Conditions for the practically oriented Construction and the Production of (Heat Exchanger) Tubes

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1. Introduction

The philosophy is:
To automize the process of work - as far as it is economically acceptable.
To make the worker on its working place the material with less expenditure available.

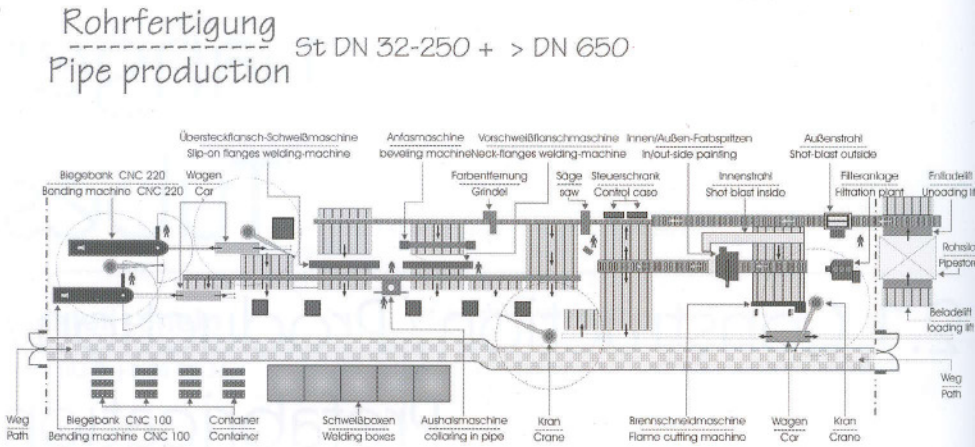

Figure 1: Logisticscheme

The user wants his problem solved in a fast and cheap way and he has got the thankless duty to search a path through the „jungle of solutions".
The complexity of the area of responsibilities makes the user it hardly possible to solve all unusual tasks.

A software-solution should unite the areas construction, simulation and production. By it ideas can be checked in a better way of profitability.

Programmes help to minimize mistakes in calculation, breakings of the tools (e.g. at the collision of a bending machine), collisions of the pipes among each other and other corrections. Analysis, if it is possible to produce, are in the run-up to the production possible.

Further production date limits will be fixed for a shorter period.

The pre-production becomes more precise and obtains constructively over 90 % of the whole tube-production. By measurement of the pipeline the share of the pre-production can come near to 100 %.

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Software, meant for a special solution of problem, contains often benefits in speed, quality and settling-in period. This cost saving should not be underestimated.

There are for all areas - planning, construction, production, mechanical control, fitting and statement - a lot of programmes. Each of these software-products contain one or more sub-programmes to realize the different tasks.

It is true the small solutions seem cheaper than an extensive system, but the costs of a single system will be added up very fast (especially inclusive support).

Bigger systems give for the most user a general solution, as they assist the planning, construction as well as production. Interfaces between the single programmes are not necessary anymore. Messages of change are general for all areas. A system with an integrated data bank is in a position to retrieve all information's only from the data of the isometry, to analyse and to produce targets.

Specialized on pipeline building and grown through longstanding use software gives here an extensive and effective solution.

2. Arrangement aspects of the logistics

The coarse criterions are known:

- quality of products
- price
- delivery time
- delivery truth
- flexibility

It is clear, many other assessments are necessary.
So e.g. data-, interface-, control-quality, time for staff and machinery.

It will be used:

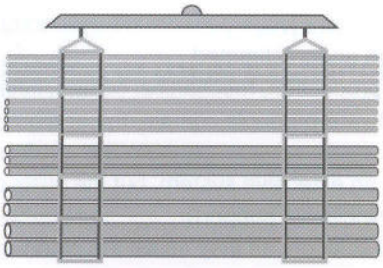
- software solutions
- automations
- control of the way of material

It will be needed:

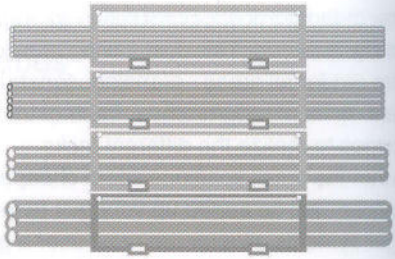
- control of staff
- sequence of operations
- feedback from production

Investments in machinery and software are useless, if the employees will not be motivated and activated. This will be achieved by realizing the ideas of the employees to a better sequence of operations.

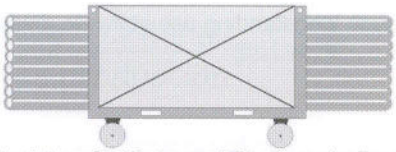
Quality improvement and saving of time by making the products is possible.
The economic efficiency of the company goes up.



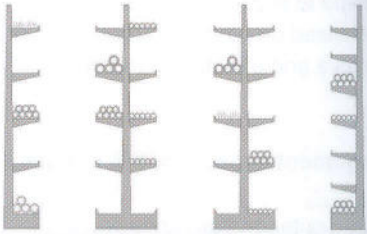
Container für Kranentnahme
Container for crane removal



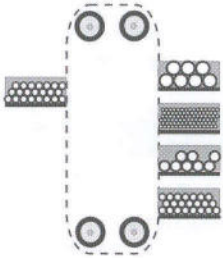
Container für Kran- und Staplerentnahme
Container for removal by crane and fork lift truck



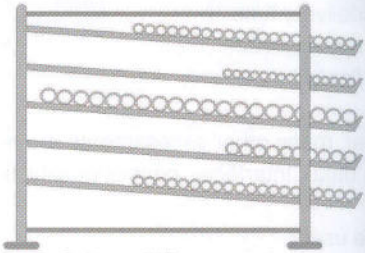
Container für Kran- und Staplerentnahme
Container for removal by crane and fork lift truck



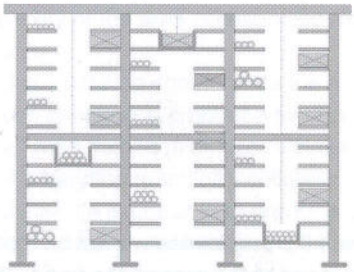
Ständer für Hand- und Staplerentnahme
Stand for removal by hand and fork lift truck



Paternoster mit Kasetten
Paternoster with caskets

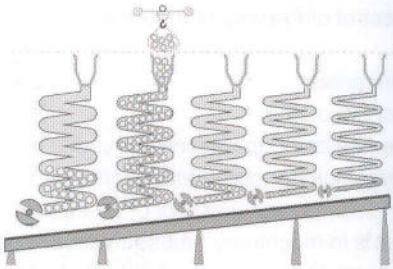


Ablaufschräge mit Zwangsentnahme
Slopes with forced removal



Kassettenform, Kopfentnahme
lose Über- Unterentnahme

Form of caskets, frontal removal
Lose upper and lower removal



Wellenschräge mit Zwangsentnahme
Serpentine stope with forced removal

Figure 2: Tube storage

The storage of the tubes should happen in fixed lengths and dependent on the material. Flanges and fittings get a separate storage place. Screws and seals go to the ware house. Order, receipt of goods and storage are supported completely by the program.

