Planning large industrial plants is a complex task. Every plant has different requirements and capacities and as a prime contractor, you are responsible for all aspects of civil work, equipment, piping, automation, and commissioning of the whole plant. In this class, you will learn how we use different Autodesk products to completing a plant. You will learn how we handle all the data that is created in several programs which are unfortunately not linked together directly. We will talk about how we handle changes in comprehensive data sets and how we do revisions and documentation. You will learn how to merge the whole plant in Autodesk® Navisworks® software for coordination and visualization purposes and render realistic pictures that are not only essential for modern facilities, but can also be used for sales and acquisition. Come and see how we do plant engineering and get some ideas for improving your own processes.
Learning Objectives

At the end of this class, you will be able to:

• use Plant 3D, Inventor and Revit in a more efficient way to plan industrial plants
• create and manage your own special part-libraries in Plant 3D with the right configuration
• merge drawings from different programs in Navisworks to visualize the whole plant including all relevant elements
• create a tight structure to be able to complete complex plants smoothly
About the Speakers

**Klaus Schachinger**

Klaus is 24 years old and studied mechanical engineering. Now he is working for BOWAS-INDUPLAN in Salzburg (Austria), which designs industrial chemical plants. Creating 3D-Models of diverse plant equipment and the corresponding workshop drawings with Autodesk Inventor were his first tasks. In 2009 BOWAS-INDUPLAN decided to introduce AutoCAD Plant 3D to finalize a running project. Since then he has been responsible for implementing and configuring the Plant 3D. The library with the required fittings, valves and instruments was built up in a few weeks and so this project was successfully completed. In following projects he worked with Plant 3D, Inventor and Navisworks and could gradually refine his skills.

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**Markus Hiermer**

Max has been a Revit Freelancer since 2006 and works for his own company as author, trainer and Revit implementer for a wide variety of clients. Since 2009 he has been involved into plant design at BOWAS-INDUPLAN, where he is responsible for the building models and civil work plans. The models have to meet the requirements for proposals as well as for the construction of the buildings, which means that it is necessary to collaborate tightly with other disciplines like mechanical and piping.

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About the company: BOWAS-INDUPLAN

BOWAS-INDUPLAN CHEMIE Ges.m.b.H., originally founded in 1974 as Induplan Chemie Ges.m.b.H., is a company specialized in designing, planning and constructing plants for the chemical and explosives industry.

Range of services

BOWAS-INDUPLAN provides the complete range of services following the principle "Everything from one supplier" for plants for the chemical and explosives industry:

- Feasibility studies
- Project management
- Basic and detail engineering
- Procurement, manufacturing, inspection and shipment of equipment
- Process know-how, transfer of technology
- Supervision, installation, start-up
- Training of personnel

BOWAS-INDUPLAN has already successfully completed over 250 projects for the chemical and explosives industry in more than 35 countries in the world.

Our main activities are either covered by our own process know-how, experiences gained within the BOHLEN group or by cooperation with leading companies. Only thoroughly proven processes and equipment will be incorporated into plants designed and supplied by BOWAS-INDUPLAN.
The Project-Workflow

A typical project can be separated into three phases:

- **Proposal**
- **Basic engineering**
- **Detail engineering**

Each phase has its own challenges and requirements. In the following we will show some of the typical problems that might occur in each phase and how we try to work around them.

**Phase 1: Proposal**

**3D or not 3D...**

Everyone who has already been working in our field knows the drill: “We don’t know what we want, but we want it now and we want plenty of options!” Deadlines are tight but the foundations are being laid in this phase as well. If you get a wrong start here, you will go down a long bumpy road later on! And of course you will be measured by fotorealistic-3D-sixmillion-colors pictures by your customer in the end as well. Therefore it is important to get a good start here and you will get the job!

But before we can get to this point, we have to make a few decisions at first: How can we set up the plant in the given time? Can't we do this project in 2D? Can’t we just count up the things we need or is it really necessary to produce all the schedules and therefore “real” 3D elements?

When it comes to the edge, it really is tempting to skip the 3D modeling and go back to 2D – at least for the beginning!

But once you are drawing the second or third option of the plot and therefore recalculating the quantity take-off’s, the 3D modeling is regaining its beauty again! Keeping track of the length of the pipes when you have reworked the layout several times is a real pain and the risk of redundant or completely outdated data is rising quickly. The ensuing lack of time to recheck everything in the end will do the rest to bring you in real trouble a few weeks later on ...
The experience of the last few years showed us that in the end it has always paid off to go the “hard” (3D) way. The possibilities and the quality of a properly set up 3D model is not comparable to a 2D drawing. That’s why we decided to do as much work as possible in 3D in our department.

For the proposal we will need (and CAD-Programs used for this purpose)

- process flow diagrams (P&ID or vanilla AutoCAD)
- equipment arrangement plans (Revit)
- a site and infrastructure layout (Revit)
- a nice visualization (Revit and Navisworks)

**Everything flows!**

Before we can model anything in 3D, we have to get through the chemical processes to be able to gain a general overview. The result will be a first (coarse) sketch of the process, the Process Flow Diagram.

In the Process Flow Diagram (shortened: PFD) you can see the necessary equipment and the way of the main flows to get the final product. Hence you get the identification list of the equipment, which will be used as a basic document for our further project.

The PFDs are set up by the process engineers and are the basis for all future discussions and thoughts. For this purpose we prefer to use the P&ID feature of AutoCAD Plant 3D, to be able to take advantage of having the pieces of equipment tagged with a specific ID-number to keep track of them in case we have anything forgotten or some things twice in our later model.

With AutoCAD P&ID you can create completely new PFDs as well as just copy PFDs from an old similar project and modify them, even if these are simple AutoCAD drawings.
Looking into Buildings!

