



Frangible Masts



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1. Introduction

1.1 Frangible Masts by AmpliSafe®

Frangible Masts by AmpliSafe® is a product family of frangible aluminium masts developed and manufactured by Normeka AS. The manufacturing takes place in our facilities located approximately 80 km from Oslo, Norway. The carefully chosen aluminium alloy in combination with our lattice structure design, automated production line and in-house tempering process result in aluminium masts which stands out with an unparalleled set of characteristics. As the masts are manufactured out of aluminium, the weight is kept very low and so are the need for future maintenance. The lattice-design gives the mast good strength, but even more important, makes the mast frangible in case of a collision with an aircraft.

1.2 Applications

The Frangible Masts by AmpliSafe® can be used for a wide array of applications. The examples below show some of the most common areas of use.

- Approach lights
- Meteorological equipment
- Wind cones
- Surveillance equipment

1.3 Product Owner / Manufacturer

Normeka AS

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E-mail: normeka@normeka.no

2. General Information Normeka AS

Normeka AS has been manufacturing the major share of hardware for NORMARC's Instrument Landing System since 1980, e.g. the ILS-antennas, ILS-masts and GP-tower. During this period, we have gained a vast experience in mechanical manufacturing for the global aviation industry. We process a number of different materials, but consider mechanical manufacturing of aluminum-products our area of expertise. We always strive to improve our customer service, and since the very beginning, we have continuously invested in manufacturing technology, automation and competence. As a result, we have gained the capabilities needed to offer our customers world class products, at competitive terms, on a global scale.

3. Frangibility

There is a long list of equipment required to operate a landing strip of a modern airport e.g. antennas, approach lights, meteorological equipment and wind socks, to mention a few. A challenge related to this is that the masts used to support this equipment are a possible hazard for an airplane which, of any reason, is off course. In order to reduce the possibility for accidents, it has been decided that masts, which might be hit by an aircraft during takeoff/landing/taxiing, shall be frangible to the greatest extent possible.

3.1 Definition of frangibility

ICAO Doc 9157 AN/901 – “Aerodrome Design Manual, part 6, Frangibility” defines frangibility. The essence of this definition is that frangible objects should have low mass and be designed to break, distort or yield on impact. This can be verified by a FEA (Finite Elements Analysis), or full-scale testing. Certain criterias must be met in order to claim that a structure is frangible.

Frangible Masts by AmpliSafe®, has been simulated and verified by the Swedish company DYNAmore Nordic AB. The conclusion is that the Frangible Masts by AmpliSafe® fulfill the requirements given in the above mentioned ICAO document, and the masts are considered frangible.

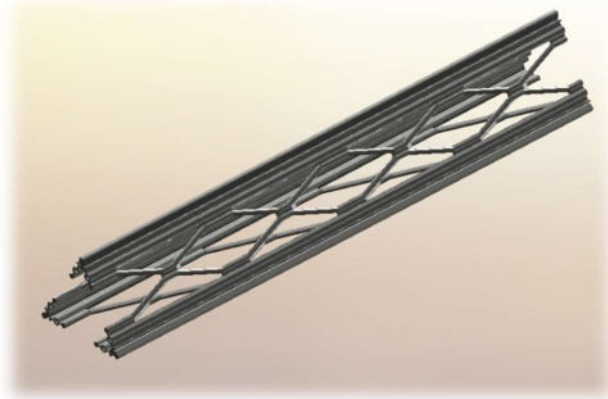
3.2 Description of Frangible Masts by AmpliSafe®

As mentioned above, Frangible Masts by AmpliSafe® can be used in many applications, e.g. approach lights, antennas, meteorological equipment, wind socks etc. The mast itself will be the same, but the interface between the mast and the equipment will be individually tailored for each application.

Frangible Masts by AmpliSafe® are made in four different sizes. The size of the mast is determined by

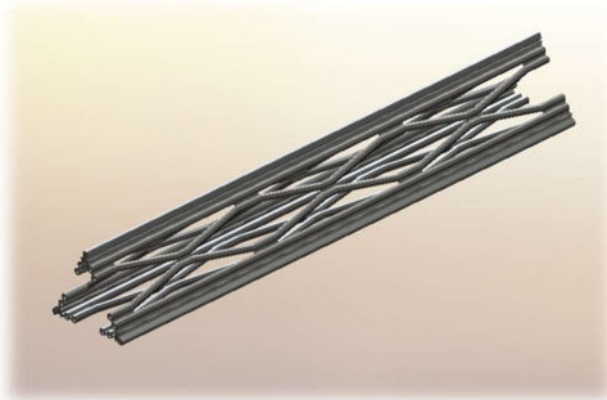
- Specified height of the mast
- Specified equipment (size, weight) to be mounted to the mast

4. 4 types of Masts



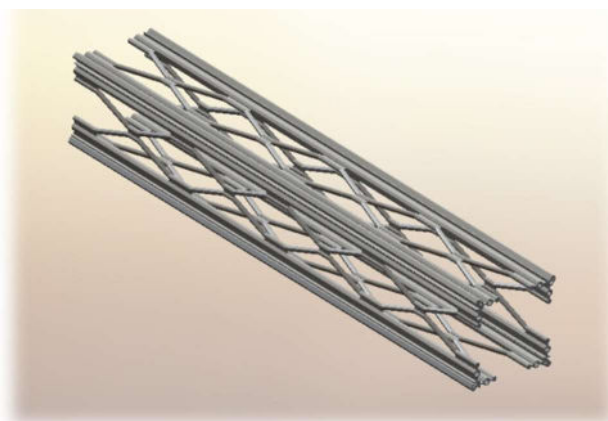
1 Mast 3S195

3S195. This is the smallest mast, it has a triangular cross-section where the side-wall is 195mm. This mast is generally used for one or two approach lights (or similarly sized equipment), the mast can be delivered in heights up to 6 m.



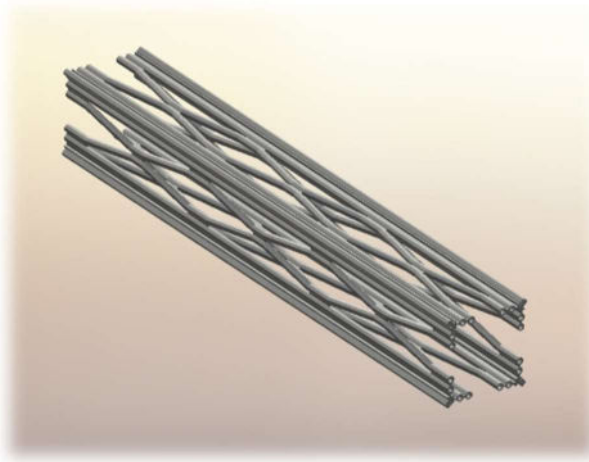
2 Mast 3M240

3M240. Triangular mast, with a slightly larger sidewall; 240mm. Used as a base for the 3S195 mast when one or two approach lights shall be mounted on a mast up to 10 m. The first 5 m will then be the larger 3S240, and the upper 4.5 m will be the smaller 3S195