The requirement of place for the individual tubes results in the diameter, wall thickness and kind of material. The amount is decided by the constructive requirements.

The average cut-length of the tubes plays a decisive role for the cycle time of the intervention on the tube storage.

The material should lay under a roof, but not in the work-shop. The central office gets information about the stock.

3. Cleaning of tubes

Alternatively shot-blast or acid treated tubes can be used.

Proceeding on the assumption that the tube is rusty and scaling we have to make the conditions for a quality-conscious work.

Sandblasting removes rust and scales because welding, sawing, flame cutting, bending and deforming is more save with a shot-blasted tube.

Now there is only the choice between several tubes or a single tube.

Several tubes

Several tubes will be straighten coarsely on a roller-conveyor. The tubes are taken to equal distance with different combs according to the diameter. The shot-blasting process works

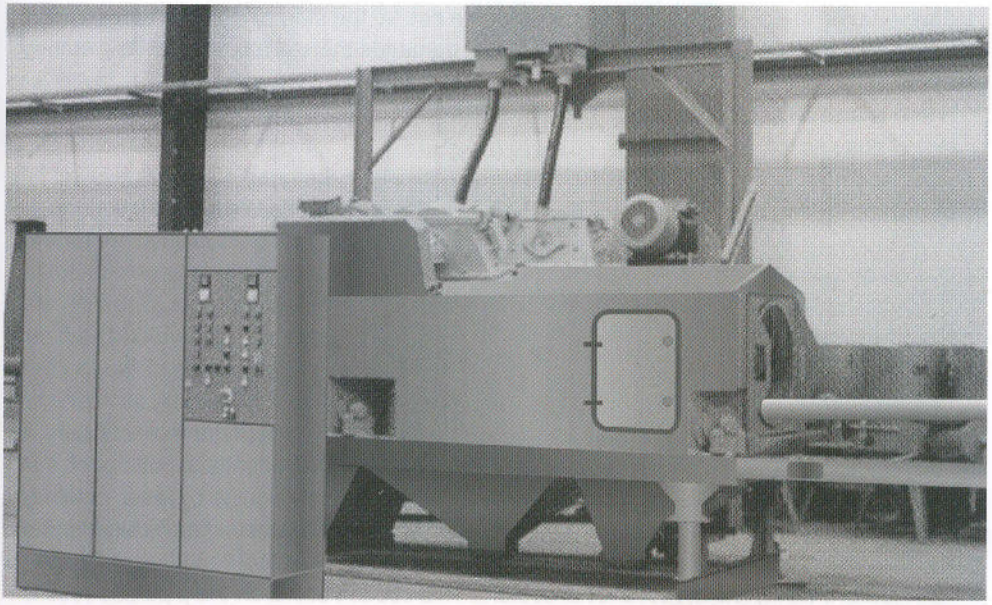


Figure 3: Single tube cleaning apparatus

here with 0.6 - 1.6 m/min in each case from the top with 2 and from the bottom with 2 centrifugal wheels, although the tubes are not symmetrically clean all around.

Disadvantage
- intensive on staff
- granule stay in the tube

Advantage
- greater amount of tubes after a suitable time
- other components (flanges, fittings) can be cleaned too

The shot-blasting process works here to up 40 m/min, in doing so with 2 centrifugal wheels. According to the task both kinds of machines can be equipped with more centrifugal wheels.

Advantage
- symmetrical quality of the surface
- rapid pass, shorter cycle-time
  - DN 40: 32 m/min
  - DN 300: 5 m/min

At single tubes a rest of granule can be automatically removed out of the tubes in 1 min.

4. Cutting, sawing

Not considering the quality and the diameter at the cut, so the stamping of the tubes on the length is the fastest way. Because of the different demands there are corresponding cutting systems.

Here is a small selection:
- circular saw
- Band saw
- flame cutting
- plasma cutting
- laser cutting
- cutting head
  - tube turns
  - head turns
- stamping

The CAD-system makes a prepared and optimized sawing list, on paper or more modern on the monitor.

The sawing becomes more and more coupled with automized signing by laser, colour or labels. The sized tube, transporting to galvanize, gets a stamped sign , which is legible after galvanization too.

Generally it will be sawn with a lot of coolant. This coolant sticks on the pipe and results in mistakes at later welding.

It is advisable to take maximal one spray-film on the saw blade at tubes which has to be welder later on.

The band saw (picture 4) can treat economically the greatest diameter-area and works in the upper price range with a good cut exactness. Tubes with a higher wall thickness strength can be bevelled, picture 5, fully automatic with the scanning of the inner diameter, picture 1.

With these automates, picture 5, an improved joint preparation for plasma welding of the tube queues, picture 9, can be reached.

