SAVINGS IN SHIP PRODUCTION USING TRIBON

Tom Lindberg, Naval Architect, MSc, Senior Consultant
Tribon Solutions AB, Malmoe, Sweden
tom.lindberg@tribon.com

Sivert Jörud, Naval Architect, MSc, Area Manager
Tribon Solutions AB, Malmoe, Sweden
sivert.jorud@tribon.com

INTRODUCTION

The purpose of this paper is to present an overview of the areas where Tribon contributes to practical cost savings in ship production. The paper is organised to describe the savings in three main sections.

Two that cover the main phases of production

- Part Manufacture
- Assembly

And a final section that covers more general issues

- Other Area of Savings

The paper describes all areas of Tribon that lead to savings in production at a shipyard. However all shipyards will currently have a production process with very different characteristics and performance levels, therefore this paper can not specify the exact savings that can be created at any shipyard without knowledge of the current production process. The paper should be used as a guide to identify areas for investigation at a shipyard, and to compare the current process with that promoted by the use of the Tribon system. Based on this comparison the actual potential savings at any shipyard can be evaluated.

However, our experience from shipyards where Tribon has been implemented, even in the most efficient shipbuilding companies, shows that major savings in production can be achieved. In general these savings can be in the range of 5 to 15% of production costs depending on the starting point.

Within the Parts Manufacturing section the savings areas are

- Better fitting when parts geometry is adjusted for production
- Higher design maturity before start of parts manufacture
- More efficient manufacture by ensuring parts are suitable for production machines and facilities

Within the Assembly Area the section savings areas are

- Better assembly process control
- Better and easier fitting of parts
- Increased pre-outfitting in assembly due to specific documents for each stage of assembly
- Welding savings
- Use of jigs
- Use of control information

Within the Other Area of Savings section the savings areas are

- Less Rework due to more efficient process in parts manufacture and assembly
- Improved worker efficiency due to simple and clear production documents
- Less excess material because of accuracy in parts manufacture and assembly
- Less adjustment work to fit at ship items such as template pipes because of accuracy in parts manufacture and assembly.

SAVINGS IN PARTS MANUFACTURING

Some of the items mentioned below will be true savings in parts manufacturing. Some other items mentioned here (although they also may have to be considered during parts manufacturing) are used in the assembly process making the use of parts easier and the assemblies more accurate.

Better fitting of parts when parts geometry is adjusted for production

Plate parts geometry is more accurate; *Geometry compensated for shrinkage*. Tribon handles two different principles regarding shrinkage, the statistical method and the local application of shrinkage. The local method is described below.

<u>The method for local application of shrinkage</u>
This method relates to the fact that plate material will be affected only where the heat is applied.

The total evaluation will be made on part level. Shrinkage compensation for butt-welding (plate seams) is applied locally along **plate edges**, which are butt-welded.
Shrinkage compensation for fillet welding (stiffeners against plate) is applied locally along the **weld trace**. Moreover, depending on the trace pattern there may be two independent sets of shrinkage directions. The corresponding compensations are applied independently of each other.

Shrinkage compensation for fillet welding is applied locally along the weld trace (the outer geometry of the part is actually split, translated and then combined again). However, before doing so an analysis is made of the length of the trace compared to the size of the part. Shrinkage is applied only if certain conditions are fulfilled. These conditions can be set-up and modified by the customer.

When the plate part has several different plate thicknesses (which may happen in "assembly parts" for panel lines) the shrinkage compensation will consider the thickness where the stiffener is located on the part.

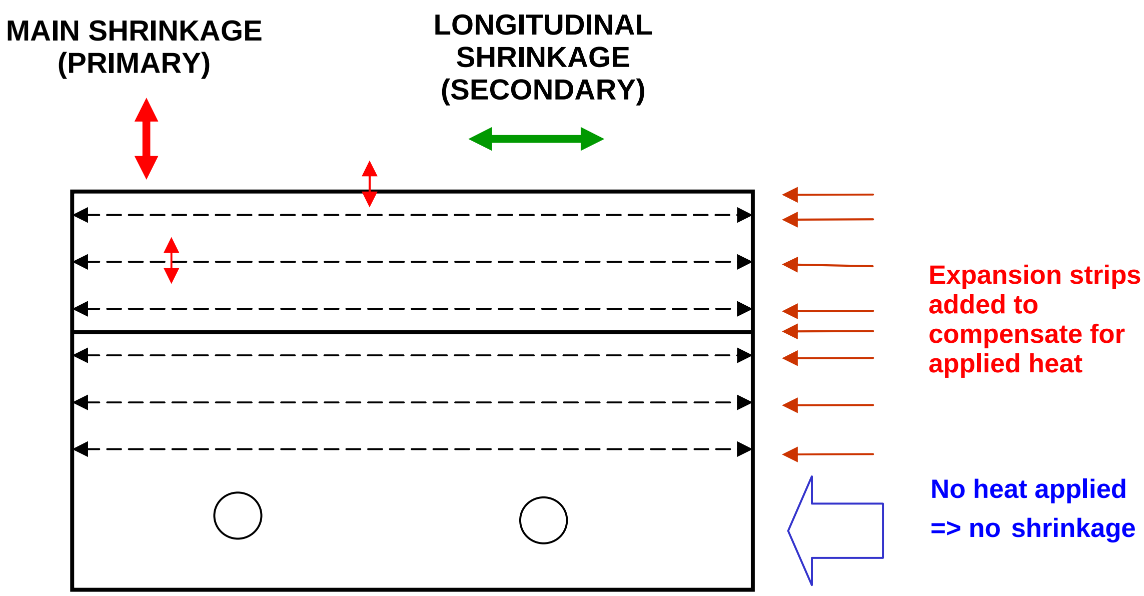


Fig. 1:

The longitudinal shrinkage compensation is applied as a scaling factor. However, all weld traces are considered in the evaluation of the pitch and of the scaling factor.
The shrinkage compensation is applied according to the same principles for both plane panel plates and shell plates.

The longitudinal shrinkage in plane panel stiffeners is applied so that the change in length of the profile is identical to that of its marking trace in the plate part(s), even if the trace should pass several plate parts.

A special local shrinkage compensation may be applied at the ends of butt welded profiles (including shell stiffeners).

Note that all the markings defined on each part will also be moved in accordance with the added strips.

Geometry compensated for seam gaps. Seam characteristics will define whether a seam gap is required. When this is the fact a strip of material is cut off the plate material giving allowance for the gap. If seam characteristics change along the seam, the gap may change. This will also result in a changed geometry along the seam, See schematic picture below.

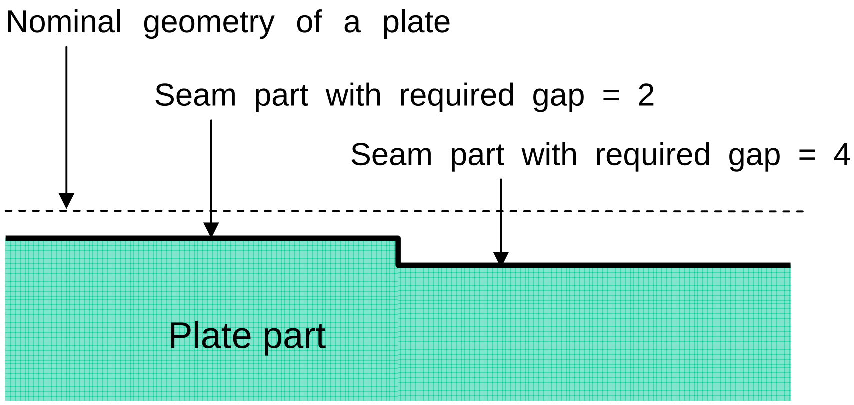


Fig. 2:

Geometry compensation for bevel geometry (a DOTORI feature). The example shows a planar plate attached to the shell. The edge of the plate has via its context and customer defined rules been selected to be of X-bevel type.

<u>Notations:</u>
N: Nominal geometry of hull structure and panel intersection
G: Guiding contour, controlling the vertical cutting
B: Bump geometry, used for material ordering and nesting
U: Geometry for upper bevel
L: Geometry for lower bevel

<u>Result:</u>
The nominal geometry N (= where the mould lines intersect) is replaced by
- New contour for vertical cutting => G.
- Angles / offsets for bevel cutting based on U and L.
- New contour B is used for nesting to maintain gaps between nested parts.

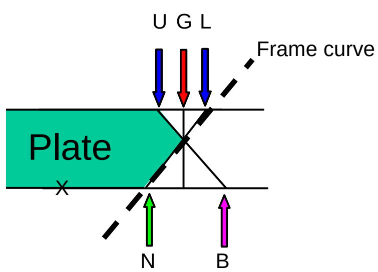


Fig. 3:

The resulting geometry is thus a set of curves used for different purposes giving best possible accuracy. For instance, when nesting a plate part with a bevel the B-contour will be used as an outer geometry reference curve (bump contour) to prevent parts from interfering with each other.

Without Dotori **With Dotori**

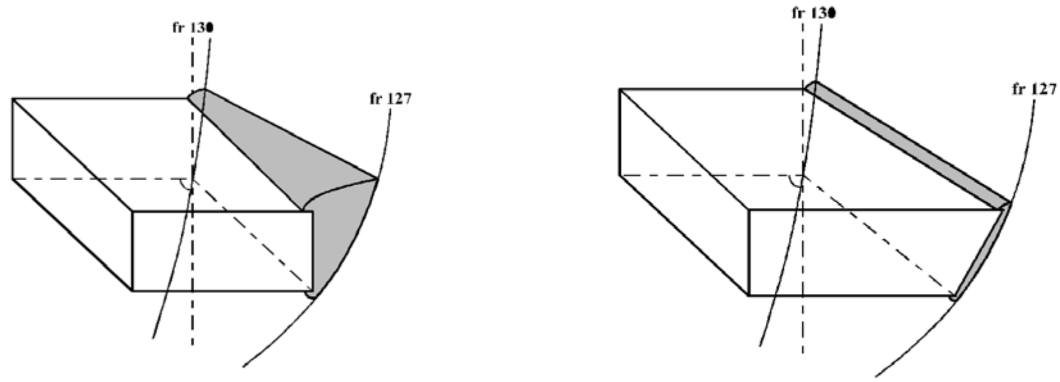
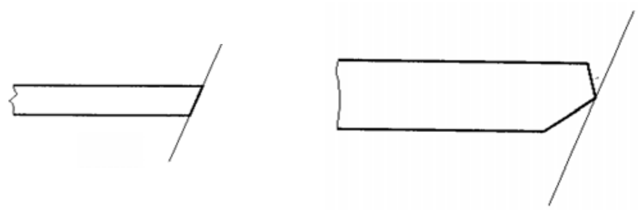
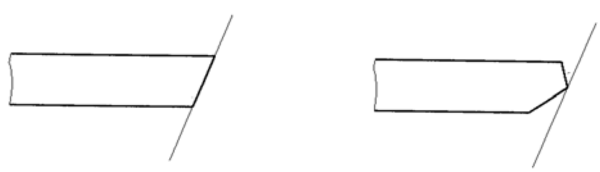


Fig. 4: This picture shows a simple case on the effect of using Dotori:



Variable bevel is supported and geometry adjusted (DOTORI). Bevel can be generated according to surrounding structure, i.e. variable bevel for deck connecting to shell. Bevel standard will be selected according to plate thickness and angle of connecting element and geometry will be adjusted accordingly. The geometry is adjusted as explained in 0. Below some cases are shown where Tribon automatically selects the bevel according to rules set up by the shipyard:



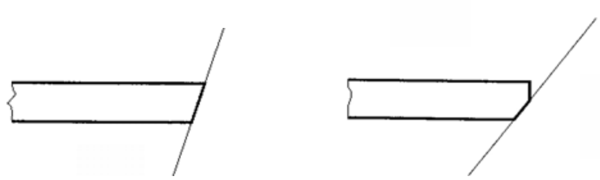


Fig. 5: Example 1: Same angle but different thickness results in different bevel types:
Fig. 6: Example 2: Same thickness but different angle results in a change of bevel type:
Fig. 7: Example 3: Different production line gives different bevel standard to apply even if thickness and connection angle are the same:

The variable bevel is also illustrated by the following example where the adjusted curve represents the trace for a bevelled panel or for a curved panel profile (as in the picture):

- An auto-selection feature for the bevel based on the attachment angle is used here. For example, the flanges of profiles are not necessarily parallel to the attached panel.
- The same settings should be possible for shell stiffeners as well.

