1. General

1.1 Introduction

This specification covers gabions and gabion mattresses produced from:

- metallic-coated (zinc or Zincalu®) or stainless steel welded wire fabric,
- metallic-coated or stainless steel wire for spiral binders,
- lacing wire,
- stiffeners used to assemble the product.

The metallic coated fabric, spiral binders, lacing wire and stiffeners may be polyvinyl chloride (PVC) coated.

1.2 Normative references

ASTM A 974: Standard Specification for Welded Wire Fabric Gabions and Gabion Mattresses (Metallic Coated or Polyvinyl Chloride (PVC) Coated).

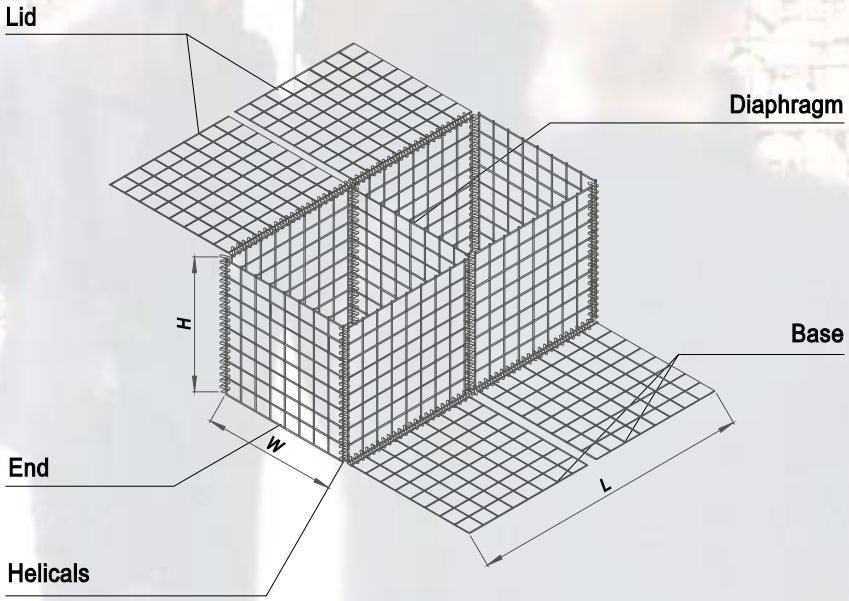
- EN 10016-2: Non-alloy steel rod for drawing and/or cold rolling,
  Part 2: Specific requirements for general purposes rod.
- EN 10088-1: Stainless steels
  Part 1: List of stainless steels.
- EN 10218-2: Steel wire and wire products – General,
  Part 2: Wire dimensions and tolerances.
- EN 10223-4: Steel wire and wire products for fences,
  Part 4: Steel wire welded mesh fencing.
- EN 10244-2: Steel wire and wire products - Non-ferrous metallic coatings on steel wire
  Part 2: Zinc or zinc-alloy coatings.
- EN 10245-2: Steel wire and wire products - Organic coatings on steel wire
  Part 2: PVC finished wire.

07.10.2009

1.3 Définitions

Nominal wire diameter (d): the diameter in mm to designate the wire.

- Real wire diameter: the average value of the minimal and the maximal diameter, measured in the same section of a straight piece of wire, by means of a micrometer accurate to 0,01 mm.
- Mesh sizes: the mesh size is the center–to-center distance between two consecutive longitudinal or transverse wires.
- Zincalu® (Zinc Aluminum) is an alloy with 95% zinc and 5% aluminum.
- Welded wire fabric: fabric composed of a series of longitudinal and transverse zinc or zinc-alloy coated steel wire arranged at right angles to each other, welded together at the points of intersection, by electrical resistance welding. The fabric can be subsequently PVC coated. The fabric is available on rolls from which the panels are cut.
- Gabion: a wire fabric container, of variable size, interconnected with other similar containers, and filled with stone on side, to form flexible, permeable, monolithic structures such as retaining walls, sea walls, channel linings, revetments, and weirs for erosion control: see fig.1.
- Gabion mattress: a gabion with relatively small height relation to the lateral dimensions.
- Lacing wire: a metallic-coated steel wire or metallic-coated and subsequently PVC coated used to assemble and interconnect empty gabion units and to close and secure stonefilled units.



