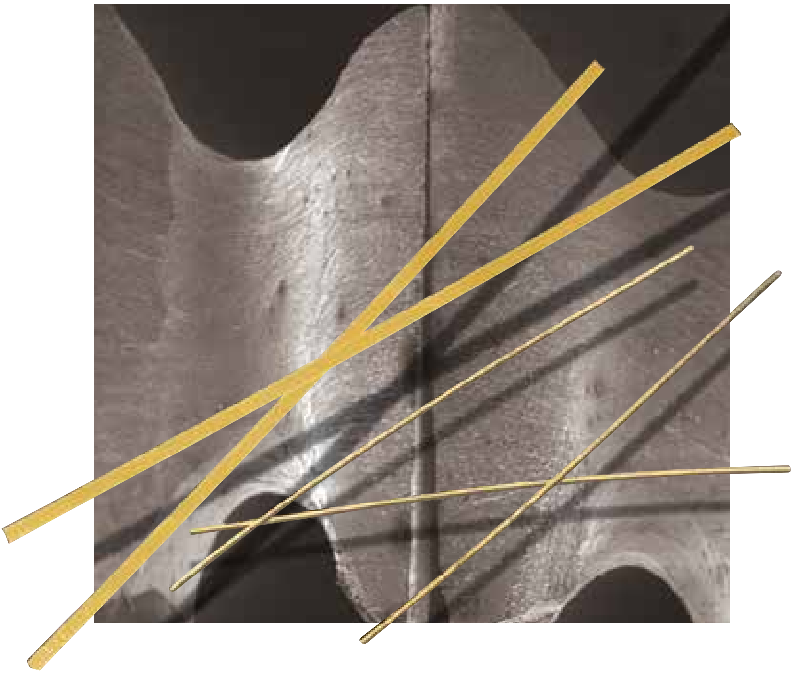

S O L D E R I N G

Processing Manual

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In the past, present, and also in the future, „soldering“ as a joining technique has been and will be an important part of dental-lab procedures.
Soldering is the most frequently used joining technique for metals.
In order to obtain a soldering joint, the necessary materials must be processed with utmost care.
It also involves thorough knowledge of the materials and their correct technical application.
Nevertheless, the ultimate objective of the users should be to work in such a way that joining metals is largely unnecessary.

This Manual will provide you with the most important information about soldering before and after ceramic firing. In this way, you will be able to fabricate even more successful restorations for the benefit of the patients.

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Past

The ancient Egyptians melted gold and used the material to fabricate beautiful artifacts as testimony to their sophisticated culture.

Soldering has also been practiced since the earliest days of history. The soldering technique of those days involved copper ore and helped goldsmiths fabricate the finest jewelly.

In dentistry, soldering has been used for more than 100 years.

Present

Given its universal application possibilities in dental-lab technology, soldering has not lost its importance despite modern welding techniques and adhesive procedures. In dental laboratories, the number of daily soldering procedures still clearly exceeds that of other joining methods.

Future

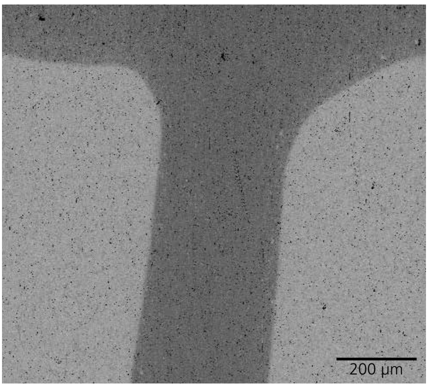
Soldering everywhere – even in space ...
... might be instrumental for the survival on missions to Mars in the future.

Future space travellers to Mars will be expected to carry out repairs on their space ships.

Joining Technique "Soldering"

Soldering is a procedure to join metal components with the help of a molten joining metal with a processing temperature below the solidus temperature of the alloys to be joined. The solder wets these alloys without melting them during soldering.

During the soldering procedure a reciprocal diffusion between the liquid solder and the solid-hot alloy takes place.



The decisive factors for the long-term success of the solder joint is the bond strength (quality of the diffusion structure) and the corrosion resistance.

Solders

Given the required resistance to the oral environment, only hard solders are used in dental-lab technology.

Depending on the designated use, solders are classified as high-fusing solders with a processing temperature of approximately 950–1,200 °C / 1742–2192 °F and low-fusing solders with a processing temperature of approximately 700–900 °C / 1292–1652 °F.

A high fusing solder should always be selected first. To allow additional repair procedure to be accomplished with a flow fusing solder.