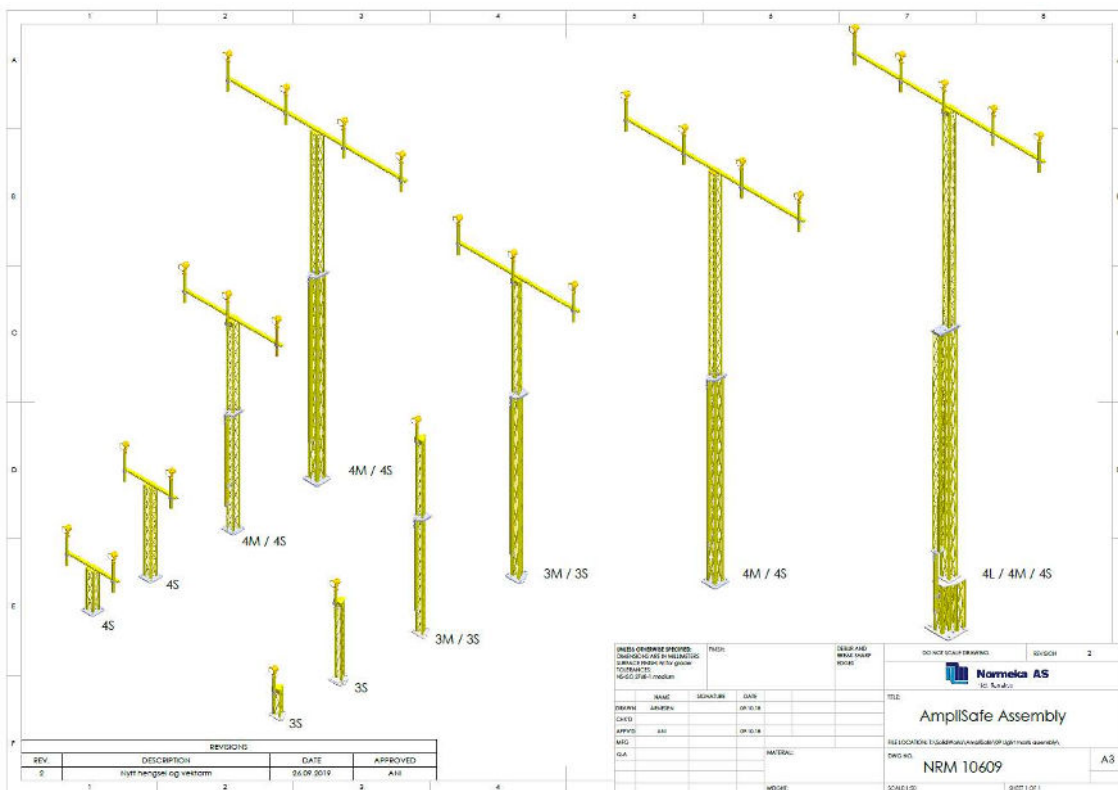
3 Mast 4S195

4S195. The smallest mast with square cross-section, sidewall is 195mm. This mast is normally used as a moderate tall mast with more than two lights or as the top-section when combined with 4M240. It is used for up to five approach lights (or similarly sized equipment), the mast can be delivered in heights up to 7 m.



4M240. Square mast, with a slightly larger sidewall; 240mm. Used as a base for the 4S195 when the requested height of the square mast exceeds 7 m. Maximum height for the combination 4M240 and 4S195 is 12 m. This combination of masts is also applicable when the requested height for the 3M/3S combination exceeds 10 m.

4 Mast4M240



4.1 Selection of masts

		X-bar length																			
		1350		1650		2850		2550		3150		5550		3750		4650		4150		4950	
		Spacing between lights																			
		Lights																			
Art nr	Light between	1	2	2	2	3	3	3	4	4	4	5	5	5	5	5	5	5	5	5	
3S-1	0,64	1,14																			
3S-2	0,93	1,43																			
3S-3	1,21	1,71																			
3S-4	1,49	1,99																			
3S-5	1,77	2,27																			
3S-6	2,07	2,57																			
3S-7	2,35	2,85																			
3S-8	2,63	3,13																			
3S-9	2,91	3,41																			
3S-10	3,19	3,69																			
3S-11	3,47	3,97																			
3S-12	3,76	4,26																			
3S-13	4,04	4,54																			
3S-14	4,32	4,82																			
3S-15	4,6	5,1																			
3S-16	4,88	5,38																			
3S-17	5,16	5,66																			
3S-18	5,44	5,94						5,9	5,9												
3S-19	5,72	6,22					6,2														
3S-20	6	6,5		6,5																	
3S-21	6,28	6,78																			
3S-22	6,57	7,07	7,0																		

		X-bar length																			
		1350		1650		2850		2550		3150		5550		3750		4650		4150		4950	
		Spacing between lights																			
		Lights																			
Art nr	Light between	1	2	2	2	3	3	3	4	4	4	5	5	5	5	5	5	5	5	5	
3M-7/3S-10	6,79	7,29																			
3M-8/3S-10	7,28	7,78																			
3M-8/3S-11	7,56	8,06																			
3M-9/3S-11	8,06	8,56																			
3M-9/3S-12	8,35	8,85																			
3M-9/3S-13	8,63	9,13						9,1	9,1												
3M-10/3S-13	9,13	9,63					9,6														
3M-10/3S-14	9,41	9,91		9,9	9,9																
3M-10/3S-15	9,69	10,19	10,2																		

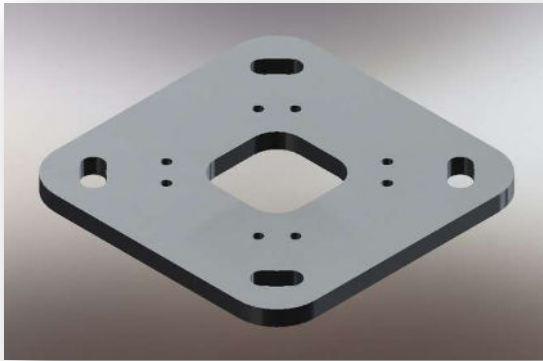
		X-bar length																			
		1350		1650		2850		2550		3150		5550		3750		4650		4150		4950	
		Spacing between lights																			
		Lights																			
Art nr	Light between	1	2	2	2	3	3	3	4	4	4	5	5	5	5	5	5	5	5	5	
4S-1	0,65	1,15																			
4S-2	0,94	1,44																			
4S-3	1,22	1,72																			
4S-4	1,5	2																			
4S-5	1,78	2,28																			
4S-6	2,08	2,58																			
4S-7	2,36	2,86																			
4S-8	2,64	3,14																			
4S-9	2,92	3,42																			
4S-10	3,2	3,7																			
4S-11	3,48	3,98																			
4S-12	3,77	4,27																			
4S-13	4,05	4,55																			
4S-14	4,33	4,83																			
4S-15	4,7	5,2																			
4S-16	4,98	5,48																			
4S-17	5,26	5,76																			
4S-18	5,54	6,04																			
4S-19	5,83	6,33																			
4S-20	6,11	6,61																			
4S-21	6,39	6,89																			
4S-22	6,67	7,17																			
4S-23	6,95	7,45																			
4S-24	7,23	7,73																			
4S-25	7,51	8,01	8,0																		

		X-bar length																			
		1350		1650		2850		2550		3150		5550		3750		4650		4150		4950	
		Spacing between lights																			
		Lights																			
Art nr	Light between	1	2	2	2	3	3	3	4	4	4	5	5	5	5	5	5	5	5	5	
4M-7/4S-10	6,79	7,29																			
4M-8/4S-10	7,28	7,78																			
4M-8/4S-11	7,56	8,06																			
4M-9/4S-11	8,06	8,56																			
4M-9/4S-12	8,35	8,85																			
4M-9/4S-13	8,63	9,13						9,1	9,1												
4M-10/4S-13	9,13	9,63																			
4M-10/4S-14	9,41	9,91																			
4M-10/4S-15	9,69	10,19																			
4M-11/4S-15	10,19	10,69																			
4M-11/4S-16	10,47	10,97																			
4M-11/4S-17	10,75	11,25																			
4M-12/4S-17	11,24	11,74																			
4M-12/4S-18	11,52	12,02																			
4M-12/4S-19	11,80	12,30																			
4M-13/4S-19	12,30	12,80																			
4M-13/4S-20	12,58	13,08	13,0	13,0	13,0																

