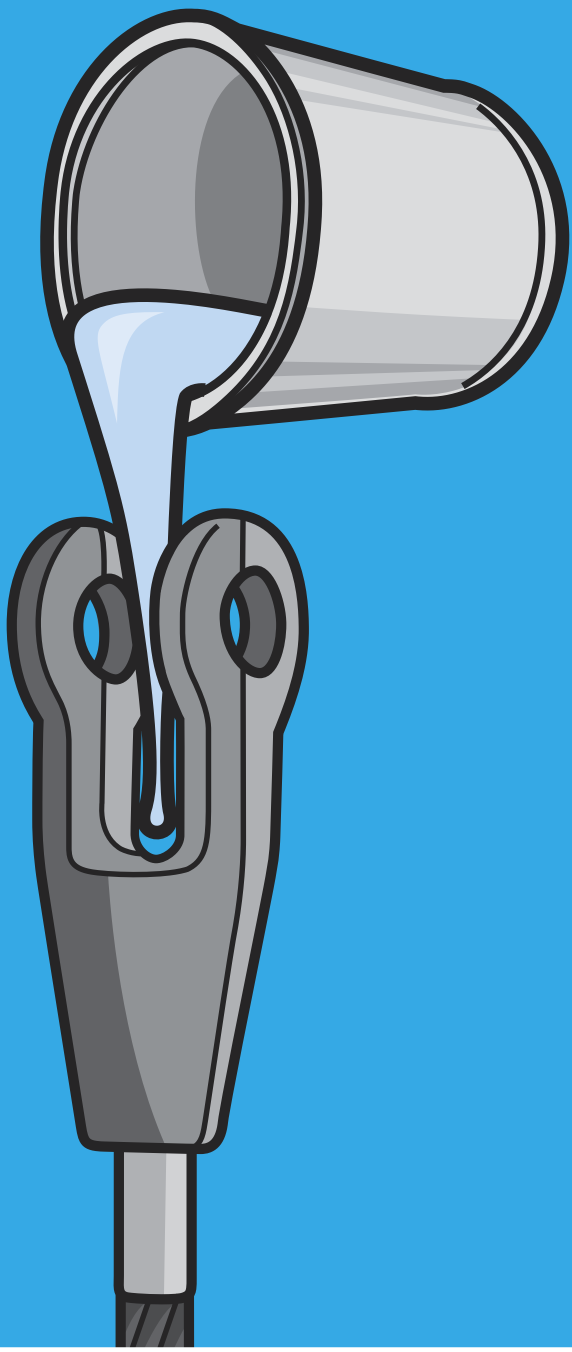
WIRELOCK®



Technical data manual

Millfield

Developed & manufactured in the UK by
Millfield Enterprises (Manufacturing) Limited

Introduction

WIRELOCK® is the original cold socketing compound for use with wire ropes. With a track record spanning over 50 years it is quite simply the best socketing solution for safety, dependability and unparalleled fatigue performance.

Manufactured in the UK, by Millfield Enterprises (Manufacturing) Ltd, **WIRELOCK®** produces standard kit sizes ranging from 100cc – 2000cc and our highly skilled workforce can create kit sizes to order for projects large and small.

Distributed internationally **WIRELOCK®** has a worldwide reputation as the number one product for safe and reliable use with bridges, structures, mining, offshore and general engineering.

WIRELOCK® meets the requirements of ISO 17558 and DNV-OS-E304 and has Type Approval from DNV, Lloyds and ABS.

The London Eye where **WIRELOCK®** was used.

Contents

Printed in the United Kingdom

Instructions

This technical data manual explains the proper use of **WIRELOCK®** for socketing wire rope terminations using standard taper sockets. When reading and following these instructions, pay close attention throughout to warning and safety information presented in bold print. For maximum safety and efficiency, use **WIRELOCK®** only as instructed.

Section 1: Warning on correct application of **WIRELOCK®**

It is very important when deciding upon the use of **WIRELOCK®** to note the following:

WARNING

- Incorrect use of **WIRELOCK®** can result in an unsafe termination which may lead to serious injury, death, or property damage.
- Crevice Corrosion will occur in the rope near the socket rope interface, where a termination of stainless steel wire rope is permanently immersed in salt water. When using **WIRELOCK®** within this environment regular inspection must be carried out.
- Seizing - use tinned or galvanised soft wire or strand for galvanised rope. Use bright, tinned or galvanised wire or strand for bright rope.
- Do not use copper or brass wires or strand for seizing.
- Never use an assembly until the **WIRELOCK®** has gelled and cured and a successful scratch test has been completed.
- Remove any non-metallic coating from the broom area.
- Sockets with large grooves need to have those grooves filled before use with **WIRELOCK®**.
- Read, understand, and follow these instructions and those on the product containers before using **WIRELOCK®**.

Section 2: Health & safety precautions for using **WIRELOCK®**

It is important that certain precautions be taken when using **WIRELOCK®** for a wire rope socket termination. When using the product be sure to read information on product containers and note the following:

CAUTION

- **WIRELOCK®** resin, in liquid state, is flammable.
- Chemicals used in this product can give off toxic fumes and can burn eyes and skin.
- Only use in well-ventilated work areas.
- Never breathe fumes directly or for an extended time.
- Always wear safety glasses to protect eyes
- Always wear gloves to protect hands.
- Avoid direct contact with skin anywhere.
- Always wear a dust mask/ fume filter.

Section 3: Selection of socket

3.1 **WIRELOCK®** is recommended for use with sockets that comply with International, European or National (ISO, CEN) Standards.

3.2 **WIRELOCK®**, as with all socketing media, depends upon the wedging action of the cone within the socket basket to develop full efficiency. Seating is required to develop the wedging action. Please note a rough finish inside the socket may increase the load at which seating will occur and must be avoided.