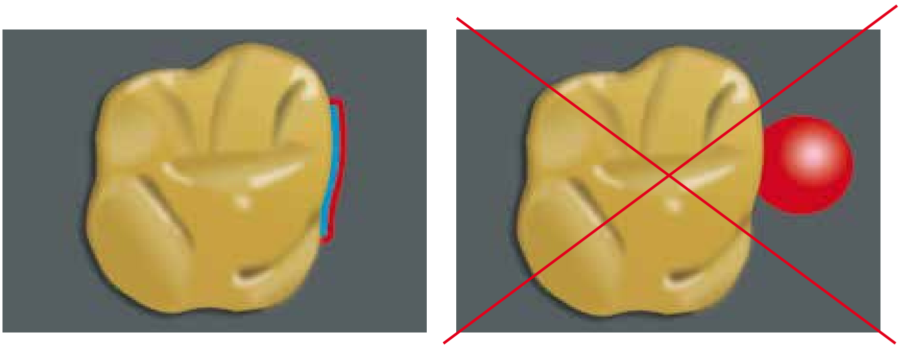
The solder and alloy must be compatible with each other. Please refer to the solder table in the Appendix for recommended solder / alloy combinations.

A solder with the correct processing temperature is selected according to the alloys to be soldered. Dental solders must be corrosion resistant and demonstrate a composition similar to that of the alloys to be joined.

Metallurgical compatibility and similar coefficients of thermal expansion of solders and alloys are the prerequisites for the ideal solder joint.

Surface Tension / Diffusion

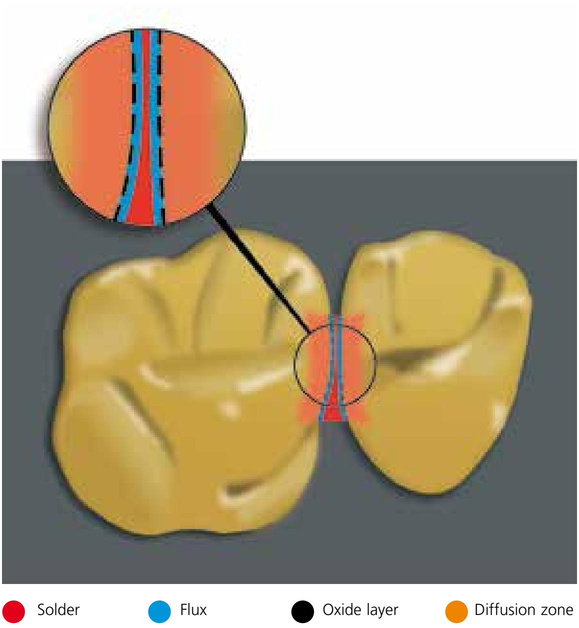
Good wetting of the alloy with the molten solder is a prerequisite for a successful soldering procedure.



With optimum wetting, the solder spreads out evenly over the alloy, wets both surfaces, and fills the soldering gap. The formation of droplets by the solder is a sign of poor wetting. As a result, the solder does not flow and diffusion does not occur.

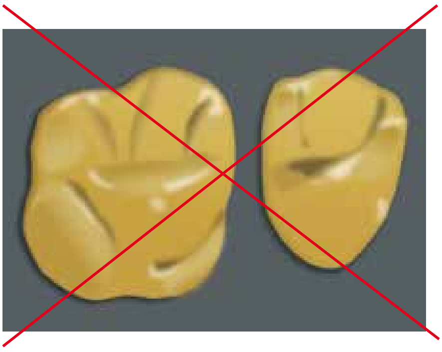
Diffusion refers to the process in which certain metals of the alloy and the solder are mixed. A diffusion structure is formed at the interface.

A sufficiently high temperature of the framework elements to be joined by soldering is required for good flow behaviour and optimum wetting. The temperature at the soldering site must be higher than the processing temperature of the solder, but must not exceed the solidus temperature of the alloy.



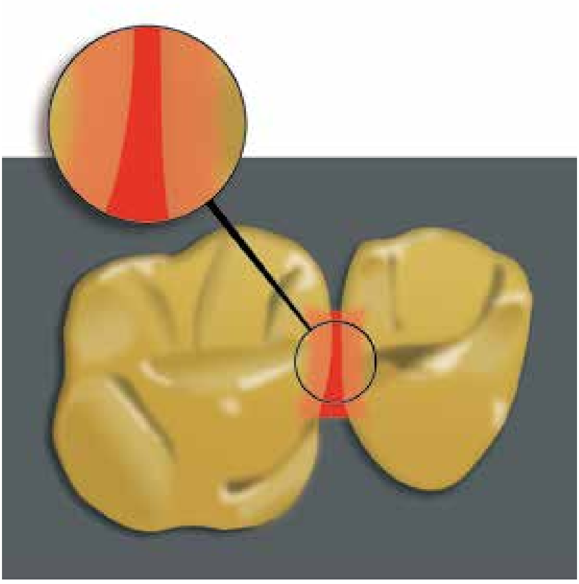
- **If the surfaces of two parallel framework elements are wetted with solder, the solder is pushed into the soldering gap by the released energy. The corresponding force is called „capillary filling pressure“.**
- **An ideal diffusion structure is produced if the temperature difference between the processing temperature of the solder and the solidus point of the alloy is minimal. The alloy must not melt during the soldering procedure.**

Solder Joint



A „solder gap“ is an even distance of 0.05 to 0.2 mm between the framework elements to be joined by soldering. For that purpose, the soldering surfaces must be parallel.