1.4 Classification

Welded wire gabions can be classified according to the coating, as follows:

- Welded wire fabric made from wire, which is zinc-coated before being welded into fabric. Spiral binders, lacing wire and stiffeners are produced from zinc coated wire.
- Welded wire fabric made from wire, which is Zincalu®-coated before being welded into fabric. Spiral binders, lacing wire, and stiffeners are also produced from Zincalu® coated wire.
- Welded wire fabric, spiral binders, lacing wire, and stiffeners produced from zinc or Zincalu®-coated wire and over coated with PVC

2. Raw material

2.1 Wire rod low carbon steel

Chemical composition:

In accordance with EN 10016-2 – C9D

Element	%
C	≤ 0.10
Si	≤ 0.30
Mn	≤ 0.60
P	≤ 0.035
S	≤0.035

2.2 Stainless steel

Element	AISI 304L	EN 10088-1	
		1.4306	1.4307
C	0.030	0.030	0.030
Si	0.750	1.000	1.000
Mn	2.000	2.000	2.000
P	0.045	0.045	0.045
S	0.015	0.015	0.015
Cr	18.0 to 20.0	18.0 to 20.0	18.0 to 20.0
Ni	8.0 to 12.0	10.0 to 12.0	8.0 to 10.0

2.3 Zinc

A minimum 98.50% of pure zinc is used.

2.4 Zincalu ® Ultra

Slabs used are in accordance with ASTM B 750

3. Requirements

3.1 Wire diameter and tolerances

Coating	Gabions	Gabion Mattress
Zinc and Zincalu	Either all wires 3.00mm or 4.55mm or 3.00mm and 4.55mm as a frontpanel	All wires have the same diameter : 3.00mm or 4.55mm
PVC	Either all wires 2.70/3.20mm or 3.80/4.30mm or 2.70/3.20mm and 3.80/4.30 mm as a frontpanel	All wires have the same diameter : 3.00mm or 4.55mm

Remark : other diameters and diameters in stainless steel , in accordance with costumer requirements.

3.2 Tolerances , coating weight and tensile strength

Coating (2)		Diameter mm		Coating weight min. gr/m²	Tensile Strength N/mm²
		Core	Outer		
Gabion and Gabion Mattress	Zinc	-	3.00 ± 0.07	255	350 to 800
	Zinc	-	4.55 ± 0.08	280	350 to 800
	Zincalu	-	3.00 ± 0.07	255	350 to 800
	Zincalu	-	4.55 ± 0.08	280	350 to 800
	PVC	2.70 ± 0.06	3.20 ± 0.20(1)	245	350 to 800
	PVC	3.80 ± 0.06	4.55 ± 0.20(1)	275	350 to 800
Lacing Wire	Zinc or Zincalu	-	2.50 ± 0.06	245	400 to 550
Locking Pins	PVC	2.25 ± 0.06	3.15 ± 0.20(1)	230	400 to 550
	Zincalu	-	4.00 ± 0.07	275	400 to 550
	Stainless Steel				650 to 950

(1) Thickness PVC layer : Minimum 0.20mm
(2) Zinc and Zincalu coating is in accordance with EN10244-2 class A

3.3 Mesh size and tolerances :

Spacing of the longitudinal wires : 76.2 ± 2.5mm
Spacing of the transverse wires : 76.2 ± 2.5mm

Other mesh sizes in accordance with costumer requirements

4. Gabion and Gabion Mattress sizes

The sizes are designated by means of L x W x H
Some typical standard sizes are shown in the table below.

Nominal sizes of standard gabions and gabion mattresses

	Unit Length (L)	Unit Width (W)	Unit Height (H)
Welded Wire Mesh Gabion	1.00 m	1.00 m	0.30 , 0.50 or 1.00 m
	1.50 m	1.00 m	0.30 , 0.50 or 1.00 m
	2.00 m	1.00 m	0.30 , 0.50 or 1.00 m
	3.00 m	1.00 m	0.30 , 0.50 or 1.00 m
	4.00 m	1.00 m	0.30 , 0.50 or 1.00 m
	5.00 m	1.00 m	0.30 , 0.50 or 1.00 m
Welded Wire Mesh Gabion Mattress	2.00 m	2.00 m	0.15 , 0.225 or 0.30 m
	3.00 m	2.00 m	0.15 , 0.225 or 0.30 m
	4.00 m	2.00 m	0.15 , 0.225 or 0.30 m
	5.00 m	2.00 m	0.15 , 0.225 or 0.30 m
	6.00 m	2.00 m	0.15 , 0.225 or 0.30 m

The actual value is a multiple of 76,2mm (3"). This table refers to the industry standard unit sizes, non-standard unit sizes are available in dimensions of multiples of the mesh opening.
The permissible tolerance on L,W and H is ± 3,5 mm.