3.3 Measure the rope ends to be socketed. The rope end should be of sufficient length so that the ends of the unlaid wires (from the strands) will be at the top of the socket basket.

For standard taper sockets, apply the seizing one (1) socket basket length from the end of rope minus one (1) rope diameter. The length of the seizing must be at least two (2) rope diameters long. Additional information can be secured from your Wire Rope User's Manual or your wire rope manufacturer's catalogues or national standards. Please note when seizing, use tinned or galvanised soft wire or strand for galvanised rope. Use bright, tinned or galvanised wire for bright rope.

3.4 It is very important to seize correctly. If using pear shaped or other specialist sockets, the position of the seizing and the length of the broom may have to be adjusted to suit the socket being used.

Figure 1: Seizing of wire rope.

3.5 Plastic coated or plastic filled wire ropes must have all plastic material (non-metallic materials) removed from within the broomed area.

3.6 The socket basket should be examined prior to use and any loose scale, dirt or grease removed.

Do not use oversized sockets for wire rope.

3.7 When socketing strand, the time honoured method of one size up when choosing the socket is generally still applicable in the vast majority of cases. However, caution should be exercised as tests have shown that the length of the socket basket should be five (5) times the strand diameter or fifty (50) times the maximum wire diameter, whichever is the greater.

3.8 **Inserting the broom into the socket.**
There are two procedures that can be used to position the broom within the socket. The rope can be inserted into the socket prior to brooming. Subsequently the socket can be pulled up over the broom. The second method requires that the broom is closed and compacted to enable it to be inserted into the socket without damaging the rope or seizing.

For a detailed explanation of resin socketing of steel wire ropes see Appendix A on page 16.

3.9 **WIRELOCK®** is available in several standard kit sizes (100cc, 250cc, 500cc, 1000cc, and 2000cc). Specialist kits can be manufactured at higher volumes on request. Importantly, due to differences in formulation, 100cc and 250cc **WIRELOCK®** should be used exclusively on smaller sockets, whilst larger sockets should be poured with kits above 500cc.

Section 4: Preparation of broom

4.1 The rope is secured in a vice directly below the seizing to allow the strands to be unlaid down to the seizing. They should be bent outwards to a total included angle of approximately 60 degrees but not exceeding 90 degrees (figure 2).

Figure 2: Unlay wire rope so that the angle does not exceed 90°.

4.2 Internal leakage of resin in ropes of 75mm (3") in diameter and larger can occur because of gaps between strands and the IWRC (Independent Wire Rope Core) these gaps should be filled (before brooming), by pushing small plugs of the **WIRELOCK®** putty/ clay down into the served portion.

4.3 If the rope has a fibre core, it should be cut out ensuring that the remaining fibre core extends half (1/2) a rope diameter into the bottom of the socket. In the case of fibre cores, resin is the preferred socketing medium.

4.4 If the rope has an IWRC, the IWRC should be completely unlaid to form part of the broom.

4.5 **All the wires in each strand and the IWRC must be unlaid completely down to the seizing to form a broom, being careful not to disturb or change the lay of the wires and strands under the seizing band. The wires should not be straightened.**

Brooming is one of the most critical parts of any socketing operation.

Note: the wires must be unlaid from the end of the rope to the seizing because a good fill of resin must occur to the bottom (small end) of the socket (figure 3).

Most of the load bearing capacity of the termination is concentrated in the bottom one third (1/3) of the socket.

Figure 3: Properly broomed wire rope unlaid from the end of the rope to the seizing.

Figure 4: Incorrectly broomed wire rope.

4.6 Except in the case of wire ropes of coarse construction e.g. 6 x 7, it is not necessary or desirable to hook the wires in the broom. When the rope contains large numbers of wires, hooking the ends causes congestion within the socket and can create penetration problems for the socketing medium although this is less of a problem with resin than zinc or white metal.

4.7 The open broom should be thoroughly cleaned (degreased). **Be sure that the cleaning is confined to the broom and does not extend to the rope beyond.**

4.8 The method of cleaning will depend on the lubricant and/ or coating on the wire.

4.9 The methods and materials used for cleaning should comply with the current environmental protection regulations.

4.10 Consult your wire rope supplier or the wire rope manufacturer for recommended materials and methods.

4.11 Do not clean wire rope broom with acid, soda, methol hydrate, or acetone. A flux should not be used.

4.12 The wire rope broom, after cleaning and drying, should be kept in a horizontal position to prevent any grease or mixture of grease and cleaner from running back down from the main body of the rope and contaminating the clean wires.

Section 5: Positioning of broom & alignment of socket.

5.1 The broom should be inserted into the socket using one of the methods described in 3.8. Place rope in a vertical position with the broom end up. It is recommended that there be thirty (30) rope diameters below the socket before any bending occurs in the rope, or twenty (20) rope diameters if securely clamped to a beam.

Make certain the broomed wires are uniformly spaced in the basket, with wire ends at the top edge of the basket (figure 5), and that the axes of the rope and the fitting are aligned (figure 6). A centralising clamp should be used to assist in the alignment of the axes of the socket and the rope.

Correct alignment will avoid premature failure of the assembly due to unequal loading of the wires.

Figure 5: Properly positioned broom with the wire ends protruding slightly.

5.2 **WIRELOCK®** putty/ clay is required to seal the base of the socket prior to pouring, thus preventing resin leakage which may cause voids (figure 7).

Figure 6: Axes of socket and rope properly aligned.

Figure 7: Axes of socket and rope properly aligned and sealed with WIRELOCK® putty/ clay.

Section 6: **WIRELOCK®** storage, kits & mixing

6.1 **WIRELOCK®** should be stored in a cool dry place (10°C to 24°C/ 50°F to 75°F) and has a shelf life of 18 months from the date of manufacture, subject to correct storage. **Always** check the expiry date on the cans. **Never** use out of date material.