Wider gaps are not suitable. During cooling, the solder contracts more than the soldering base and the framework element expand during heating. This is due to a solidification shrinkage of the liquid solder.
The consequences are torsion of the framework elements, inadequate flow of the solder and solder joint crack.



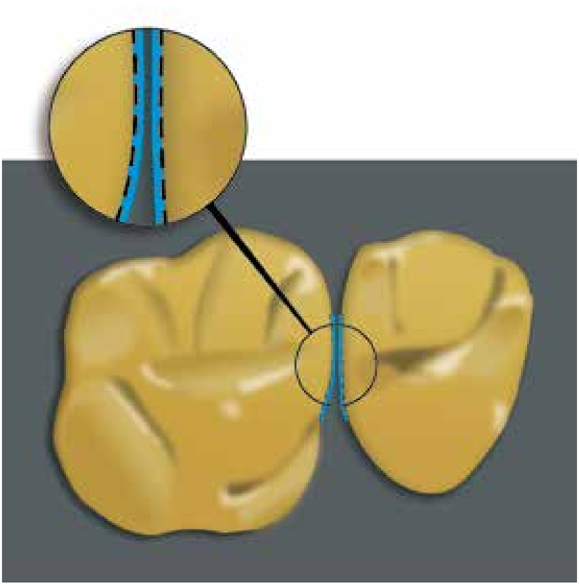
To maximize the capillary effect, framework elements should be parallel to one another with the recommended gap between parent alloys.

In order to be completely filled, the soldering gap must not be too wide. Otherwise, the capillary filling pressure is too low and the solder is not pushed into the soldering gap.

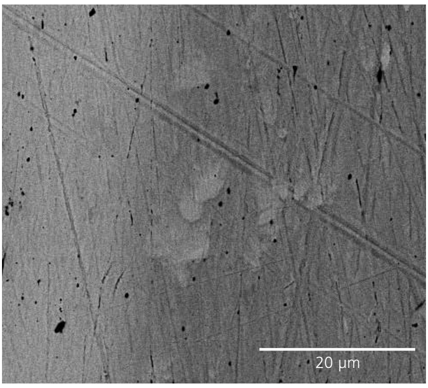
Oxidation

Soldering requires heating of the alloy, which always results in oxidation.

Oxidation is a reaction with oxygen. It occurs in all the alloys. The higher the base metal content, the more pronounced is the oxidation.



In order to prevent oxide formation, an appropriate flux may be used.



The flux breaks down the oxygen compound of the alloy surface. During this dissolution procedure, the oxides are absorbed by the flux and protect parent alloys from further oxidation. A non contaminated surface then enables optimum wetting by the solder.

To optimize the use of flux the soldering procedure should be completed immediately after application.
If the alloy oxidizes before or during the soldering procedure, the solder will not wet the alloy.

Soldering Accessories

The prerequisites for a sound soldering procedure are as follows: clean metallic surfaces, a flux that will dissolve the oxides, framework elements that have been evenly preheated to the processing temperature, and a soldering gap (0.05–0.2 mm) with walls as parallel as possible.

High-fusing Bondal™ Flux

Flux for solder with a high processing temperature:
> 960 °C (soldering before ceramic firing)

Bondal™ Flux

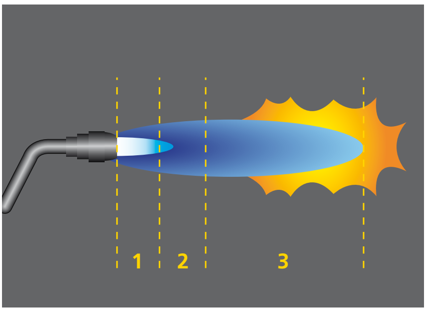
Flux for solder with a low working temperature:
< 900 °C (soldering after ceramic firing and for universal solders)

Magic wand

A torch system with a safety valve enables controlled flow of gas and oxygen during the soldering and casting of alloys.

Torch and Flame Control

For dental soldering procedures, mainly propane torches with compressed air or oxygen are used.