5. General installation data

- **Galvanized and Zincalu® coated Gabions and Gabion mattresses:**

  Zincalu® coated lacing wire, helicals and locking pins are available to secure the welded wire fabric panels together.

- **PVC coated Gabions and Gabion mattresses:**

  PVC coated lacing wire together with stainless steel helicals and locking pins are suitable to secure the welded wire fabric panels together.

- **A Fencing gun :**

  reference SC-50, is available for mechanically-crimping stainless steel rings for jointing all galvanized, Zincalu® coated and plastic-coated mesh gabions listed in table 3. The stainless steel rings, reference CL-50, are manufactured from 3,0mm diameter stainless steel wire, steel quality AISI 302 or 304.

6. Form of delivery

Gabions are supplied "flat packed" with factory fitted stainless steel joining coils to all vertical joints. Gabions and gabion mattresses are supplied in collapsed form, folded, bundled and strapped together on a 2-way pallet. Each unit labelled and identified with, at least, the dimensions of the product.

Dependant upon the configuration of the gabion :

- Lid and base panel factory connected with one joining coil
- Lid and base panel supplied separately along with joining coils for connection on site.
- Additional joining coils for connection of all base panel joints.
- Two joining pins for connection of adjacent gabions.
- Coils of Zincalu coated lacing wire, permanent connection of the lids, and connection of adjacent courses.

7. Expected Life Time

7.1 Corrosion resistance PVC

The most significant signs of degradation of organic coatings are :

- fading and chalking
- colour changes
- embrittlement of the coating
- loss of adhesion; possibly leading to flaking.

These effects are essentially caused by photochemical attack by the higher energy fraction of solar radiation (particularly UV), together with the accompanying heating induced by visible and near infrared wavelengths. In addition, atmospheric oxygen, ozone, moisture and various pollutants can also exert a deleterious influence.

A number of tests have been developed and can be performed to evaluate the lifetime of an organic coating. Some of the most important are (see also EN 10245-1 Steel wire and wire products – Organic coatings on steel wire – Part 1: General rules):

- Artificial, accelerated photoageing tests, such as the QUV (ASTM G 154), Xenontest (EN ISO 4892-2) Weather-Ometer (EN ISO 4892-4)

- Salt spray test: check of the adhesion retention and other deterioration in terms of appearance, colour,…in a controlled chlorinated atmosphere. The retention is very important for thermosetting plastic, e.g. polyester, which are hard and brittle. They will break as glass without adhesion between the plastic and the substrate

7.2 PVC Coatings: Process and Properties

The lifetime of an organic coating system depends on several parameters, such as :

- the type of coating
- the substrate
- the condition of the substrate before the coating
- the effectiveness of the surface preparation
- the conditions during the application of the coating
- the thickness of the coating
- the exposure conditions after application

PVC resins have an excellent exterior durability in atmospheric environments and are well suited to architectural applications because of their gloss retention and resistance to fading. For these reasons PVC coatings have been well established since years.

Process of PVC coating : Fluidisation or sintercoating:

The mesh or wire is passing through a primer which is cured in an oven. At the same time the product is heated up, the product passes through a bath in which PVC powder is fluidised by air. After fluidising the product is heated up, to cure the PVC (makes the PVC smooth and brilliant) and finally cooled.

Thickness of the coating :

The coating should be faultless, (the PVC and polyester layer must be closed and all parts of the substrate must be covered) free of pores and thick enough to stop/avoid the electro-chemical corrosion process of the metallic substrate. The layer has a thickness of minimum 200 µm.

PVC:

PVC is the most versatile of all plastics because of its blending capability with plasticizers, stabilisers, and other additives. It combines a good mechanical strength with a very good chemical resistance.

PVC is not attacked in an industrial or marine atmosphere. The slow breakdown time means that PVC is used in long-term applications with a life span of 10 years or more.

Betafence guarantees for a period of 10 years, the quality of the PVC coated products in all atmospheres, included the very aggressive C5 atmosphere.

