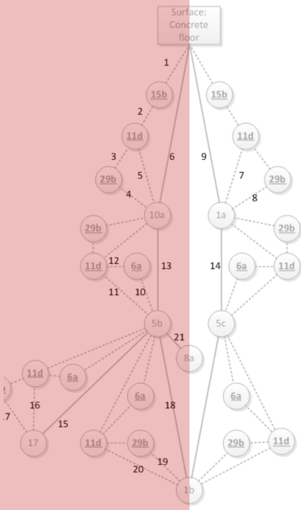
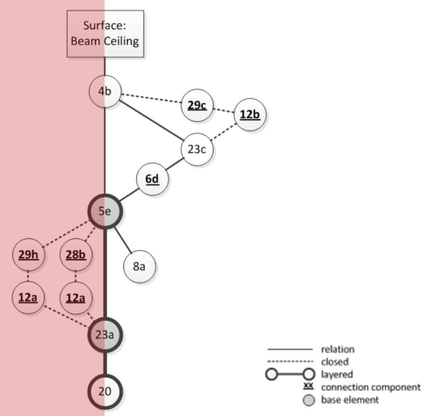
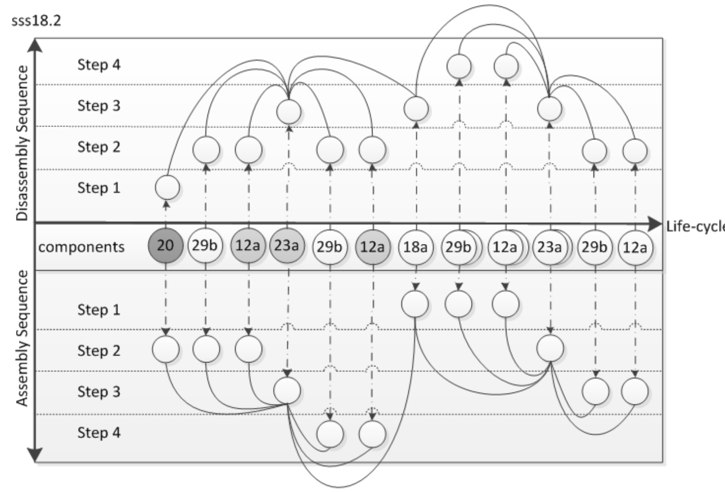
Appendices

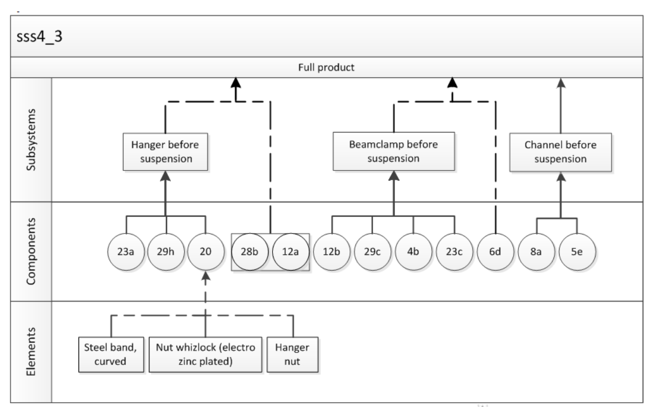
'To analyze and improve Tyco's Sprinkler Supports in the field of (de)installation efficiency'

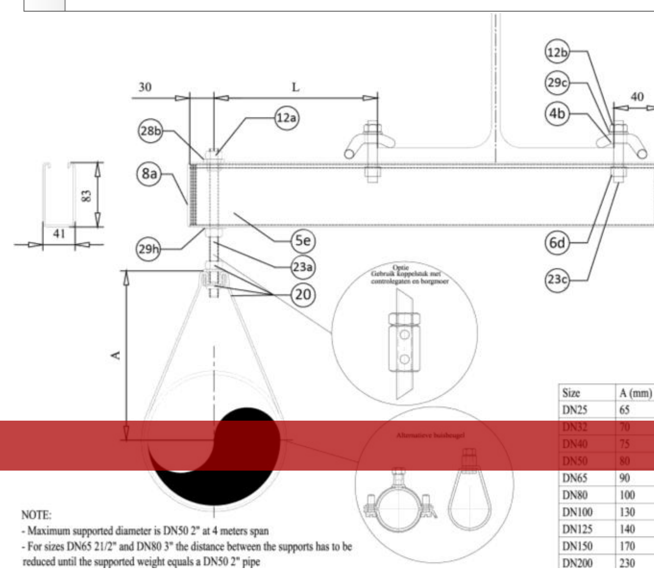
11-05-2012 Bachelorsassignment Yolanda Koevoets





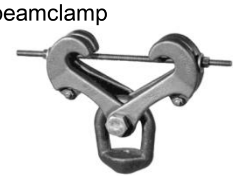
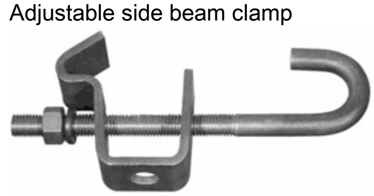
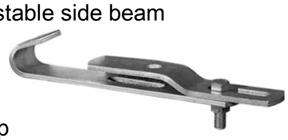
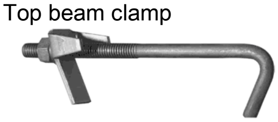
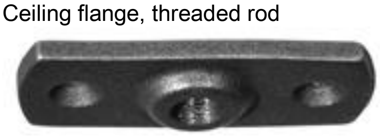
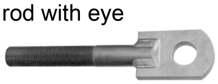
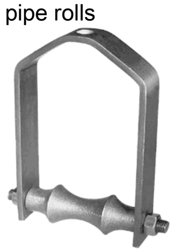
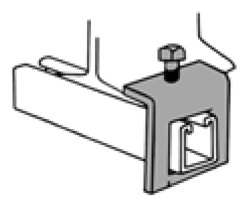
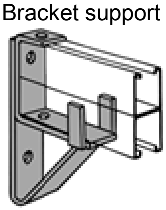
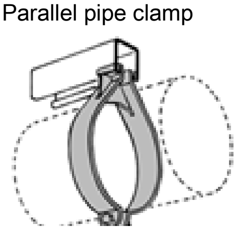
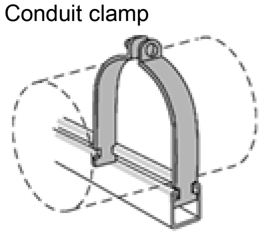






Index

Appendix A Competitive rivalry

Anvil international [1]		
Swivel ring adjustable type 	Pipe/conduit hanger Clevis 	Offset pipe clamp 
universal forged steel beamclamp 	Standard/heavy duty beamclamp 	Adjustable side beam clamp 
Adjustable side beam  clamp	Top beam clamp 	Ceiling flange, threaded rod 
rod with eye 	Coach screw rod 	Concrete screw (inserted  while concrete is poured, replaces non-drill anchor)
Clevis pin with cotters (u-bolt) 	pipe rolls 	Beamclamp 
Bracket support 	Parallel pipe clamp 	Conduit clamp 

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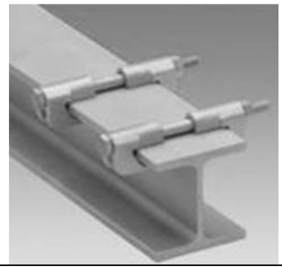</td></tr>
<tr><td colspan="2">Channel nut with rod
</td><td colspan="2">Blindnieten
</td><td colspan="2">Height adjustable threaded rods
</td></tr>
<tr><td colspan="2">Rod connector
</td><td colspan="2">Lockband
</td><td colspan="2">Spannschlösser
</td></tr>
<tr><th>Sikla[3]</th><th colspan="5">?[4]</th></tr>
<tr><td>Height adjuster
</td><td colspan="5">Snake clamps
</td></tr>
<tr><th>MEFA[5]</th><th colspan="3">?[4]</th><th colspan="2">?[4]</th></tr>
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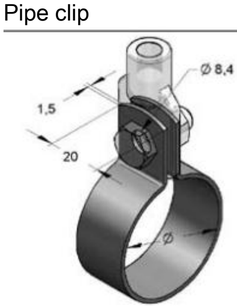
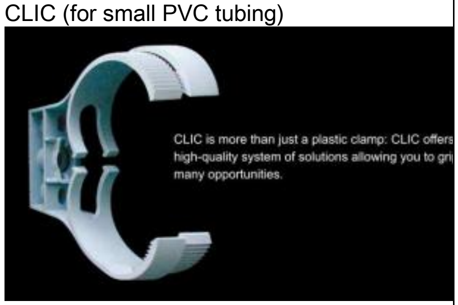

</td><td colspan="3">CLIC (for small PVC tubing)

</td><td colspan="2">Toggle hangers

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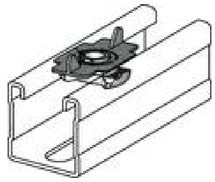
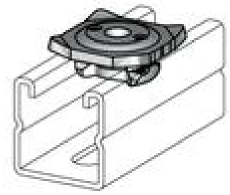
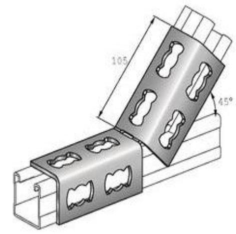
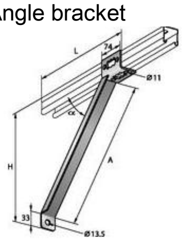
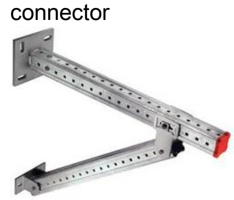
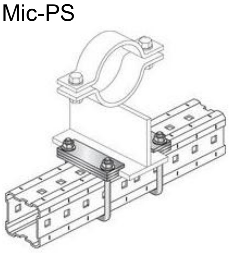
Hilti[6]			
Pushbotton (channel nut, bolt and washer) 	Wing nut (replacing channel nut) 	Saddle nut (replacing hannel nut) 	45 angle 
Angle bracket 	Speed lock clevis hanger 	Beamclamp 	Split rings 
Strut clamp 	Speed lock riser clamp 	Concrete  anchor	Mic-connector 
Mic-PS 	MIC-U-bolt 		

Tolco[7]		
Concrete insert 	pvc coated hanger 	trimline hanger 

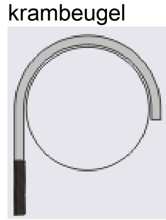
ERICO[8]				
Rod connector 	Clevis hanger 	Surge restrainer 	CADDY SPEED link 	Loop hanger 

Hazal[9]

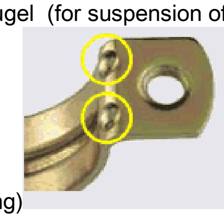
Beugel FIR,

universele pijpbeugel

krambeugel



nokbeugel (for suspension of pipes before securing)



ITW Buildex[10]

Swivel head (jack nut)

Swivel head (screw/bolt)

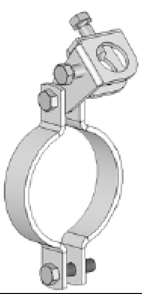
JV-industries[11]

Pipe hanger
(used before pouring concrete,
threaded rod can be screwed in)

Ferry international[12]

PHD manufacturing

PHD manufacturing[13]



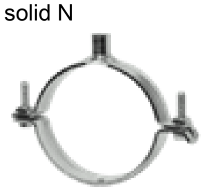
Threadless pipe attachment

Mascots[14]

pipe clamp

Flamco[15]

BKS (pipe gallow)

Tyco[16]			
Beamclamp 	Pipe clip 	Conduit pipe clamp 	Pipe clamp 
x-press (jack nut) 	Stud nut 	channel nut 	channel nut removable 
Stud nut with extended rod 	Channel extended nut removable 	DIN 6923 	Trapeze ceiling fixing + nut TCB 
Concrete screw + threaded rod 	Concrete screw + threaded tube 	Rod swivel 	Sprinkler hanger FILBOW 
Sprinkler hanger SPH 	Sammy anchoring system for vertically & horizontally dispensing rods, requires only a drill. 		solid N 

Ex-Tyco		
beam clamp swift 	Din 931 	model 260 

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Appendix B Criteria for analyses

The following criteria were used for the products suitable for analysis.

- Complexity in (dis)assembly weighing factor: 2 1/3
- Frequently sold weighing factor: 1

Since the data about the sales numbers was unreliable, complexity got a high weighing factor. But seeing that analyzing supports which are hardly ever used is useless this criteria of frequently sold were added as well. A suitable ratio of 7:3 was chosen resulting in weighing factors of 2 1/3 and 1

Complexity in (dis)assembly

To figure out which of the products is most complex the definition of complexity is considered. “A complex product is defined as a product with many interconnected or interwoven parts.” The degree to which the components are interconnected is yet undefined. But looking at the number of components per product, an estimation about complexity can be made Each product was scored between 1 and 30, 30 being a very complex product and 1 indicating a product made out of only few parts (a few parts being around 5). The scores can be found in the last table of this appendix. The highest scoring products had 62, 55, and 27 components (corresponding to sss14_2, sss14_1 and sss12).

Frequently sold

It is hard to discover which of the supports is sold most frequent. The sales list of Metal Framing & Supports, fiscal year 2011 in the Netherlands is considered. However, this list contains all support products, used for every building system. All non-sprinkler system components have to be removed in order to create a clear sprinkler supports list. The non-sprinkler systems are: heating, ventilation, air conditioning and electrical systems. A distinction was made between frame-components and pipe support components.

System	Frame components	Pipe support components
Heating	Channels, channels insulated	Insulated Pipe clamps/pipe saddles/U-bolts
Ventilation	Channels, duct bracket	Duct clamps, saddles, clips, u-bolts
Air conditioning	Channels, duct bracket	Duct clamps, saddles, clips, u-bolts
Electrical	Channels, Ladders, trays	Light duty pipe clips
Sprinkler	Channels, angle brackets, fix-points	Hanger, saddles, clips u-bolts

Frame components:

All systems use the same kind of frames, making the frames un-uniquely unsuitable for figuring out the sales numbers for sprinkler systems.

Supports components:

Electrical systems only uses light weight or light duty pipe clips and can therefore easily be distinguished from the pipe supports.

Heating system supports have to be insulated; this means that heating system pipe clamps, saddles, U-bolts and pipe clips can be distinguished from the sprinkler systems" by (lack of) insulation.

After filtering the list using above information left the list with only duct clamps, sprinkler hangers, pipe clamps, pipe saddles and U-bolts. Ventilation systems, air-conditioning systems and sprinkler system almost use the same support products. Therefore it is hard to determine which of these ordered products are used for the sprinkler supports. However, considering that ventilation systems and sprinkler systems are often installed similarly (on the same building structure with the same ceiling profile), it can be concluded that the same suspension methods are used. When looking at the sales list with this information the following list can be formed.

Support type	sold in FY11	Contains how many product types	Number sold of one product type in FY11
Clips	749174	3	249724
Hanger	1701880	18	94548
U-bolts	271705	5	45284
Saddles	1443	3	288
Supports total	2724202	29	389846

A lot of these top-9 products were similar. To analyze all would not fit in the time frame of this assignment. Therefore some products were removed from this top-9. Sss7 was removed because this is the same as sss13, the only difference was that one functions as a floor connection, and one as a ceiling connection. Sss4_2 was removed because this is similar to sss4_3 since they are in the same product category. For this same reason sss14_3 was removed. Sss12 was removed from the top 9 most suitable products for analyses because it is similar to sss13, which is already picked for analyses.
The remaining supports within this top 9 are: sss13, sss4_3, sss3, sss18_2, sss14_2 These supports are complex, frequently sold (to a small extend), vary in geometry and vary in function (wall-, ceiling- or floorconnections). Therefore these supports are suitable for analyses.

Top	Product ID	sales score	WF	complexity score	WF	Total score
1	sss7	29,5	88,5	25	175	263,5
2	sss13	29,5	88,5	25	175	263,5
3	sss4_3	18	54	27	189	243
4	sss4_2	18	54	25	175	229
5	sss3	18	54	22,5	157,5	211,5
6	sss18_2	18	54	22,5	157,5	211,5
7	sss14_2	2,5	7,5	30	210	217,5
8	sss14_1	2,5	7,5	29	203	210,5
9	sss12	2,5	7,5	28	196	203,5

Appendix C Functional decomposition

A component’s functional dependence can be described in two ways: being separated or integrated.
Integrated components fulfil multiple functions, separated components fulfil only one (or less) functions.