		X-bar length																			
		1200		1500		2700		1200		1500		2700		1200		1500		1000		1200	
		Spacing between lights																			
		Lights																			
Art nr	Light between	1	2	2	2	3	3	3	4	4	4	5	5	5	5	5	5	5	5	5	
4L-2/4M-11/4S-18	12,13	12,63																			
4L-2/4M-11/4S-19	12,41	12,91																			
4L-2/4M-12/4S-19	12,9	13,4																			
4L-2/4M-12/4S-20	13,18	13,68																			
4L-4/4M-10/4S-21	13,47	13,97																			
4L-4/4M-11/4S-21	13,97	14,47																			
4L-5/4M-11/4S-21	14,46	14,96																			
4L-5/4M-11/4S-22	14,75	15,25																			
4L-6/4M-10/4S-23	15,03	15,53																			
4L-6/4M-10/4S-24	15,31	15,81																			
4L-7/4M-10/4S-23	15,59	16,09	16,1	16,1	16,1	16,1	16,1	16,1	16,1	16,1	16,1	16,1	16,1	16,1	16,1	16,1	16,1	16,1	16,1	16,1	16,1

Other options can be delivered on request.

5. Description of Accessories, from Bottom to Top



5 Baseplate for square mast (4S195)

5.1 Base-plate

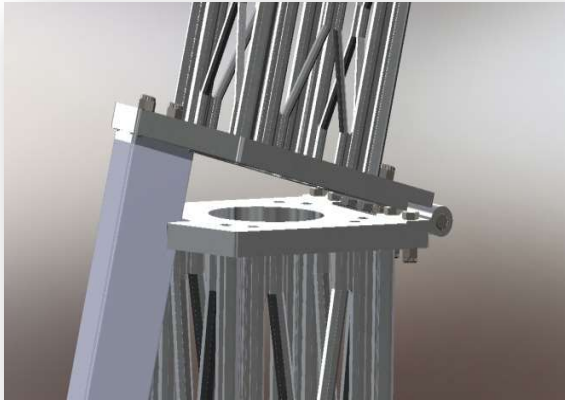
Each mast is supplied with a base plate mounted to the lower end. The base plate is made of aluminum. Three holes (triangular masts) or four holes (square masts) will be used to mount the mast to the foundation. There are four unique base plates for the different mast types.



6 Hinged base-plate for square mast (4S195)

5.2 Base-plate with hinge

Normally the base-plate is fixed, but the masts can be supplied with a hinge. The hinge will ease the maintenance of the equipment mounted on the top of the mast, as it will enable the possibility to lower the top section of the mast from the hinge placed between top and bottom section of the mast. Thus no climbing or lift is needed.

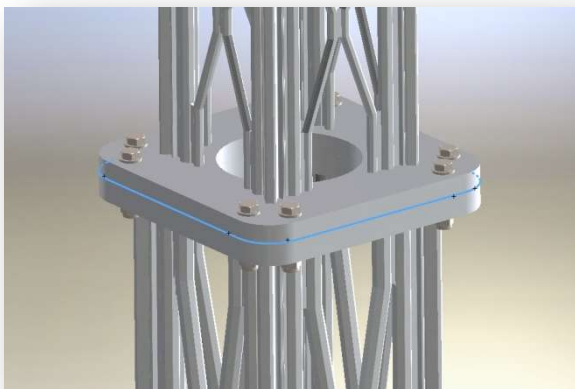


7 Hinged connection plate (4S to 4M)

hinge will normally be used in masts exceeding 4.5 m height. The mast will be supplied with a rope arrangement in order to securely lower the upper part down. The lowering rope arrangement can be operated by one person. Normally there will be supplied one rope arrangement for each Site.

5.3 Hinged connection plate between M and S mast

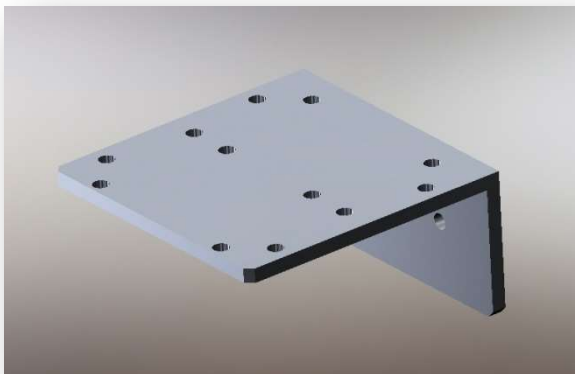
Taller masts, which comprise one Small and one Medium mast, will normally be supplied with a hinged connection plate. The reason for the hinge is the same as described in chapter 5.2, but the hinge is placed in the connection plate between the two masts because a hinged tall mast will be very heavy to lower and raise if hinged in the base. Middle



8 Fixed connection plate (4S to 4M)

5.4 Connection plate between M and S mast

Some customers will have easy access to masts with a lift. In such cases it will be cheaper to supply a mast without a middle hinge, only a connection plate.



9 Top plate (4S)

5.5 Top plate

The top plate will always be mounted on top of the mast. Its geometry will depend on the actual equipment which the customer wants to place in the top of the mast. This will be manufactured according to customer specifications