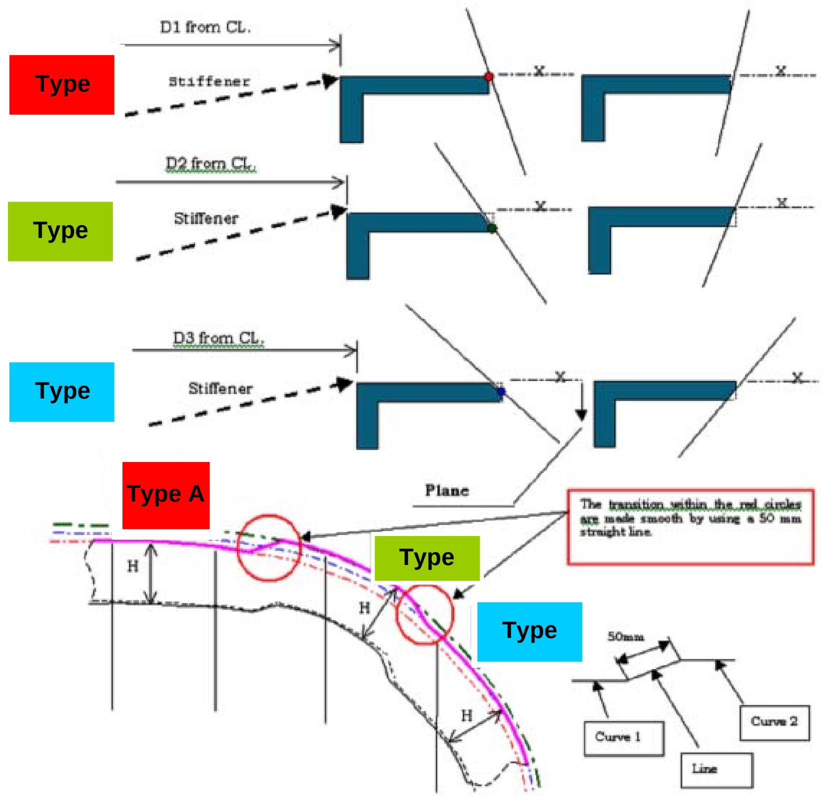
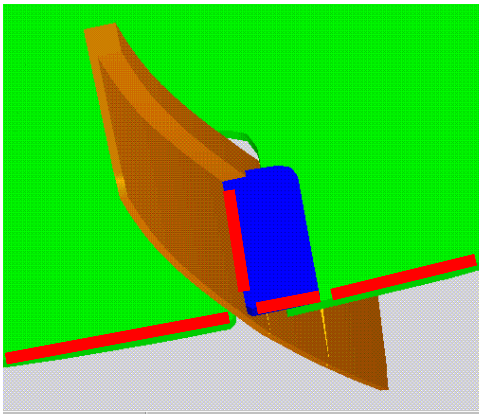


Fig. 8:

The location of attached profiles, brackets, cut outs and clips should also be calculated considering the bevel, resulting in different heights of the bevelled profile.

The pictures below show a typical cut out arrangement. The edges marked in red will be automatically adjusted depending on the connection angle and a bevel shape will be selected from a set of customised edge preparation shapes. In this example the following plate parts are effected: Clip edge abutting shell and shell profile, Cut out edge abutting shell profile and the Double bottom plate edge abutting shell. Furthermore the shell profile itself is adjusted as shown in previous example in 0 above (not marked red in this picture).



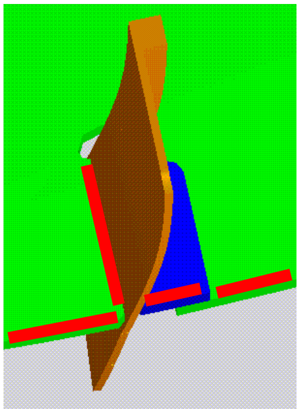


Fig. 9

Handling of inclined penetrations. To allow for instance a pipe to go through a plate only one contour (circle) is needed to define the hole when the pipe is perpendicular to the plate. This is the normal case.

But when the penetrating pipe is inclined two contours will be calculated, which in this case would be two ellipses lying on each surface of the penetrated plate, ellipses 1 and 2.

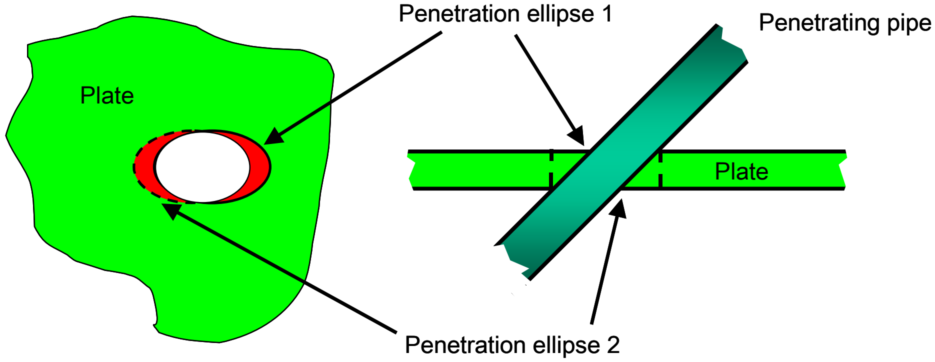


Fig. 10:

This “inclined” hole can now be treated in two ways:

a) Vertical cutting is used
Then the guiding contour will be the curve covering the white and red areas shown in the picture above

b) Bevelled cutting is used (with DOTORI)
Then the guiding contour will be the curve covering only the white hole area in the picture above.

The production software will, based on the guiding contour, produce the burner control information that generates the hole with the intended shape. If the hole is defined with a gap the contour(s) will be adjusted accordingly.

Stiffeners are more accurate
Stiffener lengths and end cuts are accurate since an adjustment is made according to applied end-cut standard. End gap information is taken from the standard and through the end-cut type and adjusted according to surrounding structure (angles etc.)
Example:

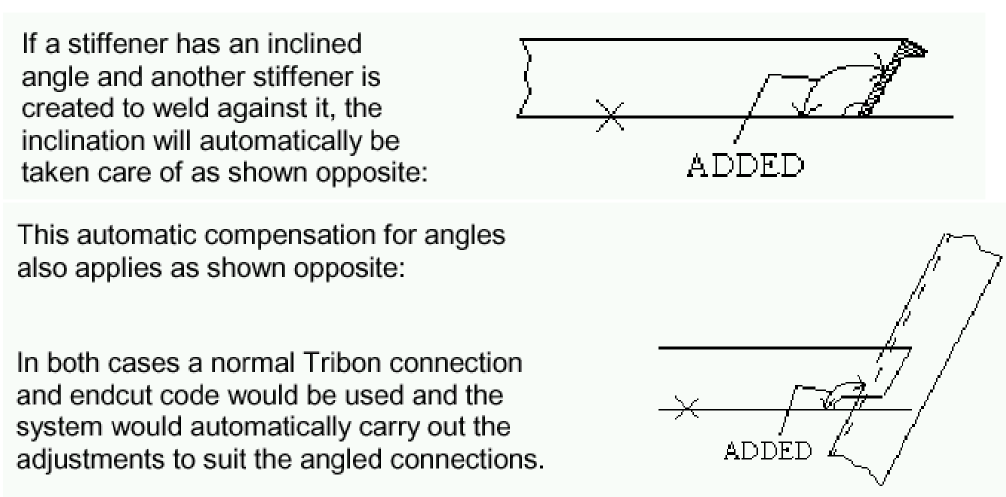


Fig. 11:

Fig. 12:
Stiffener bending information for inverse bending line geometry or bending templates produced automatically.

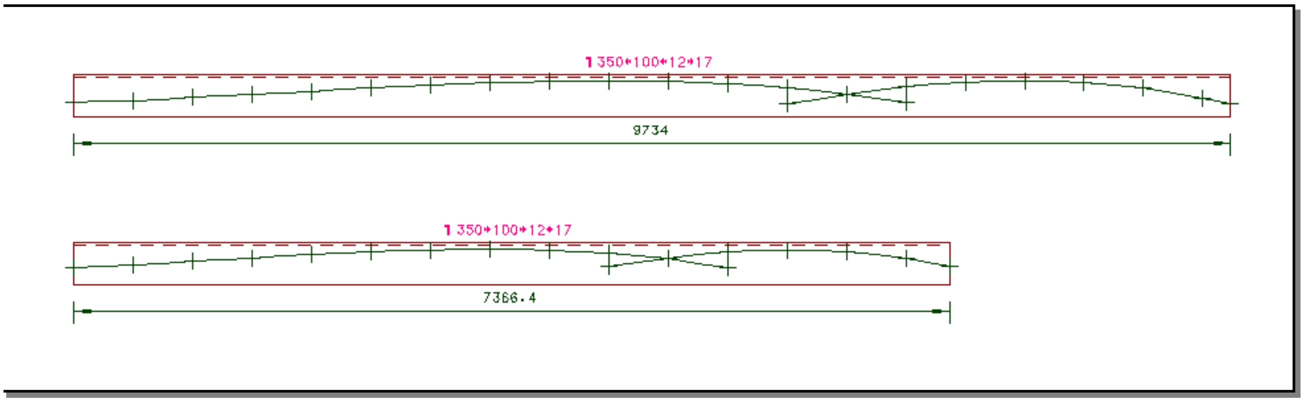
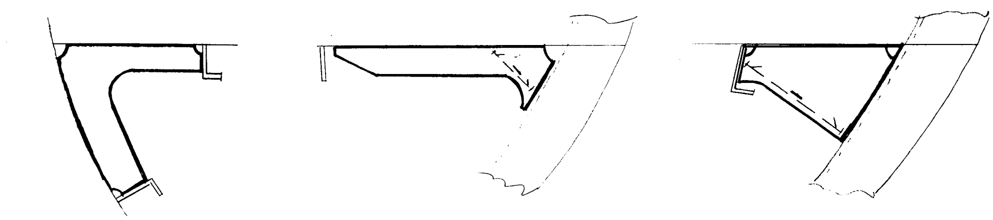


Fig. 13: Inverse geometry line as plotted on a stiffener is shown on the sketch.



Brackets are accurate. Tribon brackets are "intelligent" in the sense that they adapt themselves to the surrounding objects. If these objects would change, for instance the flange for a profile would change side, then this would generate a change in the bracket.
Fig. 14:

Accuracy for Pipes and Pipe Spools; *Accurate length calculation*. The information for producing pipe spools is accurate. The cutting length is adjusted according to production requirements. Pipe lengths are compensated for weld gaps.

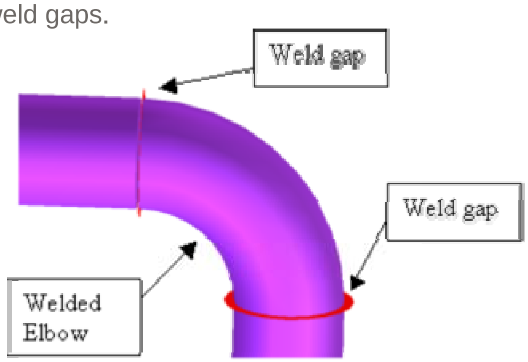


Fig. 15: Explanation: The weld gaps functions allow the insertion of welding gaps into the pipe-line. The insertion can be made at the Pipe, Spool or Part levels.
The welds can be detected automatically, and the cutting lengths of the pipe parts are adjusted to suit.