Once the PFDs are set up (or let’s say meanwhile, as time keeps ticking away…), we can start with the equipment arrangement and concomitant the building design. For this issue we use Revit Architecture, since we think that the advantage of the parametric engine helps us in many ways through our modeling process.

Often enough we start with a site plan which gives us the space we can use for our buildings. Sometimes we get some DWG’s, sometimes we have scans of old plans or just some jpg’s. This is not much to start with, but enough.

To keep things apart and be able to handle everything smoothly, it can be a good idea to set up a separate project, where all given files are stored separately. Therefore we have a separate Revit project, where all DWG files and so on are imported into individual views. Afterwards we import this “imports file” into our “modeling file” in order to be able to use this data as “bottom layer” for further modeling of the components we need in our building model.

Move it – getting furnished!

For the equipment we use both (flexible) parametric families (that’s what the components are called in Revit) and “numb” imported geometries. For example we have a family for a vessel with a “torispherical head”, which contains its foundations as well, to make things quick for the users when they need such a equipment with a certain diameter and height.

On the other side, we have some equipment which will stay relatively unique, as for example pumps. These unique items will not have to be flexible and are therefore not designed with parameters. The shape can be modeled directly in Revit, or – more often used by us – we import some existing DWG files into the Revit family.

All the vessels do not have to be very detailed, as it will be enough to have a coarse 3D-Model which is sufficient for first equipment arrangement drawings. Of course you can save quite a big bit of work by using a good library and proper templates. We will have a look on this in the last part of this lecture.

For these “dummies” we have built some families in Revit which contain all the needed data/parameters for the model, as for example the vessel weight or the volume.

For most of the projects we will keep the buildings and the site layout in separate files, as this gives us the possibility of being effective with the templates and keeping the performance up and running. Depending on the size of the
Planning Industrial Plants with Autodesk® Products

plant layout and particular buildings, we choose to break the files down even further. For example, I will set up a separate file for the layout and the infrastructure plans. In the end, you could even break down the model into “typical building parts”, for example, if you use the same (or quite similar) staircase over and over again.

Quantity take-off’s

Depending on the proposal, we will need a few quantity take-off’s for the first estimations of the costs for the plant. This may include values for the pipe lengths of the infrastructure lines, the volumina and room areas of the buildings, etc.

These charts are produced in Revit, using its parametric functions. All elements modeled in Revit can be interpreted in schedules by the program. Everything the user has to define is the category and sorting criteria’s of the specific schedule.

This does not mean that everything has to be done in 3D necessarily. For example we define the infrastructure-lines only as 2D lines (not “real” 3D piping), as we do not see the need of a 3D model for this elements right now. Nevertheless these families can contain the lengths and diameters for example. Once these parameters are filled with their values in the project, the schedules will automatically be completed in Revit and can be placed and plotted on sheets.

Furthermore the values will be automatically updated after changes in the layout occurred. This gives us the possibility to test different situations and having the correct data at hand immediately without the need to have them recalculated every time.

What you get is what you see!

Of course one main reason why we use 3D technology is that we can make 3D visualizations for our proposals. For the proposals we normally do some rendered pictures (night views are still very impressive…) as well as 3D walkthroughs through the buildings and plant to provide a proper overview about what the client is about to obtain.

Pictures are done in Revit, as the render quality is quite good and all needed settings can be done while modeling the building itself and are therefore not very time consuming.
For walkthroughs on the other hand, we prefer to use Navisworks, as setting up the camera views is very convenient there and we normally use shaded views for this purpose. For renderings we would have to redefine materials and lightings, which is time consuming and the quality of the result is – in our opinion - not as good than the ones produced directly in Revit.

At this point we have everything covered, which is normally needed for a proposal.
Phase 2: Basic Engineering

Of course not all proposals we deliver, will end up as a project, but hopefully a few will do so…

If we will receive an acceptance of a proposal, the first milestone will be the delivery of the basic engineering. The basic engineering will include about:

- Mass-Balance (Substance Flow Analysis)
- Equipment arrangement plans with lists of loads of the vessels
- Site layout plans
- Room specifications
- Process and Instrument Diagrams (P&ID)

Depending on the project-contract, there are different deadlines, but the due date of the delivery of the basic engineering package always seems to be very short. A good basic engineering is very important for the further progress of the project, but on the other side you shouldn’t get lost in detail.

Right at the start of the basic engineering we need a “non-Cad” thing: The Mass-Balance (Substance Flow Analysis). The basis of the first mass-balance is the process flow diagram and a list of the mediums which are needed to produce the final product. Our process engineers contribute their part and after their work is done, we will know e.g. how many raw materials of acids we will need to be able to produce the desired amount of final product, as well as how big our vessels and what size the product-pipelines will be.

Buildings and equipment with Revit

Inside the Revit project we still use the “dummies” (simplified geometries, created in the proposal phase) for the basic engineering to be able to give a picture of the locations of the vessels. Additionally we add the estimated weights of the vessels to our building plans and hand this information over to the structural engineers, who will use this data for their calculations.

Still, we don’t need any detailed vessel geometries (and won’t be able to deliver such detailed information, as this will be set up later on in the project), but we can add the data we received from the mass balance. The parametric engine of Revit is very fine for this kind of workflow, as we can add the values we know right now, but are able to change the geometry afterwards.