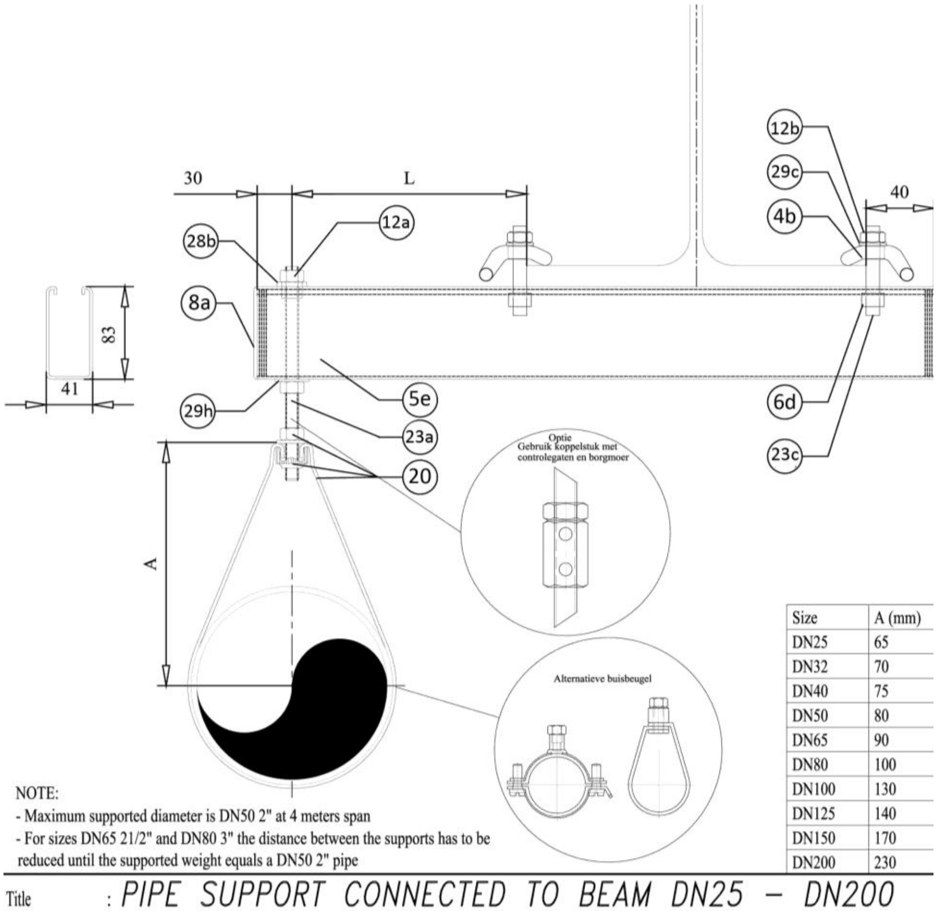
- **Functional separation**
  One function is fulfilled by one or more components.
  Separation is efficient when regular adjustments have to be made to the product. Adjustments being: a change in the product’s functionality or the renewal of a component when it is worn down. A product with functionally separated components is very clarifying in which components fulfill which functions. The removal of one function is therefore easy and does not greatly influence the total functionality of the product.

- **Functional integration**
  Multiple functions are fulfilled by one component.
  Integration is efficient when a product doesn’t need to change for a long period of time. An integrated product with many functions per component is easily installed with few installation steps and is preferably replaced as a whole.

Functional diagram

For the functional decomposition functional diagrams are created. This diagram shows the level of dependencies of the different components and contains 3 levels: subsystems, components and elements. The components are the components as identified by Tyco, elements are the different parts of these components and subsystems are subassemblies (or clusters) of components. An ideal situation is when all components are a part of a subsystem. This gives a clear division of components and makes it very clear where the components need to be in the end product. The different subsystems can be assembled separately and as a last step these subsystems can be connected to form the end product.

Functional decomposition sss4_3



*original component nrs. have been changed to correspond with excel sheet: components

COMPONENT NR.	ARTICLE. NR.	GEOMETRY	ARTICLE DESCRIPTION	FUNCTION
5e	P5000T	41x83 L=6m	Channel P5000T	Servicing as suspension area
20	SUDN…	DN…	Sprinkler hanger	Supporting pipe by connecting to threaded rod using nut.
23a	9755M10x1M	M10x1m	Threaded rod	Variably Partitioning hanger from channel using nuts Connecting hanger and channel
4b	1391275	M12	Beamclamp	Connecting threaded rod to beam ceiling
12a	9345M10	M10	Hex nut DIN934	Connecting channel to threaded rod using Channel nut
29h	3910123	M10	Washer DIN391	Partitioning bolt from surface
8a	1394197	41x41mm	End cap	Enclosing channel
28b	14041120	M10	U-shaped washer	Partitioning nut from open side of the Channel
29c	1255M12	M12	Washer DIN125	Partitioning nut from surface
12b	9345M12	M12	Hex nut DIN934	Connecting beam to threaded rod using channel nut/beamclamp
6d	PNP12ZP	M12	Channel nut	Connecting channel to threaded rod using Hex nut
23c	9765M12x80	M12x80	Threaded rod	Connecting beam to channel using beam clamp, (channel)nut

Functional independence

- The threaded rod (23a), is functionally integrated, both connecting the hanger from the channel and variably partitioning them.

- All components but number 23a are functionally separated. Some even using multiple components to fulfil one function: 12b, 4b, 6d and 23c connect the ceiling beam to the channel. 12a and 20 jointly connect the hanger to the channel

Systematization

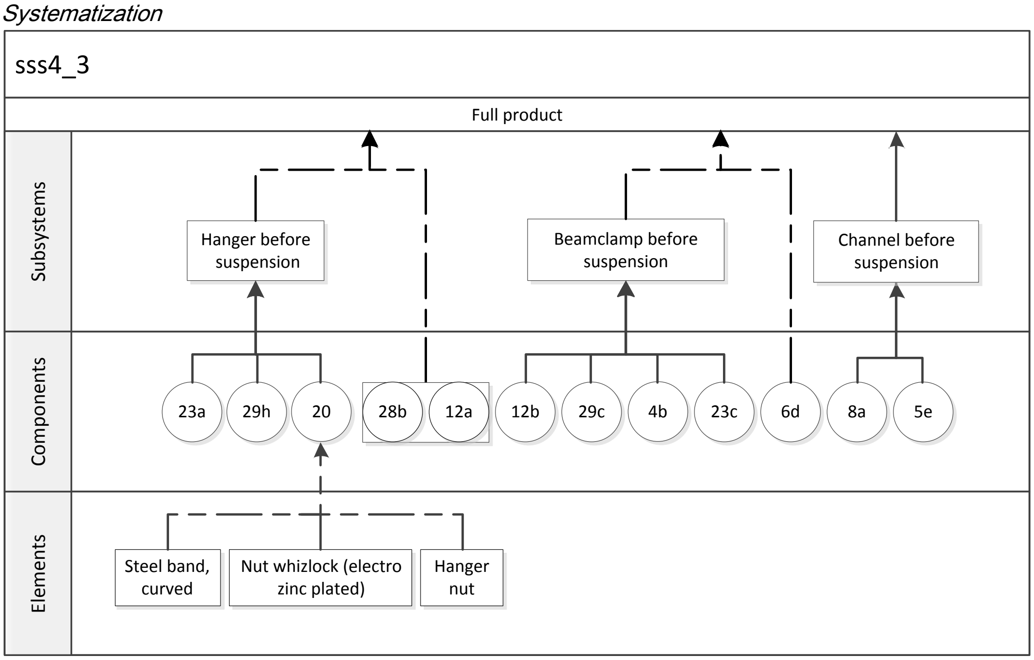


Figure: Functional diagram ss4_3, dotted lines indicate problem areas

- Three subsystems are identified. Hanger before suspension, beamclamp before suspension and channel before suspension.
- Component number 20, the sprinkler hanger, contains multiple separated elements.
- Components 28b, 12a and 6d, U-shaped washer, nut and channel nut, need to be inserted into the product singularly. In which 28b and 12a can be clustered together while doing so.
- The subsystems hanger before suspension and beamclamp before suspension contain a lot of elements/components

CONCLUSIONS

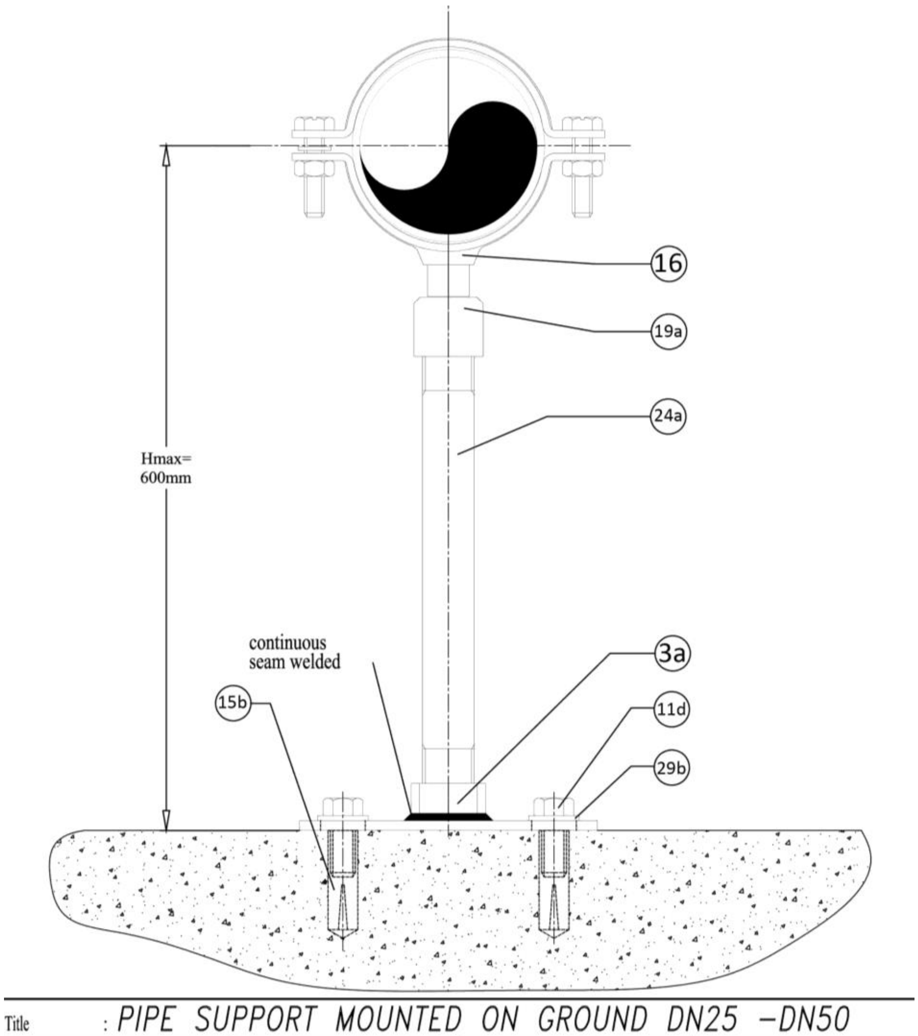
Integrated components: 23a

Separated components: 5e,20,4b,12a,29h,8a,28b,29c,12b,6d,23c (combined:12b,4b,6d,23c & 12a,20)

An ideal functional diagram only has subsystems connecting the components level to the full product level. This means easy and efficient (dis)assembly. However, the nuts and washers are not a part of a subsystem and cannot be combined with other components beforehand. Also, the sprinkler hanger consists of 3 elements which need to be combined by the customer on site.

And, the customer needs to assemble a lot of components/elements to create the clusters.

Functional decomposition sss13



*original component nrs. have been changed to correspond with excel sheet: components

COMPONENT NR.	ARTI. NR.	GEOMETRY	ARTICLE DESCRIPTION	FUNCTION
16	UNI-N..	DN…	Pipe clip UNI-N	Supporting pipe by connecting to threaded tube
24a	TUBE512	0,5” L=2m	Threaded Tube	Partitioning pipe clip from baseplate
3a	1461022	0,5"	Baseplate	Supporting threaded rod by connecting to surface
11d	933510x25	M10x25	Hex bolt DIN933	Connecting base plate to surface using non-drill anchor
29b	1255M10	M10	Washer DIN125	Partitioning bolt from surface
19a	SP12M10	0,5"	Solid adapter	Connecting pipe clip to threaded tube (Variably) partitioning Pipe clip from Threaded tube
15b	EAM10	M10	Non drill anchors	Connecting baseplate to surface using bolt

Functional independence

- Component 19a, the solid adapter, is functionally integrated. Both connecting the pipe clip to the baseplate and variably partitioning the pipe clip from the threaded tube.

- All components but 19a are functionally separated. Components 11d and 15d are multiple components fulfilling one function; connecting the baseplate to the surface.

Systematization

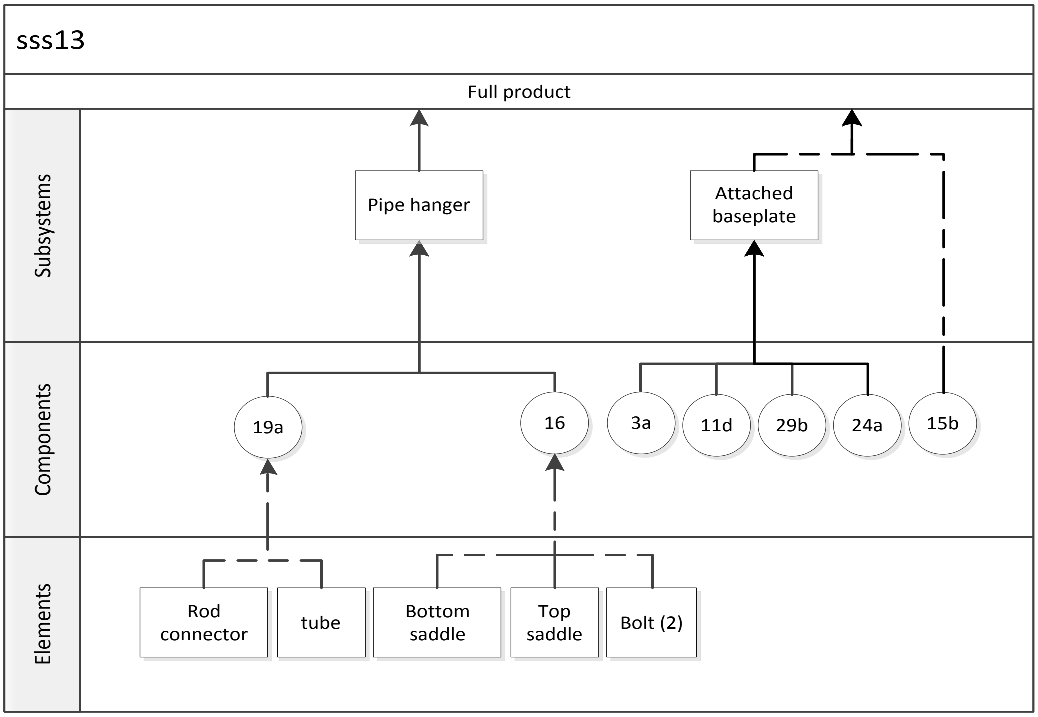
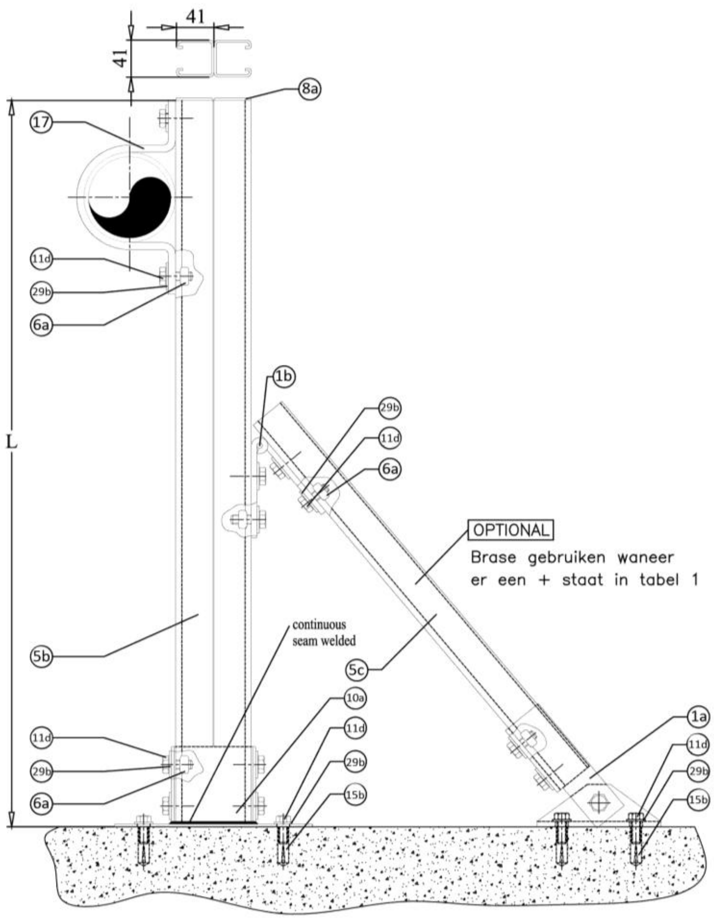


Figure: Functional diagram sss13, dotted lines indicate problem areas

- Two subsystems are identified: pipe Hanger and attached baseplate.
- 19a and 16, the solid adapter and pipe clip, contain multiple separated elements.
- Component 15b, the non-drill anchors, need to be inserted singularly.
- Both subsystems need many components to be assembled before implementation is possible.