Pipe length is also compensated for flanges and welding overlap as well as for gasket thickness.

Accurate bending information. If a pipe needs to be bent the bending process cause the pipe to stretch. Length will be compensated for stretching when bending is required.

The bending information for pipe manufacturing is compensates for spring-back effect. This means that when a certain resulting bending angle is defined the bending machine needs to bend somewhat more to compensate for the spring back.

Accurate flange rotation information. Tribon controls Flange rotation positioning in order to ensure the matching of boltholes for joining pipe spools. This feature is important when bent pipes are involved.

Production checks. When a pipe spool is defined as "ready for production" Tribon performs some production checks to control if it is possible to manufacture the spool. For this checking purpose three types of machine objects have been introduced in order to describe capacities, critical measures and other characteristics for certain machines in the pipe manufacturing workshop. These objects are for bending machines, automatic flange welder and boss extrusion machine.

As an example we describe the bending machine object:
The system stores a 3D model of the customers bending machine(s). The model contains a 3D representation of the various bending and rotation planes as well as dimensional values required for the successful automatic bending of each relevant pipe component.

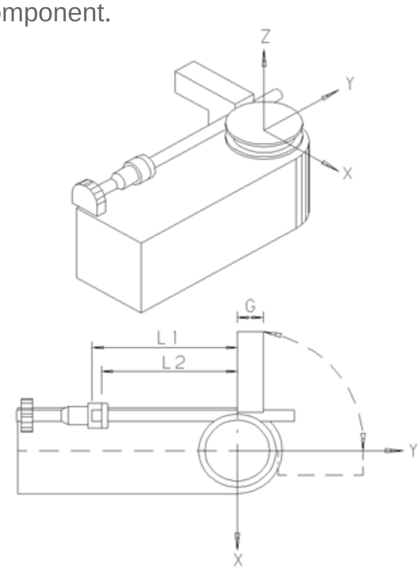
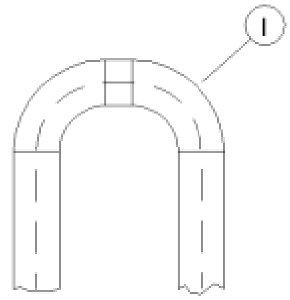
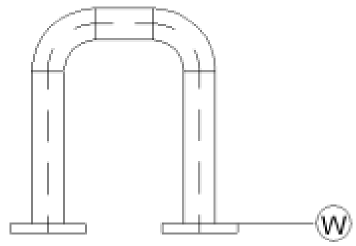
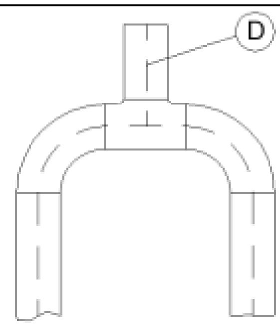
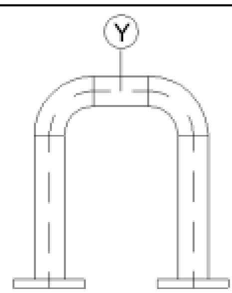


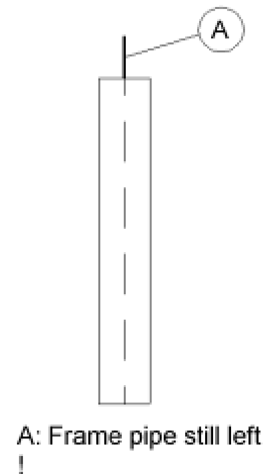
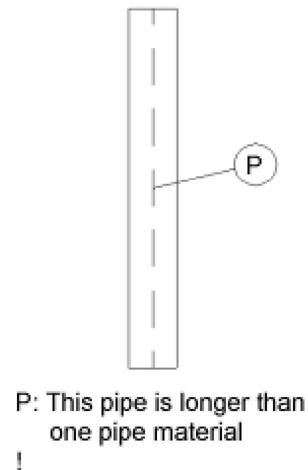
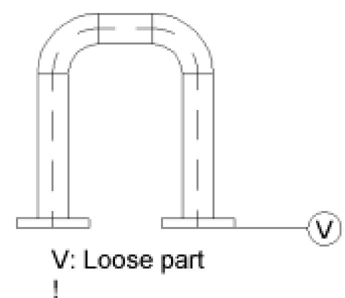
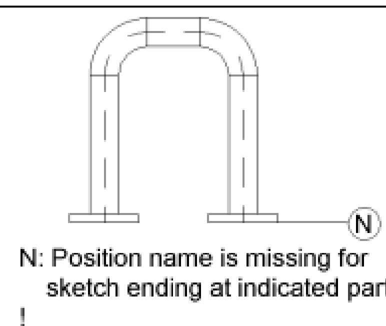
Fig. 16: G = Shortest straight pipe between two bends (grip length)
L1 = Minimum length of straight pipe to the first bend of a pipe without flange
L2 = Minimum length of straight pipe to the last bend of a pipe with flange.

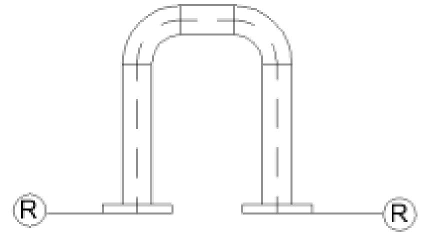
Due to the bending control function, material excess is added automatically to the pipe spool sketch information when required for parts manufacturing purpose (bend first and then cut excess away).

These machine object control will ensure production information to be of good quality regarding producibility. A summary of some checks performed in Tribon is described in this table below:

Fig. 17:

Check	Description	Must be passed	Display
Bend	Will check the pipe against the bending machine object. All lengths will be checked against those stored in the Object. Also the pipe is checked for collision with bending and turning planes. Because bending is associated with pre-welding of flanges then a check is also made against the flange-welding object.	Y	 ! Manual Bending, the straight pipe ! between two bends is too short
Excess	Will check the pipe for end excess and displays the result.	N	 W: User given excess !
Extrude	Checks the pipe against the extrusion machine object and displays the result.	N	 D: The extrusion has to be done manual !
Feed	Checks the pipe for any user given feed excess and displays the result.	N	 Y: User given feed min !
Frame	Checks the pipe for any frame still left and displays the result	Y	

			
Length	Checks the pipe for any pipe lengths greater than the maximum length stored in the pipe component and displays the result.	Y	
Loose	Checks the pipe for loose parts and displays the result.	N	
Spool name	Checks the pipe for position names and displays the result.	Y	
Non connect	Checks the pipe for non-connected parts and displays the result.	N	

			 R: Non connected connection !

Accurate cable lengths and installation marks. Cutting lengths for cables are calculated from the model according to cableway routes. This enables production to use pre-cut cables. Tribon also support marking of penetrations on the cables, which aids the installation process.

Shell plate bending becomes more accurate. Bending templates for shell plates are used by many shipyards to ease the process of bending plates so that they would fit accurately. There are different principles that can be used and Tribon supports most of them. One of the methods supported by Tribon is to automatically produce templates where each template will be placed perpendicularly against the shell plate. This gives a better judgement in the workshop on how well the plate has been formed. The benefits of this method are obvious at the ends of ship where i.e. frame templates would have to be angled against the shell.

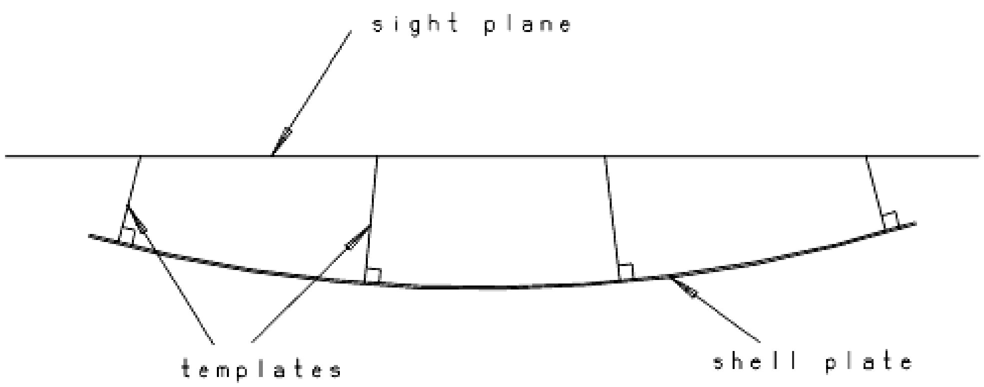


Fig. 18:

Fig. 19: This picture shows a shell plate with three templates assembled perpendicularly towards the shell plate. The back of the templates shall lie on the same plane surface so that the sight line defined by the red crosses is a straight line.

Template traces can be marked on the plate. An automatic sketch will also be produced to show the template layout.

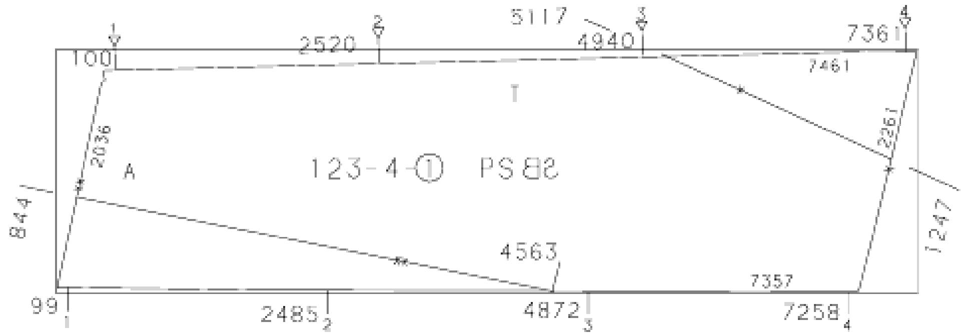


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Fig. 20: The example shows the arrangement of four templates and roll axis lines.

Higher design maturity before start of parts manufacturing

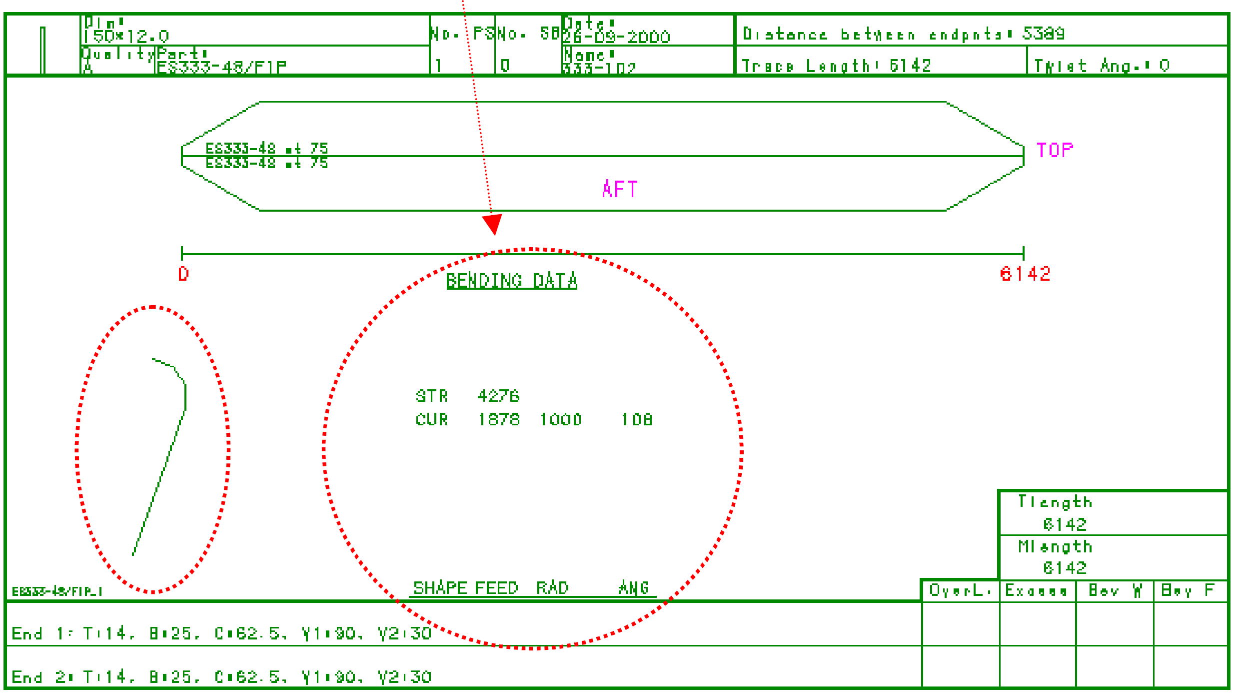
Production information produced automatically. Production information can, to a high extent, automatically be produced from Tribon. Then information can be requested at a late stage just a short time before production starts. This will give design some more time to add information when needed, due to late changes or other reasons. This will reduce the need for rework in production and will support and enable a higher degree of pre-outfitting.

