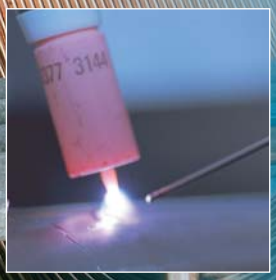
TECHNICAL DOCUMENT

SAF-FRO

Welding Consumables

Storage and Handling Recommendations



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Contents

SECTION 1

SAF-FRO Welding Consumables

1.1 - Storage Conditions

- Welding consumables should be stored on their delivery pallets or on warehouse racking in clean dry conditions.
- Stacking of full or semi-loaded pallets, one on top of another is not recommended as this may cause damage to both the packaging and the welding consumables.
- The packaging should not be stored in direct sun light or in direct contact with walls or floors.
- Products should be stored in their original unopened packaging which should be placed to ensure that the product labelling is clearly visible.
- Products should be issued for use on a date rotation basis.

1.2 - Packaging Damage

On entry to the final fabrication store, product should be inspected for damage to packaging and contents.

- If the packaging alone is damaged and a re-conditioning treatment is appropriate, consult this guide. If re-conditioning is required but no re-conditioning facilities are available, the product should be scrapped.
- If the welding consumable has been damaged, or if corrosion is evident as a result of damaged packaging, then the product should be scrapped.
- Products with significant damage, such as distorted coils, pierced sacks, and punctured tins should be scrapped.

1.3 - Storage Environment

Welding consumables are generally sensitive to moisture pick up and during storage the following ambient conditions are recommended:

Temperature, °C	Relative Humidity, %
>0 frost free storage conditions are mandatory	-
>5 and <15	<90
>15 and <25	<55
>25 and <35	<30

For frost prevention, thermostatically controlled electrical heating is recommended. Space heating using a direct flame is not recommended as this will increase the moisture content of the air.

For tropical ambient conditions, de-humidification can be used to control the ambient conditions within the warehouse.

1.4 - Avoid condensation

When issuing welding consumables from storage for welding where there is a significant difference in temperature between the two areas, products should be allowed to reach the ambient temperature of the welding fabrication area before the packaging is opened. This will avoid possible contamination with condensation.

SECTION 2

SAF-FRO MMA Electrodes

2.1 - MMA Electrode Re-conditioning treatments

The following re-conditioning treatments apply to MMA electrodes supplied in standard packaging: cardboard boxes which are HDPE shrink wrapped and packed 3 packets per outer cardboard carton.

It is **important to consult the product data sheet** in order to ensure the most appropriate re-conditioning treatment before use, should this be necessary.

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SAF-FRO MMA Electrodes

If the MMA electrodes have become wet or contaminated, they should be scrapped and no attempt made to re-condition and use.

There are many variants of MMA electrode coating but there are 3 main types used for welding ferritic steels: Cellulosic, Rutile and Basic. These are used to illustrate the principles of re-conditioning treatments, which are different in each case. The treatment required will be a function of the arc characteristic and the application.

- **Rutile MMA electrodes** are a medium - high diffusible hydrogen product, ~25 ml H_2 per 100 g deposited weld metal. The arc atmosphere is ionised from the binder and a certain amount of coating moisture is required. Generally these electrodes do not require re-conditioning. If necessary, a drying treatment of 1 hour at 100 °C -110 °C is used. Generally, these types of MMA electrode are used straight from the packet, as delivered.
- **Cellulosic MMA electrodes** are a high diffusible hydrogen product, ~40 ml H_2 per 100 g deposited weld metal. The arc atmosphere is hydrogen derived from a high moisture coating. These electrodes should not be re-dried and should be used straight from the tin.
- **Basic MMA electrodes** are a low to very low diffusible hydrogen product; ~4 ml H_2 per 100 g deposited weld metal. The arc atmosphere is designed to minimise hydrogen in the weld pool from either the process or atmospheric intrusion. Generally, to ensure low hydrogen levels, these electrodes should be re-baked at 350 °C for 2 hours. This temperature can be adjusted +/- 50 °C depending on the level of diffusible hydrogen required and the balance of the hardenability of the steel (carbon equivalent), joint combined thickness, restraint and pre-heat. The re-baking cycle should not be repeated more than 5 times or exceed 10 hours as the coating constituents will eventually begin to oxidise or break down. This will be detrimental to both operating characteristics and joint mechanical properties.