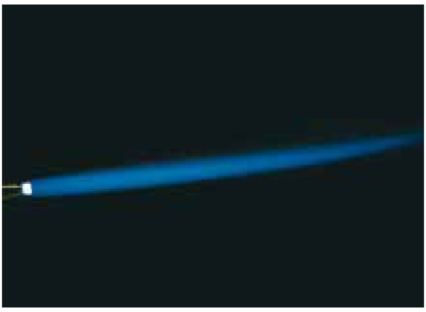
Open flame

1 Carbon rich zone

2 Reduced zone – optimum zone for soldering

3 Oxidizing zone

The correct setting of the flame, oxygen/propane or air/propane mixture, and the selection of the burner nozzle/burner head are critical for reliable soldering.



Multi-orifice torches produce a large, soft flame. In conjunction with a propane-compressed air mixture or a propane-oxygen mixture, these torches are suitable for even heating of the object to be soldered.

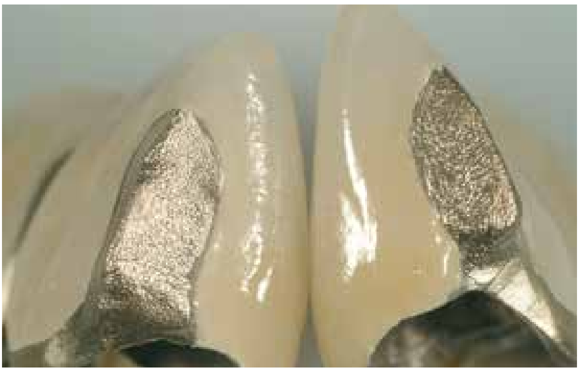
Single-orifice torches produce a pointed, hot flame of up to 2900 °C/5252 °F in temperature. A propane-oxygen mixture enables spot soldering without excessively heating up the surrounding areas.

Depending on the required temperature, different oxygen/propane or air/propane mixtures can be used for soldering. Note: The more pointed and hotter the flame, the easier it is for defects of the alloy to occur.

Surface Preparation

Clean soldering contact surfaces are a basic requirement for optimum wetting.
The surfaces of the soldering contact areas have to be prepared by grinding and/or sand blasting.

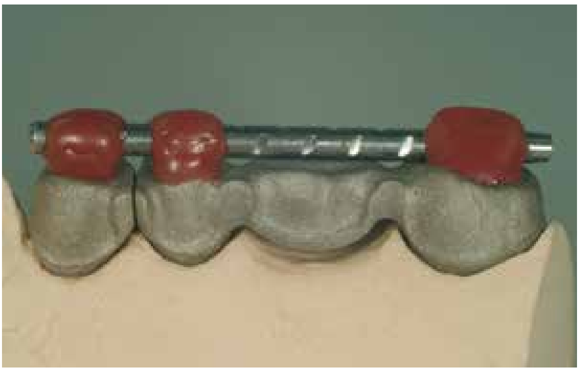
Evenly roughen the soldering contact surfaces in the direction of flow of the solder using a suitable (ceramic-bonded) grinding instrument.



The soldering contact surfaces may also be blasted with 50 micron Al_2O_3.

The soldering contact surfaces should have dimensions adequate for the intended stress-bearing situation.

Pre-Soldering (Before Ceramic Firing)



Once the surfaces of the framework elements to be soldered are prepared, the individual components are placed on the model and secured.

The soldering gap is filled with wax and the individual framework elements joined using modelling wax, sticky wax, or modelling resin. Important: Use low-shrinkage materials that fire without leaving residue to secure the components.

The individual framework elements must be secured in an absolutely stress-free manner and then lifted off the model.

Design the soldering base as small as possible and with rounded edges. Too large a soldering block withdraws heat from the soldering object. The soldering gap must be freely accessible from all sides so that the flame can reach it. Only in this way can the framework elements be evenly heated.

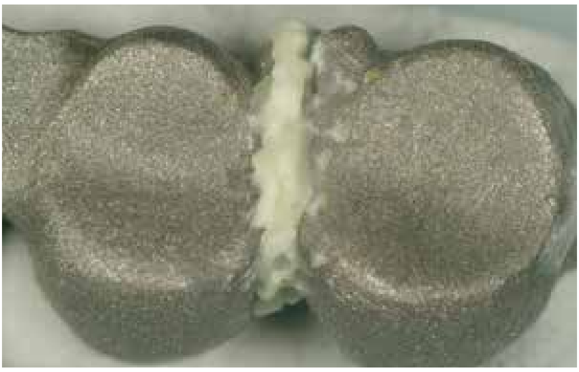
Process the soldering investment according to the instructions of the corresponding manufacturer (as regards the mixing ratios and heating times).

Pre-Soldering (Before Ceramic Firing)

Once the soldering investment has set, remove the sticky wax with steam or hot water. Burn out the modelling resin in the pre-heating furnace. Pre-heat the soldering object in the pre-heating furnace at approximately 600 °C/ 1112 °F) for 10 minutes.

Tip:
While the soldering object is still warm – after the sticky wax or modelling resin has been removed – the flux may be applied in the soldering gap with ease. In this way, possible oxidation may be prevented during pre-heating.

