Smart Energy and Sustainable Environment

2022, *25*(1): 5-14, https://doi.org/10.46390/j.smensuen.25122.443

ADVANTAGES AND CONSTRAINTS OF SPECIFIC AUTOCAD PLANT 3D FUNCTIONS FOR DYNAMIC MANAGEMENT - CASE STUDY FOR A HEAVY WATER DETRITIATION INSTALLATION AT CERNAVODA N.P.P.

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Abstract:

The advantages and constraints of the specific Autocad Plant 3D functions for dynamic management - production of technological diagrams, isometrics, orthogonal views, bills of materials and piping system erection projects for the future detritiation facility at the Cernavodă Nuclear Power Plant (Cernavoda N.P.P.) are presented in a case study.

In last decades 3D modelling of the plant has been increasing used in design of new projects in nuclear power plant (NPP) both in design period but also in design changes required during life time and extended life time of a plant.

In the proposed case we developed a model to make an engineering design application for plant design incorporating disciplines such as piping, piping support, equipment, civil and steel structure. Using 3D Plant capabilities we can improve design process, interdisciplinary check-out as well as project execution.

The project could be updated after as built revision of isometric drawings in order to obtain a training model for the system to prepare plant operators to make scheduled and unscheduled maintenance and time estimation of different maintenance procedures that could be required during plant operation in order to reduce as low as reasonable possible dose received during detritiation installation maintenance.

Article info:

Received 15 December 2021
Received in revised form
18 March 2022
Accepted 29 March 2022
Available online 04 April 2022

OBSERVATION: The article was presented to the 23rd International Conference "New Cryogenic and Isotope Technologies for Energy and Environment" *EnergEn* 2021, Băile Govora, Romania, October 26-29, 2021

Keywords*:*
Plant3D, Detritiation Installation

How to cite: Niţă, I. P., Olteanu, A. R., Coman, C., Beznila, H., (2022). Advantages and constraints of specific Autocad Plant 3D functions for dynamic management - Case study for a heavy water detritiation installation at CERNAVODA N.P.P. *Smart Energy and Sustainable Environment, 25*(1), 5-14, 2022, https://doi.org/10.46390/j.smensuen.25122.443.

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1. INTRODUCTION

The application AutoCAD Plant 3D is a software product built on the AutoCAD platform, which brings the proven benefits of 3D design and simulation of circuit models in the design of buildings and industrial installations. Designed to support the design, modeling and documentation of industrial plant processes, AutoCAD Plant 3D makes modern 3D design technology more accessible to project teams, regardless of their size.

Plant 3D includes modules dedicated to pipeline networks (creation of P&ID - Process and Instrumentation Diagram - technology schemes and 3D routes, editing of pipeline routes of pipeline elements (bends, tees, reductions) and valves with connection management, equipment (creation, modification and management of equipment models) and elements of metal and concrete structures Compatibility with documents and document libraries created with other software applications such as Autodesk Inventor, Revit Structure, AutoCAD Structural Detailing Software further simplifies the development of projects.

In addition, the inclusion of 3D modeling facilitates the generation and inclusion in a common database of isometries, orthogonal projections, and structural elements. Changing the dimensions of the pipes or creating new fittings in the data library can be done through the AutoCAD Plant 3D Spec Editor application, included in the AutoCAD Plant 3D program.

Plant 3D is designed to boost the productivity of project teams by reducing preparation time, facilitating direct information sharing and, implicitly, accurately correlate information through simpler coordination, minimizing the impact of changing project information. (www.autodesk.com)

A major project, such as the CTRF (Cernavoda Tritium Removal Facility), requires the implementation of an integrated management system. It will be designed to provide a single framework for arrangements and processes that address all of the organization's objectives, for this project a complex organization of the whole range of data and documents was necessary. Depending on their characteristics and the previous definition of project management in Creating the 3D model will cover all areas used to build the CTRF plant.

The model will be developed to ensure the contractor's demand, ensuring the standard design criteria:

- Safety
- Operability
- Ergonomics

All elements in the 3D model will maintain consistency between execution drawings using the same identification, numbering, or color assignment, allowing them to temporarily hide or isolate a particular element or categories of elements.