Some examples on automatically produced production information are shown below.

```
TRIBON Solutions UK Ltd.            FABRICATION OF PROFILES          Prod. No.                          Nest. ID
                                    Date:  00-09-26                     000123
Type/Dim.  :    FB/150x12.0                                                                    Station: 0
Stocknumber:                                 Qual :    A         Order Length: 0         Order Quant.: 1    Page: 1
                       / S B / P S /         /                Information on endcuts
Part Name         Length/ L  R/ L  R/        /     Type Marking   A  B  C  R1  R2     V1   V2   V3   V4  BEVW BEVF EXC
=================================================================================================================
                   6142 /     / 1   /        / *1*  14  DOWN        2562.             90   30                0    0   0
333-102                                      / *2*  14              2562.             90   30                0    0   0
Prod_info:      123-333-102-PS>UP.
ES333-48 U=0                  ES333-48 U=0

   +++++ Forming data +++++
U=1435,V=4028,R=0,L=4276/U=948,V=1294,R=994,L=1866/C=5389
=================================================================================================================
                   6142 / 1   /       /      / *1*  14  UP          2562.             90   30                0    0   0
333-1-102                                    / *2*  14              2562.             90   30                0    0   0
Prod_info:      DOWN<123-333-1-102-SB.
ES333-48 U=0                  ES333-48 U=0

   +++++ Forming data +++++
U=-901,V=-1327,R=994,L=1866/U=2527,V=3449,R=0,L=4276/C=5389
=================================================================================================================
```



Stiffener information example

Fig. 21:

```
TRIBON Solutions UK Ltd.           FABRICATION OF PROFILES          Prod. No.                        Nest. ID
                                   Date:  00-09-27                     000123
Type/Dim.  :    HP/260x12.0                                                                  Station: 0
Stocknumber:                            Qual :    A          Order Length: 0         Order Quant.: 1    Page: 1
                      / S B / P S /     /              Information on endcuts
Part Name         Length/ L  R/ L  R/     /     Type Marking   A  B  C  R1  R2     V1    V2    V3    V4   BEVW BEVF EXC
==================================================================================================================
                   7386 /     / 1   /     / *1*  21  OUTB                        51.6   90                0    0    0
-6                                        / *2*  21                             127.3  180                0    0    0
Prod_info:       123--6-PS>CL.

                    BENDING TABLE 1                                          BENDING TABLE 2
  ____________________________________________________   ____________________________________________________
  /            /            /            /            /  /            /            /            /            /
  /  Dist    H /  Dist    H /  Dist    H /  Dist    H /  /  Dist    H /  Dist    H /  Dist    H /  Dist    H /
  /____________/____________/____________/____________/  /____________/____________/____________/____________/
  /            /            /            /            /  /            /            /            /            /
  /     0   89 /  2000  203 /  4000   97 /  6000  174 /  /  5000  183 /  7000  158 /            /            /
  /            /            /            /            /  /            /            /            /            /
  /   500  158 /  2500  183 /  4500   90 /            /  /  5500  149 /  7386  183 /            /            /
  /            /            /            /            /  /            /            /            /            /
  /  1000  197 /  3000  153 /  5000  100 /            /  /  6000  134 /            /            /            /
  /            /            /            /            /  /            /            /            /            /
  /  1500  210 /  3500  120 /  5500  128 /            /  /  6500  137 /            /            /            /
  /____________/____________/____________/____________/  /____________/____________/____________/____________/

==================================================================================================================
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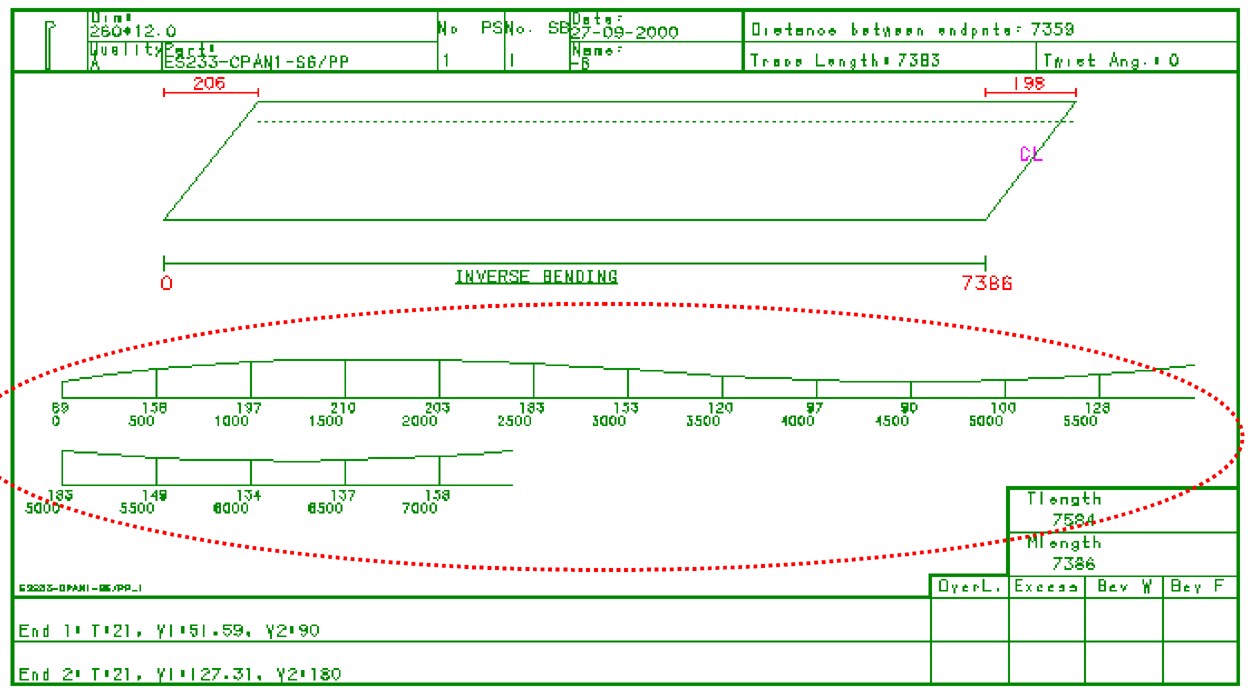


Curved Stiffener

Fig. 22:

Profile cutting

```
TRIBON Solutions UK Ltd.             FABRICATION OF PROFILES          Prod. No.                         Nest. ID
                                     Date:  00-09-27                     000123
TRAIN03
Type/Dim.  :    FB/100x12.0                                                                       Station: A
Stocknumber:    PROF4                    Qual :    A         Order Length: 12000     Order Quant.: 1    Page: 1
                       / S B / P S /     /              Information on endcuts
Part Name        Length/ L  R/ L  R/     /     Type Marking   A  B  C  R1  R2     V1   V2   V3   V4  BEVW BEVF
EXC
===============================================================================================================
==
                   814 /     / 1   /     / *1*  12  OUTB    100 50  0  50      82.2                 0    0
0
333-1-130                                / *2*  13              15                90   30           0    0
0
Prod_info:      333-1-130
===============================================================================================================
==
                   786 /     / 1   /     / *1*  12  OUTB    100 50  0  50        90                 0    0
0
333-1-131                                / *2*  13              15                90   30           0    0
0
Prod_info:      333-1-131
===============================================================================================================
==
                   786 / 1   /     /     / *1*  13  CL          15                90   30           0    0
0
333-1-131                                / *2*  12          100 50  0  50        90                 0    0
0
Prod_info:      333-1-131
===============================================================================================================
==
                   814 / 1   /     /     / *1*  13  CL          15                90   30           0    0
0
333-1-130                                / *2*  12          100 50  0  50      82.2                 0    0
0
Prod_info:      333-1-130
===============================================================================================================
==
```

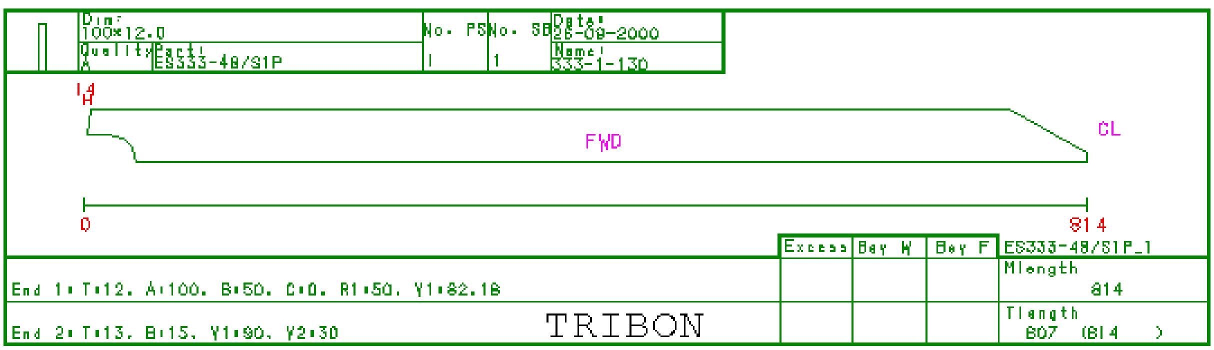


Fig. 23:

Nested profile

```
TRAIN01                         Material: PROF10      (Length: 12000       )

    1 ES333-48/F1P (ES333-102)           Len.: 7142       Acc. Len.: 7652

      Used Length: 7167          Rest Length: 4833         ( 40.3%)

TRAIN02                         Material: PROF10      (Length: 12000       )

    1 ES333-48/F1S (333-1-102)           Len.: 7142       Acc. Len.: 7652

      Used Length: 7167          Rest Length: 4833         ( 40.3%)

TRAIN03                         Material: PROF4       (Length: 12000       )

    1 ES333-48/S1P (333-1-130)           Len.: 814        Acc. Len.: 817
    2 ES333-48/S2P (333-1-131)           Len.: 786        Acc. Len.: 1573
    3 ES333-48/S2S (333-1-131)           Len.: 786        Acc. Len.: 2374
    4 ES333-48/S1S (333-1-130)           Len.: 814        Acc. Len.: 3158

      Used Length: 3166          Rest Length: 8834         ( 73.6%)

SUMMARY OF MATERIAL USED.

