CHROMET 1X and CHROMET 2X

CrMo TEMPER EMBRITTLEMENT RESISTANT CONSUMABLES

CONTENTS

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1 INTRODUCTION

In the power generation industry the creep properties of the CrMo weld metals has always been of primary interest. In the petrochemical industry, although creep resistance is still important, the weld metal toughness of the CrMo materials is also a safety-critical factor (often at sub-zero temperatures). Another important consideration is the susceptibility to in-service embrittlement, generally referred to as temper embrittlement resistance, which can have a strong influence on the impact properties of both base material and weld metal.

A lot of work has been carried out, notably that by Bruscato, which has implicated various trace elements P, Sn, As and Sb and also the essential deoxidants Mn and Si, in the susceptibility of a material to in-service embrittlement.

Chromet 1X and Chromet 2X are specially developed MMA consumables which exhibit excellent temper embrittlement resistance, designed to meet the exacting requirements of today's petrochemical industry.

2 ASSESSMENT OF TEMPER EMBRITTLEMENT RESISTANCE - STEP COOLING TESTS

The temper embrittlement susceptibility of base materials and weld metals is assessed using standard step cooling tests. After a typical post weld heat treatment (PWHT) – eg 690°C (1275°F) - the material is then put through a standard step cooling schedule. Two common schedules are attributed to Braun and GE, fig 1; they are very similar with only minor variations in cooling rates and hold time at 468°C (875°F).

To assess the in-service embrittlement susceptibility, a transition curve is developed for the material in the PWHT condition and the PWHT + step-cooled (SC) condition. From these curves the 54J (40ft-lb) transition temperature is obtained. The resistance to embrittlement is assessed on the basis of the shift in the 54J (40ft-lb) transition temperature, ΔT_{54}, where:

$\Delta T_{54} = T_2 - T_1$ T_1 = 54J (40ft-lb) transition temperature after PWHT
T_2 = 54J (40ft-lb) transition temperature after PWHT + SC

ΔT_{54} is multiplied by a 'design factor' (normally 2.5 or 3) and added to T_1. To comply, this temperature must be below another specified temperature; this temperature can range from +10°C (+50°F) to +38°C (+100°F) depending on the contractor. The most onerous requirement we have seen specified is:

Figure 1a   GE Step Cooling Schedule

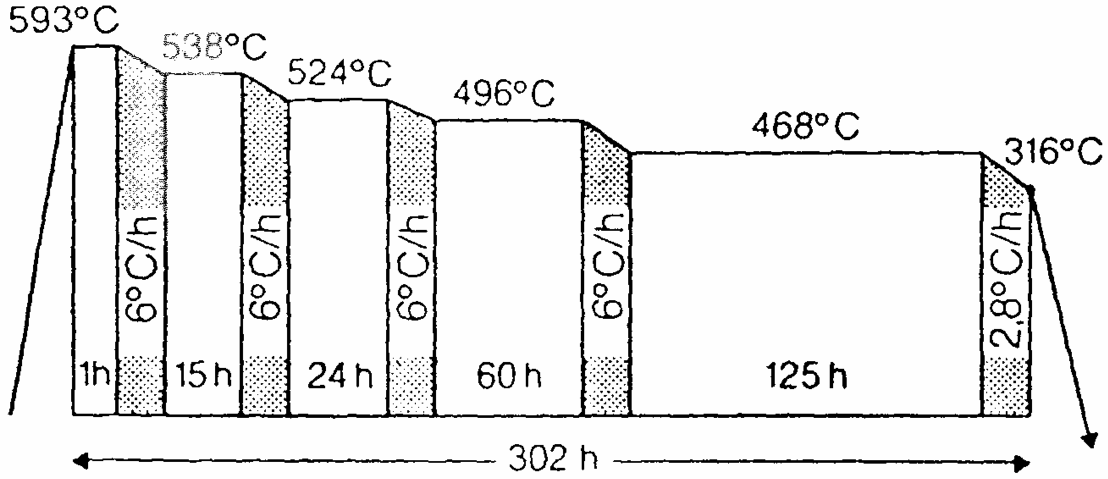
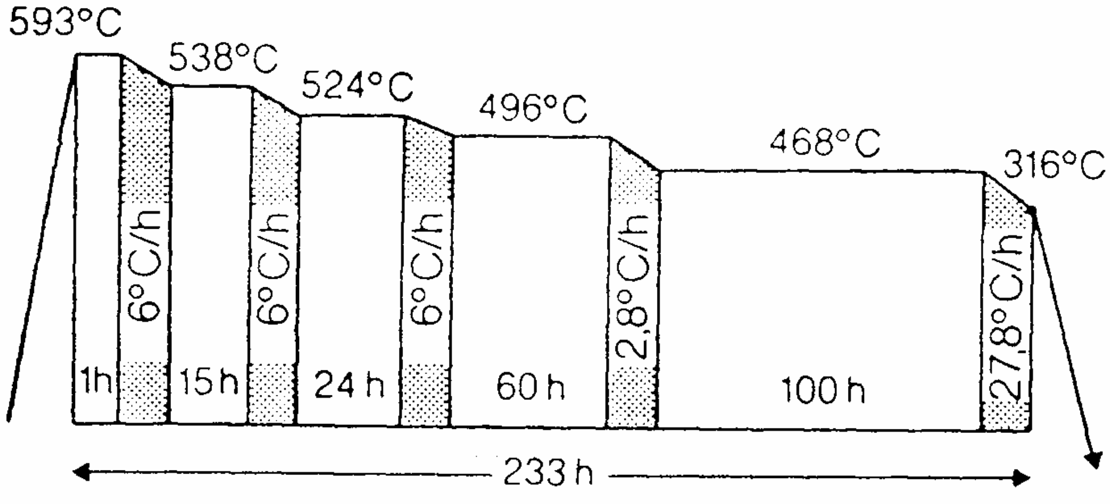


Figure 1b: Braun Step Cooling Schedule



3 GENERAL DESCRIPTION & APPLICATIONS

The Chromet 1X and 2X consumables are both all-positional, basic coated, low hydrogen MMA electrodes. The general operating characteristics are very similar to the standard Chromet 1 and Chromet 2 electrodes.

The ranges of base materials for which these consumables would be used are listed on the appropriate data sheets at the end of this Technical Profile.

The areas of application for both Chromet 1X and Chromet 2X are for prolonged elevated temperature service where temper embrittlement resistance requirements are specified. Areas where these requirements are normally specified are in the petrochemical industry for hydrodesulphurisers, boilers, pressure and reactor vessels, high pressure piping etc.

4 STANDARDS AND PROPERTIES

4.1 Specifications

The electrodes Chromet 1X and Chromet 2X conform to the standard AWS and BS EN specifications:

	AWS A5.5	**BS EN 1599**
Chromet 1X	E8018-B2	E CrMo1 B 26
Chromet 2X	E9018-B3	E CrMo2 B 26

4.2 Analysis

Typical analysis as follows:

	C	**Mn**	**Si**	**S**	**P**	**Cr**	**Mo**	**Cu**
Chromet 1X	0.06	0.7	0.25	0.012	0.009	1.25	0.55	0.05
Chromet 2X	0.06	0.7	0.25	0.012	0.009	2.25	1.05	0.05

In addition to these requirements, there are additional analytical restrictions which are common to both Chromet 1X and 2X:

	Mn	**Si**	**S**	**P**	**Sn**	**As**	**SB**	**Mn + Si**
Minimum	0.5	0.15	-	-	-	-	-	0.7
Maximum	0.9	0.30	0.015	0.012	0.005	0.010	0.005	1.10

These analytical limits combine to provide maximum Watanabe (J) and Bruscato (x) factors of:

$$J \leq 120$$

$$x \leq 15$$

where $J = (Mn + Si)(P + Sn) \times 10^4$ (in %)

$$x = \frac{10P + 5Sb + 4Sn + As}{100}$$ (in ppm)

4.3 Mechanical Properties

Minimum tensile properties and typical maximum hardness limitations are met by the Chromet 1X and 2X. The most important mechanical property of the Chromet 1X and 2X is the impact toughness.