Apply flux to the soldering gap and evenly heat the object to be soldered to the processing temperature of the solder using the torch.



Once the working temperature of the object to be soldered has been reached as a result of the heat from the flame being applied to the exposed soldering contact surfaces, the solder quickly and reliably flows into the soldering gap and fills it.

- **Wet the solder with flux. Use as little solder as possible and do not smear the solder on the alloy surface.**
- **The temperature of the object to be soldered is important. The solder always flows to the hottest area. Hold the flame on one side of the soldering gap while feeding the solder from the opposite side.**

Pre-Soldering (Before Ceramic Firing)

Allow the solder joint to cool slowly. Remove the soldering investment. Blast the object with 50 or 100 micron Al_2O_3 to remove oxides and flux residue. Instead of blasting precious metal alloys can be pickled (PCT AScid).

Carefully grind the soldering site and prepare it for the subsequent veneer.

Base metal alloys oxidize at 400–500 °C/752–932 °F. Therefore, the flux must form a protective layer to prevent additional oxygen from accessing the alloy surface (in the soldering gap).

Post-Soldering (After Ceramic Firing)

A basic requirement for functional furnace soldering is the correct design of the framework. The connecting area must demonstrate adequate dimensions. The soldering surfaces act as heat centers, towards which the solder can flow. The smaller the alloy surface in the heat center, the more difficult it is for the solder to flow into the soldering gap. The soldering gap should be 0.05 mm to 0.2 mm.

Secure the ceramic-veneered bridge components using a stress-free wax that fires without leaving residue and lift the bridge off the model.

Cover the soldering gap and all the ceramic parts with wax so that they will not come into contact with the soldering investment.

- **Do not use modelling resin to secure the bridge components for furnace soldering.**
- **The metal margins of the individual bridge components may be pre-polished before soldering. In this way, precious metal alloys only have to be pickled after soldering and may then be polished to a high gloss.**

Post-Soldering (After Ceramic Firing)

There are two different methods to fabricate a soldering base: a **soldering base** or a **soldering block** with **„support pins“**.

Fabricate the **soldering base** as small as possible with rounded edges and exposed soldering site.

When **support pins** are used, the internal surfaces of the abutment crowns are first filled with soldering investment and the firing tray support pins are inserted. After setting of the investment, the soldering object is placed on the firing tray and secured using soldering investment material.

We don’t recommend post soldering for non precious alloys.

Post-Soldering (After Ceramic Firing)

Once the soldering investment has set and the wax has been removed using steam or hot water, the soldering object is prepared for furnace soldering. Apply the flux into the soldering gap while the object is still warm.

Fill the soldering gap with flux and place the desired solder at the soldering site. If soldering is performed under vacuum, only a small amount of flux is required.

Make sure that the flux is not accidentally spilled onto the ceramic material. This may lead to discolouration or fracturing of the ceramic.

Form strip solder into a ball with the flame of a Bunsen burner. The ball will later act as a soldering reservoir to ensure complete filling of the soldering gap. Slide the flat end of the strip solder into the soldering gap. If necessary, proceed as follows:
Provide the solder with a flat taper as wide as the soldering gap.

TIP
To avoid any contamination of the ceramic furnaces muffle pre-heating may be accomplished in a pre-heating furnace according to manufacturer's directions.

Post-Soldering (After Ceramic Firing)

The soldering object is pre-heated to the stand-by temperature (approximately 450–600 °C (842–1112 °F) for 6–10 minutes and subsequently heated-up to the recommended soldering temperature with a maximum temperature increase of 50 °C (122 °F)/min.

The processing temperature of the solder must be reached. The temperature may be a maximum of 50 °C/122 °F higher than the processing temperature to allow the solder to flow into the soldering gap. However, the processing temperature of the solder must be at least 50 °C/122 °F below the last firing temperature of the ceramic material.

The holding time for the soldering temperature is 30–60 seconds. After that, slowly open the firing chamber and allow the soldering object to cool to room temperature.

Once the soldering investment has been removed, oxides and flux residue can be removed from the soldering object using a pickling agent. Finish the soldering site with rotary instruments and
subsequently polish it.

- **Note:**
  When finishing and polishing the soldering site, make sure not to educe the dimensions and diameter of the soldering site.
- **Caution:**
  Soldering after ceramic firing means an additional heat treatment for the ceramic material. This may result in an increase in the coefficient of thermal expansion (CTE value).