     2 PROF10          Total: 24000        Used: 14335        Scrap:  40.3 %
     1 PROF4           Total: 12000        Used: 3166         Scrap:  73.6 %
```

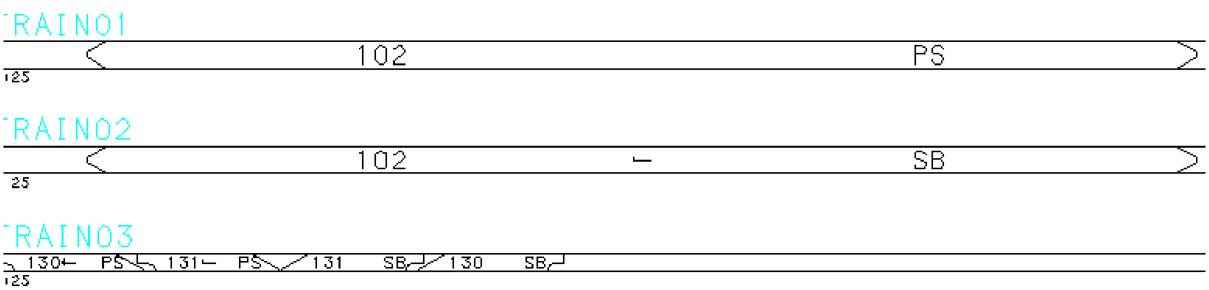


Fig. 24:

HEIGHTS FOR ADJUSTABLE PIN TEMPLATES

Bldg No:

SF820D

Sect. No:

Plate: ES233-CPAN1-4P

List. No:

Date: 00-09-28 Name:

Pin distance: 200 mm

Template no	Height for pin no 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	200	229	256	282	308	333	355	375	393	408	418	424					
2	352	368	380	390	398	404	407	407	403	394	378						
3	424	421	414	404	388	368	343	312	274	229							

Template no	From the left edge to: sight line mark	up. right angle mark	low. right angle mark	At the right edge: over-shoot	pin height
1	600	1229	1206	200	424
2	495	1082	1082	162	361
3	476	916	961	105	200

Direction mark to the right
****

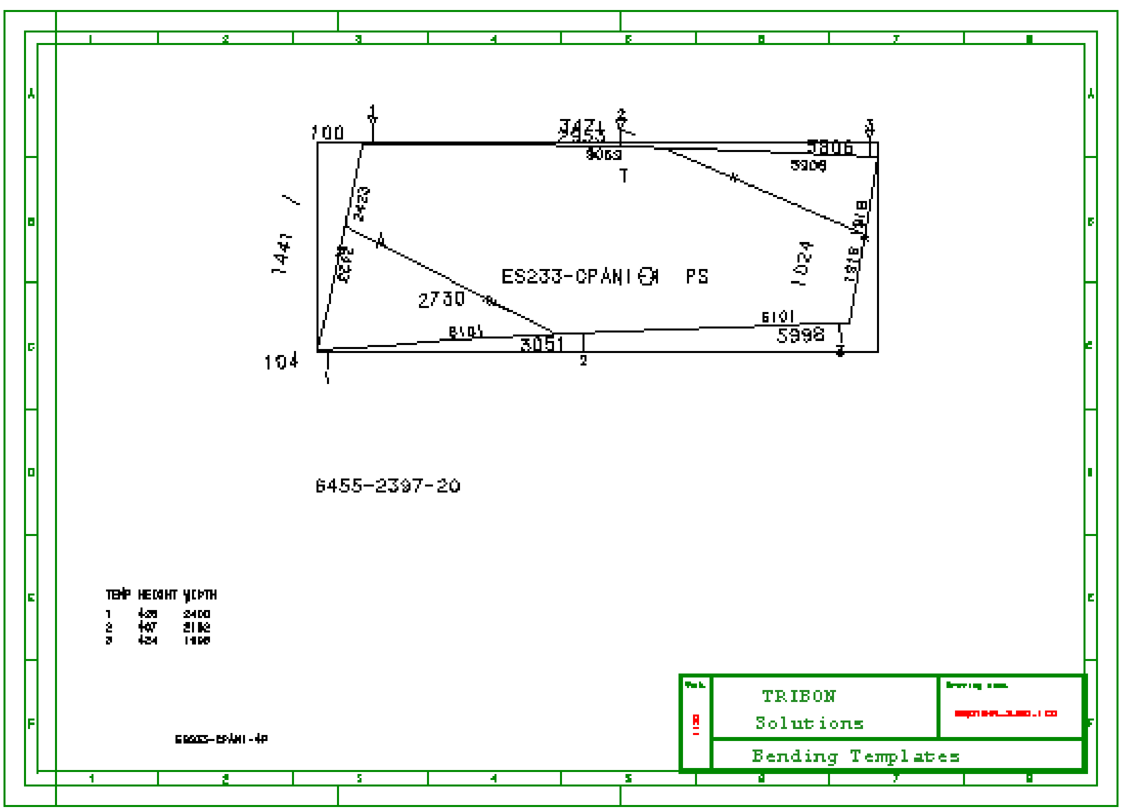
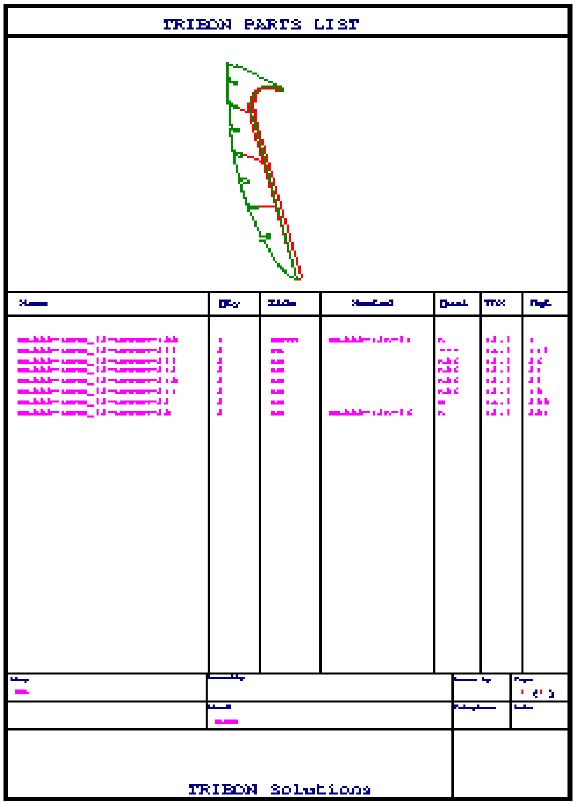


Fig. 25:

Parts list and sketch output



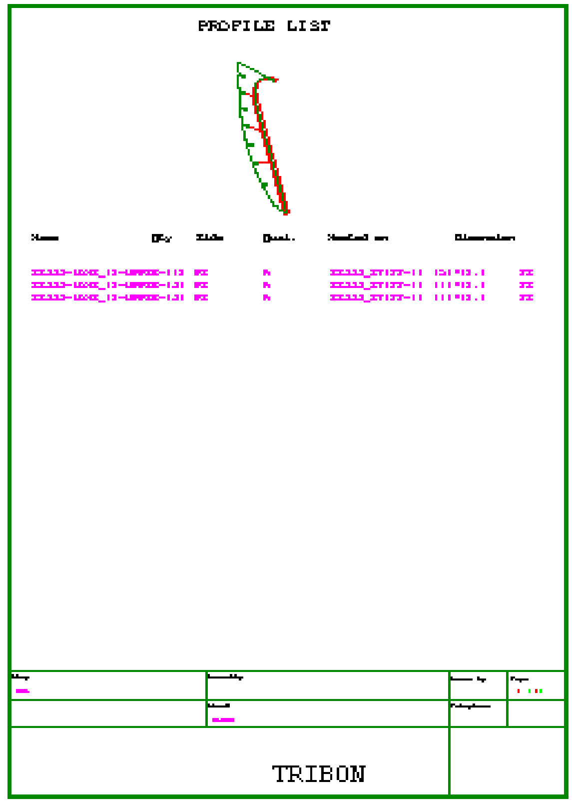
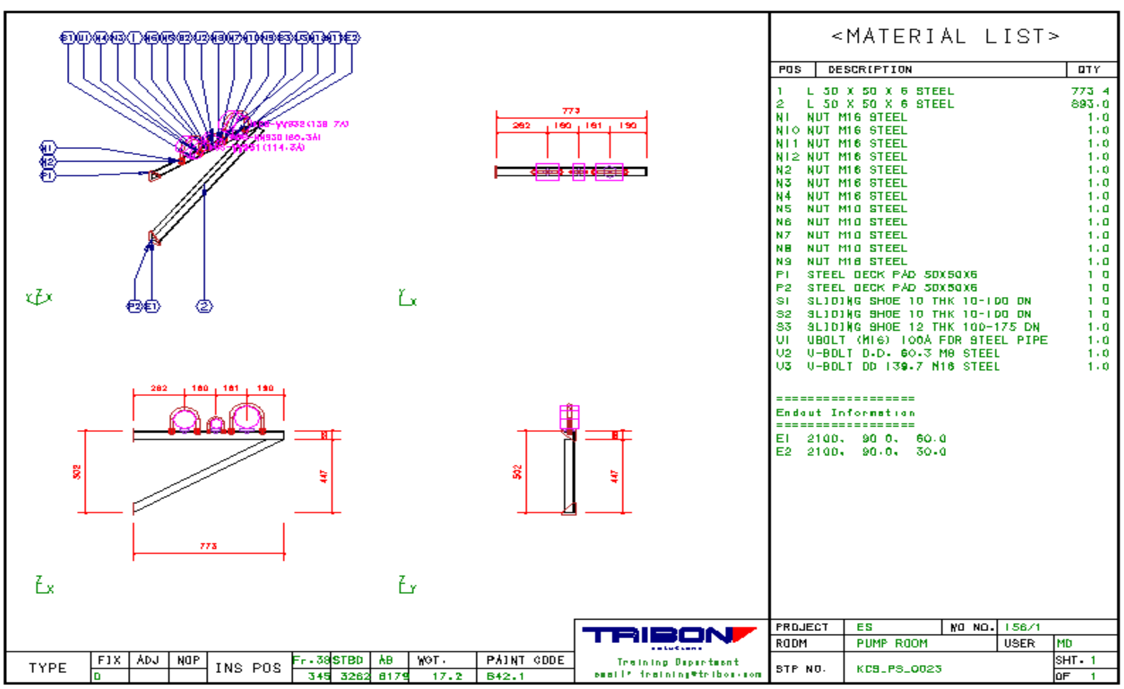


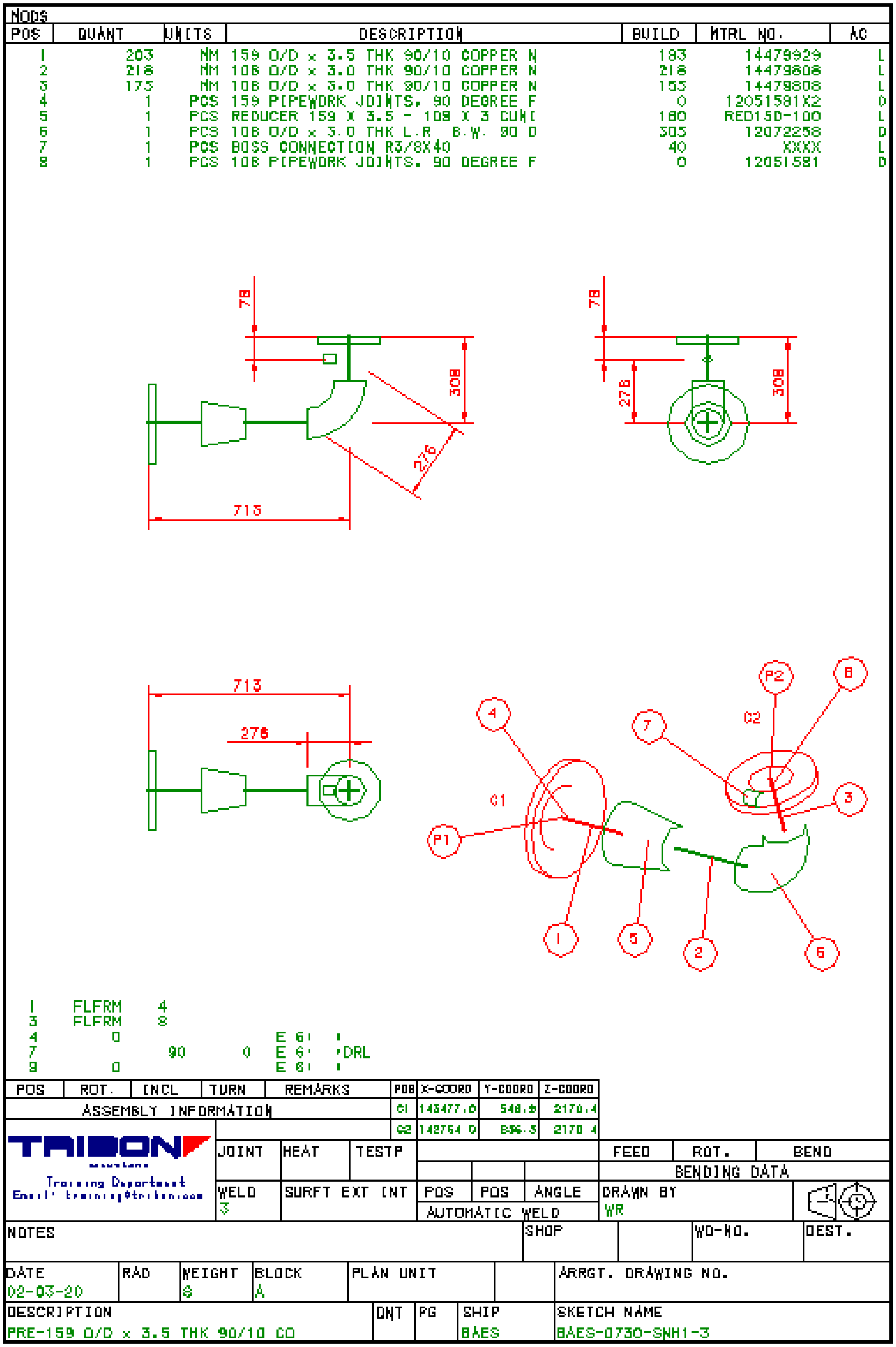
Fig. 26: **Fig. 27:**

Pipe hanger.



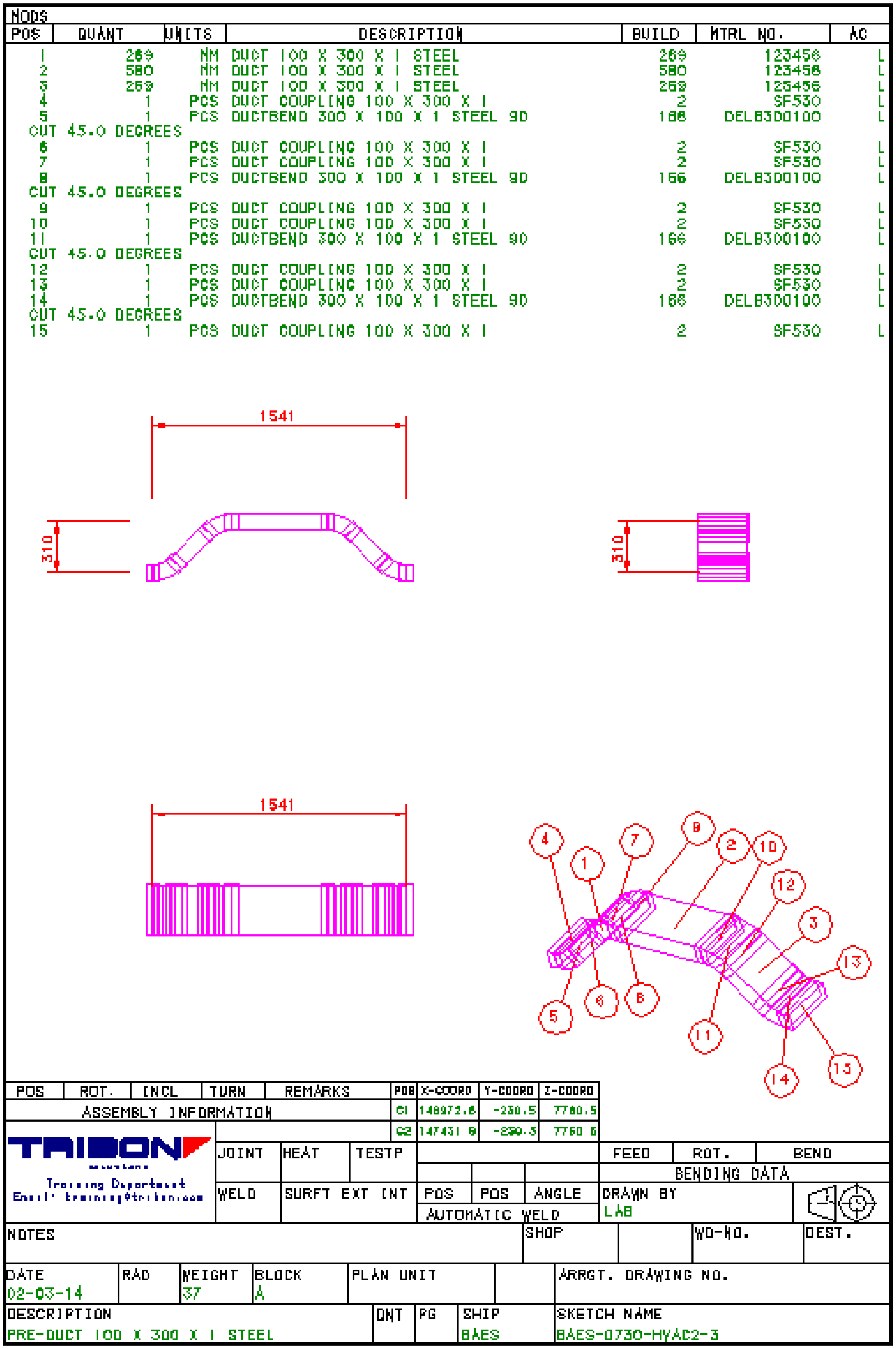
Drawings are generated automatically complete with all relevant production information; drilling, material list, cutting list, end-cuts etc.

Fig. 28:



Pipe spool sketch

Fig. 29:



Ventilation spool sketch

Fig. 30:

Better control on change information. A problem when introducing late changes is often that the impact of a change cannot fully be discovered. This problem can be of local as well as of global nature.

The Tribon model concept with its topology feature and with its status control supports the organisation to see production consequences of a change.

Local changes. By “local” change we here mean a change that is within the scope and responsibility of a designer or design group. We only give some examples on this:

- If a thickness of a plate is changed, the influence of this change will be effected on relevant parts attached to this plate.
- If a pipe has induced a topological hole in a plate and the pipe is moved, then the position of the hole will move with the centreline of the pipe (this feature is optional since it cannot always be allowed)
- If a shell longitudinal will be changed by dimension or by angle then the corresponding cut-outs will be reflected by the change.
- If a bracket is attached to two stiffeners and one of the stiffeners is changed then the bracket will change when relevant.
- If a location of a pipe flange is changed so that the raw material needed would not exist or the bending of the pipe would be impossible then a notification message would be generated from Tribon.
- E.t.c.

Global changes. By “global” change we here mean a change that has impact on other departments and disciplines. We only give one examples on this:

If a change request concerns a support structure for a equipment and the location of this equipment would need to be changed then the responsible person can check the status of the equipment foundation. Examples:

- If the “**Design Status**” would be “**Not Ready**” he may allow the change.
- If the “**Production Status**” would be “**Not Started**” he might still allow the change to happen but more investigations need to be made.
- If the “**Production Status**” would be “**Manufacturing Started**” he may decide not to allow this change to happen.

Summary on design maturity. Due to the facts explained above in this chapter the quality of production information will be high. This improves the ability for the shipyard to increase the level of pre-outfitting and reduces cases for rework and error corrections.

SAVINGS IN ASSEMBLY PROCESS

Savings due to better assembly process control