The equipment arrangement plans (as well as the site layout plans) are more or less the same as the ones in the proposal, although there are often enough some updates due to new facts from the client and/or the Mass Balance. So we have to check these facts, update our models and can produce the sheets we need.
**On the plot - plant layout**

Accompanied by the development of the building plans in Revit, we will carry on the plant layout sheets as well. For this purpose we **link all building files together in one layout model file**. To be able to coordinate the buildings and the layout we use the **Project origins** (=edge of a building) as well as the **Surveyor origin** (=absolute zero of the whole plant) inside Revit. With this setup we always can use the “origin to origin” option if we have to import any Revit files. Inside the plant layout file, we define the coordinates of the buildings, which we will need later on for the site itself as well as for the coordination of the models (see next paragraph  Navisworks).
Managing the Equipment with Inventor and Vault:

From the values we receive from the Mass Balance, we are able to produce the first models of the vessels we need. Depending on the contract, the client gets master drawings of the equipment in the basic engineering or later on in the detail engineering. However, at this point we normally start to create the mechanical models/drawings in Inventor. We don't need exact models of the vessels in this phase and although these drawings are still not fixed at that moment we send them to our partner who can already order material and start his production planning.

Additional to Inventor we use Vault for an easy handling of the correlated assemblies and drawings on network. Let me give you a short overview of our workflows with Inventor and Vault:

The most frequent equipment in our plants are vessels. Therefore we built up a parametric template for Inventor which is pretty simple to handle. Best practice here is to use i-logic which will allow you to set up a new vessel with varying dimensions very quickly. Nevertheless, a parametric model based on a skeletal-frame and an external excel-list for controlling the whole assembly is sufficient as well. You can easily change for example the diameter, the height of the shell plate and supports, the type of supports, heating jacket or not, and the amount and position of the nozzles. All in all with this template you are able to create new vessel models and drawings very quickly.

Such newly created equipments and every other relevant plant-object get a unique specification, an internal serial-number. This internal number is based on our documentary structure which is divided into groups (group 1=equipment, group 2=values, group 3=pipes, etc..) and further on into types (for group 2: ball valves, flaps, check valves, etc…) and all objects in these different type-categories get a serial number. So all inventor parts we have created can be found under this structure in Vault and if we create new equipment it will be checked in with the next free number in the corresponding category.

Instead of creating every single equipment from a project from sketch, it is of course better to use already existing (similar) equipment from previous projects. In this case we copy the whole construction, assign a new number and modify it because in that way we are faster than by creating completely new models. Sometimes we also need the exact same equipment from already existing projects. In this case we just copy the drawing files in the folder of the already existing equipment and modify the title block to the requirements of the new project. Here you only have to pay attention if something in the construction changes because then you immediately need to copy the equipment and assign a new number (as described above) to avoid getting new unwanted changes to the equipment which is the already used in another project.
First 3D-Piping & Building Adjustment

Before we can finish the building plans for basic engineering we start with the 3D Piping in Plant 3D. Particularly in closely spaced plants and complex process, a little bit of “sketch piping” is very helpful in order to get a rough orientation what the building should look like in order to have enough space available for the piping and the main cutouts in the end. Some bends, pipes and tees are already enough for a coarse pipe-routing. Although it doesn’t matter much what pipe specification you will use for this purpose, it will save you time and work to use any similar or even the correct specification, if you know it already at this point. Of course you can change the specification in P3D later on as well, but sometimes it doesn’t run very smoothly, especially if you want to change to a completely different specification (with completely different fittings).

Before you start piping you should Xref the building 3D-model from Revit (including equipment if that’s still not in Plant 3D) into your Plant 3D Piping-DWG to be able to see the surrounding elements during piping work.

During piping it certainly will be necessary to edit some parts of the buildings (e. g. moving the equipment, moving or adding new cutouts,...). This will be done in the Xrefed building-DWG inside AutoCAD Plant 3D first, then the changes will be discussed, approved and only then transferred to Revit.
The piping-DWG and the exported building-DWG (which we need as long as the changes are not applied to the Revit file) are appended to Navisworks (see paragraph below) as well as the Revit-file. But we hide the Revit file first because at this point we want to see the actual building files only.

If necessary changes are first done in Plant 3D and checked in Navisworks. Afterwards they are sent to the civil-engineer, who then will update the Revit-file. For this issue the modified building DWG is linked back to Revit.

Then we refresh Navisworks and unhide the Revit-file to check if all changes in Revit have been applied correctly.

If any elements are not matching exactly, you can easily spot this inside Navisworks. The “Clash Detection” feature of Navisworks Manage is certainly very helpful for this purpose.

*Navisworks & Point of Origin*

Navisworks helps you tremendously with coordinating your project, especially if the project consists of various different file formats. Our piping-engineers **almost always work simultaneously with Plant 3D and Navisworks** to check the piping for clashes.

You can quickly create a single Navis-file for each building to check the area you are working at, but we always create **ONE Navisworks-file which includes the whole project**. That means that we append all buildings (from Revit), all piping (from Plant 3D), all equipment (also from Plant 3D) to the Navis-file and of course any other files which we may get from suppliers, for example cable trays or steelwork drawings.
All our AutoCAD-files refer to the corresponding building origin (in Revit = Project origin). The Navisworks file refers to the project origin (in Revit = Surveyor origin). Therefore, after a DWG is appended to Navisworks, the drawing has to be shifted by the value of the distance between these two points. The coordinates of the zero-points of the building are defined in the layout-file of Revit, which is also loaded into Navisworks, primarily because it is necessary to check if all files are in the right position.

Of course we also load every single Revit building file into Navisworks. If you set “coordinates=shared” in Navisworks (Options/File Reader/Revit) the buildings should directly show up in the right place.

Process & Instrument Diagrams

The Process & Instrument Diagram (shortened: P&ID) is the foundation for the whole plant.

Normally we use the PFD from the proposal (see Phase 1) and implement further details. If you do so, you should start by scaling and moving equipment to create some spaces which you need for a complete P&ID because later on, it is harder to stretch and move all the objects.