The 3D model for CTRF will contain details for all major areas used to build CTRF, but not limited to:

• Civil/architectural structures and components (slabs, beams, pillars, etc.)

• Mechanical and process elements (all types of pipes, equipment, pipes, pipe supports, etc.)

The detritiation installation (CTRF-Cernavoda Tritium Removal Facility) from Cernavoda NPP will be made in order to reduce the tritium concentration in Units 1 and 2 Cernavoda NPP.

The principle of the project detritiation method is to remove tritium from tritiated heavy water (DTO) by using a combination of liquid phase catalyzed isotopic exchange system (LPCE) and cryogenic distillation (CD) followed by storage of tritium in a safe condition (metal hydride) (Societatea Natională NUCLEAR ELECTRICA S.A., 2019).

2. INFORMATION FLOW

As mentioned above, modeling requires a complex organization of all the data coming from the different specialties that make up the CTRF.

Respecting the beneficiary's requirements, the necessary steps were established to realize technical documentation for complete system design, by using the AutoCAD Plant 3D program.

The requirements of technical documentation for pipeline installation design refer to the elaboration of the technological scheme, of the general location plans, and the isometric plans, together with the lists of materials, afferent to a technological process system that will serve the heavy water detritiation installation from Cernavoda N.P.P.

In a unified way of presentation, this documentation must contain the configuration of that system, from which it is possible to highlight representative views and sections, respectively the pipeline routes to be identified, depending on the functional role, by type, working fluid, and materials. The technological diagram must represent all the equipment (tanks, pumps, exchangers, etc.), components (fittings, etc.), and the pipeline routes related to the system, which are to be identified in the 3D configuration, made with the AutoCAD Plant 3D program.

To exemplify the program features, in order to achieve technical documentation (project), a representative technological system was chosen for the heavy water detritiation installation from Cernavoda NPP.

It was possible, by customizing the AutoCAD Plant 3D program, to configure the specific parameters with the requirements imposed by the beneficiary, in order to achieve an appropriate project.

It is noted that, once the prototype framework has been established for a certain objective, it can be reused for the elaboration of other projects, the difference being only in updating the data from the perspective of the specificity of the new project.

After establishing, according to the requirements of the respective project, the necessary types of components (pipes, fittings, equipment) that must be chosen by observing some design codes, having certain types of dimensions and being made of certain materials, the technical specification of the component that formed the basis of that project was created.

Since the AutoCAD Plant 3D program contains its own database, with specifications taken from ASME/ANSI, DIN etc., there is the possibility to take from the default specification of the program, those components which are needed, which it has enriched with the components of who needed more.

3. REALIZATION OF THE PROJECT

For the correct realization of a project, with the help of the AutoCAD Plant 3D program, it was necessary to go through the following work steps:

1) Establishing the working prototype framework (setting the configuration parameters of the project, establishing the technical specification of components, respectively of the 3D and 2D symbol libraries);

2) Realization in the 2D space of the technological diagram (location of equipment, pipeline routes, components and the connections between them);

3) Realization in the 3D space of the technological system configuration (location of equipment, pipeline routes, components and the connections between them);

4) Realization in the 2D space of the representative views and sections, which were generated from the 3D configuration of the system;

5) Representation in the isometric 2D space, of the technological lines related to the system, by generating from its 3D configuration, the pipeline routes, which contain the related components, as well as the material lists.

Figure 1 shows a diagram of this flow of information used throughout the design of the 3D design model.