CONCLUSIONS
Integrated components: 19a
Separated components: 16, 24a, 3a, 11d, 29b, 15b, (combined: 11d, 15d)
An ideal functional diagram only has subsystems connecting the components level to the full product level. However, the non-drill anchors are not included in a subsystem. Also, the solid adapter and pipe clip consist of multiple elements which need to be put together by the customer.

Functional decomposition sss14_2



*original component nrs. have been changed to correspond with excel sheet: components

Title : PIPE SUPPORT MOUNTED ON GROUND DN25 – DN100

COMPONENT NR.	ARTI. NR.	GEOMETRY	ARTICLE DESCRIPTION	FUNCTION
17	PS…5	DN…	Pipe saddle	Supporting pipe by connecting to channel
11d	933510x25	M10x25	Hex bolt DIN933	Connecting pipe saddle to channel by using channel nut
29b	1255M10	M10	Washer DIN125	Partitioning bolt from surface
6a	PNP10HDIN	M10	Channel nut	Connecting channel to pipe saddle using bolt
5b	P1022156	41x92 L=6m	Channel P1001	Servicing as suspension area
10a	P2073A	41x83	Heavy Baseplate	Supporting threaded rod by connecting to surface
5c	P1011256	41x41x6m	Channel P1000T	Servicing as suspension area. Supporting channel
1b	P1354	102x102mm	Adjustable angle fitting	Partitioning channel from channel at angle
8a	1394197	41x41mm	End cap	Enclosing channel
1a	P2815S	Heavy	Adjustable angle Fitting	Supporting channel by connecting to surface
15b	EAM10	M10	Non drill anchors	Connecting baseplate and adjustable angle to surface

Functional independence

- Component 5c, the channelP1000T, is functionally integrated. Both servicing as a suspension area and a support for the channel.

- All components but 5c are functionally separated. Components 11d, 29b, 6a are multiple components fulfilling one function; connecting the channel to other components. Also components 11d, 29d and 15 b fulfil one function together; connecting the baseplate or adjustable angle fitting to the ceiling or floor.

Systematization

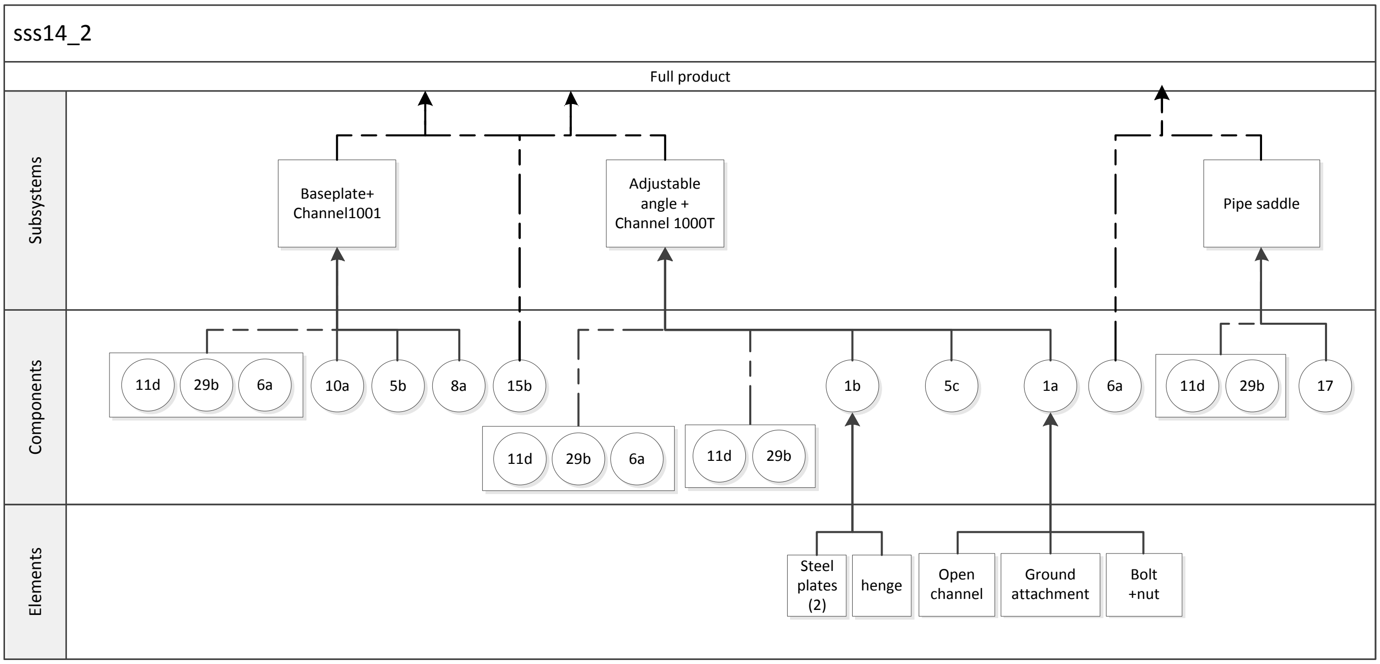


Figure: Functional diagram sss14_2, dotted lines indicate problem areas

- There are three subsystems: baseplate+channel, adjustable angle+channel and pipe saddle.
- The adjustable angle fitting (1a) and adjustable angle(1b), contain multiple separated elements.
- The channel nut (6a) and non-drilling anchor(15b), need to be inserted into the product singularly.
- Subsystems baseplate+channel1001 and adjustable angle+channel1000T contain a lot of components.

CONCLUSIONS

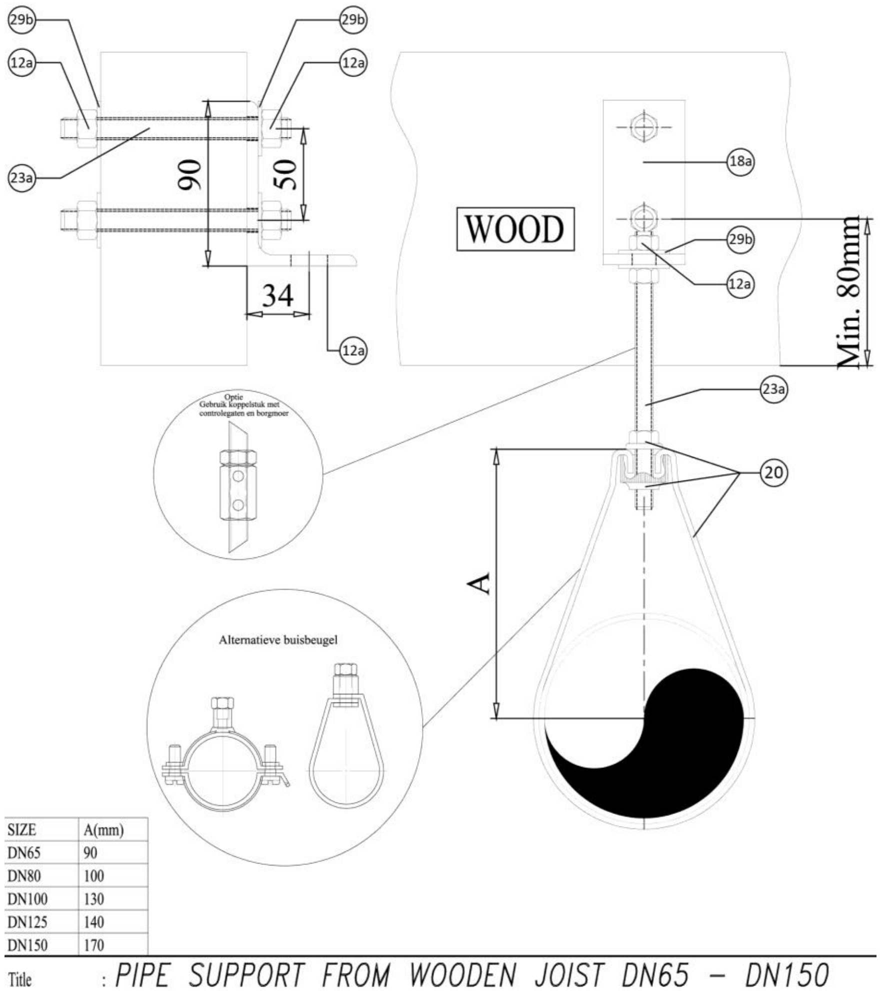
Integrated components: 5c

Separated components: 17, 11d,29b,6a,5b,10a,5c,1b,8a,1a,15b (combined: 11d,29b,6a & 11d,29b,15b)

An ideal functional diagram only has subsystems connecting the components level to the full product level. This means easy and efficient (dis)assembly. However, the channel nut and non-drilling anchors are not a part of a subsystem and cannot be combined with other components beforehand.

Also, the sprinkler hanger consists of 3 elements, these elements however, are already assembled and don't have to be put together by the customer. And, the customer needs to assemble a lot of components to create the clusters

Functional decomposition sss18_2



*original component nrs. have been changed to correspond with excel sheet: components

COMPONENT NR.	ARTI. NR.	GEOMETRY	ARTICLE DESCRIPTION	FUNCTION
20	SUDN…	DN…	Sprinkler hanger	Supporting pipe by connecting to threaded rod
23a	9755M10x1M	M10x1m	Threaded rod	Variably partitioning hanger from Sidebeam attachment using nuts Connecting hanger to sidebeam attachment using nuts
12a	9345M10	M10	Hex nut DIN934	Connecting threaded rod to sidebeam attachment Hex nut OR Connecting Sidebeam attachment to Threaded rod using Hex nut
18a	G9060	90x60mm	Sidebeam attachement	Partitioning threaded rod from surface Connecting threaded rod to surface
29b	1255M10	M10	Washer DIN125	Partitioning nut from surface

Functional independence

- Components 23a and 18a are functionally integrated. The Threaded rod connects the hanger to the Sidebeam attachment and also variably partitions them. The sidebeam attachment connects the rod to the surface and also partitions the two.

- All components but 23a and 18 are functionally separated. 12a even fulfils only part of a function, this nut, together with a threaded rod, connects the sidebeam to the ceiling.

Systematization

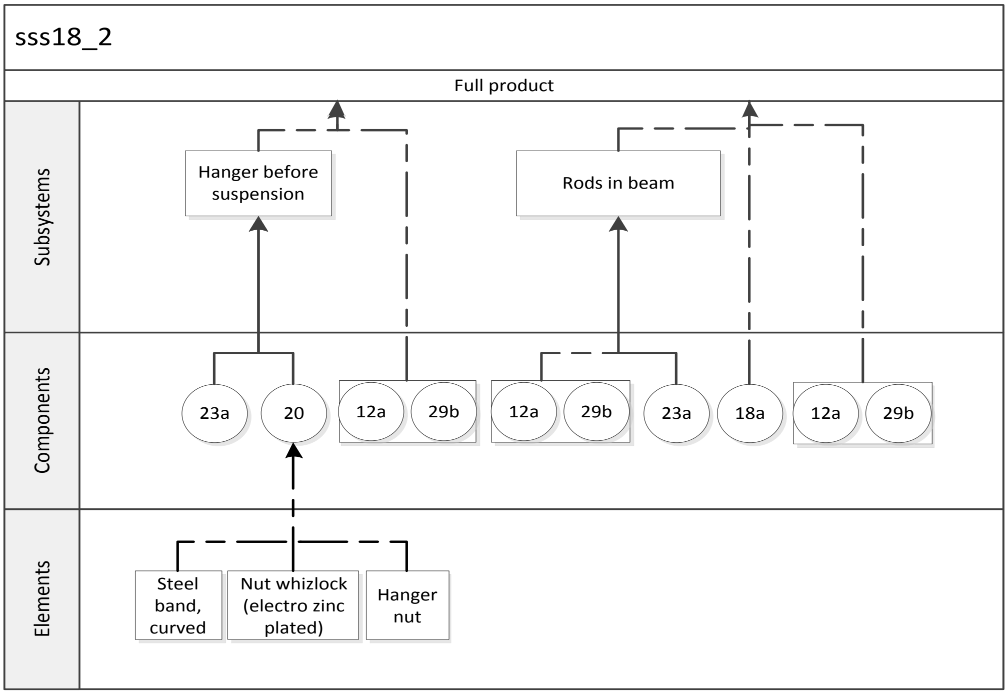


Figure: Functional Diagram sss18_2, dotted lines indicate problem areas

- Two subsystems are identified: Hanger before suspension, rods in beam
- Component number 20, the sprinkler hanger, contains multiple separated elements.
- Components 12a, 29b, 18a, nut, washer and sidebeam attachment, need to be inserted into the product singularly. In which 12a and 29b can be clustered together while doing so.

CONCLUSIONS
Integrated components: 23a, 18
Separated components: 20, 12a, 29b (combined: 12a,12a combined: 12a,20)

An ideal functional diagram only has subsystems connecting the components level to the full product level. This means easy and efficient (dis)assembly. However, some nuts, washers and the sidebeam attachment are not a part of a subsystem and cannot be combined with other components beforehand. Also, the sprinkler hanger consists of 3 elements which need to be combined by the customer on site. And, a lot of components/elements are needed to create the cluster; hanger before suspension

Appendix D Technical decomposition

Relational diagrams

Fixed vs. Dynamic assembly

Relational diagrams show the relations between components. If one component has many relations this component may be difficult to install, (dis)assembly will go inefficient because of dependencies upon other components.
Three types of assembly can be identified: fixed, dynamic, or a combination of both. fixed assembly is often indicated by horizontal relations within the diagrams, dynamic assembly is often indicated with vertical relations.

- Layered assembly (dynamic)
  Stacking components, only vertical relations. Only efficient in assembly with multiple installers.

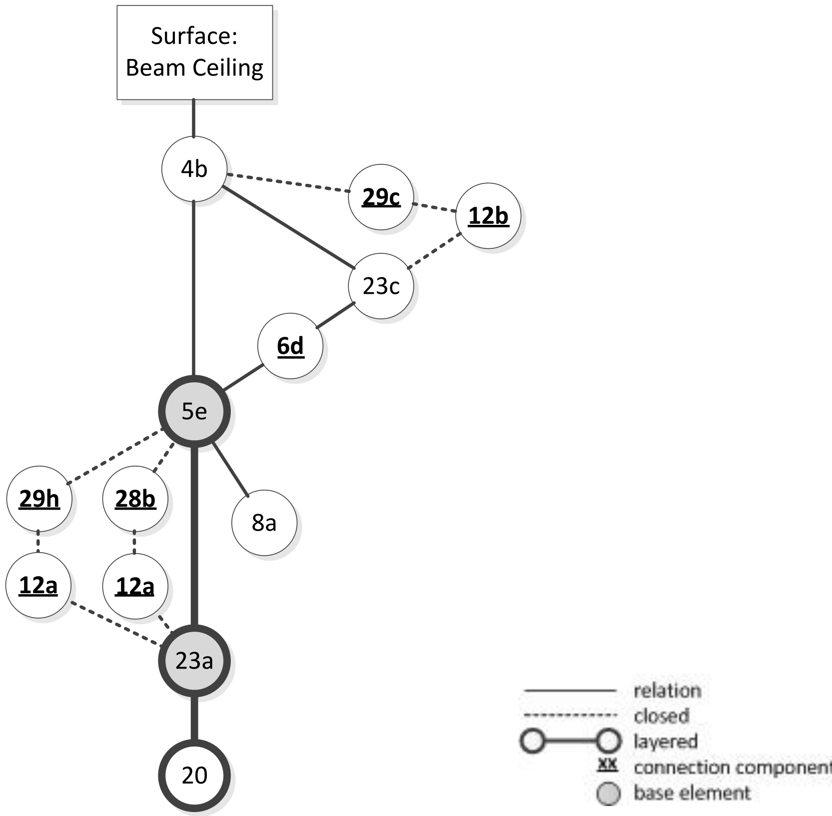
- Closed assembly (relatively fixed)
  A maze of relations. Closed assembly prohibits easy (dis)assembly.