Alternatively, if you have P&IDs from previous (similar) projects, it is also possible to copy the drawings to the new project and modify them.

When you assign the tag-numbers in P&ID, don’t forget to open the PFD-drawing where the tag-numbers are already assigned. Because when you want to assign a tag which already exists in the project, the corresponding drawing (PFD) must be opened to get the “Tag Already Assigned”-dialog box which allows you to “assign this tag to the selected component”, meaning linking the data sets. This helps you to avoid differences between the PFD and P&ID, but that doesn’t save you from checking on analogous matches manually.

For such coarse P&IDs needed for the basic engineering, we generally don’t assign or annotate valves, pipelines or nozzles because that is not important in this phase. What we really want to show are the values from the mass-balance (size of the pipelines and the media flowing in them) which will be now integrated into the P&ID. Therefore the lines get annotated with these two values. The further elaboration of the pipe numbers will be done in a later phase.
Valves and instruments are treated differently. Like vessels, they need a tag and a Spec-number, which refers to a specification-sheet to give the client an idea of the installed product. That's all you need from the P&ID at this point.

When these things are done, the basic engineering is finished for the CAD-department.
Phase 3: Detail Engineering

The goal of this phase is to obtain plans to be able to have the equipment installed on site. For this purpose we need detailed plans of the civil works as well as the piping plans.

Civil works reloaded!

Most likely the site-layout will have to be reworked. Normally we get some data from the surveyor containing the exact locations of the existing surrounding buildings from our site. Sometimes we have to make major amendments due to local authorities and requirements.

This will all happen in the Revit layout file. As all the buildings are linked together, you are able to shift them to their desired location comfortably. Furthermore, the performance of the software will suffer less which is increasingly important as the size of a project grows. For this reason we usually even shift the infrastructure elements (as for example process water routes etc.) to another linked file, which turned out to run quite smoothly.

Still the same – keep your models in line!

In order to save time we try to come forward with all these plans as much as possible simultaneously. How can we achieve this?

We have to make sure that the Equipment (Inventor), Buildings (Revit) and Pipings (Plant 3D) keep synchronized. This task is relatively easy if the whole team is located in the same office. Communication between the different disciplines is vital to keep up to date. Everyone in the team has to keep an eye on how things are linked together and if any changes are done, we all must consider which persons/disciplines will be affected by the change.

Let’s have a look at a short example: At the beginning of the detail engineering we will have a building model with the equipment arrangement from Revit as well as the (coarse) equipment models from Inventor and a few pipes from Plant 3D. As the piping specialists will now build up their piping-network rather quickly, they will probably run into some interferences and therefore we will have to change the position of a vessel. As a consequence the new coordinates have to be passed on to the civil engineer, who will then move the vessel to its new position. After applying the changes (and saving) a check in Navisworks will show if everything is in order again.

To avoid the problem that the changes have to be done twice (in Plant and Revit) we simply could link all the vessels from Plant 3D directly into Revit. But we do not prefer this method for three reasons: First, the performance in Revit will be slowed down more with the vessels directly linked into the model than via the families, second we want to keep the vessels in both programs flexible, as we often need to move the equipment around in both systems to find the best solutions. Third, we use parametric Revit families, to be able to change the size of the foundations via parameters directly inside Revit.
When working with external offices or departments, the synchronization of the data will be more difficult. For example, the building plans will be updated with the local consultants and – if necessary - amended. Usually this happens with DWG files, as this is still the CAD-standard for file exchange. To be able to handle a great amount of incoming DWG-files, we use again our “import file” (which already exists from the proposal), where all the DWG are stored and will be linked into the building models. This both saves performance resources and gives us the possibility to spot mismatching elements between our plans and the ones of the consultants. As soon as both sides are in line the plans will be released for execution on site.

**Getting Equipment from Inventor...**

Anytime in this phase we will update or complete the equipment 3D models in Inventor.

After we have modified, for example, a 3D model of a vessel in Inventor, we export a DWG which will be imported into Revit and Plant 3D. But first we delete the unnecessary, performance-consuming parts like screws or any other detailed parts in the DWG. The contour-simplification feature of Inventor can help you here, but it can be hard until you get a satisfying result, so in most cases you are quicker if you just edit some parts directly in the DWG to get the desired result.

**...into Revit**

The vessel-DWG will be imported into the (corresponding, already existing) parametric family of Revit. The foundations of the vessels will be a nested parametric family. With this workflow we are able to set up the foundations via parameters easily and we are able to get some data we need via schedules (for example the amount of embedded metal plates needed for the vessels).

**...into Plant 3D**

In Plant 3D we simply create a block including the exported vessel geometry and convert it to a Plant 3D-(intelligent) equipment. We generally convert blocks instead of 3D-solids because it is not possible to change the geometry of a Plant 3D equipment made out of a 3D-solid. So if a vessel needs to be updated you only have to replace the geometry in the corresponding block and redefine the location/size/type of the changed nozzles, but you don’t have to convert the equipment completely anew.
Normally we don’t need to use the equipment-template feature of Plant 3D because for basic engineering the equipment models of the exported Revit-DWG are sufficient and in detail engineering we create the equipment as just explained.

By saving the equipment DWG we also obtain a new version in Navisworks because the Plant 3D-equipment is directly linked into Navisworks (more about that later). The last step is to check if the changes are done correctly and that’s it.