For simplicity, we here consider the Production Outfit Assembly processes to be divided into following steps or categories:

1. Sub assembly in workshop - relative cost = 1
2. Unit assembly in workshop - relative cost = 2
3. Assembly during blocking stage - relative cost = 5
4. Assembly on board the ship while in dock - relative cost = 10

This process is schematically shown in this picture:

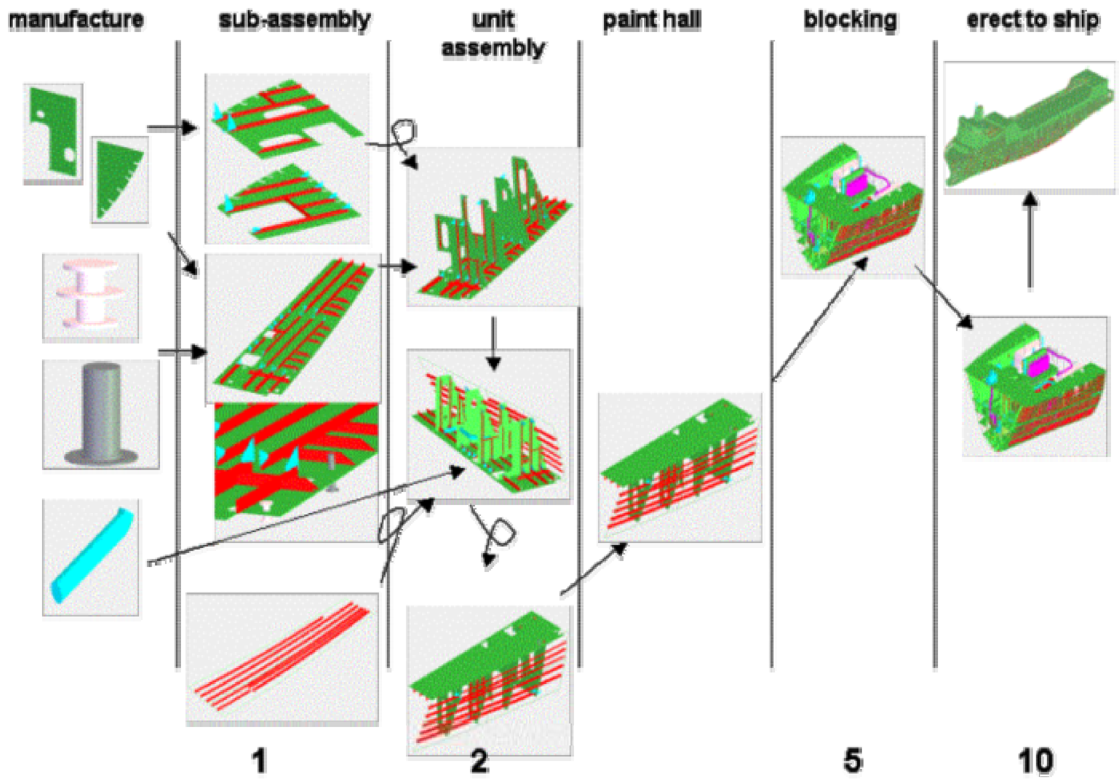


Fig. 31:

The relative costs for these stages would show that if work can be transferred to an earlier stage the result would be more cost effective. By using Tribon functionality integrated with existing systems at the shipyard, it is possible to improve assembly production using this principle.

In this new assembly process philosophy a set of work instruction documents would be produced automatically for each planned work package. The sets would be produced "Just In Time" according to production schedule and for specific workstations. The work instructions would contain job information, planning information, pars listing with status and intelligent drawings.

An example is shown below:

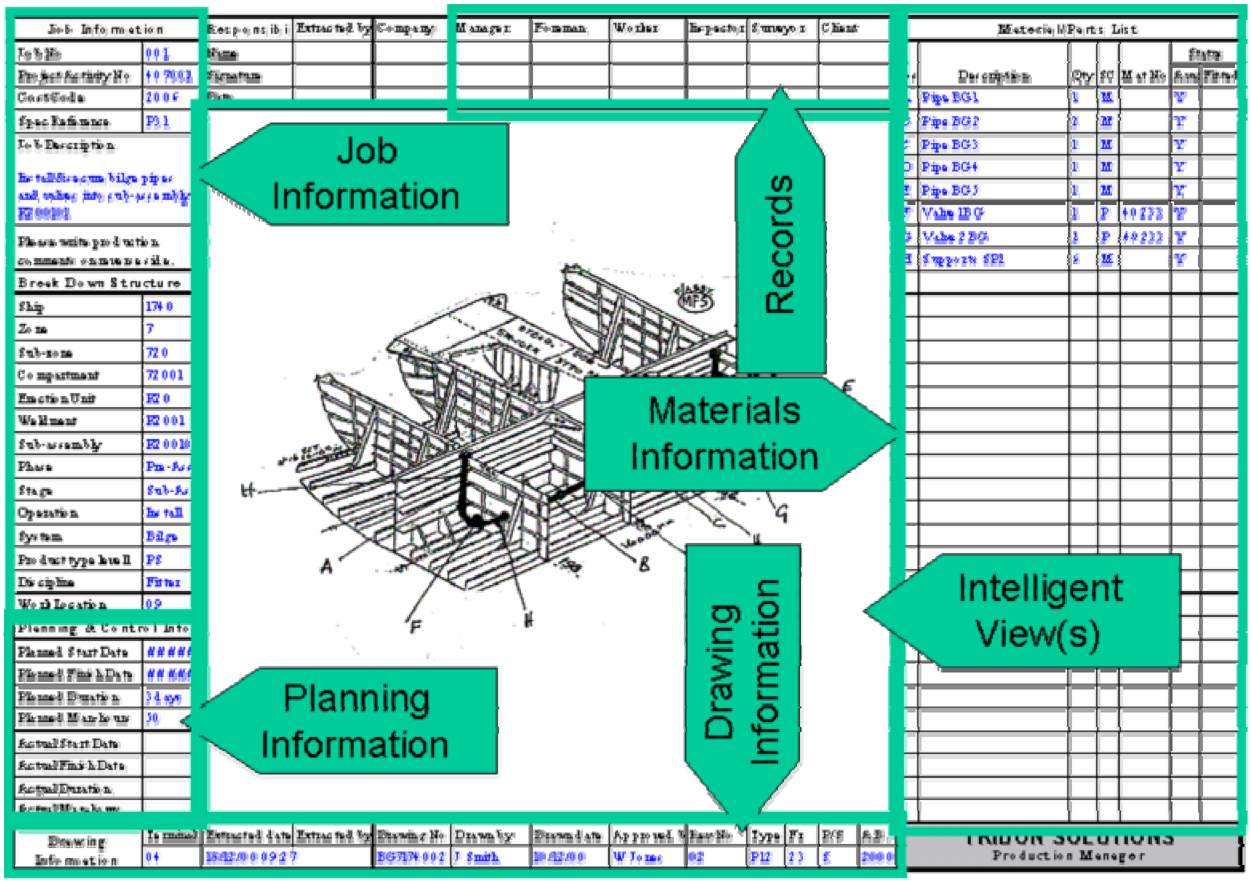


Fig. 32:

The Tribon Production Manager is a tool for production managers and production planners to prepare, control and follow up the production by:

- Having direct access to the Tribon Product Information Model including the generated Production data and documentation.
- Co-ordinating and preparing the documentation for production.
- Reporting and reviewing progress from manufacturing, prefabrication and assembly.

The Tribon M2 Production Manager gives direct access to the objects in the Tribon Product Information Model through a product tree view, a graphical view and a parts list view. The Tribon Production Manager application provides powerful mechanisms for navigation in the model.

For each assembly, up to seven drawings (a work instruction set) are generated. Each drawing is focusing on the installation of one specific type of parts: Hull parts, Structure parts, Equipment, Pipe spools and parts, Ventilation spools and parts, Cableway parts and Miscellaneous parts respectively.

<u>Benefits</u>

- More assembly can be made at an earlier stage, already as workshop assembly. Thus, more work is done in better conditions and at a more cost efficient stage.
- Better Work Instructions enables improved assembly efficiency in workshops.
- Reduced man-hours for creation and control of work instructions.

Better and easier fitting of parts and unit assemblies
The fact that parts have been produced more accurately, as explained earlier, saves time in assembly. Many parts are also defined parametrically and will therefore fit well with right dimensions, i.e. brackets.

Workshop uses automatic **marking information** with material side indication. This enables accurate positioning of part during assembly

Easier to assemble parts into sub-assemblies

It is possible to add special marking information to the parts that helps positioning of parts and subassemblies (Genauigkeit).

<u>Explanation</u>

Figure 1 shows the principle of the GSD marking arrangement for a fillet and a butt weld connection and figure 2 shows a real case for a fillet.

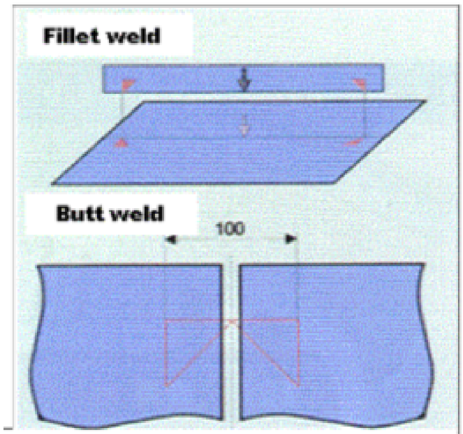


Figure 1: Assembly by means of triangles

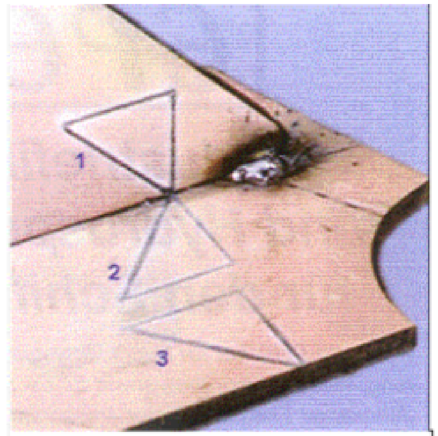


Figure 2: Assembly example

Fig. 33: (Figures 1 and 2 from HANSA - Schiffahrt - Shiffbau - Hafen - 1998 - Nr. 9)

The assembly task is to position vertex upon vertex. The triangles 1 and 2 on the first and second part are always positioned on the mould edge. With this principle parts will be correctly placed.

Depending on the attachment length of the parts to be connected, at each end or only at one end a triangle pair is designated. The line supports the positioning on one straight line from one triangle to another.