- Open assembly (dynamic, fixed)
  Components are connected to a *base element*. Usually components connected to the base element have few connections and are relatively independent. A base element indicates a group of components which can easily be merged when assembly sequences allows it to.

Components are called either 'connecting' or 'non-connecting':

- Connection components: washers, nuts, bolts, non-drill anchors, and the threaded rod/tube, although this last component has multiple functions and is not distinctly a connection component, therefore the threaded rods/tubes are not classified as connection components in the diagrams.

- Non-connection components: channels, sprinkler hangers, beamclamps, endcaps, baseplates, solid adapters, pipe saddles, pipe clips, adjustable angles, adjustable angle fittings, sidebeam attachment sss4_3



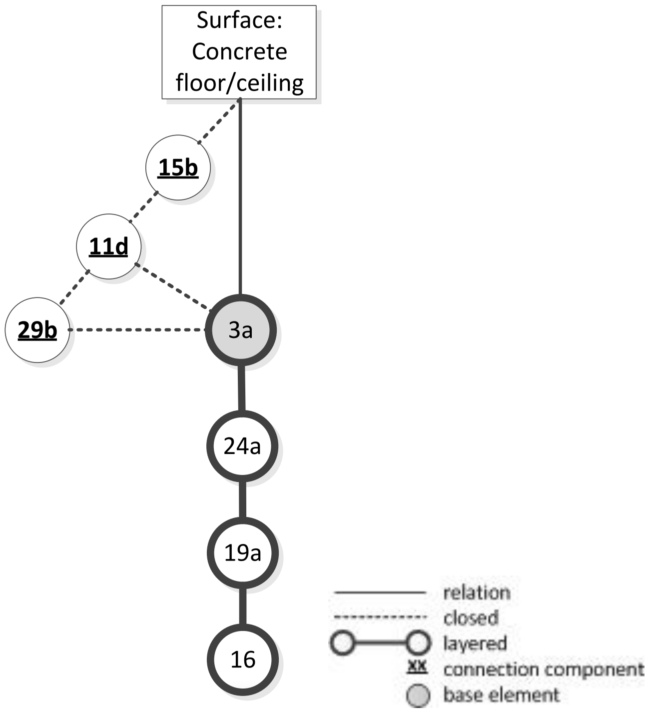
CONCLUSIONS:

- Almost all non-connection components have layered assembly relations. Except for 8a, 4b and 23c. The end cap (8a) only has one relation and the beamclamp (4b) with accessory threaded rod (23c) are both fixed in closed assembly.

- All connection components cause closed assembly.

- Two base elements can be distinguished, 5e and 23a, channel and threaded rod. But since the components connected to these elements have multiple relations they are not official base elements.

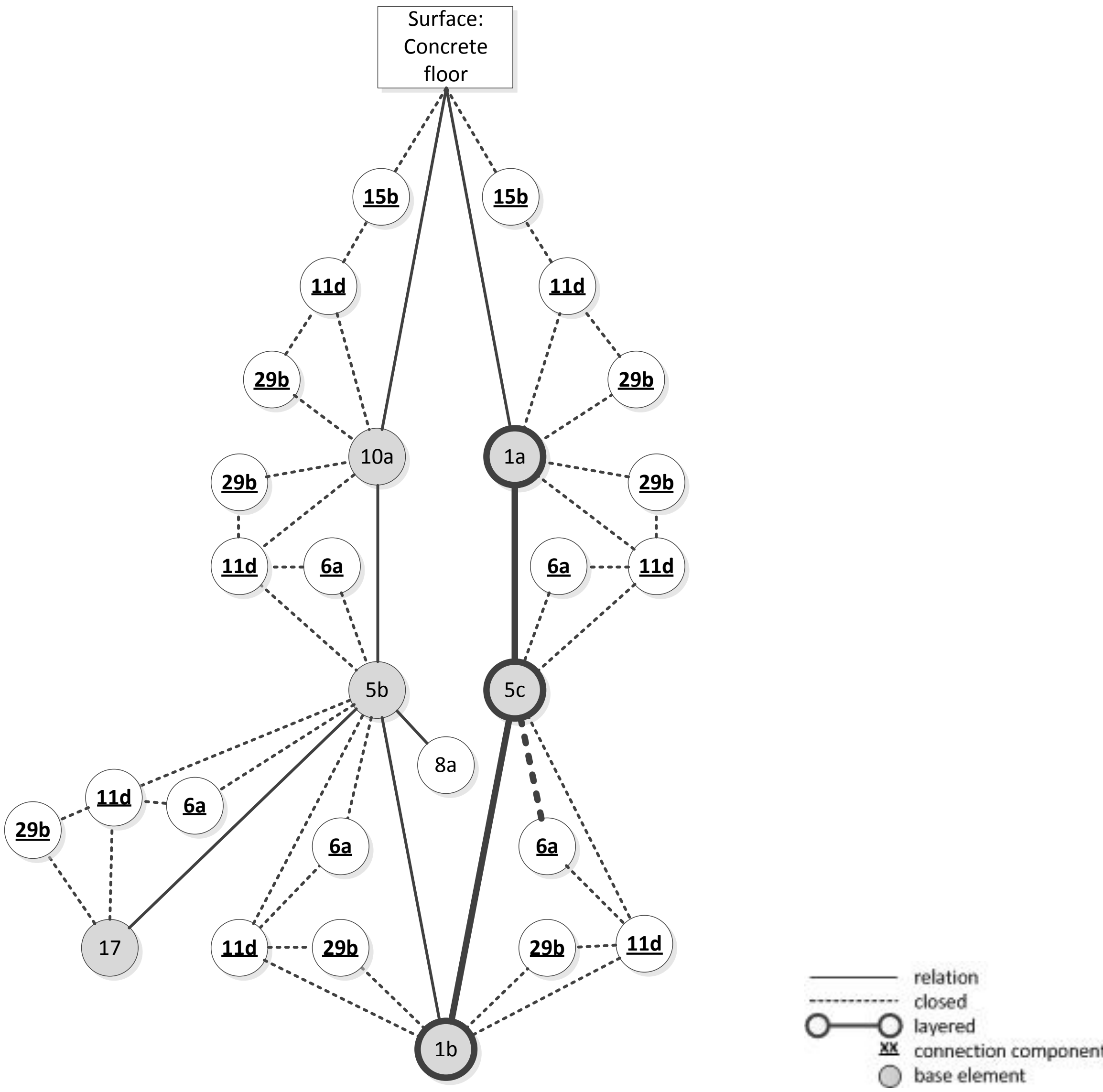
sss13



CONCLUSIONS:

- All non-connection components have layered assembly relations.
- All connection components case closed assembly although it is not an extreme form of closed assembly.
- Component number 3a, the baseplate, is conveyed as being a base element, although there is no clearly defined base element in this product.

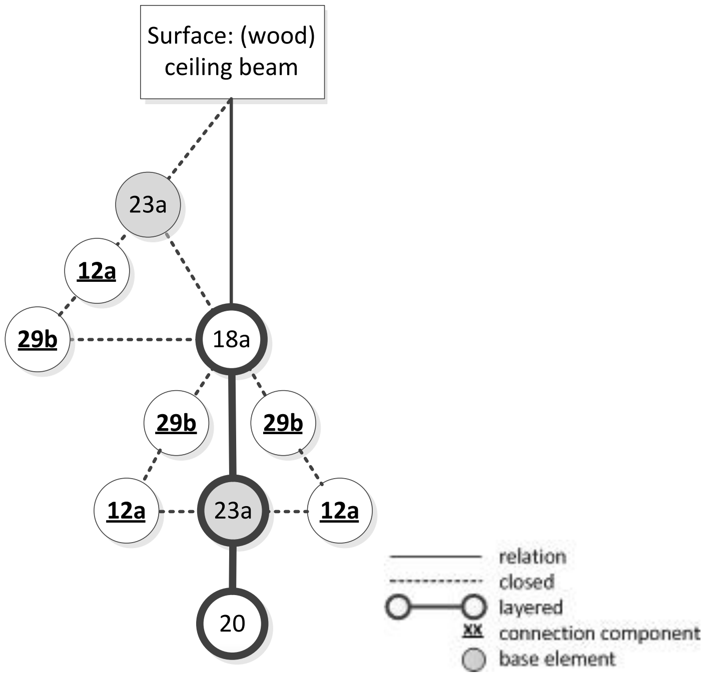
sss14_2



CONCLUSIONS

- Components 1a, 5c and 1b have layered assembly relations. This would have also been the case with the relations on the left side of the diagram, but component 5b, being a base element, prevents the layered assembly here.
- All connection components cause closed assembly.
- The End cap (8a) only has one relation. Together with the pipe saddle (17), adjustable angle (1b) and heavy baseplate (10a) the cap creates an open assembly around the channel, therefore the channel is declared the truest base element. 10a,1a,1b,5c and 17 can also be considered base elements.

sss18_2



CONCLUSIONS:

- All non-connecting components have layered assembly relations excluding 23a. This threaded rod is excluded from the layered assembly because the sidebeam attachment (18a) is also connecting to the ceiling beam.
- All connecting components cause closed assembly.
- Component 23a, the threaded rod is conveyed as being a base element, linking multiple components together

Appendix E Physical decomposition - Life-cycle coordination

A life cycle coordination gives information about the time components can be used within an assembly.

Life-cycle: Material

The material life cycle is the number of years components can be used looking at the material properties and the environment in which it is used. In the case of sprinkler supports this lifespan is around 60 years, corrosion being the main limiting factor. (The steel finish determines the exact material life-cycle) However, when looking at the scenario in which sprinkler supports and the functions they perform, some occurrences lay restrictions on the components" material life-cycles

Life-cycle: Functional (occurrences laying restrictions on the material life cycle)

Building changes
When a building changes in function, the roof layout changes, needing pipes to be displaced. Whenever this happens, the entire support is destructively removed and a new one is hung on a new location. No components are reused, meaning that the components used in a support do not have to be flexible in their removal or placement; 1 time installation is sufficient. The destructive removal of pipe supports due to building changes is estimated to happen to sections of a sprinkler system once every 30 years.

Pipe testing
Due to the destructive results of multiple types of corrosion, there are high standards for sprinkler piping. These standards include frequent testing of pipes, sometimes requiring the removal of pipe sections for metallurgic testing. When a section of pipe is removed, the support is destructively removed. This destructive removal of all components of a pipe support due to the need for pipe testing is estimated to happen to sections of a sprinkler system once every 25 years.

Life-cycle: Adjustments during installation

When reading above section it can be said that the components forming a sprinkler support should have the same lifespan, do not have to be flexible and can be designed to be destructively removed. However, in the current situation this is not the case. The components are connected in a flexible way because they should allow for adjusting during installation: a pipe needs to be added, and the height of this pipe should be adjusted. These two actions are the real restrictions on the life-cycle. They require some components to be connected in a flexible way; leaving room for movement in a certain direction.

Appendix F Physical decomposition - Geometry of product edges

3 main types of geometry describe the connections between sprinkler support components.

- Open geometry

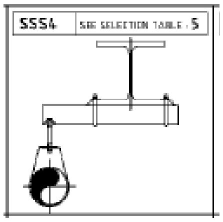
  The components can easily be removed from the products. There is no specific order in disassembly and one component should be able to separate from another in at least 2 directions in 2 opposite sites.
  Open geometry is preferred in dynamic structures; it enables the removal of each individual component without removing other parts.

- Overlapping geometry

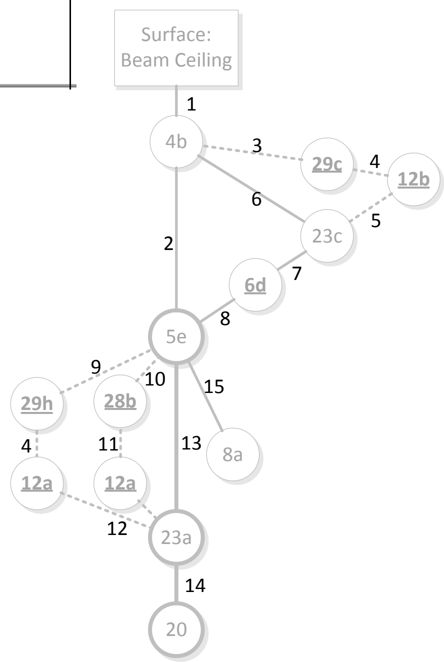
  The components can only be removed in a specific order. Therefore a component can only be removed from another in one direction. An overlapping geometry will create a relatively dynamic structure, but the components being on the most center part of the assembly are hardest to reach.

- Closed

  The components cannot be removed without an extra disassembly step or demolition of one or both components.
  Closed geometry is preferred in static structures.



Sss4_3



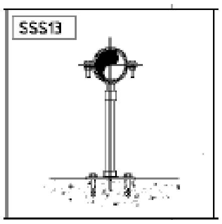
Nr.	Connecting components	Connection type	mechanism	Tools
1	Beamclamp (4b)→ Beam ceiling	Overlapping	--	--
2	Beamclamp (4b)→ Channel (5e)	Overlapping	--	--
3	Washer (29c)→ Beamclamp (4b)	Overlapping	--	--
4	Washer (29c)→ Nut (12b)	Overlapping	--	--
5	Nut (12b)→ Threaded Rod (23c)	Open	Screw thread	wrench
6	Threaded rod (23c)→ Beamclamp (4b)	Open	--	--
7	Threaded rod (23c)→ Channel nut (6d)	Open	Screw thread	--
8	Channel nut (6d)→ Channel (5e)	Closed	--	--
9	Washer (29h)→ Channel (5e)	Overlapping	--	--
10	U-shaped washer (28b)→ Channel (5e)	Overlapping	--	--
11	U-shaped washer (28b)→ Nut (12a)	Overlapping	--	--
12	Nut (12a)→ Threaded rod (23a)	Open	Screw thread	Wrench
13	Threaded rod (23a)→ Channel (5e)	Open	Pin + hole	--
14	Hanger (20)→ Threaded rod (23a)	Overlapping	Screw thread	Wrench
15	End cap (8a)→ Channel (5e)	Overlapping (closed)	Click	--

CONCLUSIONS

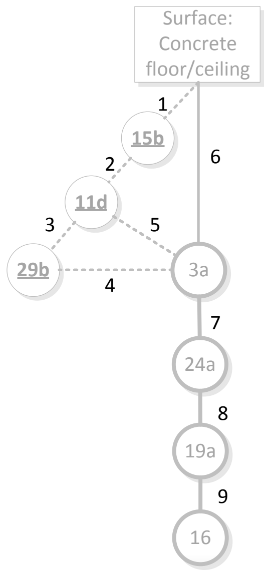
All elements connected to the threaded rod are openly connected except for the hanger. However, when looking at the threaded rod as a whole the components are not openly connected, only allowing for one way disassembly and therefore creating overlapping connections.

The channel nut and end cap are closed connected to the channel; although the end cap is made out of polypropylene and can be removed from its closed position.

Overall the product's components are overlapping.



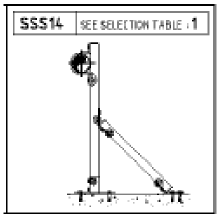
sss13



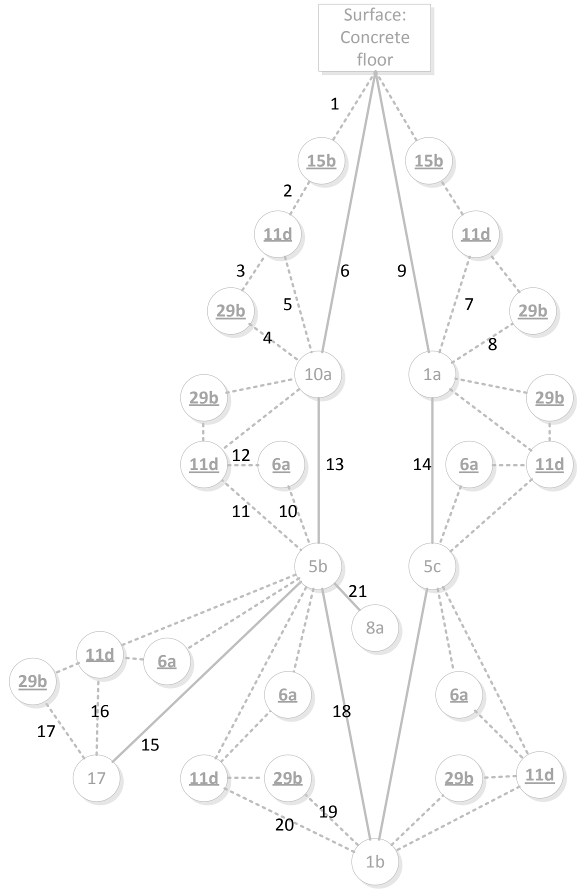
Nr.	Connecting components	Connection type	mechanism	Tools
1	Non-drill anchor (15b) → floor/ceiling	Closed	Reforming materials	Setting tool, drill
2	Bolt (11d)→ Non-drill anchor (15b)	Overlapping	Screw thread	Wrench
3	Washer (29b)→ Bolt (11d)	Overlapping	Hole + pin	--
4	Washer (29b)→ Baseplate (3a)	Overlapping	--	--
5	Bolt (11d)→ Baseplate (3a)	Overlapping	Pin + hole	--
6	Baseplate (3a)→ floor/ceiling	Overlapping	--	--
7	Threaded tube (24a)→ Baseplate (3a)	Overlapping	Screw thread	--
8	Solid adapter (19a)→ Threaded tube (24a)	Overlapping	Screw thread	--
9	Pipe clip (16) → Solid adapter (19a)	Overlapping	Screw thread	--

CONCLUSIONS

All components are overlapping connected except for the non-drill anchors. Non-drill anchors are put in drilled holes and then jammed with a setting tool. This process reforms the component and anchors it into the concrete ceiling.



