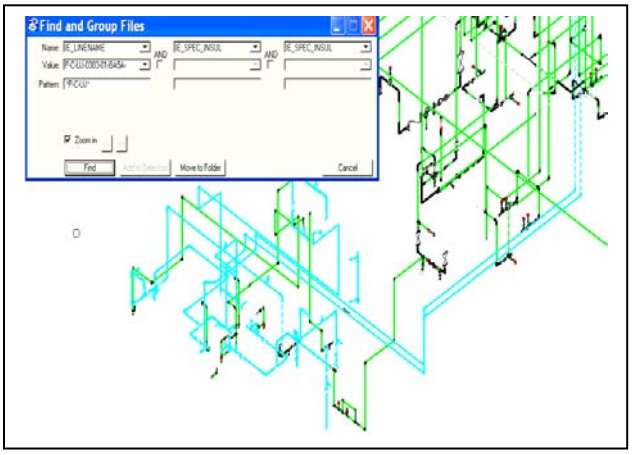

Figure 9: Material Management – selecting priority piping.

For mega and small projects, the management of materials for trace heating can be a significant factor for procurement and construction. The trace heating automated design software allows both the project construction team and the trace heating supplier to efficiently schedule the delivery of not only trace heaters but also the many components of the trace heating system. These can include:

- Trace heater termination accessories, connection junction boxes, etc.
- Temperature sensing devices
- Heated instrument enclosures
- Pre-insulated and trace instrument tubing
- Trace heating power distribution / control and monitoring panels
- Transformers
- Trace heating power distribution cable, cable glands, etc.

The trace heaters or completed trace heater sets and components can be delivered and coordinated with the construction schedule for specific areas on the construction site. In addition, the power distribution cables and hardware for the trace heating can also be delivered and managed using the output from the trace heating automated software. Combined, these automated software systems for trace heating and associated materials can greatly increase the efficiency of construction labor and the warehousing of materials. This overall coordination and material management contributes to an on-time commissioning, start-up and turn-over process for the trace heating system.

V. Conclusion

The available trace heating 3-D technology has dramatically simplified how the project workflow process is approached. The integration of electronic files containing information generated directly from the 3D model database has mitigated duplication of effort and significantly reduced the total man-hours required to complete the overall project design process. Revision control has become a much easier process with the use of software that can automatically identify and record changes to the model, and trace heating designs can be streamlined for accuracy. With the use of a design system that identifies trace heating component locations, power distribution requirements are more easily optimized, which allows the electrical design to be completed closer to the process and mechanical designs than was possible previously. Through the use of advanced design software systems, the trace heating design process has become a fully automated approach.

VI. Vita

Chris Lindsay is the Engineering Manager at Thermon (UK) Limited, joining the Thermon Group in 1985. He is vice Chairman of ETHIC (Electrical Trace Heating Industrial Council), a UK group actively involved in the review and development of British and International Standards. He is a member of IEEE.

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