The durability or technical lifetime is for PVC coated gabions and gabion mattresses much longer than the 10 years guarantee period.

7.3 Zincalu® Ultra Coating

Zincalu® Ultra coated. Zincalu® is a 95%Zn / 5%Al alloy.
Coating weight is minimum 350 g/m².

Salt spray tests, Kesternich (SO2)-tests as well as field tests were done on Zincalu® Ultra coatings, to compare the life time of these coatings with zinc coatings.

Salt Spray Tests

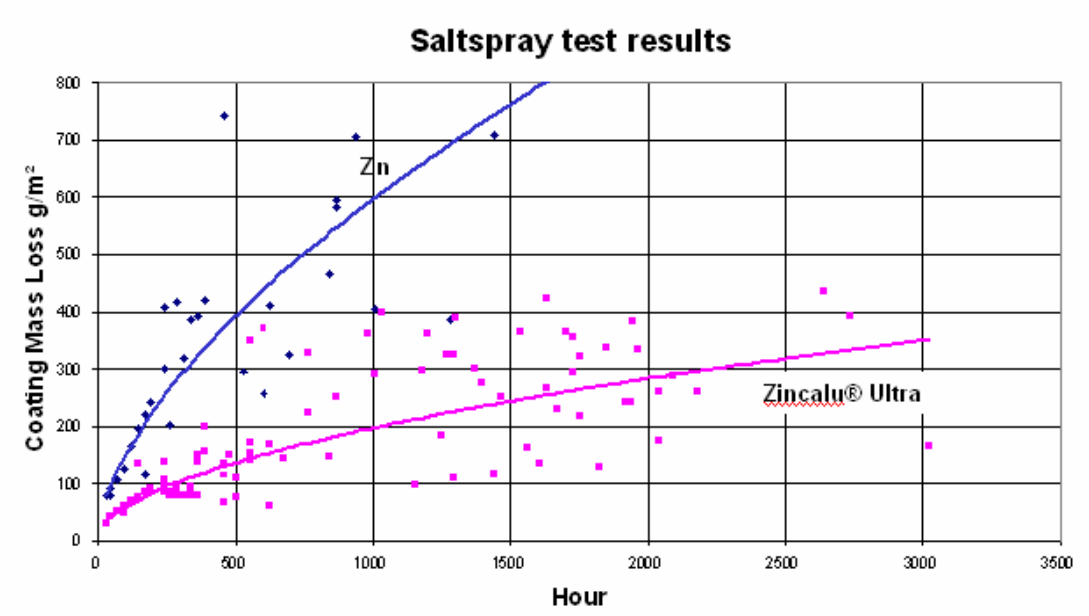
Applicable international Standards are:

- ISO 9227 Corrosion tests in artificial atmospheres - Salt Spray tests
- ISO 3768 Metallic coatings - Neutral spray tests
- National standards are DIN 50021-SS; ASTM B 117; AFNOR X 41-002

The testconditions are the same in the different standards and summarised below

- 100% relative humidity
- 35 °C
- evaluation every 24 hours

The test is stopped at a level of 5% dark brown rust



Conclusions:

Zincalu® Ultra becomes more resistant in function of time, Zincalu Ultra (95%Zn 5%Al) performs 2 to 3 times better than zinc depending of number of hours:

- after 100 h: coating loss : Zinc 1g/m²,h
  Zincalu® Ultra 0,5 g/m²,h or 2 times more resistant than zinc

- after 500 h: coating loss : Zinc 0,8g/m²,h
  Zincalu® Ultra 0,28 g/m²,h or 2,8 times more resistant than zinc

- after 1000 h: coating loss : Zinc 0,6g/m²,h
  Zincalu® Ultra 0,2 g/m²,h or 3 times more resistant than zinc