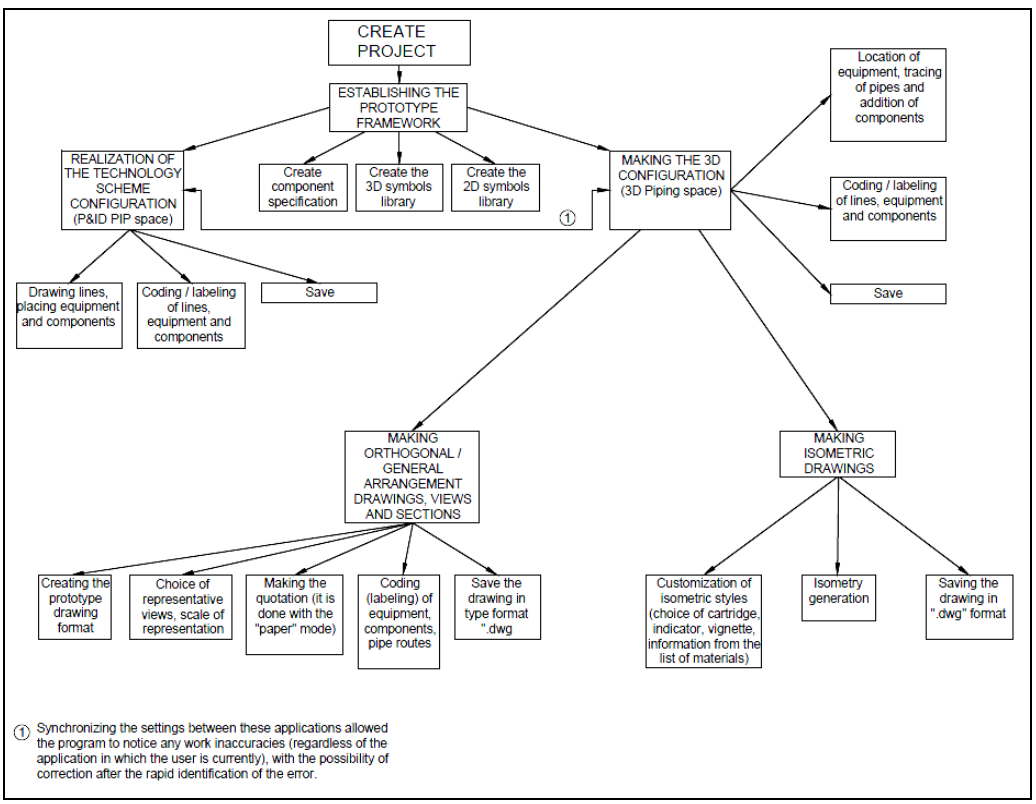

Figure 1. Logical diagram regarding the work steps with the AutoCAD Plant 3D program in order to carry out a project.

a) Establishing the prototype work framework

In order to achieve the technological scheme, the 3D configuration of the system, the general location plans, and the isometries of the system, it was necessary, as a first step, to create the specific settings. Synchronizing the settings between these applications allowed the program to detect any inadvertent work (regardless of the application in which the user is currently), with the possibility of correction, after the rapid identification of the error.

In order to create the material specifications for the project, a Plant 3D Spec Editor (Figure 2) was used as a special utility, included in the Autodesk Plant Design suite (Official Autodesk Training Guide – Introduction to Plant 3D Design) to create, access, and modify the technical specifications of a project. The additional components could be edited using the Spec Editor application.

This new specification can be used in the future to create other similar 3D projects, which is an important advantage by shortening the duration of a project.

In order for the project to be fully defined, it must have established, together with the technical specification of components, the 3D and 2D symbol libraries, with the help of which the components that are part of that project can be represented graphically in 3D or

2D space. Similarly, as per the technical specification, there was the possibility to retrieve from the libraries of the default symbols of the program, the component symbols that it needs, and then customized them by creating new symbols, or modifying the existing symbols for the components specific to the project.

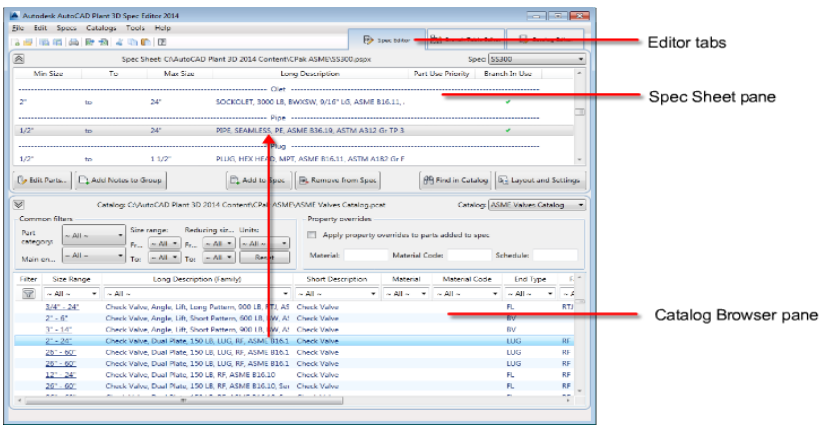

Figure 2. Representation of Plant 3D Spec Editor

b) Realization of the technological scheme

The technological scheme was made, using from the library of symbols, various types of pipe routes (lines), equipment and components. For the pipe routes, the flow direction, type and line code were indicated, but also the connections with the interface systems were represented. The codes for components and equipment have also been indicated. Figure 3 shows the technological scheme of a technological system, which will serve the heavy water detritiation installation from Cernavoda NPP. The scheme was made in the P&ID PIP (Process Industry Practices), workspace of the AutoCAD Plant 3D program.