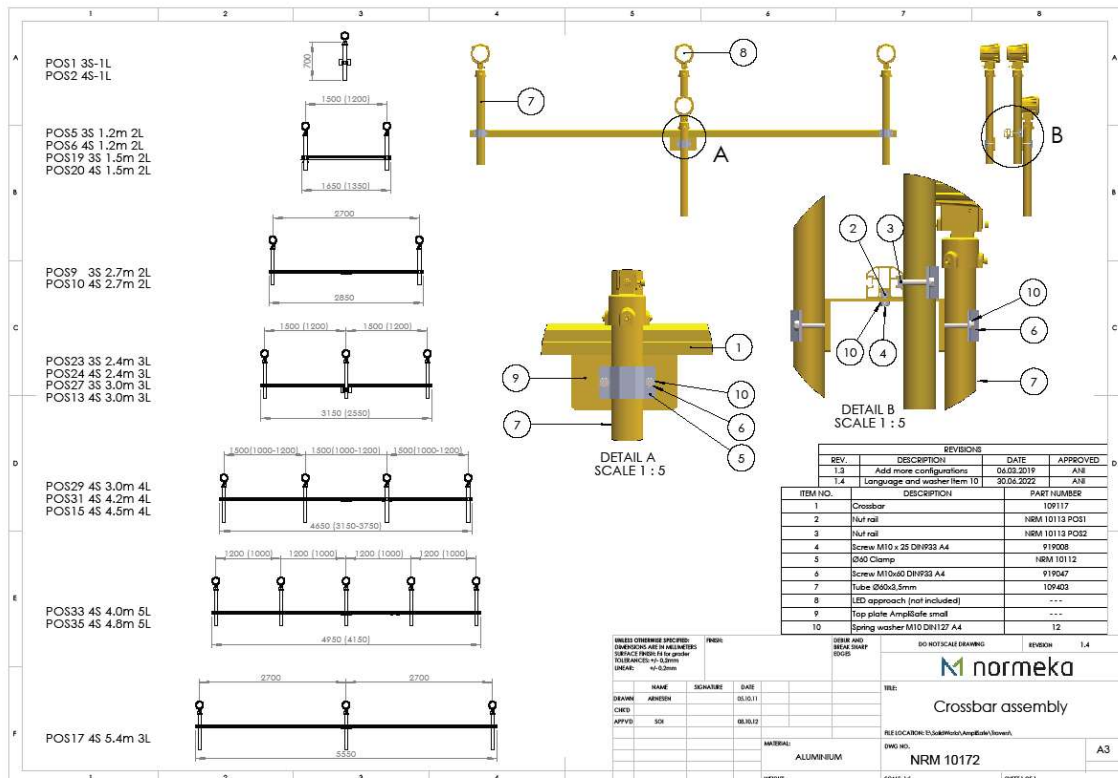


10 Crossbar with one Ø60 lamp holder

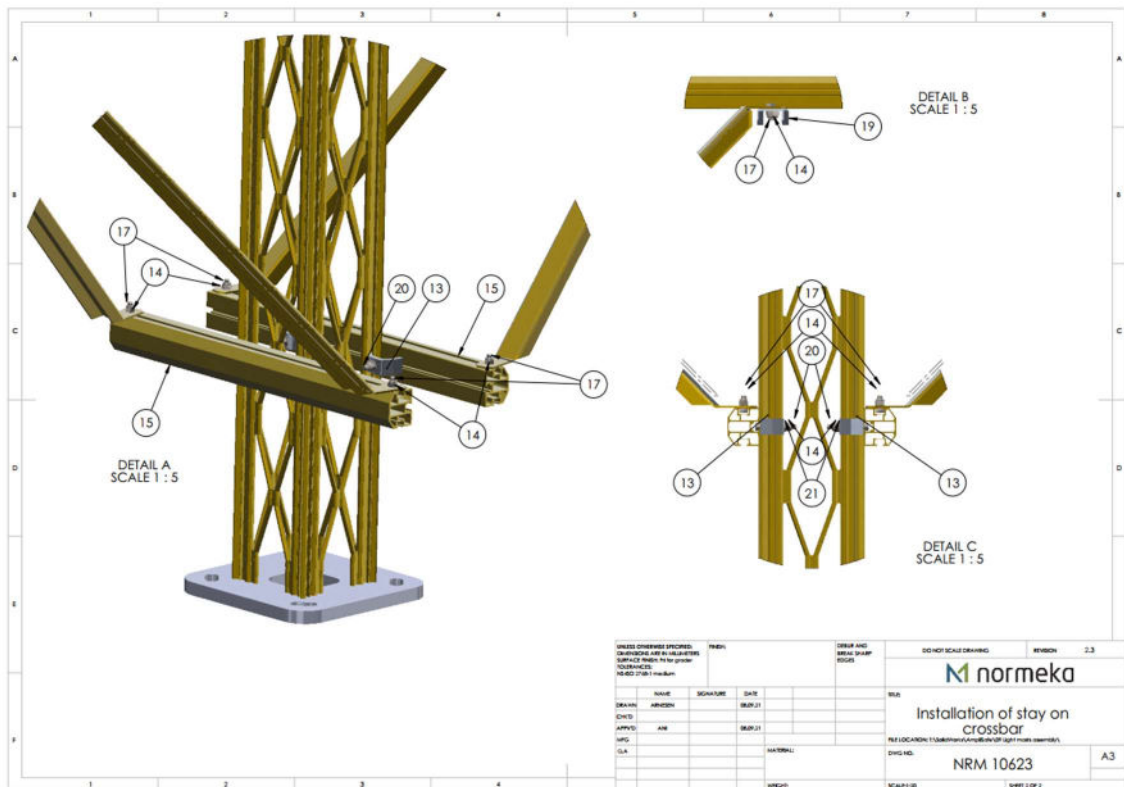
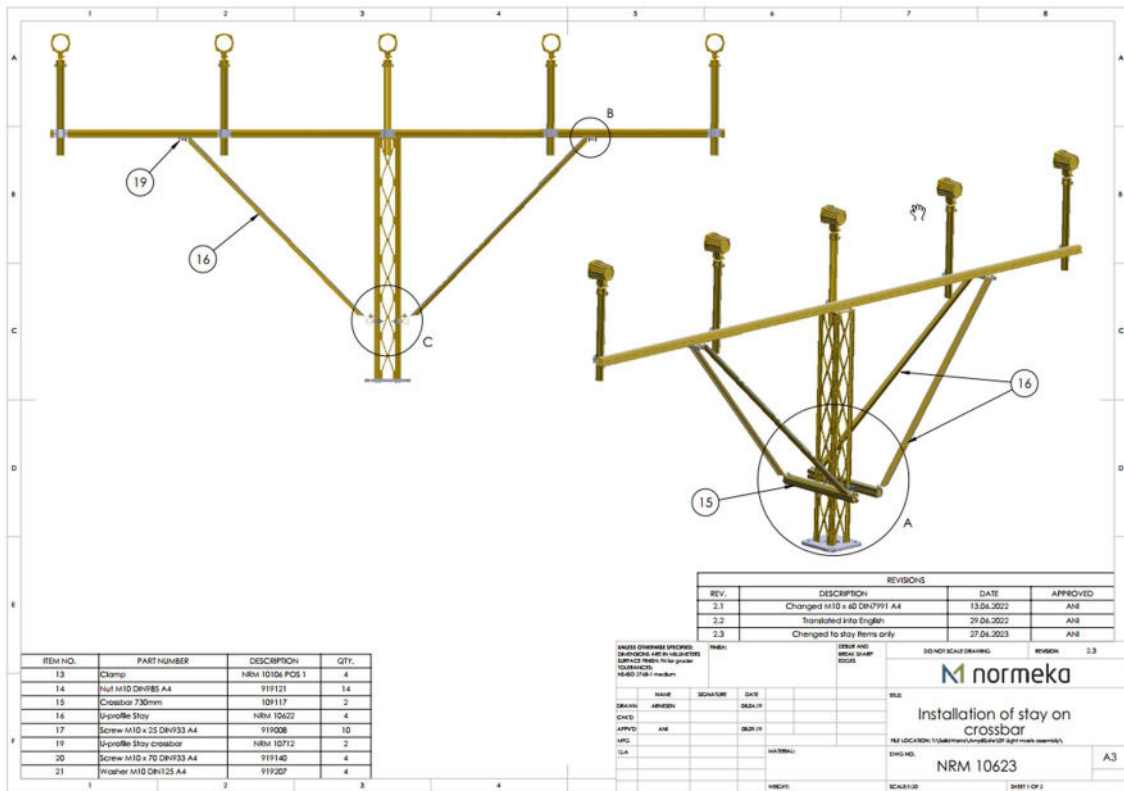
5.6 Crossbar

A special profile might be mounted horizontally on top of the mast. The mast itself is very stable, and when mounting a crossbar (which can hold up to 8 lights and be up to 5,5 m wide) the number of masts can be kept as low as possible. Vertical Ø60 aluminum pipes are mounted to the horizontal traverse, each of them holding one light.