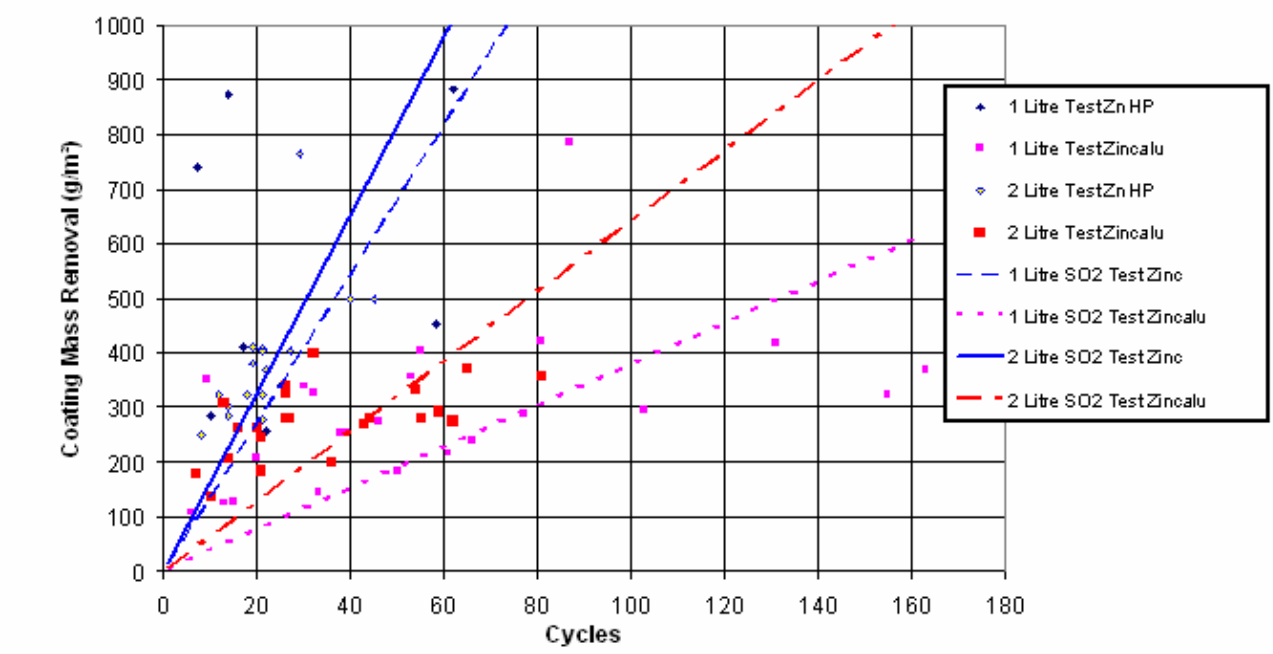
Sulpher dioxide or Kesternich test

Testconditions are described in ISO 3231 or in DIN 50018 and are summarised below

Cycle:

- 8 hours at 40°C and 100% relative humidity
- addition of sulpher dioxide
- 16 hours ventilation(no heating or additions) and 75% relative humidity
- chamber rinsed with water