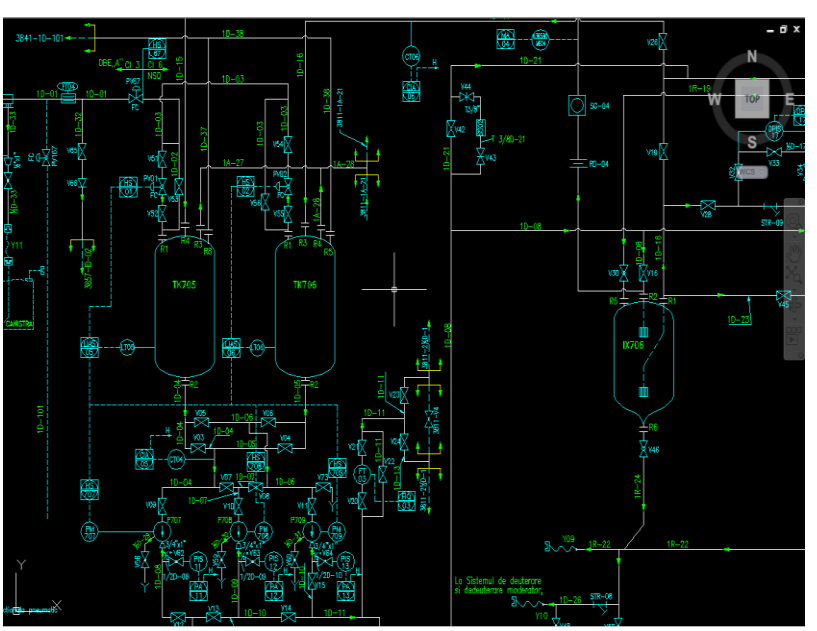

Figure 3. Technological scheme of a technological system, which will serve the heavy water detritiation installation from Cernavoda NPP.

Because in the configuration of the technological scheme, different from the default ones of the program(P&ID PIP workspace), they were created so as to correspond to the requirements imposed by the beneficiary.

c) Realization of the 3D configuration of the technological system

Creating and editing three-dimensional configurations is done using the AutoCAD 3D Piping application. Similar to the P&ID application, this application also includes default 3D symbol libraries for equipment, valves, fittings, pipes, etc., which are based on standardized symbols. Symbols can be placed, moved, scaled and coded (labelled). The application also includes the realization of pipe supports. In this sense, there are commands that can be used to create, modify, convert from other programs and add supports on lines.

There is the possibility to easily configure the system model, there are several types of pipes and equipment that can be used in designs. The equipment can be standard or customized (Figure 4).