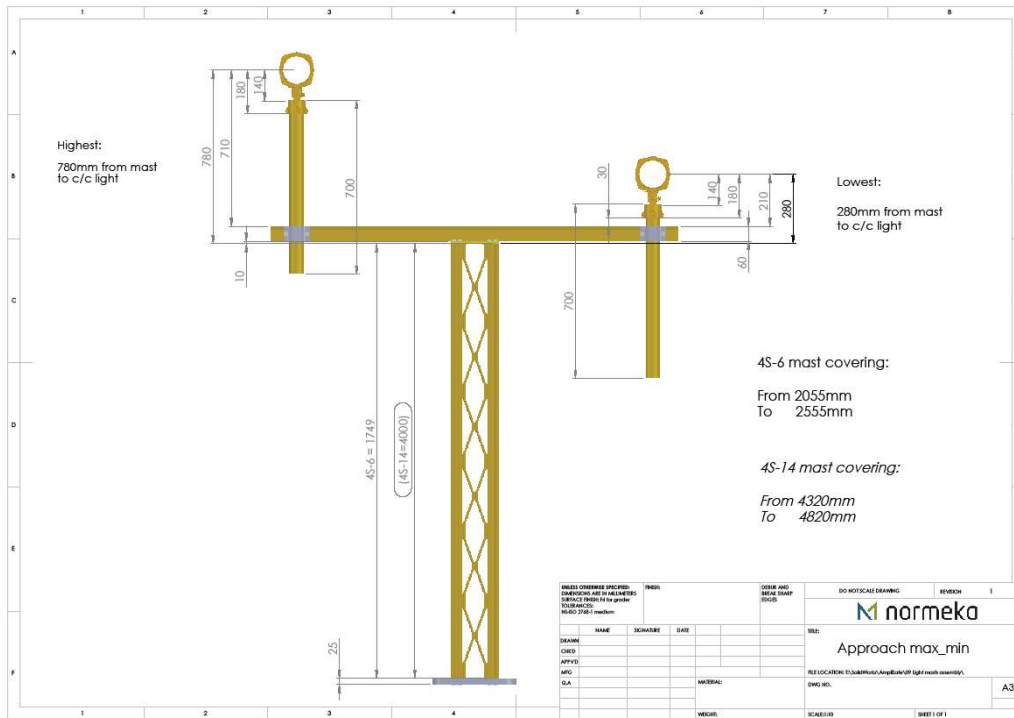
5.7 Crossbar combinations



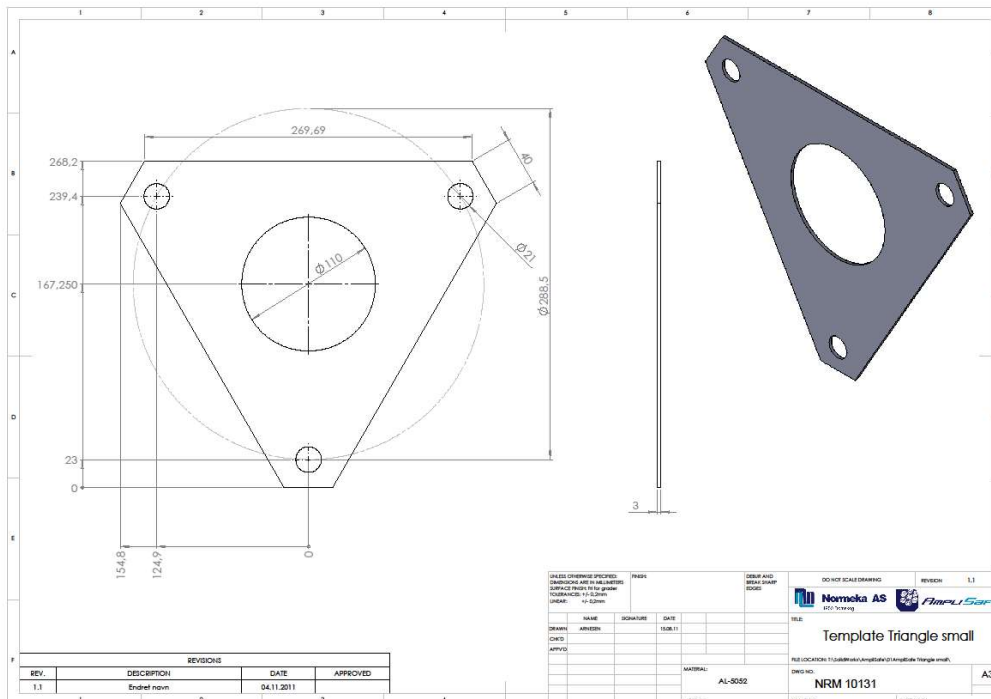
5.8 Stay for Crossbar



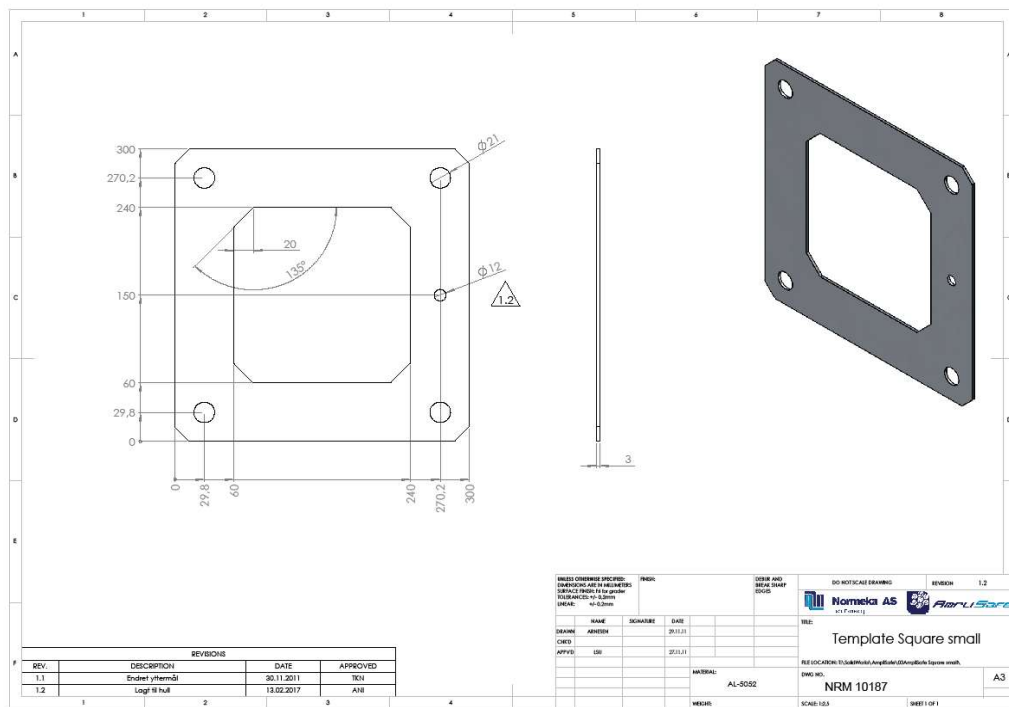
5.9 Adjustment



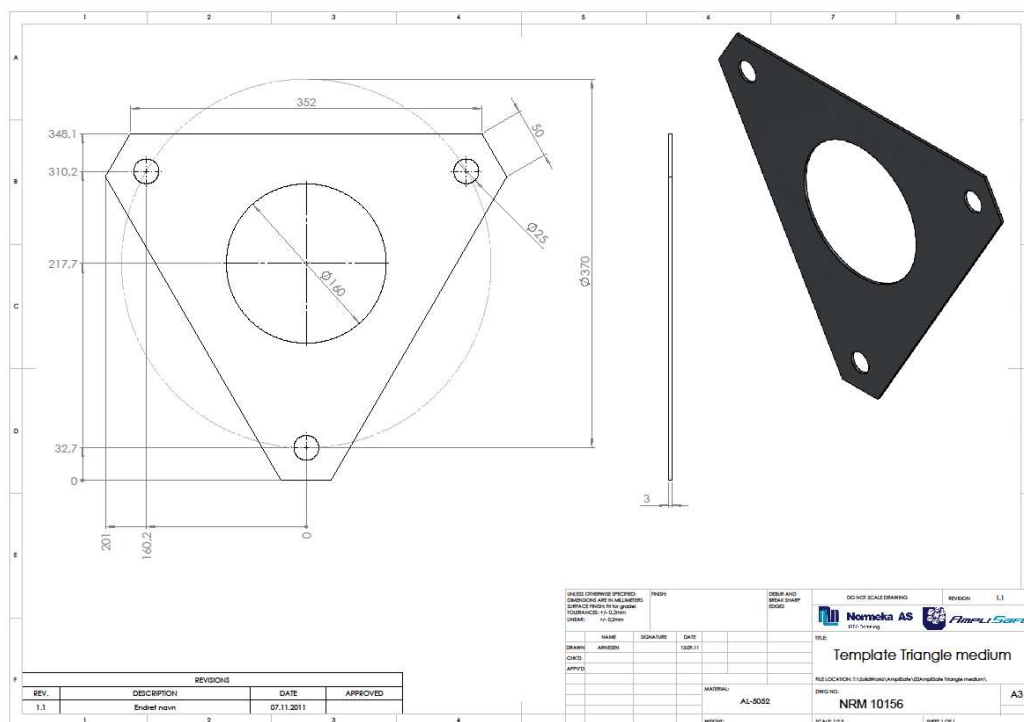
5.10 Template 3S



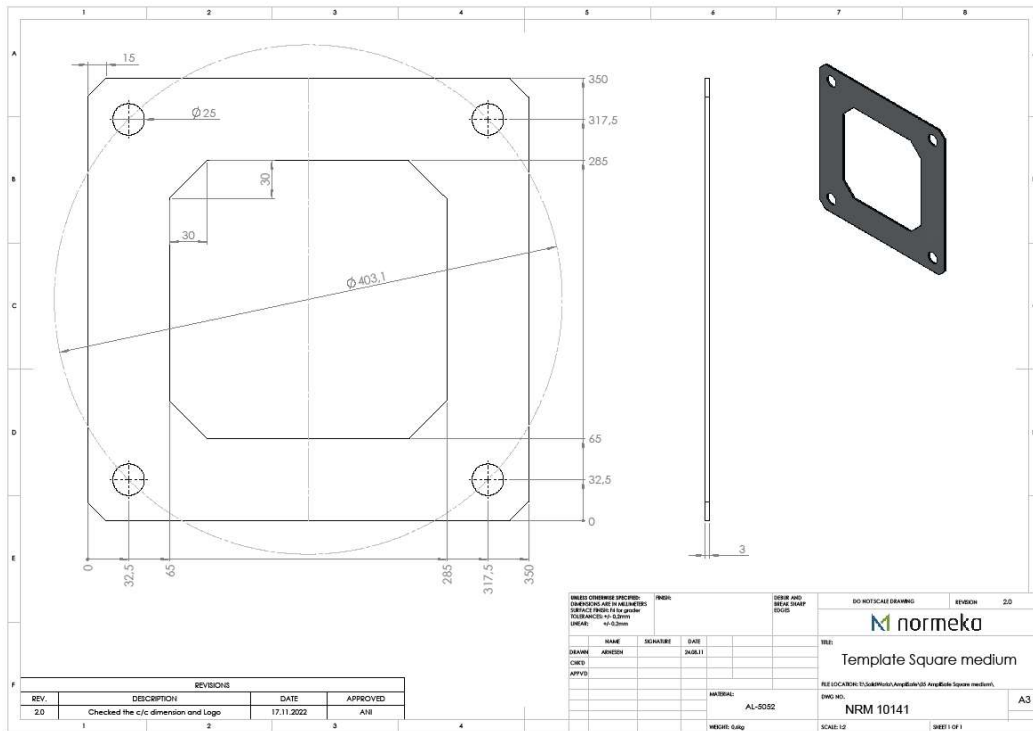
5.11 Template 4S



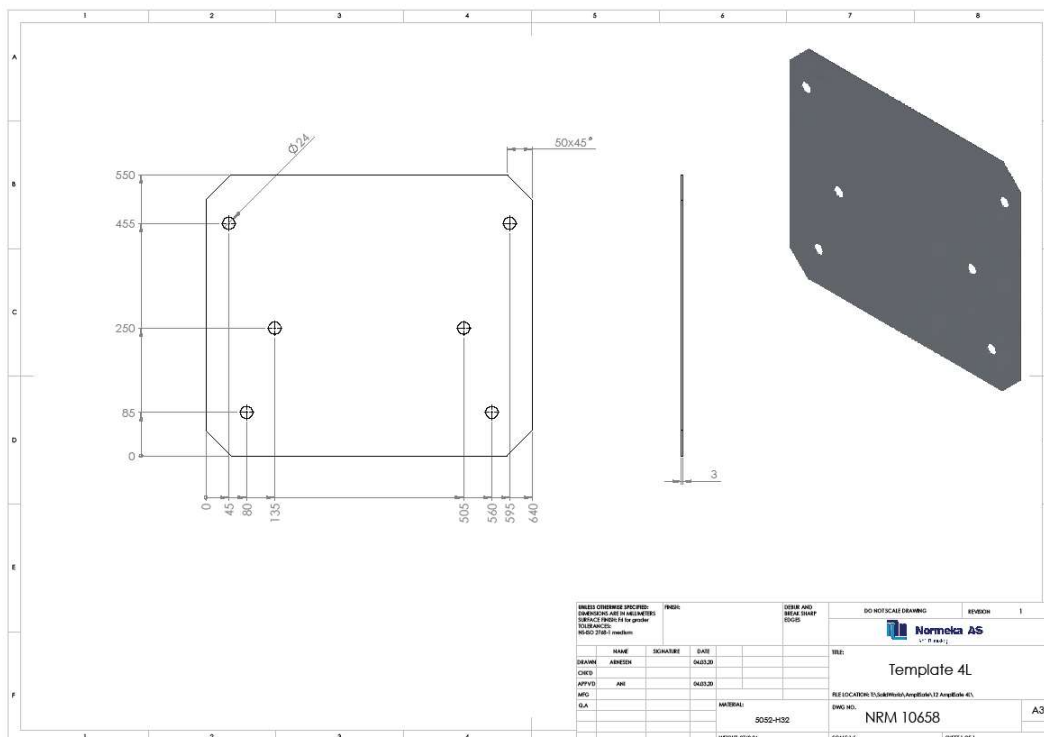
5.12 Template 3M



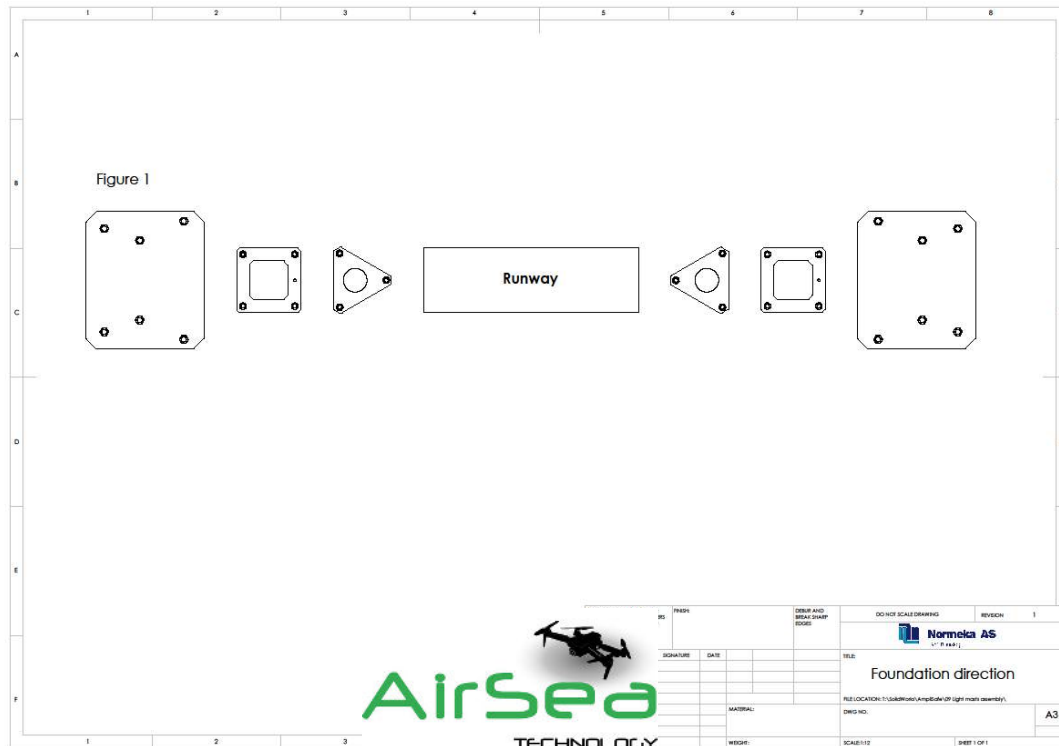
5.13 Template 4M



5.14 Template 4L



5.15 Template direction



5.16 Foundation (not included in the delivery)

The masts shall be mounted on concrete foundations. The foundations must have a certain size to withstand the forces imposed on it from the mast. Normally the foundations are casted on site. See chapter 6 for details. We supply the necessary template in order to secure correct positioning of the bolts.

6. Foundations