Even after welding a reliable retracing ability and error analysis is ensured, even if the assembly dates back a rather long time, because the length of the perpendicular sides is 50 mm as a standard. Triangle 3 serves for assembly of the whole constructional group (plate with stiffening) with another group.

When fitting butt welds the system is built up in a way that the sides of the triangle parallel to the seam are laid together at a distance of 100 mm. When positioning these triangles the weld gap (reduce material) and the weld shrinkage (add material) for the seam are considered. That means that the vertices touch each other at the centre of the seam and that a part of the triangle is cut off depending on the breadth of the welding gap.

Easier to find right part to be put in the right place

Since parts have been automatically labelled at the parts manufacturing phase it is less likely that wrong part will be picked up.

A marking line tells where the part will be attached. The material side (mould line) is also indicated. Associated to the marking line there is a label text telling the part name to be attached.

This will save time and reduce errors in production.

Welding benefits

Due to better fitting of parts and subassemblies and by applying variable bevel control certain benefits will be achieved:

- Less uncontrolled welding gaps due to accurate parts and sub-assemblies.
- More constant seam properties make manual as well as automatic welding easier to control.
- Less uncontrolled welding distortion caused.
- Less welding material needed.

- Better quality on welds is achieved

Use of jigs for curved blocks

To be able to build curved sections more accurately some shipyards use jigs as an aid. Tribon can produce information for plate jigs and for pin jigs. Below are some output examples from the pin jigs case: an extraction of numerical data and some drawing examples:

TRIBON Solutions UK Ltd. Jig Pillars
SF824D Date: 00-10-02 Time: 10.29.06 Page 01

Jig Object: ES233-CPAN1-JIG
Designation:

Position and height of jig pillars

Jig	Jigrow A		Jigrow B		Jigrow C		Jigrow D		Jigrow E		Jig
No	Dist	Height/Ang	Dist	Height/Ang	Dist	Height/Ang	Dist	Height/Ang	Dist	Height/Ang	No
1	0	0	0	0	250	1063	250	1135	0	0	1
2	0	0	0	0	1250	1163	1250	1238	1250	1242	2
3	0	0	0	0	2250	1280	2250	1350	2250	1333	3
4	0	0	3250	1243	3250	1412	3250	1466	3250	1414	4
5	0	0	4250	1393	4250	1554	4250	1574	4250	1472	5
6	5250	1248	5250	1562	5250	1699	5250	1667	5250	1506	6
7	0	0	0	0	0	0	0	0	6250	1521	7

TRIBON Solutions UK Ltd. Jig Pillars
SF824D Date: 00-10-02 Time: 10.29.06 Page 02

Jig Object: ES233-CPAN1-JIG
Designation:

Position and height of jig pillars

Jig	Jigrow F		Jigrow G		Jigrow H		Jigrow I		Jigrow J		Jig
No	Dist	Height/Ang	Dist	Height/Ang	Dist	Height/Ang	Dist	Height/Ang	Dist	Height/Ang	No
2	1250	1187	1250	1094	1250	1021	1250	1013	1250	1121	2
3	2250	1243	2250	1122	2250	1039	2250	1029	2250	1136	3
4	3250	1280	3250	1140	3250	1053	3250	1039	0	0	4
5	4250	1301	4250	1152	4250	1062	4250	1042	0	0	5
6	5250	1311	5250	1163	5250	1063	5250	1048	0	0	6
7	6250	1318	6250	1166	6250	1061	0	0	0	0	7

TRIBON Solutions UK Ltd. Jig Pillars
SF824D Date: 00-10-02 Time: 10.29.06 Page 03

Jig Object: ES233-CPAN1-JIG
Designation:

Summary table of jig pillars
Total number of jig pillars: 47
Distance from the sight line to the edges of the jig rows

	A	B	C	D	E	F	G	H	I	J
Edge1	4933	2461	105	186	369	540	704	868	1044	1242
Edge2	5637	5881	6081	6241	6377	6514	6661	6817	5265	2394

Fig. 34:

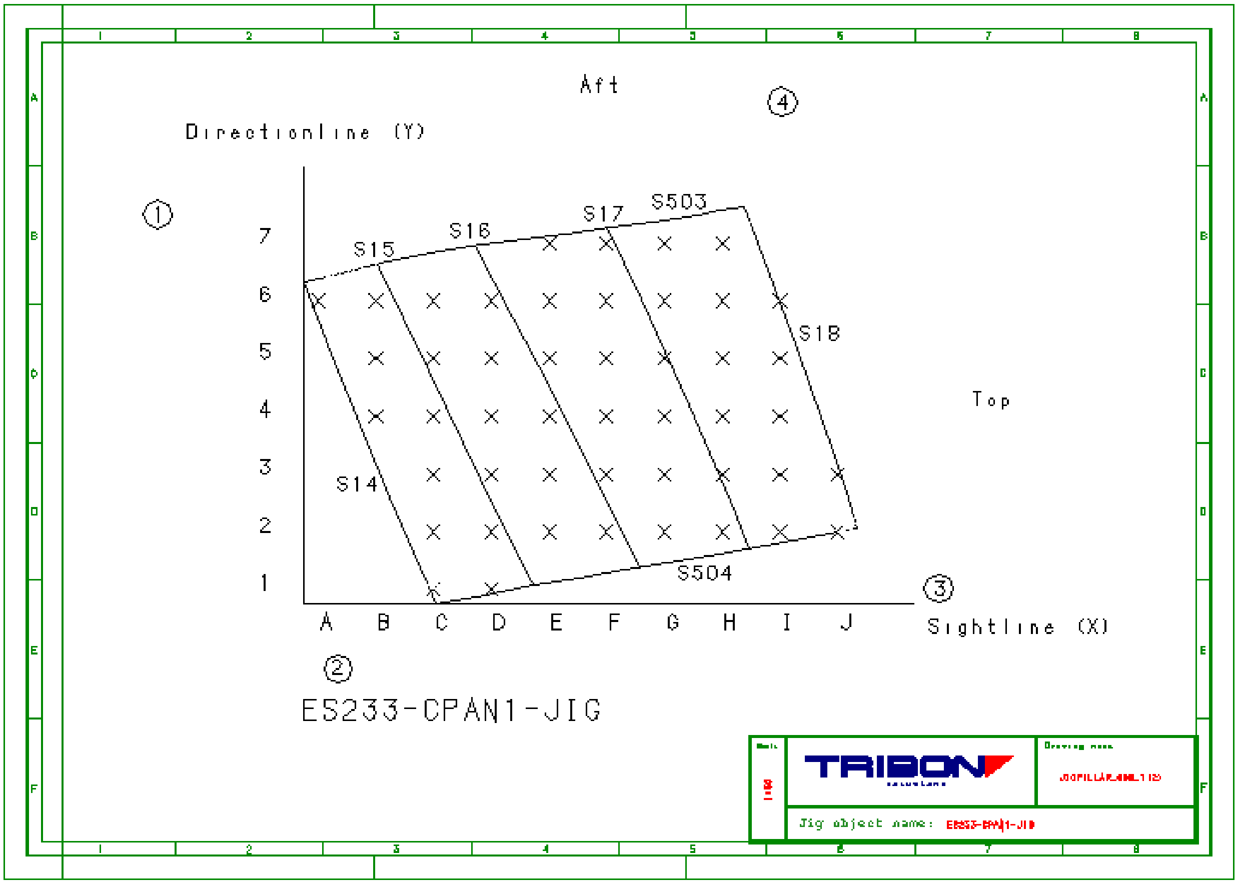


Fig. 35: Some drawing output examples.

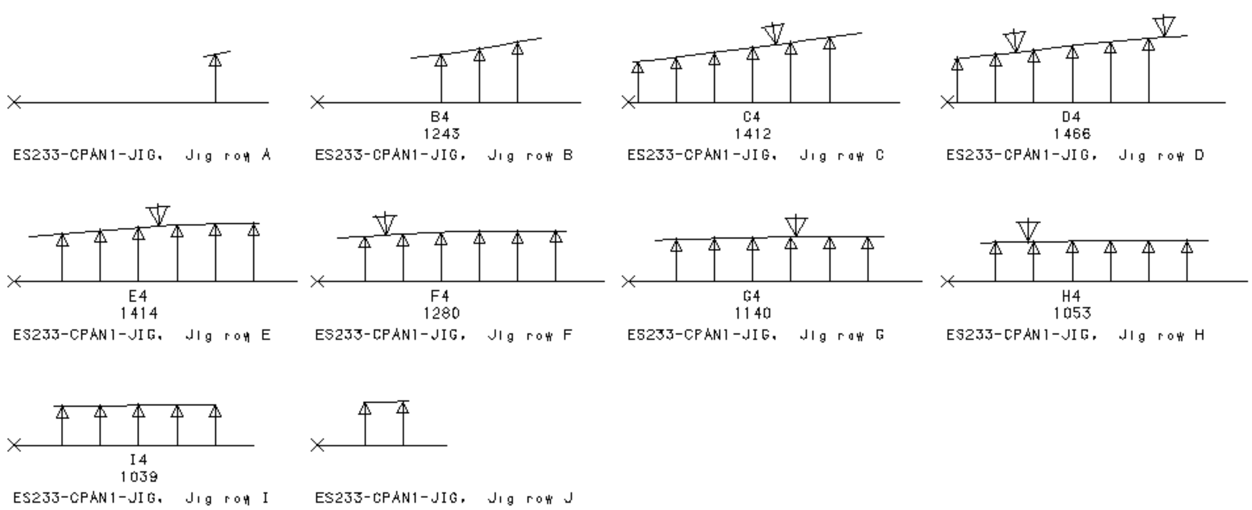


Fig. 36:

Use of control information in assembly process