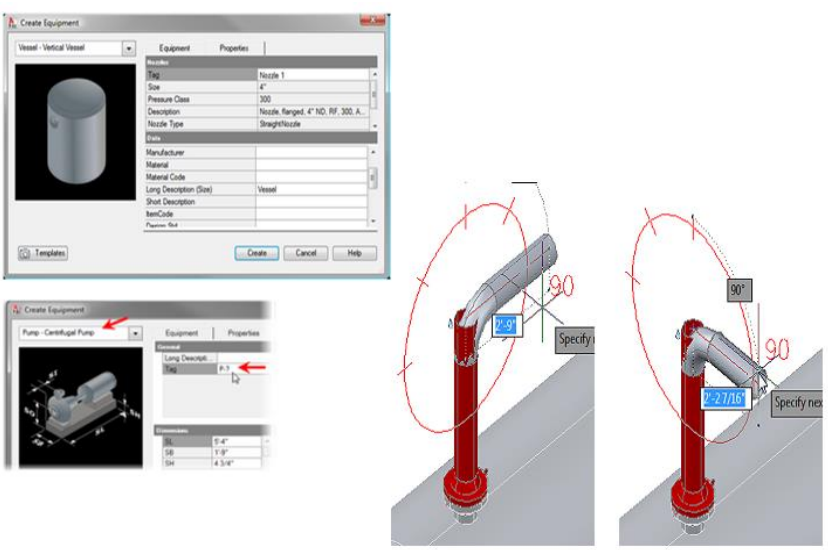

Figure 4. Equipment and piping standard

It was noted that in order to achieve the 3D configuration of a system, it is important to correctly access the plan of orthogonal axes from the perspective of which, the configuration of pipeline routes is visualized. Figure 5 illustrates a representative 3D view of the configured process system.

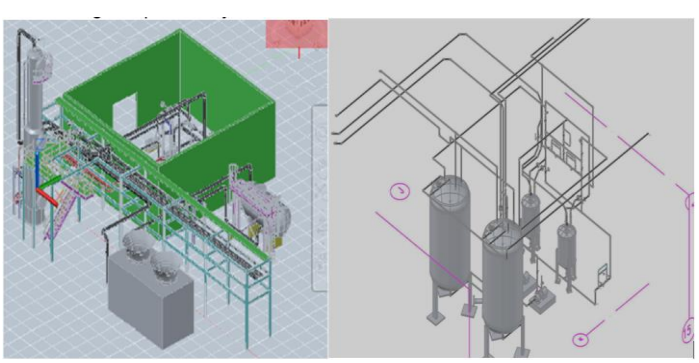

Figure 5. Representative 3D view of a technological system.

d) Creating of the representative views and sections

With the help of the AutoCAD Plant 3D program, it can be created, update and annotate orthogonal drawings, which are exact representations of the 3D model in a two-dimensional plane.

The capability of the program to generate graphics in 2D (P&ID PIP workspace), based on what was initially achieved through the 3D configuration (3D Piping workspace), led to the two-dimensional representation of the views and sections representative of the chosen system for example.

This way of representation is shown in Figure 6, which shows plan views, sections and details, of the system configuration.