**Refine the P&IDs**

The preliminary drafts of the P&IDs from the basic-engineering have to be updated and completed and this can be a quite long process until everything is completely finished. The P&ID is directly related with the 3D piping. If you are lucky you have a completely finished P&ID, so that you just have to transform it to Plant 3D, but in most cases you have to do 3D piping first to get the correct information (branches, sizes,...) back to the P&ID. Therefore you have to work more or less simultaneously on both files, or let’s say you work on one file and update the other file after some time. If several people are working on the same project, we assign every single modeler his own area he is responsible for - both the piping and the P&ID - otherwise it is harder to synchronize because any information exchange between the modelers can easily cause problems.

We give priority to the sections that include parts we need to order first. When such an area is finished (or let’s say fixed to 95%) we transfer the relevant objects to our **Microsoft Access** database via exported excel-lists.

**Microsoft Access**

Primarily we use **Microsoft Access** to produce identification-lists and other reports in a homogenous style for documentation purposes and to manage the purchasing data (and order status).

Actually we have no direct connection between the Access database and databases of the CAD-programs yet, although linking these databases together is possible right now. Setting up such a "Master
Database” is quite complex and we still need some time to finish all our tests before implementing this feature in our project environment.

At the beginning of a project the main equipment will be added to this database, during the basic engineering valves and instruments will be added as well. These items are only needed for the documentation-reports of the basic engineering, after their delivery we delete the valves and instruments in the Access database again to avoid inconsistent data from the detail engineering. When an area is finished and just a few more changes may happen, the valves are exported out of the P&ID and imported into Access again. From this point on we really have to pay attention to every change because these datasets are also used for ordering-status and other information of the project.

3D Piping

With the 3D piping it is a little bit different. We don’t import all pipes and fittings into Access because these are not really relevant parts of the plant and they have no tag-numbers. We export the bills of materials as reports out of Plant 3D whenever we need them. All these reports get a unique file-name to be able to create an affiliation to the orders and requests.

Unfortunately the validation-feature of Plant 3D sometimes doesn’t work correctly (it only compares nozzle-tags…), so we simply export lists from both databases (P&ID and 3D piping) and compare them in order to be sure that everything is matching exactly.

When we begin with 3D piping we don’t consider cable trays or supports. In our plants the primary product pipelines have priority and are drawn first, chiefly because critical and dangerous media are transported through these lines. Other lines and cable trays are secondary. Nevertheless, since the piping gets more detailed as we progress, we include the cable trays and main supports. We just use simple blocks and solids as placeholders. In most cases we are not responsible for supplying the material for the cable trays, this is normally done by external companies. So we estimate the sizes and then we create the main routing of the cable trays after our own reckoning. Later on this arrangement will be updated with our contractor and changes will be done wherever necessary. Whenever possible, we try to get a 3D-model (DWG) of the completely finished cable trays, which we link into our piping- and Navisworks-files.

Alternatively we could model the cable trays with Revit MEP and link this file into the building model, but right now, we prefer to have this data on the same platform as the piping, which is Plant 3D.
Supports

We use the **P3D-structure-feature** for main supports or any other constructions which are connected with the pipe-support and insert them in the corresponding piping drawings. **Ordering** of these items is done in the **same way as with the pipes and fittings**. To keep the installation on site as simple as possible we try to use unified types of supports wherever possible. We create **typical drawings** with variable lengths to be able to compensate any occurring tolerances on site. This typical drawing-number is added as a property to every pipe-support which in turn is **available from the Isometric**, hence the site manager knows where and how to place the supports.

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**Isometrics**

To be able to assemble the installation on site we need Isometrics. Some piping programs are not able at all to produce a flawless Isometric, Plant 3D is not much better, to be honest. When the Isometric feature was directly implemented in Plant 3D in 2012, it was really poorly made because settings you applied simply showed no effect. In 2013 it got better, but it is still not as good as it should be. We still have to **rework the isometrics manually** because some information is missing or misplaced, or you need to create certain pipes in a different way (especially sloped pipes), so that they are displayed correctly in the ISO. If you have to make changes to the piping and the ISO is already created you have to make a new (revised) ISO. If you have **already added supplements** to the old ISO you best **copy them into the new one** and update them if necessary.

**Ortho- and 3D-drawings**

Another common tool for installation on site are the Ortho drawings. These drawings should show sections of the plant including everything concerning the piping and supports. We only add a few annotations like the level-heights or dimensions of main pipelines in the Plant 3D Ortho drawings, as we don’t see much sense in using such a feature if it is not parametric like in Revit. However, we want to annotate the pipeline-numbers in a 3D view, which you also can’t create with the Ortho-feature. So we decided to use Navisworks to export 3D-view-pictures of saved viewpoints, which we link into an AutoCAD-DWG where we annotate all the line-numbers manually. Through the quick-properties in
Navisworks you can easily associate the line-numbers with the pipelines. When you do a revision you simply have to export a picture of the saved viewpoint again, overwrite the existing file, refresh Xrefs in AutoCAD and trace the annotations.

In these 3D-views only the pipelines (fully visible) and equipment (transparent) are displayed.

The biggest benefit of such drawings is that they give you a really good overview of the position and routing of all pipelines.

The supports are not shown in these drawings since they would occlude the pipelines too much. Even in an Ortho or 3D view you don't need to show or annotate them because you can see the pipe-support-drawing-number in the isometric anyway. As I said before we create a typical drawing for every type of support. Visualisation (optional)

**Visualization for documentation purposes (optional)**

Depending on our project needs, we will have to create some presentation pictures of the whole plant. Navisworks would be a good choice for this task, as we already have all our models collected in there: buildings, vessels, piping. Although we think the render engine is kind of weak with the physics and creating lighting is quite a hard task compared to Revit. On the other hand, you will get in trouble if you try to import all the piping into Revit, as the performance will suffer severely.
A possible alternative can be Showcase, where we regard the render quality to be better than in Navisworks and the setting up of small animations is relatively easy. The only disadvantage is that we have to hand over the data once more to another program, which means that there is a certain possibility that we have to redefine some details (e.g. material and lighting) all over again.