Base Metal	Type of electrode covering	Re-drying time & temperature
C-Mn and low-alloy steels	Cellulosic (C)	Not Applicable
	Rutile (R, RR)	1 h at 100 - 110 °C
	Rutile-Cellulosic (RC)	1 h at 100 - 110 °C
	Rutile-Acid (RA)	1 h at 100 - 110 °C
	Rutile-Basic (RB)	1 h at 100 - 110 °C
	Basic (B) H4	2 h at 340 - 360 °C
	Basic (B) H8	2 h at 300 - 350 °C
High strength and low temperature steels	Basic (B)	2 h at 340 - 360 °C
Chromium-Molybdenum creep resistant steels	Rutile (R)	1 h at 100 - 110 °C
	Basic (B)	2 h at 340 - 360 °C
Austenitic stainless and heat resistant steels, dissimilar joints	Rutile (R)	1 h at 250 - 300 °C
	Basic (B)	1 h at 250 - 300 °C
Stainless ferritic and martensitic chromium steels, Duplex-steels	Rutile (R)	1 h at 250 - 300 °C
	Basic (B)	1 h at 250 - 300 °C
Nickel and nickel alloys	Basic (B)	1 h at 300 - 350 °C
Hardfacing	Rutile (R)	1 h at 100 - 150 °C
	Basic (B)	2 h at 300 - 350 °C
Cast iron (Ni-base)	Basic graphite (BG)	1 h at 80 °C

- **Use of Holding Ovens for Re-Conditioned electrodes**

1 - Electrodes should be placed in a pre-heated oven <100 °C, <4 layers high. Any electrodes with chipped or mechanically damaged coatings should be scrapped.
2 - The electrodes should be brought to the desired electrode temperature with a heating rate <150 °C/h.
3 - Holding period at temperature should be approximately 2 hours.
4 - When cooling to the quiver temperature or ambient temperature, avoid sudden thermal shock as this may damage the coating. This is achieved by reducing the oven temperature to ~80 °C before removal.
5 - The electrodes can then be issued to welders in heated quivers at 70 °C -100 °C in lot sizes sufficient for one shift.
6 - Electrodes not used by the end of the shift can either be returned for re-conditioning or scrapped.

The full range of generic re-conditioning treatments for SAF-FRO MMA electrodes is given below, **the specific product data sheet should always be consulted at: www.saf-fro.com**

2.2 - MMA Electrodes supplied in Vacuum Packaging

The majority of SAF-FRO basic coated, stainless steel and special MMA electrodes are also available in vacuum packaging. The vacuum packaging is a multi-layer High Density PolyEthylene, HDPE/aluminium laminated foil which prevents moisture from coming into physical contact with the electrodes. This eliminates the need for any re-conditioning treatment prior to welding. The electrodes are ready to use straight from the vacuum packet.

The VPMD (Vacuum Pack MeDium) format of vacuum packing is supplied in an outer cardboard carton containing six individual vacuum packs.

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The advantages to the fabricator of using SAF-FRO MMA electrodes supplied in vacuum packaging are:

- No need to re-condition prior to welding, the electrodes are used straight from the vacuum packet.
- Re-conditioning and holding ovens are not required, simplifying QA and saving labour, operations and power.
- Heated quivers are not required, simplifying QA and saving power.
- Packet quantity is approximately enough for one full shift of welding, eliminating welder waiting time when electrodes are issued on large fabrication sites.
- SAF-FRO C-Mn basic and low alloy MMA electrodes are in the low hydrogen, <4 ml H_2 per 100 g deposited weld metal condition, straight from the vacuum packet.
- SAF-FRO C-Mn basic and low alloy electrodes, will retain the capability of delivering <4 ml H_2 per 100 g deposited weld metal for one working shift in typical ambient conditions, when kept in the opened vacuum packet and withdrawn singly for immediate welding.