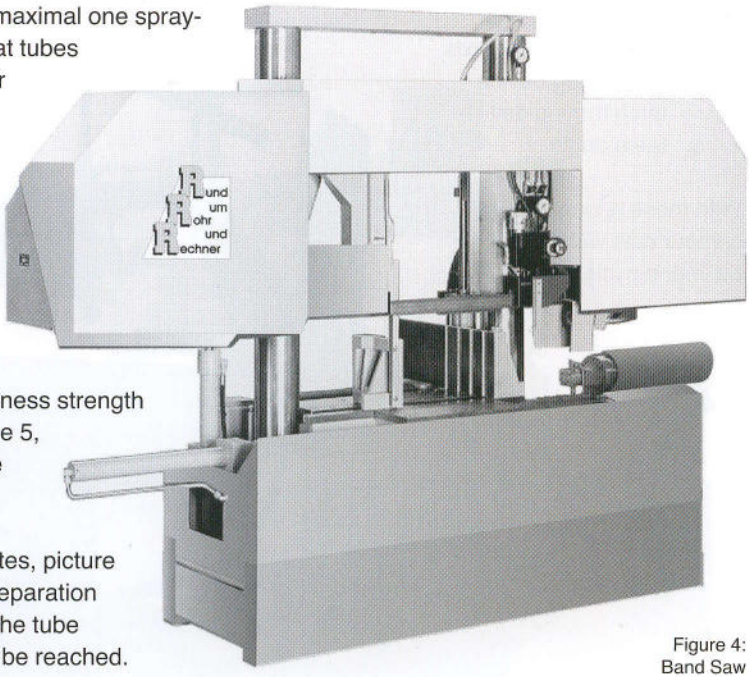


Figure 4:
Band Saw

5. Flame cutting

The tasks, which can not be cost-effectively solved by sawing, will be flamcutted. Here is the advantage that contour- and bevel cuts can be handled fast and simple. To meet all requirements flame cutting and plasma cutting should be possible. The data are coming from the CAD-system and require no further calculation and check up. In the CAD it will be adjusted too for which DN´s the cutting is admitted or possible:

The machine should have at least 5 axes movements:

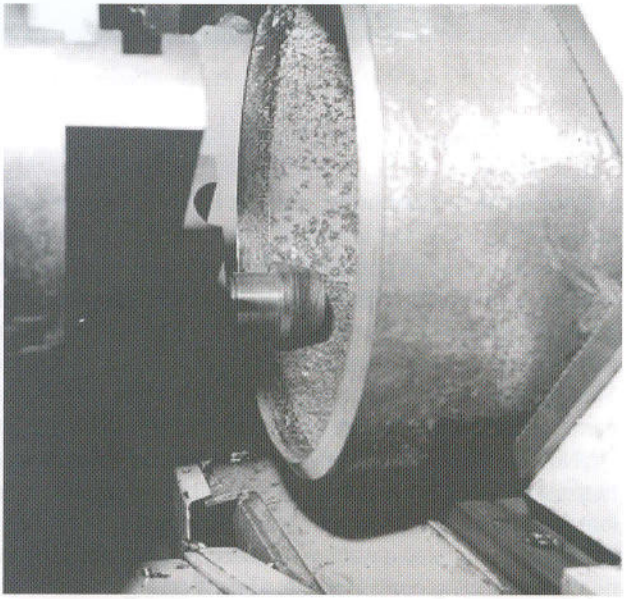


Figure 5 : Scanning of the inner diameter

1. tube rotation axis
2. longitudinal tube axis
3. torch lifting device
4. torch turning device
5. torch angle

With these a longitudinal, contour cuts with bevel can be in one cycle.

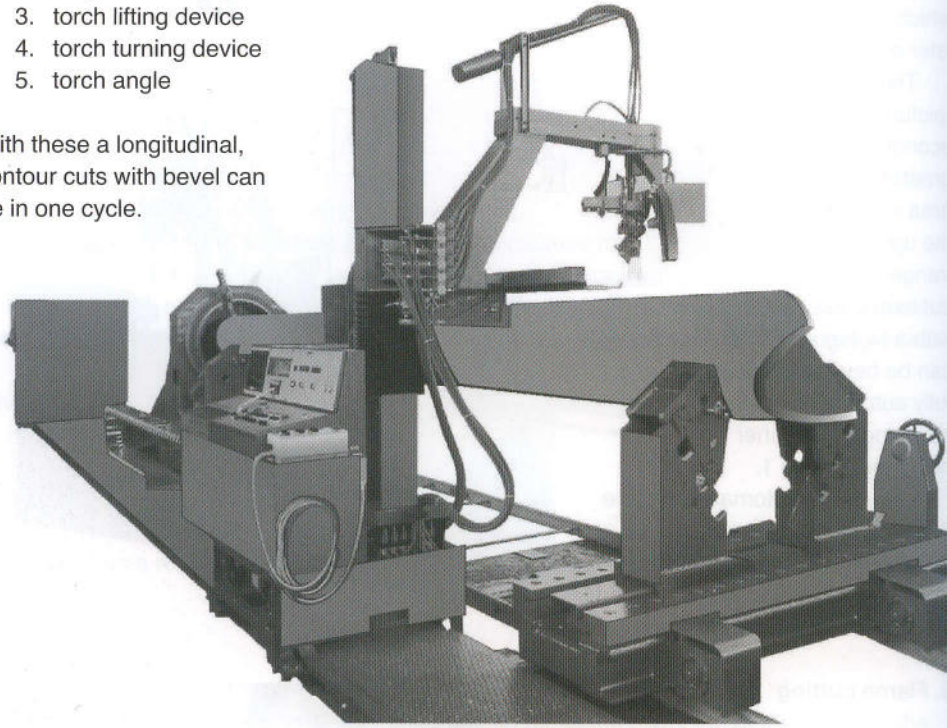


Figure 6: Flame Cutting Unit

6. Tube bending

Tubes can be bended with or without flanges. The advantage of the tube bending is there are no welding joints and it is cleaner and faster. The disadvantage is the rarefaction of the outside tube-bow round about 6 %. Bending radii smaller than 1.5 * D are hard to produce.

There are bending machines with great differences in prices, about 40 different producers, electronically or mechanically controlled, with the possibility to process different outside diameter and wall thickness.

The question is, which concept will be used? By working with flanges the cheapest production is to weld the flange at a straight tube and to bend it later on.

Note, by bending have to be 2 holes above (picture 12) because the bending machine has got its taking up 1 hole above. For that purpose a calculation is needed, so that it not look like picture 14.

The bending spike will be greased, therefore there should be a great grate and underneath a collecting container. Here is a washing machine or steam cleaner to dispose the grease before further processing.