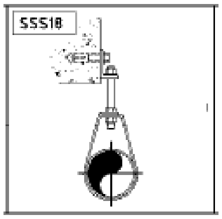
Sss14_2



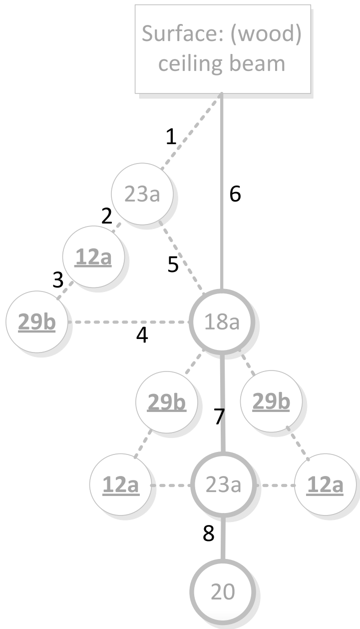
Nr.	Connecting components	Connection type	mechanism	Tools
1	Non-drill anchor (15b)→ Floor	Closed	Reforming materials	Setting tool, drill
2	Bolt (11d) → Non-drill anchor (15b)	Overlapping	Screw thread	Wrench
3	Washer (29b)→ Bolt (11d)	Overlapping	--	--
4	Washer (29b)→ Heavy Baseplate (10a)	Overlapping	--	--
5	Bolt (11d)→ Heavy Baseplate (10a)	Overlapping	Pin + hole	--
6	Heavy Baseplate (10a)→ Floor	Overlapping	--	--
7	Bolt (11d)→ Adjustable angle Fitting (1a)	Overlapping	Pin + hole	--
8	Washer (29b)→ Adjustable angle Fitting (1a)	Overlapping	--	--
9	Adjustable angle Fitting (1a)→ Floor	Overlapping	--	--
10	Channel nut (6a) → Channel (5b)	Closed	--	--
11	Bolt (11d)→ Channel (5b)	Overlapping	Pin + hole	--
12	Channel nut (6a) → Bolt (11d)	Overlapping	Screw thread	Wrench
13	Channel (5b)→ Heavy baseplate (10a)	Overlapping	Beam + holder	--
14	Channel (5c)→ Adjustable Angle Fitting (1a)	Overlapping	Beam + holder	--
15	Pipe saddle (17)→ Channel (5b)	Overlapping	--	--
16	Bolt (11d)→ Pipe saddle (17)	Overlapping	Pin + hole	--
17	Washer (29b)→ Pipe Saddle (17)	Overlapping	--	--
18	Channel (5b)→ Adjustable angle (1b)	Overlapping	--	--
19	Washer (29b)→ Adjustable angle (1b)	Overlapping	--	--
20	Bolt (11d)→ Adjustable angle (1b)	Overlapping	Pin + hole	--
21	End cap (8a)→ Channel (5b)	Overlapping (closed)	Click	--

CONCLUSIONS

Almost all components have overlapping geometry in their connections. Only the non-drill anchors, the channel nuts and the end cap have other, closed connections. However, since the end cap is made from polypropylene this connection is flexible and not really part of a closed geometry.



Sss18_2



Nr.	Connecting components	Connection type	mechanism	Tools
1	Threaded rod (23a)→ Ceiling beam	Open	Pin + hole	drill
2	Nut (12a)→ Threaded rod (23a)	Open	Screw thread	Wrench
3	Washer (29b)→ Nut (12a)	Overlapping	--	--
4	Washer (29b)→ Sidebeam attachment (18a)	Overlapping	--	--
5	Threaded rod (23a)→ Sidebeam attachment (18a)	Open	Pin + hole	--
6	Sidebeam attachment (18a)→ Ceiling beam	Overlapping	--	--
7	Threaded rod (23a)→ Sidebeam attachment (18a)	Open	Pin + hole	--
8	Hanger (20)→ Threaded rod (23a)	Overlapping	Screw thread	wrench

CONCLUSIONS

There is a lot of open geometry in the component connections in product 18_2. The reason for this is that many pieces of threaded rod are used. The threaded rod enables open connections, but when multiple components are connected to the rod they cannot be removed from opposite directions anymore and therefore the open geometry turns into an overlapping geometry.

Appendix G Physical decomposition - Assembly sequence

Combining the functional diagram and the geometry of the products edges/connections analysis the following diagrams can be made.

Diagrams

To analyze the assembly sequence, diagrams are formed. Vertically presented are the different steps in (dis)assembly. Horizontally represented are the components in order of life-cycle. Components needing changing first are positioned on the left. Components controlling height adjustments are represented as darkened components, the darkest components being most responsible.

For the sprinkler supports there often are multiple assembly sequences possible. To eliminate this aspect in the diagrams, the diagrams are set up to illustrate the most efficient way the products can be installed, using as little steps as possible, considering all facades of the components as ready for assembly, making it possible for the component to be in multiple subassemblies at the same time. Even the contact surface (ceiling/floor) is considered a component, ready to be assembled to a base element simultaneously with other components.
This may create some surreal assembly steps, creating situations that if the steps were to be realized by human hands, it would not be possible. However, this way of representing will show the efficiency problems in assembly more clearly.

Gravity assembly

When multiple components are connected to one component during the same step this is called gravity assembly. The one component to which all other components are connected is called the base element. Gravity assembly is useful when a large team of installers is present which can work at assembling one component at the same time. However, there is only one installer (two at the most) present for the assembly of the pipe supports, this one person has not enough hands to perform the installation in a short period of time.

Sequential assembly

When multiple components are connected to one component in a predetermined order this is called sequential assembly. Sequential assembly causes dependency between different elements. A large string of elements means large dependencies between components on either end.

sss4_3

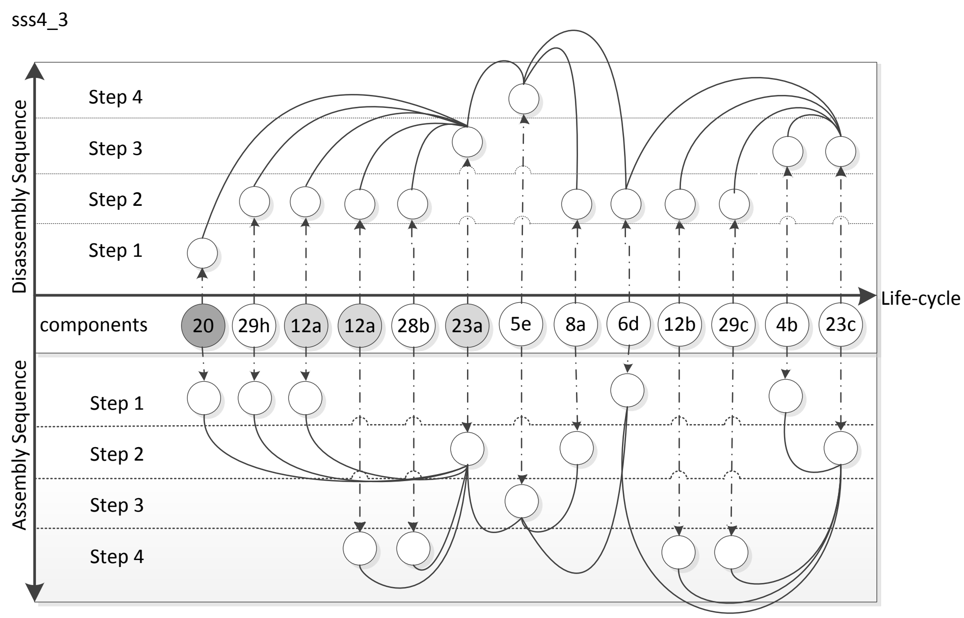


Figure: Representation assembly sequence sss4_3

Preparations

Before assembly some components need resizing before they can be used. For example, the threaded rods (23) and channels (5) are supplied in lengths of 1 and 6 meters, needing cutting before installation.

The steps from the figure above are described below.

Step 1: Connect the beamclamp (4b) onto a piece of threaded rod (23c). Also the channel nuts (6d) can be inserted into the channel and simultaneously the threaded rod assembly for the hanger can be made; connecting the hanger (20), the lower nut (12a) and the washer (29h) to a piece of threaded rod (23a).

Step 2: Place the new subassembly for the threaded rod against the channel. Also the end caps (8a) can be „clicked in" the opening at the end of the channel. And the beamclamp Threaded rod is connected to the channel.

Step 3: The channel (5e) is placed against the beam.

Step 4: The threaded rod (23a) is secured to the channel by the U-shaped washers (28b) and hex nuts (12a). And the beamclamp is secured to the threaded rod using a hex nut and washer.

Height adjustment

After a pipe is suspended into the support the hanger needs to be movable in order to realize a height adjustment when pipes in separate supports do not align. This means that the hanger nut and hex nut (elements within the hanger (20)) need to be adjustable in vertical direction. In extreme cases of height difference the threaded can be repositioned and be put higher in the channel, needing adjustment from both hex bolts (12a) as well. When the repositioning of the threaded rod still is not sufficient, the rod needs to be replaced.

Placing pipes

For the pipe to be suspended in the hanger the curved steel band needs to be removed from the hanger nut, the pipe must be placed in the band and the band must then be put back into the hanger nut. After this action the lower nut on the threaded tube is tightened to secure the connection. These are all changes made possible by the elements of the component; hanger (20).

Conclusions

Large jumps can be seen in this assembly diagram. This is because many components can be installed in the first step of the assembly sequence. However, these components can only be securely connected much later on. These jumps mostly occur with the assembly of the beamclamp.
The darker colored components for height adjustments are not all first to be disassembled. However, this is not a problem because the hanger (20) is one of the first components to be disassembled. The height variations caused by the hanger are sufficient. When a pipe needs to be replaced however, there are still 2 sub steps needed to dismantle the elements within the hanger. Again 2 steps are needed to put the hanger back into its old position

Gravity assembly
The assembly of a base element, in this case a threaded rod (23a), is done via the principle of gravity assembly, meaning that multiple components are connected to one component during the same step. Also the second threaded rod (23c) in the beamclamp and the channel (5e) are considered base elements.

Sequential assembly
Components 6d, 8a and 5e, the channel nuts, end caps and channel are assembled in sequential order. Also the beamclamp can be seen as a big sequential assembly.
The installation of the threaded rod onto the channel is also sequential, including two types of gravity assembly.

sss13

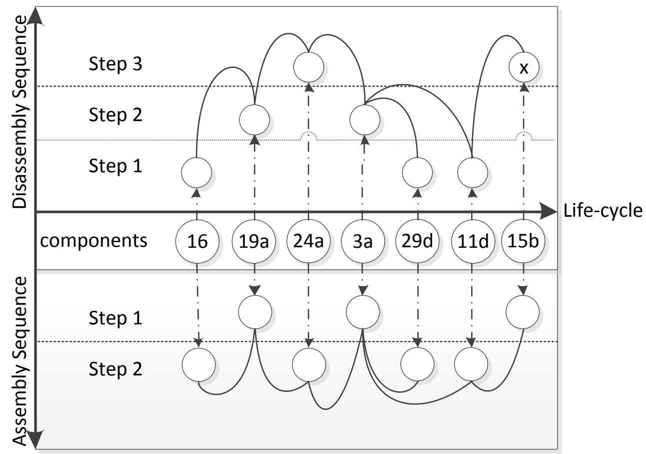


Figure: Representation assembly sequence sss13

Preparations

The threaded tube (24a) has to be cut to create the desired length for assembly.

Step 1: Install non-drill anchors. In order to place these anchors, holes needs to be drilled into the concrete. When the anchors are placed in the holes a setting tool is used. This tool is jammed into the anchor, hard enough to leave a stamp and to set the anchor. This means that a small pin within the anchor has been relocated to the back, which has flaps that can be partially separated. Meanwhile, the baseplate(3a) can be attached to the threaded tube (24a), as well as the solid adapter (19a). This connection is one of screw thread so a pivoting motion is needed.

Step 2: Attach the pipe clip (16) to the solid adapter and place the threaded tube assembly in the right position on the floor. Meanwhile the connection between the floor and baseplate can be secured using a washer (29d) and a bolt (11d).

Height adjustment

A few millimeters of height adjustments can be realized in this product by pivoting the solid adapter. This action however reduces the connection surface, therefore reducing the stability of the construction. The only functional way to adjust the height is to replace the threaded tube with a different sized one.

Placing pipes

When placing the pipe into this assembly, the 2 bolts within the pipe clip (16) need to be removed, then the top saddle can be removed and the pipe can be placed. The saddle is then put back into its original position using the bolts to secure the connection.

Conclusions

There is no way of adjusting the Pipeclip in height without replacing components. And for opening the Pipeclip up to place a pipe, 2 sub-steps within the component are needed. Again 2 steps are needed to secure the pipe in place. Furthermore is there no clear case of gravity assembly.

sss14_2

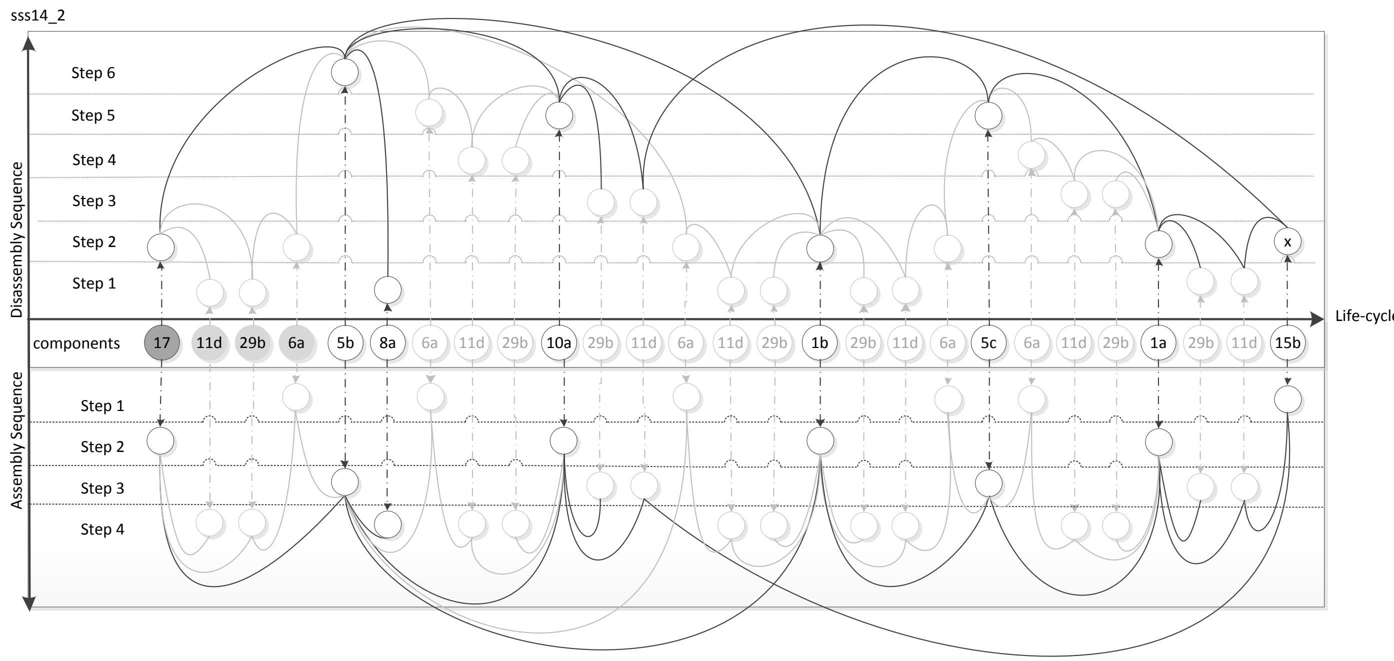


Figure: Representation assembly sequence sss14_2 (connection components are marked grey for clarification)

Preparations

The channels (5c, 5b) need cutting before they can be used for assembly. These components are only supplied in lengths of 6 meters. The steps from the figure above are described below.