Solder Table

PRE-SOLDER

	Composition											Melting Range		Flow Point	
Pre-Solder	**Au**	**Pd**	**Ag**	**Cu**	**In**	**Li**	**Mn**	**Ni**	**Ru**	**Zn**	**Others**	**°C**	**°F**	**°C**	**°F**
High Fusing Yellow Ceramic Solder (HFYC)	80.0	4.2	15.4	–	<1.0	<1.0	–	–	–	1.0	Fe <1.0 Ca, Ti	1085–1115	1985–2040	1100	2010
Y-2 Ceramic Solder	80.0	3.1	16.5	–	<1.0	<1.0	–	–	<1.0	–	Fe <1.0	1070–1100	1960–2010	1090	1995
HGPKF 1030 Y (High Gold Palladium Copper free)	63.2	–	35.0	–	–	–	<1.0	–	–	<1.0	Pt <1.0 Ir <1.0	1015–1040	1860–1900	1030	1885
HGPKF 1015 Y (High Gold Palladium Copper free)	60.0	–	36.5	–	<1.0	–	–	–	–	<1.0	Pt <2.1 Ir <1.0 Sn <1.0	975–1035	1785–1895	1015	1860
Aquarius Ceramic Solder	56.0	1.9	39.7	_	<1.0	<1.0	1.0	–	–	1.0	Re < 1.0	970–1020	1780–1870	990	1815
Golden Ceramic Solder (GC)	54.0	3.9	40.0	_	–	–	1.0	–	–	1.0	B <1.0 Re <1.0	995–1045	1825–1915	1020	1870
Spartan Ceramic Solder	50.0	24.0	–	25.0	–	–	–	–	–	1.0	Ir <1.0	1080–1105	1975–2020	1065	1950
Special High Fusing White Ceramic Solder (SHFWC)	47.0	10.3	41.0	_	1.4	–	–	–	<1.0	–	B <1.0 Ca, Ti	1045–1105	1915–2020	1105	2020
High Fusing White Ceramic Solder (HFWC)	45.0	12.4	41.5	_	1.0	<1.0	–	–	<1.0	–	–	1100–1165	2010–2130	1135	2075
Super Solder Ceramic Solder	–	53.5	7.0	_	–	<1.0	–	35.6	–	–	Sn 3.8	1085–1135	1985–2075	1135	2075

FLUX: High Fusing Bondal Flux – all Ceramic, Implant and Predominantly Base alloys

UNIVERSAL-SOLDER

	Composition							Melting Range		Flow Point	
Universal-Solder	**Au**	**Pt**	**Pd**	**Ag**	**Zn**	**In**	**Others**	**°C**	**°F**	**°C**	**°F**
Universal Solder PKF	48.8	2.8	–	40.5	7.3		<1.0	800–900	1470–1650	850	1560
Universal Solder 1015 W	18.5	–	5.99	72.5	–	3.0	Ir <1.0	985–1025	1805–1875	1015	1860

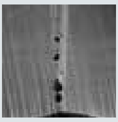
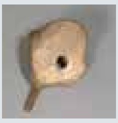
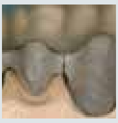
FLUX: Bondal Flux – Universal Solder PKF
High Fusing Bondal Flux – Universal Solder 1015 W

POST-SOLDER

	Composition									Melting Range		Flow Point	
Post-Solder	**Au**	**Ag**	**Cu**	**Ga**	**In**	**Li**	**Ni**	**Sn**	**Zn**	**°C**	**°F**	**°C**	**°F**
High Fusing White Gold Solder (HFWG)	79.8	–	–	–	–	<1.0	11.8	–	8.3	880–910	1615–1670	895	1645
.650 Gold Solder	65.0	13.0	19.6	2.0	–	–	–	–	<1.0	785–835	1445–1535	830	1525
.615 Fine Solder	61.5	13.1	17.4	–	7.6	–	–	–	<1.0	690–775	1275–1430	775	1425
.585 Fine Solder	58.5	16.0	18.0	7.2	–	–	–	–	<1.0	655–785	1210–1445	725	1335
Low Fusing White Gold Solder (LFWG)	56.1	27.4	–	–	<1.0	–	–	<1.0	15.8	670–730	1240–1345	730	1350

FLUX: Bondal Flux – all Crown and Bridge alloys

Trouble shooting

CAUSES	SOLUTIONS
Solder does not flow 	■ Adequately preheat the soldering object and the soldering base ■ Observe recommended flame settings ■ Use recommended flux
Soldering gap is not completely filled 	■ Use adequate quantity and the recommended solder ■ Check dimensions and the preparation of the soldering gap ■ Prevent oxide formation ■ Observe correct flame settings / temperature increase rate ■ Ensure even heating of the metal framework and the soldering base ■ Use recommended flux
Porosity in the soldering gap 	■ Do not overheat the solder / observe processing temperature ■ Prevent oxide formation; observe correct flame settings ■ Even heating of the metal framework and the soldering base ■ Use recommended flux
Distortion of the bridge 	■ Observe recommended soldering gap width ■ Observe recommended dimensions of the soldering connection ■ Follow manufacturers instructions for mixing soldering investment
Melted framework (hole) 	■ Even heating of the soldering object ■ Observe recommended flame dimensions ■ Observe recommended flame settings
Weak soldering connections 	■ Prevent oxidation before and during soldering ■ Observe recommended dimensions of the soldering connection ■ Exact preparation of the soldering surface ■ Ensure the homogeneity of the soldering structure ■ Use recommended solder

Short Instructions

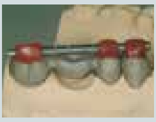
PRE-SOLDERING

1 

The soldering gap with parallel walls should show a width of at least 0.05 mm and 0.2 mm at the most and demonstrate sufficiently large surfaces.