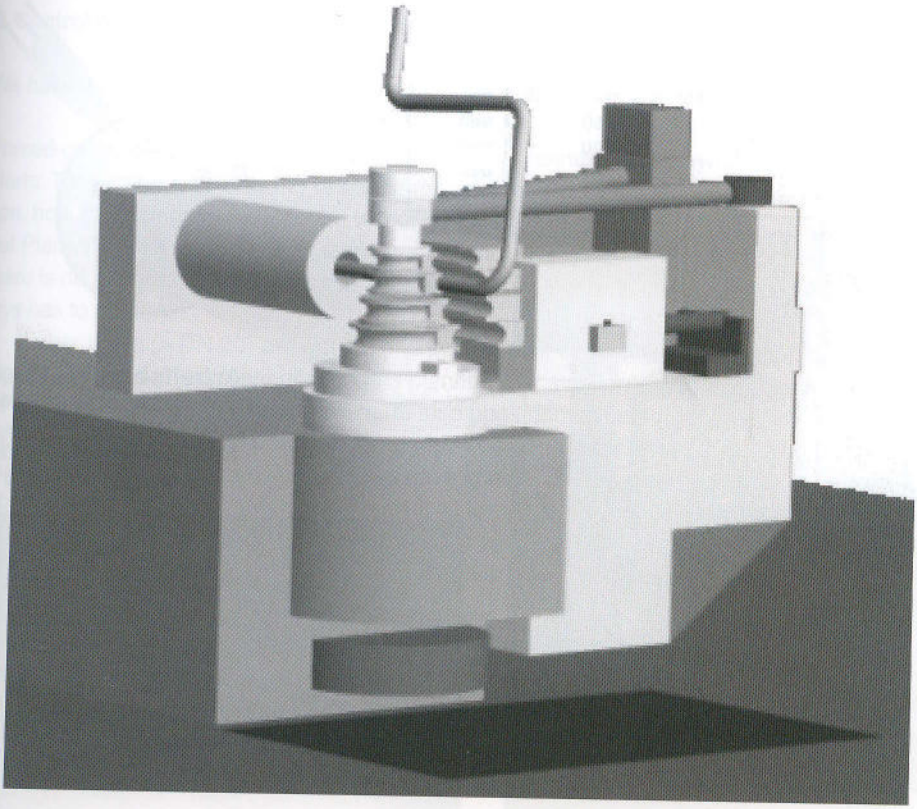


Figure 7: Tube Bending Unit

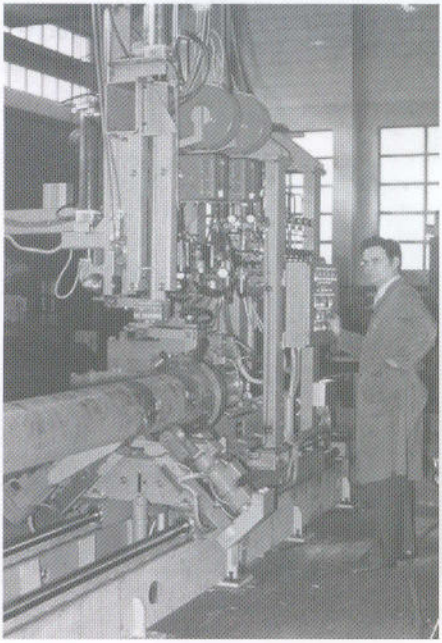
7. Connections

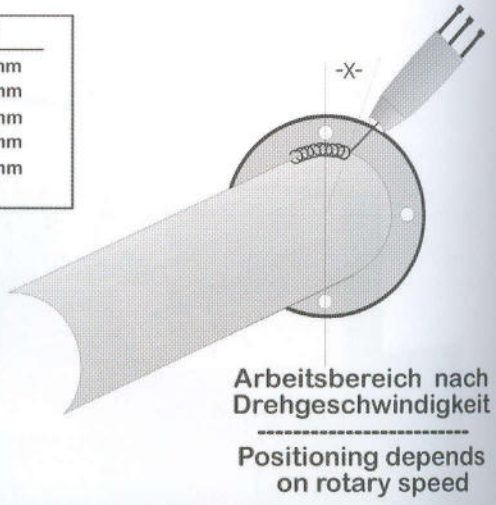
Similar to flanges there are different applications too for couplings and welding joints. The most application area is at the pressure-step to 16 bar.

Slip-on flanges, picture 8, and neck flanges can be up welded automatically, in doing so the inner welding seam is the sealing seam and will be finished first. The outer seam is used for stability and should be welded twice from DN 100 up. Depending on not round tubes and tolerances in flange inner diameter the gap between tube and flange can be to big for one welding seam.

Although there is a tendency to couplings now. Here are advantages in weight, working time in the work-shop, fit exactness and installation time. Difference in prices between flanges an couplings can be compensated by this, in doing so at couplings too are great differences. A difference of the couplings is the deformation of the tube with groove or without deformation.

DN	X	DN	X
25	10 mm	100	16 mm
32	11 mm	125	17 mm
40	12 mm	150	19 mm
50	13 mm	200	24 mm
65	14 mm	250	29 mm
80	15 mm		





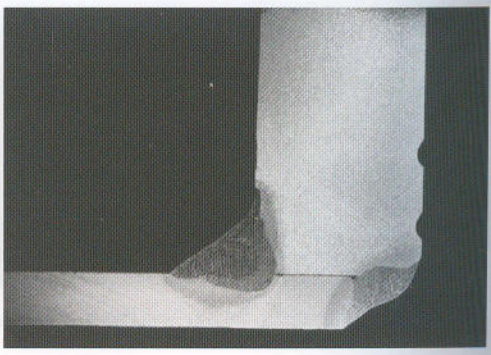


Figure 8: Production steps

8. Kinds of production

Looking at a company where each part of tube for the production looks different.

Tubes are neither straight nor round or welding technically not clean, caused by rust, tinder, wax or grease mistakes can happen.

To clean before or after the cut is a decision-conflict.
Quality improvements like the same tube length and end-parts without damages can be bought for a higher price. According to the purchase quality it is advisable to clean or shot-blast the tubes.

If the tubes are treated chemically, the conditions from the government are very high. Clean tubes make the work in the company easier, improve the quality and increase the throughput.

The ware house (with material for one week) should be able to be loaded in an easy way, so the supplier cannot calculate waiting timer.

9. Control of the company at production of component parts

We have to distinguish between working by diagrams net plans or a forced-control.

Forced-control means, the constructor, foreman or planner decides, when the production starts. The worker gets only the released material in a special sequence. There is the question, how the material will get to the working place. By using forced- control, diagrams and net Planes are not necessary by using cranes and all individual Transport systems for tubes there is no material flow. In this case a lot of compromises with containers and transport trolleys has to be done.