Foundations are not included as a part of the mast delivery and has to be casted on site before installation. The dimensions for foundations given in the tables below are alternatives that can be used as general guidelines for foundations supporting the Frangible masts by AmpliSafe®. It is however recommended to involve a local engineering company for a detailed project specific calculation, including considerations of local norms, soil type evaluation, rebar specifications etc., before start of construction.

Dimension guidelines are provided for both square slab foundations and round drum type foundations where applicable.

- Concrete class C30/327.
- Used Norm: EN 1997-1.

Moment

Mast type	Height (m)	Moment (kNm)
3S	7	14,8
3M/3S	10	30,7
4S	8	28,4
4M/4S	13	78,5
4L/4M/4S	17	161,4

Soil type

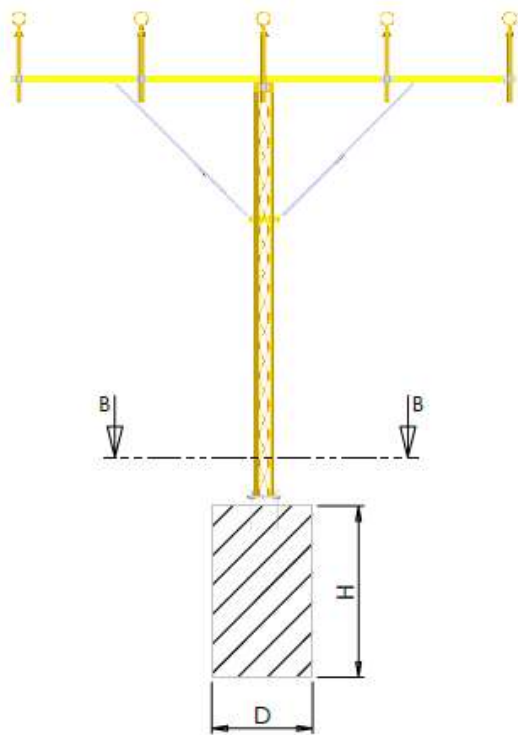
Soil type	Soil type	angle of friction ϕ_k (°)	Density γ (kN/m ³)	Cohesion c (kPa)