6.2 **WIRELOCK®** is formulated for mixing and pouring in the ambient temperature range; from -3°C to 35°C (27°F to 95°F). At lower temperatures the gel time will increase. See section 14.1 for further information regarding temperatures and gel times.

Below 9°C (48°F) acceptable gel times can be maintained by the use of **WIRELOCK®** Booster kits. Only use **WIRELOCK®** Booster kits that match the size of the **WIRELOCK®** kit being used.

Always add the **WIRELOCK®** Booster kit to the **WIRELOCK®** powder first and then add the resin.

CAUTION

- Chemicals used in this product can give off toxic fumes and can burn eyes and skin.
- Always check the expiry date on the cans. Never use out of date material.
- Use only in well ventilated work areas.
- Never breathe fumes directly or for an extended time.
- Always wear safety glasses to protect eyes.
- Always wear gloves to protect hands.
- Avoid direct contact with skin anywhere.
- Always wear a dust mask/ fume filter.

6.3 At ambient temperatures below 9°C (48°F) and above 2°C (35°F), one (1) **WIRELOCK®** Booster kit should be used. Below 2°C (35°F) and above -3°C (27°F), two (2) **WIRELOCK®** Booster kits should be used. The **WIRELOCK®** Booster kit compensates chemically for the slower gel time experienced at lower temperatures. In order to comply with all the approvals granted, **WIRELOCK®** should not be mixed and poured at temperatures below -3°C (27°F). Knowing the ambient temperature is useful, however, it should be remembered **WIRELOCK®** will for some time afterwards tend to cure according to the temperature at which it, the socket and the wire rope were stored. The temperature of the socket and the rope should conform to the temperature at which the **WIRELOCK®** has been stored for the last 24 hours.

If the socket, rope and **WIRELOCK®** are stored at normal room temperature 18°C to 21°C (65°F to 70°F) **WIRELOCK®** Booster kits must not be used if the ambient temperature is below 9°C (48°F). If the ambient temperature is 35°C (95°F) or above, the **WIRELOCK®** kit should be refrigerated for two hours before use.

6.4 It is possible to combine various kit sizes to achieve any required volume, e.g. 2500cc = 2 x 1000cc plus 1 x 500cc, etc. In this case, pour all of the liquid resin into all of the powder before mixing. **Always mix all of the resin with all of the powder. Never mix less than the total contents of all cans.**

6.5 **Only the 100cc, 250cc & 500cc can be mixed in the original packaging by pouring the resin into the granular materials container (figure 8). In the case of other kits, a proper mixing vessel should be used.**

Mixing vessels should be clean. They can be made of metal, polythene or polypropylene. Polymerisation products of styrene, i.e. styrofoam cups and similar products should not be used. A flat wooden or metal paddle, not a spike or screwdriver, should be used as a stirrer.

Figure 8: Some kits can be mixed in the original packaging.

6.6 Immediately upon pouring the resin into the granular compound, mix vigorously for two (2) minutes or until a homogenous mixture has been obtained. Make sure that no unmixed granular compound remains on the bottom of the mixing container. For larger sizes, a mechanical mixer is ideal.

Upon mixing, the WIRELOCK® will turn to a green/ blue colour. If the mix remains a pale straw yellow colour, do not use the kit. Always mix all of the resin with all of the powder. Never mix less than the total contents of both cans.

Section 7: Use of heat

7.1 Do not apply heat to sockets to accelerate the curing process prior to pouring. The application of external heat may cause the resin to gel before it reaches the bottom of the socket and lead to assembly failure. Used sockets cleaned out by heating (see Appendix B on page 19) should be allowed to cool to room temperature before re-use.

Hot sockets must not be used.

Section 8: Pouring WIRELOCK®

8.1 Once the **WIRELOCK®** is mixed, it should be poured immediately (figure 9) into the socket to ensure good penetration, preferably down one side of the socket to allow air to escape.

Figure 9: Upon mixing the compound should be poured immediately.

Immediate pouring will ensure that the gelling stage occurs in the socket and not in the mixing container. Sufficient **WIRELOCK®** should be mixed so that the socket can be completely filled in one pour. **WIRELOCK®** is designed to gel in approximately 20 minutes at 18°C (65°F). Gelling is the transition point from liquid to solid. To allow an adequate safety margin, no load should be applied to the wire rope assembly until a minimum of one (1) hour has elapsed from the time the **WIRELOCK®** has gelled in the socket and a successful scratch test completed.

As **WIRELOCK®** cures, a chemical (exothermic) reaction occurs, causing a considerable rise in temperature. Temperatures in excess of 100°C (212°F) may be reached in large volume kits in the mixing container. In the socket where the wires of the rope and the socket itself act as a heat sink, the maximum temperature likely to be achieved will be in the order of 70°C to 80°C (160°F to 175°F).

Section 9: Movement

9.1 Movement of the resin poured sockets may damage the soft resin and reduce the efficiency of the termination. Resin poured sockets should not be moved for a minimum of ten (10) minutes after the material in the socket has gelled.

Section 10: Check on penetration

10.1 A visual check for penetration of the resin into the socket bottom can be made by removing the centralizing clamp and the **WIRELOCK®** putty/clay. Seizing on the rope adjacent to the neck of the socket should be removed up to the point where it enters the socket.

Section 11: Re-lubrication

11.1 After removing the rope from the vice, any degreased area of the rope below the socket should be re-lubricated.

Section 12: Loading

12.1 The rope can be put into service or proof loaded one (1) hour after the material in the socket has gelled and a successful scratch test has been completed.

12.2 Whenever possible, the assembly should be proof loaded.

Section 13: Re-use of socket

13.1 Please consult socket manufacturer for additional information on re-use of sockets. See Appendix B on page 19 for guidelines issued by The Crosby Group Inc.

Section 14: General information

Figure 10: WIRELOCK® standard kit sizes and other kit sizes available.