Bigger tubes (> DN 20) are moved mainly with their own roll-energy. As intermediate storage are tables with different pile-lengths planned, because during production different times on the working places are needed. There, also plate conveyors for tubes with flanges, and roll (-on) passages, roll-chains, and lifting gears used. In the internal area lifting traverse, chain conveyer and suspension railways have special advantages especially at bended tubes. The advantage of suspension railway is for transportation bulky components (e.g. bended tubes, tubes with welded flanges, tubes with turn offs and other fittings). Component parts with lengths from 0.6 - 3.5 m are the greatest part of the pre-production.

Because our logic says:

- In the work-shop is the most expensive storage
- Work-shops with a great machinery work in several shifts

10. Practically oriented construction and production of tube-queues

At the point of view „erecting drawing" and „way of material" the conditions for office and work-shop are made to solve this task.

Here an example: for heat transfer tubes are bended in different kinds of queues (see e.g. drawing). The basis in this example are tubes with length about 6 m (the system can process any length precondition). A hole length about more than 150 m can be necessary. The cutted and cleaned tubes will be bended in a tube bending machine with given data and next automatically welded (in ORBITAL-welding method). A pressure-test follows. The transport is made by lorries with a maximal loading area and arrangement. Because the shapes will put out appropriate to the border-measure and weight, there are no problems at loading.

We can determine with the below described CAD-system an automatical, logical distribution at maximal tube length. Basis here are the lengths by buying of the tubes and the bending machine. Here is specially mentioned, tubes with stores (like H in picture 3) do not become plan-parallel because of the heavy-weight and mass, if the moment of inertia and torsion will not be considered before. The integrated tube bending collision check up makes the definition of the tube length with different queue lengths possible. An assignment will be erected and by labels on the tubes (to fix them on the tube, which can be stamped or inscribed too) the assembly is to spot. On the saw, fitted out with a computer, an optimised cutting list will be transmitted by the network. Hereby a minimization of the tube rests will be reached and the level which is worked off will be shown.

Figure 9: Example for a system that divides automatically a whole register in to bendtable parts

11. Marking of locality

For different tasks and product section it is necessary to put markings, so for pipelines too, with it the room in the co-ordinates-net is exact. On the other hand such a system can pick up a small part of the model tubes too. It will be inserted in chemistry and shipbuilding. Considering the heat tolerances in a section-production and the assembly, so an additional depersonalization is necessary. But this means too, the man installing the machinery puts on the machinery not at measure, but on a stable ground.

12. Software

There is no software granting all wishes of the customers; this is because of the different structure of companies impossible. But a few systems are extremely adaptable. These adaptations have to be done! Here the time of adaptation and above all the variety is often a not to underestimate problem and cost factor. Sometimes a single adaptation in the software-house is cheaper and more effective, because the end-user gets exact operation-/output-wishes granted. Time- and cost-savings are the advantages of this procedure. Potential sources of error will be eliminated in an early stage. Especially effective are continuous systems under Windows, from pattern CAP, construction CAD, production control with machinery control CAM, fitting supervision CAQ.