2 

Roughen the soldering surfaces with a suitable grinding instrument or by blasting with 50 micron Al_2O_3. The soldering surfaces must be clean, i.e. free of grease and oxide.

3 

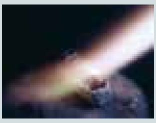
Secure the individual framework elements on the model in a stress-free fashion and close the soldering gap using modelling wax.

4 

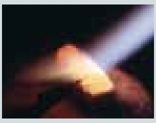
Fabricate the soldering base as small as possible and with rounded edges. After setting, remove the wax with steam or hot water.

5 

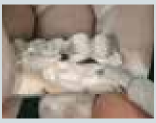
While the object is still warm, apply flux into the soldering gap and preheat the soldering base in the preheating furnace at approximately 600 °C/1112 °F for 10 minutes.

6 

Heat up the soldering object to the processing temperature of the solder.

7 

Heat the soldering object with the correctly set flame. Once the processing temperature has been reached, apply the solder to the soldering gap from the opposite direction.

8 

Allow the soldering object to cool slowly and divest. Remove oxides and flux residue by blasting and / or pickling.

9 

Grind the soldering site and prepare it for oxidation.

POST-SOLDERING

1 

A correctly prepared wax-up serves as the basis. Soldering after ceramic firing requires soldering surfaces with sufficient surface area.

2 

The soldering gap with parallel walls should show a width of at least 0.05 mm and 0.2 mm at the most and demonstrate sufficient surface dimensions.

3 

Roughen the soldering surfaces with a suitable grinding instrument or by blasting with 50 micron Al_2O_3. The soldering surfaces must be clean, i.e. free of grease and oxide.

4 

Secure the individual framework elements on the model in a stress-free fashion and close the soldering gap using modelling wax. Cover the ceramic material with wax to prevent the soldering investment from coming into contact with the ceramic.

5 

Fabricate the soldering base as small as possible and with rounded edges. After setting, remove the wax with steam or hot water.

6 

While the object is still warm, apply flux into the soldering gap. Make sure that the flux does not come into contact with the ceramic material.

7 

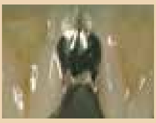
Form the suitable post-solder into a ball, wet it with flux, and position the flat end of the solder in the soldering gap.

8 

Preheat the soldering object in the ceramic furnace at approximately 600 °C for 10 minutes and subsequently heat up under vacuum to approximately 50 °C above the processing temperature of the solder.

9 

After soldering, allow the object to cool to room temperature slowly and then divest it. Remove oxides and flux residue using a pickling agent (PCT AScid).

10 

Polish the bridge to a high gloss.

Ivoclar Vivadent – worldwide

Ivoclar Vivadent AG
Bendererstrasse 2
9494 Schaan
Liechtenstein
Tel. +423 235 35 35
Fax +423 235 33 60
www.ivoclarvivadent.com

Ivoclar Vivadent Pty. Ltd.
1 – 5 Overseas Drive
P.O. Box 367
Noble Park, Vic. 3174
Australia
Tel. +61 3 9795 9599
Fax +61 3 9795 9645
www.ivoclarvivadent.com.au

Ivoclar Vivadent GmbH
Tech Gate Vienna
Donau-City-Strasse 1
1220 Wien
Austria
Tel. +43 1 263 191 10
Fax: +43 1 263 191 111
www.ivoclarvivadent.at

Ivoclar Vivadent Ltda.
Alameda Caiapós, 723
Centro Empresarial Tamboré
CEP 06460-110 Barueri – SP
Brazil
Tel. +55 11 2424 7400
Fax +55 11 3466 0840
www.ivoclarvivadent.com.br

Ivoclar Vivadent Inc.
1-6600 Dixie Road
Mississauga, Ontario
L5T 2Y2
Canada
Tel. +1 905 670 8499
Fax +1 905 670 3102
www.ivoclarvivadent.us

Ivoclar Vivadent Shanghai Trading Co., Ltd.
2/F Building 1, 881 Wuding Road,
Jing An District
200040 Shanghai
China
Tel. +86 21 6032 1657
Fax +86 21 6176 0968
www.ivoclarvivadent.com