With this task completed, we are ready to produce all needed elements for the new plant!
Libraries and Templates

Templates and libraries are **living files** and they can get updated and grow during a project. Having some main requirements of your company considered in your templates and libraries before you start working on a project will make the further run of the project much smoother.

AutoCAD Plant 3D & P&ID Project Setup

Generally every Plant3D-project in our company is based on a **SQL-server database**. I strongly recommend using a server-database-project if more people are working on it at the same time because you don’t have the high risk of a database crash, and also because the performance is better, even when the data accumulates.

Drawing-Structure

The drawing-structure in the project manager is built up similarly to our documentary system.

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**Explanation P&ID-Drawings:**

If we start a new project with a **completely new process**, of course we create all needed DWGs from **scratch** in the project manager. If we start a new project with a well-known process and **existing DWGs** of previous projects we **copy them into the project and modify** them, even the standard AutoCAD drawings, simply to keep the process drawings together in the. Normally we also update an existing
process flow diagram (usual AutoCAD), which means converting equipment to P&ID-Objects with tag-numbers.

Explanation P3D-Drawings for “Building 100” (the structure in any other buildings is similar):

In “_Gruppe1_100_komplett” all single equipment drawings for this building are linked as X-Refs.

In "Piping_100_NAVIS" all piping files for this building are linked as X-Refs.

In "Piping_100" all single equipment DWGs, also non-P3D-intelligent drawings like buildings and cable trays, which we normally don't add to the project, are attached as overlay-X-Refs.

This effects that in “Piping_100_NAVIS”, which is loaded in our NAVIS-file, you always see ONLY the piping, no X-Refs.

This avoids getting double overlaid objects in Navisworks, where only “_Gruppe1_100_komplett” is loaded for all equipment in this building. We generally don’t want to see X-Refs of the piping drawings in Navis because we got many X-Refs in it and are loading and unloading them all over again, but in Navisworks we want to see everything at any time, so the X-Refs are separately-linked to the Navis-file.

Template DWGs

Paths of P&ID and P3D are stored on the network, not locally as predefined.

For P&ID we have modified the default template so that we can use it for all official process drawings (block flow diagrams, PFDs, P&IDs,...)

We added different-colored layers for different types of media we use to mark the pipelines. The colors and media can differ from project to project and that’s why we don't use default settings or create new pipeline classes with a defined color for each medium. Furthermore, the substituting-function in the P&ID sometimes is not working the way it should, so we think this method is an easy workaround.

We replaced the title block in the layout with our standard-title block including required attributes, and we also made a dynamic block for the frame, so you can easily change the length of the P&ID.

For the work with Plant 3D drawings we have a self-made visual style which performs much better than “realistic”. If you have such a style, too, I would suggest saving it in your template drawing. If you don’t know how to create such styles just look for some AutoCAD-help on the internet. Furthermore, we also applied some minor changes in the templates like “UCS icon at origin=No”, but that depends on your individual needs.
**P&ID DWG Settings: Class Definitions**

When I created the template project I spent quite a few thoughts on class definitions. Due to our company standards and structures that simply don’t really fit to the classes of P3D, we had to do some class-modifications.

Still, the modification of the P&ID is a very complex issue and there are a lot of ways to customize and improve it and I think we still don’t have “perfect” settings, but **since we have the modified settings** and the general workflow has become well-known, the comfort of **working with P&IDs definitely has improved**.

We suggest testing your modifications before you start your project to avoid later inconsistencies.

**P&ID DWG Settings: Annotations as dynamic blocks**

Reasons why we decided to use dynamic blocks as annotations:

- it is an easy way to show things in a P&ID which need not to be evaluated for any list
- the annotations are linked to the base object which makes it easier to move them.
- it is easy to change the type of the symbols or connection lines: via visibility- & stretching-function of dynamic blocks.

Most often we need the dynamic annotations for pumps, agitators or any other special electrical equipment which has motors and an associated instrument symbol. These two parts (**motor- and instrument-symbol**) are dynamic blocks and inserted as annotation of the object. I think this is a lot better than inserting a “real” tagged motor or instrument symbol which is connected by an extra line. Furthermore, these “real” items appear in the lists, but I don’t want to have them listed, I just want to see the function of the equipment in the P&ID.

We don’t need dynamic annotations only for equipment, but also for valves and instruments or any other parts, so we created these annotations **for all classes**. For example, in the left picture you see a “safematic”-instrument which belongs to inline-instruments. In this case you need three further annotations for the correct representation on P&ID. These three annotations display different properties of the symbol they belong to. These properties were added for all classes, so you can use the annotations for every class.
As you have heard before, the structure of the default classes don't really fit to the structure we would like to have. When I began modifying, I noticed that we will have a problem in classifying our group 2 (valves). Plant 3D uses "control-valves" which is generally a good idea, but because of the ensuing two main problems we don't use them:

- We would like to have all valves in one superior class and not in two different divisions, which makes the handling and listing of this group very difficult.
- You are not able to set a control-valve back to a hand-valve.

So we decided to get all our “group 2” parts together in “hand valves”. This set-up took quite a lot of time to create, but now it works very well for us.

We solved the problem of adding an actuator symbol - a task that is quite simple with control valves - with dynamic annotations again. It is very easy to add and to delete and you can simply mirror, stretch or change the symbol of the actuator if you need to. The instrumentation-symbol is the same as used in the previous topic.