1 **WIRELOCK®** is designed to gel (change from a liquid to a solid) in approximately 20 minutes at 18°C (65°F). To ensure the kits are not adversely affected by storage, they should be kept in a dry place at a temperature of between 10°C and 24°C (50°F and 75°F) and away from any source of direct heat. **WIRELOCK®**, like all polyester resins, is temperature sensitive. An increase in temperature of 10°C (18°F) will halve the gel time. A further increase of 10°C (18°F) will halve the gel time again. A decrease in temperature of 10°C (18°F) lengthens the gel time by approximately 100%. A further decrease in temperature of 10°C (18°F) will lengthen the gel time by approximately 100% again.

2 **WIRELOCK®** is available in standard kit sizes ranging from 100cc to 2000cc. Other kit sizes can be made to order for any specific project. Technical expertise is available by telephone **44 (0) 191 2648541** or **info@wirelock.com**

The specific gravity of **WIRELOCK®** is 1.73 therefore, 1000cc's will weigh 1.73kg or 3.81lbs. 250cc will weigh.

$$\frac{1.73 \times 250}{1000} = 0.43\text{kg} \quad \text{or} \quad 0.95\text{lbs}$$

3 **WIRELOCK®** wire rope assemblies are 100% efficient when used with steel wire rope, galvanised wire ropes and stainless steel wire ropes. We do not advise the use of stainless steel wire rope permanently immersed in a salt water (marine environment) without regular inspection. In the presence of an electrolyte, i.e. sea water, electrolytic degradation of the stainless steel wire rope can occur. This phenomenon, known as Crevice Corrosion will impair the integrity of the rope in the region near to the neck of the socket. Crevice Corrosion also occurs when white metal is used for socketing (zinc should not be used to socket stainless steel rope). However, the onset of Crevice Corrosion in resin sockets appears to be faster than when white metal is used. Other rope types do not exhibit this behaviour. See figure 11.

Figure 11: Typical example of the swelling of stainless steel rope due to Crevice Corrosion

4 **WIRELOCK®** is approximately 20% the weight of zinc.

5 The strength of **WIRELOCK®**, in its cured state, is not adversely affected by cold temperatures.

6 **WIRELOCK®** must be mixed and poured (see 6.3) within the temperature range of -3°C to 35°C (27°F to 95°F). The kits are not adversely affected by storage at temperatures below -3°C (27°F). **WIRELOCK®** kits should be stored in a cool dry place.

7 The operating temperature of **WIRELOCK®** is +115°C to -54°C (+240°F to -65°F).

8 When cured, **WIRELOCK®** has a Barcol hardness of approximately 40 to 50. When the resin has set fully (opaque green or mustard colour) only a slight scratch mark will be seen when a sharp object, such as a screwdriver blade, is scraped over the surface of the resin. On a small socket, it is quite normal to have a very thin tacky layer on the surface of the resin. The scratch test can be carried out through this layer.

9 Radial cracks, which may appear on the top of the cured cone, are surface crazing only and are a result of heat stresses and shrinkage upon a thin layer of unfilled resin covering the tops of the wires. The crazing does not affect the strength of the termination within the socket.

10 Shrinkage of the **WIRELOCK®** cone may leave a gap between the cone and the socket wall in large sockets. This is normal, particularly with large sockets and high ambient temperatures. This in no way affects the efficiency of the assembly. Upon loading, the cone will, with the onset of plastic flow, be seated perfectly in the socket. The shrinkage of **WIRELOCK®** is between 1.5 to 2.5%. In high volume **WIRELOCK®**, they shrinkage is about 0.5%.

11 Excessive numbers of horizontal rings in the socket may increase the load required to 'seat' and wedge the cone within the socket. They should be avoided whenever possible and a proof load applied (not exceeding 40% of MBL) if they must be used. Alternatively they should be filled in with **WIRELOCK®** putty/ clay, prior to placing the socket on the rope.

12 **WIRELOCK®** poured sockets should not be used in environments of strong caustic or acid solutions. **WIRELOCK®** is not affected by oils, grease or salt water.

13 **WIRELOCK®** is, by design, a compressive resin. Therefore, when removed from the socket a **WIRELOCK®** cone, if hit by a hammer, may shatter. In a socket, even under extreme loads or shock loads, the **WIRELOCK®** cone remains solid and 100% efficient.

14 The shelf life of **WIRELOCK®** is eighteen (18) months (check label before use) from the date of manufacture, subject to correct storage.

Section 15: Approvals & NATO numbers

Approvals

To maintain **WIRELOCK's** premier position in the marketplace we continually strive to refine and improve the product. We operate a monitoring programme to ensure that the quality of **WIRELOCK®** never varies.

WIRELOCK® is manufactured under ISO 9001 accreditation.

WIRELOCK® meets the requirements of ISO 17558 and DNV-OS-E304.

WIRELOCK® has Type Approval from Lloyds, DNV and ABS.

NATO numbers

100cc	8030-21-902-1823
250cc	8030-21-902-1824
500cc	8030-21-902-1825
1000cc	8030-21-902-1826