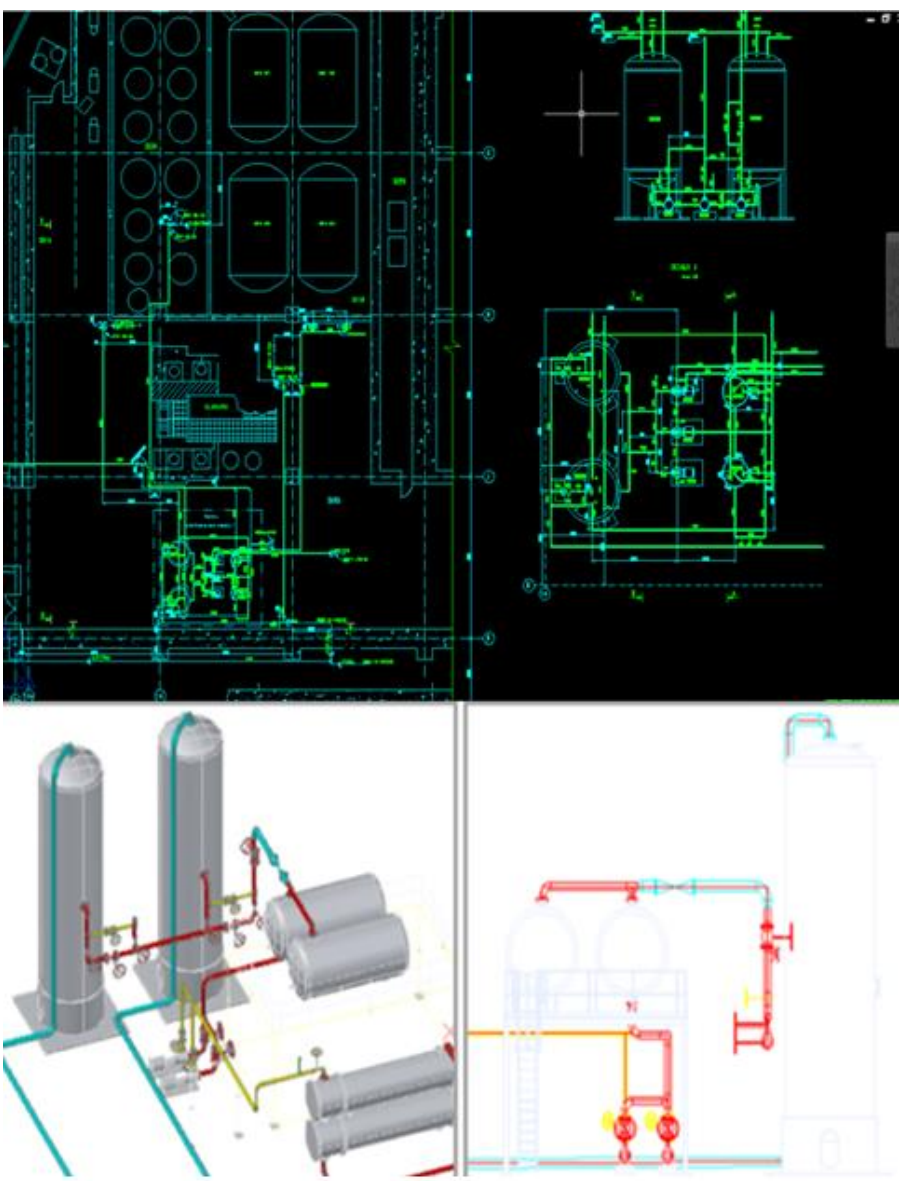

Figure 6. Plan, section and detail views, corresponding to the technological system configuration

e) Representation in isometric 2D space

With the help of the AutoCAD Plant 3D program, isometric plans can be created taking into account the requirements for pipe assembly.

It should be noted that these isometric plans also include the lists of materials of the respective lines, presented in tabular form. The table includes the component positions of the respective lines, the related quantities, the type of components, materials, code class, unit mass, respectively total, by component type, types of welds and other information, taken from the previously created specification.

It is specified that for the lists of materials of the generated isometric lines there is the possibility of organizing them in a satisfactory form. In the sense that columns can be added containing other information that the designer considers representative, certain orders can be made, can be created separate sections for manufacturing and assembly, etc.

In figure 7 is represented the isometric plane of the main pipe path, generated graphically in 2D, from the 3D configuration.