Step 1: Install the non-drill anchors (15b), the precise workings are explained in product sss13‟s assembly sequence. While the anchors are placed the channel nuts (6a) can be slid into the different channels, this has to be done through one of the endings of the channels.

Step 2: The pipe saddle (17), heavy baseplate (10a), adjustable angle (1b) and adjustable angle fitting (1a) are connected to the channels (5b, 5c). pipe saddle and heavy baseplate are connected to channel 5b and the adjustable angle and adjustable angle fitting to channel 5c.

Step 3: The channel assemblies are put in to place on the floor in the positions in which they have to be mounted.

Step 4: All connections between different elements are secured using bolts (11d) and washers (29b). Except for the adjustable angle fitting and the heavy baseplate which are connected to the non-drill anchors all connections are made using the previously installed channel nuts. Meanwhile the end caps are „clicked" into place.

Height adjustment

To adjust the height of the pipe saddles containing pipes the connection between pipe saddle (17) and channel (5b) needs to be loosened and placed on another place along the length of the channel. When the desired height is reached the bolts are tightened again securing the connection.

Placing pipes

When placing the pipe in this assembly, the 2 bolts connecting the pipe saddle (17) to the channel (5b) have to be fully removed. The pipe can then be put in place to which the saddle can be replaced in its original position using bolts to secure the connection.

Conclusions

The components needed to adjust the height of the pipe must be disassembled first, this is a good feature since this means easy access to the most used part of the support. However, when a pipe is replaced, it takes at least two steps to do so, two for opening the pipe saddle (17), and another 2 for closing it again.
The jumps in the diagrams are mostly caused by channel nuts (6a). These components can be inserted into the channel early on, but can only be secured in place by bolts at the end of the assembly.

Gravity assembly

All connection components are gravity assembled onto their base elements; 17, 10a, 1b and 1a. Except for the channel nuts (6a); they have to be inserted in the channels in one of the first steps. Component 1b is considered to be the most complete base element. From the non-connection component the double channel (5b) is the base element; both the pipe saddle (17), heavy baseplate (10a) and the adjustable angle (1b) can be assembled onto it simultaneously. Also the single channel (5c) is a base element; the adjustable angle fitting and adjustable angle are fitted on it simultaneously.

Sequential assembly

There is no clear sequential assembly. Because there are so many non-connection components there is no clear order in which to assembly them. Within the connection components sequential assembly can be seen virtually everywhere; channel nuts are inserted, components are added and the connection is secured with a bolt.

sss18_2

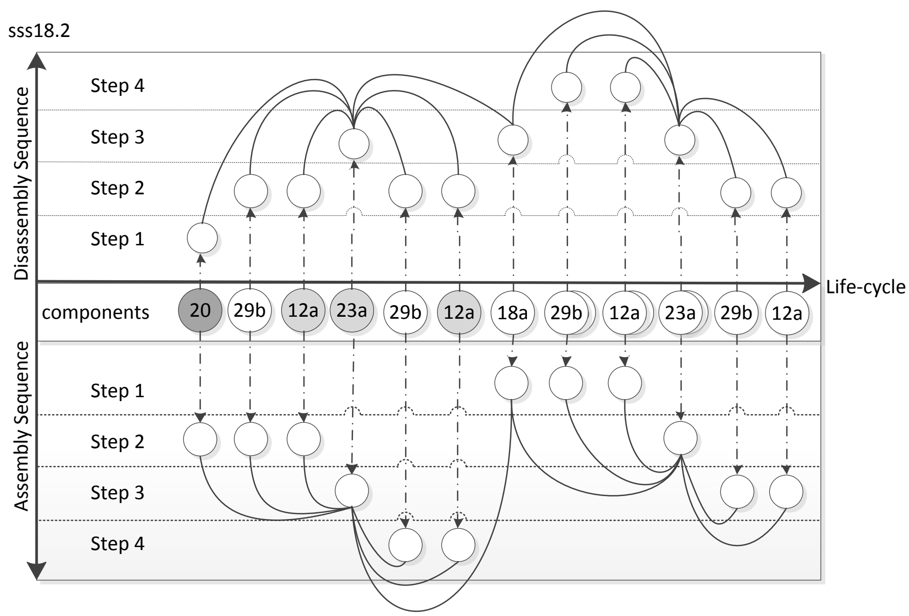


Figure: Representation assembly sequence sss18_2

Preparations

Before the assembly of product sss18_2 can begin three lengths of threaded rod have to be cut, these component are supplied in lengths of 1 meter. The steps from the figure above are described below.

Step 1: The sidebeam attachment (18a), 2 washers (29b) and 2 bolts (12a) are connected to two threaded rods (23a).

Step 2: These two threaded rods can be placed inside the ceiling beam, this can only be done when there are holes drilled or present over the entire width of the beam. In the meanwhile the hanger (20), together with a washer (29b) and a nut (12a) are assembled onto another piece of threaded rod (23a).

Step 3: The single rod assembled in step 2 can now be securely placed into the sidebeam attachment. Also the 2 rods clamping the sidebeam attachment are securely connected with the ceiling beam using a set of washers (29b) and nuts (12a).

Step 4: The last connection, the connection between the sidebeam attachment and the single threaded rod, is secured using a washer and a nut.

Height adjustment
The hanger, in combination with the threaded rod, will allow height adjustments. The hanger nut in combination with the hex nut belonging to the hanger (20) will allow some variation. And when this variation is not enough to realize the desired change in height the threaded rod can be relocated within its suspension as well, although this means that 2 nuts connecting the rod to the sidebeam attachment will have to be relocated as well.

Conclusions
The hanger, being responsible for adjusting the height of the pipe, is the first component to be disassembled; this is a good feature because it means easy access to the most used part of the support. The elements also causing height adjustments do not all come early in the disassembly sequence, but this is not a problem since the hanger will provide enough height variation.
However, when a pipe is replaced, it takes at least four steps to do so, two for opening the hanger, and two for closing it again.

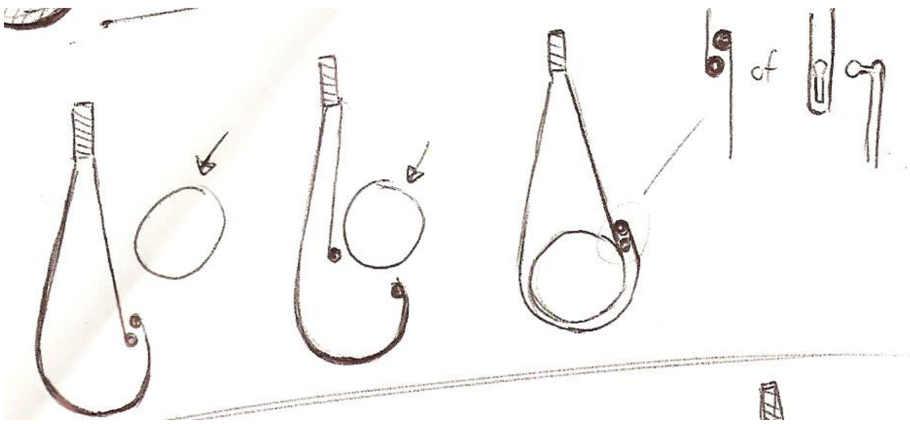
Gravity assembly
There is gravity assembly around the threaded rods (23a); all three have the washer (29b) and nut (12a) added and in the case of the single rod, a hanger (20) is attached. In the case of the double rods a sidebeam attachment (18a) is added.

Sequential assembly
Around the threaded rods is also sequential assembly, first a set of washers and nuts is added with an extra component, and afterwards the connection with this extra element is secured with another set of washers and nuts.

Appendix H Route for redesign

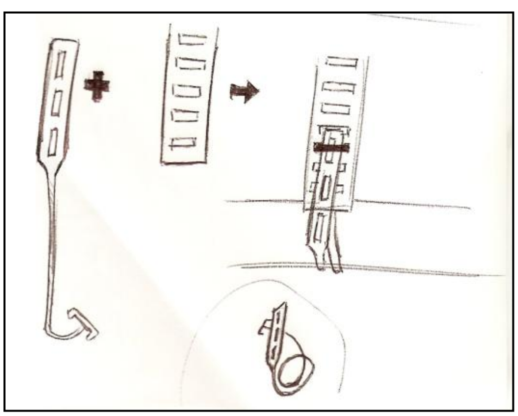
This appendix describes the steps that were undertaken for the redesign. For the redesign the USP hanger in a concrete slab was picked since this support is most offered by Tyco.
The report states that the concepts should reduce packaging volumes and weights, increase the hands on tool time, reduce the number of tools used, make early assembly possible *and* should preferably be suitable for multiple pipe sizes and heights. A big task.
However, the main goal was to merge components.

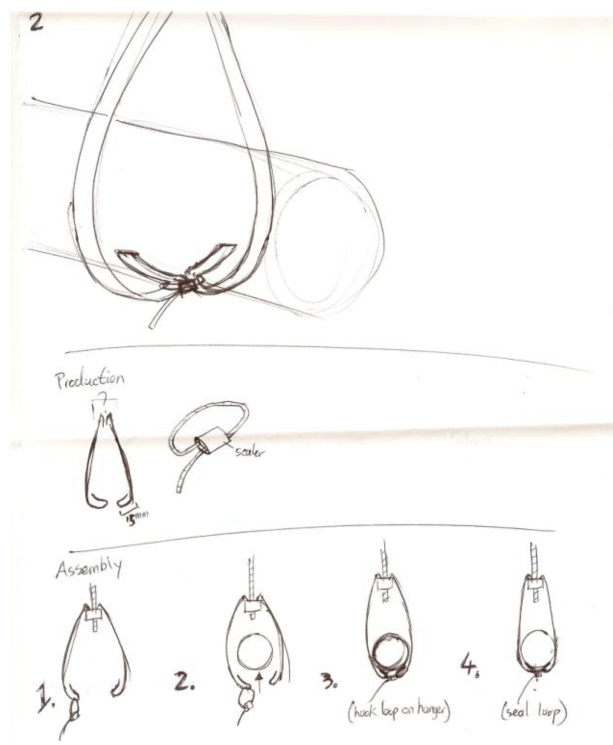
Step 1: merging all components
The initial idea to increase efficiency was to merge all components to form a one-component support.



Conclusion: Approvals state a pipe should be fully surrounded, adjustable in height *and* can allow for pipes to be hung without sliding through the hanger. These three demands could not be realized by a one component support. More components were needed.

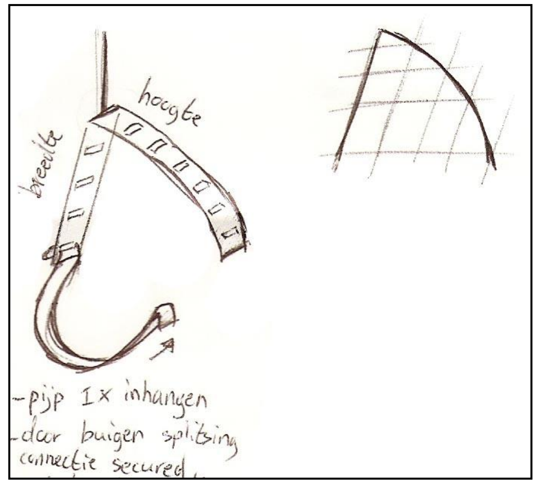
Step 2: suitable for multiple heights and diameters
The option to create a support suitable for multiple pipe diameters and heights was considered.



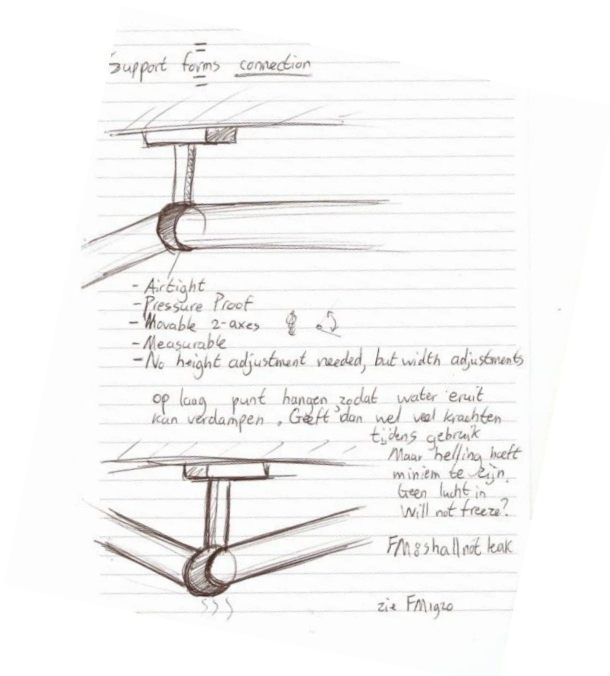


Multiple diameters: since supports need to be able to absorb shocks, they need to be 'clamped' for three-quarters or fully, tightly surrounded. It seemed the only way to do this was with bendable steel bands or steel wire. Bending bands is labor intensive and not accurate. The use of steel wire is not yet accepted by customers.

Multiple heights: On the left is an idea for a support suitable for multiple heights and widths. However, this support would bend under large traction forces, would partially compress high hanging pipes and would not allow small pipes to be hung low unless current hangers are changed.
The concept on the right would also *merge pipes*, making it possible for pipes to be hung under angles, making height adjustments unnecessary. This concept however, is a pipe*connection*, rather than a support.



Conclusion: A support, not damaging pipes, suitable for multiple pipe diameters and heights which would not reform under traction forces seemed impossible.



Step 3: create a new way of height adjustments for one pipe diameter

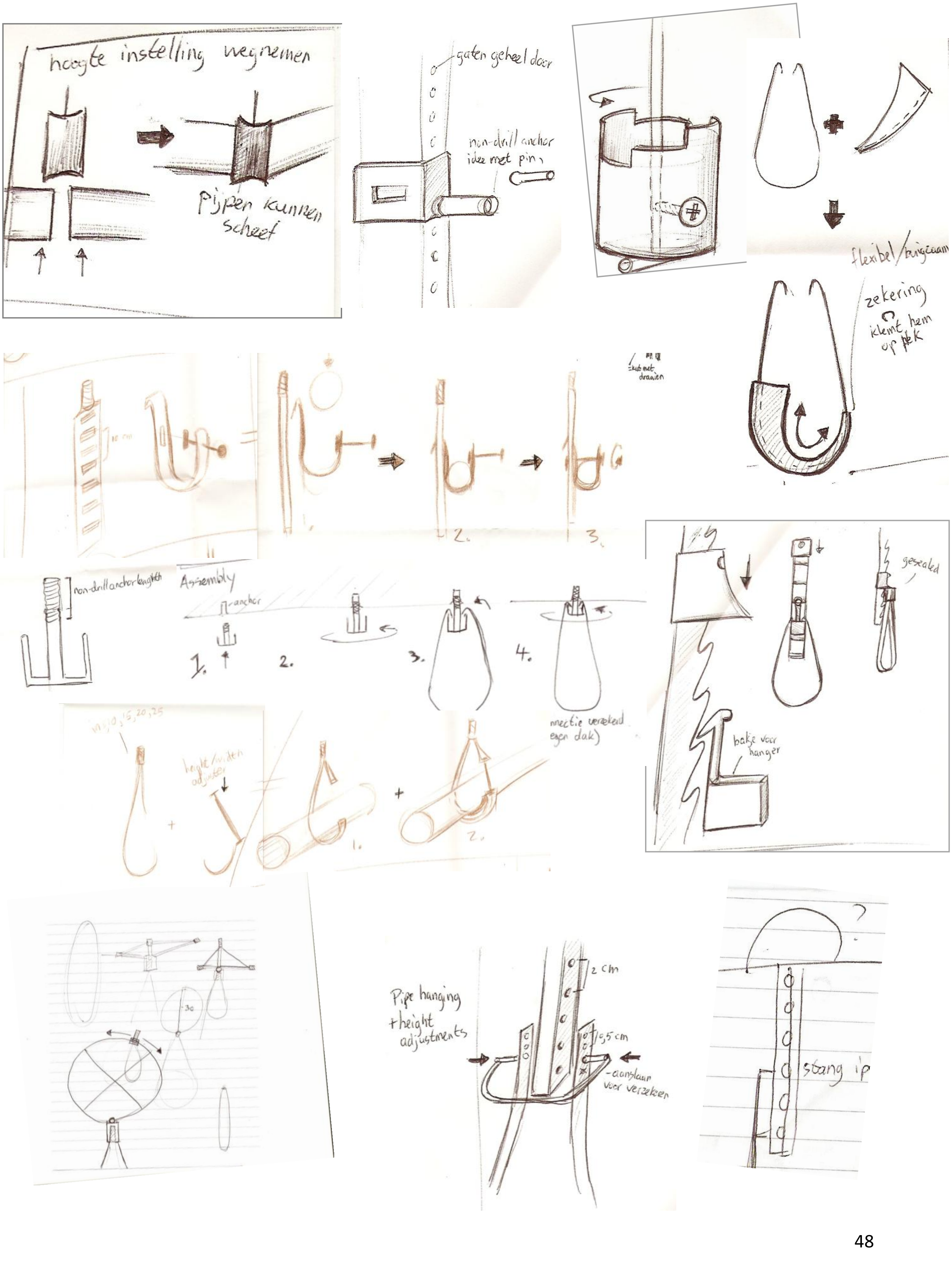
When no efficient, width adjusting concept could be generated. Strived was to create a new way to suspend pipes on different heights, which would be less LABOR and TIME intensive for installation as thread. The currently used thread allow for small height adjustments, which mean accuracy, but also create a *lack of* accuracy: The initial placement of the hanger nut determines how high the pipe hangs, however, since there are so many heights to choose from to place the nut, it cannot be placed correctly the first time; height adjustments need to be made *after* a pipe is hung.
Also, thread requires pivoting motions for assembly. In current supports, **many different components need to be pivoted, resulting in a LABOR intensive assembly by the customer since no machinery can be used.**
Considered methods to adjust height:

- propping up (too much material use)
- tent pole sliding mechanism (only two thirds of material could be used, resulting in insufficient height adjustments between 5 and 25 cm)
- Pin + holes different heights (holes weaken material)
- Hydraulics (will weaken, too pricy for one time installation.)
- Thread + gear wheel (would need clamping on two sides of the wheel)
- Clamping on different heights (Vertical clamping not possible because of traction forces. Horizonal clamping would mean material loss because a horizontal and vertical distance of 25 need to be covered.
- Flexible sheet/lint + buckle (does not absorb shocks)
- Flexible sheet/lint + clasp (does not absorb shocks)
- Flexible sheet/lint + roll (does not absorb shocks)
- Flexible sheet/lint + knots on different heights (does not absorb shocks)
- Lock/key principle on different heights. (holes weaken material)
- Pivoting 30 cm around axis. (too much material used, movement on horizontal axes)
- Tekenkoker mechanism (too much material used, no adjustments from 5-25 cm possible because only two thirds of the rods can be used)
- Veren onder spanning (stress causes metal weakness for long periods of time)
- Sliding on spiral? Das meer horizontal, soort kraaltje op een veer idee. Makkelijk om te sequren (spiral would bend under traction forces)
- Belt +3 gear whweels? Dan 1 verder van de verticale 2 afhalen :P (too much material use)

Conclusions:
* A support needs to be capable to handle large traction forces (see table). Therefore, suspensions should be directly under the anchoring point to prevent momentums on the height adjuster.
* Threaded rod is very cheap, a new way to adjust height should be very cheap as well, use little material or have many advantages.
* Pivoting leads to a LABOR intensive installation since it has to be done by hand and the adjustments can be done too accurately, therefore it should be avoided.

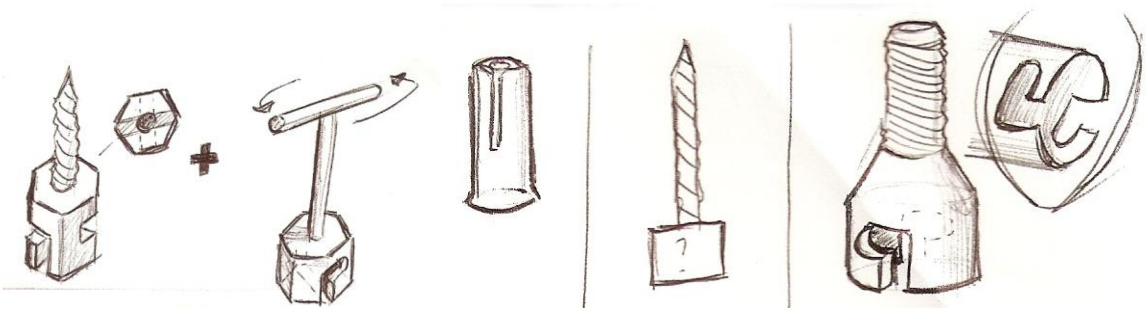
Following page shows images of this phase in design

Diameter		Length pipe		Weight waterfilled pipe		Capacity
mm	inch	m	foot	(lbs/ft)	kg	N
25	1	2,1	6,89	2,54	7,9378665	1508
32	1,3	2,1	6,89	3,56	23,363579	1665
40	1,5	2,7	8,86	4,4	47,734347	1986
50	2	3	9,84	6,3	84,378896	2498
65	2,5	3,4	11,2	9,49	163,25813	3474
80	3	3,7	12,1	13,11	267,08956	4660
100	4	4,3	14,1	19,96	549,22238	7384
125	5	4,9	16,1	28,65	1023,6879	11366
150	6	5,2	17,1	39,86	1603,9645	16249
200	8	5,8	19	63,2	3163,908	27876
250	10	6,1	20	95,84	5307,0998	43793



hoogte instelling wegnemen
Pijpen kunnen scheef
gaten geheel door
non-drill anchor idee met pin,
flexibel/buigzaam
zekering klemt hem op plek
non-drill anchor length
Assembly
anchor
1.
2.
3.
4.
gesealed
bakje voor hanger
height/widen adjuster
Pipe hanging + height adjustments
2 cm
1,5 cm
aanslaan voor verzekeren
stang ip

Step 4: change way of anchoring
Previous step in the concept generation proved it difficult to design around threaded rod. Since the most common anchoring method, the non-drill anchor for concrete, contains thread as a connection. This means all concepts should have a top section which contains thread. Not clever, production-wise, since extra transitions between geometry have to be realized. Instead, a new way of anchoring could be thought up.



A concrete screw for example. The lower extension, nut shaped, and therefore suitable for construction tools, can be partially reformed or fitted with any lining to connect other components.

However, the assignment did not leave time to redesign an anchoring method. Anchors have to be separately tested and approved on top of the new concept's tests. This would mean too much trouble for the production of the new support. This also applied on the jack nuts used for trapezium roofs. They were also too difficult to get re-tested and re-approved within the time span for this project.

Conclusion:
The assignment is too short to design a new way of anchoring, instead the non-drill anchors have to be used and the support should have a threaded top. The beamclamps however, suitable for connections to I-beams, do not require special testing and could therefore be adapted along with the rest of the support.

Step 5: beamclamp support
Seeing that I-beams are sloping, they seem to need clamping for a connection. This clamping can be done on both sides or on one side. The most used beamclamp only clamps on one side, this method can hold less weight, seeing that momentums occur, but require a lot less material than a clamp reaching both sides of the beam. Also, a two sided connection often needs more adjustments before a connection is secured.

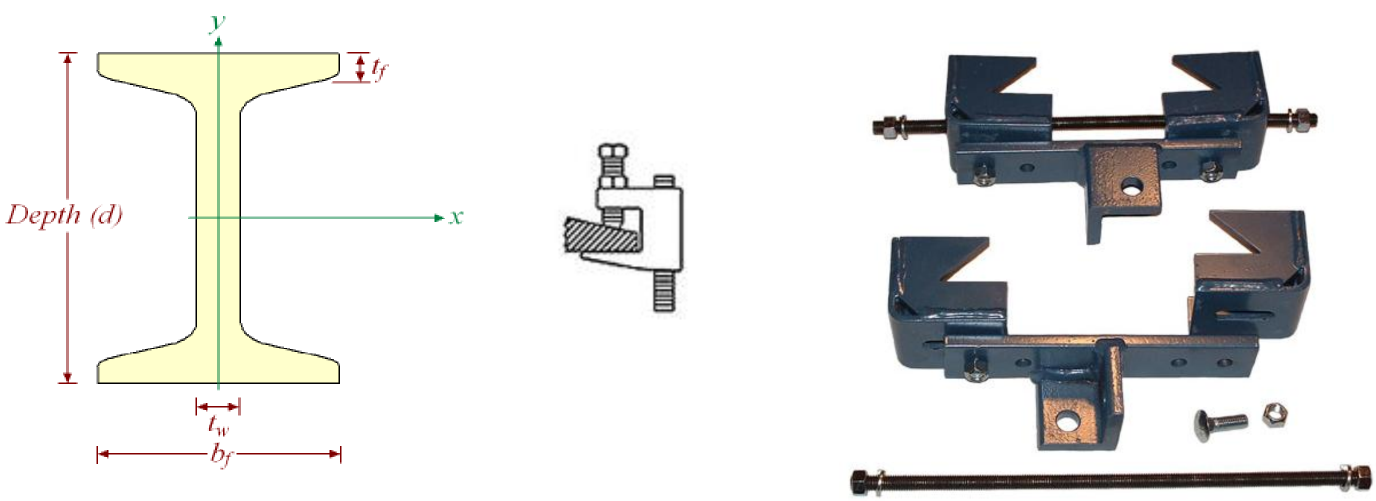
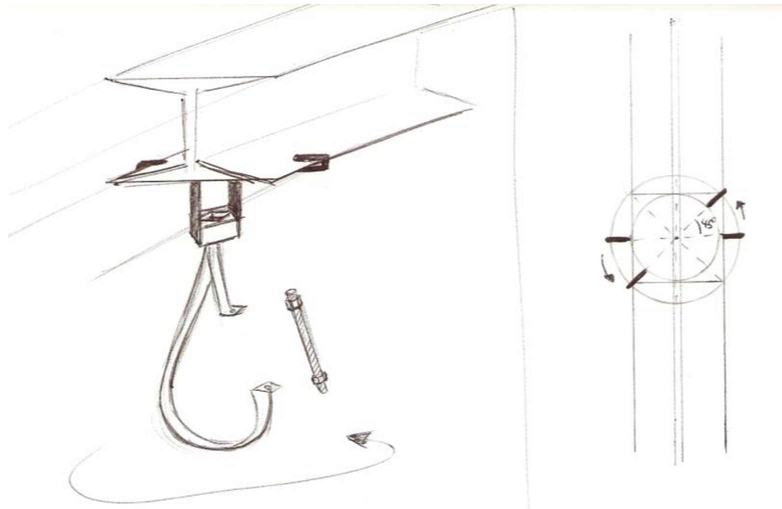


Figure: Left, I-beam with slope. Middle, one sided clamp. Right, two sided clamp.

Soon, the idea of a pivoting connection came to mind.
One 45 degrees turn could secure a connection between a support and a beam. Ones the pipe is hung, its orientation keeps the connection secured, allowing no counter pivoting motions.

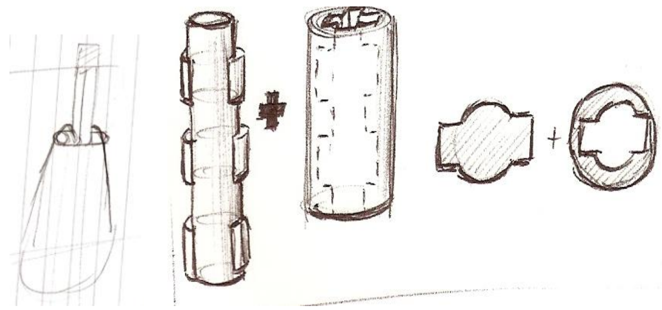


Conclusions:
However, this concept required a two sided connection, meaning much material spent, and therefore not suitable for relatively ‘light’ systems such as a single sprinkler pipe.

Step 6: turn a quarter concept

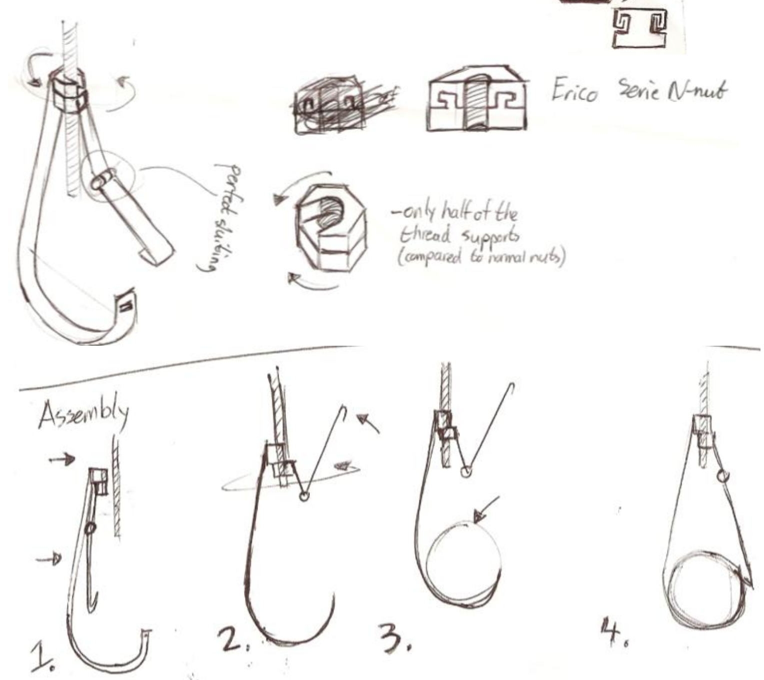
The concept of turning 45 or 90 degrees to secure a connection with pipe orientation gave new ideas.

A rod with protrusions on two sides enables height adjustments on fixed heights. A tube with one or two of these inversed protrusions can be slid on, turned a quarter, and would hang.



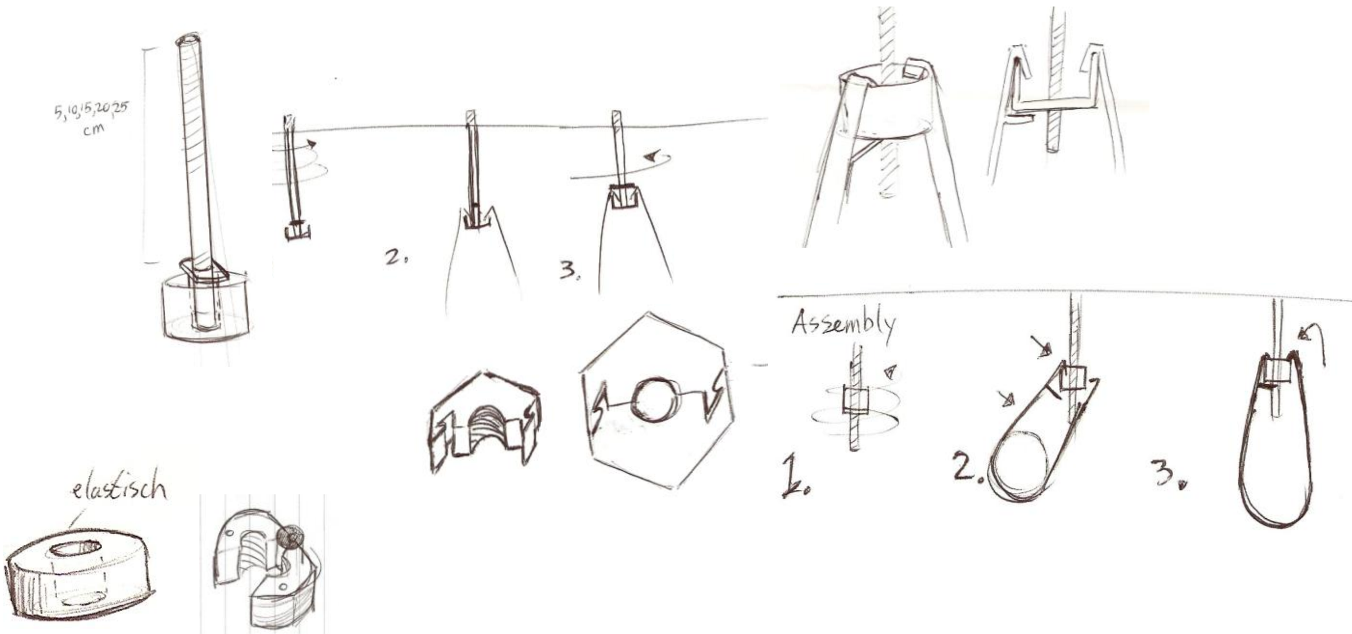
Conclusion:
such a mechanism could only effectively use 2/3 of its material, and no sufficient height adjustments between 5 and 25 cm could be realized.

Also, the principle of the Slid-On-Nut was considered. Only half a turn would seal the connection between hanger and rod.
Conclusions:
The issue of patents and whether or not the nut could handle the traction forces inhibited the use of this idea.