**P&ID DWG Settings: Structure, subordination and configuration of the P&ID classes**

The group 2 of our company does not only include valves, but also hoses, nozzles and other special piping parts belong to this group. I wanted to give them some predefined properties, and also because of the substituting-shortlist, I created classes of the same type in one subdivision. It's a pity that moving classes in the Class Definitions is still not possible because that would make changing structures much faster. Instead of moving classes you have to recreate them.

Because I had to create many new classes, I searched for a way to be a little bit faster and I found one that also has advantages for the work with the P&IDs. I didn't create one class for one symbol, I just added more symbols to one class if the symbols are similar. Of course you should only do this if you don't need to evaluate the different symbols in one class because this turns out to get difficult. One example: I have one class for pump-symbols, one class for blowers and one for compressors. All these classes have more symbols which you can easily change over the properties. But if you want a blower to become a compressor you have to use the substitution grip since some predefined properties automatically change.

If you have some special symbols in any division, I suggest creating a class for it and adding the symbol to your tool-palette (more about tool-palettes later). If you like to have a very detailed P&ID I would also suggest creating a new nozzle class, for example threaded or clamped nozzles. I think this is a great help in reading the P&ID but it's up to you how detailed the P&ID should be.
With pipelines we also work in our own individual way. The default pipelines classes are divided into the media, but we don’t want to use it that way. We only use **2 main pipeline classes**: “Pipeline Primary” and “Pipeline Secondary”, these two classes only **differ in the priority of breaking** and the line-weight. There are hundreds of exactly defined medium-numbers we use and they are only written down in a property in the pipeline group. Depending on this medium-number you have to set the right layer to pipeline-segments like this: select a pipeline segment -> select Group -> set layer. That’s quickly done and a better way than substituting the pipeline segments all the time. Furthermore, substitution is not working correctly if a pipeline is connected to another drawing. Or when you create a new project from a template, the substitution-shortlists may not be correct.

In addition we need to use the following lines:

* **Pipeline segments (tagged):**

  - **Pipeline primary**
  - **Pipeline secondary**
  - **Instrument (PIPE-)-Line**: Used for connections between tagged instruments and a pipeline segment. Belongs to the class “pipeline segments” and so they are also a part of a pipeline group. So the needed information (e.g. pipeline-number) can be conveyed to the instrument (Signal lines are not able to).

* **Signal line segments (not tagged):**

  - **Signal Line**: Only used for showing process-relevant signal connections. They don’t convey any information.
  - **Instrument Line (Signal)**: Used for connecting instruments to equipment (only). They convey information like “Instrument-Tag” or “Nozzle-Tag” to get important information in exported lists.
  - **Flowline**: Used for process flow diagrams, block-flow diagrams and any connections in P&ID which don’t get a line number.
Create your own P&ID Tool-palette

Because we have created many new classes and don't use the default symbols only, we can't use the default tool-palettes as well. And secondly we wanted to have the same tool-palette for everyone who works on the network, so we created a new one which is locked for every user and only editable by one user who keeps the tool-palette up-to-date.

The setup of our P&ID tool-palette is similar to the default one, we just adjusted and allocated the symbols to our groups and specifications as good as possible. Symbols in group 1, 2 and 6 (equipment, valves, instruments) are always tagged. Except of previously mentioned lines-classes, other symbols are generally non-tagged. A short description of the function of the symbol can be very helpful, especially for users who are working with P&ID the first time.

If you have problems to get a network-tool-palette simply google the key words and you will find a lot of help on the web.

Plant 3D DWG Settings

Layer and Color Settings

Generally we assign our layer by “Line Number Tag” and the color is assigned by “Service”. The service-list includes all main-mediads which could occur in projects we have to handle. The service-list and the mapped colors are synchronized with the layer and colors we have in the P&ID-template DWG. So if the services are mapped correctly to the line numbers, we see the colored pipelines during piping in Plant 3D and in Navisworks so that we quickly know what a specific line is used for.

Joint-Settings

This point is a very important one for 3D-piping. The settings you make here must correlate with the ones you define for the 3D-parts in your library. If you use only the default spec and there is no need for special requirements, of course the default settings are sufficient and you don't need to make many changes, but if you want to use some special parts with different connection types (e.g. different threads or hose connections…) you have to modify the joint settings. Then you have to think about which connections you will use first and which requirements these connections should have. Of course you are also able to change and add joints even during a project, but that maybe will cause problems which are very time-consuming and therefore you should really think about a flexible, extendable concept for joints.
Here I show you in an example how we use the joint-settings:

The **Buttweld joint** is the most needed joint in our projects because in our case most of the connections are welded. We only allow connections between PL and PL. PL means that only a plain end of a pipe is provided for welding, it doesn’t matter if it is beveled (BV) or not. Generally the required matches of nominal diameter, facing and pressure class apply to all joints we use.

![Joint Settings Table](image)

In this case we precisely define facing: “ISO” to “ISO”, “METIRC” to “METRIC”, “ISO” to “METRIC”, and “Luft” to “Luft” is allowed.

“Luft” means “air technical pipes” and the outside diameter of these pipes never fits a METRIC or ISO pipe since we don’t want this type of pipe welded to a pipe of another spec, so we simply avoid it that way.

ISO to METRIC is allowed. Explanation: the OD (Outside Diameter) of ISO and METRIC are only in some sizes exactly the same. Some fit not at all and some have nearly the same OD, but not exactly. So we defined the nominal sizes of the METRIC pipes, which are nearly the same as ISO, to the same as the ISO pipes have. Those of the METRIC ones which don’t fit to the ISOs have another nominal diameter which doesn’t exist in an ISO-Spec, so a wrong connection can’t happen.

A word of advice: If the program doesn’t allow something in the joint-settings (no digits for facing-matches), open “DefaultConnectorsConfig.xml” which you find in the project-folder and try to adjust the settings there.