Ivoclar Vivadent Marketing Ltd.
Calle 134 No. 7-B-83, Of. 520
Bogotá
Colombia
Tel. +57 1 627 3399
Fax +57 1 633 1663
www.ivoclarvivadent.co

Ivoclar Vivadent SAS
B.P. 118
F-74410 Saint-Jorioz
France
Tel. +33 4 50 88 64 00
Fax +33 4 50 68 91 52
www.ivoclarvivadent.fr

Ivoclar Vivadent GmbH
Dr. Adolf-Schneider-Str. 2
D-73479 Ellwangen, Jagst
Germany
Tel. +49 7961 889 0
Fax +49 7961 6326
www.ivoclarvivadent.de

Wieland Dental + Technik GmbH & Co. KG
Lindenstrasse 2
75175 Pforzheim
Germany
Tel. +49 7231 3705 0
Fax +49 7231 3579 59
www.wieland-dental.com

Ivoclar Vivadent Marketing (India) Pvt. Ltd.
503/504 Raheja Plaza
15 B Shah Industrial Estate
Veera Desai Road, Andheri (West)
Mumbai, 400 053
India
Tel. +91 22 2673 0302
Fax +91 22 2673 0301
www.ivoclarvivadent.in

Ivoclar Vivadent s.r.l.
Via Isonzo 67/69
40033 Casalecchio di Reno (BO)
Italy
Tel. +39 051 6113555
Fax +39 051 6113565
www.ivoclarvivadent.it

Ivoclar Vivadent K.K.
1-28-24-4F Hongo
Bunkyo-ku
Tokyo 113-0033
Japan
Tel. +81 3 6903 3535
Fax +81 3 5844 3657
www.ivoclarvivadent.jp

Ivoclar Vivadent Ltd.
12F W-Tower, 1303-37
Seocho-dong, Seocho-gu,
Seoul 137-855
Republic of Korea
Tel. +82 2 536 0714
Fax +82 2 596 0155
www.ivoclarvivadent.co.kr

Ivoclar Vivadent S.A. de C.V.
Av. Insurgentes Sur No. 863,
Piso 14, Col. Napoles
03810 México, D.F.
México
Tel. +52 55 5062 1000
Fax +52 55 5062 1029
www.ivoclarvivadent.com.mx

Ivoclar Vivadent BV
De Fruittuinen 32
2132 NZ Hoofddorp
Netherlands
Tel. +31 23 529 3791
Fax +31 23 555 4504
www.ivoclarvivadent.com

Ivoclar Vivadent Ltd.
12 Omega St, Rosedale
PO Box 303011 North Harbour
Auckland 0751
New Zealand
Tel. +64 9 914 9999
Fax +64 9 914 9990
www.ivoclarvivadent.co.nz

Ivoclar Vivadent Polska Sp. z o.o.
Al. Jana Pawla II 78
00-175 Warszawa
Poland
Tel. +48 22 635 5496
Fax +48 22 635 5469
www.ivoclarvivadent.pl

Ivoclar Vivadent Marketing Ltd.
Prospekt Andropova 18 korp. 6/
office 10-06
115432 Moscow
Russia
Tel. +7 499 418 0300
Fax +7 499 418 0310
www.ivoclarvivadent.ru

Ivoclar Vivadent Marketing Ltd.
Qlaya Main St.
Siricon Building No.14, 2nd Floor
Office No. 204
P.O. Box 300146
Riyadh 11372
Saudi Arabia
Tel. +966 11 293 8345
Fax +966 11 293 8344
www.ivoclarvivadent.com

Ivoclar Vivadent S.L.U.
Carretera de Fuencarral nº24
Portal 1 – Planta Baja
28108-Alcobendas (Madrid)
Spain
Telf. +34 91 375 78 20
Fax: +34 91 375 78 38
www.ivoclarvivadent.es

Ivoclar Vivadent AB
Dalvägen 14
S-169 56 Solna
Sweden
Tel. +46 8 514 939 30
Fax +46 8 514 939 40
www.ivoclarvivadent.se

Ivoclar Vivadent Liaison Office
: Tesvikiye Mahallesi
Sakayik Sokak
Nisantas' Plaza No:38/2
Kat:5 Daire:24
34021 Sisli – Istanbul
Turkey
Tel. +90 212 343 0802
Fax +90 212 343 0842
www.ivoclarvivadent.com

Ivoclar Vivadent Limited
Ground Floor Compass Building
Feldspar Close
Warrens Business Park
Enderby
Leicester LE19 4SE
United Kingdom
Tel. +44 116 284 7880
Fax +44 116 284 7881
www.ivoclarvivadent.co.uk

Ivoclar Vivadent, Inc.
175 Pineview Drive
Amherst, N.Y. 14228
USA
Tel. +1 800 533 6825
Fax +1 716 691 2285
www.ivoclarvivadent.us

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