Step 7: ease securing of connection

One advantage the concepts of previous step had was that they did not need a securing element. In current supports, a singular-functioned component provides security. A not, whose only function is to prevent upwards movement of a pipe, has to be assembled upon the support. Below are some ways to prevent, or ease the securing of a connection.



Also the idea to place a hanger against the roof was considered. The last few pivoting motions would prevent upwards movements because the hanger would be sealed against the roof. However, this would mean no height adjustments could be realized.

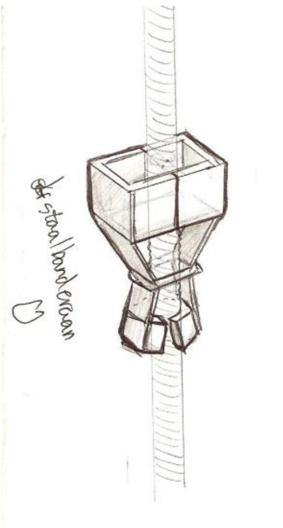
Conclusions:

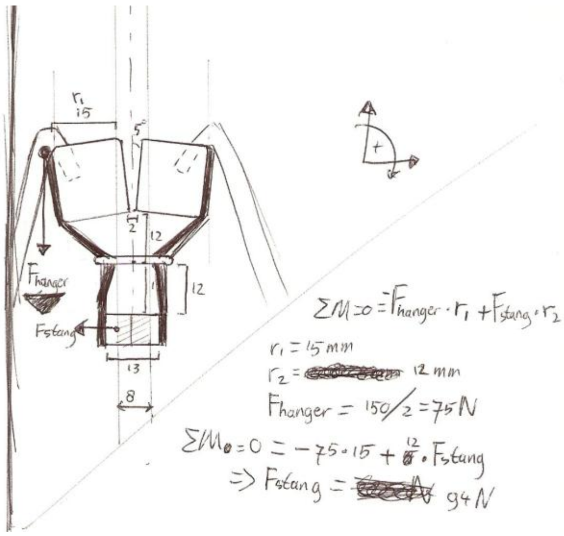
the number of components needed for one support could be lessened by making a support which does not require securing.

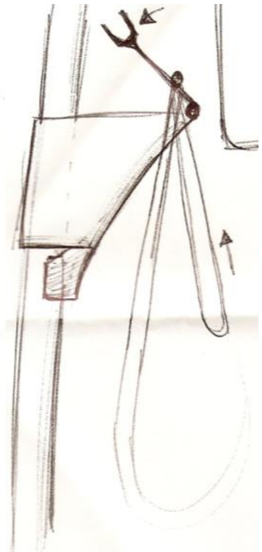
Step 8: REMOVE NEED TO PIVOT

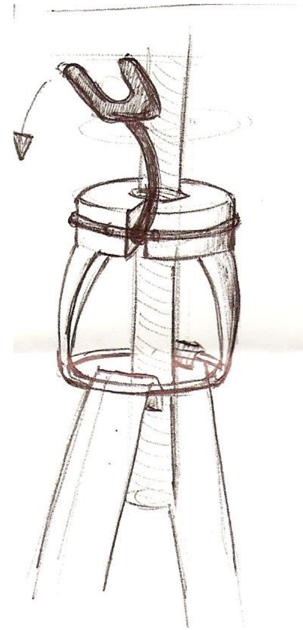
When looking at the design route so far, and the conclusions drawn along the way, a bigger picture was

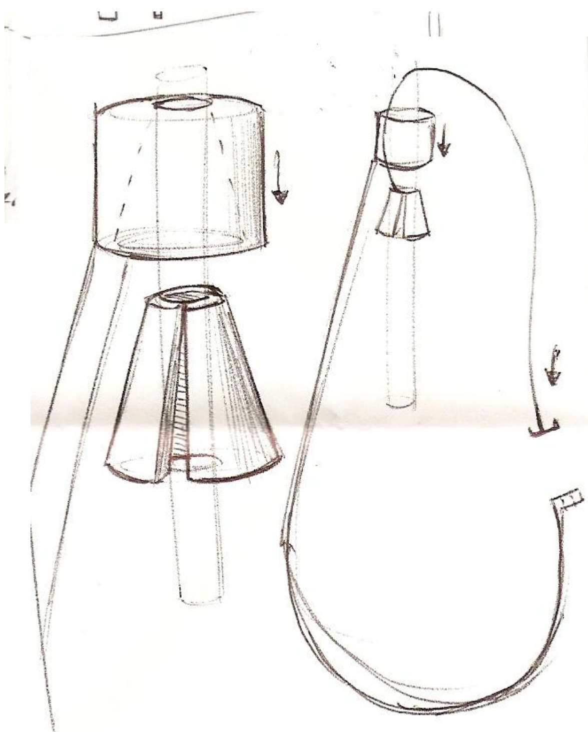
The most lucrative method to suspend pipes would use the threaded rod, would use little material and would require no pivoting. A new method to attach components to threaded rod was devised.

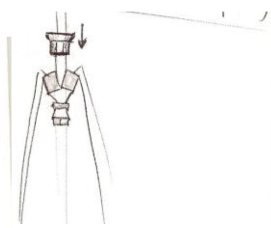


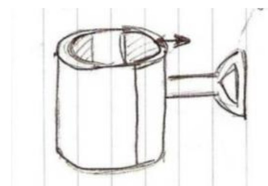










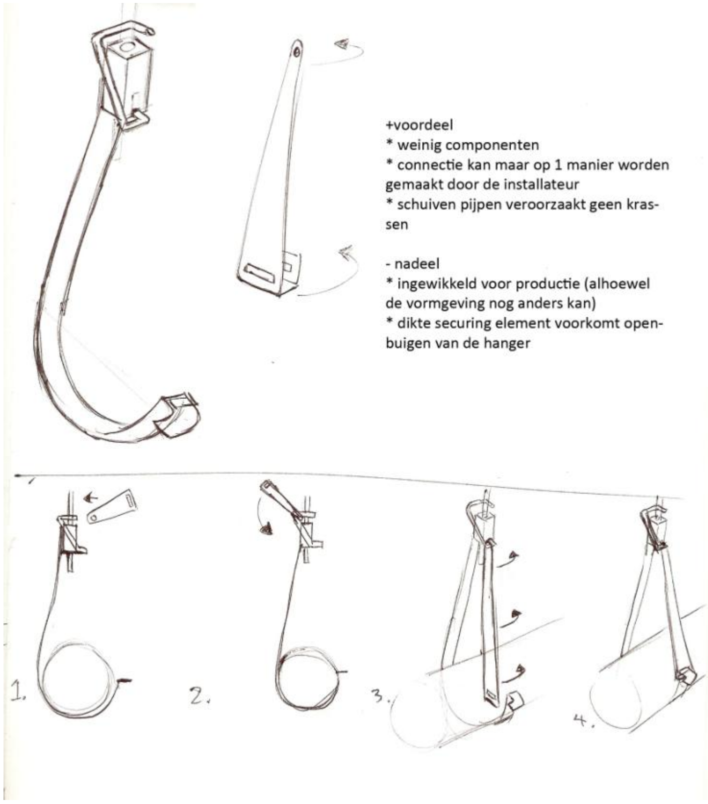


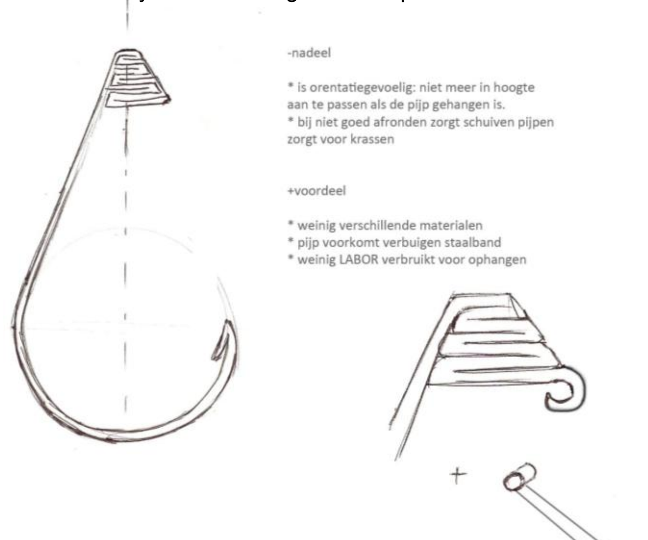
Concepts relying on the weight of the pipe to secure a connection were generated. However, these supports would still contain multiple elements which needed to turn or move in relation to one another. A clamp as in the figure on the right was taken as inspiration in some cases. Such a clamp could tighten the hold on a rod, and the motion of pulling the leaver could be used to secure a connection.

Conclusions: These concepts prevent the pivoting problems surrounding threaded rods, only they do not prevent the cutting of threaded rods. A pipe can only be suspended to a certain height until it reaches the underside of the rod. To suspend a pipe *besides* the rod would result in momentums around the anchoring point, such suspensions would not be able to handle heavy piping. This would also cause problems in locating the exact area for anchor placement.

Step 9: create hangers for easy pipe adding

As a last step, the problem of heavy piping was considered. With the current hangers, the pipes need to be held up during the assembly, or hangers need to be bent open. These are relatively LABOR intensive steps. The new ideas for easy-to-install hangers are depicted below.

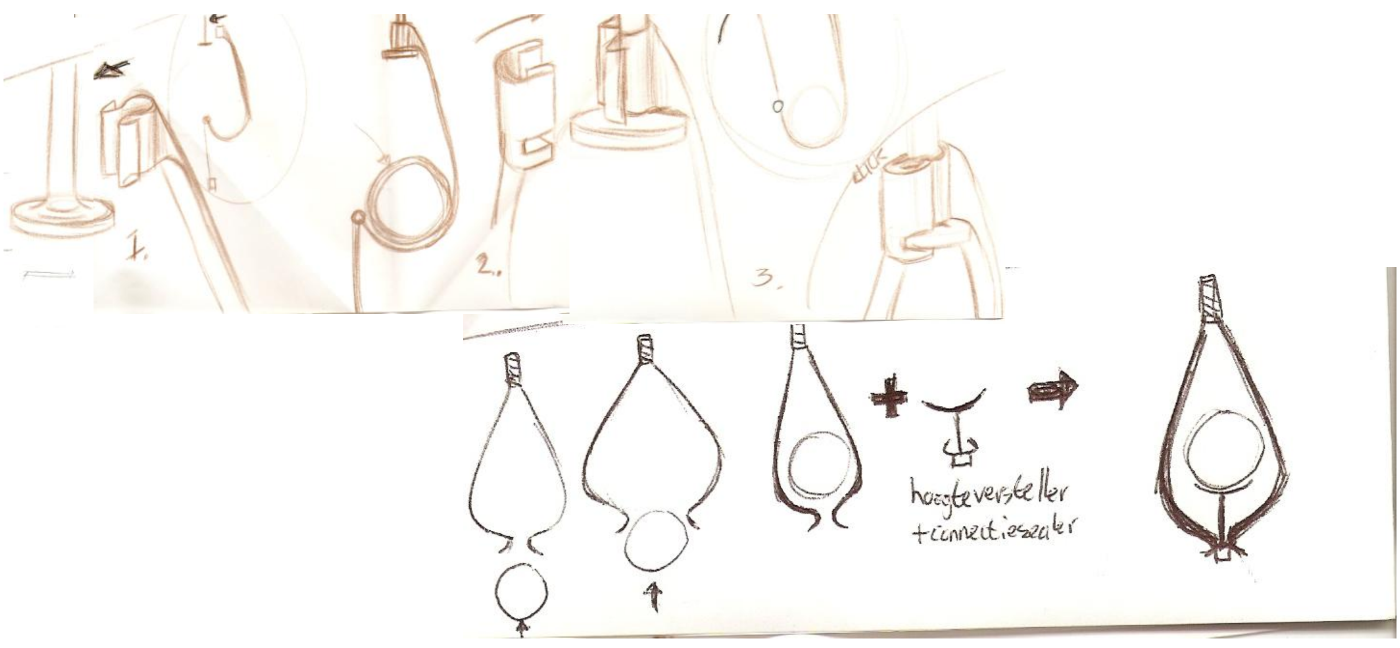




The right concept uses a hinge to create easy access for the pipe. The hinging component contains a hole which is large enough to fit the bended end of the bottom halve of the hanger. The top section of the hanger shows a way to reduce components, to bend the steel band in such a way as to create a material accumulation, thread can be spun inside it. It is unknown whether or not this is possible production-wise is.

The concept on the right also has easy pipe access, the connection is made with a swab, only able to approach the hanger in one direction. Since this swab is functionally oriented, the placement of the pipe will hold this connection in place. Below, a click-hanger-rod connection is displaced which does not need securing. Most likely, the large traction forces will make this concept unusable.

Conclusions: In most of these concepts, a location on the thread is secured by the orientation of the pipe. This means that after a pipe is suspended, no height adjustments can be made because the hanger is not able to pivot. This is a problem for accurate pipe placement. But in current situation this is not possible either, because, the most commonly used support has a pipe clip. This clip inhibits height adjustments after a pipe is hung. A conclusion could be that secondary height adjustments to level pipes are not that important to the customers.



Components with corresponding numbers

nr.	Component	Geometry
1a	Adjustable angle Fitting	Heavy
1b	Adjustable angle	102x102mm
2a	Angle Bracket	150/150
2b	Angle Bracket	200/200
2c	Angle Bracket	300/200
2d	Angle Bracket	550/350
3a	Baseplate	0,5"
3b	Baseplate	0,75"
3c	Baseplate	1"
4a	Beamclamp	41x41mm
4b	Beamclamp	M12
4c	Beamclamp	Hole=11mm
4d	Beamclamp	Hole=13 mm
4e	Beamclamp	Thread M16
5a	Channel 41/slots	41x41 S=6m
5b	Channel P1001	41x92 L=6m
5c	Channel P1000T	41x41x6m
5d	Channel P5500T	41x62 L=6m
5e	Channel P5000T	41x83 L=6m
5f	Channel UNI2	L=660mm
6a	Channel nut	M10
6b	Channel nut	M10
6c	Channel nut	M10
6d	Channel nut	M12
6e	Channel nut	M16
7a	Console 41x41	L=460mm
7b	Console 41x41	L=310mm
7c	Console 41x41	L=160mm
8a	End cap	41x41mm
8b	End cap	41x62mm
9	Fix point	DN…
10a	Heavy Baseplate	41x83
10b	Heavy Baseplate	41x41-4xϕ 14
11a	Hex bolt DIN931	M8x110
11b	Hex bolt DIN933	M6x25mm
11c	Hex bolt DIN933	M10x25
11d	Hex bolt DIN933	M10x25
11e	Hex bolt DIN933	M12x25
11f	Hex bolt DIN933	M12x25
12a	Hex nut DIN934	M10
12b	Hex nut DIN934	M12
12c	Hex nut DIN934	M16
12d	Hex nut DIN934	M8
13	Hlf Saddle Unistr	DN…
14	Jack nut M6	M6
15a	Non drill anchors	M10
15b	Non drill anchors	M10
15c	Non drill anchors	M10
15d	Non drill anchors	M12
15e	Non drill anchors	M12
16	Pipe clip UNI-N	DN…
17	Pipe saddle	DN…
18a	Sidebeam attachement	90x60mm
18b	Sidebeam attachement	M10x1m
18c	Sidebeam attachement	M12x1m
19a	Solid adapter	0,5"
19b	Solid adapter	0,75"
19c	Solid adapter	1"
20	Sprinkler hanger	DN…
21	Steel anchor	M12
22a	Strap	M10
22b	Strap	M12
22c	Strap	M16
23a	Threaded rod	M10x1m
23b	Threaded rod	M12x1m
23c	Threaded rod	M12x80
23d	Threaded rod	M16x1m
24a	Threaded tube	0,5" L=2m
24b	Threaded tube	0,75" L=2m
24c	Threaded tube	1" L=2m
25	Tipping Dowel	M10x200mm
26	Trapeze Hanger	M10
27	U-bolt	DN…
28a	U-shaped washer	M10 30mm
28b	U-shaped washer	M10
28c	U-shaped washer	M12
28d	U-shaped washer	M16
29a	Washer DIN125	M10
29b	Washer DIN125	M10
29c	Washer DIN125	M12
29d	Washer DIN9020	M10
29e	Washer DIN9021	M6
29f	Washer DIN9021	M10
29g	Washer DIN9021	M12
29h	Washer DIN391	M10
29i	Washer DIN391	M12
29j	Washer DIN391	M16
29k	Washer Large	M10
29l	Washer Large	M12
30	Z-fitting	L=88mm