In addition to create marking lines for decks, bulkheads etc and to use the special assembly triangles (GSD) Tribon can produce marking lines for controlling and measuring purposes.

- Reference planes, arbitrarily placed in the ship, can be defined to be marked on individual plates (planar and curved) for the purpose of checking production accuracy.

- Production tolerances and reference points for steel assemblies can be defined in Tribon for later export to the measurement equipment.

SOME OTHER PRODUCTION SAVINGS ENABLED BY TRIBON

Factory automation
Tribon is an open system that can provide information for automation purpose in production.

Profile Cutting Interface. The profile cutting interface is used to generate fabrication data for profiles, such as lists, sketches or basic data for cutting robots. The robot controllers and/or robot programming languages must have the possibility to read the generic interface format, which is output. The receiving system must have a pre-processor.

Plate Cutting Interface. This feature is used to extract any plate parts stored on Tribon data banks into ageneric format, suitable to be processed by programs outside Tribon.

Panel Line Control. The Panel Line Control Module (PLCM) is used to nest assembly parts onto large raw plates and produce NC information for blasting, marking, burning and text labelling. The nesting of the individual piece parts and the creation of the large raw plate is also supported.

The main functions of this module are the interactive assembly nesting program and the post-processor to convert the cutting path into NC information.

Parallel blasting, marking and burning are supported. Raster marking can be performed.

Robot Interface 1. The Tribon Robot Interface option is used to allow transfer of production information from the Tribon product model to welding robot facilities. The robot controllers and or robot programming languages must have the possibility to read the Tribon Robot Interface format. The receiving system must have a pre-processor.

Below two examples from a welding robot: installation using Tribon information:

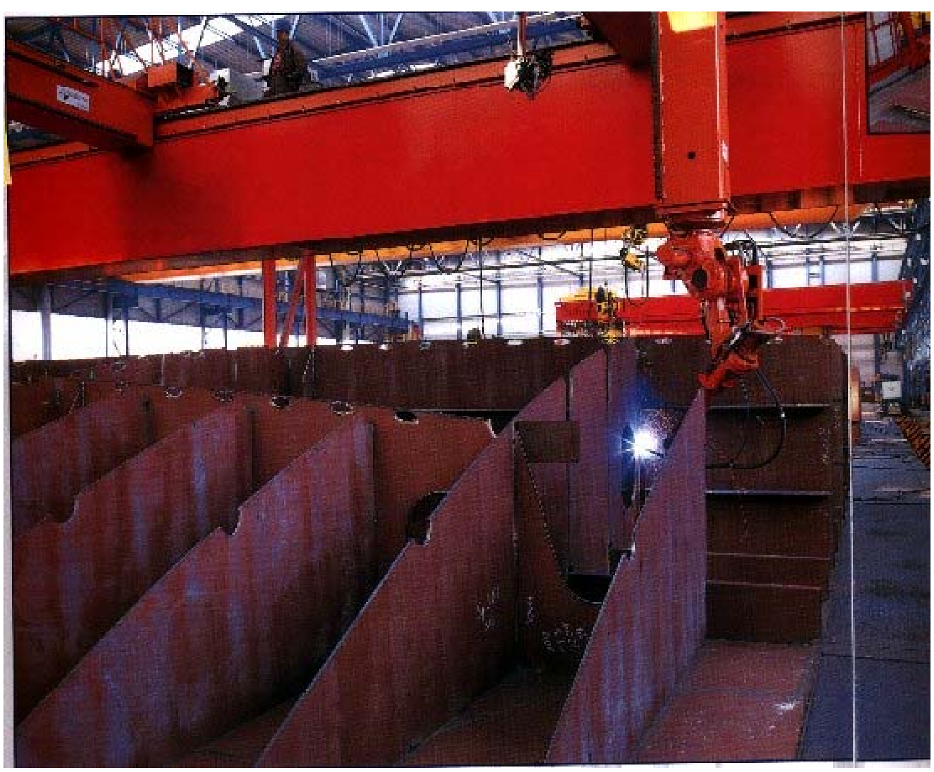


Fig. 37: Picture courtesy of Kvaerner Warnow Werft

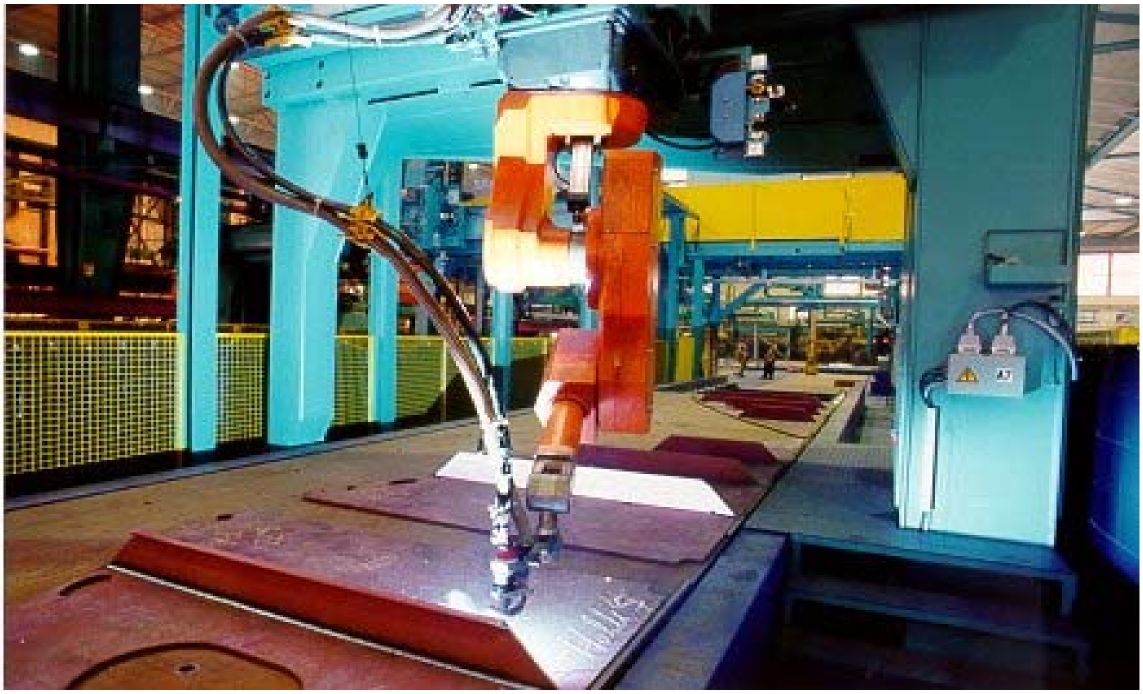


Fig. 38: Welding Robot in operation on sub assembly line at Howaldtswerke-Deutsche Werft AG.
Courtesy of Howaldtswerke-Deutsche Werft AG

Robot Interface 2. Tribon Robot Interface 2 is a variant of the Tribon Robot Interface 1. Robot Interface 2 allows to export parts geometry and welding data of assemblies to a neutral file. The files can be used for further processing for robot welding purpose (or other use of geometry and welding trace data).

The data exchange model of Robot Interface 2 is defined along the lines of (but not fully compliant to) ISO 10303-218 for weld data. The language EXPRESS (ISO 10303-11) is used for the description of this data model.
The neutral file format is defined along the lines of ISO 10303-21 (STEP).

Less excess material and adjustment work
Due to high accuracy of parts manufacturing and use of good quality assembly information the need for excess material can be reduced.

Such items as template pipes can considerably be reduced when using Tribon.

Less rework
Due to several production checks at the design stage Tribon production information is more reliable. These checks are geared to shipyards hardware facilities and prevent design errors to reach production.

Improved worker efficiency
Since Tribon can produce work instruction with a high degree of automation information can be produced for each work location and work step. The worksman will get clear and simple instructions just for the task he is doing. This saves production time and reduce misunderstandings and errors.