Section 16: Guide to amount of **WIRELOCK®** required

Formula to estimate cc's required to pour standard spelter sockets:

$$\left(\frac{D + d}{4}\right)^2 \times H \times 3.142 = cc$$

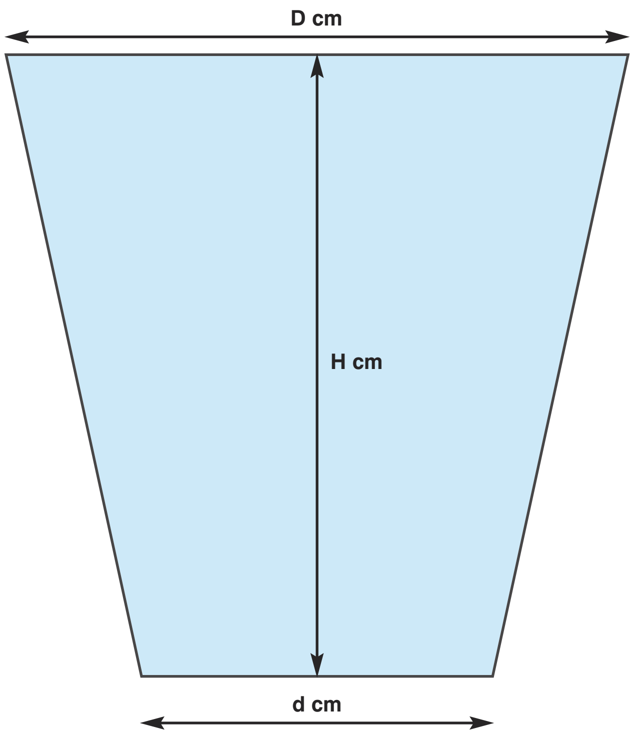


Figure 12: Socket measurements needed to estimate the amount of WIRELOCK® required.

6.5mm (1/4")	9cc
8mm (5/16")	17cc
9.5mm (3/8")	17cc
11mm (7/16")	35cc
12.5mm (1/2")	35cc
14mm (9/16")	52cc
16mm (5/8")	52cc
19mm (3/4")	86cc
22mm (7/8")	125cc
25m (1")	160cc
28.5mm (1 1/8")	210cc
32mm (1 1/4")	350cc
35mm (1 3/8")	350cc
38mm (1 1/2")	420cc
41mm (1 5/8")	495cc
44.5mm (1 3/4")	700cc
47.5mm (1 7/8")	700cc
51mm (2")	1265cc
54mm (2 1/8")	1265cc
57mm (2 1/4")	1410cc
60mm (2 3/8")	1410cc
63.5mm (2 1/2")	1830cc
66.5mm (2 5/8")	1830cc
70mm (2 3/4")	2250cc
76mm (3")	3160cc
82.5mm (3 1/4")	3795cc
89mm (3 1/2")	4920cc
95mm (3 3/4")	5980cc
101.5mm (4")	7730cc

Note: approximate measurements (U.S.A.)

250cc Kit	1 cup
500cc Kit	1 pint
1000cc Kit	1 quart

Depending on gel time (ambient temperature) do not pour more than two sockets from a mix.

Section 17: Properties of **WIRELOCK®**

WIRELOCK® in its liquid state is flammable. Flash point 31°C (88°F). **Please note:** flash point is not the auto ignition (spontaneous combustion) temperature, but the temperature above which the material will give off a significant amount of vapour.

Performance criteria

Compressive strength	Min. 100 N/mm2
Modulus of elasticity	Min. 6000 N/mm2
Barcol hardness	Min. 36
Specific gravity	1.55 - 1.95

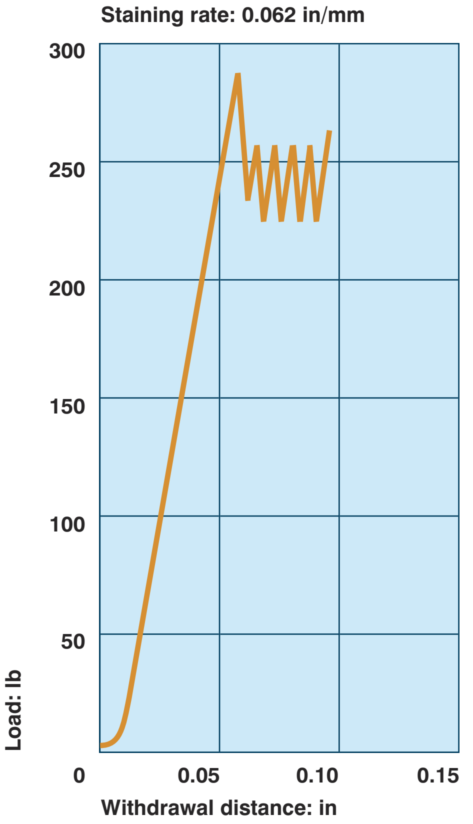


Figure 13: Pull out characteristic for single wire embedded in polyester resin/ silica.

The individual wires of the rope are retained by a combination of bonding and frictional forces.
The frictional forces are the result of:

- Shrinkage during the curing of the resin.
- Coefficient of friction between the resin and the individual wires.

The particle size of the silica has been carefully selected to maximise the frictional grip. This is illustrated in figure 13, where it is shown that when the bonds strength has been exceeded the frictional grip continues to hold the load.

Additional forces develop due to the wedging action within the socket as the rope is loaded.

As **WIRELOCK®** cures, it shrinks by between 1.5% and 2.5% (**WIRELOCK®** High Volume by less than 0.5%) and with the introduction of a hard inert filler of specific grain size, a high coefficient is obtained.

WIRELOCK® has excellent penetrating qualities and can flow through the densest wire rope broom, which would impact the flow of zinc.

The **WIRELOCK®** system is designed to have a minimal amount of creep, which ceases once the wedging and frictional forces develop for any given load.

WIRELOCK® excels in its ability to resist the action of fatigue in a wire rope assembly, which is normally prevalent in the rope close to the neck of the socket. **WIRELOCK®** will minimize such problems.

See **www.wirelock.com** for information on:

- **WIRELOCK®** testing documents
- **WIRELOCK®** SDS part A & B
- **WIRELOCK®** training aid – film outlining the correct socketing procedure when using standard taper sockets.

Appendix A: Resin socketing of steel wire rope

By J.M. Dodd B.Sc

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The concept is not new. The first published data on this topic were produced in the early sixties. In essence, these two papers by Doherty and Campbell, stated that the resin filled sockets under either static tension (tensile) or fluctuating tension (fatigue) could offer strengths that were comparable with those of the rope itself.

There is a dearth of information on socketing and the mechanisms by which it works, so it was necessary to establish some basic knowledge before a resin socketing system could be designed.