1	Sand/sandy soil	25°	17	0
2	Compacted coarse sand and moraine	40°	21	0
3	Hard clay	20°	19	20

Foundation slab (square)

Mast Type	Soil type 1			Soil type 2			Soil type 3		
	L/W m	H m	Mass kg	L/W m	H m	Mass kg	L/W m	H m	Mass kg
3S	1.5	0.5	2815	1.4	0.5	2450	1.6	0.5	3200
3M/3S	1.7	0.7	5060	1.7	0.6	4335	1.8	0.6	4860
4S	1.7	0.7	5060	1.7	0.6	4335	1.8	0.6	4860
4M/4S	2.1	0.8	8820	2.1	0.75	8270	2.2	0.8	9680
4L/4M/4S	2.5	1	15625	2.5	0.9	14065	2.6	1	16900

Foundation drum (round)

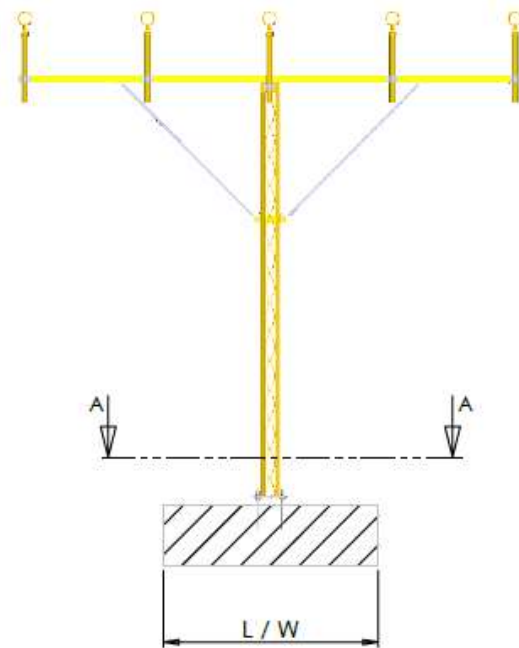
Mast Type	Soil type 1			Soil type 2			Soil type 3 (n/a)		
	D m	H m	Mass kg	D m	H m	Mass kg			
3S	1.2	1.4	3960	1.2	1.3	3675			
3M/3S	1.2	2	5650	1.2	1.8	5090			
4S	1.2	1.9	5370	1.2	1.7	4800			
4M/4S	1.2	2.5	7065	1.2	2.1	5935			
4L/4M/4S	1.3	3	9950	1.2	2.6	7350			



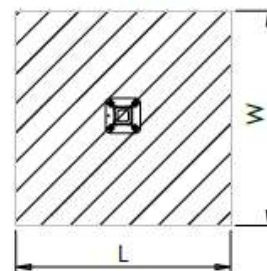
SECTION B-B



Drum (round)