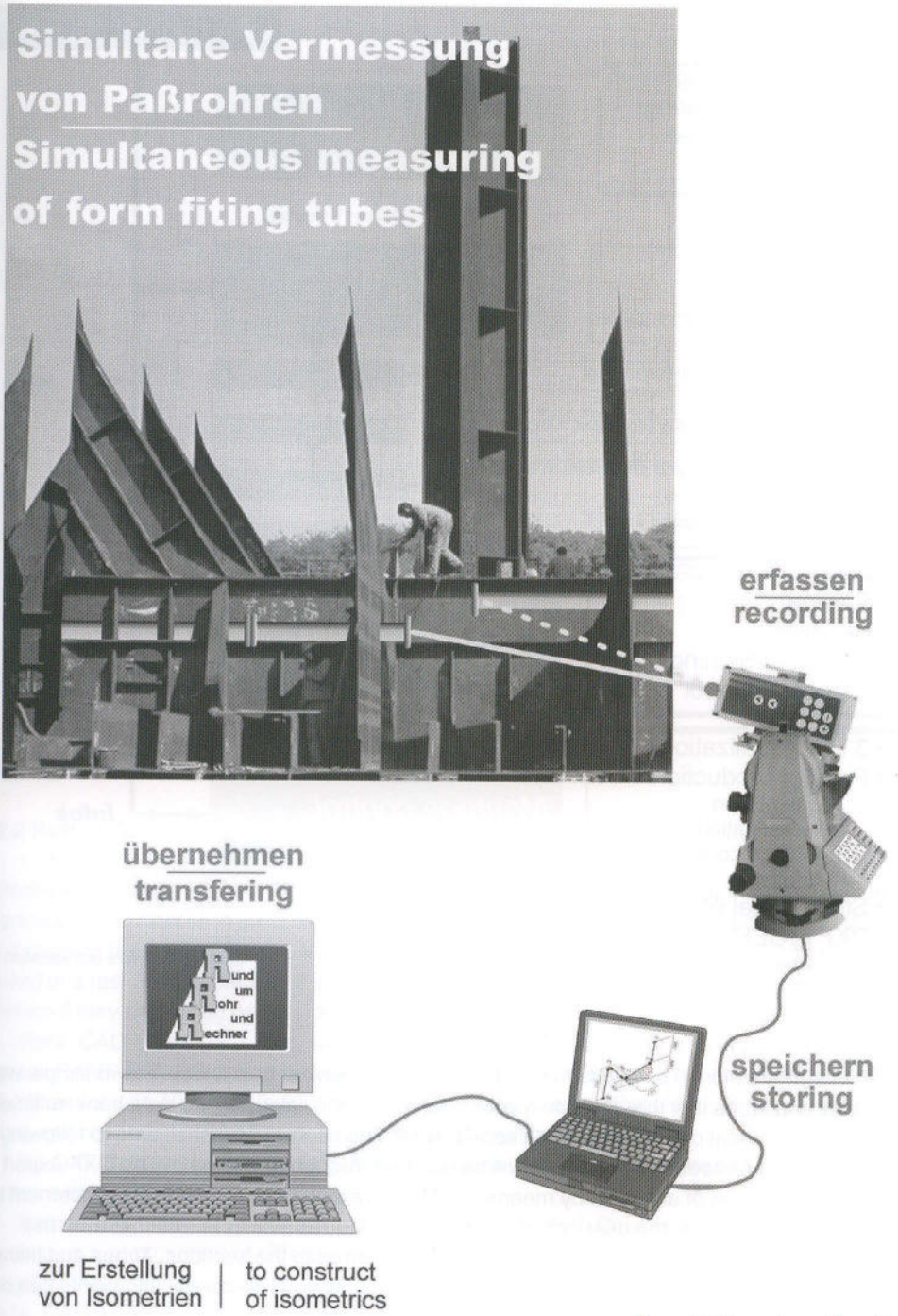


Figure 10: Measuring configuration

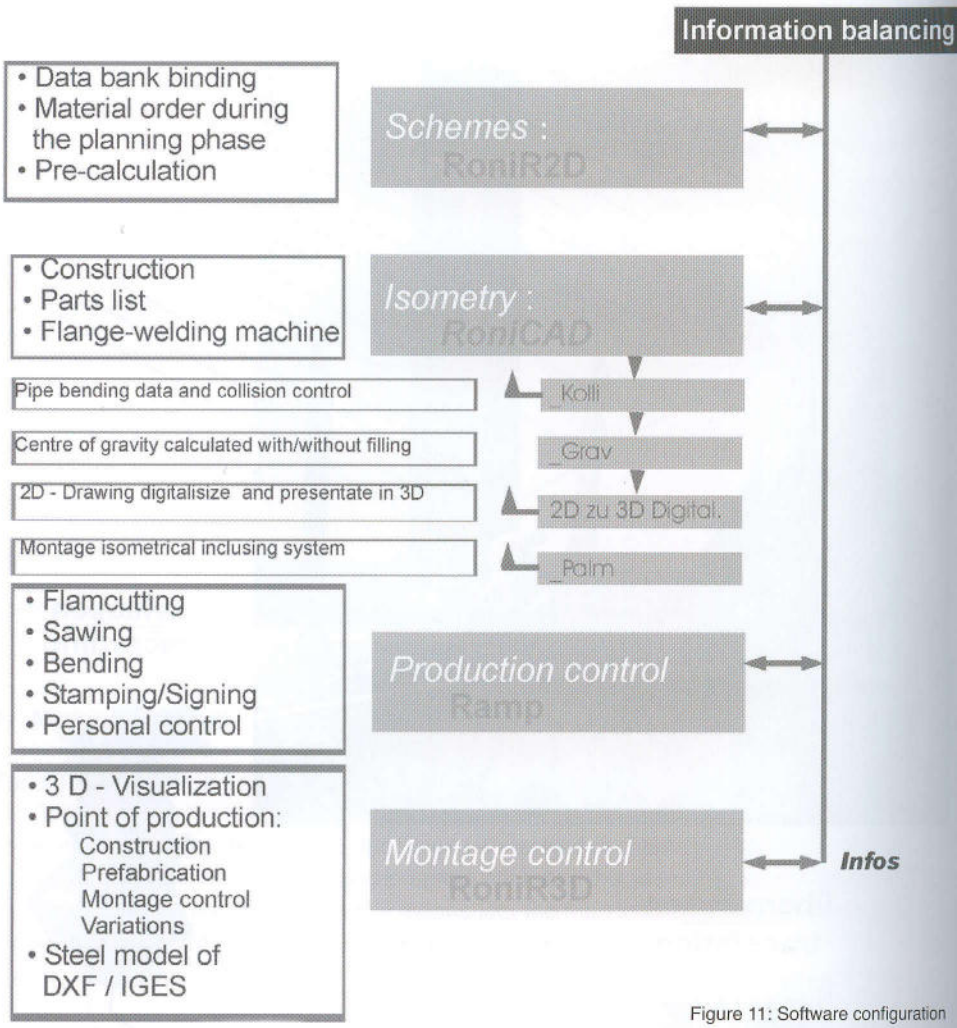


Figure 11: Software configuration

12.1 RoNi_R2D

The pattern-erection in conjunction with the RoNi-data bank sets in a well-known simple wa symbols and tubes in a true to scale representation. By the link up to the data bank sufficien erection of material can be made on a sooner time. The general flow of all data to following systems is guaranteed. Modifications will be pursued through all systems. The DXF-export makes the erection of a pattern by means of a DXF-drawing possible. The announcement in system-classes makes the user only these fittings and tubes available, which are for this system-class admissible. Parts lists can be output referred to the sections. Tubes and fitting will be automatically numbered. Symbols with as many as you like connecting points can be produced with RoNi_R2D own editor.

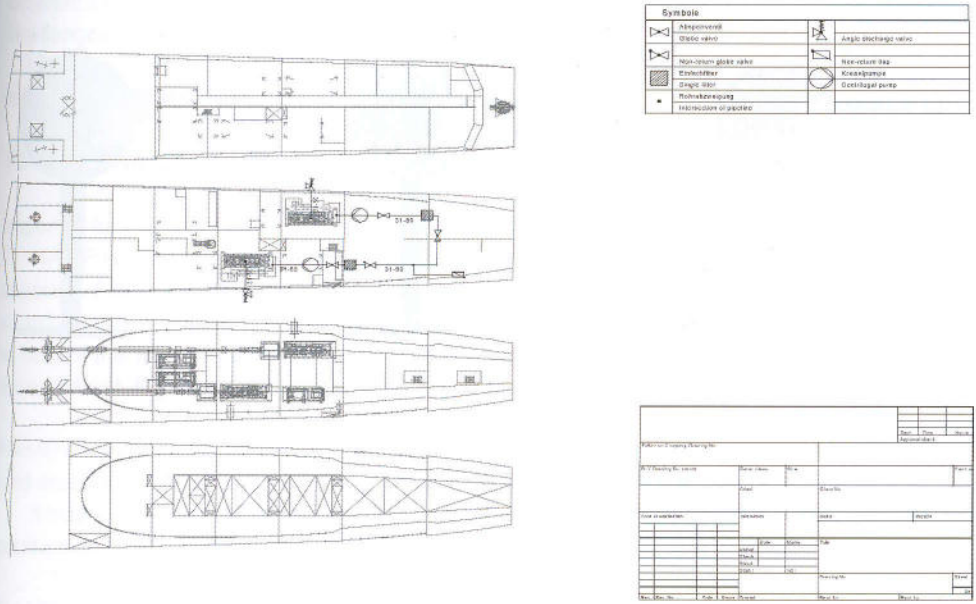


Figure 11a: Example for software application

12.2 RoNi_CAD

A high-performance 2D- and 3D-construction platform with data bank. The input is made by Cartesian co-ordinates in six directions. RoNi_CAD can digitise true to scale 2D-DXF data and convent them into 3D-data. KOLLI is integrated, so complete constructions can be tested in a fast and simple way if it is possible to produce them. The logical test checks isometrics if they are wrong or missing component parts.