In theory, the requirements for a successful system are:

1. High bond strength between resin and wire
2. High modulus of elasticity

To ascertain the bond strength and the magnitude of the predicted frictional grip, tests were done on a single, straight wire cast into a cylindrical block of resin. The embedded length being such, that the wire when loaded would slip rather than break. The cylindrical resin termination was chosen so that there would be no distortion of the figures, due to the mechanical lock, inherent in a conical termination. The results are shown in figure I.

The graph shows that high bond strengths are achievable between the resin and the wire and that shrinkage of the resin and the inclusion of hard silica in the resin gave a very high frictional grip on the wire. The classic slip/ grip peaks and troughs on the right hand side of the loading curve show that the frictional grip is very nearly of the same magnitude as the bond strength.

In practice, it has been found that the wires in the rope broom, which is about to be socketed, are rarely clean enough to achieve anything approaching a good bond strength. Indeed, it will be shown later, when dealing with uncleaned wires, that the frictional grip alone is enough to seat the cone. Either the bond strength of the resin to the wire or the frictional grip of the resin on the wire, is sufficient on their own to seat the cone. Between them they offer a comforting reassurance that the wire will hold and the cone will seat even if the wire has not been cleaned properly.

The modulus of elasticity was measured and found to be 6085 Mpa (BS63 19 Part 6, 1984).

It very soon became apparent, that the bonding action between the socketing medium and the wire was not in itself sufficient to break the rope. Therefore the focus was moved to the shape of the socket, the wedging action it would produce and the mechanism by which this occurred.

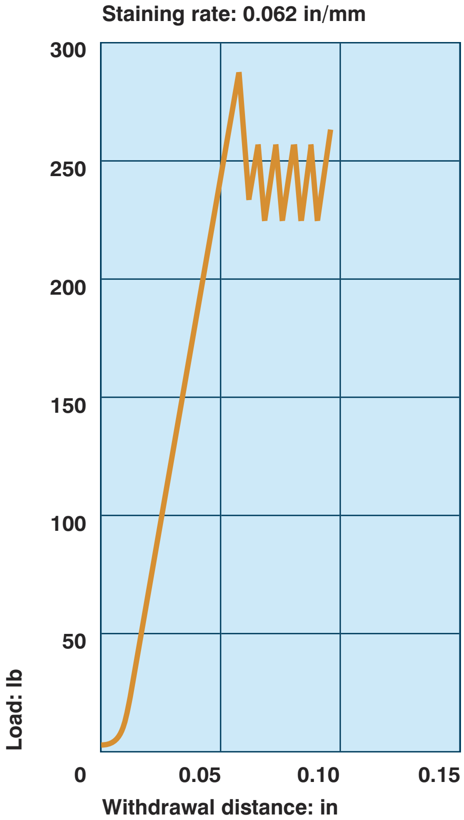

Figure I: Pull out characteristic for single wire embedded in polyester resin/ silica.

The usual 'total included angle' in sockets is between 14/15 degrees and experiments were carried out over the range 9/25 degrees total included angle. It was predicted that the narrower the angle, the lower the load at which movement occurred and the greater that movement would be. In general, this prediction was confirmed, although in the case of the lower angles, the straight line relationship experienced on the wider angles was not found. See figure II in all cases, the rope ultimately broke. This confirms that the system will cope with a fairly wide deviation from standard socket dimensions.

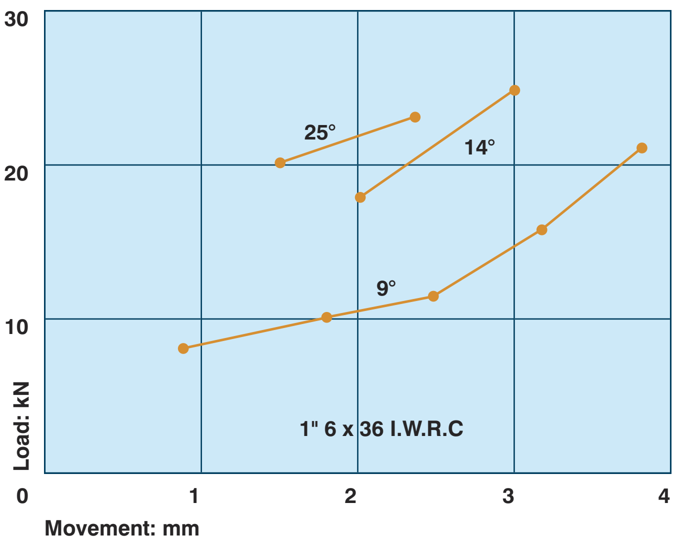

Figure II: Movement within the socket under load for the two extreme angles & the standard 14° taper.

The mechanism of this movement and wedging action were investigated by looking at the distribution of pressure through the socket. This showed that approximately two thirds of the total pressure within the socket was concentrated in the bottom third of the socket. Whilst pressure at the top of the socket was very low indeed.

It is necessary to explain why any movement is possible within the socket and to link it with the pressure distribution findings above.

When the resin is first poured into the socket there is a perfect match between the shape of the socket and the resin cone. Once the resin has cured, however, shrinkage occurs and in an exaggerated form the effect is as below (figure III).