Results of SO_2 Test on Zn & Zincalu® Ultra

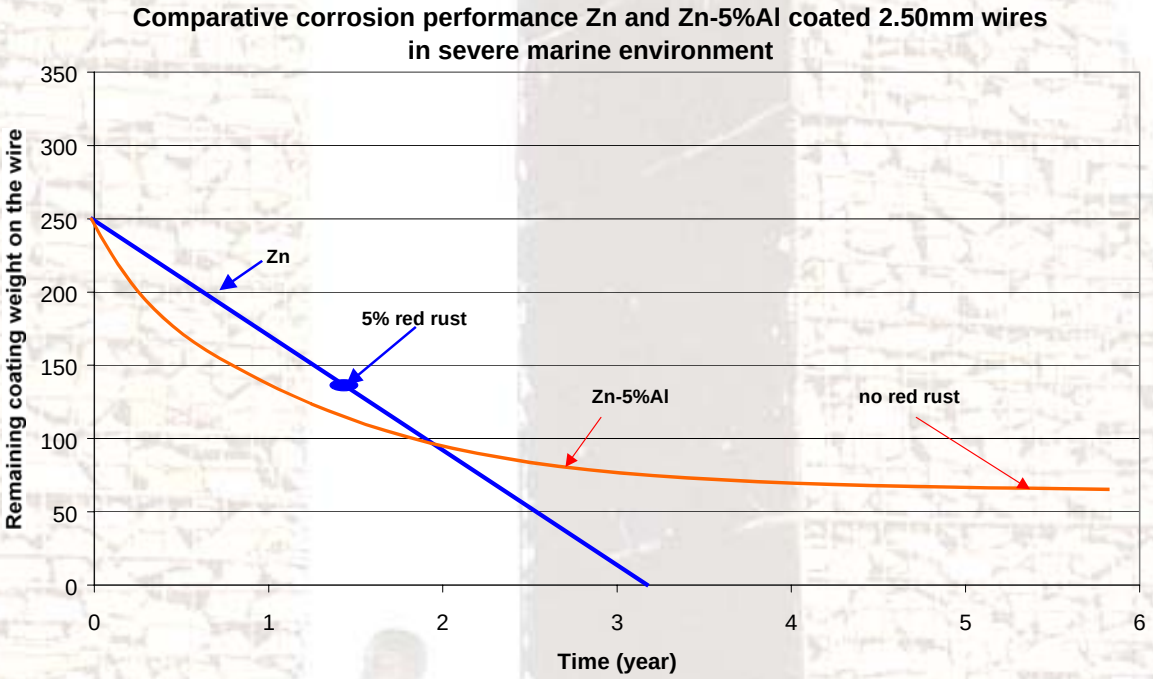


Conclusions

- Amount of SO_2 determines corrosion rate (see difference between 1 and 2 litre)
- Over 60 cycles (2 months) Zincalu® Ultra is 1,5 to 2,5 times more resistant to SO_2 environment than zinc

Outdoor or Fieldtests:

Zincalu® and zinc coated wires have been followed during years in different atmospheres. Below you will find some results:



- after 1,5 years the first red rust appears on the galvanised wire
- the galvanised wire is completely corroded after about 3 years
- no rust on the zincalu® coated one after more than 6 years

  Below a picture of a barbed wire (Motto) after 6 years. More than 60% of the galvanised wire is corroded and on the zincalu® coated wire there is no corrosion at all after 6 years exposure at the Belgium coast ('t Zwin Knokke).

ISO 12944-2 gives, based on quantitative measurements a numbered ranking of the corrosivity of the atmosphere and also the loss of zinc and of steel for the different categories.

Corrosion rate iron and zinc (ISO 12944-2)			
Category	yearly mass loss per unit surface		examples
	low carbon steel g/m²	zinc g/m²	
C1 (very low)	≤ 10	≤ 1	Heated buildings with clean atmospheres, e.g. offices, schools
C2 (low)	10 to 200	>1 to 5	rural atmospheres with low pollution
C3 (medium)	200 to 400	>5 to 15	urban and industrial atmospheres with low to moderate sulphur dioxide and low salinity
C4 (high)	400 to 650	>15 to 30	atmospheres with moderate sulphur dioxide and moderate salinity
C5 (very high)	650 to 1500	50 and more	industrial and coastal areas with high humidity and high pollution of sulphur dioxide and salinity

expected lifetime		
category	Expected lifetime	
	galvanised wires	Zincalu® coated wires
C1	much more than 10 years	much more than 10 years
C2	much more than 10 years	much more than 10 years
C3	about 10 years	much more than 10 years
C4	5 to 10 years	10 to 15 years
C5	use plastic coated	use plastic coated

Remark about panel made out of Zincalu® coated wires:

the welding points are not covered with Zincalu. The weld flash can corrode, but this is very local and generally disappears over a short period of time.
This expected lifetime excludes the presence of other kinds of pollution, which can also exert an effect on the product. Examples are: oxides of nitrogen (NOx) , industrial dust in polluted and industrial zones, specific operational and technological pollution of microclimates, chlorides (Cl_2), hydrogen sulphide (H_2S), organic acids, de-icing agents,.....

8. Corrosion of products buried in soil

A lot of parameters can have an influence on corrosion and corrosion speed of products buried in soil. You have:

- The mineral content of the soil: is it a native soil or backfill materials (as sand, gravel, crushed limestone...) or industrial refuse (as ashes, cinders...)?
- The water content: is it dry or wet or soil with differing ground water levels?
- The oxygen content: corrosivity of soil is strongly influenced by the degree of aeration. The oxygen content can vary and corrosion cells may be formed.
- Corrosion cells: due to formation of corrosion cells, local corrosion or pitting may occur.
- Some specific parameters as the formation of a galvanic cell (and an accelerated corrosion) in the neighbourhood of a railway.
- … .

9. Weld Shear Strength

Applicable for Welded Gabions, Type 2 and Type 3.
The average shear strength of 4 welds selected at random from 1 Gabion shall not be less than 70% of the breaking load of the wire.

Testmethod: EN 10223-7 (see picture below).