RoNi_CAD erects parts lists, sawing lists, burning lists and bending lists or hands over its data to RAMP. Isometrics can be erect proportionally as well as no scale. So pipelines can be represent with elements laying narrow in one place in an optical clearly arranged way. Long and not problematically pipelines (picture 16) will be contracted.

3D-DXF-data will be read in (e.g. buildings, ships, vehicles) and represent all these together with the pipeline.

Data for the different machinery control will be calculated. Causes lightenings for the work-shop e.g. by output of different list information, calculation of pricks, calculation of the length of the welding bows and Tube-beading-calculation.
RoNi_CAD works for the trade and industry.

Figure 12

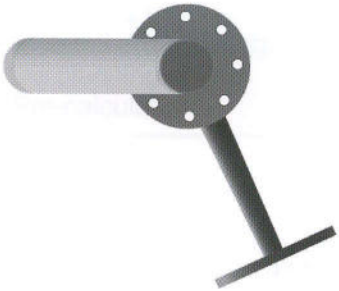


Figure 13

Figure 14

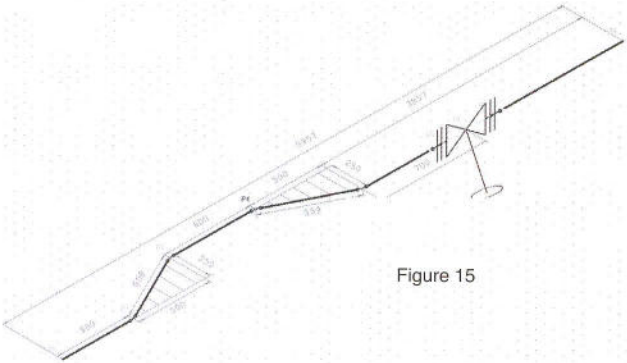


Figure 15

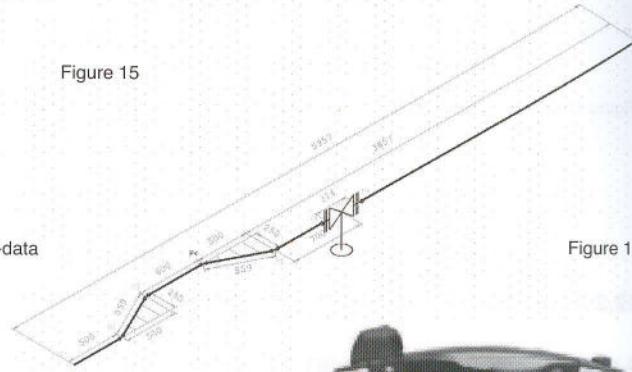


Figure 1

Figures 12-16: Examples for 2D- and 3D-data performances

12.3 RoNi_PDA

Is made of a mobile pocket device (13 cm x 8 cm x 2 cm) as well as software.

It is a installation-receptive-system for pipelines and uses as a simple feeder for RoNi_CAD or other systems.

The system makes by measurement of pipeline the erection of isometrics possible.

The input will be done by Cartesian co-ordinates in six directions. The graph shows in a three-dimensional way as a line. Set lines will be measured automatically.

Different symbols are available for the user. There are symbols for the tube separation like flanges, tube-markings for other elements, valves, pumps, reducing, turn-offs.

Text can be set on the pipelines. The data output will be in ASCII-format and a neutral median line is output too.

12.4 RoNi_RAMP

Import of tube isometrics from RoNi or unknown systems.

RAMP is a programme for production control and erects production-packages for a special period. Filters for contract/order, job, date, building group or model tube make the individual erection of packages possible. It sorts and optimises for the different machinery. It is able to control the whole machinery in the work-shop or to give the worker the appropriate spreadsheet. It gives re-massages to the central office.

RAMP should only be used from one position. This central office has got all rights for change and erection of the packages, further user can have a look at these data.

It makes suggestions for scheduling and the production target and calculates the state of production.

RAMP makes variants of operating time determination available.

1. To the different nominal widths an experience time value per meter will be added to each tube class.
2. Each element in the data bank has got a time value, at the tube are special tactics used.

Additional statistics:

- In determination of the capacity utilisation of machinery
- In sum of the elements by DN
- In tube consumption by
  - order / contract
  - time
  - kind of material
  - diameter
  - thickness of the side.