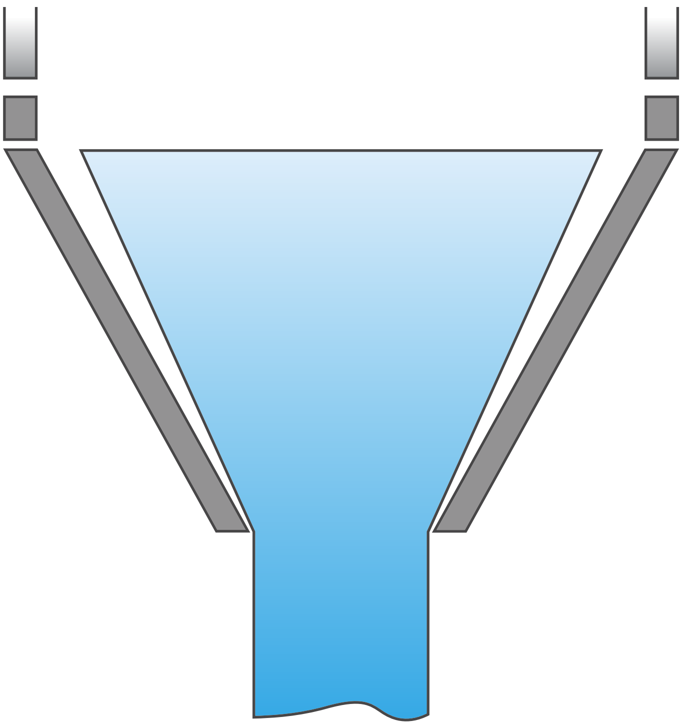

Figure III: Exaggerated relationship between cone and socket after the resin has cured.

When the load is applied the rope, any adhesion of the resin to the socket will shear and the cone, which is now slightly smaller, will begin to engage the socket wall at the neck of the socket, thereby generating pressure. Although it still retains a high modulus, the resin in contact with the socket is subject to plastic deformation and some flow is possible, allowing more of the cone to share in the loading process. This participation in load bearing diminishes as we proceed up the cone. See figures IV & V.

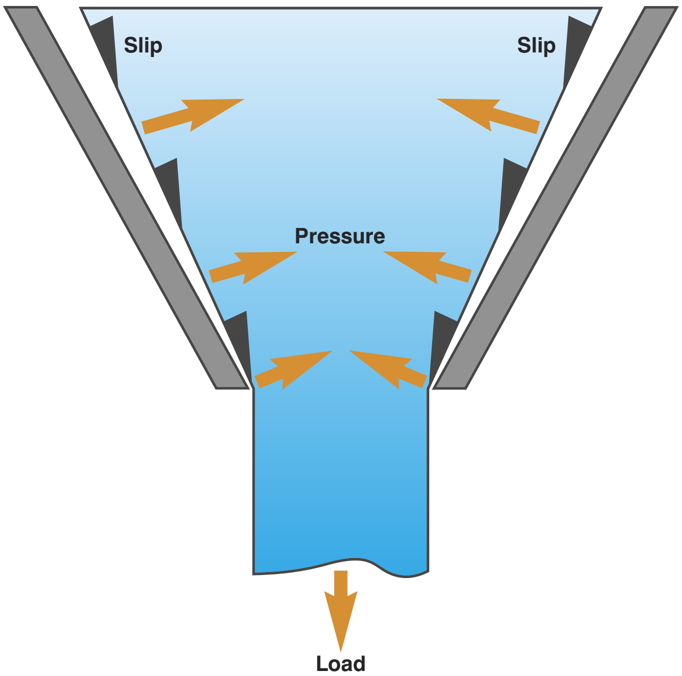

Figure IV: Load causes the cone to slip at the socket interface and the pressure generated locks the cone within the socket.

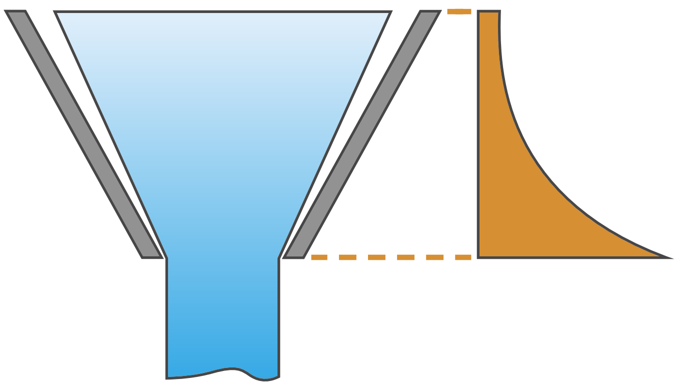

Figure V: Distribution of pressure on the cone within the socket.

If we examine the forces present in figure IV we can see that when load is applied, the cone will seat progressively generating forces normal to the socket face. These forces are transmitted through the resin to the wire surface. We are, in effect, creating a wire reinforced composite wedge on the end of the rope, which is capable of withstanding the ultimate strength of the rope.

We now have to consider two different scenarios to establish the key to this mechanism. In the first case, when the load is applied, the wire slips at the resin/wire interface before the cone slips at the cone/ socket interface. In the second case, upon application of the load, the cone slips in the socket/resin interface before the wire slips within the resin.

In the first case, we have a disaster, as the rope will pull out. In the second case we have success, as the rope will break. What is it that determines which will occur?

Assuming that the coefficient of friction between the wire and the resin and the resin and the socket are of the same order (an over simplification, but it does produce a simple model), the factor that determines which of the above scenarios will occur is the relationship between the surface area of the wire (S1) and the surface area of the inside of the cone (S2). If S1 is greater than S2 then the cone will seat and the rope will break. If S2 is greater than S1 the assembly will fail.

If, for example, we take a 13mm diameter 6 x 19 IWRC rope, the relationship between S1 and S2 is of the order of 6:1, for a 36mm diameter 6 x 36 IWRC 9:1 and for a 52mm diameter 6 x 41 IWRC 10:1. These figures give an indication of the margins of safety involved when resin socketing is employed. It also shows that the degreasing would have to be disastrously bad to reduce the coefficient of friction at the wire/ resin interface to a critical level. One factor that has been ignored in this simple model, is that the unstraightened wires in the broom produce deformation forces when any attempt is made to induce slip, thus increasing the grip of the resin on the wire and giving a further factor of safety. This wire in the cast cone, also tends to prevent any significant degree of axial extension of the cone during loading and the cone remains almost a constant length.