Many specifications for petrochemical applications, in addition to the analytical requirements, have minimum impact requirement at temperatures down to –30°C (-22°F) after PWHT. In addition to this, there may be a step cooling requirement based on the shift in the 54J (40ft-lb) transition temperature before and after step cooling. Individual batch tests are required when these properties are specified. Unless otherwise specified, test coupons are prepared according to AWS A5.5-96.

Typical tensile properties for Chromet 1X and 2X are given on the appropriate data sheets at the back of this technical profile. If hot tensile properties are specified, batch tests are carried out at the required temperature.

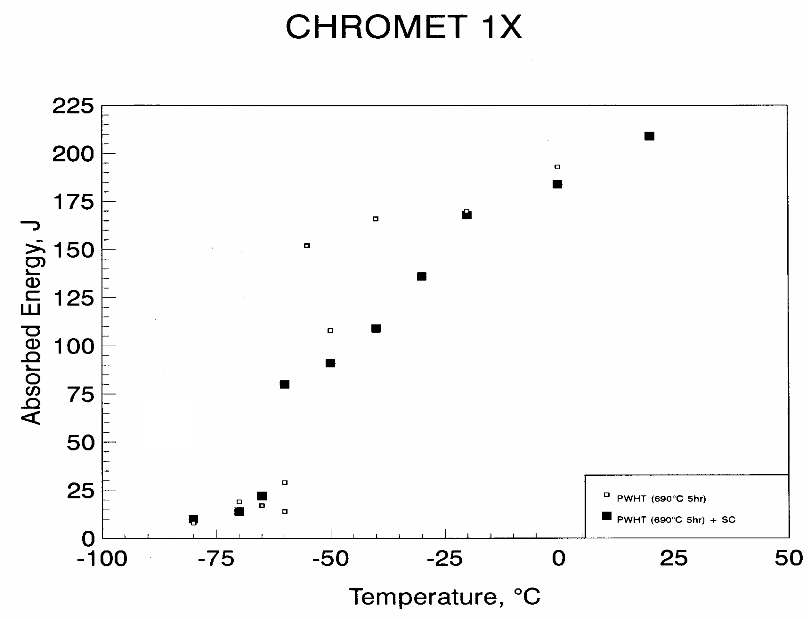
Actual step cooling tests have been carried out on a number of batches of Chromet 1X and Chromet 2X. Three sets of tests are presented here:

Product	**Diameter mm (in)**	**PWHT**	**Step Cooling**	**Figure**
Chromet 1X	3.2 (1/8)	690°C (1275°F) / 5hrs	GE (fig 1a)	2
Chromet 2X	3.2 (1/8)	690°C (1275°F) / 5hrs	GE (fig 1a)	3
Chromet 2X	3.2 (1/8)	715°C (1320°F) / 2hrs	Braun (fig 1b)	4

After just PWHT all these three tests showed 54J (40ft-lb) transition temperatures of approximately -50°C (-58°F). The shift in 54J (40ft-lb) transition, ΔT_{54}, varied slightly but all three tests passed a criterion of:

$T_1 + (3 \times \Delta T_{54}) < +10°C$ *[$T_1 + (3 \times \Delta T_{54}) < +50°F$]*