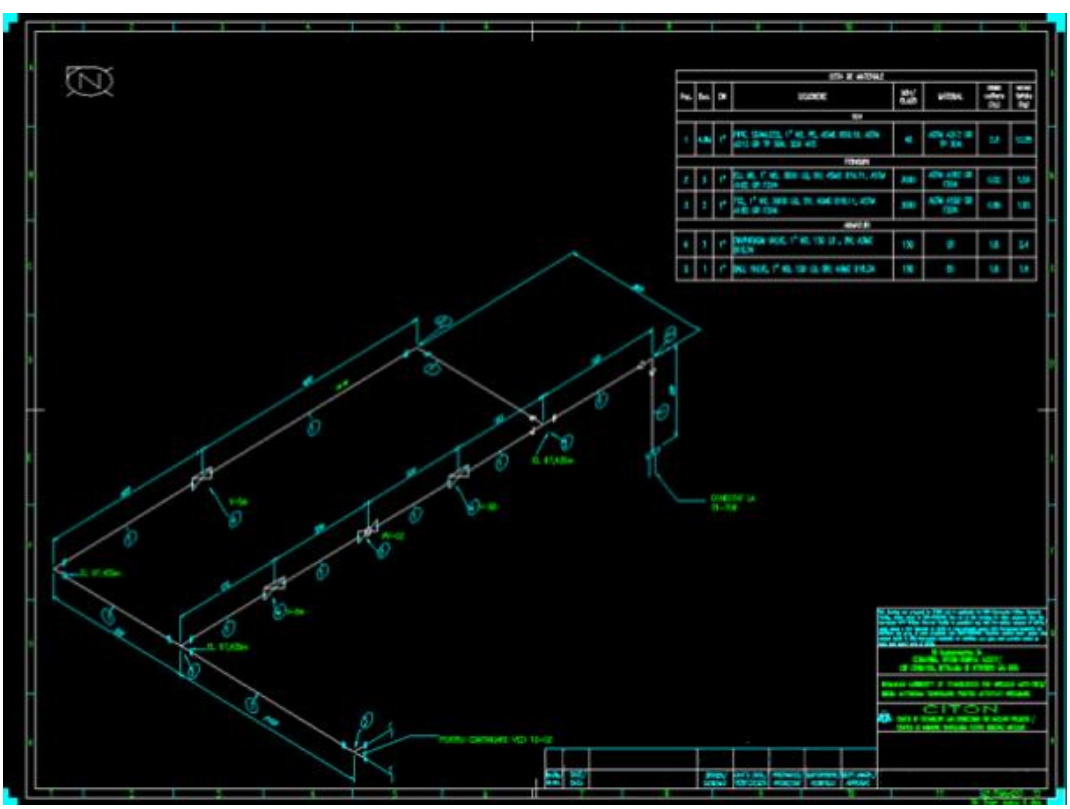

Figure 7. Isometric plane of a main pipeline route

Reports and material lists are easy to produce and share for all project teams. The files generated by AutoCAD Plant 3D can be opened by other engineering disciplines as civil, electrical, and ventilation departments. Data can be exported and integrated into other applications (CATIA, Aucotad Inventor, etc).

For the completeness of the technical documentation, the technological diagram, the general layout plans and the system isometries, witch resulted from the use of the

AutoCAD Plant 3D program, additional technical / technological data can be added during project revisions or updates.

Some information (such as indicator cartridge, revision cartridge, technical characteristics table) is included, by a preliminary setting the drawing format initiated once the project is defined. Other information (such as operating/design parameters, notes, captions, etc.) is entered later, using AutoCAD commands.

5. CONCLUSIONS

The ability of the AutoCAD Plant 3D platform to elaborate a technical project with execution details was demonstrated, from the perspective of graphic design, but also of highlighting the lists of related materials, relevant for the installation of pipeline routes.

By customizing the AutoCAD Plant 3D platform, it was possible to create the prototype work framework specific to a certain objective, in this case, the heavy water detritiation installation from Cernavoda NPP, and the premises for drawing up other similar projects were made, the difference being only in updating the data from the perspective of the specificity of the new project.

The particularly important role of the existence of a prototype framework is highlighted. Although the team of designers initially allocates enough time to properly perform the program settings in order to establish the technical specification of components and 3D and 2D symbol libraries required, subsequently, the productivity of the preparation of technical documentation is undeniable. In other words, by using the AutoCAD Plant 3D program, the way of elaborating the technical documentations containing technological schemes, general location plans and isometric plans, respectively material lists, is made more efficient. That is why it is important to have as many users as possible who know the facilities of this program and work accordingly.

The graphical presentation of a project in a three-dimensional space, which allows the visualization of orthogonal views (in plan, sections) imposed by the user, respectively the generation of pipeline routes and lists of related materials highlights the superior quality of the project, in terms of image as a whole.

We also use AutoCAD Plant 3D for other area of nuclear interest, as per conceptual design of cooling towers for ALFRED demonstrator reactor (Niţă & Pancef, 2021), conceptual design of air cooling condenser (ACC) ALFRED demonstrator reactor (Niţă & Pancef, 2022).

We are in progress with using AutoCAD Plant 3D for designing a passive safety system using isolated condensers (IC) for PHWR CANDU 6 reactor from Unit 2 of CNE Cernavoda (Niţă & Nitulescu, 2021; Niţă et al., 2021).

In conclusion, AutoCAD Plant 3D is an extremely efficient solution for current industrial projects, developed with smaller budgets and considerable limitations. Plant 3D functionalities support project teams, reducing the time allotted, the consumption of resources involved and the difficulties of managing and centralizing data within projects.

Acknowledgments: This work was obtained by team work in Process Technical Department lead with success by Mrs. Bigu Melania.

Funding: This paper was prepared based on commercial contract prior for implementation of CTRF Plant and also for implementing a passive isolation condenser (PIACE - Project - Grant agreement ID: 847715).

Author Contributions: My role was to coordinate 3D design of CTRF, ALFRED cooling tower, and for Decay Heat removal System with computational part, technical specification and finance offer.

Conflict of Interest Statement: There is no conflict of interest on this article.

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