It would be useful, at this point, to examine the Federal Specification socket which has grooves or rings internally. It is obvious that these rings must shear before the 'locking' mechanism can operate and as such, are a hindrance to that process. Incidentally, in the case of zinc and white metal, this rupturing of the rings is also required before the rope will break. The only justification for these rings is to stop the cone 'backing out' of the socket. In fact, once 'seating' of the cone within the socket has occurred, it is not reversible and the cone is then locked into position.

This irreversibility offers the bonus that the stresses created within the socket are fixed and because there is no fluctuation, it follows that the opportunities for fatigue within the socket are reduced.

Let us return to the question of clean and uncleaned wire. A series of tests were carried out by A.I.F. in France, in which two samples of each of a series of rope sizes and constructions were broomed. One sample was degreased with trichlorethane and the other sample was left uncleaned.

Both samples went on to achieve the full breaking strength of the rope and almost identical breaking loads were achieved.

This highlights the fact that the frictional grip on the wires is highly efficient. If we take an overview of the whole situation, it becomes apparent that the key operation in the resin socketing process is the brooming of the rope. Indeed this operation is vital for zinc and white metal as well.

Surface area of wire is vital, especially in the highly loaded section at the neck of the socket. From a quality point of view the broom should be opened right down to the seizing. Very often we see brooms which look very pretty and are nicely opened at the top but the strands remain substantially closed near the seizing. This state of affairs does not produce a quality assembly, even though it may break the rope.

One further point on the production of a quality assembly, is that care should be taken to ensure that the neck area of the socket has been sealed with clay or putty. Any leaks could cause voids in the neck area of the socket. These voids are able to form because the resin starts to gel – harden – in the centre of the mass and if resin leaks out at the neck of the socket, the resin above it during gel is no longer liquid and is, therefore, unable to flow down to fill the void.

It is not necessary to hook wires when resin socketing except in the case of coarse construction wire rope such as 6 x 7.

In use, the resin socketed assembly offers a higher achievable tensile strength and a better fatigue performance of the assembly. In general, this can be attributed to two factors; the excellent penetration of resin, ensuring a complete cone and secondly, the fact that there is no annealing of the wires due to heat from molten metal. A further benefit that is derived from lack of heat, is that the lubricant in the rope remains intact and is not burned off. It is an easy matter to replace the lubricant on the outside of the rope, but very difficult to replace the lubricant in the centre of the rope. It is, as it does not require any heat, acid etching or neutralising, an inherently safe method, for the rigger to use both in the shop and on site. Finally, the quality and reliability of this method is, without question, superior to other methods of socketing. It also avoids the damage caused to ropes by other mechanical methods of attachment of end fittings, which may affect both the tensile and fatigue potential.

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Appendix B: Technical bulletin for reuse of spelter sockets.

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The Crosby Group, Inc.	**Technical Data Sheet**	10/20/2017

Reuse Of Crosby Spelter Sockets & Buttons

The following are general guidelines for the reuse of Crosby® 416/417 Spelter Sockets and Crosby® 427 Spelter Buttons. The use and inspection of used spelter sockets and buttons is the responsibility of the user.

Procedure For Removing Spelter Cone

1. Cut the rope close (1/2") to the nose end of the socket/button and press the cone out of the basket of the socket/button.
2. We do not recommend the use of heat to remove the spelter cone for metallurgical, medical and environmental reasons.
   A. However, if this is the only means available for removing the zinc cone, care should be taken not to exceed 850°F (450°C) surface temperature. The preferred method would be a slow heat in a temperature controlled oven. If a torch (rosebud) is used, the heat spot shall be monitored with a tempil stick or a temperature indicator to prevent localized heating from exceeding the 850°F (450°C) limit.
   B. To remove a WIRELOCK cone, heat the surface of the socket to 350°F (do not exceed the 850°F limit for any localized hot spot). Leave for 5-10 minutes, then drive the cone out with a hammer and drift.

Selection Of Sockets & Buttons For Reuse

1. Use only sockets/buttons that do not show discoloration from excessive heating or any signs of welding.
2. Select only sockets/buttons that have been cleaned and have passed a Magnetic Particle Inspection by a qualified technician (Level II ASNT-SNT-TC-1A-Latest Rev) per ASTM E709. Acceptance criteria shall be per ASTM E125, Types II-VIII, Degree 1. No cracks are acceptable.
3. Select only sockets/buttons that do not show any signs of overloading or wear on the socket or pin, (i.e. elongated pin holes, undersized pins, etc.).
4. Select sockets/buttons that are free from nicks, gouges and abrasions. Indications may be repaired by lightly grinding until surfaces are smooth, provided they do not reduce the dimensions by more than 10% of the nominal catalog dimension.
5. Select sockets/buttons that are not distorted, bent or deformed.

Note: Sockets/Buttons having any of the indications as outlined above (A-E) shall not be reused.

Procedures For Speltering Sockets & Buttons

1. The proper procedure for speltering sockets/buttons can be found in **American Petroleum Institute (API) Recommended Practice 9B (RP9B)**, 11th Edition, September, 2002 or **ISO17558:2006 Steel Wireropes Socketing Procedures – Molten Metal and Resin Socketing**. [2]
2. Some standards (API, ISO, BSI) recommend preheating of the zinc spelter socket/button before pouring. This temperature shall **not** exceed 850°F (450°C).
3. Resin spelter sockets/buttons shall follow the procedure outlined by the resin manufacturer.

Proof Testing

We recommend the socketed assembly be proof tested at two (2) times the Working Load Limit (2 X WLL) assigned to the socketed assembly.

REV 3: Add Latest Rev to line 2 10-30-2017
REV 3: Add reference for 427 buttons 01-05-2010
REV 2: Revised Bullet For Speltering Sockets 05-02-2007

Classification	Catalog No.	Document No.	Revision No.	File Name
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