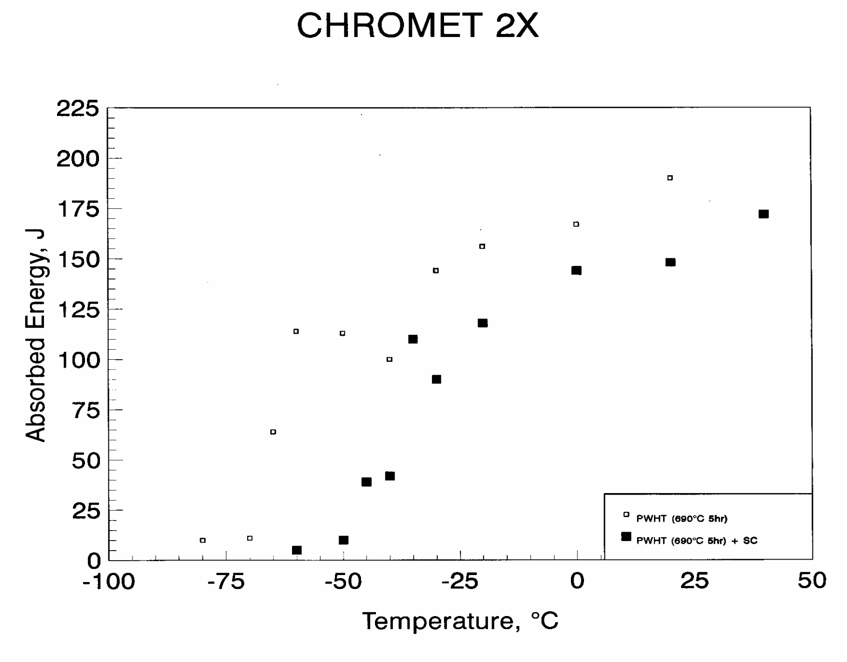
Figure 2



T_1 = 54J transition temperature after PWHT = -58°C *(-72°F)*
T_2 = 54J transition temperature after PWHT + SC = -60°*C* *(-76°F)*
ΔT_{54} = $T_2 - T_1$ = -2°C *(-4°F)*

T_1 + (3 X ΔT_{54}) = -64°C ***(-84°F)***

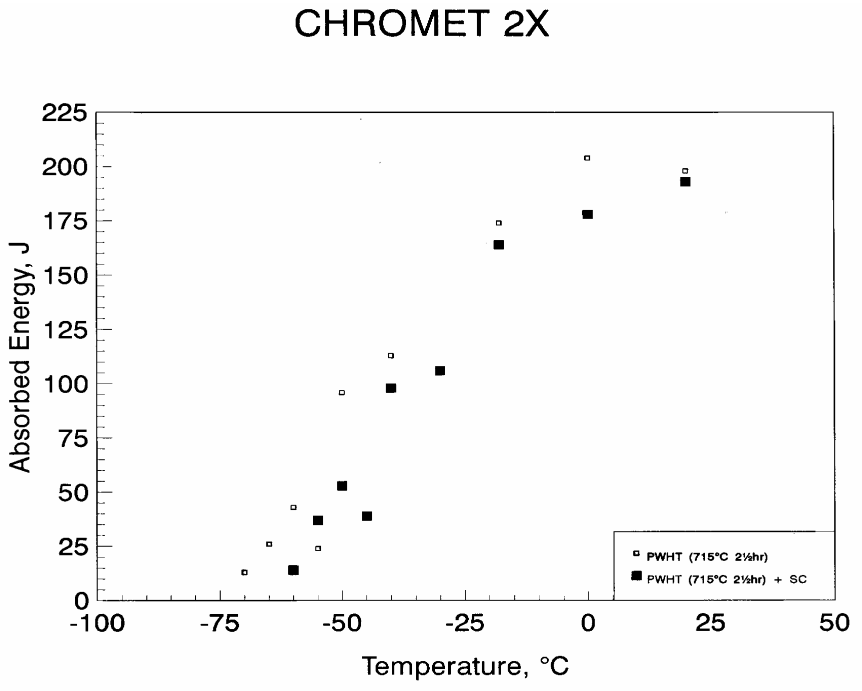
Figure 3



T_1 = 54J transition temperature after PWHT = -59°C *(-74°F)*
T_2 = 54J transition temperature after PWHT + SC = -42°C *(-44°F)*
ΔT_{54} = $T_2 - T_1$ = 17°C *(30°F)*

T_1 + (3 X ΔT_{54}) = -8°C ***(+16°F)***

Figure 4



T_1 = 54J transition temperature after PWHT = -54°C *(-65°F)*
T_2 = 54J transition temperature after PWHT + SC = -46°C *(-51°F)*
ΔT_{54} = $T_2 - T_1$ = +8°C *(+14°F)*

$T_1 + (3 \times \Delta T_{54})$ = -30°C *(-23°F)*