**P&ID Object mapping**

We don’t use this feature at the time being because I think that its functions are just not well enough developed right now. You even cannot map a P&ID valve to a block-based Plant 3D valve. Some advanced possibilities, like direct mapping of the spec-number-property to block-components are completely missing. This feature has to be improved much more to benefit from it in practice.

**Plant 3D Part Library**

We share the “AutoCAD Plant 3D content” folder on the network so that everybody can use the same catalogues and has the newest added or modified parts at an instant. Fortunately this issue was implemented in Plant 3D 2012 and you can change the path in the Specs & Catalogs Editor.

**Catalogues**

After we had done our first project with Plant 3D we decided to create the catalogues anew. We divided and named the catalogues the same as in our company structure (as we do it with our equipment in Vault). Normally we create one catalog for each different specification as you see in the picture on the right.
First division: the groups. Group 2 (valves), Group 3 (pipes and fittings) and group 6 (instruments) are relevant for piping.

Second division means “category” and third division means “specification”.

Example: The catalog is named “BIP_3-1-C.pcat”:

3 = group 3 = “pipes and fittings”

1 = category 1 = “standard purchasing parts” (2 would mean “special parts” which are not commercially available, the data-sheet of these parts are a workshop drawing too)

C = specification = “welding fittings” (B would mean “threaded fittings”)

Then every part in this submission gets a serial number.

For standard parts, such as welding-bends, tees and pipes, of course we use the parametric templates of P3D. Our most frequently used fittings are out of the DIN and these parts already exist, so we just copied the catalog, deleted all inappropriate components, renamed the catalog, the descriptions, and added the remaining information we wanted to have.

Of course you don’t need to categorize your parts and catalogues like this and could instead put all parts in the same or few catalogs, but it simply gives you a better overview and it also makes ordering easier. You want to order “threaded fittings” from one and “welding fittings” from another supplier for example. If you have a structure like the one we have, you can easily filter these parts and create the order-lists, the parts are even in the same spec or same class (e.g. elbows). Otherwise you have to export a collection list and pick out every single part because you have no other chance to distinguish them unless you allocate the component-groups specific information. Furthermore, the internal serial no. is very useful because you and everybody else sees it in Navisworks over the quick properties, so that you exactly know which part it is. Even in the isometric the internal serial number for every part is shown, what clearly retrenches the selection-options on site.

If it’s possible we therefore use the parametric templates from P3D, but if you have some unusual parts - especially valves - we use blocks. Compared to the version two years ago, when you even couldn’t copy a block-based component, Plant 3D has been improved a lot.
One big problem we still work around is the actuator of valves. You still can’t rotate them, and that’s a hassle. I hope this drawback gets solved in the near future.

So there only remains the possibility that we create blocks for every actuator position. That means you have to create many blocks for all your different possibilities of valve-body to actuator-position.

That further means that we add every size four times for the four actuator-positions 0°, 90°, 180° and 270°. Via the long-description we can differ between the positions. (Here it would be great to have the possibility to add properties manually, also for giving the parts some other special size-information). So when we order the valves we can arrange for the actuators to get completely mounted to the valve so that we can save time on site.

Another big problem, or let’s say missing feature, in the catalog-editor is that you can’t create instruments. So if you want to use instruments I would suggest creating a new project-drawing, which you use as a catalog where you store the instruments you made with the custom-parts builder. But you have to pay attention when you create reports because these parts also will appear in the lists.
Pipe-specifications

When you have your catalogues or even the parts you need finished first it’s time for the pipe-specs. Creating specs is rather simple. Of course first you have to define your spec with including parts, and then you add them to the spec, set the “part use priority” and the branch table, and you’re finished. Then you should test your spec in the project, and not until then you will see if you did a good job. Because, as I mentioned in the previous topic, the joint-settings in the project and part-settings in the catalogs must fit together, otherwise you will see it at this point (e.g. if anything can’t be connected). Especially if you put more parts than usual in a spec (for example you also add threaded fittings), it’s more difficult to configure the spec so that it acts the way you want. Therefore I have to stress again that is very important that you know what you want and how you want to do it, before you start on big settings and part-creation.

Often some of our specs only differ in material, pressure or elbow-priorities. Therefore we decided to give the usual parts no material and wall thickness because you always get this information within the spec. That means if your pipe-specs are nearly the same, you best create one, try to perfect it and then copy and rename the spec.

Use specs for hoses

In earlier times we also had the problem of making hoses. We solved this problem by using custom-parts, but that wasn’t exactly brilliant. As it’s common in plant-engineering, you will have to change details once in a while. That means that you also need to change your hoses. As the custom-parts are fixed, so you only have the option to create a new custom-part and that’s very exhausting. So recently we decided to create pipe-specs for hoses.

We create one pipe-spec for every different hose-spec. It is really comfortable “hosing” because of the new pipe-bends-function you don’t even need any elbows in your spec. Unfortunately you can’t assign a tag-number for a group of pipes, which we would need because every hose gets a tag-number (as usual for group 2). But you can simply evaluate the length of the hoses and in Isometric you only have to do some modifications for the right representation. Therefore we think that’s still the best way to create hoses in Plant 3D.
Conclusion

You've had a chance to get a quick look about our way of setting up a “BIM-Workflow” for modeling chemical plants with several Autodesk products. As you might already have experienced there is no easy way around. It is still very hard to link different platforms together to have a consistent model. We are very excited how the BIM-Workflow will develop, as we see some big problems are still to be solved.

We hope we could give you some new aspects and maybe some inspiration to make your daily work a bit easier!

For more information and questions feel free to contact us!

Thanks for attending!