SECTION 2

SAF-FRO MMA Electrodes

Instructions for opening and use of SAF-FRO VPMD vacuum packaging:

Inspect the vacuum packaging to ensure the integrity of the vacuum.

- If the pack is hard, the electrodes can be used straight from the pack.
- If there is movement and the packaging is loose, the pack has been punctured and the contents can either be re-conditioned in accordance with the product data sheet, or scrapped.

The packet seal should be opened carefully at one end at right angles to the packet, without further damage to the foil.
The vacuum packet should be opened just before starting to weld at the start of the shift.

- The packet then becomes the welders' "quiver" and should be put in a dry, convenient position close to the welding set, fully protected from wind and rain.
- Electrodes should be left in the packaging and withdrawn one by one as they are used.
- At the end of the shift, any electrodes remaining should be either returned to the store for re-conditioning or scrapped.

SECTION 3

SAF-FRO MAG, MIG, TIG, SAW solid wires, Cored wires

- No Re-Conditioning Treatment is required prior to use. These products are supplied in a wide variety of packaging formats and no re-conditioning is required for any of these products: they are used straight from the packaging or delivery system.
- Prior to use, a visual check should be made and if there are any signs of physical damage or of corrosion on the wire surface, the product should not be used.
- SAF-FRO solid wires used in accordance with instructions will deposit weld metal with <1 ml H_2 per 100 g deposited weld metal ***(figures 1a & 1b)***.
- SAF-FRO STEELCORED and SUBCORED seamless cored wires used in accordance with instructions will deposit weld metal with <5 ml H_2 per 100 g deposited weld metal ***(figure 2)***.
- For bulk MAG welding wire delivery systems such as SAF-FRO ENDURO, the handling and use procedures are given in ***Appendix 3***.
- Wires must not be left exposed in the fabrication area, or left on welding machines unused, for long periods. Following one shift working, these products should be removed from the welding machine and placed in their original packaging, re-sealed and returned to the welding consumable store in accordance with ***Section 1***.

Fig. 1a - Solid MAG coppered wire

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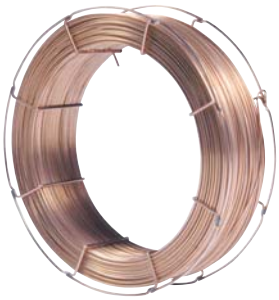

Fig.1b - Solid SAW coppered wire

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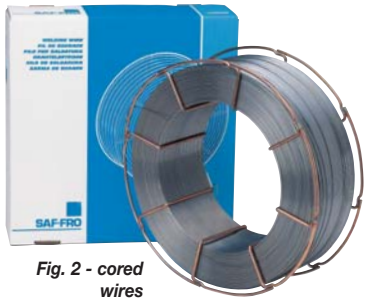

Fig. 2 - cored wires

Fig. 4 - TIG rods

Fig. 3

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SECTION 4

Fluxes for Submerged Arc Welding (SAW)

SAW fluxes are supplied for the widest range of applications in 25 kg heavy duty, heat sealed polyethylene, PE, bags.

It is **important to consult the product data sheet** in order to ensure the most appropriate re-conditioning treatment before use.

Should this be considered necessary **go to www.saf-fro.com for further details**.

However, the general guidelines are as follows:

4.1 - Fused Fluxes

- Fused fluxes are not hygroscopic and do not pick up moisture during exposure to atmosphere.
- Fused fluxes being used from undamaged SAF-FRO packaging require no re-conditioning prior to use and should be used straight from the bag.
- If the fused flux is suspected of being physically damp, it can be re-dried at 100 °C for 1 hour.

4.2 - Agglomerated Fluxes

Agglomerated fluxes pick up moisture chemically from ambient humidity to varying degrees, depending on the design of the flux.

For most general welding applications, however, submerged arc and weld overlay fluxes can be used straight from the SAF-FRO packaging provided this is undamaged.

Critical Applications requiring low hydrogen weld metal content when SAW Welding.

4.3 - SAW Agglomerated Flux re-Conditioning

For those applications requiring low and very low levels of diffusible hydrogen, <5 ml H_2 per 100 g deposited weld metal, the SAW flux must be re-conditioned prior to use. This generally relates to fully basic fluxes with a Boniszewski basicity index ~3, such as AS 589 and AS 630.