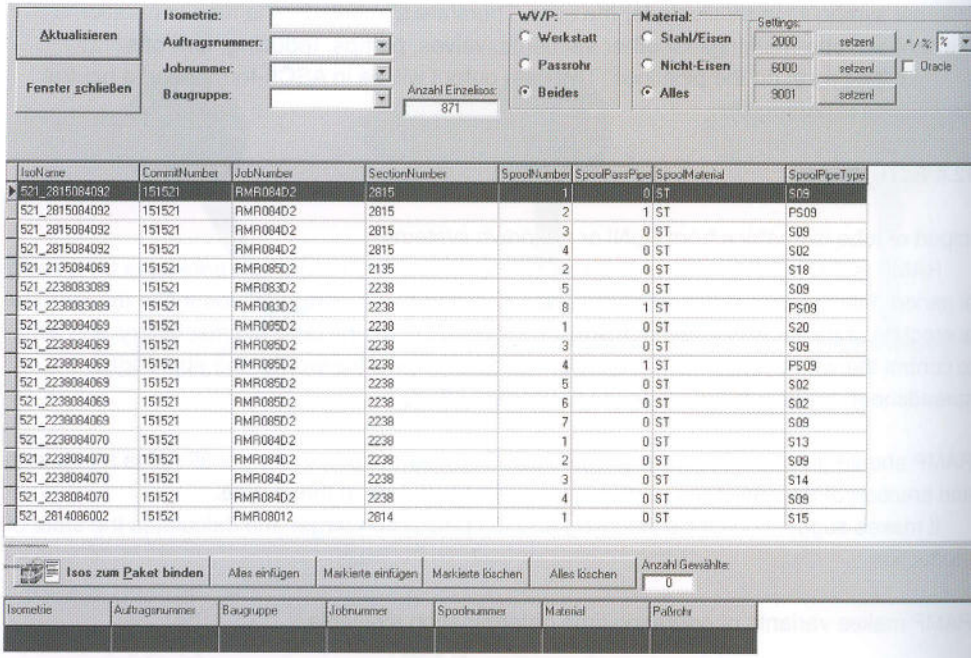


Figure 18: Example for desk-top presentation

12.5 RoNi_R3D

The state of production will be shown in real transparent 3D-surroundings (Figure 19). The actual and target position is also in the CAQ-valuation. The steel construction and the pipelines can be shown by different views. In this connection the production-positions from scheme, construction, pre-production, fitting and changes will be displayed in different colours. Building groups can also be displayed in different colours. Each element can be chosen by using the mouse in the 3D-representation and shows its basis data. The all a-round view of the tubes can have great advantages for the assembly at going round the pipe.

12.6 RoNi_KOLLI

KOLLI is a bending simulation programme to check the possibility of producing of several tubes on bending machines (Figure 7). In a CAD-system integrated complete tube systems can be checked.

At appearing collisions the programme makes suggestions for solution, e.g. if it will be bended from initial- or end-side of the tube. If there is enough space between two bows the tube will collide during the bending process with the machine, earth, building or things like that.

It calculates the bending data and shows the mistakes. The whole bending process can be (optical) shown, ruled and stopped.

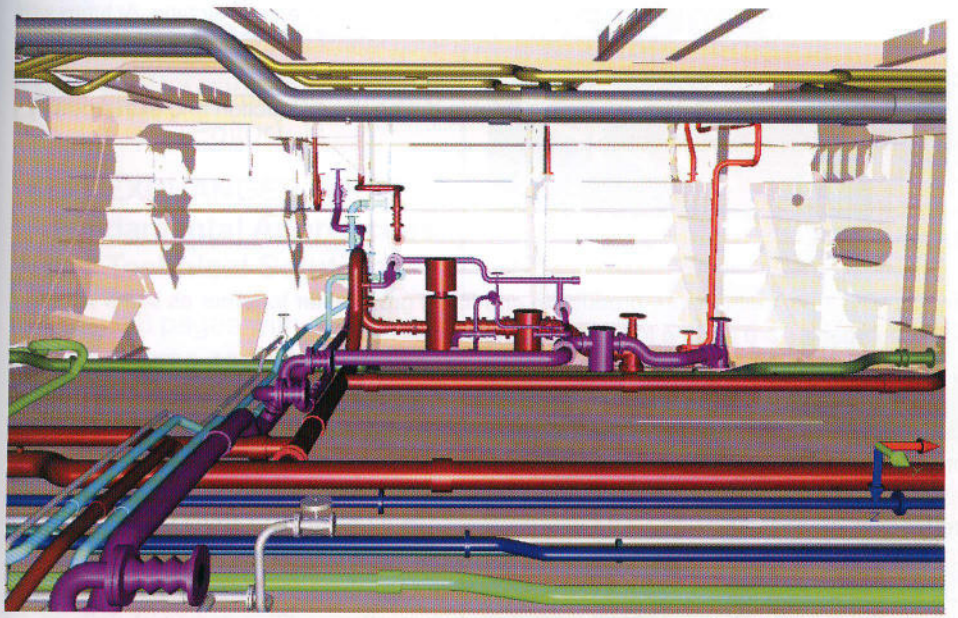


Figure 19

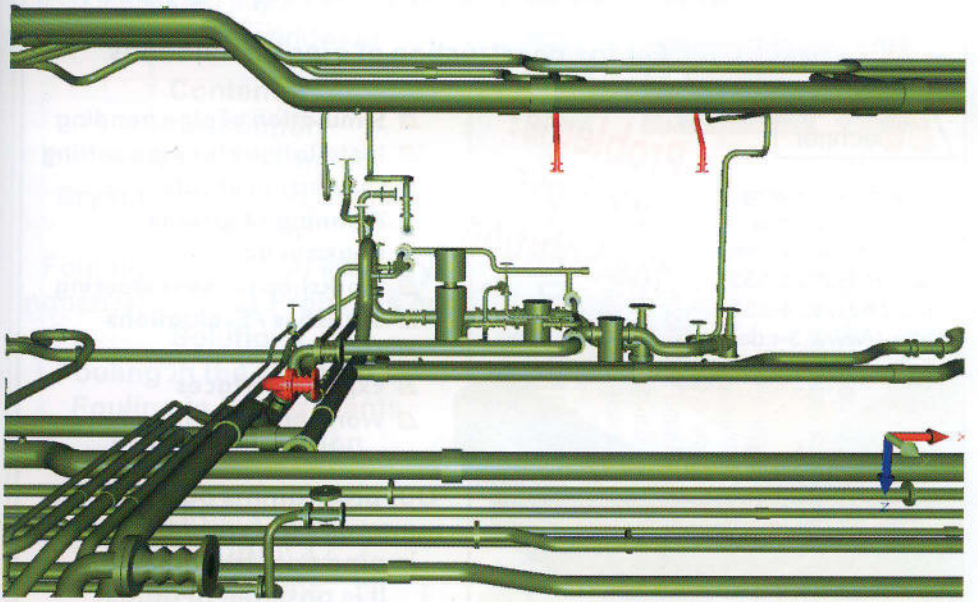


Figure 20

Figures 19+20: Bending Simulation

KOLLI calculates the sawing-length as well as the over-bending and stretching. At tubes with two flanges the position of the flanges will be calculated, with it always after bending on both sides two holes are above (Figure 12).

The tube bending simulation avoids big trouble during the production and extra costs by exact calculation and representation.

13. Conclusion

The planning, construction, pre-production and fitting grow faster together as some will see. A lot of companies are looking for a great system.

Other companies are in preparation to produce without paper.

Some stake on a super computer, the others have got a programme, which is very many-sided. Many-sided by meaning of mechanical engineering, electricity, building of apparatus, house building etc.

Desirable is a system, which can treat a (special) field (here tubes) and has got working interfaces to other systems.

All systems should be compatible and general from planning to fitting.