SECTION A-A

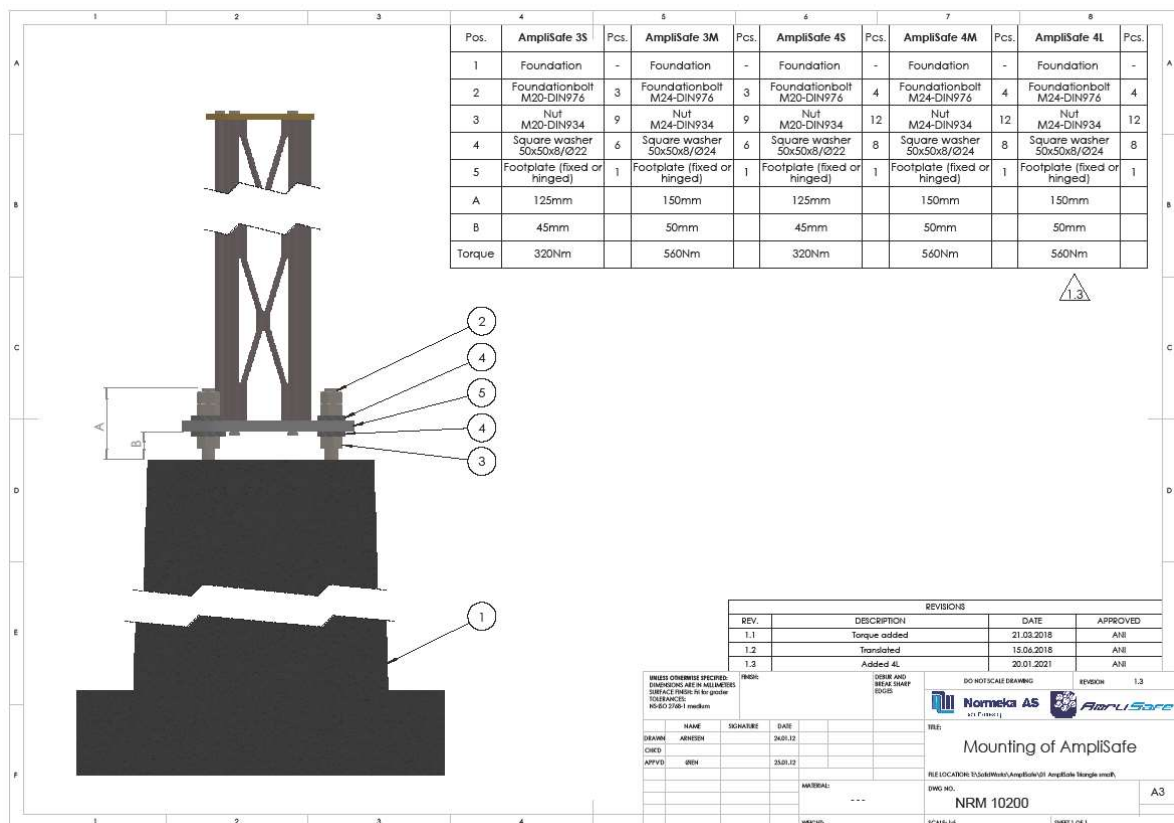


Slab (square)

7. Installation

All position references can be found in drawing NRM 10200.

- Nuts (pos3) shall be positioned on foundation bolts, leave a space of approximately 30mm between nuts and concrete foundation. Three nuts for triangular masts and four nuts for square masts.
- Washers (pos4) shall be put on top of each nut. Washers shall be aligned horizontally.
- Place the mast on top of the foundation. Fix the mast by placing one washer (pos4) and a nut (pos2) to each of the foundation bolts, and tighten to specified torque. Torque is specified in NRM 10200.
- Check that the mast is vertical, and if not, adjust by lowering or raising the nuts on the individual foundation bolts.
- When adjustment is carried out and the mast is vertical, the mast shall be secured with an additional nut (pos2) on top of the nut placed above the mast footplate. Tighten all nuts to specified torque.



8. Lowering The Mast

To facilitate safe and easy maintenance, some masts are equipped with a hinge that enables the top of the mast to be lowered to a comfortable working height. The following procedure describes how to lower and raise the mast. Normeka recommends two people for this operation as the force needed to lower and raise the masts safely depends on the mast equipment configuration. For a typical mast the force needed to lower and raise is approx. 500N (with pulley 250N).

Warning! The area directly under a descending or ascending masts path must at all times be kept clear of any personnel. A mast that, for any reason, descend uncontrolled can cause serious injury or death.

- Release the turnbuckle and attach the rope to the eye nut at the end of the lowering arm. Attach one pulley to the same eye nut with the included carabiner hook, attach the second pulley to the eye nut located on the base plate in front of the mast. Route the rope from the end of the lowering-arm through the pulley attached to the baseplate and then through the pulley attached to the lowering-arm. The routing shall be done as the picture shows.
- Make sure to have a secure grip around the rope before removing the bolt securing the lowering arm. The bolt is placed just above the bottom end of the lowering arm.



- Release the mast by gently pulling the lowering arm away from the mast. Slowly pull the swing arm further away from the mast until the center of mass has shifted enough to allow the mast to be lowered by gravity. Use the rope to control the rate of descent, do not allow the mast to descend too quickly as this will cause a violent impact between bottom and top sections of the mast, which can cause damages to the mast and installed equipment.



- To raise the mast to its upright position, simply do the steps above in reverse. It is however recommended that the top part of the mast is manually pulled out from the bottom part of the mast as far as possible, to put the swing arm in a more favorable position, before raising the mast by pulling the rope. This will reduce the force needed to raise the mast. At the end of the raising, grab the lowering arm and guide it into position.

9. Lowering Arm AmpliSafe Tower Solution

To allow the lowering arm operation on AmpliSafe installed on a Tower solution, the lowering arm is shortened.

Fixing of the lowering arm is then handle by this kit with wire.



Typical tower installation



Items included for Tower Solution:

- 1 pcs. Turnbuckles.
- 1 pcs. Wire 10mm, factory made.

10. Maintenance

The AmpliSafe® product line requires very little maintenance but Normeka AS however recommends the following preventive actions to be performed at least every five years.

- Control the tightening of bolts and nuts installed at site e.g foundation nuts, for tightening torque see drawing NRM 10200 page 15, traverse profile attachment, lowering arm attachment and lights tube attachments.
- Remove any buildup of organic material, excessive amounts of dirt etc. Pay extra attention to the areas around foundation bolts.
- Inspect the masts for visible defects which may affect the structural performance of the mast installations.

Torque table

Dimension	Material	Torque
M10	A4-80	44 Nm
M12	A4-80	85 Nm
M16	A4-80	187 Nm

11. Technical Specifications, Main Components

Description	Size	Weight	Material	Max bending moment
3S mast	Sidewall 195mm	5,8kg/m	Aluminum 6063	16,1 kNm
3S footplate	Triangular	2,9kg	Aluminum 6082	
3S footplate w/hinge		6,7kg	Aluminum 6082	
3S top-plate		1,0kg	Aluminum 6082	
4S mast	Sidewall 195mm	7,7kg/m	Aluminum 6063	29,1 kNm
4S footplate	Square	5,2kg	Aluminum 6082	
4S hinged footplate		8,9kg	Aluminum 6082	
4S top plate		1,4kg	Aluminum 6082	
3M mast	Sidewall 240mm	11,1kg/m	Aluminum 6063	31,4 kNm
3M footplate	Triangular	5,9kg	Aluminum 6082	
3M-3S middle hinge		9,2kg	Aluminum 6082	
3M top plate		2,0kg	Aluminum 6082	
4M mast	Sidewall 240mm	14,3kg/m	Aluminum 6063	83,7 kNm
4M footplate	Square	9,0kg	Aluminum 6082	
4M-4S middle hinge		9,4kg	Aluminum 6082	
4M top plate		2,5kg	Aluminum 6082	
Top traverse (for mounting >1 lamp/mast)		3,55kg/m	Aluminum 6063	Max length 5500 mm
Light fitting pipe	Ø60 mm x 700	1,2kg	Aluminum 6060	

Document Revisions and Changes

Issue	Date	Paragraph Heading / Description of Change
1.0	26.10.11	First issue
1.1	15.11.11	
1.2	15.11.12	
1.3	22.09.14	
1.4	10.03.15	Normarc Frangible Masts by AmpliSafe®
1.5	10.04.15	
1.6	28.02.18	New layout
1.7	21.03.18	Chapter 6 and 7 added
1.8	09.10.18	Changed description 3S195, 4S195 and 4M240
1.9	11.10.18	Correction and proofing changed
2.0	18.06.19	New design and layout
2.1	02.07.19	Added warning text in chapter 8
2.2	07.01.20	Added maintenance chapter
2.3	11.11.20	Updated masts, crossbar and Selection of masts
2.4	24.11.20	Some maintenance update
2.5	26.02.21	Chapter 6 foundations added.
2.6	30.06.22	Drawings updated, Chapter 8 updated
2.7	22.11.22	Template added in chapter 5
2.8	10.09.24	Text changed, Normarc removed



For more information

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