Typical welding applications requiring a basic SAW flux to be re-conditioned include the joining of thick and very thick combined sections of structural steels, 50<t<220 mm, heavily restrained components and hardenable low alloy steel welding.Typically, those steels with a carbon equivalent, CE, value of >0.40.

- The flux should be re-dried at 300 °C - 350 °C for between 2 - 4 hours. This should only take place in a SAW flux oven specifically designed for this purpose. The temperature should be measured using an independent thermocouple immersed in the flux.
- SAW fluxes are good insulators and layer thickness during re-conditionning depends on the design and ventilation of the baking oven. When an oven with a static drawer system is used, the maximum height of the flux layer should be <50 mm.
- If re-dried flux is not used completely within one shift, it should be stored in heated hoppers at 100 °C<t<200 °C and protected from open air. If there is flux remaining which has not reached temperature when required for use, then it should be discarded.
- For the most demanding applications using flux recycling systems, it is recommended that the system is fully cleaned out every two weeks and re-filled with new flux straight from the flux re-conditioning oven.
- When work is interrupted, the pressure system should be turned off.
- If in doubt, contact SAF-FRO Service.

4.4 - SAW Flux re-Circulation

- In a well designed flux re-circulation system the flux can be re-circulated several times without damaging the agglomerate. Well designed systems are characterised by low flux travel speeds, no sharp bends and minimised flux travel distances.
- The contents of the central flux hopper should be consumed by approximately 50% after which re-filling with new flux from re-conditioning oven is required.
- Fine particles or dust created during re-circulation should be limited to 5% with a grain size <200 µm by using dust filters. Dust filters should be regularly inspected, emptied and maintained.
- The re-circulated flux must be kept free of all foreign particles such as welding slag, rust, plate scale, grinding dust and steel brush bristles.
- It is **imperative** that the compressed air used in any recirculation system is **clean and dry**. Devices such as a frost condensation drier and oil traps should be used. The performance of these devices should be regularly monitored. The importance of this cannot be over-emphasized.

APPENDIX 1

Hydrogen Cracking and How to avoid it

Mechanism

Hydrogen cracking is also known as cold cracking or delayed cracking. It can occur during the welding of ferritic steels or after welding, hence the term delayed cracking.

Cracking is usually located in the HAZ: in butt welds the cracks are generally parallel to the weld bead and in fillet welds occur at the weld root, particularly as a result of poor fit up.
As modern steels may be produced using a thermo-mechanical steel processing route with lean weld chemistries, so the weld metal chemistry may be similar to the plate chemistry. As a result, cracking in the weld metal is becoming more common.

There are three components required for hydrogen cracking to take place:

- susceptible microstructure,
- stress acting on the joint,
- hydrogen.

When to be cautious:

- thick joints, >40 mm in structural steels,
- higher carbon equivalent* steels, CE>0.40 and all low alloy steels,
- highly restrained joints and roots in double-V joints,
- very clean steels with low sulphur and low oxygen contents.

Avoiding hydrogen cracking

Susceptible microstructure

For the majority of welding engineers, the material and cast to be fabricated are given, rather than selected.

In this case, the important factors are:

- to calculate the carbon equivalent* value,
- decide on the heat input.

* The carbon equivalent value quantifies the hardenability of the steel: IIW CE = C%+(Mn%/6)+(Cr%+Mo%+V%)/5+(Ni%+Cu%)/15

Stress acting on the joint

In many cases the fabrication design will be given, rather than selected by the welding engineer.

In this case, the important factors are to calculate the combined thickness of the joint and to avoid large root gaps and poor fit up.

Hydrogen

Control of hydrogen cracking sensitivity is a function of 3 main factors:

- pre-heat, interpass control and soaking,
- plate surface condition,
- selection of the welding consumables.

Preheat and control of interpass temperatures are used to decrease the cooling rate, allowing hydrogen the time to diffuse away, generally reducing hardness, and therefore the susceptibility to cracking. The recommended levels of preheat for carbon and structural C-Mn steels are detailed in EN 1011-2.

Preheat can be reduced by using low hydrogen welding consumables, which is cost effect and can increase productivity.

Dirty plate with oil, grease, rust, primer etc on the surface should be thoroughly cleaned before welding. All of these surface contaminants are capable of producing unwanted quantities of hydrogen.

Select SAF-FRO low hydrogen welding consumables.

It is important to select welding consumables which will conform reliably to the low hydrogen condition <5 ml H2 per 100 g deposited weld metal after re-conditioning or when used straight from vacuum packaging.

It is also important to select welding consumables which have a very low rate of moisture pick up from the atmosphere over the period of a shift when exposed to ambient conditions.

SAF-FRO low hydrogen welding consumables are designed for the welding of thicker section hardenable steels and to reliably deliver very low levels of weld metal hydrogen and to resist moisture pick up. Used in conformance with the advice from SAF-FRO, these consumables will remain in the low hydrogen condition for the working shift under normal conditions.

Finally, the moisture content of a welding consumable is relatively straightforward to measure but the diffusible hydrogen content is both more complex to measure and takes much longer. The relationship between the moisture content and the diffusible hydrogen potential is product specific and there is no general relationship, as it depends on the design of the welding consumable. Low moisture content is a relative term and may not signify a low diffusible hydrogen content.

Recommended Reading:

Welding Steels without Hydrogen Cracking
N. Bailey et al
Woodhead Publishing Ltd
ISBN 1 85573 014 6
ISBN -13: 978 1 85573 014 4

APPENDIX 2

Ambient Conditions when Storing Welding Consumables

Ambient temperature and relative humidity are relatively easily measured and recorded in a store or warehouse in order to build an understanding of the prevailing conditions over a period of time. Wall mounted units with data recording facilities are readily available.

g of water vapor / kg of dry air		Temperature							
		5	10	15	20	25	27	30	35
Relative humidity %	40	2	3	4	6	8	9	11	14
	45	2	3	5	7	9	10	12	16
	50	3	4	5	7	10	11	13	18
	55	3	4	6	8	11	12	15	20
	60	3	5	6	9	12	13	16	21
	65	4	5	7	10	13	15	17	23
	70	4	5	7	10	14	16	19	25
	75	4	6	8	11	15	17	20	27
	80	4	6	9	12	16	18	22	29
	85	5	7	9	13	17	19	23	31
	90	5	7	10	13	18	20	24	33

Satisfactory storage conditions Marginal storage conditions Unsatisfactory storage conditions

This table relates data for relative humidity, %, and temperature, ºC, to show the weight of water vapour in grammes per kg of dry air.

The polyethylene PE packaging materials specified for SAF-FRO welding consumables, stored in atmospheric conditions containing <11g absolute water content, results in a negligible rate of moisture transport through the PE packaging.

Thus, the standard storage recommendations are shown in ***Section 1*** as follows:

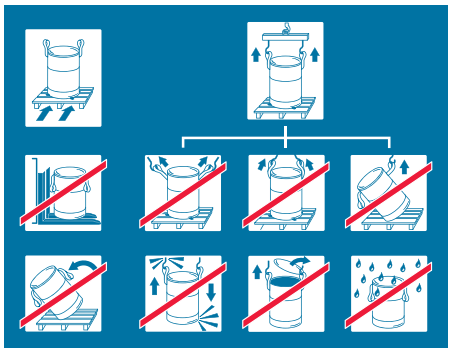
Temperature, °C	Relative Humidity, %
>0 frost free storage conditions are mandatory	-
>5 and <15	<90
>15 and <25	<55
>25 and <35	<30

APPENDIX 3

SAF-FRO Welding Consumables

Instructions for handling MIG/MAG bulk packs.

- All SAF-FRO bulk packs can be forklifted.
- Fork lifting is possible using the original pallet. The container should always be in the vertical position.
- Handle with care and avoid impact and damage to the pack.
- Distortion or damage to the sides of a pack will detrimentally affect wire feeding.
- When using fork lifting, care must be taken to engage the pallet correctly to avoid piercing the pack.
- Damaged or pierced packs will detrimentally affect wire feeding characteristics and should be not be used.



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- For the safety of operators always take into account the handling instructions shown on the pack.

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